

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



ESCOLA TÈCNICA SUPERIOR
D'ENGINYERIA QUÍMICA
Universitat Rovira i Virgili

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Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM I

Document 1: Índex general

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VOLUM I

Document 2: Memòria descriptiva

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RESUM

En aquest treball de final de grau d'enginyeria mecànica, es proposa dissenyar un sistema de refrigeració per una motocicleta elèctrica de competició, concretament per refrigerar l'inversor d'aquest vehicle.

La motocicleta en qüestió va participar al campionat de MotoStudent celebrat el juliol del 2021, al circuit d'Alcanyís, amb el problema que l'inversor, (element que transforma l'energia elèctrica de la bateria al motor), treballava per damunt dels seus límit màxims de funcionament, prescindint de l'entrega prestacions que podia oferir el motor de la motocicleta i anat a una velocitat molt inferior a l'esperada.

A partir d'un disseny CAD i de la telemetria realitzada per l'equip, es realitzen els càlculs corresponents per aconseguir dissipar la calor, de manera que el sistema entri en els rangs de temperatura establerts de treball. Totes les solucions estan cenyides al reglament tècnic del certamen, de manera que hi ha limitacions a l'hora d'afrontar la resolució del problema.

FULL D'IDENTIFICACIÓ DEL PROJECTE

Títol del projecte

Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició.

Promotor del projecte

Organització: URVoltage Team O.R.G.

Redactor del projecte

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Nom: Héctor González Montarelo

Signatura del redactor



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DOCUMENT 2. MEMÒRIA DESCRIPTIVA

1.- Objecte del projecte

L'objecte d'aquest projecte consisteixen en el càlcul i disseny d'un sistema de refrigeració d'un inversor per a una motocicleta de competició, provinent de l'equip URVoltage Team que competeix al certamen "MotoStudent", que va competir en la competició realitzada el 2021. Aquesta necessitat sorgeix a partir dels problemes de refrigeració d'aquest component, de manera que es vol solucionar aquest fet per a un funcionament de tota la motocicleta. Tot i que la competició es va realitzar el 2021 i la actual motocicleta no hagi de tornar a participar, s'ha escollit el reglament de l'edició 2022-2023 perquè tot el desenvolupament que es pugui realitzar, serà adquirit per al desenvolupament de la nova motocicleta.

1.1.- Promotor del projecte

El promotor d'aquest projecte és l'equip de competició de la Universitat Rovira i Virgili (URV), amb l'objectiu de millorar el rendiment de la motocicleta en la part de l'inversor i solucionar els problemes sorgits.

1.2.- Equip redactor

L'equip redactor està format per un projectista estudiant de quart curs d'enginyeria mecànica. Les seves dades són les següents

- Nom: Arnau Ferré Queralt
- NIF: 39944030E
- Direcció: C/ unió 2, Alcover (43460)

2.- Abast

L'abast d'aquest projecte és el disseny, anàlisis, càlcul i optimització dels sistema de refrigeració d'un inversor per a una motocicleta de competició, cenyint-se a la reglamentació del certamen "MotoStudent". Tots aquests aspectes es projectaran sobre la motocicleta ja realitzada en l'edició del 2021, que va ser la segona en la que va participar l'equip de la universitat.

3.- Antecedents

Com s'ha pogut observar en els darrers anys, el sector automobilístic està desenvolupant una constant evolució per obtenir una font d'energia neta i sostenible que pugui perdurar en el temps sense comprometre el medi ambient. Per aquest motiu s'ha realitzat una forta aposta per les motocicletes elèctriques. Aquestes han portat les competicions de motocicletes elèctriques, i des de la universitat fa anys que s'hi participa.

Aquestes motocicletes tenen alta complexitat i problemes degut a la seva poca experiència i dades que se'n tenen, tot i que se n'està accelerant el seu ritme de millora i eficiència. En el cas concret del projecte, tot l'estudi es realitzarà sobre l'inversor, que és el component encarregat de transformar l'energia que emmagatzema la bateria a la corresponent que sol·licita el motor. Aquesta transformació consisteix en canviar el tipus de corrent (continua a alterna), canvi de voltatge i canvi de fase. Aquestes transformacions són molt eficients (fregant el 90%-95%) d'eficiència, i la resta es dissipa en forma de calor. Per a petites potències aquest fet no és transcendent, però a mesura que augmenta la potència, la calor dissipada, i per tant que produeix sobreescalfament va augmentant.

Com que l'equip ja ha rodat amb aquest vehicle, s'han proporcionat les dades de la telemetria al projectista per a poder estudiar-les i emprar un recurs adient i trobar una solució.

3.1- Competició MotoStudent

La competició MotoStudent és un certamen bianual que es celebra amb universitat d'arreu del món. La finalitat és desenvolupar una motocicleta de competició que acabi competint al circuit d'Alcanyís i que s'enfronti a altres universitats. La primera edició del certamen va ser el 2009, i no va ser fins al campionat del 2015-2016 que va aparèixer la modalitat 100% elèctric. El certamen disposa d'un reglament tècnic d'estricta compliment per a poder participar, de manera que el projectista ha hagut de tenir en compte l'aspecte tècnic d'aquest durant el devanir del projecte. Per tant, tots els càlculs, estudis i dissenys realitzats han d'estar dins del marc legal que permet dit reglament.

4.- Normes i referències

4.1- Disposicions legals i normes aplicades

S'ha aplicat la següent normativa durant l'execució del projecte:

- Norma espanyola UNE 157001:2014 *Criterios generales para la elaboración formal de los documentos que constituyen un proyecto técnico*
- Reglament tècnic MotoStudent 2022-2023
- Norma espanyola UNE 1039:1994 *Dibujos técnicos. Acotación. Principios generales, definiciones, métodos de ejecución e indicaciones especiales.*

4.2- Programes de càlcul

Durant el transcurs del projecte s'han emprat els següents programes per a la realització dels càlculs i disseny:

- SolidWorks 2022: Emprat per a la simulació termodinàmica del conjunt, així com per la modelització del disseny a la motocicleta.
- AutoCad 2022: Emprat per a la realització de plànols i representació.
- Presto 2022: Emprat per a la realització del conjunt del pressupost, amidament i justificació de preus.
- Microsoft Excel: Emprat per a la realització de càlculs realitzats durant el transcurs del projecte.

5.- Definicions i abreviatures

Es defineixen les següents definicions i abreviatures per tal d'agilitzar i normalitzar el vocabulari tècnic usat en aquest projecte.

- C12: (Corba 12)
- Stint: (Seqüència de voltes cronometrades)
- Moto: (Abreviatura de "motocicleta")

6.- Requisits de disseny

6.1.- Introducció

El model dissenyat i simulat que a continuació es mostrarà, està estudiat per a la pràctica de curses de competició, concretament al circuit de MotorLand d'Aragó. A continuació s'exposarà les consideracions realitzades i requerides.

6.2.- Característiques del traçat

Com s'ha mencionat, el model s'ha dissenyat tenint en compte les consideracions específiques del traçat aragonès de MotorLand. En aquest s'hi duen a terme diferents tipus de cuses amb les diferents variants que presenta, de manera que per a la competició MotoStudent s'emprarà la variant per a motocicletes. Així doncs, la variant la qual la motocicleta competirà és la següent:

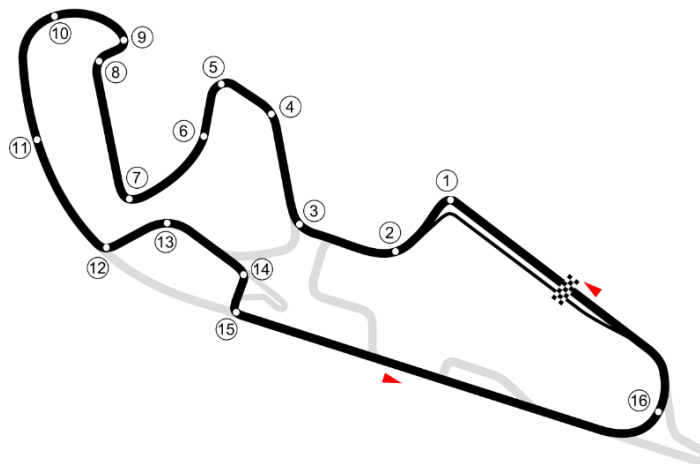


Figura 1.1: Traçat MotorLand per a motocicletes (Font: es.wikipedia.org)

Algunes de les característiques tècniques principals del circuit són les següents:

Taula 1.1: Característiques tècniques circuit MotorLand (Font: motorlandaragon.com)

Característiques Circuit de MotorLand	
Longitud traçat	5077 m
Corbes	7 a dretes/9 a esquerres
Recta més llarga	1211 m

També es mencionen les temperatures del circuit durant els darrers anys, a tenir en compte per saber la temperatura la qual el radiador dissiparà la calor.

- Temperatura ambient=30°C

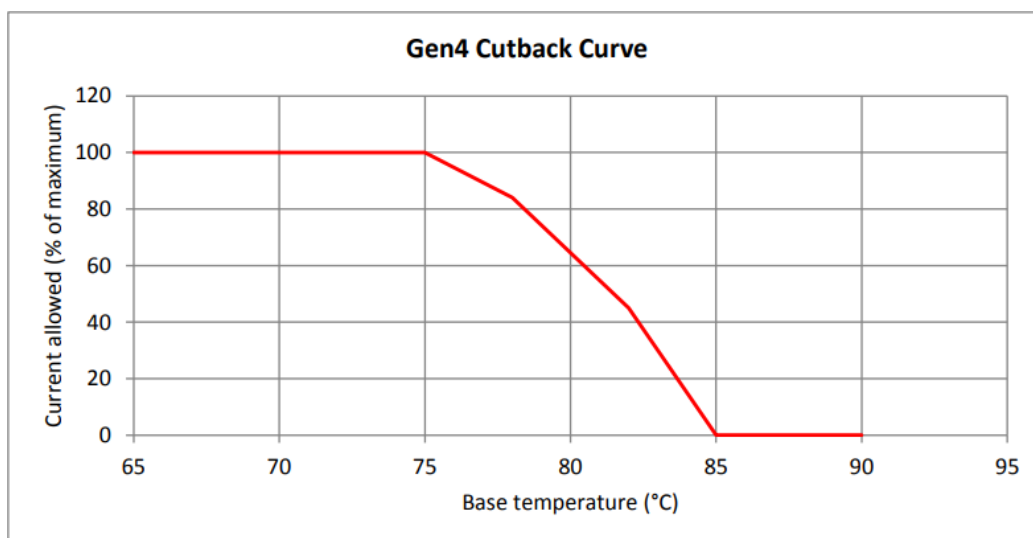
6.3.- Característiques del vehicle

La motocicleta creada per part de l'equip promotor del projecte té les següents característiques a tenir en compte a l'hora de desenvolupar el projecte.

6.3.1.- Inversor

L'element encarregat de transformar l'energia de la bateria per transmetre-la al motor té el requisit de no sobre-passar la temperatura màxima de treball per a garantir un bon funcionament.

Taula 1.2: Corrent de sortida segons temperatura de treball (Font: Sevcon.com)



Com s'observa en la il·lustració anterior, s'enforna la corrent subministrada per l'inversor amb la temperatura de treball de la base. Com es pot veure, el rendiment comença a decaure a partir dels 75 °C, essent aquest el punt màxim amb la major potència, que és el que es pretén aconseguir. Per aquest motiu, es marca coma temperatura màxima de treball 70 °C, deixant un marge de seguretat per a errors o sobre-potències que la motocicleta pugués arribar a assolir en un moment pic.

6.3.2.- Dimensions i disseny del conjunt

El disseny prèviament realitzat del prototip fa que la integració de components s'hagi de realitzar a partir de la motocicleta actual. Aquest fet comporta la posició de les bateries, que marcaran la posició del radiador, així com la forma del xassís, que marcarà la disponibilitat de realitzar els suport pels element que conformen el sistema.

Per a les característiques tècniques a desenvolupar a l'hora de realitzar el prototip, s'han realitzat múltiples visites al taller on es disposava de la motocicleta físicament. A més a més, es va aprofitar per a l'adquisició de fotografies per a comprar la correlació entre el model CAD i el realitzat realment per a competitiu (es pot veure en més detall a l'apartat de "Treball de camp" al seu corresponent annexa.

7.- Anàlisis de solucions

7.1.- Introducció

Un cop comentats tots els requeriments per a la realització del projecte, es procedeix a mostrar les solucions emprades en cada cas.

7.2.- Disseny del sistema tèrmic de dissipació

Per extreure la calor produïda a l'inversor, les alternatives estudiades han estat les següents:

- Sistema de refrigeració convecció natural d'aire: S'estudia la possibilitat d'afegir un dissipador amb aletes, que mitjançant la circulació d'aire durant l'avanç de la motocicleta aprofiti per dissipar la calor.
- Sistema de refrigeració per convecció forçada d'aire: A part d'afegir aletes de dissipació, s'estudia afegir ventiladors per extreure la calor produïda per l'element.
- Sistema de refrigeració per refrigeració líquida: Es contempla l'opció de realitzar la dissipació de calor mitjançant un sistema per refrigeració líquida, on un fluid refrigerant sigui l'encarregat d'extreure la calor de l'element dissipador.

De les opcions contemplades, es decideix escollir el sistema de refrigeració líquida. Pel perfil de motocicleta escollit, la dissipació mitjançant només aire no esdevé eficient, ja que pel propi disseny del carenat, no arriba flux d'aire a la part del colí de no moto. Aquests fet comporta que es creï un buit d'aire just en aquesta zona, que és on es troba tota l'àrea d'intercanvi de l'inversor.



Figura 1.2 i 1.3: Col·locació de l'inversor a la motocicleta. (Font: Imatge pròpia)

A més a més, el sistema de refrigeració per aire va quedar sentenciat ja que l'equip va provar d'afegir tubs per augmentar el flux d'aire en aquesta zona, i es seguien tenint problemes de temperatura en aquesta mateix punt.



Figura 1.4 i 1.5: Incorporació de tubs per augmentar el flux d'aire. (Font: Imatge pròpia)

Així doncs, es procedeix a centrar-se en l'estudi de refrigeració mitjançant un fluid refrigerant per dissipar la calor generada.

7.3.- Disseny hidràulic del sistema de refrigeració líquida

Es presenta el disseny del sistema a realitzar, i paral·lelament es calcula el sistema hidràulic. A continuació es mostra la representació del sistema integrat a la motocicleta.

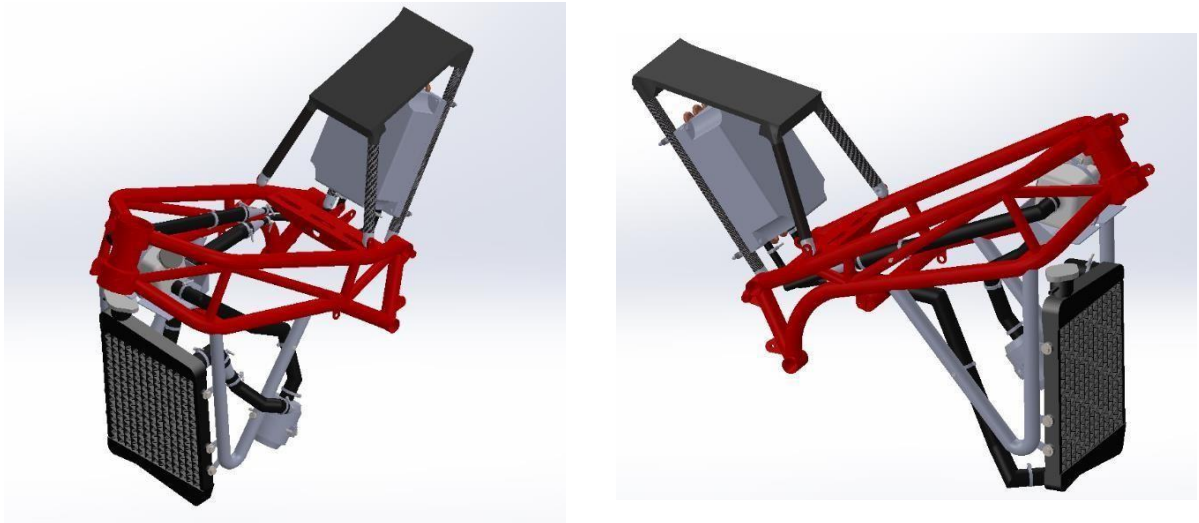


Figura 1.6 i 1.7: Vistes amb la integració del sistema de refrigeració (Font: Imatge propia)

En les imatges anteriors es mostren els perfils amb la integració del sistema al xassís i al colí. Un cop vista l'alternativa definitiva, es desglossarà per parts dins del sistema hidràulic i s'analitzaran les alternatives i decisions preses en cada component.

El fluid emprat coma refrigerant és aigua destil·lada, ja que és una de les condicions obligatòries expressades en el reglament tècnic.

7.3.1.- Sistema de dissipació

Per al sistema de dissipació s'ha optat per emprar un dissipador de calor comercial, exclusivament creat per a refrigerar l'inversor en qüestió, de manera que se'n garanteixi un rendiment, a més de l'obtenció d'un cost més baix que si es dissenyés a mesura.



Figura 1.8: Placa dissipadora per inversor Sevcon Gen4 Size4. (Font:electricmotorsport.com)

A grans trets, els materials emprats en aquest conjunt són alumini i coure. Els detalls tècnics sobre aquesta placa es troben a l'annex, a l'apartat de catàleg.

Des del primer moment s'ha pensat en aquesta recurs, ja que és una manera de definir una part del sistema, de manera que s'elimina una variable. D'altra banda, es simplifiquen els càlculs per part del projectista i se n'assegura el funcionament, de manera que també s'augmenta la fiabilitat del conjunt.

A partir d'aquest punt, es realitza la simulació d'aquest element a partir de les potències consumides per la motocicleta durant el transcurs d'una volta. S'estableixen potències mitjanes consumides per realitzar un estudi transitori i veure com evoluciona la temperatura del component en funció del pas del temps. Per veure els valors de la telemetria, s'ha de consultar els annexes de la memòria, a l'apartat de càlculs. A continuació es mostren els resultats obtinguts de l'estudi.

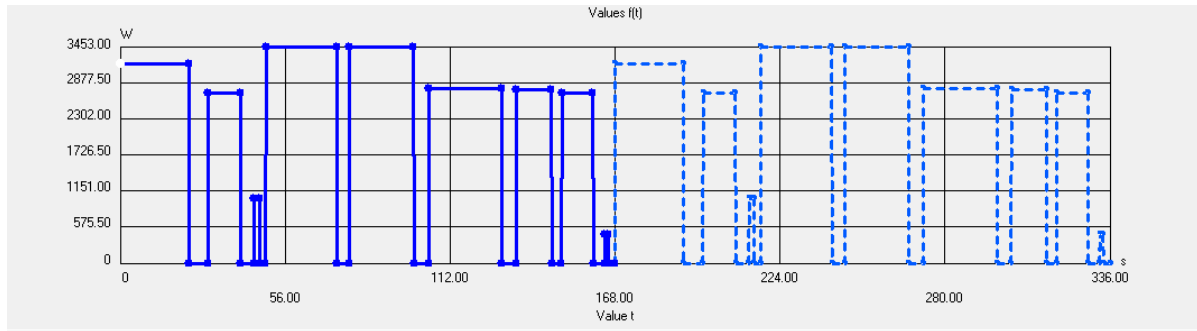
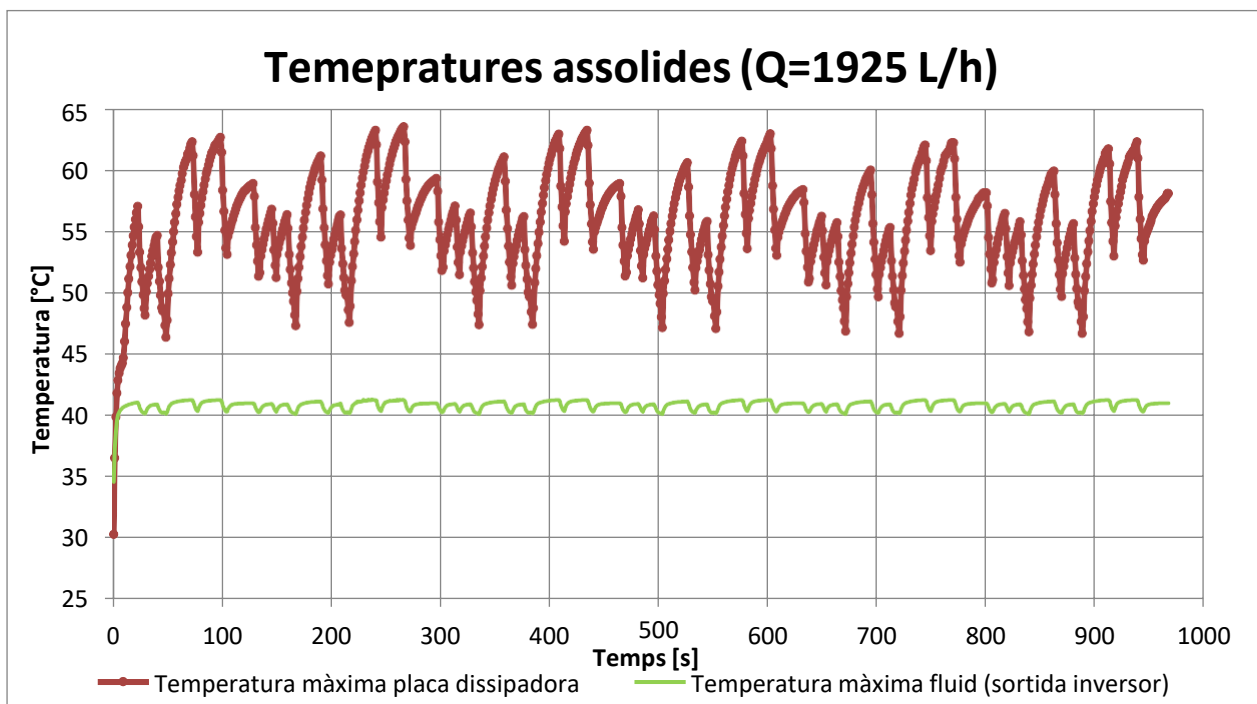


Figura 1.9: Valors de potència dissipada a l'inversor (Font: Imatge pròpia)

Com s'observa a la imatge, s'ha suposat una potència mitjana prèviament calculada i es repeteix de forma periòdica en el temps, de manera que simula la repetició de voltes consecutives.

A continuació es mostra el resultat obtingut de la simulació, on tots els càlculs es troben explicats explícitament a l'annex de càlculs.

Taula 1.3: resultats final de la temperatura aïll dissipador (Font: Taula pròpia)



Al tenir un caudal elevat, provoca que el fluid no s'escalfi en excés i per altra banda, que no es refredi en excés. En aquest cas, la placa es refreda per la quantitat d'aigua que hi passa més que per la diferència de temperatures entre el fluid i el sòlid.

7.3.2.- Radiador

Per al sistema de dissipació de calor del fluid refrigerant s'empra un radiador per a motocicleta, també comercial. La ubicació cercada per aquesta es troba darrere de la roda davantera, com s'empra en les motocicletes amb motor de combustió.



Figura 1.10: Radiador seleccionat per evacuar la calor. (Font: webshop.nrf.eu/automotive/engine-cooling-products)

Aquest element està pensat per refrigerar fluids amb temperatures pròximes a les d'ebullició. Per aquest motiu, al costat del tap per omplir de refrigerant el sistema hi ha una petit tub, per a evacuar les sobrepressions del sistema, ja que el tap actua com una PSV. En el cas del projecte, aquesta mesura no actua, a menys que hi hagués una obstrucció del sistema hidràulic o una altre anomalia, per aquest motiu el tub esmentat no es connecta al dipòsit de compensació. A més a més la temperatura de vaporització és per sota de la temperatura màxima de funcionament de l'inversor, i per aquest motiu no es connectarà la seguretat al dipòsit perquè condensi, de manera que en el cas que s'alliberés per aquest tub, descarregaria directament a l'atmosfera. Al tractar-se d'aigua no suposa cap risc mediambiental.

Per a estudiar la posició idònia del radiador, s'ha modelitzat la roda davantera al programa de càlcul per avaluar el punt més òptim de col·locació del mateix, així com per definir l'espai disponible de treball per a la tria del radiador.

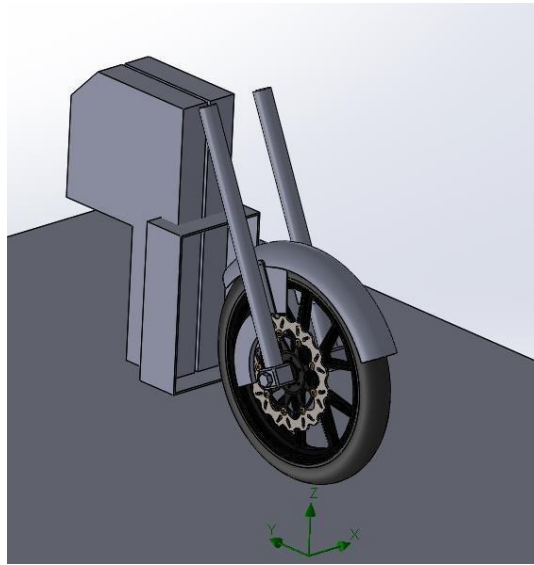


Figura 1.11: Modelització de la zona del radiador. (Font: Imatge pròpia)

Amb aquesta modelització, s'ha calculat el flux d'aire que arriba a la zona del radiador, ja que la velocitat al radiador esdevé més baixa que la velocitat que assolix la motocicleta. S'han realitzat una sèrie de simulacions per avaluar la velocitat real en aquest punt, i aquest n'ha estat resultat.

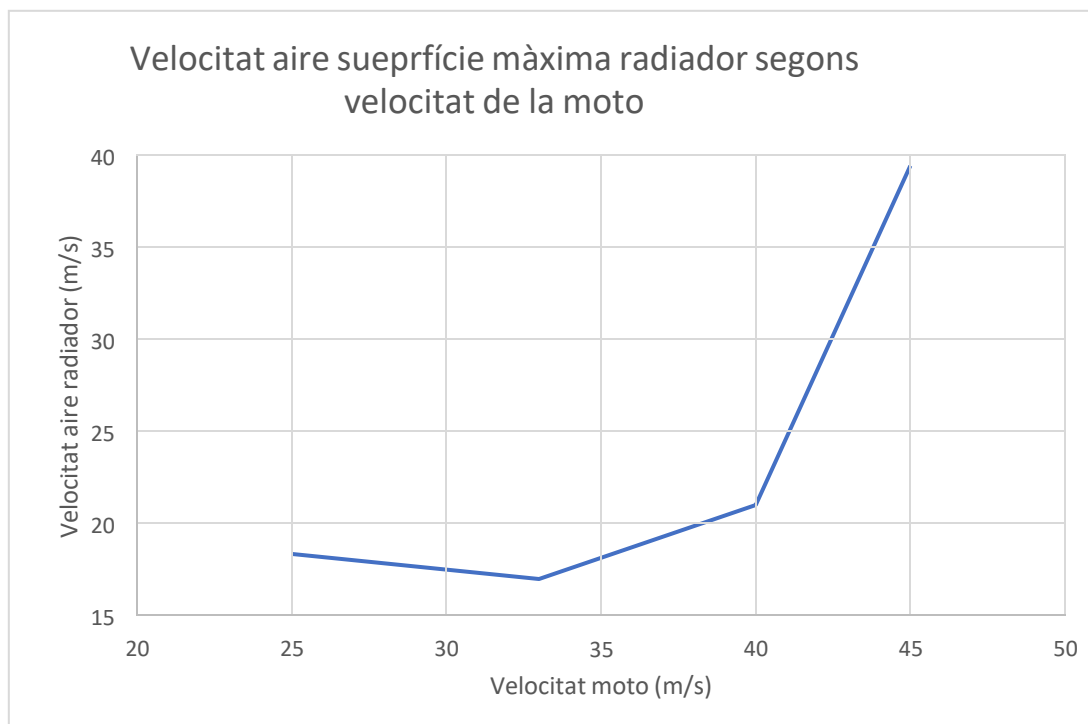
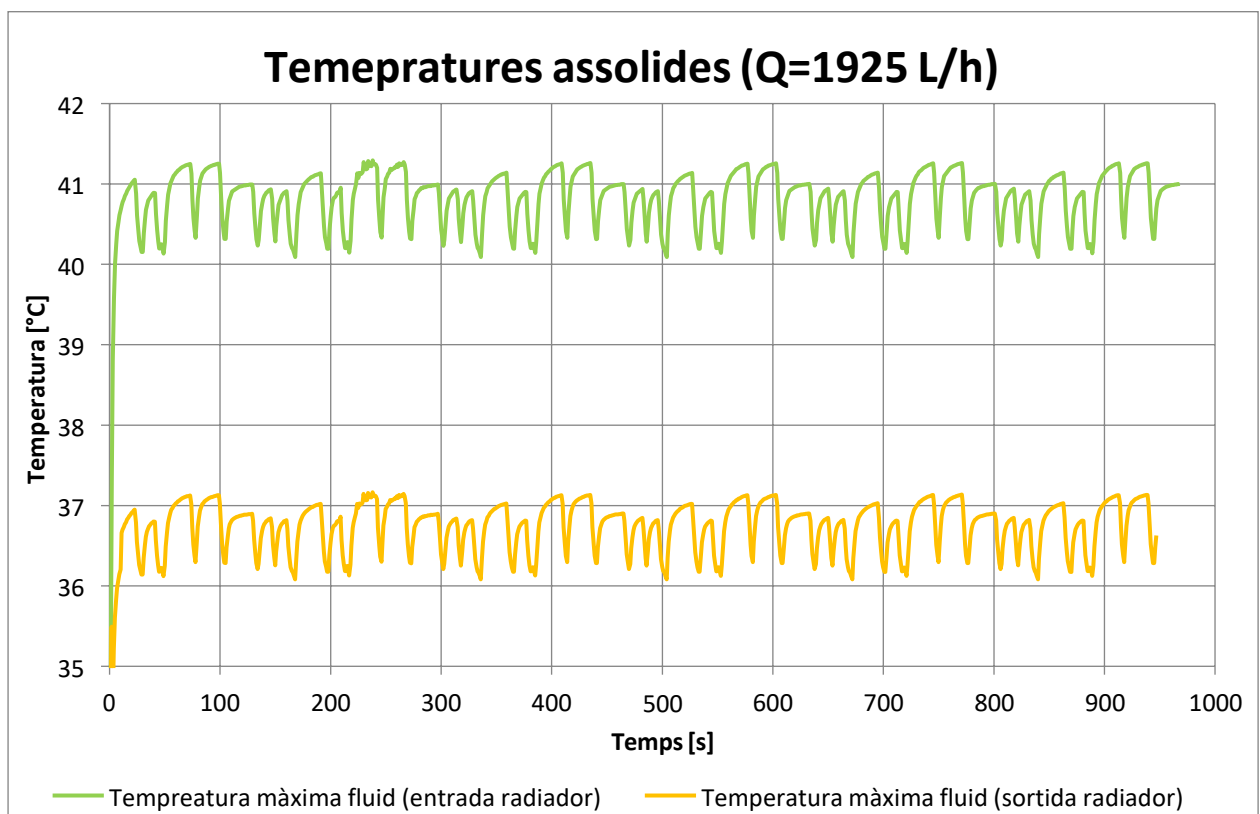


Figura 1.12: Comparació velocitat motocicleta amb velocitat al radiador

En aquesta gràfica s'observa un comportament que és diferent al pensat. A l'augmentar la velocitat de la motocicleta, no augmenta proporcionalment la velocitat al radiador. El punt quan la motocicleta passa entre els 30-35 m/s, decau la velocitat. Per aquest motiu s'ha aplicat un factor correctiu a les potències que es dissipen en aquest interval de temps, per contrarestar la velocitat perduda degut a la turbulència generada i que evita l'entrada d'aire al radiador. Un cop arribat a aquest punt es procedeix a realitzar novament la simulació amb el software, però en aquest cas al radiador.

Els resultats finals obtinguts al radiador han estat els següents:

Taula 1.4: Comportament temperatures amb caudal 1925 L/h (Font: Taula pròpia)



7.3.3.- Dipòsit de compensació

Es va pensar de prescindir d'aquest element per estalviar pes i complexitat al sistema, però finalment s'ha decidit incorporar-lo, ja que d'aquesta manera s'evitarà la bomba en els instant d'arrancada i en els revolts. Aquest dipòsit es situa en un punt alt, de manera que per la mateixa gravetat es pugui omplir gran part del circuit refrigerant. Amb la incorporació d'aquest dipòsit, s'assegura l'eliminació de bosses d'aire al sistema, de manera que el fluid optimitzi les seves propietats refrigerants, que són millors que les que conté l'aire, ja que els punts més alts podria ser que per gravetat no s'eliminessin les bosses dites i també provoqués problemes de cavitació a l'element que subministra pressió al circuit, la bomba. Aquest element també és element comercial.



Figura 1.13: Dipòsit DT Spare Parts 2.30046. (Font:recambioscoche.es)

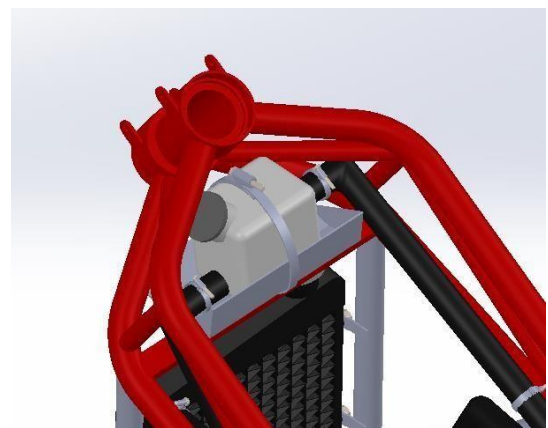


Figura 1.14 i 1.15: Integració del dipòsit al xassís. (Font: Imatge pròpia)

La zona on s'ubica el dipòsit de compensació és a la part davantera, sobre el radiador. Aquest punt és estratègic, ja que connecta directament amb l'aspiració de la bomba, assegurant permanentment l'arribada de fluid sense aire. Dita posició també és emprada ja que es troba una zona sense components, amb un espai buit on cap el dipòsit.

Com que aquesta zona es troba pròxima a la zona de les bateries, es suporta el dipòsit es decideix crear-lo de per evitar el possible vessament (degut a una fuita), cap a la zona de les bateries, poden provocar una falla no desitjable en aquest àmbit.

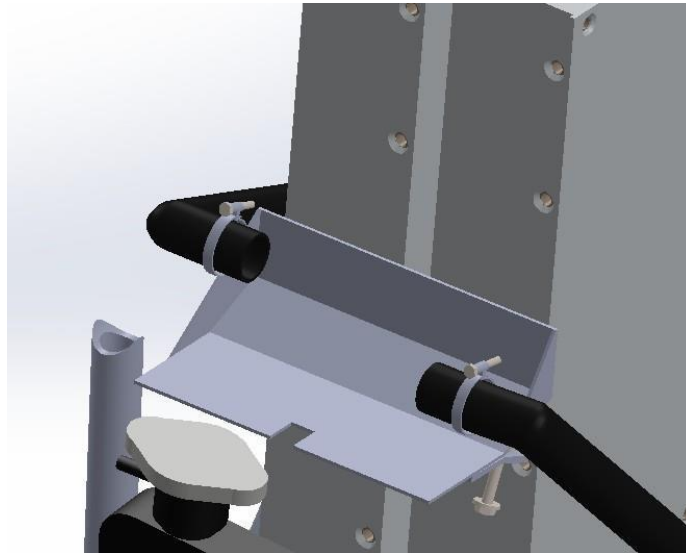


Figura 1.16: Detall del suport del dipòsit. (Font: Imatge pròpia)

A la figura 1.16 es mostra l'aspecte comentat anteriorment, amb el conjunt de la bateria integrat novament al xassís.

7.3.4. - Bomba d'impulsió

Per a proporcionar el caudal i pressió desitjats al circuit, s'empra una bomba. En aquest cas s'ha cercat per una bomba de refrigeració que s'utilitzi en el sector de l'automòbil.

Per a aquesta aplicació s'utilitzen 2 tipus de bombes; les mecàniques i les elèctriques.

Per aquest sistema, es decideix seleccionar una bomba elèctrica, ja que la mecànica va en consonància amb les revolucions del motor, d'haver disposar d'una ubicació concreta per a realitzar la transmissió a l'eix del motor mitjançant una corretja. Tots aquests problemes desapareixen amb la bomba elèctrica, de manera que la col·locació és lliure i la l'energia elèctrica arriba mitjançant cables connectats a la bateria, a canvi d'una menor fiabilitat respecte les mecàniques.

Per tant, es cerquen bombes comercials per a la introducció d'una d'aquestes al sistema, de manera que a partir de la corba característica de la bomba i les propietats físiques del sistema, s'aconsegueix obtenir el cabal i la pressió de treball del circuit.

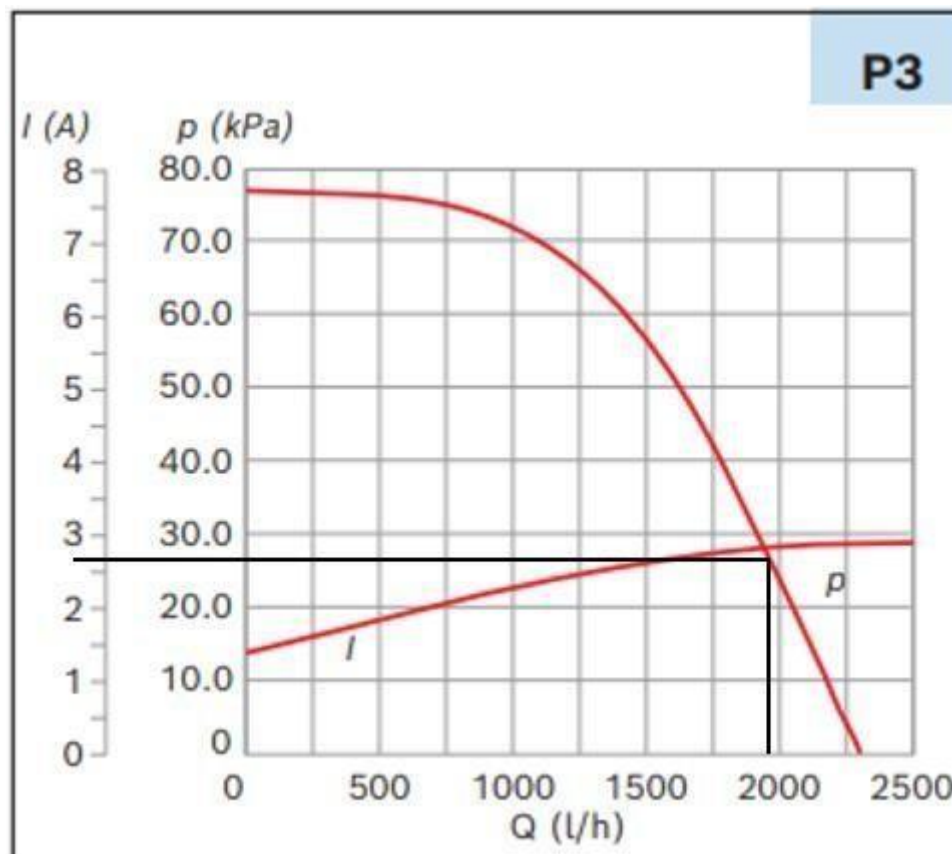


Figura 1.17: Corba característica bomba BOSCH 0 392 024 041. (Font: bosch-ibusiness.com)

D'aquesta manera, el resultat de la bomba seleccionada, es realitzen els càlculs per avaluar les pèrdues del circuit i es realitzen les iteracions corresponents, fins a arribar al resultat és el mostrat en la imatge 1.17. A diferència d'altres bombes, la seleccionada treballa a 24V, permeten una menor intensitat i minimitzant les pèrdues de calor per efecte Joule. D'aquesta manera, també es pot reduir el cablejat per alimentar la bomba.

Les dades de la corba característica es troben a l'annex, a l'apartat de catàlegs.

Per la col·locació de la bomba al sistema, es posiciona posterior al dipòsit de compensació (explicat anteriorment a l'apartat de dipòsit de compensació).

Inicialment es va pensar de posicionar la bomba a la sortida del radiador per poder refrigerar-la al mateix sortir del radiador, assumint que es perdria certa potència dissipadora. Aquest fet finalment s'ha desestimant, ja que amb la posició del dipòsit de compensació desafavoria aquest fet. D'aquesta manera, s'ha posicionat abans de l'entrada al radiador, cosa que produeix que no es refrigeri tant com si s'hagués posicionat a la sortida.

Un altre fet que no es pot menysprear és el NPSH. Tot i que la corba característica de la bomba no proporcioni la corba del NPSH, s'ha estudiat a partir de les dades del fabricant el funcionament per aquest circuit. Com que les temperatures de funcionament es troben lluny de la pressió de vapor del fluid refrigerant, i la bomba està pensada per aquest tipus de funcionament, és donat per acceptada la comprovació del NPSH.

D'altra banda, la corrosió dels elements interior de la bomba com el rodet, no suposa un problema per quan a la corrosió es parla, ja que aquestes bombes estan preparades per impulsar refrigerants més corrosius que la pròpia aigua.

7.3.5.- Unions hidràuliques dels components

Un cop dimensionats tots els elements que conformen el circuit hidràulic, es procedeix a unir dits elements per a que el fluid pugui passar i complir les funcions estipulades en cada cas.

Per a unir els diferents components del circuit hidràulic s'ha emprat tubs de cautxú amb reforç tèxtil, emprat al sector per aquesta aplicació. S'han els tubs en funció dels diàmetres donats per cada cas, de manera que s'han hagut de realitzar toveres amb reduccions i augments de pas segons les necessitats del sistema.

Per a acollir els diferents tubs als elements, s'han usat abraçadores metàl·liques, a mode que la pròpia pressió d'aquestes asseguri la fixació dels tubs. Amb aquesta solució, s'ha prescindit d'usar canonades metàl·liques, ja siguin roscades o bridades, aconseguint un pes menor i una mantanabilitat major.

Les toveres realitzades per adequar els diàmetres en cada cas han estat fabricades per a l'ocasió, ja que no es trobaven models comercials amb els diàmetres d'entrada i sortida desitjats.

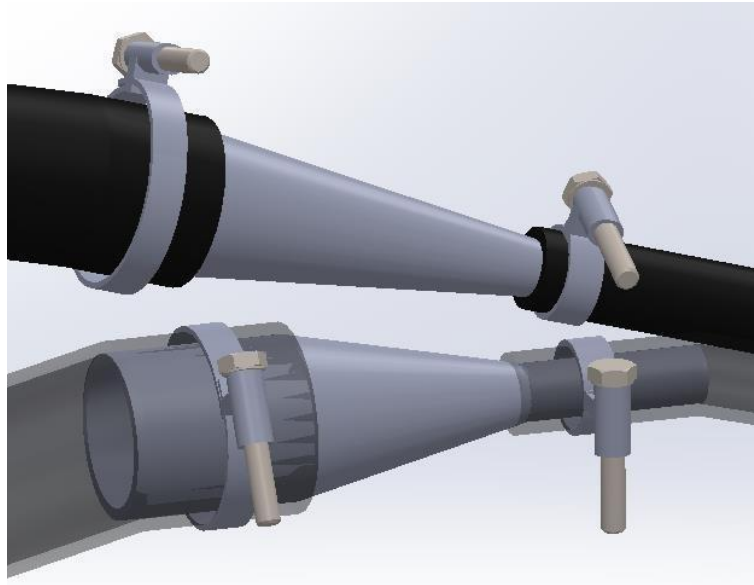


Figura 1.18: Exemple unions toveres. (Font: Imatge pròpia)

S'ha realitzat el "Cooling Layout" per a esquematitzar el sistema de refrigeració prèviament esmentat.

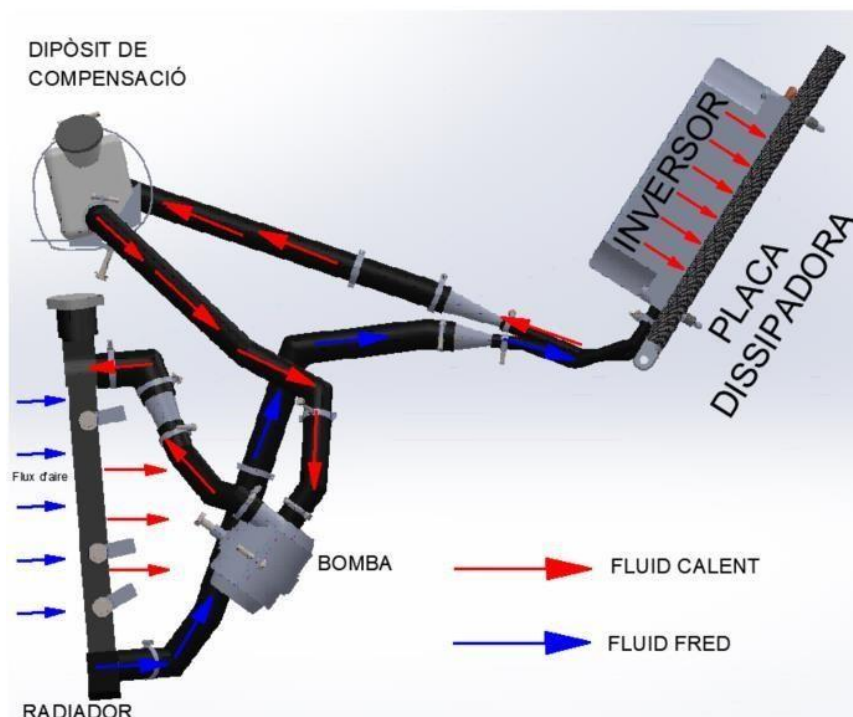


Figura 1.19: "Cooling layout". (Font: Imatge pròpia)

En la figura 1.19 es mostra el diagrama de refrigeració senyalitzant els sentits del fluid en cada cas (refrigerant i aire).

Com s'observa en el Layout, s'ha precedit d'un element típic usat en els sistemes de refrigeració de vehicles, com seria la vàlvula termostàtica. Aquesta no s'ha incorporat per treure complexitat al sistema, ja que en els automòbils de combustió es busca l'augment progressiu de temperatura, sobretot quan està fred el sistema, de manera que inicialment no és necessari extreure calor al sistema. En aquest cas, al tractar-se d'una motocicleta elèctrica, convé que l'electrònica de l'inversor treballi el més fred possible, de manera que no és convenient que comenci a dissipar calor a certa temperatura. D'altra banda, l'inversor assoleix una alta temperatura en breus instants, de manera que aquesta vàlvula termostàtica seria només per breu instant de temps, degut a aquesta concentració de la calor degut a la poca massa que té l'inversor.

Al document bàsic de plànols es resumeixen les mesures i diàmetres corresponents de cada secció de tub, per a poder definir la totalitat del sistema.

7.3.- Disseny mecànic pel sistema hidràulic

Per a adequar el sistema hidràulic al conjunt de la motocicleta, s'han realitzat una sèrie d'adaptacions i modificacions a la motocicleta existents per la correcta integració del sistema.

De les peces que a continuació es mostraran, n'hi ha de fabricació pròpia i n'hi ha que provenen d'un model comercial. Per les de fabricació pròpia, es poden veure tots els detalls al document bàsic de plànols.

Subjecció de la placa dissipadora

L'element encarregat de suportar la placa dissipadora juntament amb l'inversor, és el sub-xassís que suporta el colí de la motocicleta.

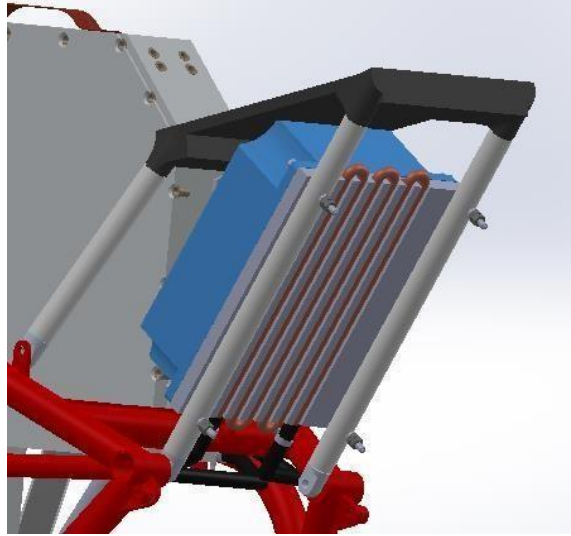


Figura 1.20: Ensamblatge dissipador al sub-xassís. (Font:Imatge pròpia)

En color blau s'ha marcat l'inversor per a diferenciar-lo de la placa dissipadora. En aquest element, no s'ha hagut de realitzar cap modificació al colí ni al sub-xassís, ja que l'inversor encara disposa d'un marge extra per a poder separar-se de l'estructura, que és el gruix necessari per a poder posicionar la placa dissipadora. Així doncs, la única modificació realitzada és la col·locació de pernns més llargs, ja que anteriorment no es contemplava el gruix de la placa. També s'ha aposat per doble femella per bloquejar el possible afluiament dels cargols.

7.3.1.- Subjecció del radiador

Com ja s'ha comentat anteriorment, la posició del radiador es troba posterior a la roda davantera. La zona de col·locació del radiador no ha suposat un problema a nivell de dimensions, però sí a nivell de subjeccions, ja que en aquell punt no hi ha cap peça estructural i el radiador quedaria a l'aire. Per aquest motiu, s'ha realitzat un suport per a adequar la subjecció del radiador, el qual va soldat directament al xassís.

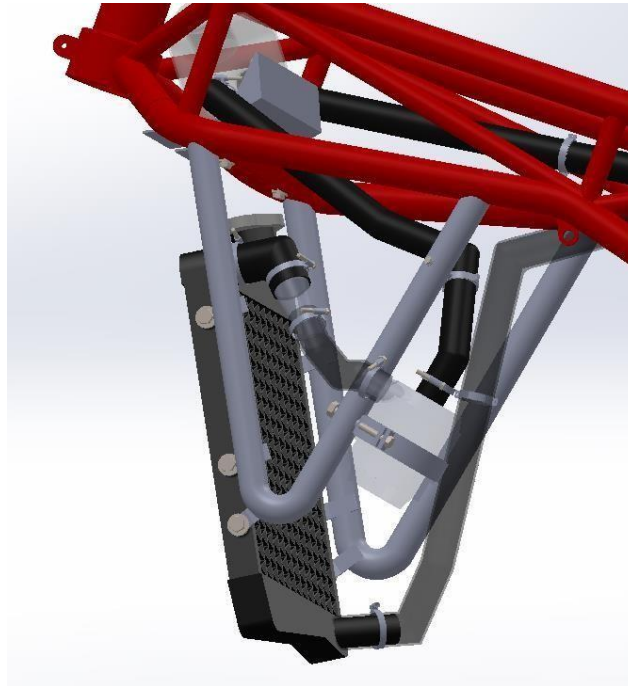


Figura 1.21: Disposició dels suports del radiador. (Font: Imatge pròpia)

Les unions completament soldades al xassís permeten assegurar-ne la fixació, prescindint de possibles aflixaments dels cargols un cop es posi en funcionament la motocicleta. S'ha dissenyat amb el perfil mostrat de "V" per aconseguir rigidesa i evitar vibracions del conjunt. A més a més, s'ha pensat en aquesta forma per afegir components, com ara la bomba o abraçadores per subjectar el conjunt.

D'altra banda, per incorporar el radiador a aquest sub-xassís, s'opta per soldar 3 platines per costat a les barres prèviament mencionades, i que aquestes s'acollin directament al radiador mitjançant els forats roscats que aquest ja incorpora. Aquesta peça s'ha dissenyat per acollar-la amb cargols ja que d'aquesta manera no s'ha de modificar el radiador. L'últim factor tingut en compte és la mantenibilitat del sistema, ja que en un moment donat potser s'ha d'extraure el component per a realitzar una reparació en alguns dels elements pròxims a aquest, com a la bateria o al motor.

El material emprat en aquest component és acer F-112, essent un material sense grans característiques i buscant un baix cost. Tampoc s'ha canviat el material a un més lleuger (com alumini), ja que hi hauria problemes a l'hora de soldar ambdós materials.

7.3.2.- Acoblament i subjecció del dipòsit de compensació

Com s'ha mencionat anteriorment a l'anàlisi de solucions del mateix dipòsit, la col·locació del mateix ve donada per l'espai trobat en aquest punt, on no s'hi incorpora cap altre element. Aquest fet, juntament que ocupa una posició alta per poder cebar la bomba i ompli el circuit per gravetat fan la posició idònia pel mateix. Per a subjectar-lo al xassís, s'usen els colissos usats per subjectar la bateria, de manera que es comparteix l'espai i es deixa joc axial per a la col·locació en el lloc correcte.

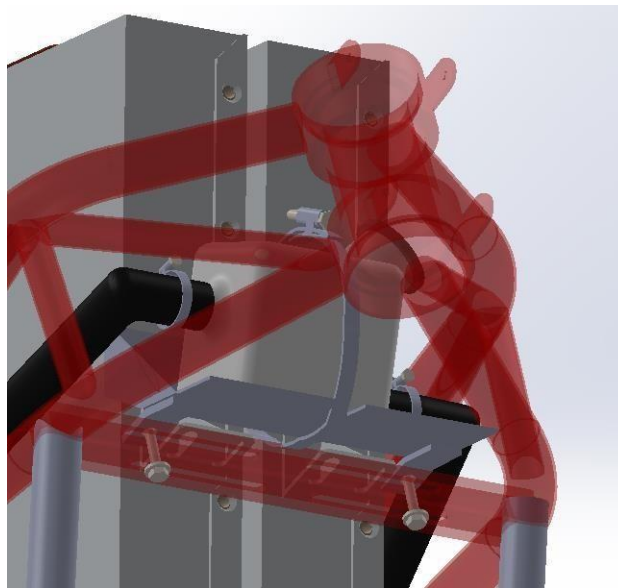


Figura 1.21: Acoblament del suport del dipòsit al xassís. (Font: Imatge pròpia)

En la figura 1.21 s'observen els colissos prèviament, amb el joc que s'aconsegueix amb la col·locació de la bateria.

Per a la subjecció del dipòsit al suport, s'empra una abraçadora metàl·lica, per a garantir la subjecció sense haver de realitzar modificacions al dipòsit, ja que difícilment hagués quedat amb la consistència adequada al tractar-se d'un material polimèric.

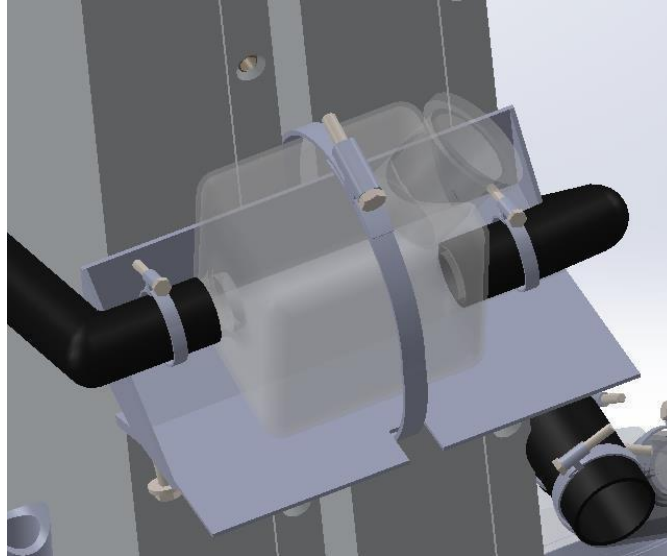


Figura 1.22: Abraçadora per unir el dipòsit. (Font: Imatge pròpia)

Tal i com s'observa en la figura 1.22, es fa servir la separació de les bateries, juntament amb una ranura realitzada a la xapa del suport, per a garantir la subjecció radial, de manera que la pròpia pressió serveixi per garantir també la posició axial.

Aquesta peça es conforma amb xapa d'acer de 2 mil·límetres de gruix, d'un acer F-112, sense grans requeriments mecànics ja que només s'empra com a suport.

El disseny realitzat, com s'ha comentat anteriorment, està realitzat pensant amb possibles fuites que es puguin torbar en les unions dels tubs. A l'estar tant a prop de la zona de bateries d'alt voltatge, s'ha realitzat el disseny vist amb forma de recipient per evitar el contacte amb l'emmagatzematge d'energia.

7.3.3.- Subjecció de la bomba

La solució emprada per a la subjecció de la bomba al conjunt ha estat aprofitar el disseny del suport del radiador per acoblar en aquest punt la bomba.

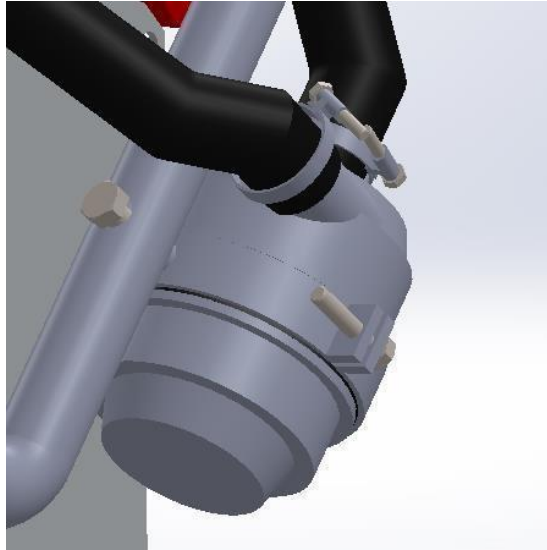


Figura 1.23: Subjecció bomba al suport. (Font: Imatge pròpia)

L'abraçadora emprada per a la subjecció d'aquest element és una de tipus isofònica, pensada per a canonades, amb un recobriment de goma per agafar perfectament el contorn del tub a subjectar. Aquesta abraçadora també es tracta d'un model comercial.

7.3.4.- Subjeccions de tubs al conjunt

Per a la subjecció de tubs s'han emprat abraçadores metàl·liques pel que fa a la unió amb els altres component hidràulics. Pel que fa a la subjecció amb el xassís, s'han usat abraçadores isofòniques per a tubs (explicat en la subjecció de la bomba). Aquestes es cargolen directament al sub-xassís pel radiador, o bé al propi xassís.

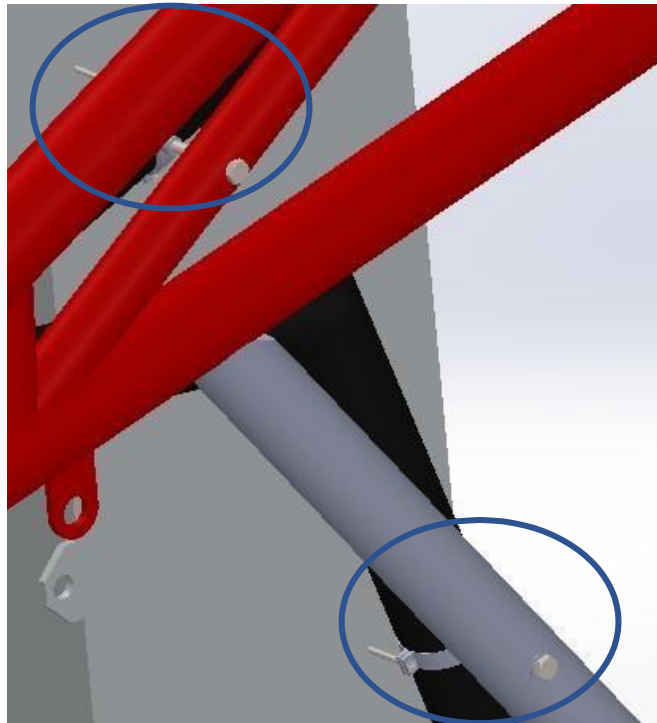


Figura 1.24: Subjecció de les abraçadores. (Font: Imatge pròpia)

A la figura 1.24 es mostra el recurs emprat pera questa subjecció. Aquest fet no s'ha utilitzat per tots els tubs, sinó que només pels de major longitud o posició crítica.

8.- Resultats finals

Un cop anomenades totes les solucions emprades en cada apartat, es procedeix a analitzar el resultats finals aconseguits en cada apartat. En aquest capítol es procedeix a anomenar els recursos emprats indistintament l'àrea afectada (hidràulica o mecànica), de manera que es passa directament a l'anàlisi de resultats del conjunt de l'element. S'elabora una taula resum per cada element i se n'exposen les característiques de cada un.

8.1- Placa dissipadora

Característiques generals de la placa dissipadora:

Taula 1.5: Valors finals obtinguts al dissipador (Font: Taula pròpia)

Element	Material	Subjecció	Modificacions	Model	Fabricació pròpia
Placa dissipadora	Alumini 6063 i coure	Unions cargolades	Canviar cargols	Dissipador SEVCON Gen4 Size6	-

Característiques tècniques de funcionament:

Taula 1.6: Valors finals obtinguts al dissipador (Font: Taula pròpia)

Valor de la meta	Unitats	Valor mitjà	Valor mínim	Valor màxim	Temps de l'estudi (s)
Temperatura màxima dissipador	[°C]	57,2	47,5	63,9	939
Temperatura màxima fluid	[°C]	40,1	41,5	42,3	939

8.2- Radiador

Característiques generals del radiador:

Taula 1.7: Característiques generals del radiador (Font: Taula pròpia)

Element	Material	Subjecció	Modificacions	Model	Fabricació pròpia
Radiador	Alumini	Sub-xassís soldat, unió amb cargols	Soldar els suports al xassís	Radiador AUSTIN Mini 1.0 68 54604	Suposrts al xassís

Taula 1.8: Valors finals obtinguts al radiador (Font: Taula pròpia)

Valor de la meta	Unitats	Valor mitjà	Valor mínim	Valor màxim	Temps de l'estudi (s)
Temperatura màxima fluid entrada radiador	[°C]	40,1	41,5	42,3	967
Temperatura màxima fluid sortida radiador	[°C]	26,7	36,1	37,2	967

8.3- Dipòsit de compensació

Característiques generals del dipòsit de compensació:

Taula 1.9: Característiques generals dipòsit de compensació (Font: Taula pròpia)

Element	Material	Subjecció	Modificacions	Model	Fabricació pròpia
Dipòsit de compensació	Polímer	Abraçadora al suport i cargolat al xassís	-	Dt spare parts 2.30046	Suport del dipòsit

8.4- Bomba

Característiques generals de la bomba:

Taula 1.10: Característiques generals de la bomba (Font: Taula pròpia)

Element	Material	Subjecció	Modificacions	Model	Fabricació pròpia
Bomba	Acer i polímer	Abraçadores isofòniques cargolades als suports	-	BOSCH 0 392 024 041	-

Característiques tècniques de la bomba:

Taula 1.11: Punt de treball de la bomba (Font: Taula pròpia)

Punt de treball	
Q (L/h)	1925
ha (bar)	0,29

Taula 1.12: Consum energètic de la bomba (Font: Taula pròpia)

Consum energètic de la bomba	
Vol (V)	24
I (A)	2,8
Pot (W)	67,2
Temps 1 volta (s)	268
Temps 1 volta (h)	0,074
E/volta (Wh/volta)	5,003

8.5- Unions hidràuliques de components

Per veure el conjunt de canonades amb els seus respectius diàmetres i longituds, consultar a l'annex de plànols els plànols número 8 i 9



9.- Planificació temporal

9.1.- Programació de l'execució

A continuació es mostra la programació temporal proposta per l'execució del projecte. Inicialment s'han definit les activitats a realitzar i s'han assignat a una lletra per a poder identificar-les posteriorment al digrama de PERT. També s'han assignat les activitats precedents a cadascuna.

Taula 1.13: Llistat d'activitats amb activitats precedents designades (Font: Taula propia)

Activitats	Definició	Activitat Precedent
A	Adquisició de material	-
B	Fabriació suports radiador	A
C	Fabriació suports dipòsit	A
D	Instal·lació suports radiador	B
E	Instal·lació suport dipòsit	C
F	Instal·lació radiador	D
G	Instal·lació dipòsit compensació	E
H	Instal·lació bomba refrigerant	D
I	Instal·lació tubs i toveres	F,G,H
J	Posada en marxa i verificació del procés	I

Un cop assignades les activitats a les lletres i a les activitats precedents, se'l hi assigna 3 duracions; Temps mínim, temps mig i temps màxim, de manera que se n'acaba calculant el temps de PERT, que és el que s'utilitzarà a partir d'aquests instant.

Taula 1.14: Càlcul dels temps de PERT (Font: Taula propia)

Activitats	Temps (hores)			
	T min	T mig	T max	Temps PERT
A	2,50	3,00	3,50	3,00
B	3,50	4,00	4,50	4,00
C	1,00	1,25	1,50	1,25
D	0,75	1,00	1,25	1,00
E	0,25	0,50	0,75	0,50
F	0,25	0,50	0,75	0,50
G	0,25	0,50	0,75	0,50
H	0,13	0,25	0,38	0,25
I	1,75	2,00	2,25	2,00
J	0,25	0,50	0,75	0,50

Les activitats s'enfronten en la següent matriu d'encadenaments:

Taula 1.16: Matriu d'encadenaments (Font: Taula propia)

		ACTIVITATS PRECEDENTS									
		A	B	C	D	E	F	G	H	I	J
ACTIVITATS	A										
	B	*									
	C	*									
	D		*								
	E			*							
	F				*						
	G					*					
	H				*						
	I						*	*	*		
	J									*	

A continuació s'incorpora l'elaboració del diagrama de PERT. Si bé, s'han saltat alguns passos, com la formació de la matriu de Zaderenko o el càlcul de les folgances, aquests es troben a l'apartat de planificació dels annexes a la memòria.

Per tant, el diagrama de PERT per a realitzar l'execució del projecte acaba esdevenint el següent:

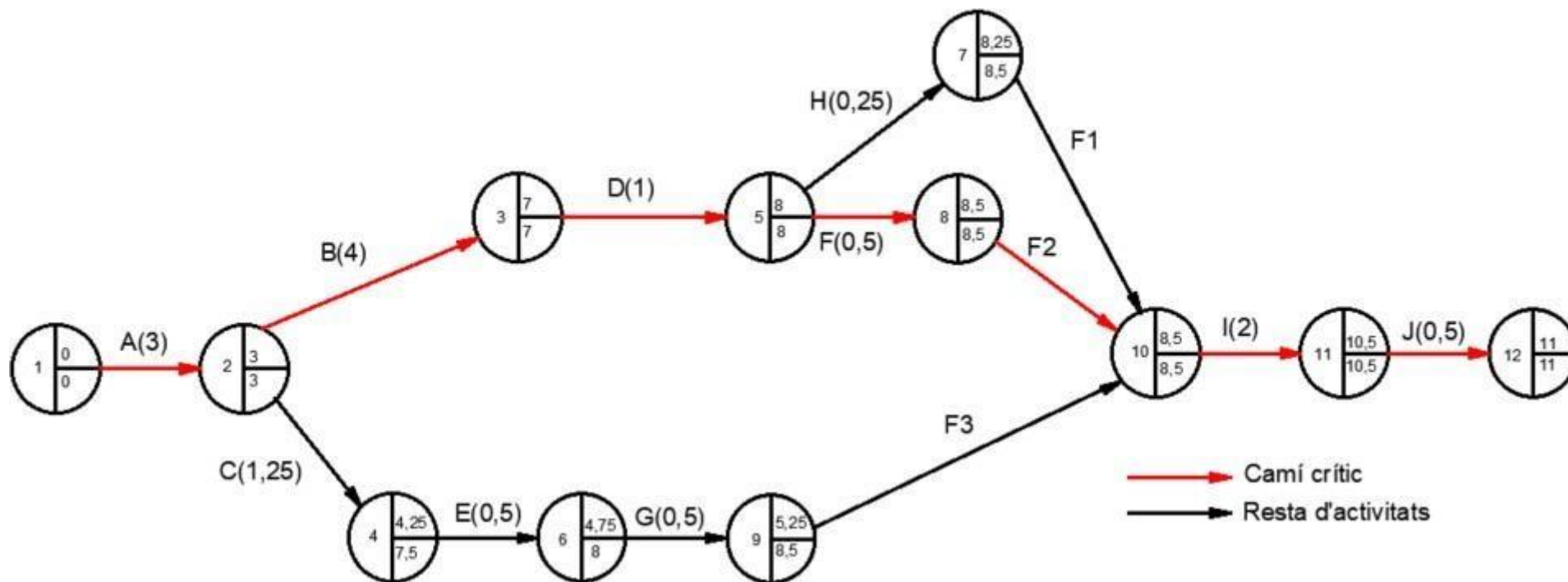


Figura 1.25: Diagrama de PERT

10.- Avaluació financera del projecte

Per al projecte prèviament esmentant sobre el disseny del sistema de refrigeració d'un inversor de motocicleta, no s'ha realitzat una avaluació financera. Al tractar-se d'un projecte dedicat a un element de competició, on s'inverteixen molts diners en prototips que finalment no s'acaben construïnt massivament, ni tenen grans anys de vida útil com a projecte, es precedeix d'aquest estudi. Se n'exposen tots els motius més desglossats a l'avaluació financera a l'annex.

11.- Conclusions

Un cop finalitzada la projecció del projecte, es procedeix a sentenciar les conclusions les quals arriba el projectista. Després de la feina realitzada es poden extreure les conclusions següents

- Millora del sistema de dissipació de calor

S'ha aconseguit l'objectiu principal del projecte que era poder dissipar la calor produïda per l'inversor, de manera que la motocicleta pogués competir sense problemes de sobreescalfament en aquest component. S'ha realitzant mitjançant refrigeració líquida ja que s'ha cregut la millor solució degut als problemes sorgits en aquest component anteriorment.

- Compliment de la normativa de MotoStudent

Tot el disseny i càlcul ha estat influenciat per la normativa tècnica de MotoStudent. Aquesta organització decreta el reglament d'obligat compliment, de manera que era una condició indispensable per a la resolució del problema plantejat. A mesura que s'ha avançat en la fase de disseny i en la resolució del problema, s'ha anat cercant el reglament per complir, durant tot moment en el mateix.

- Import total del projecte

Un cop finalitzat el projecte es pot concloure que s'ha sobrepassat el condicionant econòmic proposat pel promotor. Si bé, aquesta opció ja estava contemplada, ja que en projectes de competició els costos es disparen i realitzar una estimació exacte del preu a invertir és molt relatiu.

RESUM DE PRESSUPOST

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CAPÍTOL	RESUM	IMPORT	%
01	Capítol 1: Fabricació	399,02	28,09
02	Capítol 2: Muntatge mecànic	84,31	5,93
03	Capítol 3: Sistema hidràulic	937,31	65,98
		1.420,64	
PRESSUPOST D' EXECUCIÓ MATERIAL			
6,00 % Despeses generals		85,24	
13,00 % Benefici industrial		184,68	
Suma		269,92	
PRESSUPOST BASE DE LICITACIÓ SENSE IVA		1.690,56	
21% IVA		355,02	
PRESSUPOST BASE DE LICITACIÓ		2.045,58	

Puja el pressupost l'esmentada quantitat de DOS MIL QUARANTA-CINC EUROS amb CINQUANTA-VUIT CÈNTIMS

Alcover, 09 de juny de 2022.

Arnau Ferré Queralt

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14.- Altres referències

També s'han emprat les següents referències.

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Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM II

Document 3: Annexes a la memòria

Annex A – Annex I.3

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



ESCOLA TÈCNICA SUPERIOR
D'ENGINYERIA QUÍMICA
Universitat Rovira i Virgili

etsEQ

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DOCUMENT 3. ANNEXES DE LA MEMÒRIA

ANNEX A. Condicionants del projecte

A.1.- Introducció

Per a la realització del projecte s'estableixen un seguit de condicionants, ja establert pel promotor, com externs al promotor i degut a les pròpies característiques físiques de la màquina, de l'entorn, entre d'altres. A continuació es decretaran aquests condicionants que participen en l'esdevenir del projecte, tant els que afecten de manera positiva com negativa.

A.2.- Condicionants imposats pel promotor

A.2.1.- Recursos humans

El promotor d'aquest projecte és l'equip de competició de la URV (URVoltage Team). El grup de joves estudiants pretén realitzar una motocicleta per a la competició MotoStudent Electric, celebrada cada 2 anys. Aquest equip ja ha disputat la competició en 2 anteriors edicions (2018 i 2021), i de cara la tercera edició es vol millorar el rendiment corregint els errors anteriorment comesos.

A.2.2.- Punt de partida

El promotor vol aconseguir arreglar la motocicleta de l'edició del 2021 per a realitzar test i recollir informació per incrementar el rendiment de la futura moto competidora, de manera que es demana solucionar els problemes que van sorgir en l'anterior motocicleta, que també es pugui emprar el recurs escollit per a desenvolupar la motocicleta de l'edició del 2023 perquè no aparegui el mateix problema.

En la motocicleta del 2021 hi va haver diversos problemes en diferents àmbits (elèctrica, electrònica, mecànica...), tot i que només s'esmentaran els problemes en la part mecànica i de disseny, on els principals van ser els següents:

- Dinàmica de motocicleta: L'adaptació de l'amortidor al basculant ni va ser la adequada i no es va obtenir els resultats obtinguts, realitzat alguns canvis d'última hora per poder fer funcionar la motocicleta.

- “Packaging” del conjunt: L'ancoratge dels components al xassís i al subxassís no va ser l'òptim. Per una part, no es va pensar en preparar suports al xassís pensat per subjectar els components, i d'altra banda es van distribuir malament els espais, per exemple posant components de mes pes a la part del culin, fent augmentar el centre de gravetat d'aquesta i empitjorant el comportament dinàmic.
- Refrigeració: No es va realitzar una refrigeració òptima de l'inversor, ja que com s'ha comentat anteriorment, la col·locació d'aquest no va ser òptima i a part de comprometre la dinàmica de la moto, la refrigeració no era l'adequada, fent treballar l'inversor per sobre del seu rang de temperatures i sense poder desenvolupar la potència nominal del motor.

De tots els principals problemes principals esmentats, es procedirà a resoldre l'inconvenient de la refrigeració, essent aquest el coll d'ampolla per a desenvolupar la potència adequada per poder competir.

A.3.- Condicionants tècnics

El projecte es desenvoluparà a de la motocicleta existent. Per tant, tots els aspectes tècnics i les solucions emprades en aquest model seran presents i s'hauran de tenir en compte en l'esdevenir del projecte. Els aspectes a tenir en compte són els següents:

- Posicionament de la bateria

EL posicionament de les bateries determina el marge útil per calcular el màxim gruix que pot tenir el radiador. Els seu ancoratge al xassís també s'ha de tenir en compte per com dimensionar els elements i no tenir problemes de mantenibilitat.

- Estructura del xassís

Per a la disposició d'elements, així com per la possible integració de nous sub-xassís per subjectar elements, el punt de partida de l'estructura del xassís és important ja que determinarà la forma, material i disseny de les noves peces a dissenyar.

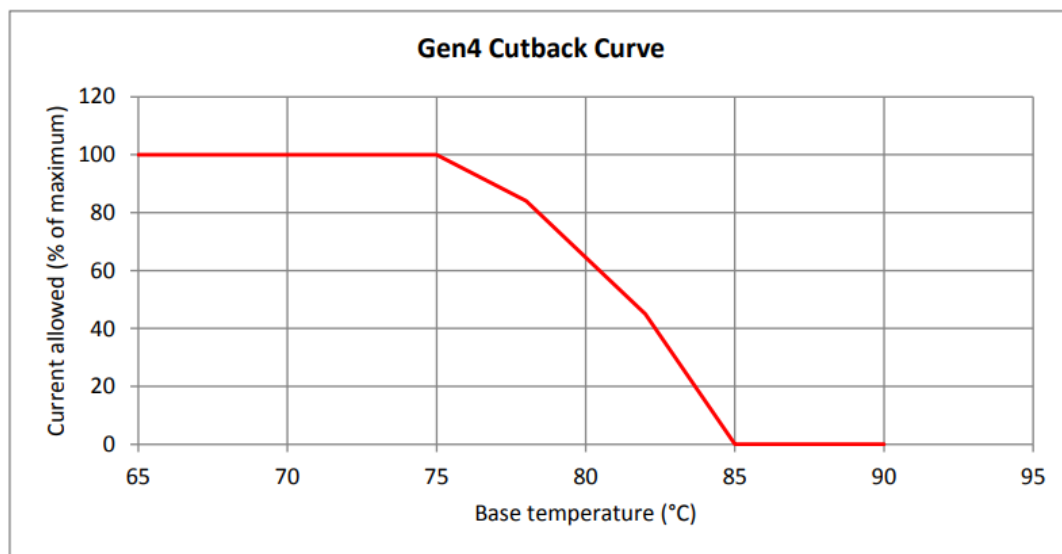
- Disseny del carena

El disseny del carenat limita l'espai útil a emprar per a la col·locació del radiador, de manera que s'haurà d'acotar

- Dades de l'inversor

El component el qual s'ha de dissipar la calor és l'inversor, de manera que els rangs màxims permesos de temperatura per al seu correcte rendiment són important per a la realització dels càlculs pertinents.

Taula A.1: Corrent de sortida segons temperatura de treball (Font: Sevcon.com)



A partir de les dades proporcionades pel propi fabricant, es pot observar la caiguda de rendiment a mesura que augmenta la temperatura, essent 75 graus el punt màxim de funcionament.

A.4.- Condicionants de reglament

A.4.1.- Legislació competició MotoStudent Electric

La motocicleta a dissenyar per part del promotor ha de ser apte per a competir en el campionat MotoStudent Electric. Per aquest motiu la norma que marcarà el disseny de la motocicleta serà el reglament tècnic de la pròpia competició (MotoStudent International Competition 2022-2023, Competition Regulations Rev. 12/2021, que s'adjunta a l'apartat de l'annex de catàleg)

En aquest document es separen els següents apartats segons el tipus de sector que abasta. S'estudiaran els punts que afectin directament al desenvolupament del projecte. Els apartats citats a continuació s'extreu del reglament anteriorment mencionat i traduïts al català.

- Regulacions tècniques generals: Com que es disposen de dues competicions diferents on el canvi principal és la propulsió de la motocicleta, es decreta un reglament genèric en certs apartats. A continuació s'exposen els documents per al projecte, tot i que com s'ha mencionat anteriorment, s'adjunta el reglament sencer a l'annex, a la secció de catàlegs.

A.4.2- Introducció a les regles tècniques

B.1.1.1 Els dissenys i construccions dels prototips presentats han de complir amb les lleis imposades per poder competir a les fases de puntuació de la competició.

B.1.1.2 Els prototips han de mantenir els requeriments de les lleis tècniques durant tots els test de l'esdeveniment final. L'organització revisarà el correcte compliment amb la reglamentació a qualsevol moment de l'esdeveniment final.

B.1.1.3 Qualsevol fallo a l'hora de complir amb els requeriments tècnics i restriccions serà corregit i es tornarà a inspeccionar abans que el prototip pugui participar en qualsevol test durant l'esdeveniment final.

B.1.1.4 Les regles reflexades a la secció B afecta igualment a la competició "MotoStudent Petrol" i "MotoStudent Electric", excepte pels articles on estan indicats requeriments especials per a cada categoria específica.

B.1.3 Canvis i reparacions

Un cop l'escrutini sigui passar i els prototips estiguin validats per la competició MotoStudent, cap canvi no explícit serà permès sense supervisió del staff tècnic de la organització. Abans de dur a terme cap modificació, la organització ha de ser informada, la qual ha d'aprovar i tornar a inspeccionar el prototip després dels canvis aplicats.

Els canvis permesos després de l'escrutini que no importen supervisió per la organització seran:

- *Ajustaments secundaris a la transmissió*
- *Ajustaments del sistema de frenada*
- *Canvis i ajustaments al sistema d'adquisició de dades*
- *Ajustaments a les pressions dels pneumàtics*
- *Reomplir fluids*
- *Canvis generals de set-up*
- *Ajustaments de set-up del motor*

ARTICLE 2: Requeriments generals de disseny

B.2.1 Dimensions

Les dimensions del prototip són lliures, excepte els següents requeriments bàsics

B.2.1.1 La mínima longitud entre els finals del manillar ha de ser de 450 mm

B.2.1.2 L'angle d'inclinació mínim del prototip sense cap element (excepte rodes) tocant la superfície del terra ha de ser de 50°. Aquesta mesura serà presa amb el prototip descarregat de pes (sense el pilot) però plenament equipada, fluids inclosos, per aquesta operació.

B.2.1.3 La distància mínima entre el prototip verticalment i l'asfalt ha de fer de mínim 100 mm en la resta de situacions. Aquesta mesura serà presa amb el prototip descarregat de pes (sense el pilot) però plenament equipada, fluids inclosos, per aquesta operació.

B.2.1.8 La màxima longitud del carenat serà de 600 mm.

B.2.2 Pes

B2.2.1 EL pes mínim total del prototip sense pilot ha de ser de 95 Kg per ambdues categories, incloent tots els fluids que siguin necessaris per la correcta operació del prototip.

ARTICLE 3: Estructura

B.3.1 Disseny

L'ús d'un xassís comercial no està permès, ni tant sols una unitat modificada, ha de ser de disseny propi.

El xassís, el sub-xassís i el basculant estan inclosos en cadascun punt.

B3.1.1 No hi ha restriccions en el tipus de disseny o materials del xassís, sub-xassís o basculant, sempre i quan compleixi amb les lleis imposades.

B.3.1.2 En cas de dubte sobre la seguretat del xassís subministrat, la organització pot requerir una declaració justificada de seguretat que inclogui anàlisi usant el mètode d'element finits, simulacions o altres test de demostració.

B3.1.3 El xassís ha de ser dissenyat de manera que tots els elements del motor, combustible, ingestió de combustible, elements elèctrics i electrònics de control i sistemes de seguretat, incloent el paquet de bateries, estigui protegit en cas de caiguda, especialment en cas de caiguda lateral.

B.4.3 Parafang

B4.3.1 L'ús de parafang frontal i posterior es obligatori

B4.3.2 El parafang frontal no pot cobrir més de 135° de la circumferència de les mesures de la roda des de la part posterior de la roda; l'origen de l'angle sent la línia horitzontal de l'eix de la roda. El punt d'ancoratge dels parafangs a la forquilla davantera, la forquilla i la coberta del disc de frens pot excedir aquestes restriccions.

B.9.1 Llantes

Les llantes són de lliure elecció per cada equip

B.9.1.1 Els tamanyes de les llantes (considerant àrees disponibles per l'acomodació de les rodes) han de ser de:

- Roda davantera: 2.5" x 17"

Roda posterior: 3.5" x 17"

B.9.2.2 L'ús d'escalfadors és permès.

- Regulacions tècniques específiques (categoria MotoStudent Electric): aquest apartat decreta la normativa per les motocicletes de propulsió elèctrica, amb les peculiaritats i restriccions per aquest tipus de motocicletes:

ARTICLE 1: Definicions i aspectes generals

D1.1 Alt voltatge-HV, Baix voltatge-LV, Sistema d'alt voltatge-VDC.

Cap circuit amb una diferència de potencial superior a 40 VDC formarà part del circuit d'alt voltatge (HV) del prototip. Per sota aquest voltatge, serà considerat sistema de baix voltatge (LV)

D.1.1.1 El voltatge màxim permès de HV serà de 126 VDC.

D1.1.3 Els cables de HV han d'estar protegits.

D1.2 Sistema d'alt voltatge - HVS

El sistema d'alt voltatge (HVS) està compost per totes les peces de la part del motor, controlador, acumulador o qualsevol altre part elèctrica connectada a aquest.

D.1.2.1 El HVS ha d'estar elèctricament separat del prototip de xassís o terra.

D.1.3 Sistema terra de baix voltatge – GLVS

El sistema terra de baix voltatge (GLVS) està format de tots els circuits o parts elèctriques del prototip (xassís) i d'aquí que no sigui part del HVS.

D.1.3.1 El GLVS ha de ser un sistema LV, amb un voltatge menor a 40 VDC.

D.1.4 Separació entre HVS i GLVS

D.1.4.1 El HVS i el GLVS han d'estar separats galvànicament.

ARTICLE 2: MOTOR ELÈCTRIC I DEMANDA DE POTÈNCIA

L'organització proveirà un motor elèctric comú pels equips registrats a la categoria MotoStudent Electric.

El motor subministrar ha passat rigorosos controls de qualitat anteriorment a l'enviament, i ha estat dissenyat i testejat en competició i situacions similars. Com que serà muntat en un banc extern i/o un prototip sense parts OEM, la organització no assumirà responsabilitats per cap dany que el motor pugui sofrir durant el festeig o ús d'aquest.

D.2.3 Regeneració d'energia

La regeneració d'energia està permesa usant el motor com un generador durant la frenada.

D.9.4 Cablejat

D.9.4.1 La longitud del cablejat ha de ser exacte, no està permès

D.9.4.2 Passar el cablejat de la instal·lació elèctrica per possibles punt calents serà possible fins el que es pugui.

D.9.4.3 La instal·lació elèctrica ha d'estar perfectament ben integrada a l'assemblatge del prototip, i la distància entre les fixacions dels cables a les cel·les no pot sobrepassar els 15 cm.

D.9.4.4 Cap interferència entre la instal·lació elèctrica i mecànica serà permesa, en cap rang de geometria (durant el rang complert del manillar, la suspensió,...).

ARTICLE 12: SISTEMA DE REFRIGERACIÓ

D.12.1 Resum del sistema de refrigeració

D.12.1.1 El disseny del sistema de refrigeració per diferents components és de lliure configuració.

D.12.1.2 La refrigeració de components està permesa amb sistemes d'aire i líquid refrigerant.

D.12.2 Sistema de refrigeració per aire

D.12.2.1 La refrigeració per mitjà de conductes aerodinàmics està permesa.

D.12.2.2 Sistemes per aire forçat per mitjà de ventiladors o altre mètodes d'impulsió o extracció d'aire estan permesos.

D.12.3 Sistemes refrigerats amb líquid

D.12.3.1 Només aigua destil·lada podrà ser usada com a líquid refrigerant.

D.12.3.2 L'ús d'additius a l'aigua destil·lada està prohibit

D.12.3.3 El nombre, localització, dimensionat o composició dels radiadors del sistema e refrigeració són lliures, previst que compleixin amb els requeriments dimensionals de totes les dimensions del prototip.

A.5.- Condicionants de l'entorn físic de la màquina

La zona on operarà la motocicleta serà al circuit d'Alcañiz, on es realitzarà la prova durant la tardor del 2023, tot i que la prova realitzada a l'edició del 2021 es va realitzar al juliol. Tot i que això, es realitzaran test previs a aquesta per realitzar la posar punt i arreglar possibles problemes que sorgeixin. Aquestes proves es realitzaran a un circuit prop de la universitat, com és el circuit de Calafat. Es realitzarà l'estudi d'ambdues localitzacions per determinar les condicions més òptimes per al disseny.

A continuació s'exposaran les gràfiques de temperatura i precipitacions mensuals calculat entre el 2010 i el 2020, que és l'últim any natural que es té completament registrat.

- Circuit de Calafat

El circuit tarragoní localitzat a la localitat de la localitat de l'Ametlla de Mar. La localització d'aquest és la següent:

Taula A.1: Dades circuit de Calafat (Font: Imatge pròpia)

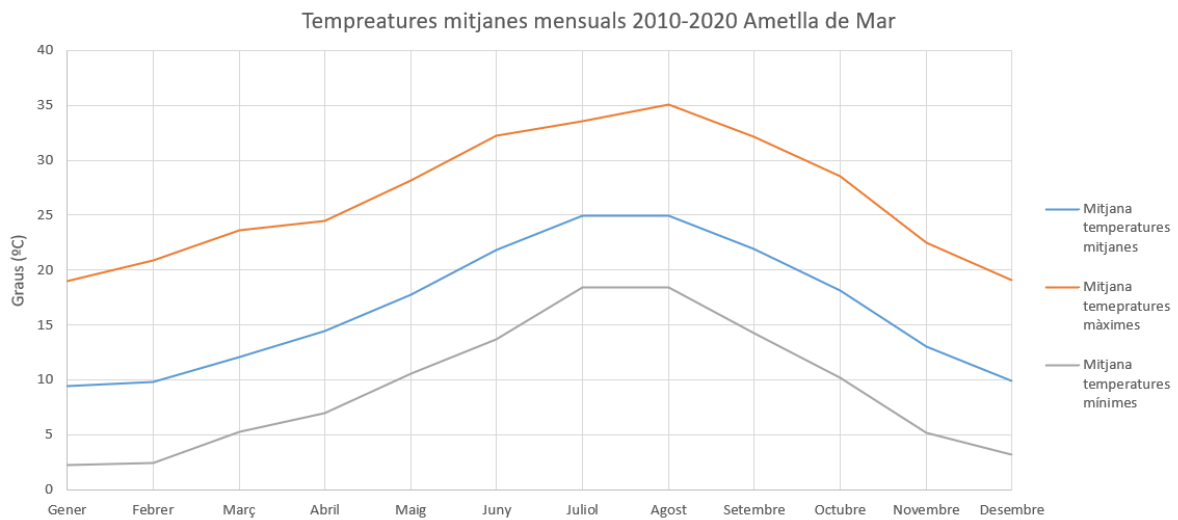
Dades Circuit de Calafat	
Població	Ametlla de Mar, Tarragona (43860)
Coordanades UTM	Zona 31 Hemisferi Nord Est (UTMX): 318268,1 Nord (UTMY): 4533542,7
Referència cadastral	8337901CF1383N0001DZ



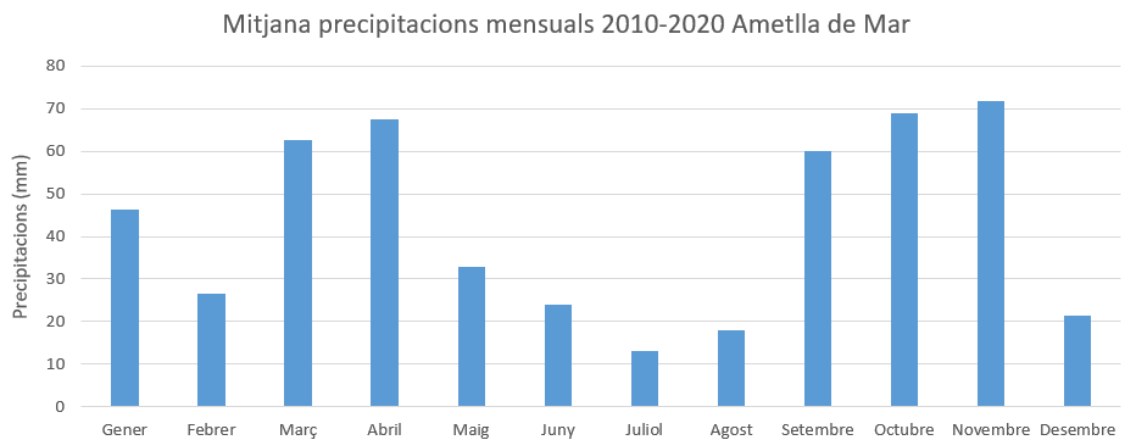
Figura A.1: Vista aèria circuit de Calafat (Font:sedecatastro.gob.es)

Les condicions meteorològiques per al circuit de Calafat són les següents:

Taula A.3: Temperatures mensuals entre 2010-2020 (Font: meteoecat.cat)



Taula A.4: Precipitacions mensuals entre 2010-2020 (Font:meteocat.cat)

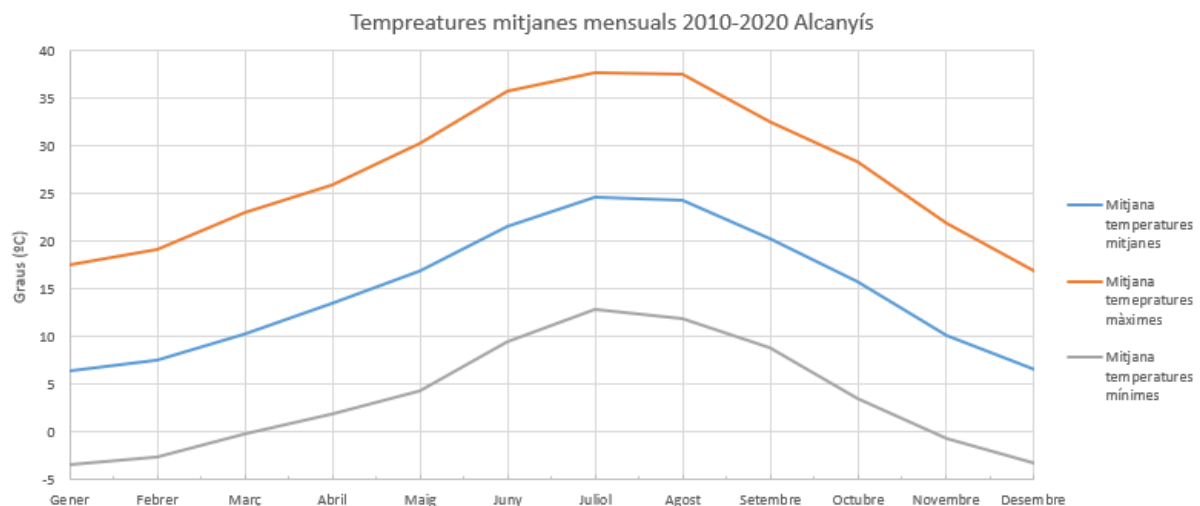


La primera gràfica exposa l'evolució mensual de les temperatures, tant de les temperatures màximes, mínimes i mitjanes. També s'han estudiat les precipitacions mitjanes mensuals.

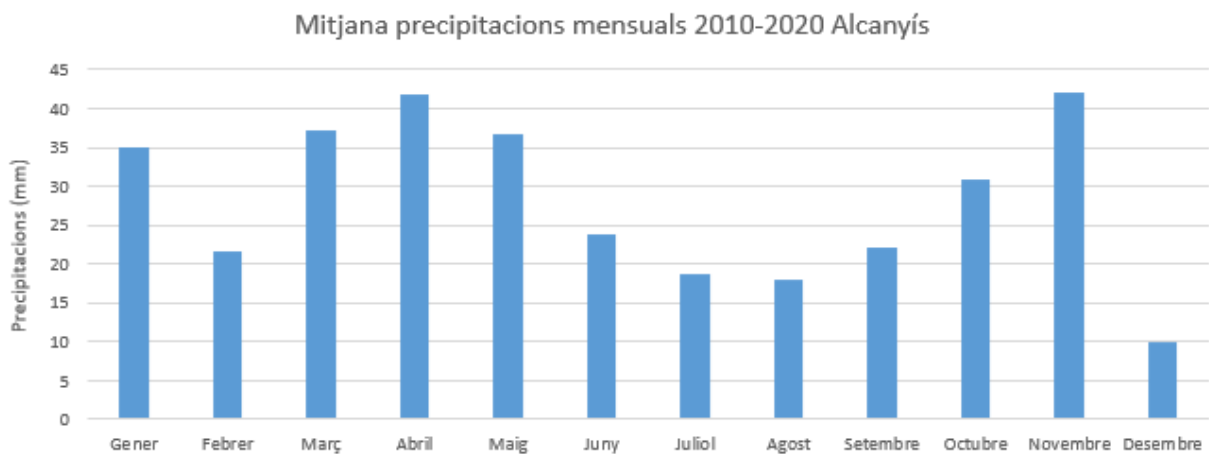
- Motorland Aragó (Alcanyís)

El circuit ubicat a la província de Terol serà el que albergarà l'esdeveniment final. Es realitza el mateix estudi realitzat anteriorment per comparar les dades i establir-ne les mes desfavorables en cada cas.

Taula A.5: Tempreatures mensuals entre 2010-2020 (Font: aragon.es)



Taula A.6: Precipitacions mensuals entre 2010-2020 (Font: aragon.es)



El factor transcendental en la comparació d'ambos circuits és la temperatura ambient de partida que es tindrà, que afectarà en la dissipació de la calor generada pels components.

A.6.- Característiques del traçat

De forma paral·lela a l'apartat anterior, es realitza un estudi de cada circuit i se'n comparen les característiques més a tenir en compte; longitud del traçat, corbes i longitud de la recta més llarga.

- Circuit de Calafat

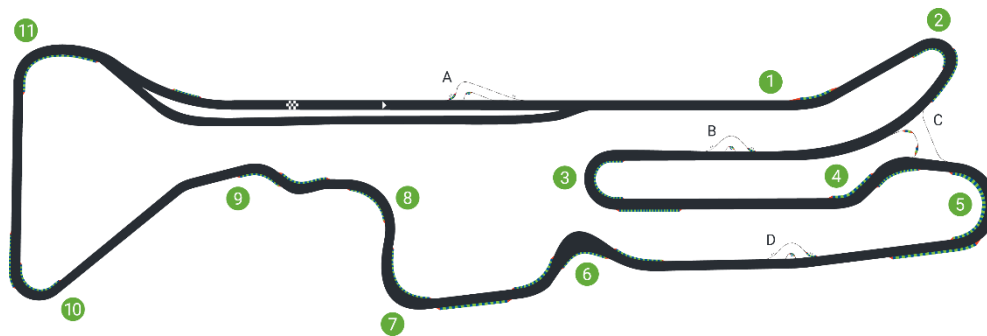


Figura A.2: Traçat de calafat (Font:viquipèdia.cat)

Taula A.7: Característiques del circuit de Calafat (Font: Imatge pròpia)

Característiques Circuit de Calafat	
Longitud traçat	3250 m
Corbes	9 a dretes/7 a esquerres
Recta més llarga	600 m

- Circuit de MotorLand (Alcanyís)

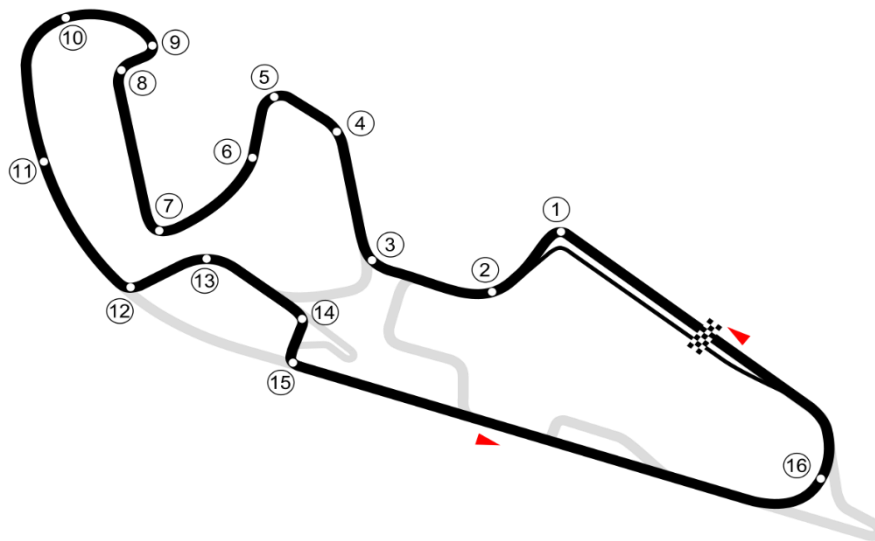


Figura A.3: Traçat de MotorLand (Font: wikipedia.es)

Taula A.8: Característiques circuit MortorLand (Font: Imatge pròpia)

Característiques Circuit de MotorLand	
Longitud traçat	5077 m
Corbes	7 a dretes/9 a esquerres
Recta més llarga	1211 m

A partir de totes les dades estudiades dels circuit on la motocicleta competirà, se n'avaluaran les situacions més crítiques en les que el mecanisme es sotmetés sota les condicions més desfavorables, i se'n realitzaran els càlculs per al dimensionat i dels components.

A.7.- Condicionants del mercat

Pel que fa a les condicions del mercat, s'han avaluat l'oferta i la demanda del producte que es vol construir en aquest projecte.

El projecte parteix d'una necessitat específica, ja que es tracta de resoldre un problema sorgit d'un prototip que no es tornarà a construir i que servirà de base per a una propera moto de competició. D'aquesta manera, si que es disposa d'oferta de components i de distribuïdors per a poder adquirir els components. D'altra banda, el projecte no va destinat a captar una àmplia demanda de vendes ni distribucions, ja que ni tant sols s'assegura la incorporació del sistema per a diferents edicions del certamen MotoStudent, tenint per present que aquesta competició modifica el reglament tècnic comportant modificacions del prototip que puguin afectar a les parts de la motocicleta. Si bé, es parirà d'una molt bona base per a futures edicions. Un altre aspecte a tenir en compte és que les universitats competeixen per poder desenvolupar la motocicleta més ràpida, de manera que no es venen els mecanismes creats per a altres universitats per evitar l'espionatge industrial i cedir avantatge a un competidor directe.

Per tant, pel que fa a la oferta es disposen de les següents empreses per a l'adquisició dels components a emprar. Tot i que les empreses només s'encarreguen de distribuir els productes, es disposen de dues empreses més (que patrocinen l'equip URVoltage Team), situades a la mateixa província de Tarragona, que dissenyen i desenvolupen els equips de primera mà. D'aquesta manera, si sorgeixen problemes en el disseny es poden sol·licitar recursos a aquestes, que són les següents:

- MAHLE Group: Montblanc (43400), Tarragona
- Lear Corporation: Valls (43800), Tarragona

A part de l'experiència que poden aportat aquestes empreses en el procés de disseny i càlcul de components, es disposen de diversitat d'empreses distribuïdores de components per suplir les necessitats del projecte. Algunes d'aquestes es mencionen a continuació, totes dins la província de Tarragona:

- Reflow Recambios S.L. a la localitat de Salou
- Recambios Aicrag S.A. a la localitat de Tarragona
- Recambios Leibat S.C.P. a la localitat de Valls
- Recamvios y Servicios Avicolos S.L. a la localitat de Valls
- Grafer Recambios y Accesorios Automóviles S.C.P. a la localitat de Reus

A.8.- Condicionants de béns i serveis

Un cop avaluades les possibilitats que ofereix el mercat, s'avaluen els béns i serveis disponibles, no menys importants ja que són imprescindibles per a conformar els enginyers realitzats al departament de càlcul i disseny.

En primer lloc, es fa una llista amb la maquinària i béns disponibles al taller de l'equip.

- Eines de mà
- Impressora 3D
- Soldador d'elèctrode revestit
- Elements de protecció individual (EPI's)

Pel que fa serveis, el taller disposa d'un operari especialitzat en mecanització, soldadura i muntatge que la universitat destina per a l'equip de competició. Tot i això, es realitza una llista amb diferents centres de mecanització de la província com a "back-up" a falta dels recursos que pugui aportar l'operari que ja té el taller.

- Deneb Mecanizados S.L. a la localitat de Reus
- Compymed Mecanizados S.L. a la localitat de Tarragona
- Mecanizados Rm S.L. a la localitat de Valls
- Soldaduras y mecanizados Industriales Europa S.L. a la localitat de Tarragona.

A.9.- Condicionants econòmics

Pel que fa a la part econòmica, el departament de finances disposa de 45.000 € per a la realització del prototip de MotoStudent per a una sola edició. A partir d'aquí, es destinen els recursos per a cada departament en funció de les seves necessitats. Tot i això, al no disposar-se de suficients diners com per poder realitzar proves, assajos... No es disposa d'un pressupost per cada departament, sinó que a partir de les parts importants de la motocicleta (bateries, motor, llantes, llicències, inscripcions...), es van destinant recursos per poder cobrir totes les necessitats i poder competir. So bé, al tractar-se d'un problema que va impedir mostrar un bon rendiment la passada edició, s'ha comentant amb els membres de comptabilitat i es disposa d'un pressupost de 1.500€ per solventar el problema.

ANNEX B. Estudi d'alternatives

B.1.- Introducció

En aquesta annex es realitza l'estudi de les diferents alternatives amb les que es conten a l'hora d'afrontar la resolució del problema prèviament esmentat.

Així doncs, s'estudien les possibilitats de recursos a emprar a partir del reglament de la competició per adequar-ne el disseny.

B.2.- Interpretació de la normativa

A partir de tota la normativa visualitzada en l'apartat d'"ANNEX A. Condicionants del projecte", es procedeix a adequar tots aquests aspectes en la formulació del disseny i els seus pertinents càlculs.

Al tractar-se d'un disseny per a una competició en concret i no al món industrial, s'ha decidit emprar la normativa de la vigent competició sense aplicar cap normativa en UNE pel que es refereix a disseny.

B.3.- Alternatives de disseny

B.3.1.- Metodologia

A continuació es mostren els criteris emprats en quant al disseny es refereix. A partir del disseny realitzat i cedit per part de l'equip de la motocicleta de l'edició del 2021, es procedeix a integrar els elements necessaris per a dur a terme el bon funcionament del sistema sol·licitat.

B.3.2.- Consideracions inicials i punt de partida

Tot i gaudir del document CAD de l'edició del 2021, del qual s'han realitzat els plànols i dissenys posteriorment, s'ha realitzat treball de camp per a verificar les mesures i visualitzar si el disseny en 3D equipara amb la motocicleta real. Es van realitzar fotografies a la motocicleta de les mesures més crítiques i que afectaven directament a l'esdevenir del projecte.

Un cop verificades les mesures entre la motocicleta real i l'arxiu CAD, es realitza una pluja d'idees per a definir el sistema a emprar per a realitzar la refrigeració de l'inversor.

La primera premissa ha estat pensar si la refrigeració es realitzaria a partir d'aire en convecció forçada o en refrigeració líquida forçada.

B.3.2.1.- Tipus de refrigeració

Sistema per aire en convecció natural d'aire

Aquesta opció pretén incorporar unes aletes de dissipació tèrmica per augmentar l'àrea de dissipació i reduir la temperatura del conjunt.

Sistema per aire en convecció forçada d'aire

Aquesta solució és similar a l'anterior, però afegint ventiladors per accelerar el flux d'aire i dissipar la calor.

Sistema per refrigeració líquida

Es compon d'un sistema on a través d'un fluid refrigerant, es permet alliberar la calor dissipada pel component a refrigerar. Aquest conjunt és més complexa i comporta més pes, però permet extreure més calor del sistema. A nivell esquemàtic, el sistema proposat per evacuar aquest excés de calor que provoca la baixada de rendiment de l'equip és el següent:

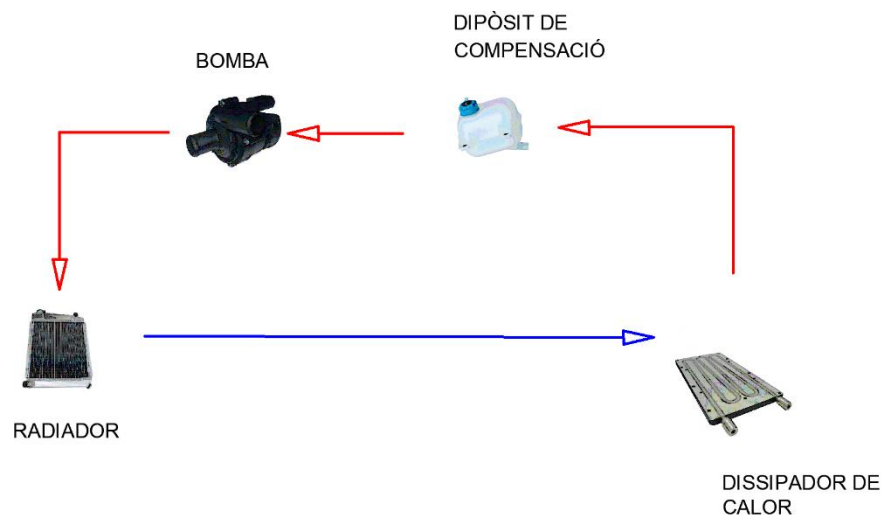


Figura B.1: Representació sistema hidràulic (Font: Imatge pròpia)

Les fletxes de color vermell simbolitzen zona d'alta temperatura, mentre que la fletxa blava mostra la zona de baixa temperatura. A partir d'aquest esquema es procedeix a realitzar el disseny i integració dels elements a la motocicleta existent, afegint altres components (tubs, reduccions, abraçadores...) per al correcte funcionament del conjunt.

B.3.2.2.- Tipus de refrigerant a emprar

En un sistema de refrigeració el líquid a emprar esdevé part molt important ja que permet optar per canviar el tipus de dissipador segons les propietats que disposa el fluid.

En aquest cas, la organització decreta que en cas d'emprar refrigeració líquida, el fluid a emprar ha de ser aigua destil·lada. D'aquesta manera, aquest component ha de ser inviolable, tot i que aquest fluid no gaudeixi de les millors propietats per evacuar la calor. S'ha realitzat un breu estudi i s'ha pogut determinar que l'aigua destil·lada és químicament igual (H_2O) que l'aigua normal, i la diferència que té és que es purifica i es neteja mitjançant el procés de destil·lació. Aquest fet comporta que no s'acumuli calç a les parets de les canonades i que no es puguin obstruir amb el pas del temps. A termes termodinàmics no comporta cap inconvenient a utilitzar aigua normal.

B.3.2.3.- Sistema d'impulsió del fluid

Al tractar-se d'un sistema de refrigeració forçat per canonades s'opta per a un sistema de bomba per a poder donar el caudal i pressió que el sistema requereixi. Dins del sector de l'automoció, es gaudeixen de bombes centrífugues per a moure el fluid refrigerant, però l'accionament d'aquestes pot ser mecànic o elèctric. Convencionalment, s'han optat per bombes d'accionament mecànic ja que es troben acoblades a la corretja de distribució (en els cotxes de combustió), i també de funcionament elèctric, amb un motor elèctric ja inclòs en aquestes bombes per al seu funcionament.

B.3.2.3.- Dipòsit de compensació

En nombrosos sistemes hidràulics, s'incorpora un dipòsit d'expansió per a absorbir l'alliberació de sobrepressions en el circuit durant el seu funcionament, i posterior reomplert per no deixar el circuit sense refrigerant. El fet d'afegir el dipòsit de compensació vindrà definit segons les característiques que conformin el sistema.

B.3.2.4.- Radiador

Per a evacuar la calor absorbida pel fluid, s'utilitza un radiador amb aletes de dissipació per dissipar l'energia a l'ambient. Tota aquesta energia es transfereix per mitjà de conducció i convecció, i mitjançant aquest element es permet reduir la temperatura del fluid per poder refrigerar el sistema.



Figura B.2: Radiador (Font: recambioscoches.net)

La figura B.2 mostra la tipologia de radiador emprada, amb l'alliberació mencionada anteriorment al costat del tap.

Habitualment la col·locació del radiador és posterior a la roda davantera, ja que en aquesta posició encara es gaudeix d'un bon flux d'aire i la resistència aerodinàmica no augmenta en excés.

B.3.2.5.- Dissipador de calor

Al igual que en el cas del radiador, el dissipador de calor de l'inversor serveix per extreure tota la calor dissipada i en aquest cas, que es transfereixi al fluid per posteriorment dissipar-la. Igual que en el cas del radiador, la calor transferida és tota per convecció i conducció.

En aquest cas, els dissipadors usats en automoció tenen forma de serpentí per intercanviar la calor com el de la següent imatge, ja que és l'element més senzill i ja garanteix un bon resultat en aquest tipus de sistema.

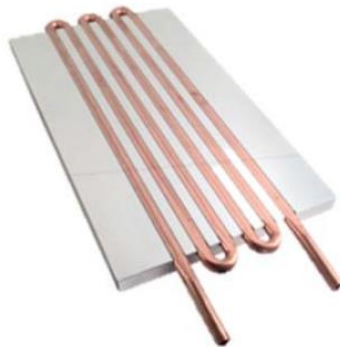


Figura B.3: Tipologia dissipador calor (Font: electricmotorsport.com)

B.3.2.6.- Tubs i toveres

Per a unir els diferents elements que contenen el fluid refrigerant s'han estudiat tubs d'acord amb els diàmetres que disposen els elements comercials adquirits. Per unir tubs de diferent diàmetre, s'ha cercat la solució, mitjançant toveres reductores o difusores.



Figura B.4: Tubs per a refrigeració d'automòvil. (Font: cautex.com)



Figura B.5: Toveres (Font: kaercher.com)

B.3.2.7.- Suports i subjeccions d'elements

Per a la integració dels elements del sistema de refrigeració al conjunt de la motocicleta, és a dir al xassís, es pensa en la forma del conjunt del xassís per adaptar-ne el conjunt del sistema.

B.3.2.8.- Modificacions de la motocicleta actual per a l'adaptació del sistema

Com s'ha anat mencionant, es valora la opció de realitzar lleus modificacions a algun element per adaptar el sistema a la motocicleta actual. De totes maneres, les modificacions queden fora de l'abast del projecte i corren a càrrec del promotor.

B.3.2.9.- Materials

Pel que fa a l'apartat de materials, cal destacar dues vessants; la part hidràulica i la part mecànica.

Part mecànica

Per a la conformació de peces metàl·liques, s'ha visualitzat la selecció de materials emparada pel promotor per a la realització del xassís. Aquest va emprar un aliatge d'acer estàndard, prenent com a prioritat la resistència de l'estructura i deixant de banda el pes del conjunt per assolir un millor preu del conformat.

Part hidràulica

Pel que fa als materials que conformen el sistema hidràulic, s'ha realitzat una cerca sobre els materials que s'empren en aquests components per a la realització de peces si s'escau.

Els següents elements que es troben al mercat, contenen els següents materials genèrics:

Taula B.1: Materials genèrics segons elements (Font: Taula propia)

Element	Material
Radiador	Alumini
Bomba	Acer i polímers
Tubs	Cautxú amb reforç tèxtil
Dissipador	Alumini i coure

Per a elements dissenyats per al projecte, s'avalua l'ús d'acers i acers inoxidable per evitar les corrosions dels elements hidràulics degut al pas del fluid refrigerant per l'interior dels components.

ANNEX C. Càlcul d'elements

C.1.- Introducció

Per a al dimensionat dels elements corresponents per a una bona execució del problema inicial, s'han realitzat anàlisi tèrmics i de fluids. El procediment seguit per a la formulació dels càlculs ha estat la següent:

A partir de les dades de telemetria adquirida al circuit de MotroLand el juliol del 2021, es van extreure les dades de consum d'energia de la bateria, que aquesta passa directament a consumir-se a l'inversor. A partir d'aquestes dades s'ha pogut extreure la potència que consumia la motocicleta de manera instantània, per extreure la potència dissipada a l'inversor. A partir d'aquí, s'ha realitzat l'estudi tèrmic al dissipador i el radiador, i paral·lelament s'ha dissenyat el circuit hidràulic segons les necessitats requerides pel sistema, variant les seves característiques segons les prioritats tèrmiques que eren el que marcaven el sistema hidràulic.

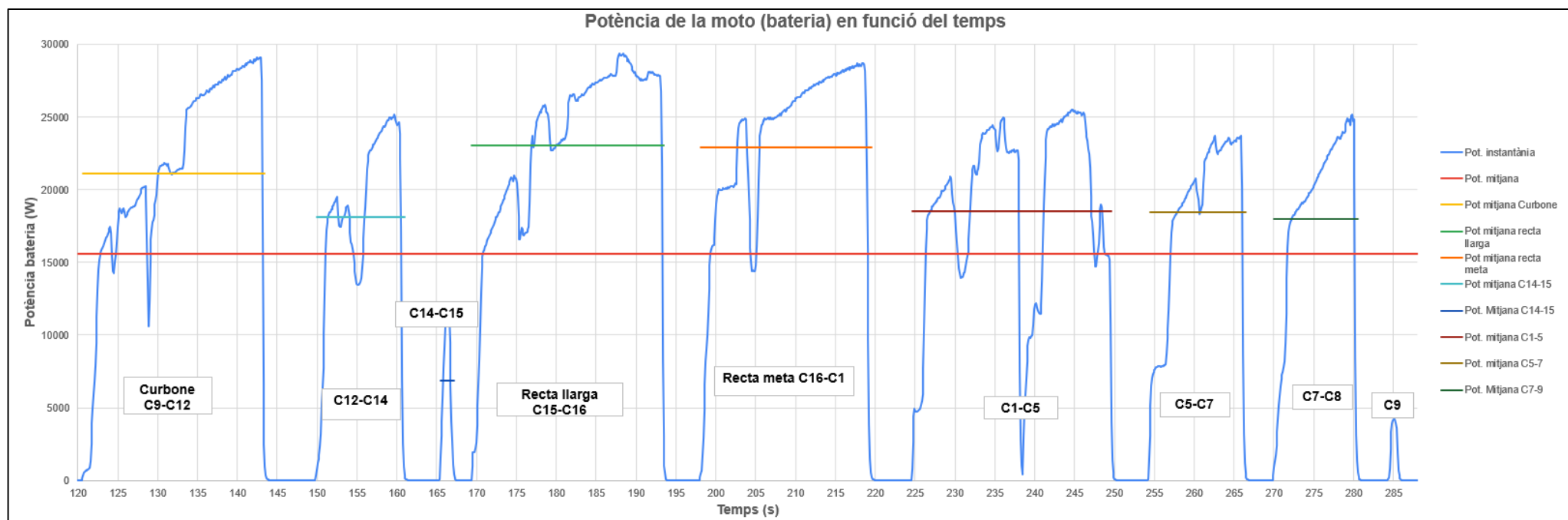
Aquestes dues serien les bases dels càlculs i les que necessitats principals que requeria el projecte, però també s'han realitzat altres càlculs que es mostraran posteriorment.

A partir d'aquesta breu introducció, es procedeix a l'explicació en detall del prèviament esmentat:

C.2.- Estudi de la telemetria

El primer pas que es realitza és realitzar l'estudi de la telemetria. A partir de les dades obtingudes al mateix circuit d'Alcanyís durant la prova el juliol del 2021, s'obtenen els següents resultats.

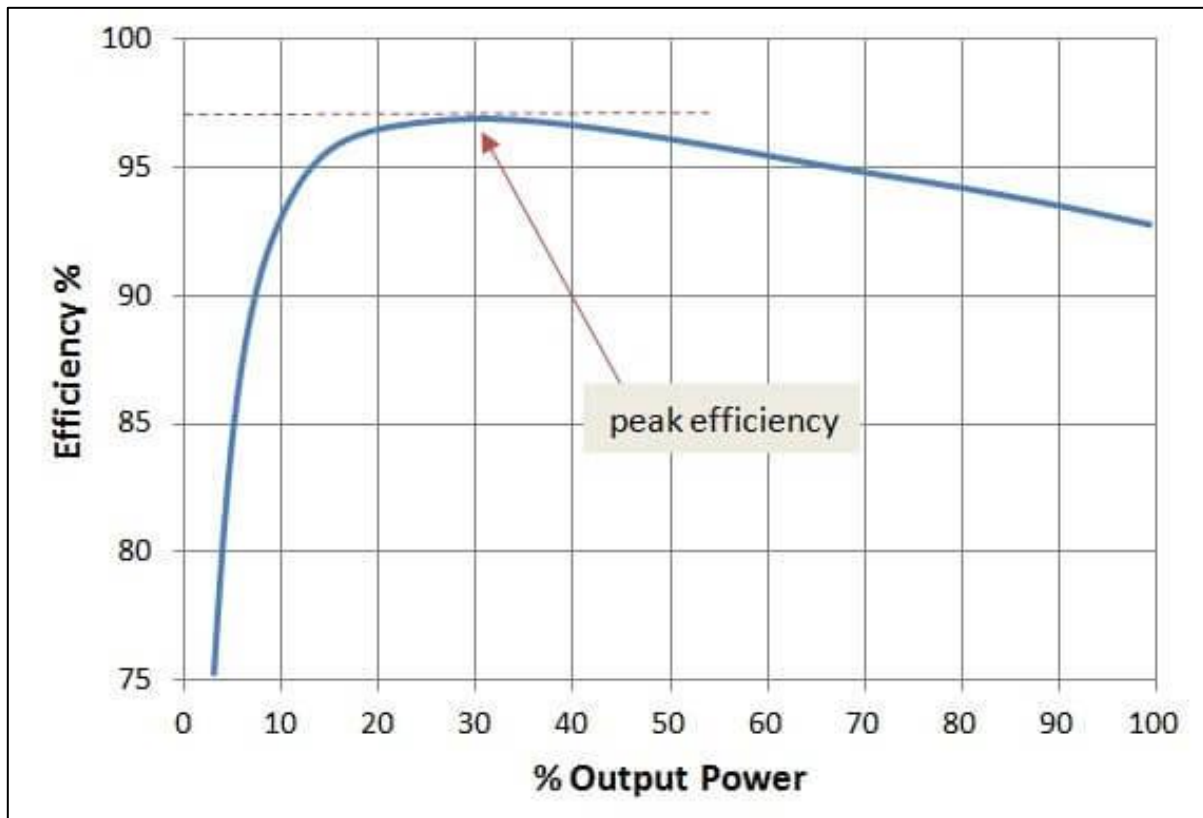
Taula C.1: Potència de la motocicleta en funció del temps en 1 volta completa (Font: Imatge pròpia)



A partir de les dades donades per l'equip, s'analitza un stint complet analitzant les dades desitjades, amb valors significatius i interpretables, amb potències adequades per competir i amb valors significatius.

S'han caracteritzat les potències segons els trams del circuit, i s'ha extrapolat la potència dissipada per part de l'inversor. Com que l'eficiència de dit inversor no era proporcionada pel fabricant, s'ha estipulat una eficiència comparant els valors amb altres inversors de mercat.

Taula C.2: Eficiència segons potència de sortida en inversors convencionals (Font: topbateriaexterna.com)



Com es mostra en el gràfic anterior, l'eficiència comença a decaure si les potències sol·licitades augmenten o disminueixen en excés. Per aquest motiu, s'ha decidit assignar eficiència del 85% de l'inversor, convertint el 15% restant en energia que es dissipa durant la transformació de l'energia. Aquest valor es troba per sota dels valors caracteritzats a la taula C.2 per disposar d'un marge de seguretat. Tot i que l'eficiència varia segons la potència de sortida, s'ha assignat el valor del 15% de pèrdues de manera constant, per estar novament a favor de la seguretat.

Un altre factor que ha fet augmentar la potència dissipada és el flux d'aire aconseguit al radiador. S'ha realitzat un estudi sobre quin és el flux aconseguit partir de la velocitat d'una motocicleta de tipus MotoStudent. L'estudi s'explicarà en detall més endavant, però s'ha vist com el flux d'aire al radiador decau a les corbes de velocitat mitja. Per aquest motiu, s'ha aplicat un factor ponderat de 1,1 a les potències que es troben en aquest rang de velocitats.

Amb la potència instantània, l'eficiència suposada i el factor que pondera la compensació de flux a les corbes de velocitat mitja, es crea una gràfica amb els valors dissipats en cada període de temps durant 1 volta sencera a partir dels valors de la taula C.1 i l'eficiència suposada.

Taula C.3: Potència dissipada per sectors (Font: Taula pròpia)

Tram Circuit	Pot mitjana(W)	Temps (s)	Pot. dissipada tèrmicament (W)
Curbone C9-C12	21138,9	22,7	3170,8
C12-C14	18094,0	11,0	2714,1
C14-C15	6871,9	1,7	1030,8
Recta llarga C15-C16	23017,7	24,2	3452,7
Recta meta C16-C1	22918,5	21,5	3437,8
C1-C5	18554,7	25,2	2783,2
C5-C7	18447,4	13,8	2767,1
C7-C8	18019,4	10,6	2702,9
C8-C9	3085,1	1,1	462,8

A partir d'aquest punt, es procedeix a la simulació de tots els valors a l'estudi tèrmic.

C.3.- Càlcul d'elements tèrmics

C.3.1.- Dissipador inversor

A partir de les dades obtingudes per a la simulació, es procedeix a realitzar la parametrització amb el programa *SolidWorks*.

Per a realitzar els càlculs, es prenen els valors de referència d'un inversor comercial pensat per aquest inversor.

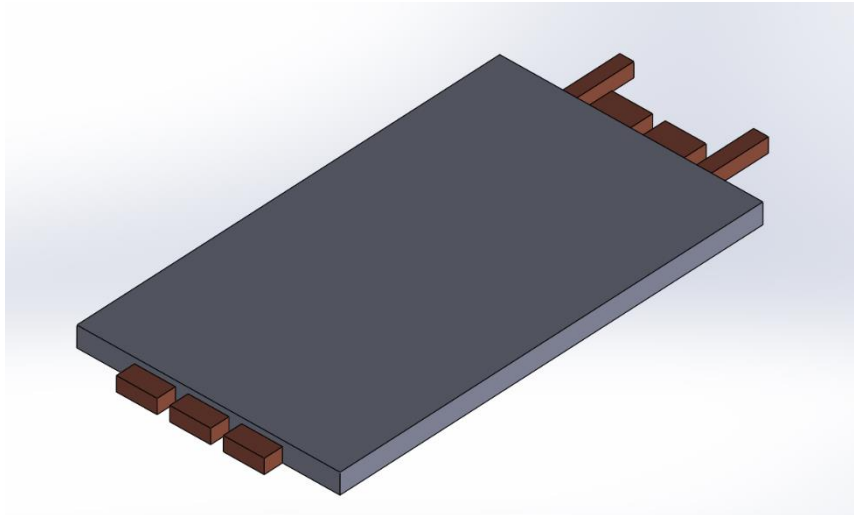


Figura C.1: Disseny del dissipador pel càlcul (Font: Imatge pròpia)

La figura C.1 mostra el disseny realitzat per a la simulació del comportament de l'inversor. D'aquesta manera, tot i no tenir les formes corbades dels tubs de coure als extrems, s'ha dissenyat d'aquesta manera per a la optimització dels dominis dels fluids per a la simulació. Un cop dissenyat, se li assigna una font de calor discontinua amb la informació proporcionada per la telemetria.

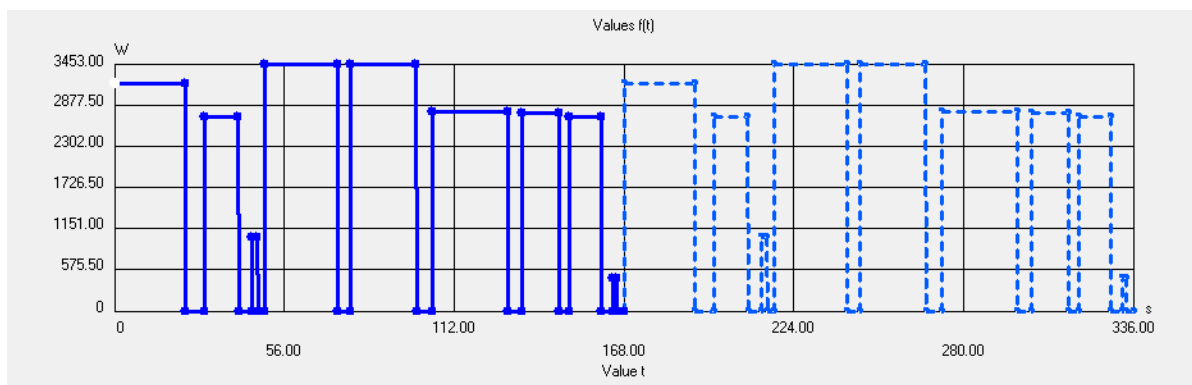


Figura C.2: Parametrització de la potència al programa de simulació (Font: Imatge pròpia)

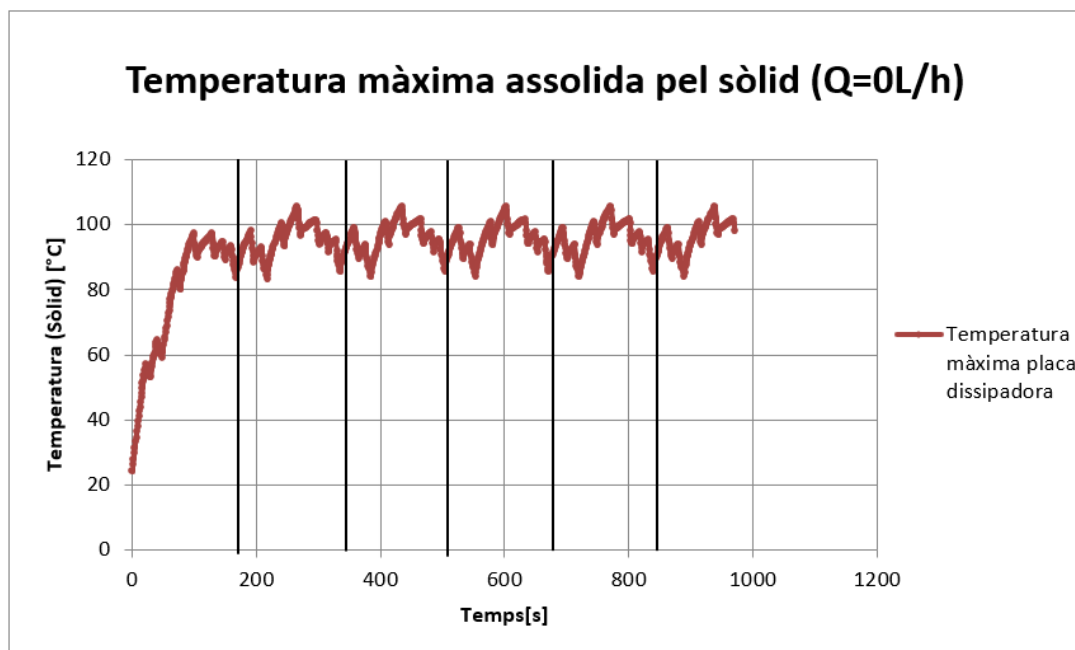
S'ha parametritzat la potència vista a la taula C.1, i repetint aquests valors periòdicament, ja que es tracta de voltes consecutives.

Com s'observa en les gràfiques, es realitza l'estudi durant un període llarg de temps, de diverses voltes consecutives com s'ha caracteritzat anteriorment la font de calor.

A partir del caudal calculat a l'estudi del sistema hidràulic, es procedeix a realitzar la simulació de la placa dissipadora. Per a la simulació, s'estableix una meta a escollir, de manera que el programa calcula en funció del paràmetre designat i en retorna els resultats per dit paràmetre.

S'arriba als següents valors:

Taula C.4: Evolució temperatures al dissipador $Q=0L/h$ (Font: Taula pròpia)



Les línies verticals negres simbolitzen l'inici d'una volta. Per a arribar als següents valors, el programa comença a realitzar les iteracions pertinents, fins a arribar a un punt on la temperatura ja no variï, que és quan s'acaba de realitzar la simulació. Per tant, a partir del temps de 971 segons, s'aniria repetint periòdicament el resultat. El resultat no s'estabilitza fins a la volta 6, però els gradients respecte els mateixos punts anteriorment són molt baixos, de manera que es pot considerar a partir de la volta 2 que el període esdevé igual.

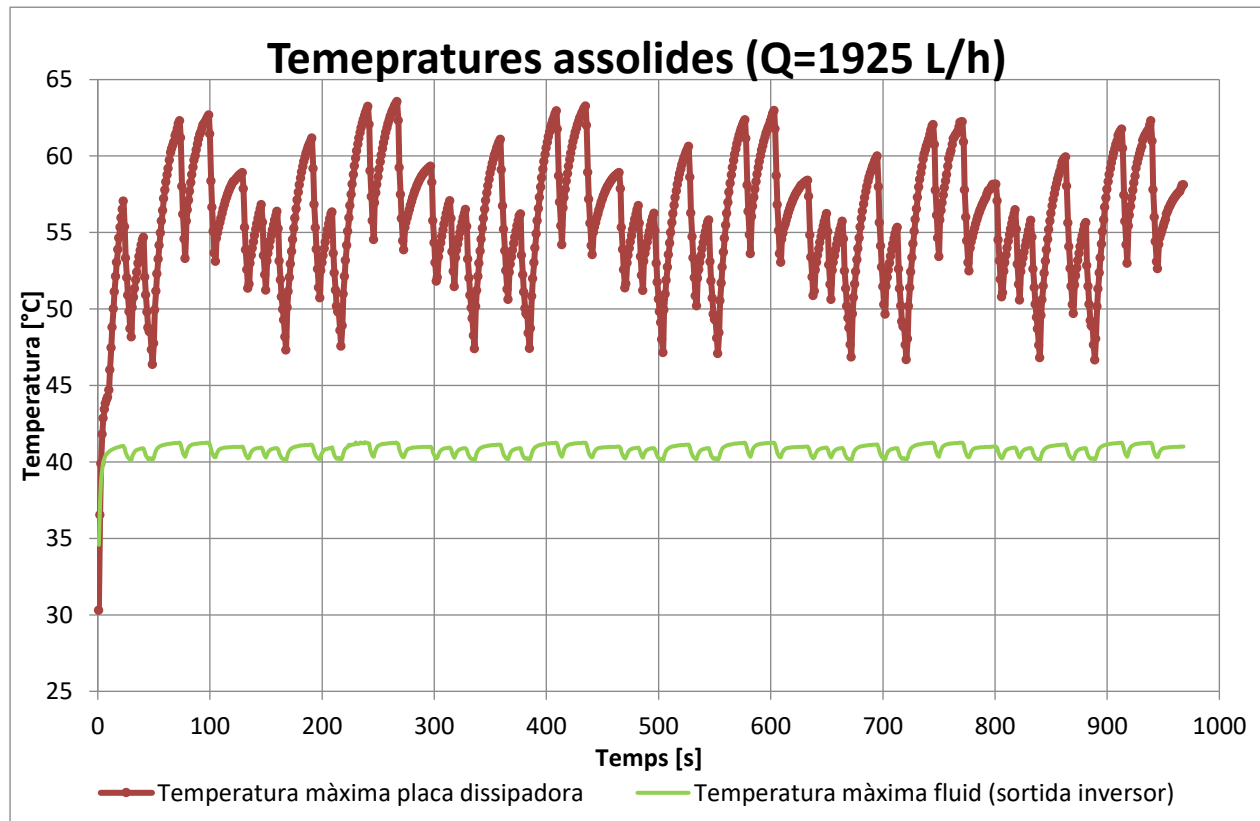
Taula C.5: Paràmetres estudi placa dissipadora $Q=0\text{L/h}$ (Font: Taula pròpia)

Valor de la meta	Unitats	Valor mitjà	Valor mínim	Valor màxim	Temps de l'estudi (s)
Temperatura màxima dissipador	[°C]	100,8	30,0	101,6	971

Inicialment es calcula la temperatura la qual arriba el sòlid sense refrigeració, forçant el caudal a 0 L/h, per simular el problema mostrat per part de l'equip. Es suposa una temperatura inicial de 30°C, avaluada a partir de l'estudi de condicionants del clima.

A partir d'aquesta gràfica, es va repetint el resultat fins a arribar al punt òptim de treball. Aquest procés iteratiu es va repetint, juntament amb el radiador, de manera que es van re-calculant els temps fins a convergir en que l'entrada del dissipador és la mateixa temperatura que la sortida del radiador, i que l'entrada al radiador tingui la mateixa temperatura que la sortida del dissipador.

Taula C.6: Tempreatures assolides al dissipador (Font: Taula pròpia)



Taula C.7: Dades iteració final dissipador (Font: Taula pròpia)

Valor de la meta	Unitats	Valor mitjà	Valor mínim	Valor màxim	Temps de l'estudi (s)
Tempepratura màxima dissipador	[°C]	57,2	47,5	63,9	939
Tempepratura màxima fluid	[°C]	40,1	41,5	42,3	939

C.3.2.- Radiador

A continuació es procedeix a realitzar la mateixa simulació amb el radiador, que intercanvia la calor del refrigerant adquirida al dissipador de l'inversor i la intercanvia amb l'aire per extreure-la del sistema.

Per saber la calor que dissipa el radiador amb l'aire, es realitza un estudi aerodinàmic. A partir de la velocitat d'un model de motocicleta de MotoStudent, es realitza una simulació amb la roda davantera i el lloc de col·locació del radiador per saber el flux d'aire en aquell punt.

Es separen les velocitats de la motocicleta en 4, segons el tipus de velocitat assolida en cada punt

- Velocitat corba lenta: 25 m/s
- Velocitat corba mitja: 33 m/s
- Velocitat corba ràpida: 40 m/s
- Velocitat punta màxima: 45 m/s

A partir d'aquets principi, realitza la simulació i es calcula la velocitat al radiador.

Per a la realització de la simulació, es crea un nou model CAD per simplificar el càlcul, d'aquesta manera se'n disminueix substancialment el temps. S'ha definit amb un rectangle la zona màxima per a capacitat pel radiador, de manera que no es poden superar les dimensions acotades.

Taula C.8: Dimensions màximes del radiador. (Font: Taula pròpia)

Dimensions màximes del radiador		
Amplada	Llargada	Profunditat
250	405	60

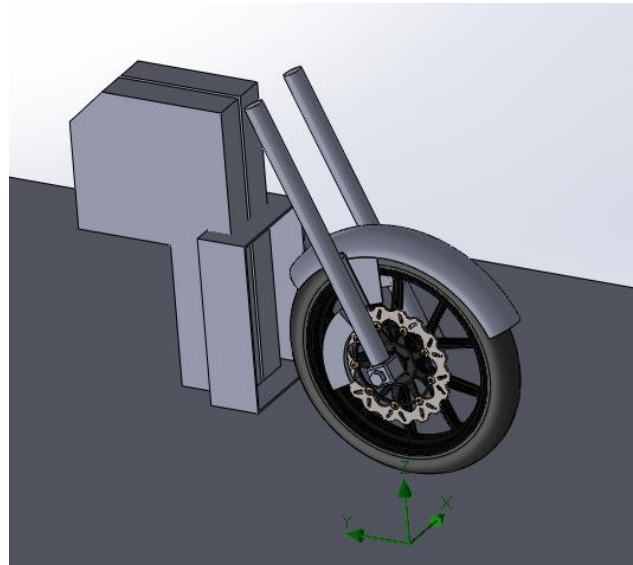
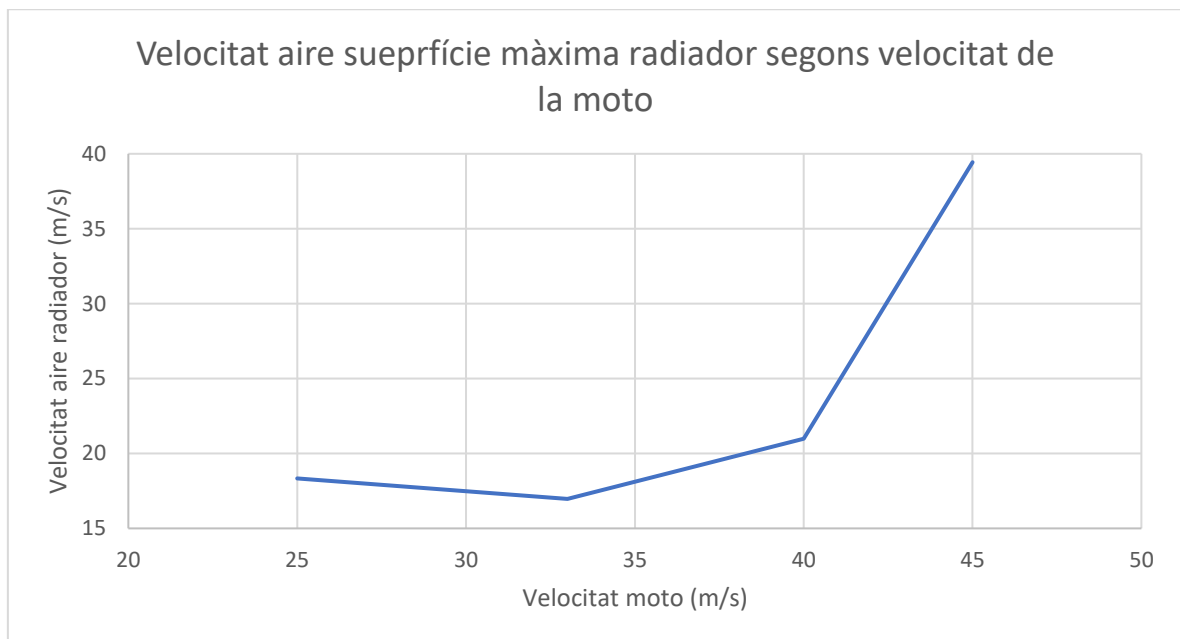


Figura C.3: Model per anàlisi aerodinàmic (Font: Imatge pròpia)

Els resultats de l'estudi han estat els següents:

Taula C.9: Comparativa velocitat moto amb la velocitat al radiador (Font: Taula pròpia)



S'ha anat parametrizant els valors per a cada velocitat i com es mostra a la taula, la velocitat al radiador no és lineal ja que en aquesta mateixa velocitat es genera una turbulència a la part posterior de la roda que frena el fluid en comptes d'accelerar-lo.

Com que l'estudi del radiador es realitza a una velocitat d'aire constant i amb un altre model CAD, es decideix augmentar la potència a dissipar, aplicant un factor de 1,1 a les potències que es trobin a la zona de dita velocitat. Aquest factor corrector s'aplica a la potència que dissipa la placa dissipadora, de manera que ja es magnifiquen els valors en aquest element.

Un cop fet aquest aclariment, es procedeix a realitzar l'estudi tèrmic del radiador. El radiador modelitzat amb el programa de simulació és el següent:

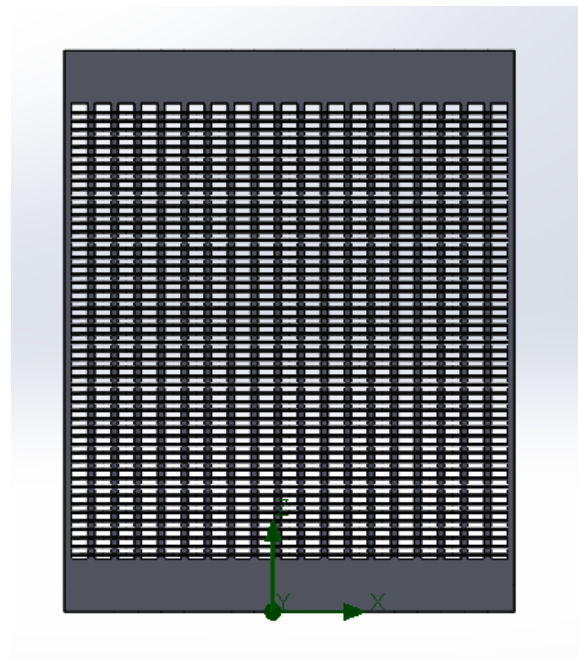


Figura C.4: Prototip radiador per simulació (Font: Imatge pròpia)

El procediment de càlcul ha estat el mateix que el mencionat anteriorment, comparant les entrades i sortides dels dos elements i anat iterant.

A partir de l'estudi aerodinàmic, es calcula la velocitat del d'aire al radiador, i se n'extrapola a la velocitat mitjana que assoleix la motocicleta durant 1 volta.

Taula C.10: Càlcul velocitats (Font: Taula pròpia)

Velocitat mitjana MotorLand			
Distància (m)	Temps per volta (s)	V mitjana moto (m/s)	V mitjana radiador (m/s)
5077	168	30,22	18,74

Amb totes les dades obtingudes es procedeix a avaluar el radiador.

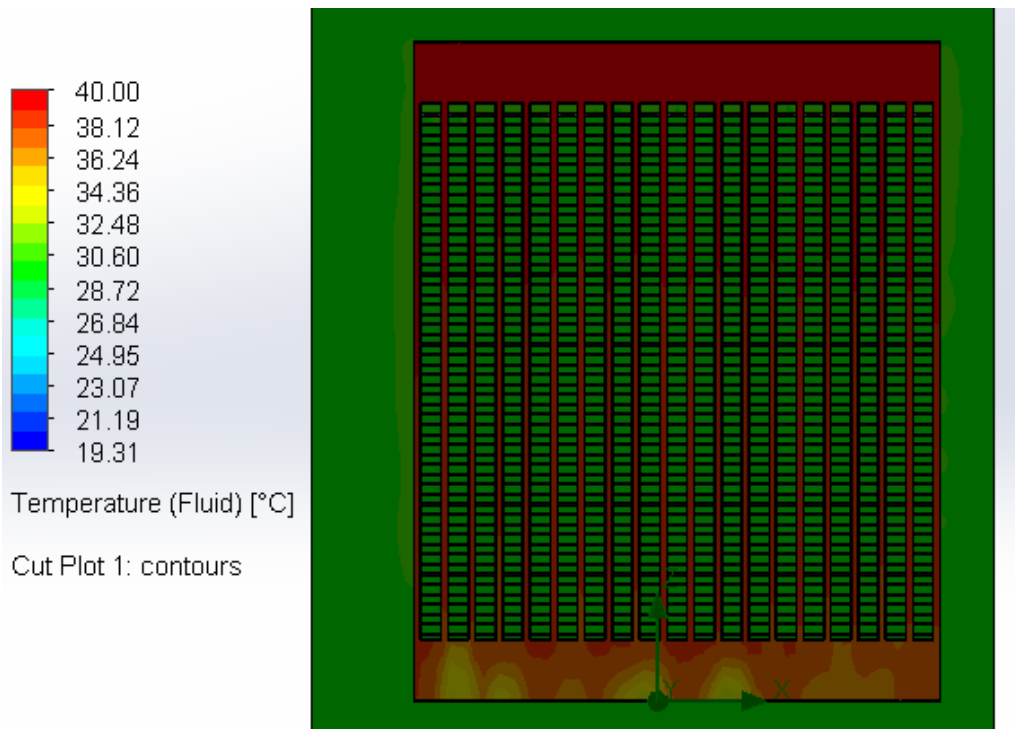
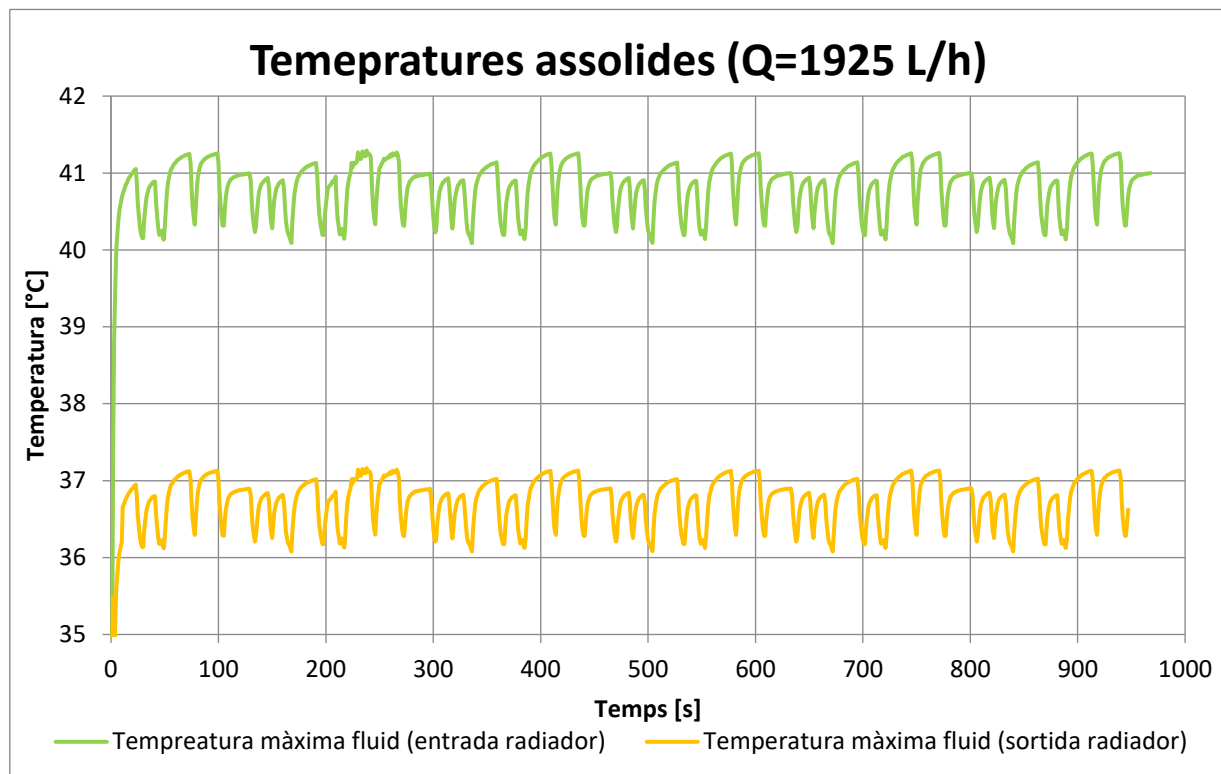


Figura C.5: Simulació tèrmica del radiador (Font: imatge pròpia)

A partir de les temperatures retornades al dissipador segons la primera iteració d'aquí que les temperatures obtingudes no siguin les definitives, es va iterant fins a arribar al resultat adequat, que seria el mostrat a la taula C.11. Se'n mostra el resultat de la última itearció.

Taula C.11: Resultats finals càlcul radiador (Font: Taula pròpia)



Igual que en el cas del radiador, s'arriba a l'iteració final, que seria mb la que es treballaria durant la utilització del sistema.

Taula C.12: Valors finals obtinguts al radiador (Font: Taula pròpia)

Valor de la meta	Unitats	Valor mitjà	Valor mínim	Valor màxim	Temps de l'estudi (s)
Temperatura màxima fluid entrada radiador	[°C]	40,1	41,5	42,3	967
Temperatura màxima fluid sortida radiador	[°C]	26,7	36,1	37,2	967

C.4.- Disseny del sistema hidràulic

C.4.1.- Introducció

Paral·lelament a l'estudi termodinàmic, es realitza l'estudi del sistema hidràulic per definir el cabal que el sistema assolirà. D'aquesta manera, es quantifiquen tots els valors de les pèrdues de càrrega produïdes durant tot el sistema i se n'extreu el caudal pel sistema hidràulic, que serà emprat en l'estudi termodinàmic a mesura que es realitzin les iteracions en aquest apartat.

Al tractar-se d'una zona de dissipació de calor, es decideix treballar en règim turbulent, de manera que les expressions emprades seran per aquest tipus de fluid.

C.4.2.- Càlcul del circuit hidràulic

Es calculen les mesures de les canonades (que es poden veure desglossades a l'apartat de plànols a l'annex corresponent), i se'n calcula la el valor de "ft" i "K" per posteriorment calcular la pèrdua de càrrega a través de l'expressió de Darcy.

Les expressions usades en aquest punt són les següents:

$$f_T = \frac{0,25}{\left[\log \left(3,7 \cdot \frac{D}{\varepsilon} \right) \right]^2} \quad (\text{Eq. C.1})$$

On:

D= Diàmetre hidràulic del tub (m)

ε = Rugositat de la canonada (m)

Per a les pèrdues locals s'avalua el valor de K, segons els accessoris que incorpori el sistema. Els resultats obtinguts són els següents:

Taula C.13: Definició de trams i càlculs hidràulics (Font: Taula pròpia)

Tram	Element	Diàmetres h. (mm)	Radi (mm)	A (m ²)	Longitud tubs(mm)	Accessoris	ft	K
1-2	Sortida bomba	24	12	4,52E-04	90	32	2,8E-02	9,1E-01
2-3	Augment diàmetre	-	-	-	-	-	-	-
3-4	Entrada radiador	32	16	8,04E-04	75	30	2,6E-02	7,8E-01
5-6	Sortida radiador-reducció	27	13,5	5,73E-04	710	32	2,7E-02	8,8E-01
6-7	Reducció Diàmetre	-	-	-	-	-	-	-
7-8	Dissipador	7,05	3,525	3,90E-05	1670	180	4,2E-02	7,6E+00
8-9	Reducció Diàmetre	-	-	-	-	-	-	-
9-10	Tub fins dipòsit	24	12	4,52E-04	410	30	2,8E-02	8,5E-01
11-12	Dipòsit-bomba	24	12	4,52E-04	395	76	2,8E-02	2,2E+00
4-5	Radiador	-	-	-	-	-	-	-

Un cop avaluades les pèrdues locals per trams, es procedeix a preparar la fase iteratòria per poder calcular el cabal i pressió obtinguts. El procés realitzat ha estat calculat totes les pèrdues i resta'ls-hi de la pressió total que dona la bomba, de manera que es pugui torbar el punt de caudal de funcionament.

$$\frac{p_1}{\rho \cdot g} + \frac{v_1^2}{2 \cdot g} + h_1 + h_a - h_l = \frac{p_2}{\rho \cdot g} + \frac{v_2^2}{2 \cdot g} + h_2 \quad (\text{Eq. C.2})$$

On:

p_1 = Pressió del fluid al punt 1 (m.c.a)

v_1 = Velocitat del fluid al punt 1 (m/s)

ρ = Densitat del fluid (kg/m³)

g = Gravetat (9,81 m/s²)

h_1 = Altura en el punt 1 (m)

h_a = Altura aportada per la bomba (m.c.a.)

h_l = Pèrdues per fricció (m.c.a.)

p_2 = Pressió del fluid al punt 2 (m.c.a.)

v_2 = Velocitat del fluid al punt 2 (m/s)

h_2 = Altura en el punt 2 (m)

Les pressions i velocitats no s'han considerat ja que es calcula referenciant el punt 1 i 2 al dipòsit.

$$h_1 + h_a - h_l = h_2$$

$$h_a = h_2 - h_1 + h_l \quad (\text{Eq. C.3})$$

Es mostra la fase iteratòria, amb els resultats buscats, que són pèrdua de càrrega velocitat, el nombre de Reynolds i el factor "f", amb les seves respectives expressions:

$$h_l = \left(f \left(\frac{L}{D} \right) + K \right) \cdot \frac{v^2}{2 \cdot g} \quad (\text{Eq. C.4})$$

h_l = Pèrdues per fricció (m.c.a)

f = Factor de Swame&Jain (adimensional)

L = Longitud de la canonada (m)

D = Diàmetre hidràulic de la canonada (m)

K = Pèrdues Locals (adimensional)

g = Gravetat (9,81 m/s²)

v = Velocitat del fluid (m/s)

A partir de l'expressió de Darcy per al càlcul de pèrdues, es calcula també el factor "f" i el nombre de Reynolds:

$$f = \frac{0,25}{\left[\log \left(\frac{1}{3,7 \cdot \left(\frac{D}{\varepsilon} \right)} + \frac{5,74}{Re^{0,9}} \right) \right]^2}$$

(Eq. C.5)

On:

f = Factor de Swame&Jain (adimensional)

D = Diàmetre hidràulic de la canonada (m)

ε = Rugositat de la canonada (m)

Re = Nombre de Reynolds (adimensional)

$$Re = \frac{v \cdot D}{\vartheta}$$

(Eq. C.6)

Re = Nombre de Reynolds (adimensional)

v = Velocitat del fluid (m/s)

D = Diàmetre hidràulic de la canonada (m)

v = Velocitat del fluid (m/s)

$$v = \frac{Q}{A}$$

(Eq. C.7)

On:

v = Velocitat del fluid (m/s)

Q = Cabal volumètric (m³/s)

A = Àrea de mas (m²)

Taula C.14: Resultats obtinguts de la primera iteració. (Font: Taula pròpia)

Iteració 1 (Q=1000L/h)	Càlcul pèrdues			
	hL (m.c.a)	v (m/s)	Re	f
Tram 1-2	1,93E-02	0,614	2,46E+04	2,45E-02
Tram 2-3 *	3,57E-03	-	-	-
Tram 3-4	4,36E-04	0,345	1,84E+04	2,64E-02
Tram 4-5**	1,68E+00	-	-	-
Tram 5-6	1,91E-03	0,485	2,18E+04	2,53E-02
Tram 6-7*	9,78E-01	-	-	-
Tram 7-8	3,40E-01	7,116	8,36E+04	1,86E-02
Tram 8-9*	1,26E+00	-	-	-
Tram 9-10	8,05E-03	0,614	2,46E+04	2,45E-02
Tram 11-12	7,72E-03	0,614	2,46E+04	2,45E-02

Els trams amb * són calculats a continuació, ja que es tracta de trams amb reduccions i amplificacions, on es divideixen els diàmetres i se'n calcula la seva expressió en cada cas.

Taula C.15: Resultats d'amplificacions i reduccions. (Font: Taula pròpia)

		D1/d2	d2/D1	v2 (m/s)	v1 (m/s)	K
Ampliació (2-3)*	3,57E-03	-	1,33	-	1,86E-01	1,86E-01
Reducció (6-7)*	9,78E-01	3,83	-	7,12	-	3,79E-01
Ampliació (8-9)*	1,26E+00	-	3,40	-	6,93E-01	6,93E-01

El cas del resultat de la taula 6(resultats primera iteració) amb **, és perquè el valor d'aquesta pèrdua de càrrega s'ha calculat a partir de les simulacions realitzades amb el programa de simulació *SolidWorks*.

Al cap d'haver realitzat un total de 5 iteacions, s'aconsegueix arribar al resultat desitjat, ja que el resultat convergeix i l'error disminueix, fins a arribar a una variació del 2%

Taula C.16: Resultats iteracions. (Font: Taula pròpia)

Resultats iteracions prèvies				
Núm. Itració	Q(L/h)	hL (bar)	ha (bar)	Variació (%)
Iteració 1	1000	0,28	0,51	-
Iteració 2	1600	0,44	0,26	57,14
Iteració 3	1800	0,48	0,32	9,09
Iteració 4	1900	0,50	0,30	4,17
Iteració 5	1925	0,51	0,29	2,00

Els resultats complets de la última iteració són els següents:

Taula C.17: Resultat final al realitzar la 5ena iteració. (Font: Taula pròpia)

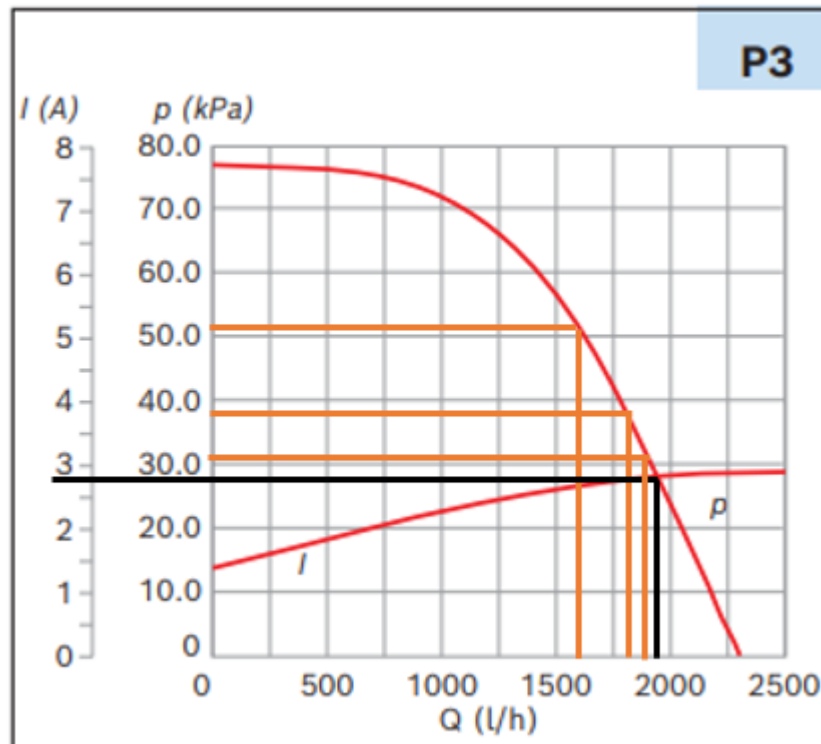
Iteració 5 (Q=1925L/h)	Càlcul pèrdues			
	hL (m.c.a)	v (m/s)	Re	f
Tram 1-2	4,07E-03	1,18	4,73E+04	2,45E-02
Tram 2-3 *	7,16E-03	-	-	-
Tram 3-4	5,66E-04	0,62	1,84E+04	2,64E-02
Tram 4-5**	2,02E+00	-	-	-
Tram 5-6	1,91E-03	0,87	2,18E+04	2,53E-02
Tram 6-7*	1,56E+00	-	-	-
Tram 7-8	7,75E-03	1,22	3,47E+04	2,26E-02
Tram 8-9*	1,51E+00	-	-	-
Tram 9-10	1,61E-02	1,17	2,46E+04	2,45E-02
Tram 11-12	1,39E-02	1,11	2,46E+04	2,45E-02



C.4.3.- Selecció de la bomba

A mesura que s'ha anat iterant, s'ha anat buscant el caudal en cada cas a partir de les pèrdues calculades.

Taula C.18: Iteracions sobre la cobra de la bomba. (Font: bosch-ibusiness.com)



Un cop s'ha aconseguit calcular el sistema, es procedeix a calcular el consum elèctric, per aconseguir obtenir l'energia consumida per volta.

Taula C.19: Consum energètic de la bomba (Font: Taula pròpia)

Consum energètic de la bomba	
Vol (V)	24
I (A)	2,8
Pot (W)	67,2
Temps 1 volta (s)	268
Temps 1 volta (h)	0,074
E/volta (Wh/volta)	5,003



C.4.4.- Càlcul quantitat líquid refrigerant

A partir de les dimensions i longituds de les canonades, es procedeix a calcular la quantitat total de líquid refrigerant a emprar.

Taula C.20. Càlcul volum canonades (Font: Taula pròpia)

Canonades		
Dh (mm)	Àrea mm2)	Volum per tubs (mm3)
9,5	14,9	8252,2
24	37,7	40111,9
32	50,3	26389,4
27	42,4	4877,3
Subtotal canonades		79630,7

Taula C.21: Càlcul volum dipòsit i radiador (Font: Taula pròpia)

Dipòsit i radiador			
Mesures	Dipòsit (mm3)	Mesures	Radiador (mm3)
80	760000	31200	2551000
100		2187000	
95		332800	

Taula C.22: Total líquid refrigerant (Font: Taula pròpia)

Total	3390631	mm3
	3,39	L
	3,5L	Aprox

Es realitzen els càlculs pertinents, i es demostra que per omplir el sistema de líquid refrigerant es necessiten un total de 3,5 litres de fluid aproximadament.

C.5.- Càlcul de fabricació d'elements

Per a la fabricació dels element dissenyats, es procedeixen a calcular els valors a tenir en compte a l'hora d'elaborar els plànols per a la posterior fabricació

C.5.1.- Plegat de xapa

Es procedeix a realitzar el càlcul total de la xapa a emprar per a la realització de la peça "Suport del dipòsit".

$$L_{Fn} = \frac{\pi \cdot \alpha}{180} \cdot \left(r_i + k \cdot \frac{e}{2} \right) \quad (\text{Eq. C.8})$$

On:

L_{Fn} = Longitud de la fibra neutre (mm)

α = Angle de curvatura de la xapa (°)

r_i = Radi interior de curvatura (mm)

k = Factor de compensació K (adimensional)

e = Gruix de la xapa (mm)

El valor de K surt de la següent expressió:

$$K = 0,2187 \cdot \ln \left(\frac{r_i}{e} \right) + 0,6528 \quad (\text{Eq. C.9})$$

A partir d'aquestes expressions es procedeix a realitzar el càlcul de la xapa. Es numeren les seccions per a realitzar la posterior definició.

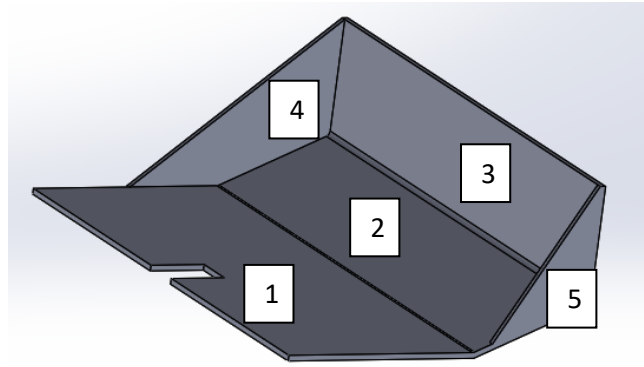


Figura C.7: Peça "Suport dipòsit". (Font: Imatge pròpia)

En la imatge anterior es mostra la nomenclatura emprada per definir les diferents longituds de la peça. Posteriorment es realitza el mateix càlcul per a les seccions 4 i 5. Com que tenen el les mateixes característiques, només es realitza 1 cop el càlcul.

Taula C.23: Càlculs fibra neutre suport dipòsit (Font: Taula pròpia)

Tram	e (mm)	R (mm)	alpha (º)	k	L fn (mm)
1-2	2	2	157	1	8,2
2-3	2	2	113,5	1	5,9
4-2,2-5	2	2	90	1	4,7

C.5.2.- Doblegat de tubs

Es realitzen les mateixes operacions realitzades per al càlcul de xapa per als tubs. Al ser un tub foradat, l'expressió varia lleugerament.

$$L_{Fn} = \frac{\pi \cdot \alpha}{180} \cdot (r_i + k \cdot e)$$

(Eq. C.10)

Taula C.24: Càlcul fibra neutra tubs (Font: Taula pròpia)

	e (mm)	R (mm)	alpha (°)	k	L fn (mm)
Longitud abans de deformat	2	12,5	40,5	6,25	22,1

C.5.3.- Dimensionat del suport del radiador

Els suports que subjecten el radiador no han estat dimensionats, sinó que s'ha escollit triar el mateix diàmetre de tubs que l'estructura del xassís per tenir un bon perímetre de soldadura. Com que el pes del conjunt és molt menor al de les bateries i el pes del pilot, no s'ha realitzat cap càlcul al respecte.

ANNEX D. Justificació del compliment de normativa

Un cop realitzat el projecte, es procedeix a comprovar el compliment de la normativa estipulada que es decreta en el reglament tècnic de la competició, de manera que els següents ítems mostraran els aspectes afectats:

- Utilització del líquid refrigerant específic

Tal com dicta la normativa tècnica, s'ha utilitzat única i exclusivament aigua destil·lada com a líquid refrigerant. Tots els càlculs han estat fets a partir de les propietats d'aquests fluid.

- Respecte de les dimensions màximes permeses

Igual que en el cas anterior, la normativa tècnica dicta les dimensions màximes que pot assolir la motocicleta. D'aquesta manera, s'han complert per acceptar les certificacions que homologa el certamen.

ANNEX E. Treball de camp

E.1.- Desenvolupament del treball de camp realitzat

Per a poder tenir més constància dels elements físics i les solucions emprades per a la construcció de la motocicleta, es realitza una sèrie d'intervencions al taller per tal de poder observar personalment el prototip. A més a més, a part de veure en persona els elements assembleats al conjunt, s'aprofita per verificar les creacions al programa CAD, de manera que es pugui correlacionar correctament els fitxers el 3D amb la realitat. A continuació s'exposen una sèrie d'imatges sobre la moto realitzades en les diferents visites al taller de l'equip. A continuació s'exposen una varietat d'imatges realitzades durant aquestes visites.



Figura E.1: Amplada disponible (Font: Imatge pròpia)

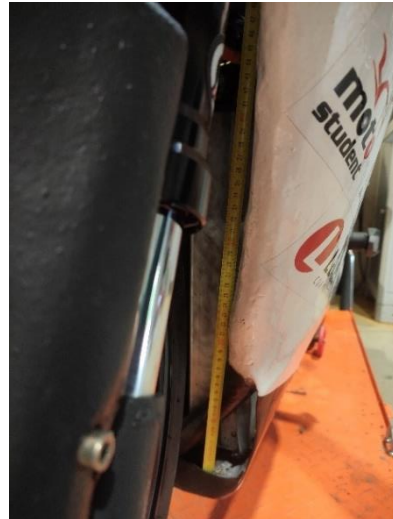


Figura E.2: Longitud disponible (Font: Imatge pròpia)



Figura E.3: Alçada de l'inversor respecte el sòl (Font: imatge pròpia)

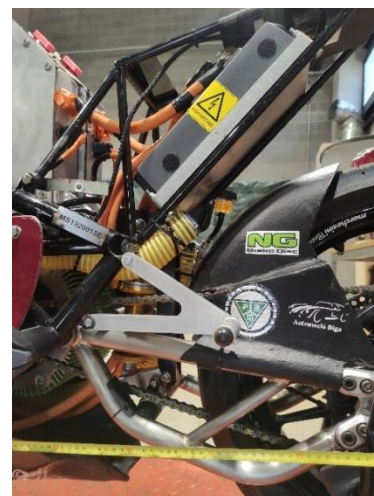


Figura E.4: Distància "X" respecte roda davantera (Font: Imatge pròpia)



Figura E.5: Profunditat disponible (Font: Imatge pròpia)



Figura E.6: Motocicleta sense colí (Font: Imatge pròpia)

ANNEX F. Programació temporal

F.1.- Introducció

Els següent annex fa referència a la programació temporal que es seguirà durant per a la fase d'execució del projecte del sistema de refrigeració de l'inversor.

Inicialment es definiran les activitats per a realitzar per assignar-les-hi unes prioritats i un temps, per posteriorment calcular les folgances i poder acabant esquematitzant tota la fase d'execució amb un diagrama de PERT.

F.2.-Fases de l'execució i definició d'activitats

F.2.1.- Activitats precedents

El primer pas per poder elaborar posteriorment el diagrama és definir les activitats a realitzar i les precedències de cadascuna. A continuació d'inserta la següent taula amb la informació per cada activitat.

Taula F.1: Activitats precedents i temps d'activitat (Font: Taula pròpia)

Activitats	Definició	Activitat Precedent
A	Adquisició de material	-
B	Fabriació suports radiador	A
C	Fabriació suports dipòsit	A
D	Instal·lació suports radiador	B
E	Instal·lació suport dipòsit	C
F	Instal·lació radiador	D
G	Instal·lació dipòsit compensació	E
H	Instal·lació bomba refrigerant	D
I	Instal·lació tubs i toveres	F,G,H
J	Instal·lació instrumentació i control	I
K	Posada en marxa i verificació del procés	J



F.2.2.- Matriu d'encadenaments

Un cop definides totes les activitats, es procedeix a realitzar la matriu d'encadenaments les precedències de cadascuna amb mitjançant una taula.

Taula F.2: Matriu d'encadenaments (Font: Taula pròpia)

	A	B	C	D	E	F	G	H	I	J	K
A											
B	*										
C	*										
D		*									
E			*								
F				*							
G					*						
H				*							
I						*	*	*			
J									*		
K										*	

En aquesta s'enfronten les activitats en els eixos d'ordenades i abscisses, i se'n col·loquen les precedències.

F.2.3.- Temps d'execució

Per a cada activitat s'assignen 3 tipus de temps; temps min o optimista, temps mig o modal i temps màxim o pessimista. Dit això, se'n calcula el temps de PERT per a realitzar el diagrama. Aquests s'extreu a partir de la següent expressió:

$$T_{PERT} = \frac{T_{Min} + 4 \cdot T_{Mig} + T_{Max}}{6} \quad (\text{Eq. F.1})$$

Taula F.3: Temps per cada activitat (Font: Taula pròpia)

Activitats	Temps (min)			
	T min	T mig	T max	Temps PERT
A	50	60	70	60,0
B	5	10	15	10,0
C	25	20	35	23,3
D	25	30	35	30,0
E	8	10	12	10,0
F	8	10	15	10,5
G	4	5	6	5,0
H	4	5	6	5,0
I	8	10	15	10,5
J	8	10	15	10,5
K	15	20	35	21,7

F.2.4.- Matriu de Zaderenko

Un cop calculat els temps de PERT de cada activitat, es procedeix a realitzar la matriu de Zaderenko i se'n calculen els temps *Early* i *Last*.

Taula F.4: Matriu de Zaderenko (Font: Taula pròpia)

Succés	1	2	3	4	5	6	7	8	9	10	11	12	13	T.Early
1		60	-	-	-	-	-	-	-	-	-	-	-	0,0
2			10	23,3	-	-	-	-	-	-	-	-	-	60,0
3				-	30	-	-	-	-	-	-	-	-	70,0
4					-	10	-	-	-	-	-	-	-	83,3
5						-	5	10,5	-	-	-	-	-	100,0
6							-	-	5	-	-	-	-	93,3
7								-	-	0	-	-	-	105,0
8									-	0	-	-	-	110,5
9										0	-	-	-	98,5
10											10,5	-	-	110,5
11												10,5	-	121,0
12													21,7	131,5
13														153,2
0,0 60,0 70,0 95,5 100,0 105,5 110,5 110,5 110,5 110,5 110,5 121,0 131,5 153,2 T.Last														



F.2.5.- Diagrama de PERT

A continuació es realitza el diagrama de PERT a partir dels valors de temps calculats anteriorment.

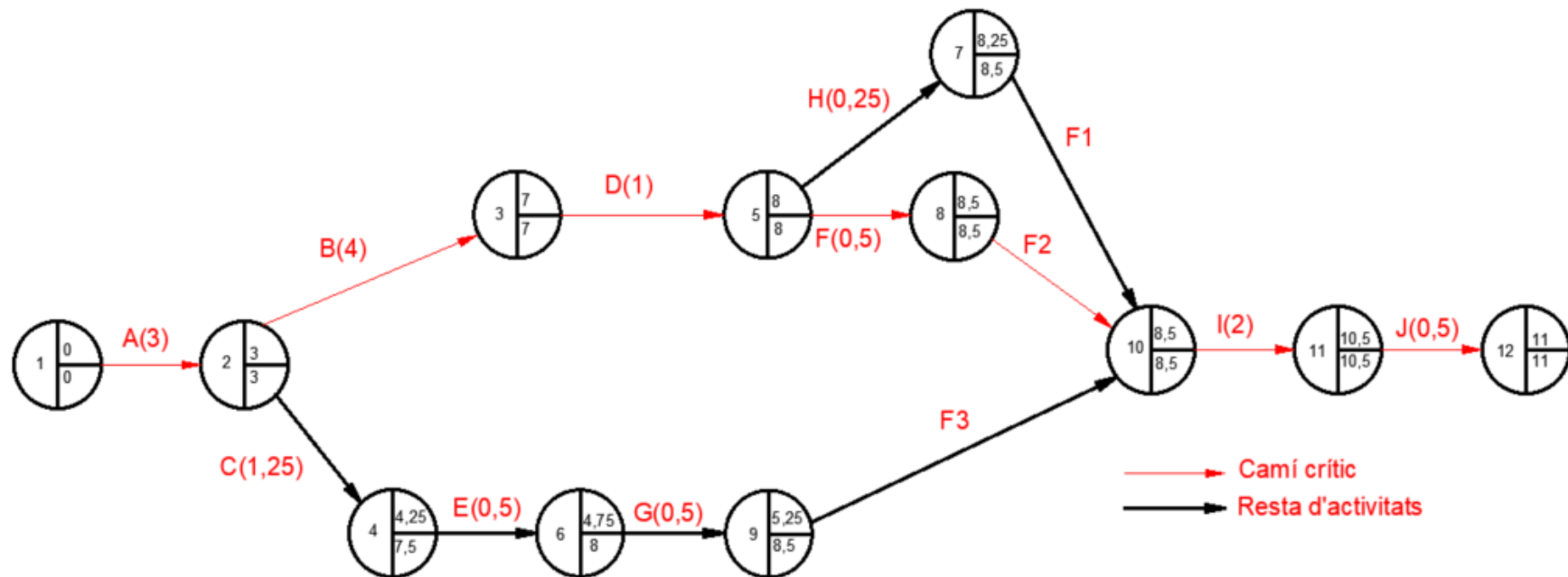


Figura F.1: Diagrama de PERT (Font: Imatge pròpia)

F.2.6.- Matriu de folgances

Paral·lelament al diagrama de PERT, es realitza la matriu de folgances i se'n troba el camí crític.

Taula F.5: Matriu de folgances (Font: Taula pròpia)

Activitat	Sucessos	Temps PERT (min)	ti	tj	ti*	tj*	Hi	Hj	HT	HL	HI	Camí crític
A	1-2	60,00	0,00	60,00	0,00	60,00	0,00	0,00	0,00	0,00	0,00	C.C.
B	2-3	10,00	60,00	70,00	60,00	70,00	0,00	0,00	0,00	0,00	0,00	C.C.
C	2-4	23,33	60,00	83,33	60,00	95,50	0,00	12,20	12,17	-0,03	-0,03	-
D	3-5	30,00	70,00	100,00	70,00	100,00	0,00	0,00	0,00	0,00	0,00	C.C.
E	4-6	10,00	83,33	93,33	95,50	105,50	12,20	12,20	12,20	0,00	-12,20	-
F	5-8	10,50	100,00	110,50	100,00	110,50	0,00	0,00	0,00	0,00	0,00	C.C.
G	6-9	5,00	93,33	98,50	105,50	110,50	12,20	12,00	12,20	0,20	-12,00	-
H	5-7	5,00	100,00	105,00	100,00	110,50	0,00	5,50	5,50	0,00	0,00	-
I	10-11	10,50	110,50	121,00	110,50	121,00	0,00	0,00	0,00	0,00	0,00	C.C.
J	11-12	10,50	121,00	131,50	121,00	131,50	0,00	0,00	0,00	0,00	0,00	C.C.
K	12-13	21,67	131,50	153,20	131,50	153,20	0,00	0,00	0,03	0,03	0,03	C.C.
F1	7-10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-
F2	8-10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-
F3	9-10	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	-



ANNEX G. Avaluació financera

Per al projecte en concret de refrigeració de l'inversor d'una motocicleta de competició, no s'ha realitzat un estudi financer com a tal. A continuació s'exposen els motius i decisions per a prescindir d'aquests estudi.

- **Projecte de competició:** El projecte realitzat es destina a una motocicleta de competició, no a una comercial. Aquest fet fa que els recursos per a realitzar la motocicleta no vagin destinats a rebre retribucions econòmiques per poder fer viable el projecte, sinó que es destina a formació d'estudiants per la introducció al sector automobilístic. A més a més, tots els recursos destinats per a projectes de competició no van destinats a rebre una retribució directe, sinó a obtenir prestigi, informació i aconseguir avenços tecnològics que posteriorment es desenvoluparan el sector comercial, que si que és on s'aconsegueixen beneficis, com passa en les grans corporacions automobilístiques que decideixen endinsar-se en el món de la competició.

També cal afegir que el projecte es destina a un únic prototip, de manera que el cost unitari serà molt més gran que si es fes a nivell comercial, i que no s'aconsegueixen ingressos directes amb el projecte realitzat.

- **Vida útil del projecte:** A l'hora de realitzar un estudi econòmic, es realitza a uns anys vista per a poder rendibilitzar la inversió (10-15 anys vista com a mínim). Aquest projecte només dura 2 anys, i la possible adaptació per a una futura motocicleta, però no assegura que es segueixi apostant pel sistema projectat. Aquest fet també comporta que es prescindi de l'estudi, ja que a part de no obtenir ingressos, la durada és curta i només per 1 prototip, sense ser comercial.
- **Promotor sense ànima de lucre:** El promotor d'aquest projecte és una entitat associada a la universitat i que pretén ser un banc de proves per qualificar els estudiants de la mateixa. EL promotor disposa de recursos públics, així com d'empreses privades, però sense d'intenció d'obtenir una rendibilitat econòmica. Per aquest motiu també es precedeix de l'estudi financer.

Amb tots els arguments comentats anteriorment, es considera que l'avaluació financera no aplica en aquest projecte.

ANNEX H. Annex de justificació de preus

H.1.- Preus bàsics



MATERIALS (PRESSUPOST)

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UT.	PREU/UT.
FM-0001	Barra acer F112 Ø28x5, 1000	m	15,89
FM-0002	Xapa acer 2mm F112 (200x200)	Ud	12,34
FM-0003	Xapa acer 2mm F112 (100x100)	Ud	9,24
FM-0004	Barra acer inox. al Cr-Ni F314 Ø35x150	Ud	16,81
FM-0005	Barra acer inoxidable al Cr-Ni F314 Ø30x150	Ud	15,93
MM-0001	Cargol M6x40	Ud	0,43
MM-0002	Volandera M6	Ud	0,12
MM-0003	Femella M6	Ud	0,23
SHM-0001	Bomba BOSCH 0 392 024 041	Ud	267,24
SHM-0002	Conjunt abraçadera per tubs WURTH DN 79-85	Ud	8,92
SHM-0003	Cargol M8x40	Ud	0,53
SHM-0004	Femella M8	Ud	0,15
SHM-0005	Dipòsit DT Spare Parts 2.30046	Ud	14,81
SHM-0006	Abraçadera DN 110	Ud	0,91
SHM-0007	Radiador AUSTIN MINI 1000	Ud	249,73
SHM-0008	Cargol M8x25	Ud	0,21
SHM-0009	Volandera M8	Ud	0,53
SHM-0010	Tub de cautxú amb reforç tèxtil DN10x500	Ud	2,84
SHM-0011	Abraçadora DN 10-15	Ud	1,21
SHM-0012	Tub de cautxú amb reforç tèxtil DN27x500	Ud	3,94
SHM-0013	Abraçadores DN20-28	Ud	2,12
SHM-0014	Abraçadora per tubs WÜRTH DN 24-28	Ud	3,12
SHM-0015	Tub de cautxú amb reforç tèxtil DN37x200	Ud	4,13
SHM-0016	Abraçadores DN30-38	Ud	2,35
SHM-0017	Abraçadora WÜRTH DN25-32	Ud	2,28
SHM-0018	Líquid refrigerant (aigua destil·lada) 5L	l	0,83
SHM-0019	Cargol M4x25	Ud	0,31
SHM-0020	Volandera plana M4	Ud	0,12
SHM-0021	Dissipador líquid per SEVCON Gen4 Size6	Ud	150,00
SHM-0022	Cargol M6x70	Ud	0,53
SHM-0023	Volandera M6	Ud	0,17
SHM-0024	Femella M6	Ud	0,26
SHM-0025	Tub de cautxú amb reforç tèxtil DN37x600	Ud	3,97

MÀ D'OBRA (PRESSUPOST)

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UT.	PREU/UT.
FMO-0001	Operari serraller	h	25,00
FMO-0002	Operari mecanitzat	h	28,00
MMO-0001	Operari muntador	h	30,00
SHMO-0001	Operari sistema hidràulic	h	35,00

MAQUINÀRIA (PRESSUPOST)

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UT.	PREU/UT.
FMA-0001	Doblegadora de tubs	h	15,00
FMA-0002	Eines de mà	h	7,00
FMA-0003	Oxital	h	15,00
FMA-0004	Soldadura amb electrode revestit 2 mm	h	12,00
FMA-0005	Torn metàl·lic	h	15,00
FMA-0006	Trepant portàtil	h	10,00
MMA-0001	Soldador electrode revestit	h	15,00
MMA-0002	Eines de mà	h	7,00
MMA-0003	Trepant portàtil	h	10,00
SHMA-0001	Eines de mà	h	8,00
SHMA-0002	Trepant portàtil	h	7,00

H.1.- Quadre de descompostos



QUADRE DE DESCOMPOSATS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT UT	PREU	SUBTOTAL	IMPORT
01	Capítol 1: Fabricació				
F-001	Fabricació suport radiador dreta	Ud			
	Fabricació del suport col·locat a la dreta que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís				
FM-0001	Barra acer F112 Ø28x5, 1000	1,000 m	15,89	15,89	
FMA-0001	Doblegadora de tubs	0,500 h	15,00	7,50	
FMO-0001	Operari serraller	2,000 h	25,00	50,00	
FMA-0002	Eines de mà	0,250 h	7,00	1,75	
FMA-0004	Soldadura amb electrode revestit 2 mm	0,500 h	12,00	6,00	
FM-0003	Xapa acer 2mm F112 (100x100)	1,000 Ud	9,24	9,24	
FMA-0003	Oxitall	0,500 h	15,00	7,50	
FMA-0006	Trepant portàtil	0,250 h	10,00	2,50	
TOTAL PARTIDA.....					100,38
F-002	Fabricació suport radiador esquerra	Ud			
	Fabricació del suport col·locat a l'esquerra que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís				
FM-0001	Barra acer F112 Ø28x5, 1000	1,000 m	15,89	15,89	
FMA-0001	Doblegadora de tubs	0,500 h	15,00	7,50	
FMO-0001	Operari serraller	2,000 h	25,00	50,00	
FMA-0002	Eines de mà	0,250 h	7,00	1,75	
FMA-0004	Soldadura amb electrode revestit 2 mm	0,500 h	12,00	6,00	
FM-0003	Xapa acer 2mm F112 (100x100)	1,000 Ud	9,24	9,24	
FMA-0003	Oxitall	0,500 h	15,00	7,50	
FMA-0006	Trepant portàtil	0,250 h	10,00	2,50	
TOTAL PARTIDA.....					100,38
F-003	Fabricació suport dipòsit	Ud			
	Fabricació del suport del dipòsit amb xapa 2mm de gruix, tallat amb oxitall i soldat amb soldadura d'electrode revestit				
FM-0002	Xapa acer 2mm F112 (200x200)	1,000 Ud	12,34	12,34	
FMO-0001	Operari serraller	1,250 h	25,00	31,25	
FMA-0002	Eines de mà	0,250 h	7,00	1,75	
FMA-0003	Oxitall	0,500 h	15,00	7,50	
FMA-0004	Soldadura amb electrode revestit 2 mm	0,500 h	12,00	6,00	
TOTAL PARTIDA.....					58,84
F-004	Fabricació tovera radiador-dissipador	Ud			
	Fabricació de la tovera radiador-dissipador mitjançant un mecanitzat amb torn				
FM-0004	Barra acer inox. al Cr-Ni F314 Ø35x150	1,000 Ud	16,81	16,81	
FMA-0005	Torn metàl·lic	0,500 h	15,00	7,50	
FMA-0002	Eines de mà	0,250 h	7,00	1,75	
FMO-0002	Operari mecanitzat	0,750 h	28,00	21,00	
TOTAL PARTIDA.....					47,06
F-005	Fabricació tovera bomba-radiador	Ud			
	Fabricació de la tovera bomba-radiador mitjançant un mecanitzat amb torn				
FMA-0005	Torn metàl·lic	0,500 h	15,00	7,50	
FMA-0002	Eines de mà	0,250 h	7,00	1,75	
FM-0005	Barra acer inoxidable al Cr-Ni F314 Ø30x150	1,000 Ud	15,93	15,93	
FMO-0002	Operari mecanitzat	0,750 h	28,00	21,00	
TOTAL PARTIDA.....					46,18

QUADRE DE DESCOMPOSATS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT	UT	PREU	SUBTOTAL	IMPORT
F-006	Fabricació tovera dissipador-dipòsit		Ud			
	Fabricacció de la tovera dissipador-dipòsit mitjançant un mecanitzat amb torn					
FMA-0005	Torn metàl·lic	0,500	h	15,00	7,50	
FMA-0002	Eines de mà	0,250	h	7,00	1,75	
FM-0005	Barra acer inoxidable al Cr-Ni F314 Ø30x150	1,000	Ud	15,93	15,93	
FMO-0002	Operari mecanitzat	0,750	h	28,00	21,00	
TOTAL PARTIDA.....						46,18

QUADRE DE DESCOMPOSATS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT UT	PREU	SUBTOTAL	IMPORT
02	Capítol 2: Muntatge mecànic				
M-001	Subjecció suports del radiador al xassís	Ud			
	Subjecció del suport del radiador al xassís mitjançant soldadura amb electrode revestit.				
MMA-0001	Soldador electrode revestit	0,500 h	15,00	7,50	
MMO-0001	Operari muntador	0,500 h	30,00	15,00	
TOTAL PARTIDA.....					22,50
M-002	Foradat xassís	Ud			
	Foradat de xassís mitjançant trepant portàtil.				
MMA-0002	Eines de mà	0,250 h	7,00	1,75	
MMO-0001	Operari muntador	0,500 h	30,00	15,00	
MMA-0003	Trepant poràtil	0,250 h	10,00	2,50	
TOTAL PARTIDA.....					19,25
M-003	Muntatge suport dipòsit	Ud			
	Acollament suport del dipòsit, atornillat als colissos del xassís.				
MMO-0001	Operari muntador	0,500 h	30,00	15,00	
MMA-0002	Eines de mà	0,500 h	7,00	3,50	
MM-0001	Cargol M6x40	2,000 Ud	0,43	0,86	
MM-0002	Volandera M6	2,000 Ud	0,12	0,24	
MM-0003	Femella M6	2,000 Ud	0,23	0,46	
TOTAL PARTIDA.....					20,06

QUADRE DE DESCOMPOSATS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT	UT	PREU	SUBTOTAL	IMPORT
03	Capítol 3: Sistema hidràulic					
SH-001	Instal·lació bomba refrigerant		Ud			
	Col·locació bomba refrigerant al xassís de la motocicleta, amb abraçadera i cargols.					
SHM-0001	Bomba BOSCH 0 392 024 041	1,000	Ud	267,24	267,24	
SHMA-0001	Eines de mà	0,250	h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,250	h	35,00	8,75	
SHM-0002	Conjunt abraçadera per tubs WURTH DN 79-85	1,000	Ud	8,92	8,92	
SHM-0003	Cargol M8x40	1,000	Ud	0,53	0,53	
SHM-0004	Femella M8	1,000	Ud	0,15	0,15	
TOTAL PARTIDA.....						287,59
SH-002	Instal·lació dipòsit compensació		Ud			
	Instal·lació del dipòsit al suport, acollat amb abraçadora metàl·lica.					
SHM-0005	Dipòsit DT Spare Parts 2.30046	1,000	Ud	14,81	14,81	
SHMA-0001	Eines de mà	0,250	h	8,00	2,00	
SHMA-0002	Trepant portàtil	0,250	h	7,00	1,75	
SHMO-0001	Operari sistema hidràulic	0,500	h	35,00	17,50	
SHM-0006	Abraçadora DN 110	1,000	Ud	0,91	0,91	
TOTAL PARTIDA.....						36,97
SH-003	Instal·lació placa dissipadora		Ud			
	Instal·lació de placa dissipadora sota de l'inversor, al colí de la motocicleta, atornillat amb cargols i doble femella de seguretat.					
SHM-0021	Dissipador líquid per SEVCON Gen4 Size6	1,000	Ud	150,00	150,00	
SHMO-0001	Operari sistema hidràulic	0,500	h	35,00	17,50	
SHM-0022	Cargol M6x70	4,000	Ud	0,53	2,12	
SHM-0023	Volandera M6	8,000	Ud	0,17	1,36	
SHM-0024	Femella M6	8,000	Ud	0,26	2,08	
TOTAL PARTIDA.....						173,06
SH-004	Instal·lació radiador		Ud			
	Instal·lació del radiador al xassís, motjançant els suports prèviament muntats, amb subjecció amb cargols M8.					
SHM-0007	Radiador AUSTIN MINI 1000	1,000	Ud	249,73	249,73	
SHMA-0001	Eines de mà	0,250	h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,500	h	35,00	17,50	
SHM-0008	Cargol M8x25	6,000	Ud	0,21	1,26	
SHM-0009	Volandera M8	6,000	Ud	0,53	3,18	
TOTAL PARTIDA.....						273,67
SH-005	Instal·lació tubs DN10		Ud			
	Instal·lació de tubs de cautxú amb reforç tèxtil, acollats amb abraçadores pels seus extrems					
SHM-0010	Tub de cautxú amb reforç tèxtil DN10x500	1,000	Ud	2,84	2,84	
SHMA-0001	Eines de mà	0,250	h	8,00	2,00	
SHM-0011	Abraçadora DN 10-15	2,000	Ud	1,21	2,42	
SHMO-0001	Operari sistema hidràulic	0,125	h	35,00	4,38	
TOTAL PARTIDA.....						11,64
SH-006	Instal·lació tubs DN27		Ud			
	Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs					
SHM-0012	Tub de cautxú amb reforç tèxtil DN27x500	1,000	Ud	3,94	3,94	
SHMA-0001	Eines de mà	0,250	h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,250	h	35,00	8,75	
SHM-0013	Abraçadores DN20-28	2,000	Ud	2,12	4,24	
SHM-0014	Abraçadora per tubs WÜRTH DN 24-28	1,000	Ud	3,12	3,12	
SHM-0019	Cargol M4x25	1,000	Ud	0,31	0,31	
SHM-0020	Volandera plana M4	1,000	Ud	0,12	0,12	

QUADRE DE DESCOMPOSATS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT UT	PREU	SUBTOTAL	IMPORT
TOTAL PARTIDA.....					22,48
SH-007	Instal·lació tubs DN27	Ud			
	Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems.				
SHM-0012	Tub de cautxú amb reforç tèxtil DN27x500	1,000 Ud	3,94	3,94	
SHMA-0001	Eines de mà	0,250 h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,250 h	35,00	8,75	
SHM-0013	Abraçadores DN20-28	2,000 Ud	2,12	4,24	
TOTAL PARTIDA.....					18,93
SH-008	Instal·lació tubs DN37	Ud			
	Instal·lació de tubs de cautxú DI32 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassis amb abraçadores per tubs				
SHM-0015	Tub de cautxú amb reforç tèxtil DN37x200	1,000 Ud	4,13	4,13	
SHMA-0001	Eines de mà	0,250 h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,250 h	35,00	8,75	
SHM-0016	Abraçadores DN30-38	2,000 Ud	2,35	4,70	
SHM-0019	Cargol M4x25	1,000 Ud	0,31	0,31	
SHM-0020	Volandera plana M4	1,000 Ud	0,12	0,12	
TOTAL PARTIDA.....					20,01
SH-009	Instal·lació tubs DN32	Ud			
	Instal·lació de tubs de cautxú DI27 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassis amb abraçadores per tubs.				
SHMA-0001	Eines de mà	0,250 h	8,00	2,00	
SHMO-0001	Operari sistema hidràulic	0,250 h	35,00	8,75	
SHM-0017	Abraçadora WÜRTH DN25-32	2,000 Ud	2,28	4,56	
SHM-0019	Cargol M4x25	1,000 Ud	0,31	0,31	
SHM-0020	Volandera plana M4	1,000 Ud	0,12	0,12	
SHM-0025	Tub de cautxú amb reforç tèxtil DN37x600	1,000 Ud	3,97	3,97	
TOTAL PARTIDA.....					19,71
SH-010	Instal·lació de toveres	Ud			
	Instal·lació de toveres a les reduccions i augments de diàmetre dels tubs.				
SHMO-0001	Operari sistema hidràulic	0,083 h	35,00	2,91	
TOTAL PARTIDA.....					2,91
SH-011	Instal·lació fluid refrigerant	Ud			
	Instal·lació de fluid refrigerant (aigua destil·lada) per a omplir la totalitat del sistema hidràulic				
SHM-0018	Liquid refrigerant (aigua destil·lada) 5L	5,000 l	0,83	4,15	
SHMO-0001	Operari sistema hidràulic	0,250 h	35,00	8,75	
TOTAL PARTIDA.....					12,90
SH-012	Verificació fugues i funcionament circuit	Ud			
	Verificació del correcte funcionament del sistema i verificació de fugues.				
SHMO-0001	Operari sistema hidràulic	0,500 h	35,00	17,50	
TOTAL PARTIDA.....					17,50

ANNEX I. Catàlegs

A continuació s'afegeixen documents adjunt usats durant el transcurs del projecte.

I.1.- Bomba refrigeració BOSCH

PAD

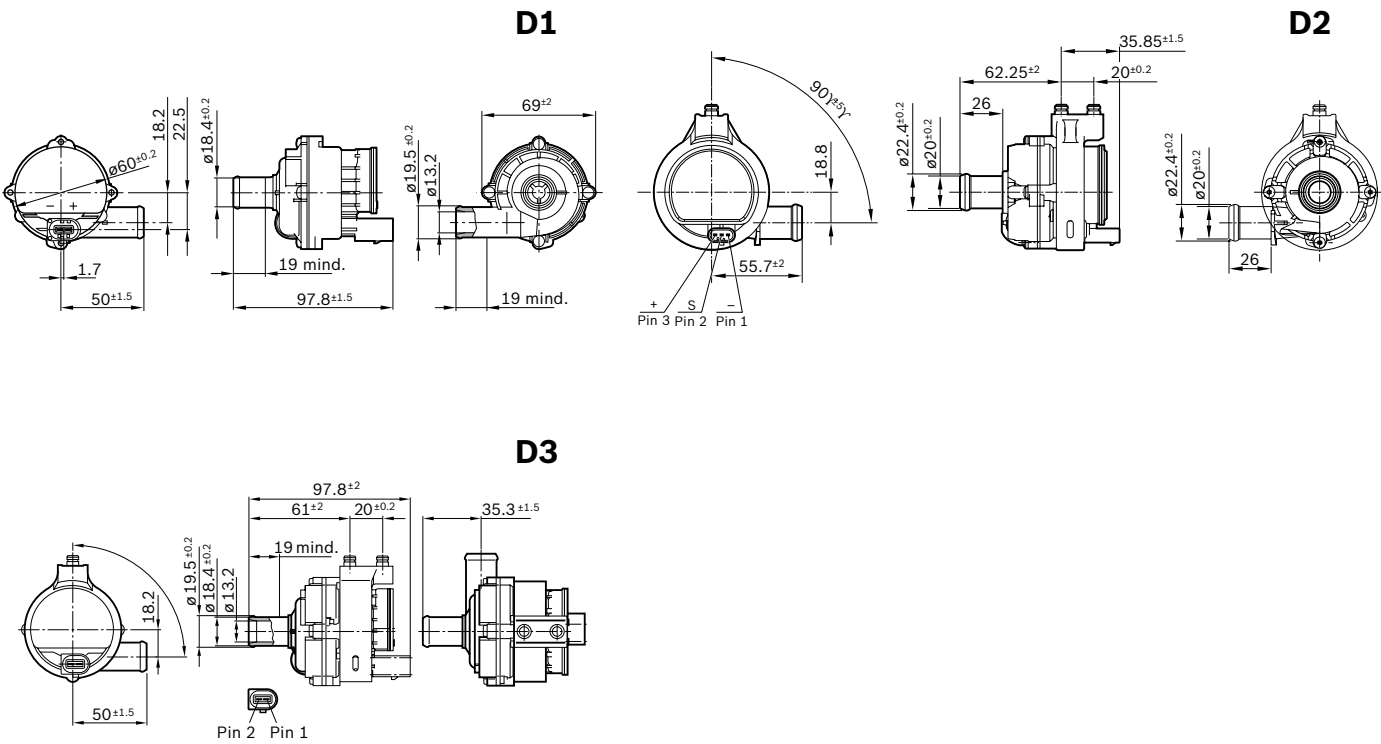


Family features:

- ▶ Silent operation
- ▶ PWM control available
- ▶ Extended temperature range available
- ▶ Extended power range available

	Part number	Nominal pump pressure	Flow rate	Direction of rotation	Control	Dimensional drawing (D)	Connector (C)	Performance curve (P)
		bar	L/hr	CW or CCW				
12 V	0 392 023 232*	0.2	500	CW	PWM	D2	C2	P1
	0 392 023 004	0.1	900	CW	On / off	D1	C1	P2
	0 392 023 117**	0.1	900	CW	On / off	D3	C1	P3

* Extended power range
** Extended temperature range



PAD

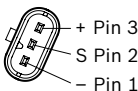
Mating connector (C)



Housing: AMP 1-967412-2

PIN 2 PIN 1

C1

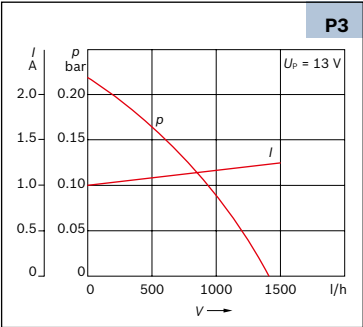
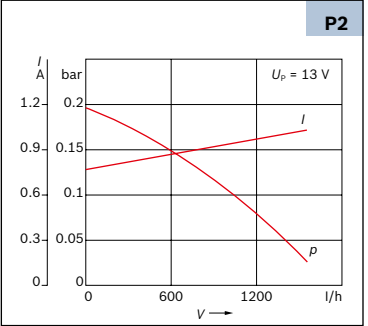
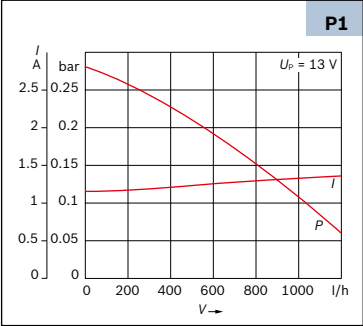


Housing: HIRSCHMAN 805-121-...00

+ Pin 3
S Pin 2
- Pin 1

C2

Performance curve (P)



I.2.- Dipòsit de compensació



DT Spare Parts 2.30046

Depósito sustituye Volvo 3986622



Aplicaciones adecuado para	Volvo		
Marca de producto			10 
GTIN	4057795804708 4057795804692		
Unidades de embalaje (UdE) Peso UdE	1 uds 0,050 kg		

Detalles producto / Resumen

Sustituye	Nº. Ref.	Propiedades	Datos
Volvo	1573868		
Volvo	3985063		
Volvo	3986622		
Volvo	8152288		
Volvo	8158299		

Descargas de producto / Enlaces

Documents	Medios de comunicación
Video The Parts Specialists – Clutch Servo & Cylinder	Ver en YouTube.com

Aplicaciones resumidas adecuado para

Marca de vehículo	Modelo, Motor, Caja de cambios, Eje, Cabina
Volvo Bus 9/11/12/13 (D/DH engine)	B 9 R, B 12 /B /M
Volvo Bus B 10/12 (TD/THD engine)	B 10 B /BLE, B 10 M, B 12
Volvo Bus B 5/6/7/8	B 6 R, B 7 /F /R
Volvo F/FL 6 (-2000), F/FL/FM 7, FLC	FL 6 1985-2000, FL 7 1985-2000, FLC 1997-2000
Volvo F/FL/N/NL 10/12/16	F 10/12/16, FL 10/12, N 10/12
Volvo FL 6 (2000-), FL, FE	FL 6 2000-2006

Otros productos

Descripción del producto			
	Cilindro de embrague replaces FTE: KG28012.0.1	adecuado para Volvo	Unidades de embalaje (UdE) 1 uds
	Nº art. sustituye	2.30002 1628218	

I.3.- Inversor SEVCON



Gen4

**Applications
Reference
Manual**

Document no:

177/52701

Rev. 3.4



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Chapter 1: Introduction

About Gen4 documentation

This version of the manual

This version of the Gen4 manual replaces all previous versions. Sevcon has made every effort to ensure this document is complete and accurate at the time of printing. In accordance with our policy of continuing product improvement, all data in this document is subject to change or correction without prior notice.

Copyright

This manual is copyrighted 2013 by Sevcon. All rights are reserved. This manual may not be copied in whole or in part, nor transferred to any other media or language, without the express written permission of Sevcon.

Scope of this manual

The Application Reference Manual provides important information on configuring lift and traction drive systems using Gen4 controllers as well as details on sizing and selecting system components, options and accessories.

The manual also presents important information about the Gen4 product range.

Related documents

The following documents are available from Sevcon:

- The Object Dictionary providing important information about CANopen communication with Gen4.
- Device Configuration Files (DCF) and Electronic Data Sheets (EDS) for each Gen4 model and revision.

Drawings and units

Orthographic illustrations in this manual are drawn in Third Angle Projection. SI units are used throughout this manual.

Dangers, Warnings, Cautions and Notes

Special attention must be paid to the information presented in Dangers, Warnings, Cautions and Notes when they appear in this manual. Examples of the style and purpose of each are shown below:



A DANGER indicates a hazard with a high level of risk, which if not avoided, will result in death or serious injury.



A WARNING indicates a hazard with a medium level of risk, which if not avoided, could result in death or serious injury.



A CAUTION indicates a hazard with a low level of risk, which if not avoided, could result in a minor or moderate injury.



A NOTE indicates a risk of damage to the process, product or surroundings or other important information that helps you make better use of your Sevcon product.

Product identification label

If you have a customized product your unique identifier will appear at the end of the Type number. When discussing technical issues with Sevcon always have your product's Type number, Part number and Serial number available. Figure 1 shows a typical product identification label.



Figure 1 Product identification label

Technical support

For technical queries and application engineering support on this or any other Sevcon product please contact your nearest Sevcon sales office listed on the inside front cover of this manual. Alternatively you can submit enquiries and find the details of the nearest support centre through the Sevcon website, www.sevcon.com.

Product warranty

Please refer to the terms and conditions of sale or contract under which the Gen4 was purchased for full details of the applicable warranty.



Chapter 2: About the Gen4

Introduction

Sevcon Gen4 controllers are designed to control 3-phase AC induction motors and Permanent Magnet AC (PMAC) motors in battery powered traction and pump applications. A range of models is available to suit a wide number of applications and cooling regimes.

The controller adapts its output current to suit the loading conditions and the ambient in which it is operating (temporarily shutting down if necessary). It will also protect itself if incorrectly wired.

Signal wiring and power connections have been designed to be as simple and straight forward as possible. Analogue and digital signal inputs and outputs are provided for switches, sensors, contactors, hydraulic valves and CAN communications. These electrical signals can be mapped to Gen4's software functions to suit a wide range of traction and pump applications.



NOTE: Given Gen4's mapping versatility it is important to ensure you map your application signals to the correct software functions (see 'Object mapping' on page 6-10). A common configuration is supplied by default which may suit your needs or act as a starting point for further configuration.

Configuration and control of Gen4 is fully customizable using Sevcon's Calibrator handset or DVT, an intuitive Windows based configuration software tool.

A single green LED is provided to give a visual indication of the state of the controller. This signal can be replicated on a dashboard mounted light for example.

Standard features and capabilities

Available options

There are three mechanical package options (Figure 2) for the Gen4 controller at various voltage and current ratings.

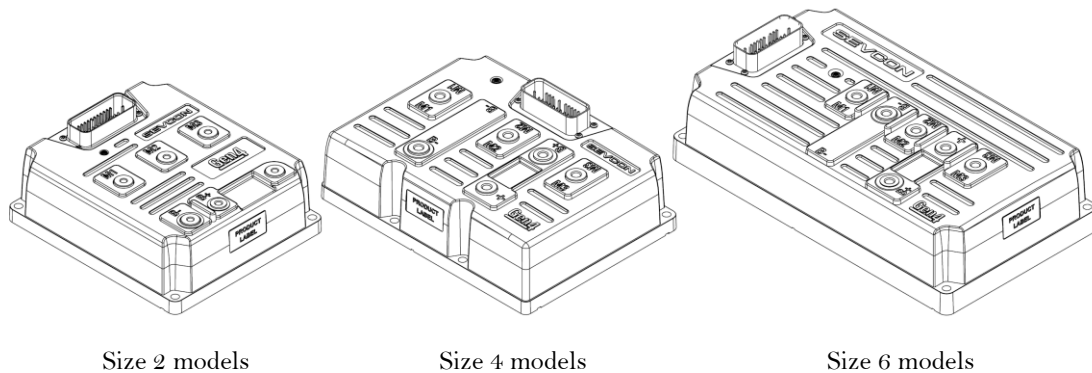


Figure 2 Mechanical package options

Intended use of the Gen4

The Gen4 motor controller can be used in any of these main applications for both pump and traction control:

- Counterbalanced, warehouse and pedestrian fork lift trucks (Classes 1 to 3, FLT1, 2 & 3)

- Airport ground support (AGS), including tow tractors
- Utility vehicles
- Burden carriers
- Sweepers and scrubbers
- Golf buggies/carts
- Neighbourhood electric vehicles (NEV)
- Scooters
- Marine

Available accessories

The following accessories are available from Sevcon

- Loose equipment kit (connectors and pins) for Gen4
- CANopen Calibrator Handset
- SmartView™ display
- ClearView™ display
- Hourmeters
- Contactors
- Fuses
- Drive Wizard - PC based configuration tool
- SCWiz – PC based motor characterisation tool

Overview of a truck drive system

Each traction or pump application requires a number of system components. The main components (excluding control inputs such as throttle and seat switch) are shown in Figure 3. In this example there are two controllers, a traction motor and a hydraulic pump, however all the main components would be the same if controller 2 was also powering a traction motor.

Communication between the controllers is achieved using the CANopen protocol. This protocol also allows Gen4 to communicate with other non-Sevcon, CANopen compliant devices.

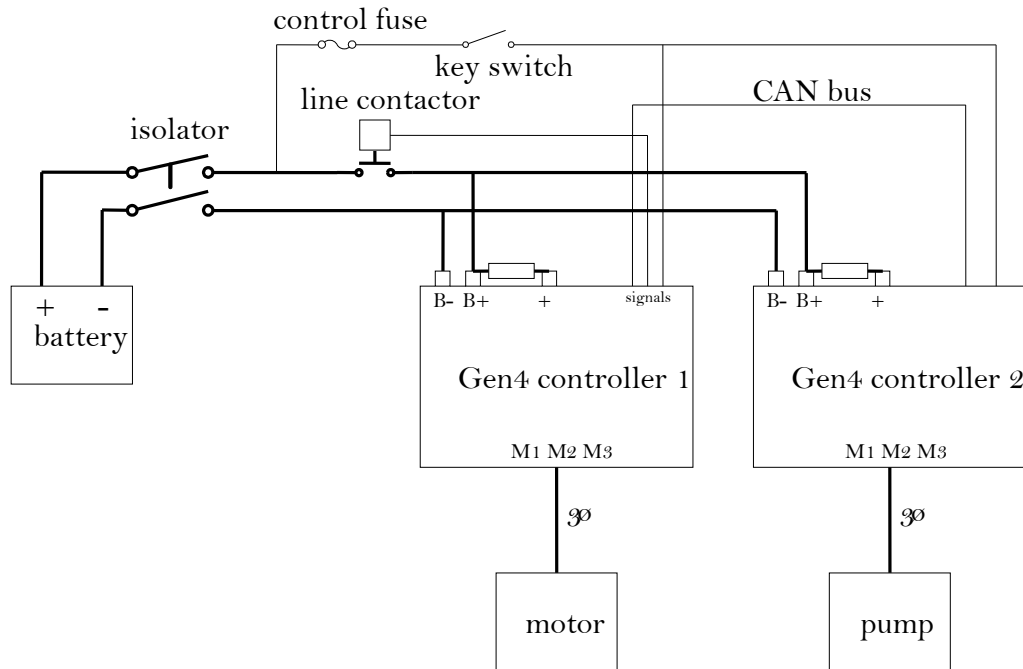


Figure 3 Truck system components

Signal power for the internal control circuits and software is derived from the battery via the control fuse and key switch as shown. No external in-rush current limiting is needed as long as Gen4 is used to control the line contactor and hence the timing of its closure. The software controls the start up sequence in this order:

1. Charge the input capacitors to within a user definable percentage (using 5820_h) of battery voltage (via the key switch signal line).
2. Close line contactor.
3. Generate output to the motor as demanded.

A line input fuse can be mounted on the body of the controller. The 'B+' terminal is a dummy terminal. If the fuse is mounted elsewhere, connections from the battery positive are made to the controller '+' terminal see "On-board fuse mounting" section.

Principles of operation

Functional description

The main function of Gen4 is to control the power to 3-phase squirrel-cage AC induction or PMAC motors in electric vehicles. Four-quadrant control of motor torque and speed (driving and braking torque in the forward and reverse directions) is allowed without the need for directional contactors. Regenerative braking is used to recover kinetic energy which is converted into electrical energy for storage in the battery.

In a traction application control commands are made by the driver using a combination of digital controls (direction, foot switch, seat switch, etc.) and analogue controls (throttle and foot brake). The controller provides all the functions necessary to validate the driver's commands and to profile the demand for speed and torque according to stored parameters.

Throttle inputs can be configured as speed or torque demands with throttle-dependent speed limits: in either case, a torque demand is continually calculated to take account of pre-set limits on the level and rate-of-change of torque. The torque demand is used to calculate current demands; that is, the controller calculates what currents will be required within the motor to generate the required torque.

There are two distinct components of the current, known as the d-q axis currents, which control current flow in the motor. The d-axis current is responsible for producing magnetic flux, but does not by itself produce torque. The q-axis current represents the torque-producing current.



NOTE: *When a vehicle is ready to drive, but no torque is being demanded by the driver, the d-axis or magnetizing current will be present in the motor so that the vehicle will respond immediately to a torque demand. To save energy the magnetizing current is removed if the vehicle is stationary and no torque has been demanded after a set period.*

Measured phase currents and current demands i_d and i_q , the d-q axis currents, are used as part of a closed-loop control system to calculate the necessary voltage demands for each phase of the motor. Voltage demands are then turned into PWM demands for each phase using the Space Vector Modulation (SVM) technique. SVM ensures optimum use of the power semiconductors.

Power conversion section

The power conversion section of Gen4 employs a 6-switch MOSFET bridge operating at an effective frequency of either 16 kHz or 24kHz (equates to a PWM switching frequency of 8kHz or 12kHz and is set via object 5830_h). Excellent electrical and thermal efficiency is achieved by:

- Minimization of thermal resistances.
- Use of the latest MOSFET technology
- Internal thermal protection (if temperatures are excessive, output torque is reduced).
- Overcurrent protection using device characteristics.
- Internal measurement of output current.
- Overvoltage trip in the event of regenerative braking raising battery voltage to unsafe levels.

Dual traction motor

In the case of dual traction motors, there is additional processing of the associated steering signal (from a potentiometer or switches) in order to generate separate torque demands for the left and right motors of the vehicle. This allows the two motors to be operated at different speeds, which greatly assists in turning the vehicle and prevents wheel scrub. After the torque demands have been generated, the operation of each motor control system is as described in the case of a single traction motor.

Pump motors

Pump motor control is similar to traction motor control, although motion is requested using a different combination of switches.

Interfaces

In addition to its motor control functions, Gen4 offers many other functions designed to interface with electric vehicles. A variety of digital and analogue input sources are supported, as listed in 'Signal connections' on page 3-14.

Voltage and current control of up to three contactors or proportional valves is provided by Gen4, and includes built-in freewheeling diodes for spike suppression. All I/O on the Gen4 controller is protected against short-circuit to the battery positive and negative terminals.

Connectivity and interoperability with other system devices (for example another Gen4 controller) using a CANbus and the CANopen protocol is provided. In addition to in-service operation, the CANopen protocol allows the controller to be commissioned using the Calibrator handset or Sevcon's DVT tool. In addition Sevcon's SCWiz PC based tool provides the function to self-characterize most induction motors and hence simplify the process of putting a new motor into service.

For simple visual diagnosis of system faults and to monitor system status, a green LED is provided on the body of the controller. It is continuously lit when there is no fault but flashes a different number of times, in a repeated pattern, when there is a fault. The number of flashes indicates the type of fault (see " on page 1).

Master-slave operation

The Gen4 controller contains both master and slave functions as shown in Figure 4. They operate as follows:

- **Slave function:** implements the CANopen Generic I/O Profile (DS401) and the Drives and Motion Control Profile (DSP402).
- **Master function:** implements vehicle functionality (traction and pump control) and CANopen network management.

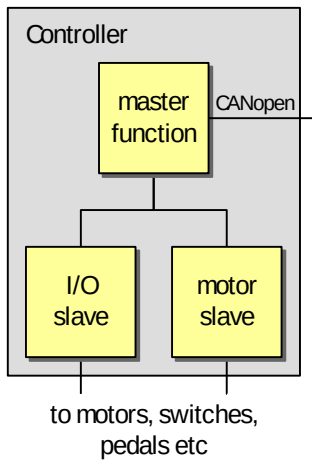


Figure 4 Single controller

Torque mode

In this mode Gen4 maintains the motor torque output at a constant value for a given throttle position. This is similar to DC motors (in particular, series wound DC motors) and provides a driving experience like a car. To prevent excessive speed when the load torque is low, for example when driving down hill, a maximum vehicle speed can be set.

Speed mode



WARNING: Speed mode (or speed control) is not recommended for on-highway vehicles as it can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.

In this mode Gen4 maintains the motor at a constant speed for a given throttle position as long as sufficient torque is available. Speed mode differs from torque mode in that the torque value applied to the motor is calculated by the controller based on the operator's requested speed (determined by throttle position) and the vehicle's actual speed. This mode is useful where accurate speed control is required irrespective of the motor torque.

Safety and protective functions

General



WARNING: Electric vehicles can be dangerous. All testing, fault-finding and adjustment should be done only by competent personnel. The drive wheels should always be off the floor and free to rotate during the following procedures. The vehicle manufacturer's manual should always be consulted before any operation is attempted.



WARNING: The battery must be disconnected before replacing the controller. After the battery has been disconnected, wait 30 seconds for the internal capacitors to discharge before handling the controller.



WARNING: Battery vent caps must be securely in place before connecting the controller to a battery as an arc may occur due to the controller's internal capacitance when it is first connected.



WARNING: If a PMAC motor is being used at the maximum motor speed the peak line to line back emf must not exceed the non-operational voltage limit specified in (add ref to section 4 input voltage table). The controller may be damaged if the back emf exceeds this level.



WARNING: Do not tow vehicles that have PMAC motors, the motors act as generators and may cause high currents to flow in the motor, controller or battery system. If towed at a speed in excess of the vehicle rated speed the voltage generated by the motor may damage the controller or battery.



WARNING: When a PMAC motor is acting as a generator, for example when braking or driving down hill, the short circuit current must not exceed the controller current rating. The short circuit current should be calculated for all vehicle speeds and must be less than the controller current rating. If the current is greater than the controller current rating then measures must be taken to protect the controller from the motor acting as a generator. Possible measures include adding a disconnect switch between the motor and controller on at least 2 out of the 3 phases, or adding fuses in each phase. Contact your local Sevcon representative for further information and guidance.



WARNING: The Gen4 controller **MUST** be isolated from a battery charger if powered on and connected to the system. Failure to do so may result in the Gen4 controller being damaged if exposed to voltages in excess of its rating.



CAUTION: Ensure that contactors with blow-out magnets are wired with the correct polarity to their power terminals as indicated by the + sign on the top moulding.



NOTE: Do not attempt to open the controller as there are no serviceable components. Opening the controller will invalidate the warranty.



NOTE: Do not mechanically modify the controller in any way as unexpected damage may occur. Mechanically modifying the controller will invalidate the warranty.



NOTE: Use cables of the appropriate rating and fuse them according to the applicable national vehicle and electrical codes.



NOTE: Do not use any other form of fasteners other than those supplied with the controller without contacting Sevcon for advice. Use of inappropriate fasteners or torques could damage the controller.



NOTE: Where appropriate use of a suitable line contactor should be considered.



CAUTION: Electric vehicles are subject to national and international standards of construction and operation which must be observed. It is the responsibility of the vehicle manufacturer to identify the correct standards and ensure that it's vehicle meets these standards. As a major electrical control component, the role of the Gen4 motor controller should be carefully considered and relevant safety precautions taken. The Gen4 has several features which can be configured to help the system integrator to meet vehicle safety standards. Sevcon accepts no responsibility for incorrect application of its products.

On-Highway Vehicles

General

This applies to all on-highway vehicles, such as motorcycles and cars.

The installer must ensure an appropriate controller configuration is set to ensure that the vehicle remains in a safe condition, even in the event of a fault.

Inputs

Always ensure drive inputs have adequate protection. Inputs such as the throttle should have appropriate wire-off detection configured. Single point failures should never cause an unsafe condition.

Gen4 supports wire-off detection on all analogue inputs, and it contains various safety interlocks to prevent unexpected drive due to a wiring fault (e.g. FS1 switch, dual throttle inputs).

Sevcon recommends that the following features are enabled for all applications:

- Wire-off detection on analogue inputs, particularly the throttle.
- A valid analogue input voltage which is more than 0.5V from wire off limits
- Appropriate safety interlocks to ensure a single point of failure cannot cause an unsafe driving condition.

Refer to sections Analogue inputs (page 6-13) and Vehicle performance configuration (page 6-16) for more information.

Notes on Features

The Gen4 is a generic motor controller intended for use in both highway AND non-highway industrial applications. Not all of the controller features are suitable for an on-highway vehicle. Some features, if activated, could lead to the controller forcing a motor condition that is not directly requested by the throttle, such as undesired drive or harsher than expected braking.

Sevcon recommends that the following features are DISABLED for any on-highway applications:

- Proportional Speed Limit¹.
- Hill Hold¹.
- Controlled Roll-Off¹.
- Speed mode (or speed control)¹.
- Electromechanical Brake output¹.
- Inching².
- Belly switch².
- Unused Driveability Profiles³.

NOTES:

1. These features can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.
2. These features can cause unexpected drive if accidentally activated.
3. This feature can cause a sudden reduction in maximum speed if a driveability profile is accidentally activated and is incorrectly configured.

In addition, the following features must be configured correctly

- Steering map, if used to reduce maximum outer wheel speed with steering angle.

Fault detection and handling

There are five categories of faults as described in Table 1. For a detailed list of faults see Table 7 on page 7-9.

Fault severity	Controller latched off until	Consequences
Return to base (RTB)	Cleared by Sevcon personnel	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Very severe (VS)	Cleared by authorized service personnel	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Severe (S)	Keyswitch recycled (turned off then on)	Immediate shut down of the system with the exception of the power steering if needed. Power is removed to nearly all external components.
Drive-inhibit (DI)	User deselects all drive switches before reselecting	Neutral brakes or coasts the traction motor(s) to a stop. The fault prevents the operator initiating drive, but does not inhibit braking function, in particular, controlled roll-off braking.
Information (I)	Not latched	Information faults do not require immediate action, although some cutback of power or speed may occur.

Table 1 Fault categories



Chapter 3: Installation

Mounting Gen4

Location

The mounting location for the controller should be chosen with care taking into account the following considerations:-

- Do not mount the controller on the outside of a vehicle where it would be assessable to unauthorized personnel (for the purposes of UL, the controller enclosure is not considered to be the 'ultimate enclosure' and should be sited within another enclosure).
- Do not mount the controller where it may be susceptible to damage due to minor collisions, impact from road debris or chemical contamination (see 'Protection from chemical contamination' below).
- Although the controller has a high degree of ingress protection the electrical power terminals do not. Avoid mounting the controller in locations where it may be submerged in water or subjected to long term exposure to jets of water or exposed to potentially conductive contamination and or debris.
- Take note of the thermal and EMC considerations as explained later in this section of the manual.

Protection from chemical contamination

The Polycarbonate cover of Gen4 controllers are designed for good all-round protection of the electronics. However the controller should be sited so it cannot come into contact with significant quantities of industrial chemicals. The following have shown to be damaging to the cover:-

- Most esters (contained in some 'bio' hydraulic fluid such as Shell Naturelle HF-E)
- Most industrial alcohols (contained in some contact grease such as Electrolube CG53A)



Electrical terminals on the controller present an electric shock hazard. High currents can also present a burn hazard. You must ensure that the electrical terminals of the controller are protected against access by unauthorized personnel.

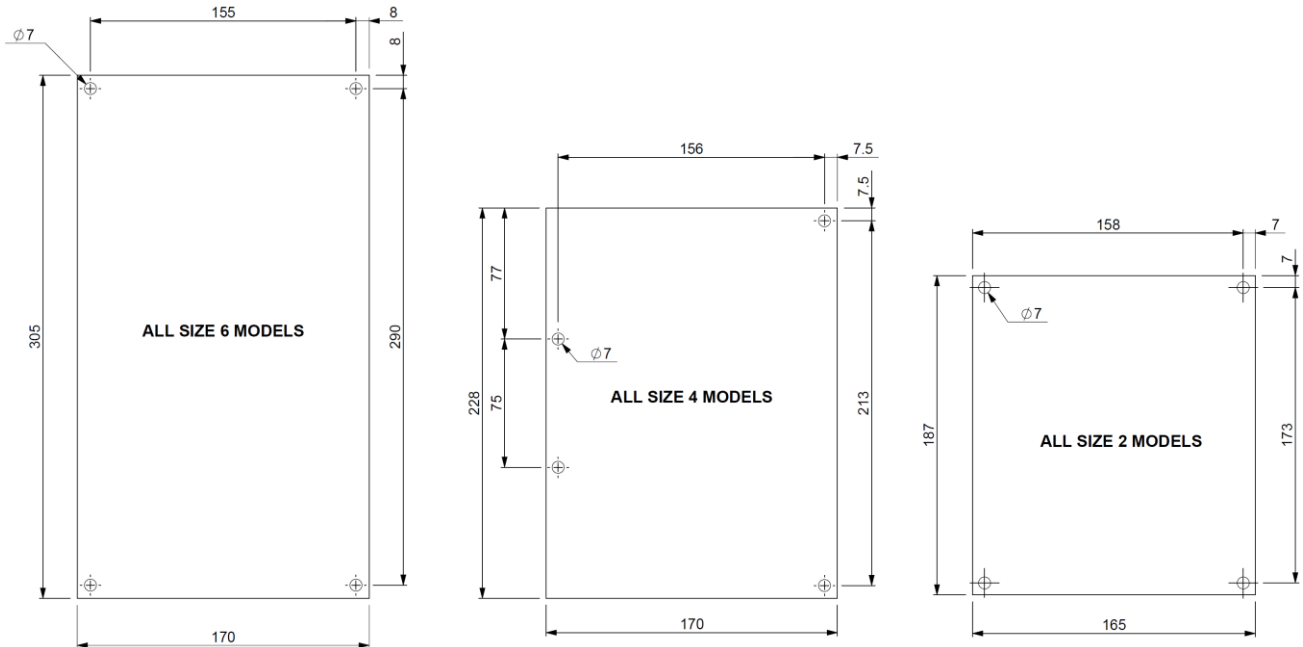
Orientation

The controller can be mounted in any orientation.

Clearance for LED access

If you want an operator of your vehicle to be able to view the onboard LED, it is advisable to consider the line of sight to the LED at this time.

Mounting hole pattern



Minimum flatness of mounting surfaces: 0.2mm



Failure to comply with this flatness specification can cause deformation and damage to the product.

Equipment required:

- 4 x M6 socket cap head bolts, nuts and spring washers. Bolts need to be long enough to pass through 12 or 20 mm of Gen4 base plate (depending on controller type) and your mounting surface thickness.
- T hand-socket wrench or Allen key
- Thermal grease

Recommended torque setting: 10 Nm $\pm$ 2 Nm

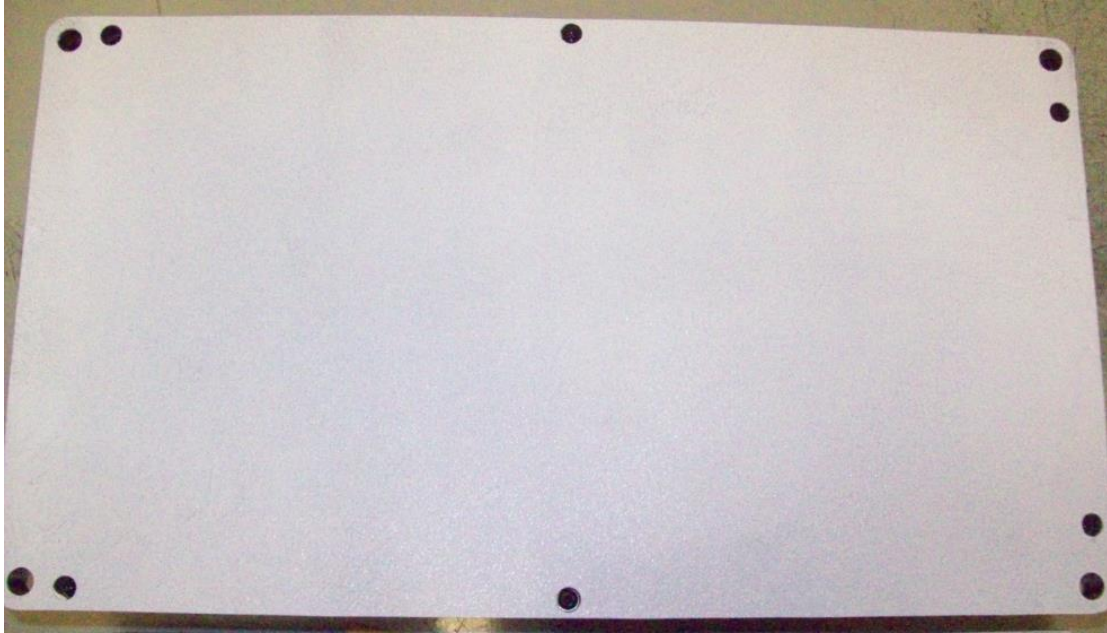
Thermal grease application

It is recommended that a thermal interface material or thermal paste is used between controller and mounting face. Spread a layer of thermal grease (such as Dow Corning 340) as described below, before bolting to your mounting surface.

- Thermal compound should be applied with a small soft paint roller to ensure an even spread of thermal compound.
- The most appropriate thickness will look white but with a greyish colour still showing through from the controller base or vehicle mounting face material. *It should be noted that too little thermal compound will not fill all gaps left the flatness mismatch of the contact surfaces, but too much thermal compound may prevent the gap from closing up when tightening.*
- It is recommended that thermal compound is applied to both the Controller base and the vehicle/panel/boost plate surfaces.
- The controller should then be placed onto the vehicle/panel/heatsink.

- It is important that the two surfaces are then rubbed together in order to help transfer the thermal compound between the two surface.
- The entire assembly is then bolted together at all mounting holes.

An example of a good thermal compound spreading can be seen in the photo below:-



How effective the spreading technique is can be checked by removing the controller and inspecting the paste residue left on the mounting faces. On a well applied paste application, the controller will be difficult to remove and a rippled surface will be left on the paste surface as shown (magnified) below:-



Cooling requirements

To ensure you get the maximum performance from your Gen4 controller:

- Keep it away from other heat generating devices on the vehicle
- Maintain its ambient operating temperature below the specified maximum (see 'Operating environment' on page 4-6)

To obtain maximum performance it is important to keep Gen4's base plate within the operating temperature range. To do this, mount Gen4 to a surface capable of conducting away the waste heat. Finned heatsinks are considerably better at doing this than flat plates. For example, a finned heatsink used at Sevcon has a footprint of 330mm x 200mm and thermal resistance of 0.3°C/W, whereas a plate approximately 420 mm x 270 mm x 9.5 mm will give approximately the same thermal performance (0.3°C/W). Ratings achievable with conductive heatsinking are shown in Figure 10 on page 4-3.

In Sevcon's experience the thermal resistance of the stand-alone Gen4 packages and achievable thermal resistances to ambient using conductive heatsinking are as shown in the table below. These are given as a guide: actual performance in an application must be verified.

Gen4 Size	Thermal resistance without additional heatsinking (°C/W)	Thermal resistance achievable with finned heatsink (°C/W)	Dimension of finned heatsink (W x L)
Size 2	0.7	0.5	250mm x 180mm
Size 4	0.6	0.3	330mm x 200mm
Size 6	0.5	0.2	330mm x 280mm

Cooling performance is affected by mounting surface flatness and the thermal transfer between mounting surface and Gen4. Ensure your application of thermal grease is effective and your mounting surface meets the flatness figures as described in the 'Mounting' section above.

EMC guidelines

The following guidelines are intended to help vehicle manufacturers to meet the requirements for Electromagnetic Compatibility. Any high speed switch is capable of generating harmonics at frequencies that are many multiples of its basic operating frequency. It is the objective of a good installation to minimise, contain or absorb the resultant emissions. All wiring is capable of acting as a receiving or transmitting antenna. Arrange wiring to take maximum advantage of the structural metal work inherent in most vehicles. Link vehicle metalwork with conductive braids.



CAUTION: It is the responsibility of the vehicle manufacturer to ensure compliance of the vehicle to all applicable EMC standards.

General measures

Power cables

Route all cable within the vehicle framework and keep as low in the structure as is practical - a cable run within a main chassis member is better screened from the environment than one routed through or adjacent to an overhead guard. Keep cables short to minimize emitting and receiving surfaces. Shielding by the structure may not always be sufficient - cables run through metal shrouds may be required to contain emissions.

Parallel runs of cables in common circuits can serve to cancel emissions - the battery positive and negative cables following similar paths is an example. Tie all cables into a fixed layout and do not deviate from the approved layout in production vehicles. A re-routed battery cable could negate any approvals obtained.

Keep power cables at least 300mm from signal cables.

Signal cables

Keep all wiring harnesses short and route wiring close to vehicle metalwork. Keep all signal wires clear of power cables and consider the use of screened cable. Keep control wiring clear of power cables when it carries analogue information - for example, accelerator wiring. Tie all wiring securely and ensure it always follows the same layout.

Controller

Thermal and EMC requirements tend to be in opposition. Additional insulation between the controller assembly and the vehicle frame work reduces capacitive coupling and hence emissions but tends to reduce thermal ratings. Establish a working balance by experiment. Document the complete installation, in detail, and faithfully reproduce on it all production vehicles. Before making changes, consider the effect on EMC compliance. A simple cost reduction change could have a significant negative effect on the EMC compliance of a vehicle.

Measures required for specific signals

Battery power cables

Cables should be as short as possible. Minimise the loop area of the B+ and B- wiring. A common mode ferrite choke may be required.

Motor power cables

Cables should be as short as possible. Minimise the loop area of the M1 M2 M3 wiring. A common mode ferrite choke may be required

Motor encoder connection

The encoder cable must be as short as possible. A multi-core screened cable should be used. The inner cores should be used for the encoder supply and encoder ground and the AB or UVW signals. The cable screen should be connected to the B- terminal. Ensure that the screen does not connect the motor chassis back to the B- terminal to avoid motor power cable current returning through the encoder cable screen.

CAN bus

A multi-core screened cable should be used. The inner cores must be twisted pairs. One twisted pair should be used for CANH and CANL. The other twisted pair should be used for CAN supply. Ensure that there is a common ground connection for all nodes on the CAN bus. If there is a node on the bus which is galvanically isolated from the Gen4 controller then the CAN ground on this node must be connected to the Gen4 controller B-. The cable screen should be connected to the B- terminal at the Gen4 controller

Keyswitch

The keywire should be as short as possible. Minimise the loop area of the loop formed by the traction battery, keyswitch, keyswitch supply on the Gen4, and the B- return wire to the battery. Do not connect additional battery loads to the keyswitch wire.

Contactor drivers

Minimise the loop area formed by the contactor driver output and the contactor supply +. Use of twisted pair will reduce emissions. Use of screened cable with the screen connected to B- will further reduce emissions.

Throttle input

The throttle input is referenced to the controller B- connection, it is therefore very important that the throttle ground connection goes directly to the B- terminal on the controller. Ensure that there is no common ground path for the throttle with the battery power connection or any other power or switching loads on the vehicle. Screened cable for the throttle supply and wiper may be required for higher levels of immunity, the screen should be connected to B-.

Additional measures

Where it has not been possible to meet the required EMC specifications using the standard measures listed above it may be necessary to use one or more of the following measures:-

- Use of screened cable for all control connections
- Use of a Faraday cage around the controller and motor
- Addition of an LC filter on the keyswitch supply
- Battery cable should be screened with the screen connected to the battery chassis and controller chassis.
- Motor cable should be screened with the screen connected to the motor chassis and controller chassis.
- A common mode ferrite choke for all the small signal connections will attenuate common mode emissions

Problems to avoid



EMC is a complex subject and on a typical vehicle there are many potential radiators and receivers. Measures taken on a vehicle to improve EMC can unintentionally make the situation worse.

- Beware of devices that are connected to the small signal wiring which have a significant ($>10\text{nF}$) capacitance to vehicle chassis. The capacitance to vehicle chassis can cause currents to flow out of the Gen4 controller along the signal wiring to the device and back to the controller via the vehicle chassis.
- When using screened cable beware of generating ground loops in which currents may be induced or which may cause noise currents to flow via unintended paths.

Connecting power cables

See also 'EMC guidelines' on page 3-6.

Battery and motor connections



CAUTION: Cables carrying high AC currents are subject to alternating forces and may require support in the cable harness to avoid long-term fatigue.

Equipment required for **size 4 or 6 models**:

- Cables sized to suit the controller and application (see table below)
- M8 crimp ring lugs
- Crimp tool
- Suitable torque wrench and socket

Torque setting: 11 Nm $\pm$ 2 Nm

Equipment required for **size 2 models**:

- Cables sized to suit the controller and application (see table below)
- M6 crimp ring lugs
- Crimp tool
- Suitable torque wrench and socket

Torque setting: 7 Nm $\pm$ 1 Nm

Consider cable routing before making connections.

- Keep cable runs short
- Minimize current loops by keeping positive and negative cables as close together as possible.
- Route cables away from the LED if you intend to make this visible under normal operating conditions.

Connect your power cables using the bolts supplied. **USE THE CORRECT TORQUE.** They are sized to clamp one ring lug thickness. Use a longer bolt if you are fastening more than one ring lug. You need thread engagement of at least 10 mm and the maximum penetration is 15 mm.



CAUTION: If you use a bolt which is too long, damage to the terminal and overheating of the connection may occur. If you use a bolt which is too short and there isn't enough thread engagement you may damage the threads.



CAUTION: 'Bottoming out' a screw in the terminal marked 'B+' will damage the cover leading to liquid ingress

Cable sizes



CAUTION: When deciding on power cable diameter, consideration must be given to cable length, grouping of cables, the maximum allowable temperature rise and the temperature rating of the chosen cable.

The following table gives guidance on the cable size needed for various currents in welding cable, not grouped with other cables, in 25°C ambient with 60°C temperature rise on the cable surface.

Gen4 average (rms) current	Cable sizes	
	metric	US (approx equivalent)
180 A	25 mm ²	4 AWG
225 A	35 mm ²	2 AWG
280 A	50 mm ²	1 AWG
350 A	70 mm ²	2/0 AWG

On-board fuse mounting

You can mount your main input protection fuse directly onto the controller body as shown below . Select the appropriate fuse from the table below. Connect the battery positive cable to the B+ terminal. Connecting to the end marked '+' (or un-named in the case of size 2) will leave your installation without a fuse unless located elsewhere in the system. The B+ terminal is a dummy terminal to allow fuse connection only and has no internal connection.

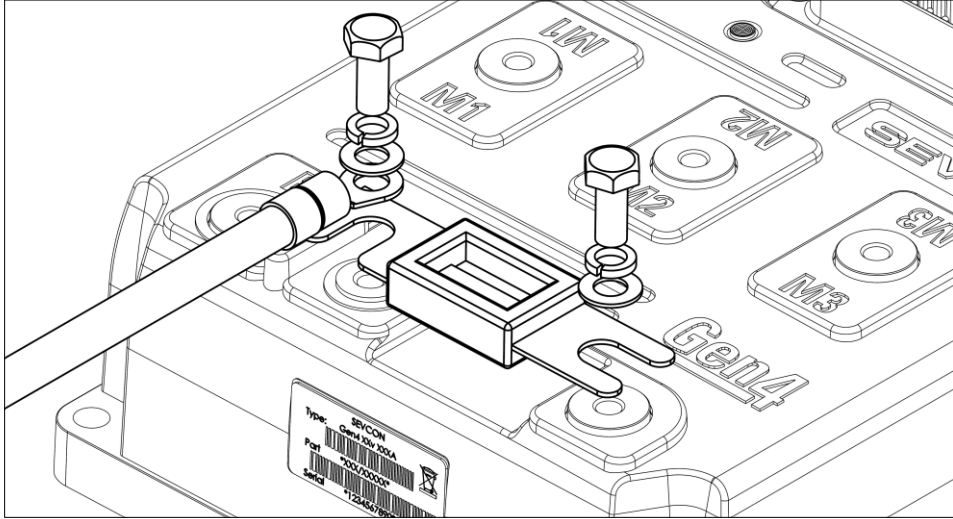


Figure 5 On-board fuse mounting – size 2 models

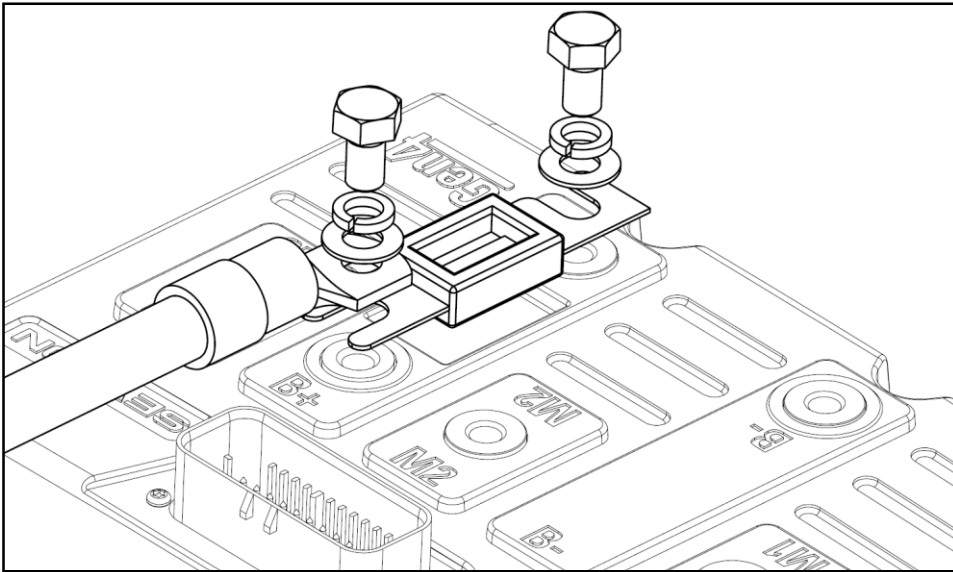


Figure 6 On-board fuse mounting – size 4 models

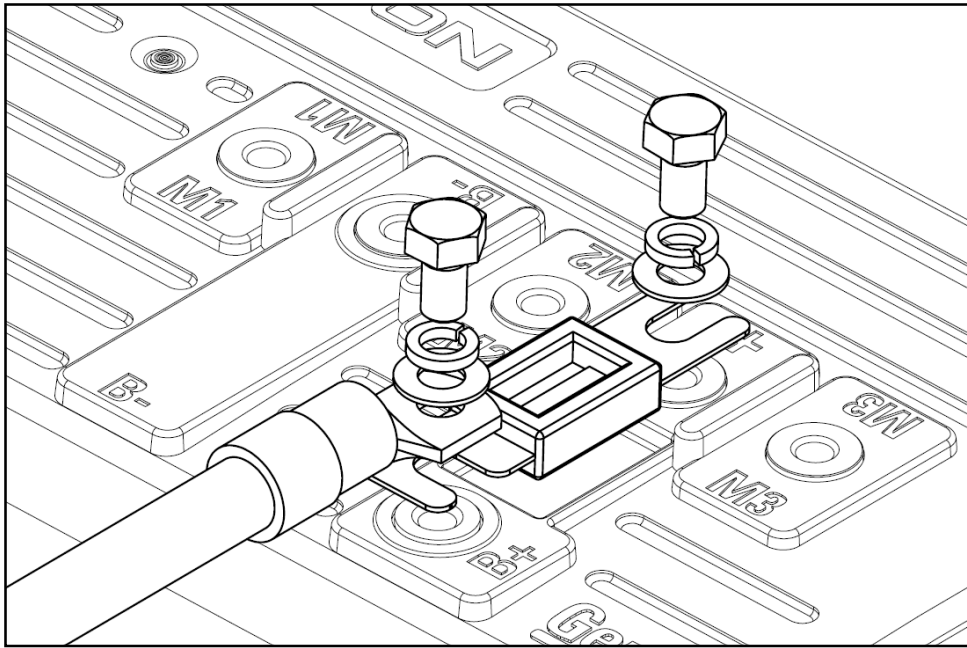


Figure 7 On-board fuse mounting – size 6 models

Fuse rating and selection

On-board fuse dimensions are in accordance with DIN43560/1

Gen4 input voltage	Gen4 peak output current	Fuse rating	Sevcon part number
24V/36 V	300 A	325 A	858/32044
	450 A	425 A	858/81990
	650 A	750 A	858/33021
36V/48 V	275 A	250 A	858/29043
	450 A	425 A	858/81990
	650 A	750 A	858/33021
72V/80 V	180 A	200 A	858/83339
	350 A	355 A	858/32045
	550 A	500 A	858/32043
96V/110V	300A	355A	858/32045

Signal wiring

Assemble your wiring harness using wire of the sizes recommended below and the Sevcon loose connector kit (P/N 661/27091). The use of twisted pair and in some cases twisted-screened cables is recommended for the speed sensor and CANbus wiring.

To make a connection, gently push the connector housing onto the appropriate mating half on the Gen4. Never force a connector. Connectors are keyed to prevent incorrect insertion.

Twisted, shielded wire is recommended. Keep signals away from power cables to avoid interference. See also 'EMC guidelines' on page 3-6.

Signal wire sizes

Use wire between 0.5 mm² (20 AWG) and 1.5 mm² (16 AWG) for all signal wiring. Single twisted pair cable is readily available in 0.5 mm² (20 AWG).

CANbus termination

See also 'EMC guidelines' on page 3-6.

If your system has more than one CAN node, connect the nodes in a 'daisy chain' arrangement (Figure 8) and terminate the connections of the two end nodes with a 120 Ω resistor. If the end node is a Gen4, link pins 2 and 24 on the customer connector, a 120 Ω resistor is built into the controller. If you have a single node system the termination resistor should be connected so that the bus operates correctly when configuration tools are used.

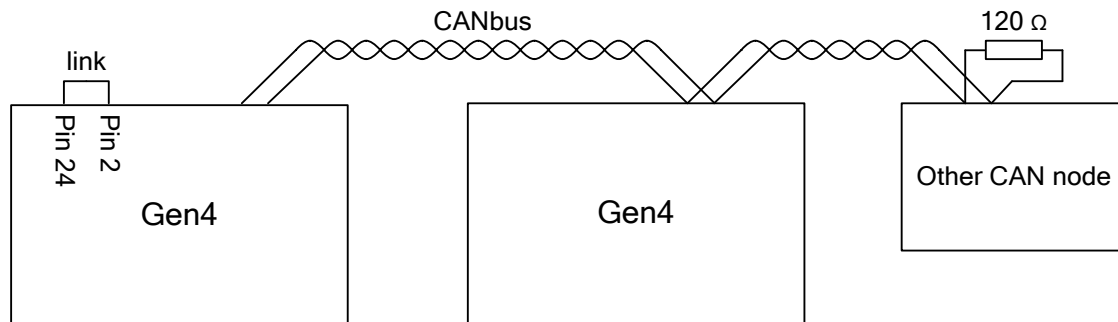


Figure 8 CAN node termination

Signal connections



CAUTION: Do not use contactors which have built in 'economiser' circuits, the internal circuits are not compatible with the controller and may cause malfunction or damage. The same power reduction can be achieved with a standard coil by using the configurable pull-in and hold voltage settings.

Signal connections are made to Gen4 via a 35 way AMPSeal connector.

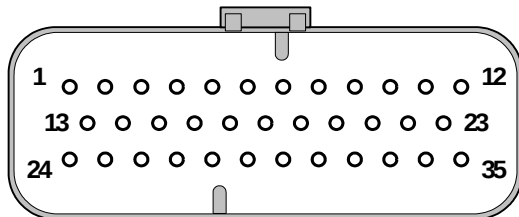


Figure 9 Customer Connector

Pins are protected against short-circuits to the battery positive or negative terminals.



NOTE: Please see *Tyco Application Specification 114-16016* and *Instruction sheet 408-3229* before assembling the AMPseal connector.

Inserting contacts into connector housing pierces the sealing diaphragm to make the seal to the wire. To maintain IP rating, unused positions must be sealed with appropriate hardware (available from Tyco) if a contact is inserted and then subsequently removed. It is recommended that Tyco strain relief 776463-1 is used (especially for applications where the connector is less than fully populated) to reduce change of ingress through connector body.

Starting in 2014, function of pin 10 of the Gen4 Size 4 will be changed from a 3rd key switch input to that of a fixed 5V, 100mA output power supply.

Before connecting pin 10 of the Gen4 Size 4 to your system wiring, check the function of the part that you have.

Generic parts with the new 5V output can be identified by it's new part number:

Old part 634A44101 becomes new part 634A44103 with 5V output

634A44201 will change to 634A44205

634A44203 will change to 634A44206

634A44301 will change to 634A44305

634A83101 will change to 634A44105

634A83201 will change to 634A44205

634A83203 will change to 634A83207

634A83301 will change to 634A83305



For enquiries about status of any other Gen4 Size 4 part numbers, contact your local Sevcon representative.

All Size 2 parts already offer pin 10 as 5V output

All Size 6 parts continue to offer pin 10 as a 3rd key switch input only

Installation

Pin	Name	Type	What to connect	Maximum rating	Comment
1	Key switch in	Power	From 'dead' side of key switch via suitable fuse	7A (Total of all contactor output currents plus 1.0A)	This input supplies power from the battery for all the logic circuits. The unit cannot operate without "Key switch in" supply. Pins 1 and 6 (and 10 on Size 4 & 6 models) are connected together internally and can be used individually or in parallel.
2	CAN termination	Comms	To terminate a Gen4 CAN node link pin 2 to pin 24. This connects a 120Ω termination resistor, mounted inside the controller, across the CANbus.		Make the connection only if the Gen4 is physically at the end of the CANbus network (see 'CANbus termination' on page 3-13).
3	Contactor out 1	Out	To the switched low side of contactor or valve coil. Contactor out 1 usually drives the line contactor. (DO NOT USE WITH CAPACITIVE LOADS).	2.0A per output, subject to a limit of 6A for the total of all the outputs. $V = V_b$	This output provides low side voltage or current control to the load depending on configuration. The output goes low or is chopped to activate the load. It goes high (to V_b) to de-activate the load.
4	Output 1 Supply +	Power	To one end (high side) of a contactor to be controlled by Contactor out 1	2A	This output feeds power to the contactors. The output is at battery voltage.
5	Encoder "U"	Digital pulse	Position encoder	10V	Use in conjunction with "V" and "W" for PMAC motors.
6	Key-switch in	Power	From 'dead' side of key switch via suitable fuse	7A (Total of all contactor output currents plus 1.0A)	This input supplies power from the battery for all the logic circuits. The unit cannot operate without "Key switch in" supply. Pins 1 and 6 (and 10 on Size 4 & 6 models) are connected together internally and can be used individually or in parallel.

Pin	Name	Type	What to connect	Maximum rating	Comment
7	Contactor out 2	Out	To the switched low side of contactor or valve coil. (DO NOT USE WITH CAPACITIVE LOADS).	2.0A per output, subject to a limit of 6A for the total of all the outputs. $V = V_b$	This output provides low side voltage or current control to the load depending on configuration. The output goes low or is chopped to activate the load. It goes high (to V_b) to de-activate the load.
8	Output 2 Supply +	Power	To one end (high side) of a contactor to be controlled by Contactor out 2	2A	This output feeds power to the contactors. The output is at battery voltage.
9	Digital Input 6	Digital	From digital switch input 6.	Type B $V = V_b$ See Table 3	See note to Table 3
10	Size 2 and later size 4 models: 5V supply output	Power	5V supply output	$I = 100\text{mA}$. $V = 5\text{V}$	This output can be used to power transducers or similar devices at 5V and up to 100mA.
	Size 6 models: Key switch input	Power	From 'dead' side of key switch via suitable fuse	7A (Total of all contactor output currents plus 1.0A)	This input supplies power from the battery for all the logic circuits. The unit cannot operate without "Key switch in" supply. Pins 1, 6 and 10 are connected together internally and can be used individually or in parallel.
11	Contactor out 3	Out	To the switched low side of contactor or valve coil. (DO NOT USE WITH CAPACITIVE LOADS).	2.0A per output, subject to a limit of 6A for the total of all the outputs. $V = V_b$	This output provides low side voltage or current control to the load depending on configuration. The output goes low or is chopped to activate the load. It goes high (to V_b) to de-activate the load.
12	Output 3 Supply +	Power	To one end (high side) of a contactor to be controlled by Contactor out 3	2A	This output feeds power to the contactors. The output is at battery voltage.
13	CAN High	Comms	CANbus High signal	$V = 5\text{V}$	Maximum bus speed 1 Mbits/sec Alternative connection to pin 16

Installation

Pin	Name	Type	What to connect	Maximum rating	Comment
14	Encoder A Input	Digital pulse	From the speed encoder A channel	I = 25 mA (internally limited) V = 8 V (for current-source encoders) V = 2.5V or 5V (for open-collector encoders)	Check the speed encoder signals have the correct number of pulses per revolution. Check Gen4 is configured for the type of encoder you are using (open-collector or current-source)
15	Encoder power supply -	Power	To the negative supply input (0 V) of the speed encoder	I = 100 mA V = 0.5 V	We recommend the use of screened cable for the encoder wiring. Connect the screen to this pin only along with the negative supply.
16	CAN High	Comms	CANbus High signal	V = 5 V	Maximum bus speed 1 Mbits/s. Alternative connection to pin 13
17	Encoder “V”	Digital pulse	Position encoder	10V	Use in conjunction with “U” and “W” for PMAC motors.
18	Digital Input 1	Digital	From digital switch input 1. In a basic configuration this is usually the forward switch.	Type A V = V _b See Table 3	See note to Table 3
19	Digital Input 3	Digital	From digital switch input 3. In a basic configuration this is usually the foot switch (FS1).	Type A V = V _b See Table 3	See note to Table 3
20	Digital Input 5	Digital	From digital switch input 5.	Type B V = V _b See Table 3	See note to Table 3
21	Digital Input 8	Digital	From digital switch input 8.	Type B V = V _b See Table 3	See note to Table 3. Alternative: Sin input from Sin-Cos analogue encoder, only if specified in h/w build

Pin	Name	Type	What to connect	Maximum rating	Comment
22	Pot. 1 wiper in	Analogue	From potentiometer 1 wiper.	V = 9.5 V Z _{in} = 82 kΩ (24V/36V and 36V/48V models) Z _{in} = 100 kΩ (24V/36V and 36V/48V models)	Suitable for potentiometers in the range 500 Ω to 10 kΩ, or voltage-output device (e.g. Sevcon linear accelerator) 0 to 5 V or 0 to 10 V. Ensure that at least 0.5V margin exists between the maximum valid throttle and the wire-off threshold
23	Pot. 2 wiper in	Analogue	From potentiometer 2 wiper.	V = 9.5 V Z _{in} = 82 kΩ (24V/36V and 36V/48V models) Z _{in} = 100 kΩ (24V/36V and 36V/48V models)	Suitable for potentiometers in the range 500 Ω to 10 kΩ, or voltage-output device (e.g. Sevcon linear accelerator) 0 to 5 V or 0 to 10 V. Ensure that at least 0.5V margin exists between the maximum valid throttle and the wire-off threshold
24	CAN Low	Comms	CANbus Low signal	V = 5 V	Maximum bus speed 1 Mbits/s. Alternative connection to pin 27
25	Encoder B Input	Digital pulse	From the speed encoder B channel	I = 25 mA (internally limited) V = 8 V (for current-source encoders) V = 2.5V or 5V (for open-collector encoders)	
26	Encoder power supply +	Power	To the positive supply input of the speed encoder	I = 100 mA V = 5V or 10V software selectable	Check the speed encoder you use is compatible with Gen4. See page 6-12 for configuration details.
27	CAN Low	Comms	CANbus Low signal	V = 5 V	Maximum bus speed 1 Mbits/s. Alternative connection to pin 24
28	CAN power supply +	Power	To CAN device requiring external supply	V = 24 V I = 100 mA	Check that the CAN device power supply requirement is suitable for Gen4.

Installation

Pin	Name	Type	What to connect	Maximum rating	Comment
29	Encoder “W”	Digital pulse	Position encoder	10V	Use in conjunction with “U” and “V” for PMAC motors.
30	Digital Input 2	Digital	From digital switch input 2. In a basic configuration this is usually the reverse switch.	Type A V = V _b See Table 3	See note to Table 3
31	Digital Input 4	Digital	From digital switch input 4. In a basic configuration this is usually the seat switch.	Type A V = V _b See Table 3	See note to Table 3
32	Digital Input 7	Digital	From digital switch input 7.	Type B V = V _b See Table 3	See note to Table 3
33	Motor thermistor in	Analogue	From a thermistor device mounted inside the motor	V = 5V (via 2.2 kΩ internal pull-up resistor)	A NTC thermistor having a resistance of approximately 2.2 kΩ at 100°C will give best sensitivity. Connect the other lead of the thermistor to the B- terminal of the Gen4 controller. Can also be used as an additional analogue input
34	Pot. 1 power supply +	Power	Supply feed to potentiometer 1. In a basic configuration this is the throttle.	V = 10 V I = 15 mA	Suitable for potentiometers in the range 500 Ω to 10 kΩ
35	Pot. 2 power supply +	Power	Supply feed to potentiometer 2.	V = 10 V I = 15 mA	Suitable for potentiometers in the range 500 Ω to 10 kΩ. Alternative: Cos input from Sin-Cos analogue encoder, only if specified in h/w build

Table 2 Connector A pin out and wiring information

Controller voltage	Digital Input Type	Impedance to B+	Impedance to B-
24V/36V	A	9k	9k
	B	13k	9k
36V/48V	A	16k	16k
	B	24k	16k

Controller voltage	Digital Input Type	Impedance to B+	Impedance to B-
72V/80V	A	44k	44k
	B	66k	44k
96V/110V	A	66k	66k
	B	100k	66k

Table 3: Impedance at Digital Input Pins

Note to Table 3:

Configure the digital input switches as active-high (switched to Vb) or active-low (switched to battery negative). Configuration applies to all digital input switches (1 to 8) i.e. they are all active-high or all active-low. See section Digital inputs (page 6-13) for more details.

When a switch is open the digital input pin sits at approximately $0.5 \times V_b$ (type 'A') or $0.4 \times V_b$ (type 'B'). The input sinks current in active-high configurations and sources current in active-low configurations.



Chapter 4: Specification

Electrical

Input voltage

	24V only (Size 2 24V)	24/36V controllers	36/48V controllers	72/80V controllers	96/110V controller
Conventional working voltage range (Note 1)	16.8V to 28.8V	16.8V to 43.2V	25.2V to 57.6V	50.4V to 96V	67V to 132V
Working voltage limits (Note 2)	12.7V to 34.8V	12.7V to 52.2V	19.3 V to 69.6 V	39.1 V to 120 V	48V to 150V
Non-operational overvoltage limits:	39.6V	59.4V	79.2 V	132 V	150V
Battery voltage droop:	Vnom to 0.5 x Vnom for 100 ms				
Input protection:	Input protected against reverse connection of battery				

Note 1: Conventionally the controller may be set to operate without cutback in the range 70% to 120% of the nominal battery voltage, although cutback parameters may be used to set cutbacks higher or lower than this range. Cutbacks are set by the user for various reasons, including:

- Battery protection against high current in deep discharge condition
- Providing smoothly reducing performance at extremes of working voltage range, rather than a sudden loss of function

Note 2: Working voltage range outside which the controller will be non-operational.

- Upper working voltage limits for 72V/80V Gen4 has been increased to 120V for all versions which use the latest controller firmware.

Output protection

Output current:	Reduced automatically from peak to continuous rating depending on the time a peak load is applied to the controller (see Figure 10 on page4-3). Reduced automatically if operated outside normal temperature range.
Short-circuit:	Protected against any motor phase to B- or B+ at power-up. Protected against any motor phase to another motor phase at any time during operation. At switch-on Gen4 detects valid output loads are present before applying drive current.



CAUTION: Repetitive short circuits may damage the controller.

Output ratings

Input (Vdc)	Function	Short term rating* (A rms)	Continuous rating** (A rms)
24	Single traction size 2	300	120
24/36	Single traction size 4	450	180
	Single traction size 6	650	260
36/48	Single traction size 2	275	110
	Single traction size 4	450	180
	Single traction size 6	650	260
72/80	Single traction size 2	180	75
	Single traction size 4	350	140
	Single traction size 6	550	210
96/110	Single traction size 4	300	120

*2 minute rating (lower ratings are possible for longer periods; see example in Figure 10)

** 1 hour minimum without forced-air cooling

Size 2 long-term rating achievable with finned heatsink approx 250mm x 180mm, 0.5°C/W

Size 4 long-term rating achievable with finned heatsink approx 330mm x 200mm, 0.3°C/W

Size 6 long-term rating achievable with finned heatsink approx 330mm x 280mm, 0.2°C/W

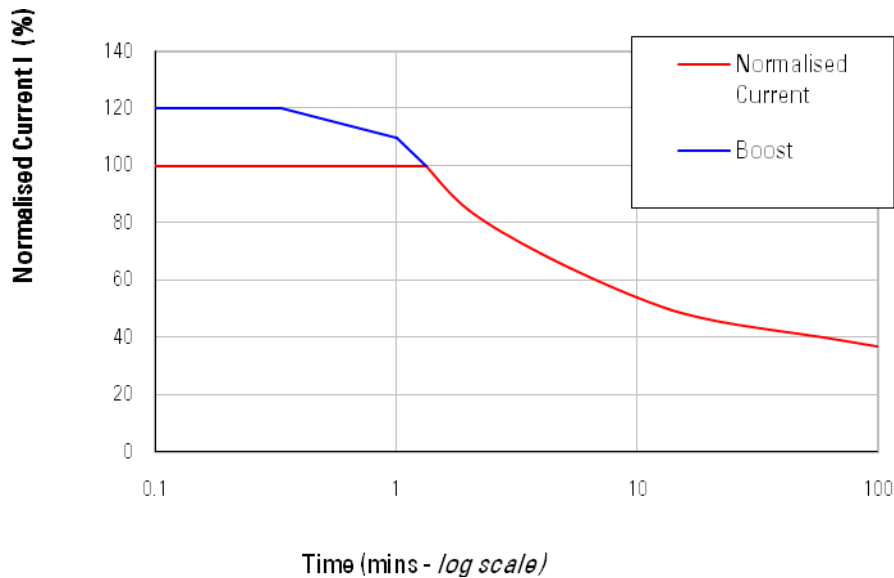


Figure 10 Output current available for various durations of sustained current demand

CAN interface

CAN protocol:	CANopen profiles DS301, DS401 and DSP402 are supported. Physical layer uses ISO11898-2.
Baud rates supported:	1 Mbits/s (default), 500 kbits/s, 250 kbits/s, 125 kbits/s, 100 kbits/s, 50 kbits/s and 20 kbits/s.

Control inputs and outputs

Digital inputs:	8 digital switch inputs (software configurable polarity). 24/36V controllers: Active low inputs < 2.6V, active high inputs > Vb – 2.6 V 36/48V controllers: Active low inputs < 2.9V, active high inputs > Vb – 2.9 V 72/80V controllers: Active low inputs < 4.4V, active high inputs > Vb – 4.4 V 96/110V controllers: Active low inputs < 5.5V, active high inputs > Vb – 5.5 V
Analogue inputs:	2 general purpose inputs which can be used for 2-wire potentiometers, or as supplies for the 3-wire potentiometer wiper inputs. Motor thermistor input All analogue inputs can also be used as digital inputs.
Potentiometer wiper inputs:	Two 3-wire protected inputs.
Inductive drive outputs: (DO NOT USE WITH CAPACITIVE LOADS).	3 configurable PWM outputs. Use in voltage or current control mode. Voltage-controlled: Continuous sink current = 2A Peak current limited to < 2.5A Open-circuit detection ($I_{out} < 0.1 \text{ A}$) is a configurable option Short-circuit detection ($I_{out} > 0.2 \text{ A}$) when drive is in “off” state Voltage-controlled (PWM) mode allows contactors with a rating less than Vnom to be used (range 24 V to Vnom). Current-controlled: Current output configurable between 0 and 2A
Motor speed sensor inputs:	Quadrature AB encoder signal inputs provided for control of induction motors UWV digital position sensor or sin-cos analogue position sensor inputs provided for control of permanent magnet motors

Isolation

Any terminal to the case:	Meets EN1175-1:1998 and ISO3691 Complies with IEC-60664

EMC

Radiated emissions:	EN12895 (Industrial Trucks – Electromagnetic Compatibility) EN 55022:1998, 6, class B EN 12895:2000, 4.1 Emissions. When part of a system with a motor operating, FCC Part 15, Radiated Emissions. Meets the standards given in FCC Part 15, Section 15.109:
Conducted emissions:	No mains port, therefore not required
Susceptibility:	Performance level A (no degradation of performance) or level B (degradation of performance which is self-recoverable) subject to the additional requirement that the disturbances produced do not: • affect the driver's direct control of the truck • affect the performance of safety related parts of the truck or system • produce any incorrect signal that may cause the driver to perform hazardous operations • cause speed changes outside limits specified in the standard • cause a change of operating state • cause a change of stored data
Radiated RF field:	EN 61000-4-3, 5.1 Test Level: user-defined test level of 12 V/m EN 12895:2000, 4.2 Immunity EN 61000-4-6, Table 1 - Test Levels
Electrical fast transient:	EN 61000-4-4, Table 1 - Test Levels, Level 2
Electrostatic discharge:	EN 12895:2000, 4.2 Electrostatic Discharge 4 kV contact discharge 8 kV air discharge
Electrical surge:	EN 61000-4-5:1995, Table A.1 – Selection of Test Levels, Class 3

Regulatory compliance

Designed to meet:	EN1175-1:1998 (which covers EN1726 for the controller) ISO 3691 UL583 ASME/ANSI B56.1:1993

Mechanical

Operating environment

Operating temperature:	-30°C to +25°C (no current or time derating) +25°C to +80°C (no current derating, but reduced time at rated operating point) +80°C to +90°C and -40°C to -30°C (with derating)
Non-operation temperature:	-40°C to +85°C (can be stored for up to 12 months in this ambient range)
Humidity:	95% at 40°C and 3% at 40°C
Ingress of dust and water:	Signal connector mated: IP66 rated (all sizes) Signal connector un-mated: IP66 rated (size 4 & 6 models) Signal connector un-mated: IP42 rated (size 2 models only)

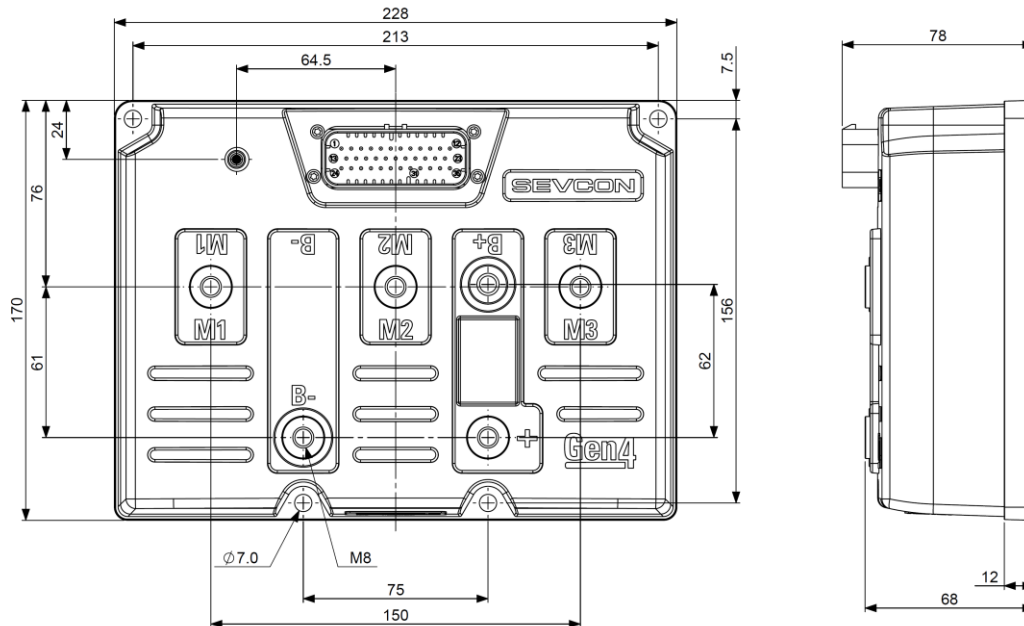
Shock and vibration

Thermal shock:	EN60068-2-14, Test Na
Repetitive shock:	50 g peak 3 orthogonal axes, 3+ and 3- in each axis, 11 ms pulse width
Drop test:	BS EN 60068-2-32:1993 Test Ed: Free fall, appendix B, Table 1
Bump:	40 g peak, 6 ms, 1000 bumps in each direction repetition rate 1 to 3 Hz.
Vibration:	3 g, 5 Hz to 500 Hz
Random vibration:	20 Hz to 500 Hz, acceleration spectral density 0.05 g ² /Hz (equivalent to 4.9 g _{rms})

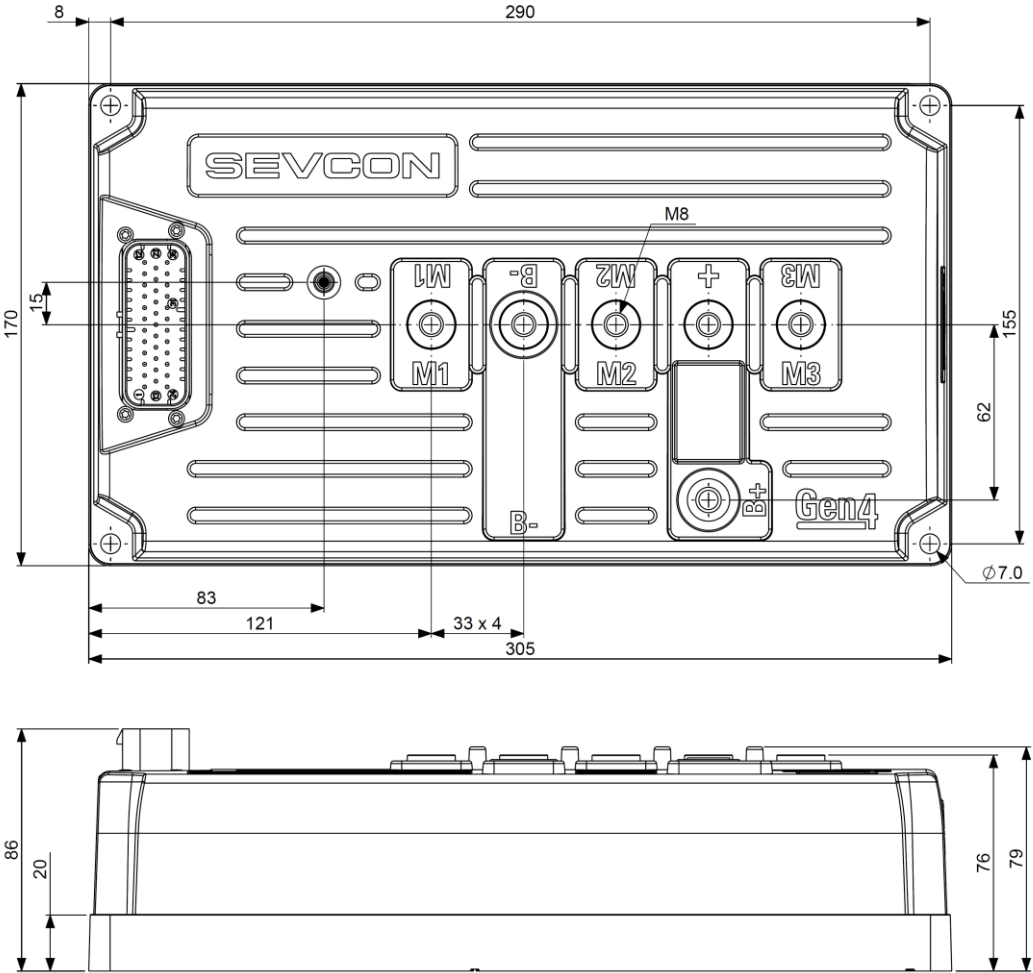
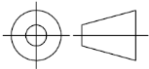
Controller weight

Size 2:	1.3kg
Size 4:	2.7kg
Size 6:	4.6kg

Size 2 models



Size 6 models





Chapter 5: System design

Sizing a motor

Information required about the application

To select an appropriate induction motor for an application find or estimate the following information:

- Minimum battery voltage
- Maximum motor speed required
- Peak torque required at base speed
- Peak torque required at maximum motor speed
- Continuous (average) motor power output required to perform the work cycle
- Peak motor power output required and duration

Include inertia and friction contributed by the motor, as well as any gearing in the drive chain, when calculating torque and load requirements. If replacing a DC motor with an AC motor in an existing application, the DC motor torque vs. speed curve is a good starting point to determine the required ratings.

Motor maximum speed

Determine the maximum motor speed using the required vehicle or pump maximum speeds and the ratio of any gear box or chain between the motor and the load. Most motor manufacturer rate induction motors at synchronous speed which is 1,500 and 1,800 rpm for a 4-pole motor when operated from 50 Hz and 60 Hz line frequencies respectively.

The maximum speed an induction motor can be used at is determined by the limit of the mechanical speed, typically 4,000 to 6,000 rpm, and the reduction in useful torque at higher speeds. Increasing losses in the iron of the motor at higher speeds may further limit the maximum speed. Always check the maximum speed with the motor manufacturer. Check also any limitations imposed by the maximum frequency of the encoder input signal (see 'Motor speed sensor (encoder)' on page 5-10).

Torque required between zero and base speed

Calculate the torque required by the application. Use figures for the work that needs to be done against friction and gravity, plus those required to accelerate the load inertia and momentum. Up to rated speed the peak torque that can be supplied when using a correctly specified Gen4 is equal to the breakdown torque. Select a motor with a breakdown torque rating greater than the peak torque required.

Torque required at maximum speed

Calculate the torque as above. As speed increases beyond base speed the maximum torque an induction motor can supply falls as defined by the following two equations:

In the constant power region;

$$T = \frac{T_{\max}}{\left(\frac{\omega}{\omega_{\text{rated}}}\right)}$$

In the high speed region;

$$T = \frac{T_{\max}}{\left(\frac{\omega}{\omega_{\text{rated}}}\right)^2}$$

This is shown in Figure 11. Select a motor with a torque rating greater than the peak torque required.

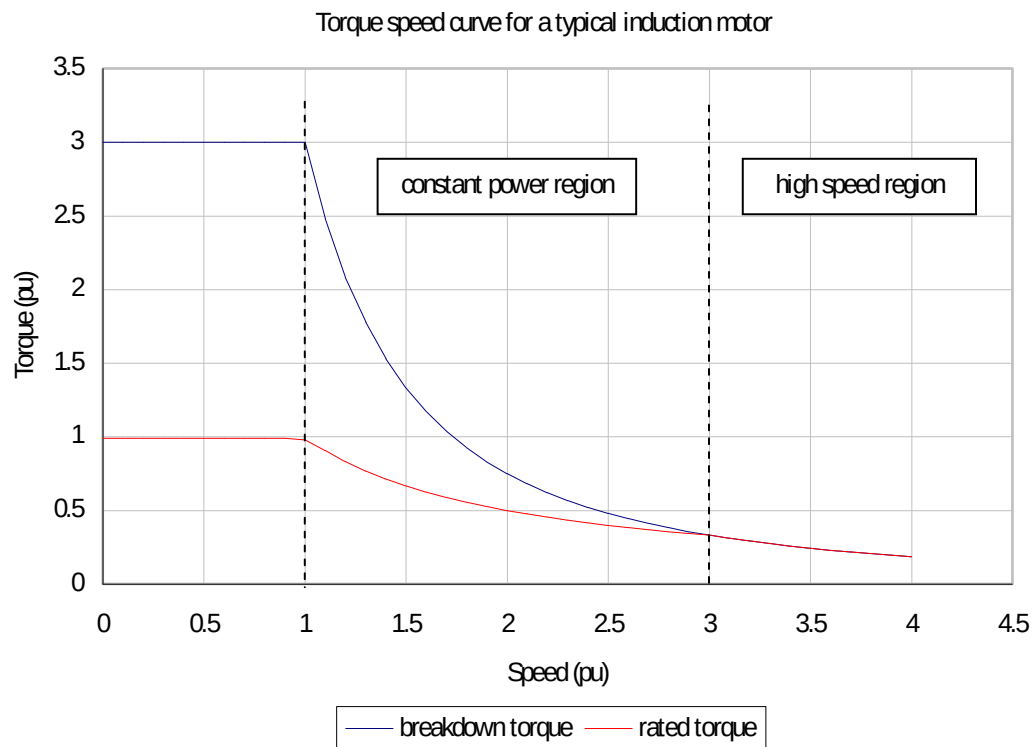


Figure 11 Torque speed curve

Continuous power rating

The required continuous power rating of the motor is governed by the application load cycle over a shift. Use the maximum RMS current over a period of one hour to determine the motor rating required. The motor manufacturer will typically specify a 1 hour or continuous rating. Select a motor whose ratings are equal to or greater than your calculated load over 1 hour.

Peak power rating

The peak power rating required for the application is actually determined by the peak torque required, as this determines the motor current required. Motor manufacturers will provide S1, S2 or S3 duty cycle ratings for the motors.

Selecting the correct Gen4 model

Matching motor and controller ratings is not an exact exercise and therefore you may need to perform iterative calculations. The main considerations when choosing an appropriate Gen4 controller are described below.

Current and power ratings considerations

Consider the following when choosing the appropriate Gen4 controller:

- Ensure the controller chosen matches or exceeds the peak current and average current requirements of the motor(s) in the application.
- Ensure the application can dissipate the waste heat generated by the controller. If the controller gets too hot it reduces its output, limiting vehicle performance.

Power output restrictions at motor and drive operating temperature limits

A controller protects itself by reducing the current and hence torque available when its temperature limit is reached (Figure 12).

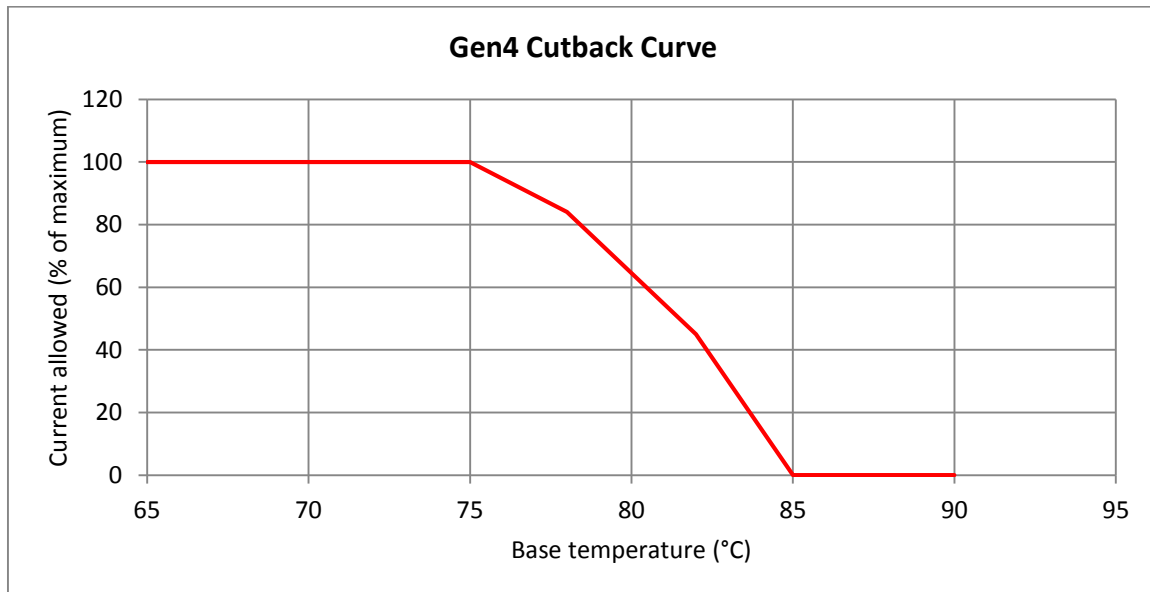


Figure 12 Current allowed vs. controller base temperature



The Gen4 also looks at a number of internal temperature measurements and estimates. These can also influence the thermal cutback operation, depending on installation and operating duty cycle

Circuit configuration

Once motor size is determined the application circuit configuration can be defined. A basic single traction configuration (Figure 13) is provided as a starting point for new designs. Given the flexibility of the I/O it is possible to configure a wide range of systems. Refer to 'Signal connections' on page 3-14 to see what each I/O signal is capable of doing as you design your system. For pump applications a basic single pump system is shown in Figure 14.

Single traction wiring diagram

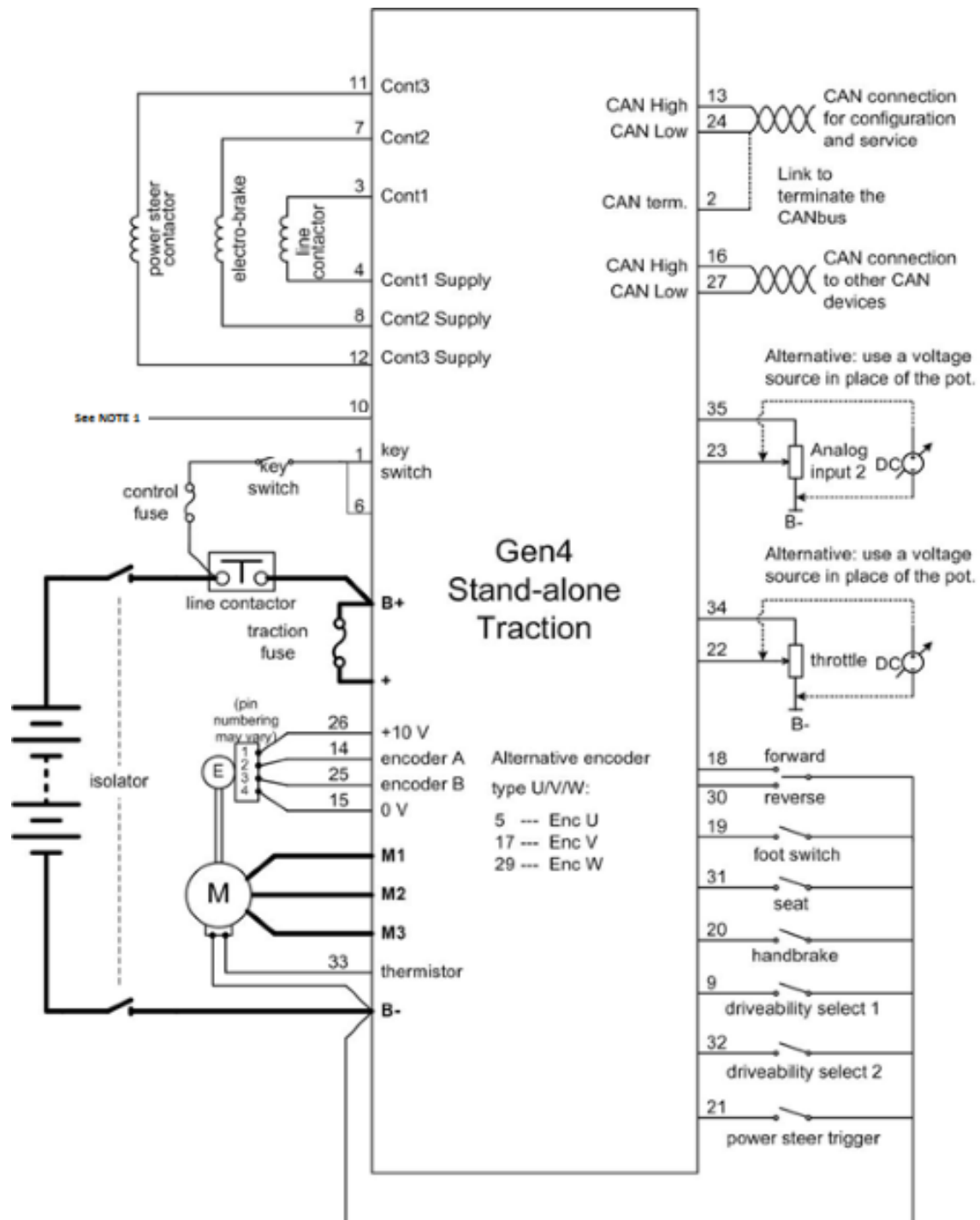


Figure 13 Single traction wiring diagram

NOTE 1: pin 10 is 5V output for Size 2 and key switch for Size 6. Size 4 function is being changed from keys switch to 5V output during 2014

Single pump wiring diagram

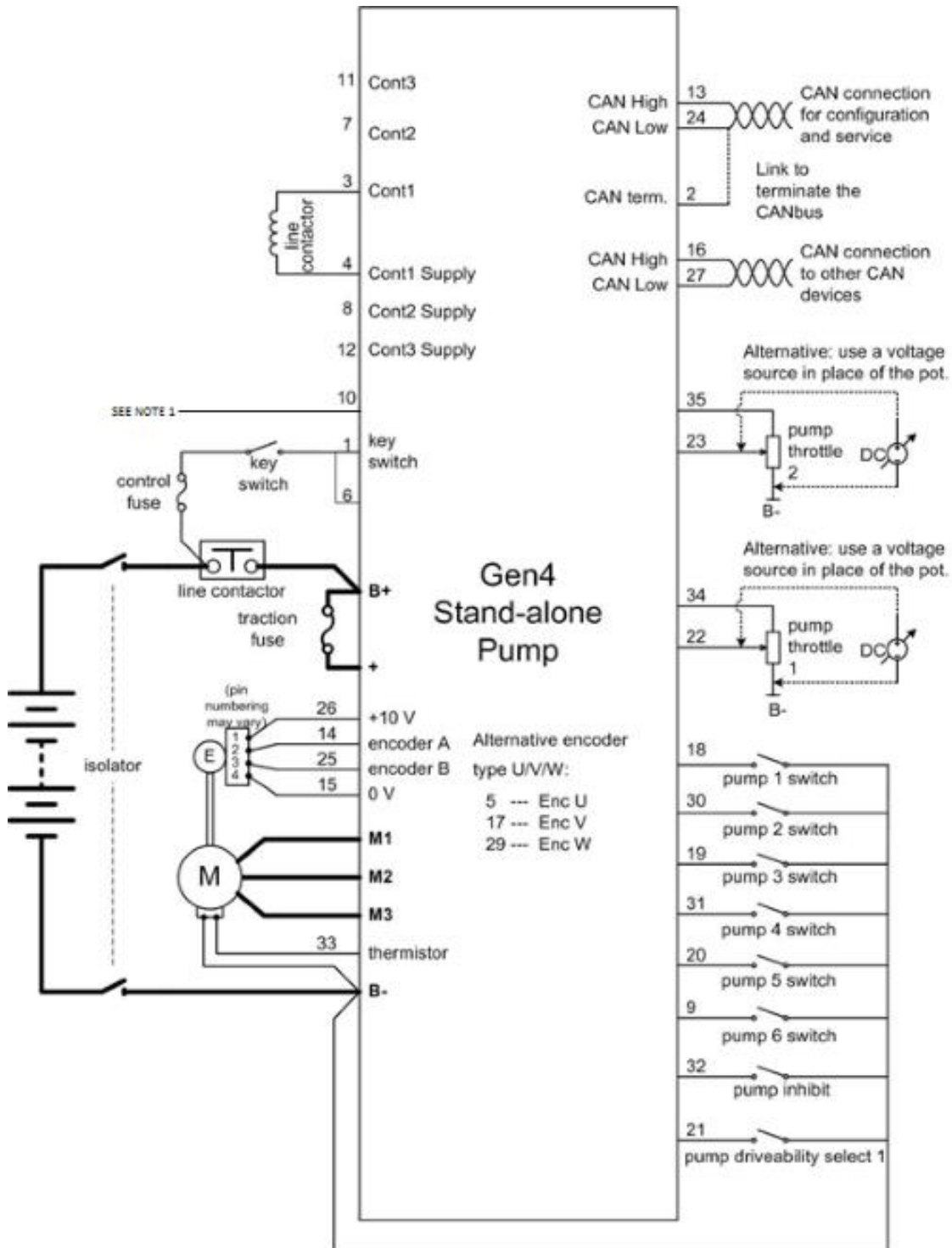


Figure 14 Stand-alone pump wiring diagram

NOTE 1: pin 10 is 5V output for Size 2 and key switch for Size 6. Size 4 function is being changed from keys switch to 5V output during 2014

Twin motor systems

A twin motor system may be powered by two Gen4 controllers operating in master–slave configuration. In this case the necessary commands are transmitted by the master node to the slave node via the CANbus.

Motors may be operated independently in a combined traction–pump application or operated in tandem where each motor drives a separate wheel. In this latter case the controller (where there are two controllers, the controller configured as master):

- Assists in the steering of a vehicle by adjusting the torque of each motor dependent on the steering angle.
- Reverses the direction of the inner wheel in order to provide a smaller turning circle. The speed of the outer wheel is also limited during a turn.

An example of possible wiring for Gen4 traction controllers operating in master–slave configuration is shown in Figure 15.

Auxiliary components

Main contactor

Select the appropriate contactor line contactor from Table 4. A line contactor used at its rated coil voltage must be rated ‘continuous’. Contactor coil voltage chopping allows the use of coils rated ‘intermittent’, provided the manufacturer’s conditions are met.

Gen4 peak output current	Coil	Sevcon P/N	Manufacturer	Notes
Up to 450 A	24 V	828/37024	Albright SW200-29	See paragraph below
	48 V	828/57026	Albright SW200-20	
	80 V	828/67010	Albright SW200-460	
Up to 650 A	24 V	828/39001	Albright SW200	Chop at 17 V (intermittent coil)

Table 4 Main contactor rating

The controller can drive any contactor with coil voltages from 12 V to Vb. It is worth considering the use of 24 V contactors with the contactor drive output set to voltage–control mode. This allows you to use one type of contactor for any battery voltage (24 V to 80 V). Pull-in voltage, pull-in time and hold-in voltage values are all configurable.

Contactor coils must not be wired to the supply side of the key switch. Use the Output 1 Supply / Output 2 Supply / Output 3 Supply pins provided (see Table 2).

35 Way AMPSeal Connector Kit

Kit consists of Gen4 mating 35 way AMPSeal connector and pins, Sevcon p/n 661/27091

Emergency stop switch

Refer to the appropriate truck standards.

On-board fuse

See ‘On-board fuse mounting’ on page 3–11.

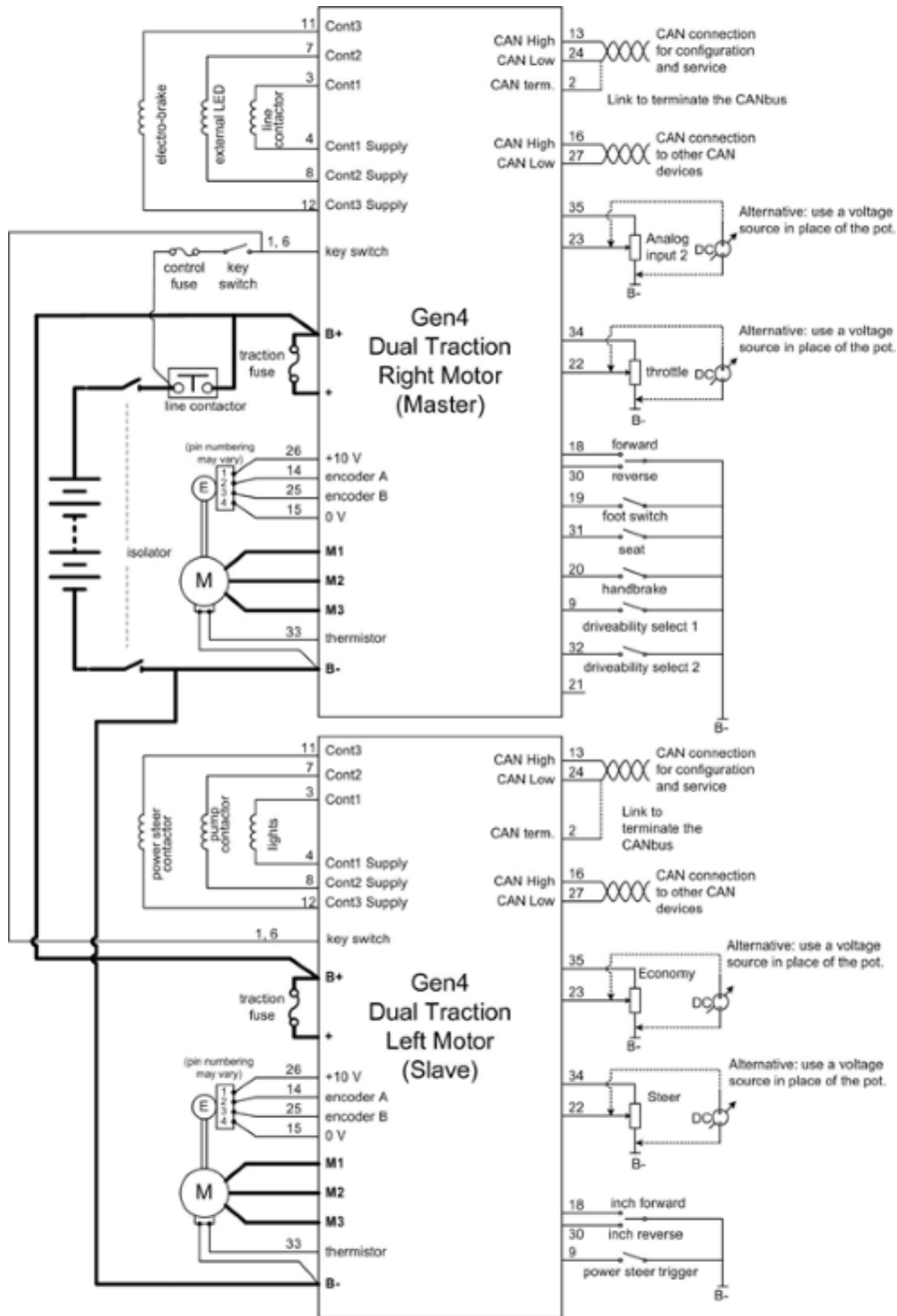


Figure 15 Dual traction wiring diagram



pin 10 is 5V output for Size 2 and key switch for Size 6. Size 4 function is being changed from keys switch to 5V output during 2014

Key switch fuse F2

Use a fuse rated for the larger of: A) the sum of the drive currents plus 1A for internal circuits, and B) the capacitor pre-charge circuit. In the following example there are two contactors each drawing 2 A:

	Device	Current
A	Line contactor	2 A
	Pump contactor	2 A
	Gen4 control circuits	1 A
B	Pre-charge circuit	7 A

Fuse choice: 7A.

Motor speed sensor (encoder)

A 4-wire connection is provided for open-collector or current-source quadrature pulse encoder devices (software configurable). These types of encoder are optimized for accurate speed measurement, required for efficient control of induction motors.

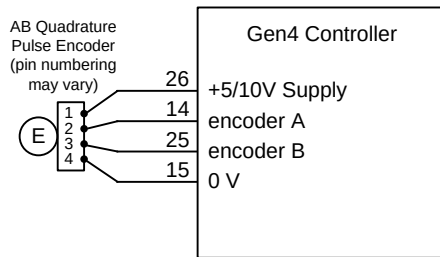


Figure 16 - Sample wiring for an AB quadrature speed encoder

You can use the following types of encoder, or equivalents:

Type	Output	Supply	Specification
Bearing Type (SKF and FAG)	Open collector	5 to 24 V DC	64 and 80 pulses per revolution Dual quadrature outputs Output low = 0 V (nominal)
HED Type (Thalheim)	Constant current	10 V nominal	80 pulses per revolution Dual quadrature outputs Output low = 7 mA Output high = 14 mA

Single channel encoders (without the encoder B connection) are also supported. However, when using this type of encoder, torque output is limited to the forward direction only. While these encoders can be used for belt drive or pump motors, the torque output limitation makes these unsuitable for traction applications.

The number of encoder pulses per revolutions (**n**) and the maximum motor speed (**N**) are related to, and limited by, the maximum frequency of the encoder signal (**f_{max}**). The following table shows the maximum motor speed for a given encoder on a 4-pole motor.

Encoder ppr	Maximum motor speed (rpm)

128	6000
80	10000
64	10000

For other types of encoder and motor use the formulae:

$$f_{\max} (\text{Hz}) = \frac{n(\text{per revolution}) \times N(\text{rpm})}{60}$$

with $f_{\max}$ limited to 13.3 kHz.

and

$$N_{\max} (\text{rpm}) = \frac{20000(\text{rpm})}{(p/2)}$$

Encoder PPR is set at 6090_h. Additional encoder configuration (pull-up, supply, etc) is set at 4630_h.



Encoder PPR (6090_h) must be configured correctly to ensure reliable control of the motor. Failure to do so could cause the controller to output incorrect torque.

Motor commutation sensor

UVW Commutation Sensors

Commutation sensors are designed to measure the position of the rotor shaft within the motor, rather than its rotational speed. Rotor position information is used for control of permanent magnet motors, as it allows the controller to energise the motor phases appropriately based on the measured position of the magnets on the rotor.

The Gen4 controller provides inputs for both digital UVW style position sensors and analogue sin-cos sensors. Either of these can be used for control of permanent magnet motors.

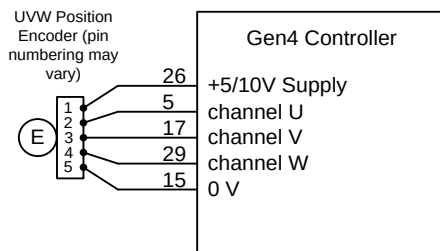


Figure 17 - Sample wiring for a UVW commutation sensor

3 digital inputs are provided for UVW encoders. The encoder should provide one pulse on each channel per electrical cycle of the motor, and each pulse should be 120° out of phase with the others and have a 50% duty cycle:

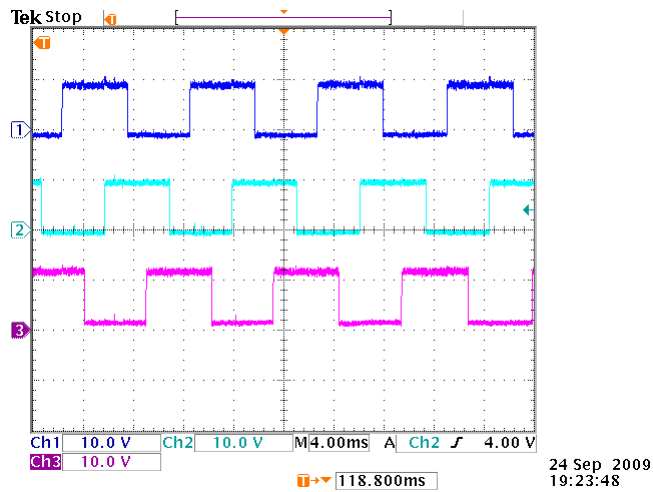


Figure 18 - Example pulse train from a UVW commutation sensor

UVW encoder power supply can be configured with 5V or 10V supply voltage. For 10V supply the low to high transition threshold is 5.3V and for 5V supply it is 2.7V

Sin-Cos Commutation Sensor

Analogue sin-cos encoders should provide one sine wave and one cosine wave per mechanical rotation of the motor. Peak and trough signal voltages must have a minimum of 1V difference.

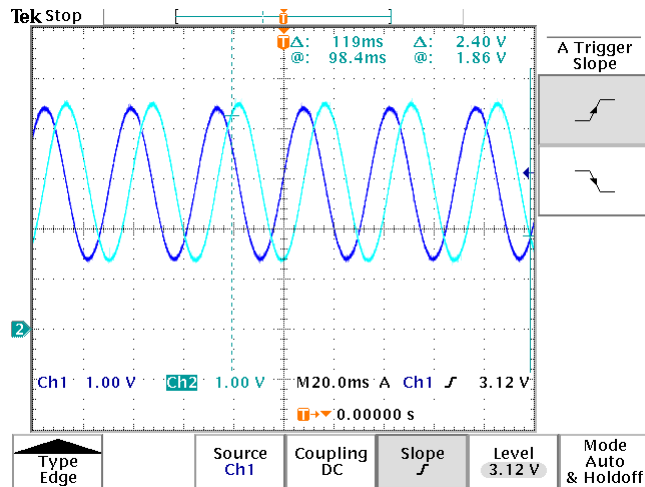


Figure 19 - Example of signals from a sin-cos position sensor

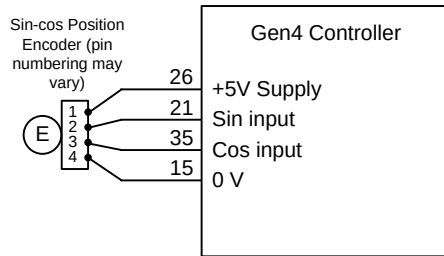


Figure 20 - Sample wiring for a sin-cos commutation sensor

Sin-cos encoders are typically powered by a 5V supply. Therefore it is important to ensure that the controller is configured to supply 5V on pin 26. This should be done by setting the encoder configuration object dictionary entry at 4630_h.



NOTE: The standard Gen4 build does not provide inputs for the sin and cos signals. Therefore, if operation with a sin-cos analogue encoder is required then this must be specified as a hardware build option. Controllers built for use with sin-cos encoders have the functions of pins 31 and 35 reassigned from digital and analogue inputs to sin and cos signal inputs respectively. Please contact your local dealer for more information on the sin-cos encoder build option.



Encoder offset (4630_h,4+16), Sin/Cos Waves/Mechanical Revolution (4630_h,14) and Sin/Cos Latency (4630_h,15) must be configured correctly to ensure reliable control of the motor. Failure to do so could cause the controller to output incorrect torque.

Initial power up sequence



WARNING: Incorrectly wired or configured vehicles may behave in unexpected ways. Always confirm correct operation of the motor and encoder before lowering the drive wheels to the ground.

Checks prior to power up

Follow this checklist prior to applying power to your system:

- Jack up the vehicle so that the drive wheels are clear of the ground.
- Confirm all connections are tightened to specified level.
- Ensure all plugs are fully inserted.
- Confirm power wiring connections are made to the correct terminals (B+, B-, +, M1, M2 and M3).
- Ensure the controller is securely mounted (from a mechanical and thermal perspective).
- Ensure there is adequate and correctly ducted airflow for any fan cooling system.
- Check the routing of cables is safe with no risk of short circuit, overheating or cable insulation wear due to rubbing.

Checks after power is applied

Apply power and do the following:

- Use Sevcon DVT (see page 6-2), the Sevcon Calibrator handset or any configuration tool to complete the configuration process which starts on page 6-6.
- Using the drive controls ensure the wheels rotate in the expected direction. If they do not, check the motor wiring, encoder wiring and encoder configuration (page 6-12).

It should now be safe to lower the vehicle to the ground and test drive. Proceed with caution.



Chapter 6: Configuration

Introduction

This section covers what you need to do to configure Gen4's software once you have designed and installed your hardware. All of Gen4's parameters have a default value and the amount of configuration needed is dependent on your particular system.

The main topics are:

- DVT configuration tool: installation and use
- CANopen: an introduction to the protocol and its use in Sevcon products
- An overview of the configuration process outlining what needs to be done and the order in which it must be done
- The configuration steps

DVT configuration tool

DVT is Sevcon's proprietary configuration tool. It allows the user to monitor, configure and duplicate the parameters of any Sevcon CANopen node such as the Gen4 controller. The information presented here is an overview only. Contact Sevcon for more information about DVT and the functions it provides

DVT functionality

DVT provides the following facilities:

- Configuration of controller IO, CANBus, motor parameters & vehicle drive performance parameters
- Loading DCF configuration file into the Sevcon controller
- Saving of DCF configuration file from controller to file on computer
- Controller status and fault diagnosis
- Data logging of controller/motor performance on test bench or vehicle
- Update controller firmware

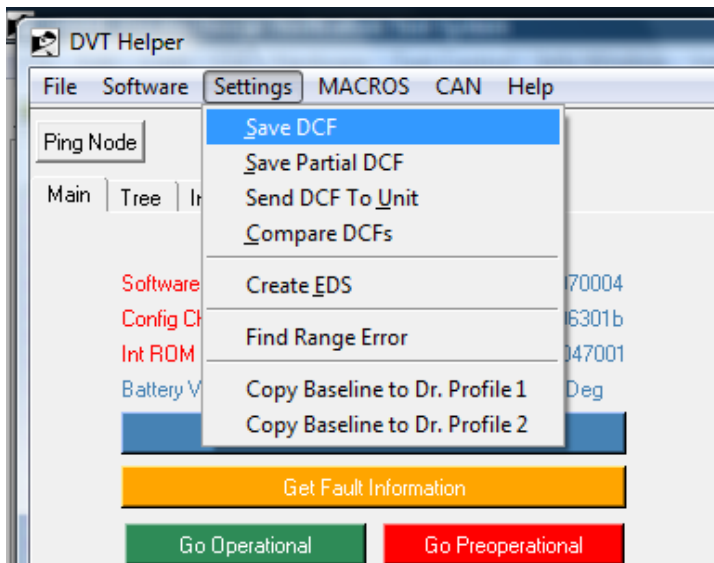
Saving, duplicating and restoring a node's configuration

You can use DVT to:

- Save a node's configuration. This can be used at some later date to clone the node's configuration.
- Duplicate a node's configuration, in real time, to another node on the CANbus.
- Restore a configuration to a node.

For example, if you want to save the Gen4 controller configuration, you will need to create a DCF file.

To do this, open the helper by clicking the  icon at the top of the DVT main window.



Data Logging.

You can use DVT to monitor data or parameters of a Sevcon node in real time and graph the data.

CANopen

This section assumes you have an understanding of CAN and are familiar with its use. If you are new to CAN or CANopen please refer to the CiA (CAN in Automation) website,

www.can-cia.org for further information.

The following information provides an introduction to the important CANopen terminology used in this manual and how it relates to the configuration of your Gen4 controller.

CANopen protocol

CANopen is a CAN higher layer protocol and is defined in the DS301 'Application Layer and Communication Profile' specification. All CANopen devices must adhere to this standard. To provide greater standardization and interoperability with 3rd party devices, Gen4 is designed to use the CANopen protocol for communication on its CANbus and meets V4.02 of DS301.

CANopen also supports standardized profiles, which extend the functionality of a device. The controller supports the following CANopen standardized profiles:

- DS401 (V2.1) – Device Profile for Generic I/O Modules
- DSP402 (V2.X) – Device Profile for Drives and Motion Control

Object Dictionary

Any device connected to the CANopen network is entirely described by its Object Dictionary. The Object Dictionary defines the interface to a device. You setup, configure and monitor your Gen4

controller by reading and writing values in its Object Dictionary, using a configuration tool such as Sevcon's DVT (see page 6-2).

There are two important text files associated with the Object Dictionary. These are:

EDS (electronic data sheet)

An EDS is a text file representation of the Object Dictionary structure only. It contains no data values. The EDS is used by configuration software such as Sevcon's DVT to describe the structure of a node's Object Dictionary. An EDS for each Gen4 model and software version, is available from Sevcon. The EDS file format is described in the DSP306 – Electronic Data Sheet Specification.



NOTE: Each Object Dictionary matches a particular Gen4 software revision, and its structure is hard coded into the controller software.

DCF (Device Configuration File)

This is a text file similar to an EDS except that it contains data values as well as the Object Dictionary structure.

DCFs are used to:

- Download a complete pre-defined configuration to a node's Object Dictionary.
- Save the current configuration of a node's Object Dictionary for future use.

Communication objects

These are SDO (service data object) and PDO (process data object) as described below. There is a third object, VPDO (virtual PDO), used by Gen4 which is not a CANopen object. It is described here because its function is important and similar to that of a PDO.

SDO (Service Data Object)

SDOs allow access to a single entry in the Object Dictionary, specified by index and sub-index. They use the client-server communication model, where the client accesses the data and the server owns the target Object Dictionary.

SDOs are typically used for device configuration (e.g. via DVT) or for accessing data at a very low rate.

PDO (Process Data Object)

PDOs are used by connected nodes (for example in a twin motor configuration) to exchange real time data during operation. PDOs allow up to 8 bytes of data to be transmitted in one CAN message.

They use the producer-consumer communication model, where one node (the producer) creates and transmits the PDO for any connected nodes (consumers) to receive. Transmitted PDOs are referred to as TPDOs and received PDOs as referred to as RPDOs.

VPDO (Virtual Process Data Object)

VPDOs do a similar job as PDOs for data exchange, but internal to a single Sevcon node. They are unique to Sevcon and are not part of CANopen.

Network Configuration

General

If non-Sevcon nodes need to be added, use the following procedure to setup the network:

1. Set node ID and baudrate in 5900_h to the required values. Node IDs must be unique, and the baudrate must be the same for each node.
2. Set SYNC COB-ID in 1005_h to 0x40000080 for the master node, or to 0x00000080 for all slave nodes. Bit 30 is set to indicate to a node if it is the SYNC producer. Only one node in the network should be configured as the SYNC producer. This should normally be the master. On the SYNC producer, set the SYNC rate in 1006_h.
3. Set the EMCY message COB-ID to 0x80 + node ID in 1014_h.



WARNING: EMCY COB-IDs must be configured correctly to ensure the master handles EMCYs from slaves correctly.

4. Configure the heartbeat producer rate in 1017_h. This is the rate at which this node will transmit heartbeat messages.
5. Configure the heartbeat consumer rate in 1016_h. A consumer should be configured for each node to be monitored.



WARNING: Heartbeats must be configured correctly for correct network error handling. The master node should monitor heartbeats from all slave nodes. Slave nodes should, at a minimum, monitor heartbeats from the master node.

6. On standalone systems with non-CANopen nodes attached, hardware CANbus fault detection should be enabled at 5901_h. CANbus fault detection is automatically enabled for multi-node CANopen systems.
7. Configure additional SDO servers. An SDO server allows another CANopen device to SDO read/write from a node's object dictionary. Each node has one default SDO server (1200_h) which is reserved for communication with configuration tools like DVT or the calibrator. Another 3 SDO servers can be configured at 1201_h to 1203_h. These should be used as follows:
 - a. On slave nodes, configure a server to allow the master node to communicate.
 - b. If there is a display in the system, configure a server to allow the display access.
8. On the master node, configure SDO clients at 1280_h to 1286_h. There must be one client for each slave node. The SDO clients must be configured to match the corresponding SDO server on each slave.
9. On the master node, list all slave node IDs at 2810_h.
10. Configure RPDOs (1400_h to 17FF_h) and TPDOs (1800_h to 1BFF_h) appropriately for the system. See section, Object mapping (page 6-10), for more information.
11. Configure the RPDO timeout function if required. See section PDO mapping (page 6-11) for more information.

3rd Party CANopen Devices

At power up, the Gen4 master will communicate with all slave nodes to identify which nodes are Sevcon devices and which are not using the vendor ID in 1018_h. This instructs the Gen4 how to handle EMCY messages from each node.

Gen4 knows how to react to EMCYs (faults) from Sevcon slaves and can take appropriate action. Gen4 does not know how to react to EMCYs from 3rd party devices, so the required fault reaction to 3rd party device EMCYs must be set at 2830_h.

Configuration process overview



WARNING: Electric vehicles can be dangerous. All testing, fault-finding and adjustment should be done only by competent personnel. The drive wheels should always be off the floor and free to rotate during the following procedures.



NOTE: We recommend saving parameter values by creating a DCF, before making any alterations so you can refer to, or restore the default values if necessary. Do this using DVT.

This part of the manual assumes you have a vehicle designed and correctly wired up with a CANopen network setup. Before you can safely drive your vehicle it is necessary to go through the following process in the order presented:

Step	Stage	Page
1	Motor characterization	6-7
2	I/O configuration	6-10
3	Vehicle performance configuration	6-16
4	Vehicle features and functions	6-33

Access authorization

To prevent unauthorized changes to the controller configuration there are 5 levels of accessibility: (1) User, (2) Service Engineer, (3) Dealer, (4) OEM Engineering and (5) Sevcon Engineering. The lowest level is (1), allowing read only access, and the highest level is (5) allowing authorization to change any parameter.

To login with DVT, select User ID and password when prompted.

To login with other configuration tools write your password and, optionally, a user ID to object 5000_h sub-indices 2 and 3. The access level can be read back from sub-index 1. The password is verified by an encryption algorithm which is a function of the password, user ID and password key (5001_h).

The password key allows passwords to be made unique for different customers. The user ID also allows passwords to be made unique for individuals.

How NMT state affects access to parameters

Some important objects can only be written when the controller is in the pre-operational state. DVT takes Gen4 in and out of this state as required.

If you are not using DVT you may need to request the CANopen network to enter pre-operational before all objects can be written to.

To enter pre-operational, write '1' to 2800_h on the master node.

To restore the CANopen network to operational, write '0' to 2800_h.

The controller may refuse to enter pre-operational if part of the system is active: for example, if the vehicle is being driven. The request is logged in the EEPROM however, so if power is recycled the system won't enter operational and remains in pre-operational after powering up.

The NMT state can be read at 5110_h where 05 = operational and 7F = pre-operational.

Motor characterization

Ensure you have completed the CANopen network setup process.

Determining motor parameters

To provide optimum motor performance Gen4 needs the basic motor information normally found on the name plate as well as the following information:

- A value for each of the electrical parameters of the induction motor as shown in Figure 21.
- The magnetic saturation characteristics of the motor in the constant power and high speed regions.
- Current and speed control gains.

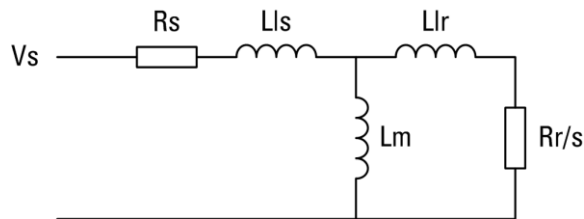


Figure 21 AC motor single-phase equivalent circuit

To determine these parameters use one of the following methods:

1. Ask the motor manufacturer to provide the data and enter it in the Object Dictionary at 4640_h and 4641_h. Also enter encoder data at 4630_h and 6090_h and motor maps at 4610_h to 4615_h. The motor maps are dependant on the motor type:

Motor Type	Map Object	Usage
PMAC	4610 _h	Motor flux map showing torque versus magnetising current.
	4611 _h	Motor power limit map showing maximum torque versus speed.
	4612 _h	Voltage cutback map showing voltage versus torque reduction factor.
	4615 _h	Second motor power limit map. Overrides map in 4611 _h based on trigger defined in 4652 _h .
Flux Vector	4610 _h	Motor flux map showing torque versus magnetising current.
	4611 _h	Motor power limit map showing maximum torque versus speed.
	4612 _h	Voltage cutback map showing voltage versus torque reduction factor.
	4614 _h	Saturation map showing magnetising current versus inductance.
	4615 _h	Second motor power limit map. Overrides map in 4611 _h based on trigger defined in 4652 _h .
Open Loop Slip Control	4610 _h	Motor flux factor map showing slip versus magnetising current factor. Used to give additional torque at low speed.
	4611 _h	Motor power limit map showing maximum slip versus speed.
	4612 _h	Voltage cutback map showing voltage versus torque reduction factor.

2. Use the motor name plate data and the self characterization routine provided by Gen4 and DVT (described below).

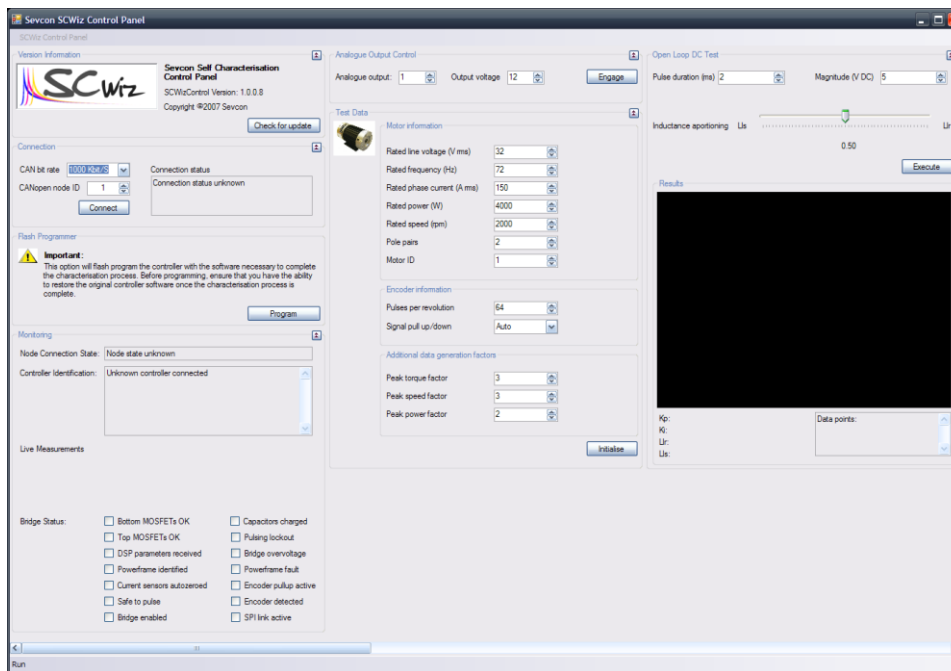
The flux vector variant of software includes motor temperature compensation which can be used to adjust rotor resistance (4641_{h,8}) with motor temperature. This is set at 4621_{h,4} to 7.

Self characterization



WARNING: The self characterization function will cause the motor to operate. Always ensure the vehicle is jacked up, with the driving wheels off the ground and free to turn before starting the test.

The motor self-characterisation process allows a user to determine the electrical parameters required for efficient control of AC induction motors using a Gen4 controller connected to a PC or laptop running characterisation software. For further information, please contact your local Sevcon representative.



At time of writing, SCWiz is not yet compatible with 110V version of Gen4. Induction motor parameter characterisation therefore needs to be carried out using a lower voltage (48V or 80V) Gen4 controller.

Additional Motor Configuration

The motor algorithms can be further configured using 4650_h. Not all features are available for each motor type.

Configuration

Feature	PMAC	FV	OLSC
Software over current disable. Set to disable software over current protection. Note that hardware over current protection is still active.	X	X	X
Low speed gain scheduling enable. If set, motor speed control algorithms interpolate gains from low speed to high speed gains from 25 RPM to 50 RPM, instead of the standard 50 RPM to 200 RPM.	X	X	
Current control gain scheduling enable. If enabled, current control proportional gains increase with frequency. Can reduce audible noise at low motor speeds.	X		
Drive/Braking torque inhibit to 0 RPM enable. If enabled, allows motor torque to be disabled to 0 RPM.	X	X	
Motor open circuit detection enable.		X	
Disable automatic discharge function for line contactor checks at power up	X		
Salient motor lookup table enable. If enabled, motor control uses lookup tables for salient motor control.	X		
Allow power frame to disable when motor is moving. If set, power frame can be disabled when no torque is demanded for 3s even if motor is rotating. <i>NOTE: PMAC software uses 5831_h to configure bridge disable functionality.</i>		X	
Equal and opposite speed limits enabled. If set, speed limit (6080 _h) is applied in both directions.	X		
PI based Iq_max limit enable.	X		
Sin/cos min/max tracking algorithm disable.	X		
Torque demand generated from peak torque or power limit map output.			
Disable Steer cutback.			
Disable capacitors charged check			
Use saturation in slip and rotor time constant calculation. If enabled, the motor control will take into account the saturation of Lm (from the saturation table) for calculations, this will give improved accuracy torque output and should be enabled for all new configurations. Do not enable if the motor parameters were tuned with this option disabled.		X	

I/O configuration

Ensure you have completed the CANopen network setup and Motor Characterization processes described above.

The individual characteristics and mapping of the I/O in your application need to be setup. This can be done manually, or one of a selection of predefined setups can be selected. Predefines setups exist for many of the common vehicle functions such as standalone traction, standalone pump and twin traction.

For configuration, it is necessary to use PDOs and VPDOs to map application objects on the master node (2000_h to 24FF_h) to the hardware I/O objects on all other nodes (6800_h to 6FFF_h). To configure I/O:

- **Either** configure PDOs and VPDOs to map application objects on the vehicle master node to hardware I/O objects on other nodes, **or** select a pre-defined configuration and use auto-configuration to set up PDOs and VPDOs
- Setup each hardware I/O object, including wire-off protection.

Object mapping

To enable the controller to perform the functions required in your system it is necessary to map object to object (e.g. a measured input signal mapped to a steer operation).

This is achieved by setting up PDOs (node to node mapping) and VPDOs (internal mapping on each controller) as described below.

Apply mapping to Gen4 as follows:

- Standalone controllers: setup VPDOs only
- Networked controllers: setup VPDOs and PDOs



NOTE: Before starting the mapping process it is a good idea to draw out a map of what you want to do. The amount of mapping required depends on the electrical wiring of your vehicle. Check to see if the default settings satisfy your needs before making changes.

VPDO mapping

VPDO mapping is defined by objects in the range 3000_h to 3FFF_h as shown in the table below. Use DVT, or any other configuration tool, to access these objects.

Feature	Object indices	Notes
Motor	3000h	Used to map the master to the type of local motor
Input mapping	3300h	Used to map digital input signals to application inputs
	3400h	Used to map analogue input signals to application inputs
Output mapping	3100h	Used to map application outputs to digital output signals
	3200h	Used to map application outputs to analogue output signals

To help understand how to map internal objects an example VPDO mapping is shown in Figure 22. A digital switch input is mapped to the seat switch function to control the traction application, i.e. with no seat switch input the vehicle is prevented from moving.

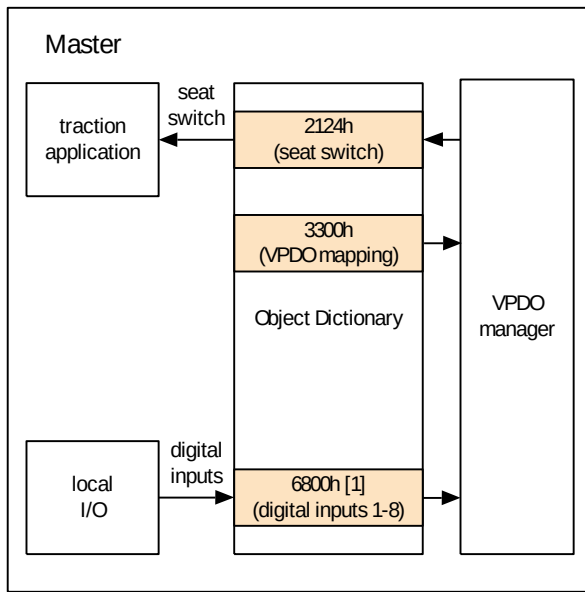


Figure 22 Example of a digital input mapped to the seat switch via VPDO

The number of sub-indices of each VPDO object depends on the amount of I/O on the device. For example, 3300_h has 14 sub-indices on a device with 8 digital inputs and 5 analogue inputs. Sub-index 0 gives the number of I/O channels in use. In 3300_h sub-indices 1 to 8 correspond to the digital inputs and sub-indices 9 to 14 correspond to the digital state of analogue inputs.

To map the local I/O to an application signal object, set the appropriate VPDO sub-index to the application signal object index. If the seat switch shown in the above diagram was connected to digital input 4 (bit 3 in 6800_h, 1), sub-index 4 of 3300_h would be set to 2124_h.

Some further examples are:

- Map FS1 to read the value of digital input 8 (connector A, pin 11): at 3300_h sub-index 8 enter the value 2123_h.
- Map the electromechanical brake signal to be applied to analogue output 2 (customer connector, pin 7): at 3200_h sub-index 2 enter the value 2420_h.

The data flow direction between the application signal objects and the local I/O objects depends on whether they are inputs or outputs. For inputs, the flow is from the local I/O to application objects, and vice versa for outputs.

Motor VPDOs are slightly different. There are six parameters for each motor, some of which flow from application to local I/O (controlword, target torque and target velocity) and some of which flow from local I/O to application (statusword, actual torque and actual velocity).

PDO mapping

The controller supports 5 RPDOs (receive PDOs) and 5 TPDOs (transmit PDOs). Up to 8 Object Dictionary entries can be mapped to each PDO. Every PDO must have a unique identifier (COB-ID).

Setup RPDOs and TPDOs to transmit and receive events between nodes, and map I/O from one node to applications in another node.

The easiest way to do this is using DVT. If you are using a 3rd party configuration tool, the relevant Object Dictionary indices are listed in Table 5.

Feature	Object indices	Notes
Input mapping	1400h-15FFh	RPDO communication parameters
	1600h-17FFh	RPDO mapping
Output mapping	1800h-19FFh	TPDO communication parameters
	1A00h-1BFFh	TPDO mapping

Table 5 Objects associated with mapping

An example mapping (Figure 23) shows the movement of PDOs in a master-slave configuration in which a digital input to the slave has been mapped to the seat switch object in the master.

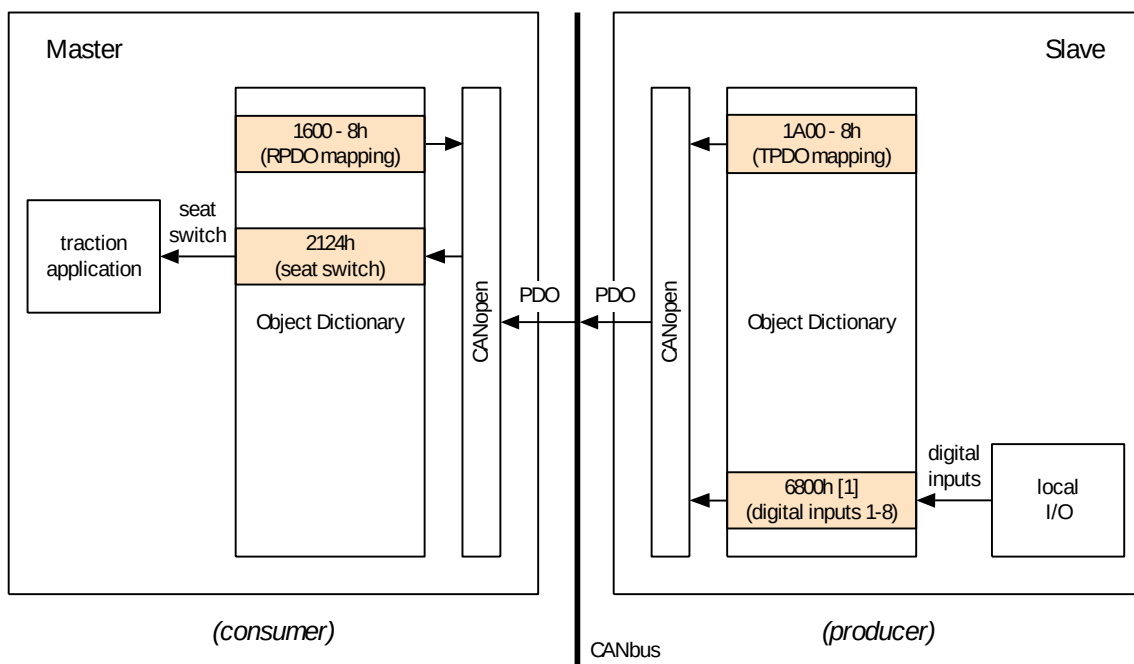


Figure 23 Example of a digital input mapped to the seat switch object via PDO and the CANbus

Gen4 supports RPDO timeout fault detection. This can set a warning, drive inhibit or severe fault depending on the configuration in 5902_h.



NOTE: RPDO timeout can be used for non-CANopen systems which do not support heartbeating. By default, RPDO timeout is disabled, and normal CANopen heartbeating protocol (see section Network Configuration (page 6-4)) is assumed to be used.

Encoder



WARNING: It is important that the number of encoder pulses per revolution is entered correctly. If this information is not correct, the controller may not be able to brake the motor effectively.

To configure the encoder:

1. Enter the resolution pulses/rev at 6090_h.
2. Check whether the encoder requires controller pull ups enabled (e.g. open-collector type) and enable pull-ups if needed at 4630_h. The default setting is no pull-ups, which is suitable for current source encoder types.
3. Select the required encoder supply voltage (10V or 5V) at 4630_h.

Refer to the instructions in sections Motor speed sensor (encoder) (page 5-10) and Motor commutation sensor (page 5-11) for more information regarding encoder configuration.

Stall detection can be configured at 4626_h. This can disable the torque in the event of a stalled motor or a failed incremental encoder.



NOTE: Configurable internal pull-up is only available with inputs dedicated to AB encoder. UVW inputs always have internal pull-up present.

Digital inputs

The state of the digital inputs can be read at object 6800_h.



NOTE: Digital inputs are either all active low (switch return to battery negative) or all active high (switch return to battery positive). A mixture of active low and active high inputs is not possible. The default setting is active low.

To configure digital inputs:

- Set active high/low logic at 4680_h.
- Set wire off protection at 4681_h. Any two digital inputs can be configured with wire-off protection. See Table 2 Connector A pin out and wiring information on page 3-19 (pins 14 and 15) for more details.
- Set digital input polarity at 6802_h. This is used to configure normally closed/open switches.

Analogue inputs

The analogue input voltages can be read at object 6C01_h. Voltages are 16-bit integer values with a resolution of 1/256 V/bit.

Although each input is usually assigned a specific task by default, any of the inputs can accept a variable voltage or a potentiometer. Analogue inputs can also be used as additional digital inputs.

The following table summarises the analogue inputs and any special features:

Name	Object	Pin	Usage
Wiper Input 1	6c01 _h ,1	22	Input from external voltage source or 3-wire pot wiper. Use pin 34 as supply for 3-wire pot.
Wiper Input 2	6c01 _h ,2	23	Input from external voltage source or 3-wire pot wiper. Use pin 35 as supply for 3-wire pot.

Analogue Input 1 or Supply for Wiper Input 1	6c01 _h ,3	34	Use for 2-wire pot input or as a supply for wiper input 1. Has internal pull-up.
Analogue Input 2 or Supply for Wiper Input 2	6c01 _h ,4	35	Use for 2-wire pot input or as a supply for wiper input 2. Has internal pull-up.
Motor thermistor	6c01 _h ,5	33	Use for motor thermistor input or 2-wire pot input. Has internal pull-up.

Wire-off detection

Enable wire-off detection for analogue inputs at 46C0_h to 46C4_h. For each input specify the allowable range of input voltages. To disable, set the ranges to maximum.

Motor thermistor input

You can connect a thermistor sensor to the Motor thermistor input or a switch to any digital input.

Type	Specification
PTC Silistor	Philips KTY84, KTY83 or equivalent
Switch	Connected to a general purpose digital input

To setup go to object 4620_h:

- Configure as none, switch, PTC or CAN based thermistor
- For KTY84 thermistors, set the PTC type to KTY84.
- For KTY83 thermistors, set the PTC type to KTY83.
- For non-KTY84, KTY83 PTC thermistors, set the PTC type to User Defined and then set the expected voltages at 100°C (high temperature voltage) and 0°C (low temperature voltage). The Gen4 will linearly interpolate temperature with voltage.
- If you are using a switch select the digital input source
- For CAN based thermistors, the temperature can be loaded into object 4600_h sub 16 using an RPDO.

Read the measured motor temperature (PTC) or switch operation at object 4600_h.

Analogue inputs configured as digital inputs

Each analogue input can also be used as a digital input.

To configure an analogue input as a digital input, set the high and low trigger voltages at object 4690_h.

The digital input status object, 6800_h, contains enough sub-indices for the digital and analogue inputs. Sub-index 1 is the states of the digital inputs, and sub-index 2 is the states of the analogue inputs converted to digital states.

Analogue (contactor) outputs



CAUTION: Do not use contactors which have built in 'economiser' circuits, the internal circuits are not compatible with the controller and may cause malfunction or damage. The same power reduction can be achieved with a standard coil by using the configurable pull-in and hold voltage settings.

There are 3 analogue outputs which you may have mapped to one or more contactor functions such as: line contactor, pump, power steer, electro-brake, external LED, alarm buzzer and horn.

Configure each of the outputs used in your system:

- Choose voltage control or current control for each analogue output at 46A1_h.
(At the time of writing, current controlled devices can only be operated from Gen4 by mapping a signal input to the controller from an external 3rd party node).
- Set the frequency of each output to a fixed value of 16 kHz or any value between 40 Hz and 1 kHz at 46A2_h and 46A3_h. You can have only one low frequency setting per controller. Low frequencies are normally used with current-controlled outputs.
- Set the analogue output values at object 6C11_h. The value is either a voltage or current depending on whether the output is voltage controlled or current controlled. Values are 16-bit integers with a resolution of 1/256 V/bit or A/bit.

Error control



WARNING: It is important that analogue outputs on nodes other than the master must have appropriate error configuration to protect against CANbus faults. This section explains how to configure the outputs to go to a safe state in the event of a CANbus fault. It is the installers responsibility to define what a safe state is for each output.

In a CANopen network, the slave node on which the analogue (contactor) outputs reside can be different to the master node which calculates the output value. If the CANbus fails, the master node is no longer able to control the slave outputs. In this situation, the outputs may need to change to a safe value. This is achieved with error control.

To configure error control:

- Set each output at object 6C43_h to use its last set value or the value at 6C44_h if the CANbus fails.
- Set values if needed at 6C44_h for each output. These values are 32-bit integers, but the bottom 16-bits are ignored. The top 16-bits give the error value in 1/256 V/bit (or A/bit for current controlled outputs).

Some examples of typical configurations may be:

- Electro-mechanical brake on slave node. If CANbus communication is lost, it may be desirable to apply the electro-mechanical brake on the slave device. In this case, enable error control in 6C43_h and set the error value in 6C44_h to 0.
- Power steer contactor on slave node. If CANbus communication is lost, it may be desirable to leave the power steer output in its previous state. In this case, disable error control in 6C43_h.
- CANbus communication error lamp on slave node. If CANbus communication is lost, it may be desirable to activate an output on the slave device. In this case, enable error control in 6C43_h and set the error value in 6C44_h to an appropriate voltage for the lamp.



NOTE: The above examples are for illustration purposes only. It is the responsibility of the installer to decide on the required state for each output in the event of a CANbus failure.

Vehicle performance configuration

Ensure you have completed the CANopen network setup, Motor Characterization and I/O Configuration processes described above.

Safety Interlocks

FS1

The FS1 switch is normally part of the throttle assembly. It closes when the throttle is pressed. The throttle voltage is ignored until FS1 is closed.

FS1 features are configured at 2914_h:

- SRO (static return to off): inhibits drive if FS1 is closed for the SRO delay without any direction (forward or reverse) being selected.
- FS1 recycle: forces the operator to lift their foot off the throttle before allowing drive after a direction change.

Deadman

The deadman switch operates similar to the FS1 switch, whereby, it inhibits drive until it is active. However, the deadman switch applies the electro-mechanical brake immediately on deactivation, whereas FS1 waits for the vehicle to stop before applying the brake.

Seat

The seat switch indicates operator presence on the vehicle. Drive is not allowed if this switch is open. If the seat switch opens during drive for a period longer than the seat switch delay, a fault is set, disabling drive. To clear a seat fault, close the seat switch, open FS1 and deselect the forward/reverse switch.

Set the seat switch delay at object 2902_h.

Handbrake

If mapped to a digital input, the handbrake switch inhibits drive if the vehicle handbrake is applied. Controlled roll-off detection is still active when the handbrake is applied in case the brake fails.

Sequence Fault Masking

If an application does not require it, sequence fault checking can be disabled on selected drive inputs. This is set at 2918_h.

Similarly, drive inputs can be masked when clearing drive inhibit faults. This is set at 291A_h.



CAUTION: These masks must only be applied if the application has other adequate means of protection. It is the responsibility of the installer to ensure this.

Torque mode/speed mode



WARNING: Speed mode (or speed control) is not recommended for on-highway vehicles as it can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.

The Gen4 controller provides both torque and speed control modes. Objects 2900_h and 6060_h are used to set which mode to use. The default setting is torque mode.



WARNING: Always ensure 2900_h on the master node and 6060_h on all the traction nodes (master and slaves) match otherwise motor signals between the master and slaves may be misinterpreted.

The speed control (speed mode) or speed limit (torque mode) is controlled using PI loops. These loops are configured at 4651_h. The following parameters can be configured:

- Standard proportional and integral gains (4651_h, 1+2). Used to configure the loops during normal operation.
- Low speed proportional and integral gains (4651_h, 3+5). Used to configure the loops at low speeds (<50 RPM) and during hill hold. These are normally set lower than the standard gains to dampen oscillation as the vehicle comes to a stop.
- Roll back integral gain (4651_h, 4). Used to boost the integral term to prevent vehicle roll-off down inclines, particularly when Hill Hold is enabled. Normally, this gain is higher than the standard integral gain.
- dw/dt gain (4651_h, 6). For speed mode this is used to boost the torque output when a large increase in speed demand occurs. For torque mode this is used to apply compensatory torque to damped oscillations induced from the vehicle drive train.
- Integral initialization factor (4651_h, 7). Used to initialize the integral term on entry to speed limit in torque mode. This factor is multiplied by the actual torque to set the integral term. Not used in speed mode.
- Speed filter pole (4651_h, 8). Used to filter speed used by speed limit loop.
- Speed pre-limit threshold (4651_h, 9). Speed limit algorithm will start cutting back torque when speed is within this threshold of the maximum.
- Opposing maximum speed limit ramp rate (4651_h, 10). Rate at which opposing speed limit ramps back to 0 RPM.

These settings affect how driver demands are interpreted by the controller. In torque mode, the throttle push translates into a torque demand, which is applied to the traction motor. In speed mode, the throttle push translates to a speed demand. The controller then calculates the torque required to maintain this speed.

The difference between these control methods is most apparent when driving on an incline. In torque mode, when the vehicle is driven uphill, the vehicle speed will decrease due to the increased load. The operator must apply more throttle demand in order to maintain speed. In speed mode, the controller will apply additional torque in order to maintain the operator's speed demand, without the operator having to increase throttle demand.

Throttle

General

The controller can use 2 or 3 wire throttle inputs of the following types:

- Linear potentiometer in the range 470 Ω to 10 k Ω
- Voltage source in the range 0V to 10V: compliant with the standard 0..5 V, 0..10 V or 3.5..0 V ranges

To setup throttle inputs see 'Analogue' on page 6-13. The throttle voltage (2220_h) must be mapped to an analogue input.



CAUTION: Inputs with wire-off detection should be used for the throttle input to detect wiring faults. This is especially important if a wire-off sets maximum throttle. See section Analogue inputs (page 6-13) for more information. Configure throttle wire-off detection threshold at 2910_h, 21.

Setup the characteristics of the throttle at 2910_h, sub-indices 2 to 21.

- Define the throttle voltage input: this is the relationship between the throttle voltage and the throttle value. Separate relationships can be specified for forward and reverse. Each relationship has two points, a start and an end. The points are configured differently for standard and directional throttles as shown in Figure 24 and Figure 25 respectively.

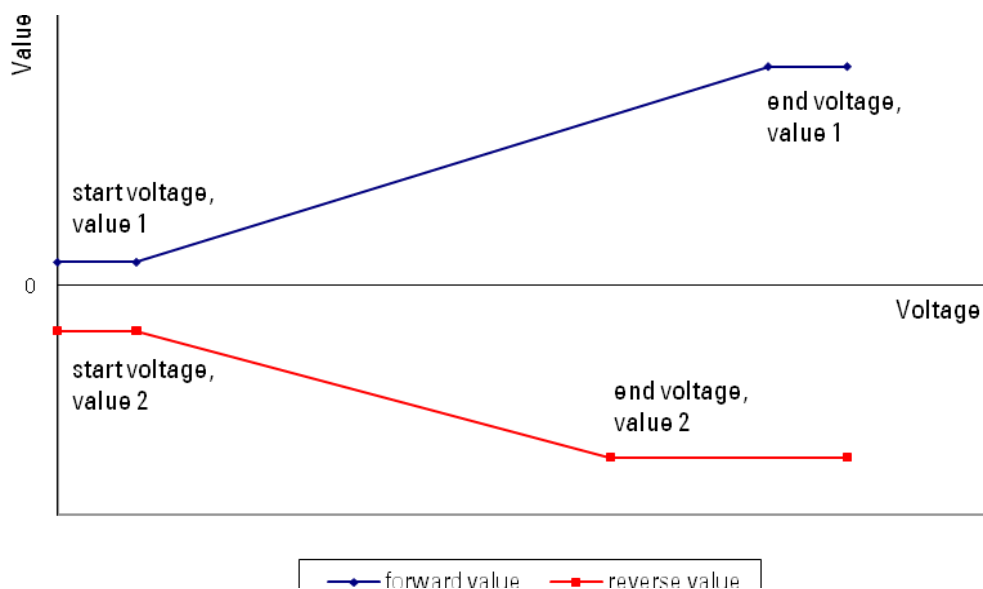


Figure 24 Standard throttle configuration



Note: If the reverse characteristic is the same as the forward characteristic, just set all the reverse throttle parameters to 0 in 2910_h.

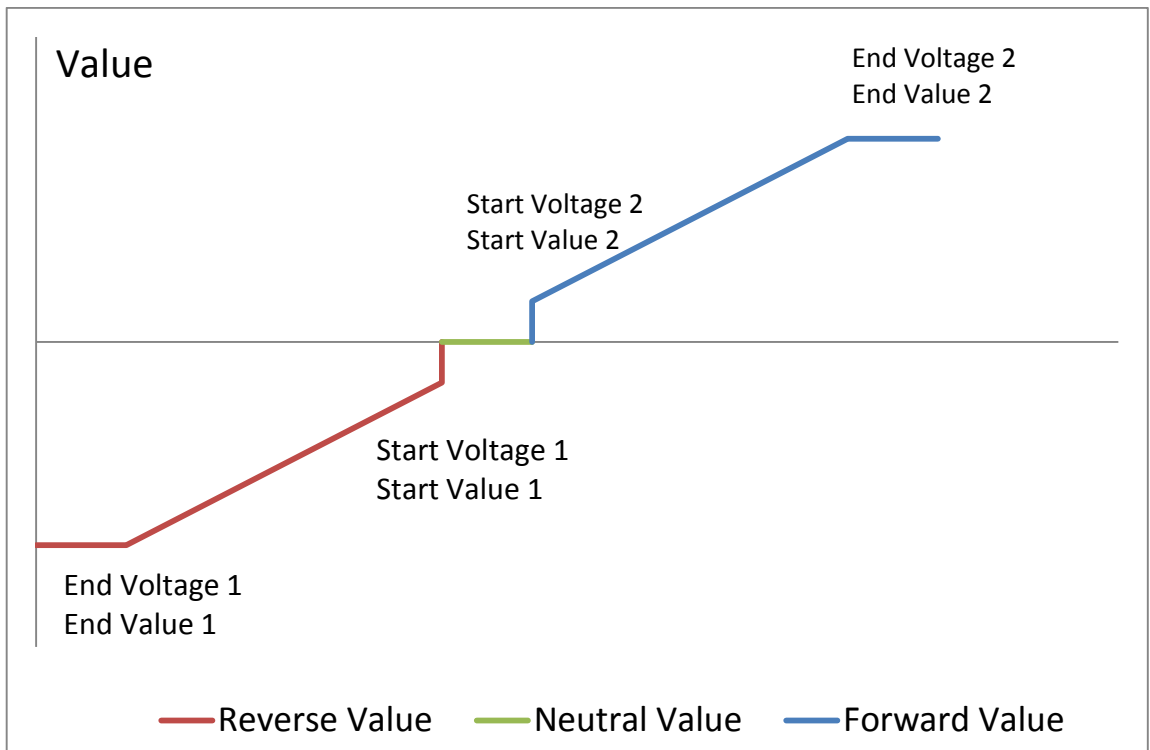


Figure 25 Directional throttle configuration

- Define the input characteristic: this is a profile to the throttle value and can be linear, curved, crawl or user-defined as shown in Figure 26. The curved and crawl characteristics give greater throttle control at low speeds.

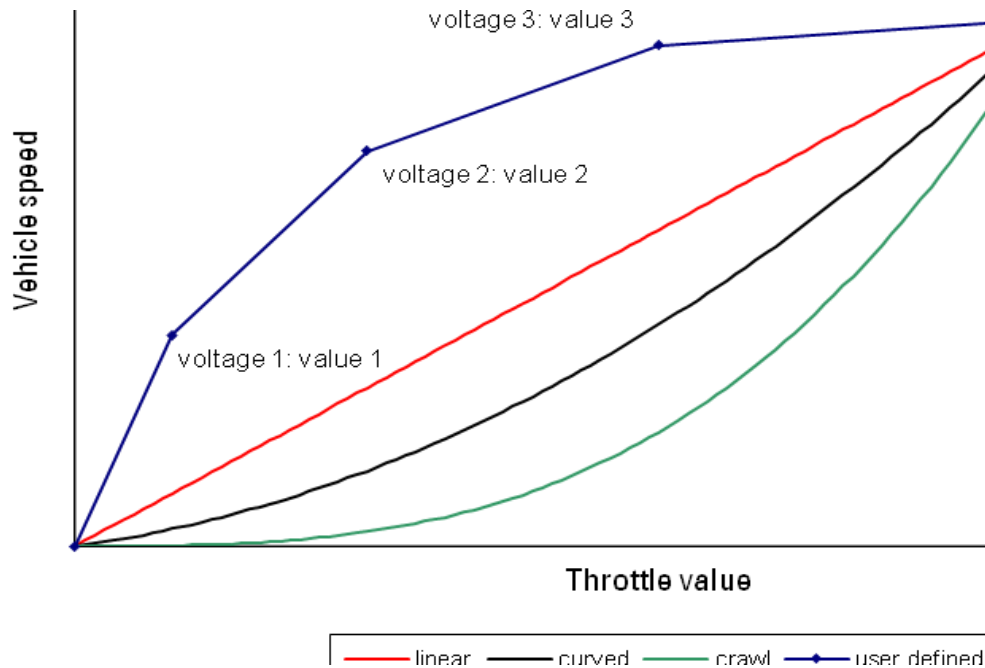


Figure 26 Input characteristics

The throttle value calculated from the voltage can be read at 2620_h.

Dual Throttle Inputs

Single and dual throttle inputs are supported.

Single throttle inputs are normally used with other interlock inputs (eg FS1, deadman, etc) and use a single input voltage to determine driver demand.

Dual throttle inputs use two separate input voltages, each of which is converted to a throttle value using 2910_h, sub indices 3 to 6 (throttle input 1) and sub indices 7 to 10 (throttle input 2). If the throttle values differ by more than 5%, a throttle fault is set and the system will not drive.

To enable dual throttle functionality, map a second analogue input to 2224_h. The throttle value for the second throttle input can be read at 2626_h.

Dual throttle systems allow a virtual FS1 feature, which can be used instead of an actual FS1 switch. This feature can be enabled on dual throttle systems using 2910_h, 1.



CAUTION: The voltage input characteristics of the two analogue throttle inputs must be different.

Creep Torque

Set creep torque at 291f_h. Creep torque allows a small amount of torque to be applied as soon as the throttle is closed. This can be used on some vehicles to overcome the friction required to achieve initial vehicle movement.

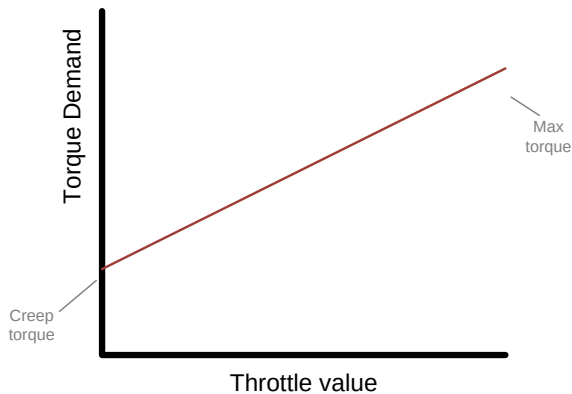


Figure 27 - Illustration showing behaviour of creep torque

Increasing the creep torque level can improve how the vehicle feels when drive is first selected and the vehicle starts to move. However, too much creep torque can make the vehicle uncontrollable at low speeds.



CAUTION: Creep torque will be applied as soon as drive is selected and the throttle is closed. Do not increase the creep torque value to a level that would cause unexpected high levels of torque output for comparatively low levels of throttle push. If in doubt, set the creep torque level to 0%.

Driveability Features



CAUTION: These features are used to configure how the system uses throttle information and how it handles speed limits (in torque mode). The installer must ensure these features are configured appropriately.

Set the following driveability features at 2910_h,1:

- Enable/disable proportional braking. If enabled, the braking torque during direction braking is proportional to the throttle.
- Enable/disable directional throttle. If configured as a directional throttle, the throttle voltage indicates the direction as well as the speed demand. This removes the need for forward and reverse direction switches.
- Proportional speed limit enable/disable. If enabled, speed limit is proportional to the throttle, otherwise speed limit is fixed at the forward or reverse maximum speed. Only used in torque mode.



WARNING: Proportional Speed Limit is not recommended for on-highway vehicles as it can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.

- Braking directional throttle enable/disable. If enabled, a directional throttle can be used to demand a drive or braking torque in conjunction with the direction switches. Only used in torque mode.
- Reverse speed limit encoding. Controls how reverse speed limits are handled in torque mode. Must always be enabled on Slip control systems, and must always be disabled on flux vector and PMAC systems.
- Handbrake fault. If enabled, a handbrake fault is set when a direction is selected whilst the handbrake input is active.
- Proportional speed limit during braking enable/disable. If enabled, speed limit is proportional to throttle only in drive states. Maximum speed limit is allowed in braking states. Only used in torque mode and for open loop slip motors. Proportional speed limit above must be enabled for this option to have any effect.
- Driveability Consolidation. Normally, driveability profiles are only used to reduce vehicle performance, however, if this is enabled, an active driveability profiles over-writes the baseline. This allows vehicle performance to increase when a profile is active. Note, that this feature is not available in all software builds.
- Allow step change in steering angle. If enabled, steering angle can change instantly with steering voltage. If disabled, steering angle is rate limited to 90°/s which prevents sudden steering angle changes in the event of a steering sensor wire-off.
- Virtual FS1 enable/disable. If enabled, this sets up a virtual FS1 feature on systems with dual throttle inputs configured.
- Positive (absolute) Steer Angle only enable/disable. If enabled steer angle is always positive in both directions. Used for single traction systems with steering cutback. Motor mapped must be left motor
- Separate Seat Regen Braking enable/disable. If enabled, separate regen setting is activated for regenerative braking with operator off the seat. Seat Regen settings are set at 2928_h.
- Slave Left Motor Speed Inversion enable/disable. Inverts left motor slave actual speed when slave inversion switch activates.
- Proportional speed limit during drive enable/disable. If enabled, speed limit is proportional to throttle only in braking states. Maximum speed limit is allowed in drive states. Only used in torque

mode and for flux vector motors. Proportional speed limit above must be enabled for this option to have any effect.

Set the following driveability features at 2910_h,22:

- Direction selected indication in controlword is latched enable/disable. If enabled the selected direction bit in the control word holds the previous selected direction and doesn't return to neutral. This will help prevent the vehicle from rolling back uncontrolled on an incline if the throttle is pressed very briefly when hill-hold or controlled roll-off is active.
- The latching on the seat regen braking enabled/disable. If enabled (default) the seat regen braking state can only be exited by closing the seat switch, then changing the direction selection, for example from Forward to Neutral. If disabled, the seat regen braking state will be exited when the seat switch is closed.
- Brake feathering during seat regen braking enable/disable. If enabled (default) brake feathering will be applied to the braking torque during seat regen braking state. If disabled it will use the level set in 2928_h to 0 RPM.

An s-curve profile can be applied to the speed target (in speed mode) or maximum speed (in torque mode). This can be set at 290A_h.

Acceleration and braking

See 'Driveability profiles' for more information on page 6-24.

Some vehicles can exhibit shock due to the rapid reversal of torque after a direction change. 2909_h can be set to force the vehicle to remain stationary for a period before driving in the new direction.

To prevent early exit from neutral braking, a debounce timer can be set at 290D_h. Neutral braking only finishes when the vehicle has been stopped for longer than this time. This can help prevent early exit of neutral braking due to motor oscillation caused by under damped suspension.

On vehicles with gearbox meshing issues, a slower rate of torque ramp up at low speeds can be configured at 291C_h. This slow rate of change of torque lessens shock due to gear meshing. Used in torque mode only.

Brake feathering reduces neutral and foot braking torques as the vehicle speed approaches 0 to prevent any roll-back in the opposite direction. This is set at 290E_h. Use 290E_h,1+2 to set start and end speeds for feathering, 290E_h, 3 to configure the final torque at the end of braking and 290E_h, 4+5 to configure entry and exit ramp rates for feathering torque to prevent disturbance in torque when changing between drive and braking conditions. Used in torque mode only.

Footbrake

The controller can use a switch or analogue voltage as the footbrake input. If a footbrake switch is mapped, it applies maximum foot braking when the switch is closed. The footbrake switch object (2130_h) must be mapped to a digital input.

If the footbrake input is an analogue voltage, configure the voltage levels in the same way as the throttle. The footbrake voltage (2221_h) must be mapped to an analogue input.

Configure the characteristics of the footbrake at 2911_h:

- Drive/foot braking priority. If the throttle and footbrake are pressed at the same time, this setting determines whether the system attempts to drive or brake.
- Minimum speed for braking. Foot braking stops when the vehicle speed drops below this level.
- Footbrake voltage input and Input characteristic. These settings are similar to those for the throttle. Refer to the Throttle section above for more information.

- Footbrake priority timeout allows the configured priority to change after a timeout period. Setting zero will disable this feature.

The footbrake value calculated from the voltage can be read at 2621_h.

Steering inputs – twin driving motor systems



CAUTION: Loss of steering information can make a vehicle operate erratically. The analogue input use for the steering sensor should have suitable wire-off protection configured.

Twin motor systems, which use the drive motors for turning, require some means of determining the angle of the steering wheel.

To do this use one of these options:

- A steering potentiometer to give an analogue voltage which is a linear function of the steering angle. The steer potentiometer voltage (2223_h) must be mapped to an analogue input.
- Four digital inputs representing 'inner left', 'inner right', 'outer left' and 'outer right'. The inner switches indicate the steering angle where torque to the inner wheel motor is removed. The outer switches indicate the steering angle where inner wheel motor changes direction. The outer switches are optional. The steer switches (212B_h to 212E_h) must be mapped to digital inputs.
- Steering angle from 3rd party CAN device. This can be received via RPDO on object 2624_h in 0.01°/bit resolution.

To configure steering inputs go to index 2913_h in the Object Dictionary:

- Setup the voltages corresponding to fully left, fully right and straight ahead. Using this information, Gen4 calculates the steering angle based on the voltage from a steering potentiometer.
- Setup the steering map. This map defines the relationship between the inner and outer wheel speeds and the steering angle. Each map has 4 user definable points as shown in Figure 28.

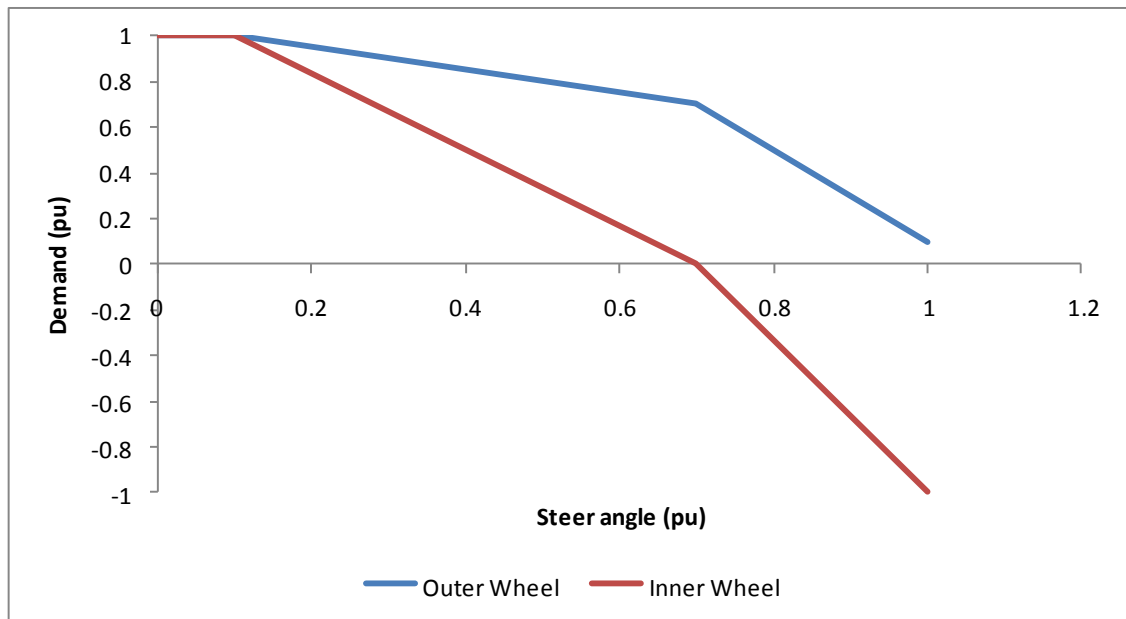


Figure 28 Graph of speed vs. steering angle

The speed and steering angle are normalized. Speed is normalized to maximum vehicle speed and the steering angle to 90°.

In speed mode, outer wheel speed target and maximum torque is scaled according the outer wheel map. Inner wheel speed target and maximum torque is scaled to the outer wheel demands according to the inner wheel map.

In torque mode, both inner and outer wheel maximum speeds are scaled according the outer wheel map. The outer wheel target torque comes from the throttle. The inner wheel target torque is scaled to the outer wheel actual torque according the inner wheel map.

In object 2913_h, 0 to 1 is represented by values in the range 0 to 32767. The inner wheel is scaled according to the outer wheel. Where a demand (pu) of -1 is shown at 90° for the inner wheel, this means the inner wheel demand will be equal and opposite to the outer wheel.

The calculated steering angle can be read at 2623_h. An angle value of -32767 indicates full steering to the left, +32767 full steering to the right and 0 is straight ahead.

If steering switches are used instead of a steering potentiometer, only part of the steering map is used as shown in Table 6.

Value	Description
2913 _h ,9	Outer wheel speed during inner wheel cutback
2913 _h ,11	Outer wheel speed during inner wheel reversal
2913 _h ,17	Inner wheel cutback speed
2913 _h ,19	Inner wheel reverse speed

Table 6 Objects to set when using steering switches



NOTE: During a turn the inner wheel speed is slowed by power reduction instead of braking to prevent the outer wheel motor working against the inner wheel motor.

Driveability profiles



WARNING: Ensure driveability profiles are disabled when not required. Activation of a driveability profile can cause driving parameters to change.

Driveability profiles allow you to set maximum values for speed, torque, acceleration and deceleration for use in a range of operational situations. In addition, in torque mode, there are ramp rates for speed limits as well. and Figure 30 show the change in speed and torque target under various driving conditions over a period of time.

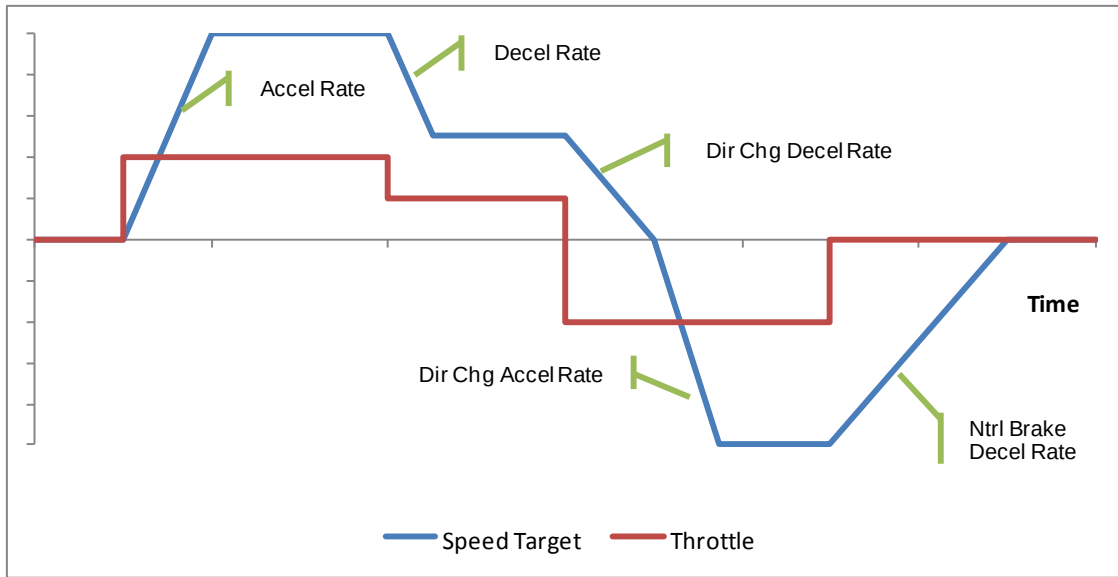


Figure 29 Speed mode acceleration/deceleration

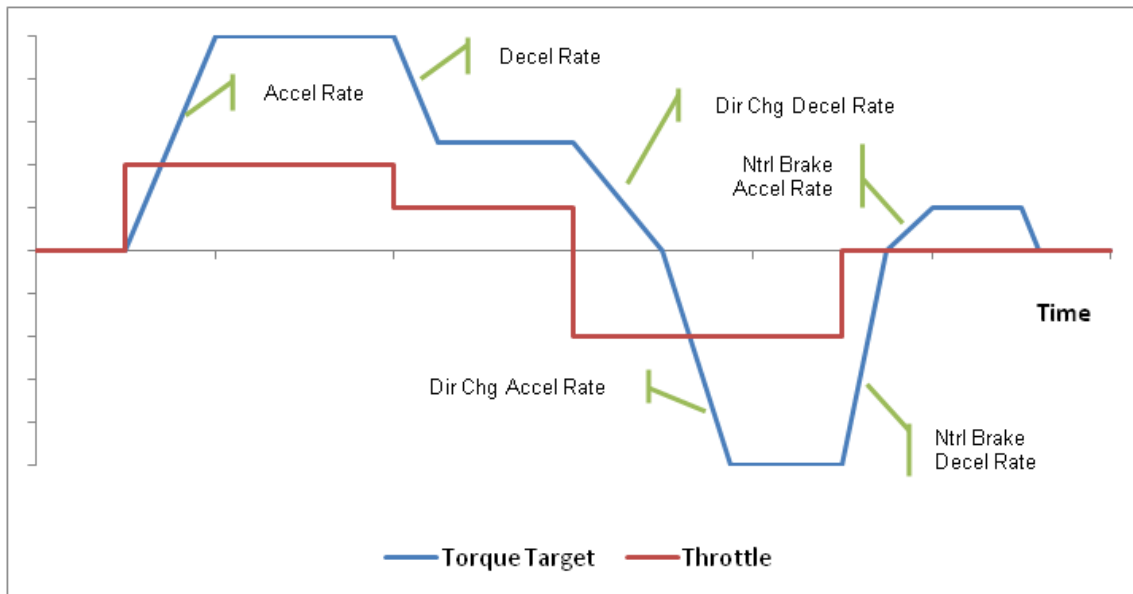


Figure 30 Torque mode acceleration/deceleration

In Torque mode, the acceleration and deceleration rates control the rate of change of torque. In Speed mode, the acceleration and deceleration rates control the rate of change of speed.

You can select reverse while driving in the forward direction with your foot still on the throttle. In this situation the controller applies braking in the form of a direction change deceleration rate down to zero speed. It then applies a direction change acceleration rate to increase the vehicle's speed in the reverse direction up to the set maximum speed as shown above.

Configure the following drivability profiles to suit your application (each containing the same set of parameters):

- Traction baseline profile: the default and highest set of values (2920_h).

- Drivability select 1 profile: invoked when drivability select 1 switch is active (2921_h) or an alternative trigger is active (see below).
- Drivability select 2 profile: invoked when drivability select 2 switch is active (2922_h) or an alternative trigger is active (see below).

The traction baseline profile contains the default maximum values. All of the remaining profiles apply lower, modifying values to the baseline profile. BDI and service profiles, when configured, are automatically applied by the software under preset conditions. For example you may want to limit the acceleration and maximum speed of a vehicle when the battery gets low to maximize the operating time before recharge. The remaining profiles are applied by the driver with a switch.

Drivability profiles can also be invoked by internal software triggers, such as BDI low, service required or low speed. These can be selected to suit specific application requirements. Set the profile triggers in 2931_h.



NOTE: *Where more than one profile is active, the lowest value(s) are used by the software.*

Speeds in driveability profiles are scaled according to the vehicle gear ratio (2915_h). This is used to convert speed in RPM to any other preferred unit such as KPH or MPH. To remove this scaling and leave driveability profile speeds in RPM, set 2915_h,3 to 1.

Torques in driveability profiles are in 0.1%/bit resolution. These are converted to Nm using the motor rated torque value at object 6076_h.

Ramp rates in driveability profiles are in either RPM/s for speed mode, or %/s for torque mode. In speed mode, RPM/s becomes “User Defined Units” / s if the gear ratio is used to rescale the driveability profile speeds.

Speed limit ramp rates are only used in torque mode and are in RPM/s (or user defined units / s).



WARNING: In addition to the speed limit ramp rates in the profiles, 291E_h can be used to configure safety limits on speed limit ramping. The installer should set these ramp rates to suitable levels to ensure speed limits cannot ramp faster than could actually happen on a vehicle. This can protect against harsh braking if traction wheels are momentarily locked.

Smoothing Output Torque

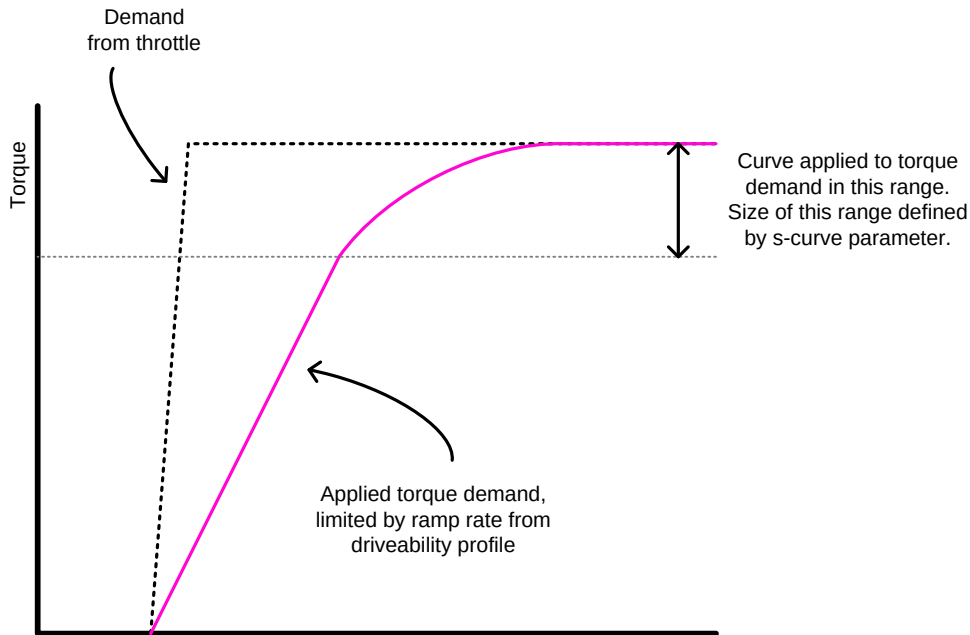


Figure 31 - Illustration of s-curve on torque demand

The controller provides an option to insert an s-curve to the torque demand as it approaches the value requested by the throttle. This curve feature can serve two purposes:

The amount of curve applied can be configured in the object dictionary at index 2933_h. Generally, applying a greater curve range will result in smoother drive, but too much can lower vehicle response. S-curve is applied according to this table:

Value in 2933 _h	S-curve behavior
0	None applied
1	Curve applied within 0.2% of target
2	Curve applied within 0.4% of target
3	Curve applied within 0.8% of target
4	Curve applied within 1.6% of target
5	Curve applied within 3.2% of target

This table continues, with each increment in 2933_h doubling the range over which the curve is applied.

Preventing Wheel Lock Scenarios

For certain vehicle types, particularly on-highway vehicles or electric motorcycles, the possibility of wheel locking during drive must be considered.

During braking, the controller will maintain a speed limit to ensure the vehicle does not over speed if entering braking whilst travelling downhill. If proportional speed limit is set then the speed limit will follow actual speed toward zero whenever actual speed is dropping rapidly, usually due to some external influence such as application of mechanical brakes.

If the brakes are applied too harshly, then there is possibility to lock the drive wheels. In these circumstances, the normal reaction of the driver is to release the brake to allow the wheels to rotate again. The correct operation of the controller in this scenario is to allow the wheels to continue to rotate, and not impose a speed limit.

The maximum rate at which the speed limit can increase or decrease is specified in object 291E_h. By limiting the rate at which the speed limit can decrease, we can ensure that if the brakes are released after they had locked the drive wheels, the controller's speed limit will allow them to rotate again. The operation of this is shown in Figure 32 below.

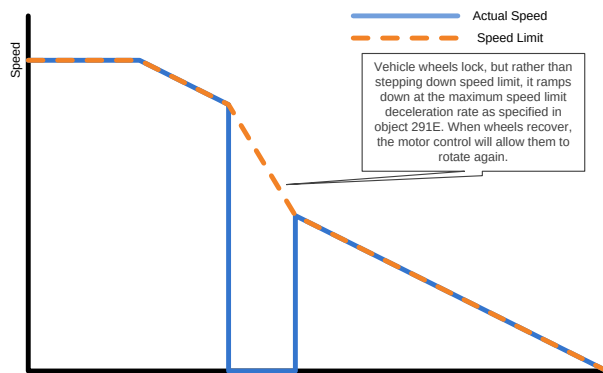


Figure 32 - Example of behaviour of speed limit when drive wheels are locked



WARNING: It is important to consider the behaviour of the vehicle under all drive conditions, including when traction is lost due to locking of the drive wheels. When testing a vehicle, check that the vehicle behaves in a safe manner when performing harsh braking on low-friction surfaces such as gravel.

Controlled roll-off



WARNING: Controlled Roll-Off is not recommended for on-highway vehicles as it can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.

Controlled roll-off limits a vehicle to a slow, safe speed if it starts to move without any operator input. Primarily, it is to prevent uncontrolled movement if a vehicle's brakes fail on an incline. Controlled roll-off operates whether the operator is present or not.

Configure the following at object 2930_h:

- Enable/disable controlled roll-off
- Set a roll-off maximum speed
- Set a roll-off maximum torque

Alternatively, Gen4 can apply an electromagnetic brake if one is mapped and roll-off is detected. Refer to 'Electro-mechanical brake' on page 6-33 for more information.

Hill hold



WARNING: Hill Hold is not recommended for on-highway vehicles as it can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking.

A vehicle on a hill can be held at a standstill for a configurable time when the operator selects neutral. At the end of this time or if the seat switch indicates the operator is not present, hill hold terminates and the vehicle can start to move if parked on an incline. If enabled, the system will enter controlled roll-off after hill hold.

You can set the hill hold delay at object 2901_h. Set the hill hold delay to 0 to disable this feature.

In speed mode, drive torque is disabled whilst neutral braking to stop. However, drive torque must be re-enabled when entering Hill Hold to allow torque to be applied to hold on the incline. Set the speed to re-enable drive torque at 2908_h.

Inching



WARNING: Ensure inch switches are only mapped to digital inputs when required. Activation of these inputs can cause a drive condition to occur.

Inching allows an operator to manoeuvre a vehicle, at low speeds, towards a load. Inching can be initiated with one switch. A time-out is used to prevent the vehicle from continuing to drive indefinitely if the switch gets stuck or goes short circuit.

To configure inching:

- Ensure forward and reverse inching switches have been mapped to two digital inputs.
- Specify an inching speed (0% to 25% of the full speed of the vehicle) at 2905_h sub-index 1. This is either a speed target in speed mode, or maximum speed in torque mode.
- Specify an inching throttle (0 to 100%) at 2905_h sub-index 3. This gives a torque target in torque mode. This is not used in speed mode.
- Specify a time-out (0.1 s to 5.0 s) at 2905_h sub-index 2.

Belly Switch



WARNING: Ensure the belly switch is only mapped to a digital input when required. Activation of this input can cause a drive condition to occur.

The belly switch is normally connected to the end of the tiller arm on class 3 vehicles. When activated it forces a drive condition in forward at a user specified throttle value and maximum speed for a specified time.

To configure belly:

- Ensure the belly switch is mapped to a digital input.
- Specify the maximum belly speed at 290C_h sub-index 2.
- Specify a belly throttle at 290C_h sub-index 1. This will determine the torque demand in torque mode or speed demand in speed mode.
- Specify a belly time out at 290C_h sub-index 3. The belly function will cease after this time has expired.

Drivability select switches



WARNING: Ensure the driveability switches are only mapped to digital inputs when required. Activation of these inputs can cause driving parameters to change.

There are two drivability select switches (2126_h and 2127_h).

To enable either of these they must be mapped to digital inputs. When they are active, the corresponding drivability profiles (2921_h and 2922_h) are applied.

See Drivability profiles (page 6-24) for more information.

Economy

The economy input is an analogue input which can be used to increase vehicle efficiency and extend battery life. It is normally controlled using a potentiometer mounted on the vehicle's dashboard. The economy voltage (2222_h) must be mapped to an analogue input.

Efficiency is improved by reducing the acceleration rate or the maximum torque.

Configure the economy input at object 2912_h as follows:

- Economy function: select acceleration or torque.
- Economy voltage input: These settings are similar to those for the throttle (see page 6-17).

The economy value calculated from the voltage can be read at 2622_h.

Seat Regen Braking

The seat switch can be used to override the current driveability settings with a higher value as set in 2928_h. This allows the vehicle to use stronger braking to bring the vehicle to a halt when the driver is not present. This overrides the following settings:

- Maximum torque, Acceleration and Deceleration rates in Neutral Braking
- Maximum torque, Acceleration and Deceleration rates in Footbraking

This can be configured to only be activated above a certain speed to prevent activation when the vehicle is stationary. A "Seat Warning" fault is set in this state.

Pump configuration

The controller can use a mixture of switch and analogue voltages as the pump input. In addition, the power steer function can be used as an extra input to the pump if the pump motor is required to supply pump and power steering.



NOTE: Pump motors always run in speed mode. Ensure the motor slave is also configured for speed mode in 6060_h.

General Setup

Configure the pump features at 2A00_h:

- Inhibit pump when BDI drops below cut-out level. If already operating when the cut-out occurs, the pump will continue to operate until all pump inputs are inactive.
- Drive Enable switch and/or Seat switch input disables pump.

- Ignore Line Contactor state. Allows the pump to operate if it is not connected to the battery through the line contactor. Should be set if the pump also supplies power steering and the power steer is required to operate when the line contactor is open.
- Use Power Steer target velocity as pump input, if pump also supplies power steering.
- Enable minimum pump speed. Enable this to force the pump to run at minimum speed (2A01_h, 2) even when there is no trigger. Can be used to maintain minimum pump pressure.
- Pump to stop on Low Battery. Enable to force pump to stop immediately on low battery condition.
- Use power steer demand to minimum pump speed. Enable this to force the pump to use power steer demand as a minimum speed. Can be used to maintain minimum pump pressure for power steering.

Set the pump minimum and maximum speed, maximum torque, acceleration and deceleration at 2A01_h. The pump speed is calculated as the value from the inputs multiplied by the maximum speed.

Priority/additive inputs

Each pump input can be configured as a priority input or an additive input. When calculating the pump demand, the controller selects the demand from the highest priority active input, and then adds the demand from all the active additive inputs.

Configure priority/additive levels in 2A10_h and 2A11_h, and 2A20_h to 2A26_h.

Pump throttles

There are 2 pump throttle inputs, which can be configured independently at 2A10_h and 2A11_h. The pump throttles allow proportional control of the pump speed.

Configure inputs as priority or additive and set the voltage levels in the same way as the traction throttle. The pump throttles must be mapped to analogue inputs.

Pump switches

There are 7 pump switch inputs. Configure each input as priority or additive and assign it a value at 2A20_h to 2A26_h. The pump switches must be mapped to digital inputs.

Pump Driveability Profiles

Pumps have configurable driveability profiles. Profiles are triggered by pump driveability select switches (2152_h and 2153_h). One or more of these switches must be mapped to enable pump profiles.

Each profile allows the installer to reduce acceleration and deceleration rates, throttle and switch values and maximum torque.

Set pump driveability profiles at 2A30_h and 2A31_h

Power steer configuration

General

Power steering can be provided using:

- Contactor. Map the power steer contactor drive object to an analogue output.
- Pump motor controller. Configure pump to provide power steering. Power steer demand is added to pump demand.
- Dedicated motor controller. Map power steer application motor object to motor control slave.



NOTE: *Power steer motors always run in speed mode. Ensure the motor slave is also configured for speed mode in 6060_h.*

-

The power steer can be triggered by a number of events:

- Vehicle moving
- FS1 switch activating
- Direction selected.
- Seat switch activating
- Footbrake activating



CAUTION: The power steering function will always attempt to execute, even if the line contactor is open due to a fault condition. This is to ensure power steering continues to operate at all times.

Set the power steer motor speed, acceleration and deceleration at 2B01_h. This is not required if the power steer motor is operated by a contactor.

Variable Assist Power Steering

Gen4 supports a variable assist power steering algorithm which can be used to reduce the power steering speed as vehicle traction speed increases to a user configurable level. Set the reduction factor and traction speed in 2B02_h. This allows power steering effort to be reduced as vehicle speed increases to prevent steering becoming too light.

Vehicle features and functions

Ensure you have completed the CANopen network setup, Motor Characterization, I/O Configuration and Vehicle Performance Configuration processes described above.

Contactors

Ensure voltage control has been selected (see 'Analogue' on page 6-14).

To configure any contactor:

- Set pull-in voltage, pull-in time and hold-in voltage at 2D00_h
- Enable each output to operate at the pull-in voltage or at the maximum voltage at 2D01_h
- If required enable each output to reduce to the hold voltage level at 2D02_h

Line contactor

The line contactor object (2400_h) must be mapped to an analogue output.

The line contactor is used to isolate controllers and motors from the battery during power down or in case of a serious fault. It is normally closed all the time the vehicle is powered, but it can be configured to open when the vehicle has been stationary for a period of time.

Configure line contactor dropout at object 2820_h. See also 'Contactors' above.

The controller has a capacitor pre-charge feature used to protect line contactor tips from damage due to in-rush currents when the contactor closes.



NOTE: Writing to 5180_h starts a pre-charge cycle. The pre-charge circuit can only supply enough current to charge the capacitors of one controller. Where more than one controller is present, the pre-charge circuit on each must be used. If an Gen4 is configured as the vehicle master, it controls the pre-charge of all slave nodes automatically.

The pre-charge level is configurable between 50% and 90%. The level can be adjusted by object 5820_h.

The minimum capacitor voltage allowed for the line contactor to close is set in 5821_h.

Electro-mechanical brake



WARNING: Electro-mechanical brakes are not recommended for on-highway vehicles as they can cause the traction motor/wheel to remain locked or brake severely if the wheel is momentarily locked due to loss of traction on a slippery surface and/or mechanical braking. Also, electro-mechanical brakes normally fail to the applied state, meaning any loss of power, or wiring fault can cause the brakes to be applied.

The electro-mechanical brake object (2420_h) must be mapped to an analogue output.

Set the conditions under which it is applied at 2903_h.

The brake can be applied when the vehicle stops or when roll-off is detected. If the brake is configured to apply when the vehicle stops, it is not applied until the vehicle has been stationary for more than the brake delay time. The brake also can be configured to not apply if the vehicle speed exceeds a minimum, configured in 2903_h,6, during the brake apply timer period. This can be used to prevent the electro brake being applied whilst the vehicle is moving.

In the event of a severe fault the brake can be configured (via 2905_h,5) to apply immediately or to wait until the vehicle stops before applying the brake. In the event of an encoder fault however brake remains released.



WARNING: In the event of an Encoder Fault on a *slave node* causing a perceived zero speed by the master traction controller, the brake will apply regardless of the setting in (via 2905_h,5). This caveat only applies to multi node systems.

It is possible to detect an electrobrake wire off by configuring a minimum brake coil current in 2903_h,4. Should the coil current drop below this value whilst energised then the controller sets a Drive Inhibit Fault and neutral brakes to a stop. The fault clears when neutral is selected, if the brake is commanded to be applied, or neutral is selected and the current exceeds the minimum value.



WARNING: It is not possible to configure electro brake wire off on slave nodes, where the brake is released via a CANopen PDO.

To prevent vehicle roll away on inclines, the electro-mechanical brake normally does not release until the traction motor(s) are producing torque. This feature can be disabled using 2903_h,3.

External LED

This mirrors the operation of the controller's on board diagnostic LED. The external LED object 2401_h can be mapped to an analogue output to drive a lamp on a vehicle dashboard.

Alarm buzzer

The alarm buzzer object (2402_h) must be mapped to an analogue output.

Configure the alarm buzzer output, if required, to be activated by one or more of these conditions at 2840_h:

- forward motion or forward direction selected
- reverse motion or reverse direction selected
- faults other than information faults
- controlled roll-off
- BDI low.

A different cadence for each of the above conditions can be configured.

Brake Lights

A brake light output object is available (2404_h) and can be mapped to an analogue output. The brake lights will illuminate whenever the footbrake is pressed (providing either an analogue or digital footbrake input is available) or the system is in direction change braking.

Horn

Ensure a digital input switch is mapped to the horn switch object (2101_h) and an analogue output is mapped to the horn object (2403_h).

Vehicle Speed Calculation

The controller can be configured to calculate vehicle speed from motor speed by setting a configurable ratio between these values in object 2915_h. Calculated vehicle speed can then be transmitted to the CANbus for use with compatible displays, or used to keep a log of total distance travelled by the vehicle.

The convention is to calculate vehicle speed as a signed number in 12.4 format in kph. This is required for compatibility with ClearView displays and the odometer. In case a custom display is used whose units are different, a user speed calculation is also provided whose units are independent from all other features.

Two sets of ratios are provided for calculation of a vehicle and user speeds, located in object 0x2915. While vehicle speed is a signed value, the option to have unsigned user speeds is also provided (an absolute value will be calculated).

The ratio between motor speed and vehicle speed will be dependent on vehicle drive train parameters such as gearbox ratio and wheel size. However, the ratio should be calculated such that when it is multiplied by motor speed (which is in rpm), the result is vehicle speed in kph 12.4 format. To do this, the following equation can be used:

- Set the divisor (object 2915_h sub index 2) to a known speed point of the motor
- Set the multiplier (object 2915_h sub index 1) to the corresponding scaled vehicle speed for the known motor speed.

For example, if it is known that 1000rpm on the motor results in a vehicle speed of 5kph, then the divisor should be set to 1000, and the multiplier should be set to 0x0050, which is 5kph in 12.4 format.

The same process should be repeated for the user speed ratio, setting the multiplier for the user speed in the desired custom format. Both the vehicle and user speeds, objects 0x2921 and 0x2922, can be mapped to TPDO for transmission to other devices via CAN if required.

Distance Calculation

Total vehicle distance and trip distance counters are available at objects 0x29A0 and 0x29A1. Counters will operate and will be accurate provided that the vehicle speed calculated at object 0x2721 is in kph in 12.4 format. Counters are available in the following formats:

- Distance travelled in km in 24.8 format
- Distance travelled in km in 0.1km/bit increments
- Distance travelled in miles in 0.1mile/bit increments

Both distance counters objects can be mapped to TPDOs for monitoring over the CANbus, or for use by a dashboard display. The trip distance counter can be reset by holding the reset switch, object 0x217D, closed for 1 second. The total vehicle distance counter cannot be reset by the user.

Service Indication

The controller can reduce vehicle performance and indicate to the operator when a vehicle service is required. The interval between services is user-configurable.

Configure the following at object 2850_h:

- Service indication: via an analogue (contactor) output (e.g. to drive a dashboard lamp) and/or Gen4's LED.
- Source hours counter: selects the hours counter and is used to determine when a service is required.
- Service interval: hours between vehicle services. Can be used by the reset function (see below) or for information only.

- Next service due: Servicing is required when the source-hours counter reaches this time. This can be set manually, or automatically using the reset function; see below.
- Reset function: write to the reset sub-index at 2850_h to automatically reset the service timer for the next service. The next service due time is calculated as the source hours counter time plus the service interval.

Service profile

This is a drivability profile where you can set maximum torques, speeds and acceleration rates to be applied when a vehicle needs servicing (2925_h). See 'Driveability profiles' on page 6-24.

Traction motor cooling fan

This object can be used to drive a motor cooling fan when the operator is present on the vehicle (as indicated by the seat switch). The cooling fan object (2421_h) must be mapped to an analogue output.

Controller heatsink / motor cooling fan

An external fan to cool the controller heatsink or a motor may be connected to one of the analogue outputs. The fan will be turned on by the controller when either the heatsink temperature or the motor temperature exceed a specified temperature. The fan turns off when the nominated temperature is cold. The temperatures at which the fans should turn on and off, the analogue output to use for the fan, the fan voltage and the temperature source (heatsink or motor) can be programmed using the heatsink fan object (5A01_h). Note that the contactor driver outputs may be damaged if connected to capacitive loads. It is quite common for fans to incorporate capacitive elements, in which case a relay should be used to isolate the fan from the contactor driver output.



*NOTE: The temperature set-point to turn on the fans should be higher than the set-point to turn off the fans
The fans will not operate if another function is configured to run on the specified analogue output.*

Motor over-temperature protection

The controller protects motors from over-temperature. It maintains a motor temperature estimate and can also accept a direct temperature measurement via an analogue input (for a thermistor) or a digital input (for an over-temperature switch).

The temperature estimate is calculated by monitoring current to the motor over time. The estimate is configured at 4621_h.

The estimate is always applied, since it can detect increases in motor temperature more quickly than the direct measurement. Direct measurement is normally done on the motor casing, which lags behind the internal temperature.

Additional protection is provided for thermistor wire-off conditions. If the temperature sensor input measures a completely short circuit or open circuit signal, then the output torque will begin to reduce gradually over time. A recovery rate can also be specified should the signal become valid again. This means that wire-off situations, should they occur during drive, do not result in an instant loss of torque. Both the torque ramp down and recovery rates can be configured using object 4620_h.

Motor over-speed protection

A facility to protect the motor or vehicle power train due to damage by overspeeding is available on the controller. A maximum speed can be configured at object 4624_h. Under normal operation the controller should output braking torque to prevent the overspeeding initially, if the measured speed exceeds this limit then the controller will shut down and a fault will be set.



CAUTION: The trip speed offers a final level of protection for the vehicle mechanics, and should be set to a minimum level that would not be expected to be reached under normal operation.

Battery protection

The nominal battery voltage must be set at $2C00_h$.

Over voltage

Battery over voltage usually occurs during regenerative braking.

To provide protection set values for these parameters at $2C01_h$:

- Over voltage start cutback: the value at which the braking effort is linearly reduced to limit voltage increase.
- Over voltage limit: the value at which the controller cut-outs out. A fault is set if the voltage exceeds the cut-out voltage.

Under voltage

To prevent excessive battery discharge, set values for these parameters at $2C02_h$:

- Under voltage start cutback: the value at which the current drawn from the battery is reduced to limit voltage decrease.
- Under voltage limit: the value at which the controller cut-outs out. A fault is set if the voltage drops below the cut-out voltage for longer than the protection delay
- Protection delay: the time it takes for the controller to cut-out after the under voltage limit has been reached ($2C03_h$).

Battery Discharge Indicator (BDI)



CAUTION: When not in use ensure the BDI function is disabled by setting the Cell Count (in $2C30_h$, 6) to 0.

Monitor battery voltage using Gen4's Battery Discharge Indicator (BDI). The BDI presents the driver with a percentage remaining charge figure and has become an industry standard in recent years.



NOTE: The BDI is not a measure of the absolute battery charge remaining and therefore we recommend you regularly check the absolute value in accordance with the battery manufacturer's instructions.

To use the BDI, configure the following parameters at $2C30_h$ in the Object Dictionary:

- Cell count: this is the number of battery cells and is normally half the battery voltage, as cells are usually 2 volts each.
- Reset voltage (V): set this to the cell voltage when the batteries have just been charged. This resets the BDI back to 100%.
- Discharge voltage (V): set this to the cell voltage when the battery is discharged.
- Cut-out level (%): this is the level at which the vehicle adopts the low battery drivability profile.
- Discharge rate (s/%): this is the rate at which the BDI remaining charge value discharges. Set to 0 to use default value of 16.8s to reduce by 1%. This default should suit most lead-acid battery types, however, this can be increased/decreased for different battery technologies.



NOTE: Setting the warning and cut-out levels to 0% disables the warning and cut-out functionality

An additional table exists at index 2C31_h which allows an initial BDI value to be specified at start up based on the measured battery voltage. At start up, the measured battery voltage is taken, and the corresponding BDI percentage remaining value is then used as the starting point for the BDI. After this, the BDI remaining value operates in the standard way. Note, this function is only available if the corresponding bit is set in object 2C30_h sub 1.

Read the percentage remaining charge value from 2790_h sub-index 1 in the Object Dictionary.

Battery Current Limit

Battery current can be limited by the controller for the purposes of efficiency or to protect batteries that are sensitive to high levels of current flow. Charge and discharge currents can be limited independently.

If limiting the discharge current flow, this can extend the time taken for the vehicle to reach top speed. Note that limiting the charge current flow back to the battery can impede the performance of regenerative braking.

Object 2870_h controls how the battery current limit is calculated. Sub-index 1 of this object can be set to one of the following values to specify how the current limit behaves:

Value	Mode
0x00	Master control of battery current limit disabled. To completely disable battery current limit, object 4623 _h sub index 3 must also be set to 0x0000.
0x01	Battery current limit set by object 4623 _h sub index 2 and 3.
0x02	Battery current limit controlled by compatible BMS
0x03	Battery current limit set by object 4623 _h sub index 2 and 3, but the drive current limit is multiplied down by factors set in sub index 4 and 5 when driveability profiles are activated
0x04	Battery current limit is calculated to maintain a power limit as set in sub index 6 and 7.

Object 2871_h provides a means to have TracApp cut back the torque demand in situations where the battery current limit is reduced. This is useful for configurations where an external BMS can cut back the current limits to low levels. Effectively, it prevents TracApp requesting torque that cannot be achieved.

Object 4623_h shows the current limits that are in effect. Sub index 3 of this object allows you to specify the cutback aggressiveness and a measurement correction factor. Setting this to zero. Battery current flow can be monitored at object 5100_h.

Note that regen currents flowing back to the battery are specified as negative numbers.

Displays

Gen4 is compatible with Smartview and Clearview displays.

Clearview displays use the CANopen protocol. To use, set up TPDOs to transmit the required data for the display.

Smartview displays use Sevcon's proprietary CAN protocol. To use set the CAN baudrate to 100kHz at 5900_h, enable Smartview and select hours counter and/or real speed at 2E00_h.



Chapter 7: Monitoring Gen4

Reading status variables

All status variables are in Gen4's object dictionary. They can be accessed using SDOs. Some can be mapped to PDOs for continuous transmission to remote nodes such as displays and logging devices.

Motor measurements

The following status objects can be read:

- Motor slip frequency, currents, voltages and temperature at object 4600_h.
- Additional motor debug information is available at 4602_h.
- Motor torque, speed, etc. at objects 6000_h to 67FF_h.

Heatsink temperature

Read the heatsink temperature at object 5100_h, sub-index 3.

Identification and version

Read identification and version information at:

- 1008_h – Controller name.
- 1009_h – Hardware version.
- 100A_h – Software version.
- 1018_h – Identity object. Contains CANopen vendor ID, product code, CANopen protocol revision, and controller serial number.
- 5500_h – NVM (EEPROM) format.
- 5501_h – Internal ROM checksum.

Battery monitoring

The controller measures actual battery voltage at two points:

- Battery voltage; measured at keyswitch input and read at 5100_h sub-index 1.
- Capacitor voltage; measured at the B+ terminal and read at 5100_h sub-index 2.

The controller also has a battery discharge indicator (BDI), which can be read at 2790_h.

Hours counters

The controller supports many different hours counters for various functions. Some counters run on all units and some only run on the Gen4 configured as the vehicle master.



Hours counters are preserved with a minimum resolution of 15 seconds when the system is powered down.

Local hours counters

Local hours counters which run on all units are:

- Controller key hours: increments while the keyswitch is in the ON position (5200_h).
- Controller pulsing hours: increments when the controller is powering its connected motor (4601_h).

Vehicle hours counters

Vehicle hours counters which run only on the Gen4 configured as the vehicle master are:

- Vehicle key hours: increments as controller key hours (2781_h).
- Vehicle traction hours: increments when the vehicle is driving or braking (2782_h).
- Vehicle pump hours: increments when the pump motor is running (2783_h).
- Vehicle power steer hours: increments when the power steer motor is running (2784_h).
- Vehicle work hours: increments when the traction, pump or power steer motors are running (2785_h).

Since these hours are specific to the vehicle, they are writeable so that they can be reset to known good values if the master controller is replaced.

Logging

The controller can log events in the system (along with additional event-related information) and minimum and maximum levels of important parameters. You need different levels of access to clear the contents of the logs.

Logs are normally reset individually. However, to reset all logs at once write to 4000_h.

FIFO event logs

Events are recorded by these two separate FIFOs (first in, first out logs), which operate identically:

- System: this FIFO is 20 elements deep and is used for events such as software upgrades, user logins and some hardware upgrades (4100_h to 4102_h).
- Faults: this FIFO is 40 elements deep and is used for fault logging (4110_h to 4112_h).

At object 41X0_h:

- Reset the FIFO
- Read its length

You can access the FIFO using objects 41X1_h and 41X2_h. The FIFO index is entered at 41X1_h and the data is read from 41X2_h.

Event counters

The controller provides 10 event counters at 4200_h to 420A_h. Each event counter can record information about occurrences of one event. The allocation of event counters to events is user-configurable however Gen4 will automatically count important events in unused counters. The information recorded in each event counter is:

- The time of the first occurrence
- The time of the most recent occurrence
- The number of occurrences

Operational monitoring

At objects 4300_h and 4301_h, Gen4 monitors and records the minimum and maximum values of these quantities:

- Battery voltage
- Capacitor voltage
- Motor current
- Motor speed
- Controller temperature

Two instances of the operational monitoring log are maintained. Service engineers can access and clear the first log; the second is accessible and clearable only by Sevcon engineers. The Customer copy is normally recorded and reset each time the vehicle is serviced. The Sevcon copy records data over the controller's entire working life.

CANopen abort code

The controller will sometimes respond with a CANopen General Abort Error (08000000_h) when the object dictionary is accessed. This can occur for many reasons. Object 5310_h gives the exact abort reason. These are:

0	None	12	Invalid value	24	Cannot read from DSP
1	General	13	EEPROM write failed	25	Peek time out
2	Nothing to transmit	14	Unable to reset service time	26	Reserved for future use
3	Invalid service	15	Cannot reset log	27	Reserved for future use
4	Not in pre-operational	16	Cannot read log	28	Reserved for future use
5	Not in operational	17	Invalid store command	29	Reserved for future use
6	Cannot go to pre-operational	18	Bootloader failure	30	Reserved for future use
7	Cannot go to operational	19	DSP update failed	31	Reserved for future use
8	Access level too low	20	GIO module error failed	32	Checksum calculation failed
9	Login failed	21	Backdoor write failed	33	PDO not copied
10	Range underflow	22	Reserved for future use		
11	Range overflow	23	Cannot write to DSP		

Faults and warnings

Introduction

In the event of a fault Gen4 takes the following action:

1. Protects the operator and vehicle where possible (e.g. inhibits drive).
2. Sends out an EMCY message on the CANbus.
3. Flashes the LED in a pattern determined by the fault type and severity.
4. Logs the fault for later retrieval.

Fault identification

You can identify a fault as follows:

- Check the number of LED flashes and use below to determine what action can be taken. A complete and comprehensive fault identification table will be available from Sevcon in due course.
- Pick up the EMCY on the CANbus and read the fault condition using configuration software
- Interrogate the fault on the node directly using DVT or other configuration software.

LED flashes

Use below to determine the type of fault from the number of LED flashes. The LED flashes a preset number of times in repetitive sequence (e.g. 3 flashes – off – 3 flashes – off – and so on). Only the faulty node in a multi-node system flashes its LED. Possible operator action is listed in the right hand column of the table.

LED flashes	Fault	Level	Set conditions	Operator action
0 (off)	Internal hardware failure	RTB	Hardware circuitry not operating.	
1	Configuration item out of range	VS	At least one configuration items is outside its allowable range.	Set configuration item to be in range. Use 5621 _h to identify out of range object.
1	Corrupt configuration data	VS	Configuration data has been corrupted.	
1	Hardware incompatible with software or invalid calibration data	VS	Software version is incompatible with hardware. Calibration data for sensors invalid.	
2	Handbrake fault	I	Direction selected with handbrake switch active.	Release handbrake
2	Sequence fault	DI	Any drive switch active at power up.	Reset drive switches
2	SRO fault	DI	FS1 active for user configurable delay without a direction selected.	Deselect FS1 and select drive
2	FS1 recycle	DI	FS1 active after a direction change	Reset FS1

LED flashes	Fault	Level	Set conditions	Operator action
2	Seat fault	DI	Valid direction selected with operator not seated or operator is not seated for a user configurable time in drive.	Must be seated with switches inactive
2	Belly fault	DI	Set after belly function has activated.	
2	Inch sequence fault	DI	Inch switch active along with any drive switch active (excluding inch switches), seat switch indicating operator present or handbrake switch active.	
2	Invalid inch switches	DI	Inch forward and inch reverse switches active simultaneously.	Both inch switches inactive.
2	Two direction fault	DI	Both the forward and reverse switches have been active simultaneously for greater than 200 ms.	Reset switches
2	Invalid steer switch states	VS	Steering switches are in an invalid state, for example, both outer switches are active.	Check steer switches.
3	Fault in electronic power switching circuit	VS	Fault in electronic power switching circuit (e.g. MOSFET s/c).	
3	Hardware over voltage activated	VS	Hardware over voltage circuit activated	Investigate and reduce battery voltage below user defined maximum level. Ensure suitable over voltage is configured in 2C01 _h and 4612 _h .
3	Hardware over current trip activated	VS	Hardware over current circuit activated	Check motor load and wiring. Check motor parameters are correct.
4	Line contactor welded	S	Line contactor closed at power up or after coil is de-energized.	Check line contactor condition/wiring.
4	Line contactor did not close	S	Line contactor did not close when coil is energized.	Check line contactor condition/wiring.
5	PST fault	DI	Fault detected on PST power steer module.	Check PST condition.
5	Motor open circuit	S	Unable to establish current in motor.	Check motor condition/wiring.
6	Throttle pressed at power up	DI	Throttle demand is greater than 20% at power up.	Reduce demand
6	Analogue input wire-off	VS	Analogue input voltage is outside allowable range.	Check analogue input wiring

Monitoring

LED flashes	Fault	Level	Set conditions	Operator action
6	Analogue output fault (over/under current, failsafe, short circuit driver)	VS	Analogue output fault caused by over current (>4A), under current if actual current < 50% target (current mode only), failsafe circuit fault, short circuit driver MOSFET.	Check analogue output wiring.
7	BDI warning or cut-out	I	BDI remaining charge is less than warning or cut-out levels.	Charge battery.
7	Battery low voltage protection	I	Battery voltage or capacitor voltage is below a user definable minimum battery level for a user definable time.	Increase battery voltage above user defined level
7	Controller low voltage protection	I	Battery voltage or capacitor voltage is below the minimum level allowed for the controller.	Increase battery voltage above minimum level
7	Controller high voltage protection with line contactor closed.	I	Battery voltage or capacitor voltage is above the maximum level allowed for the controller with line contactor closed.	Investigate and reduce battery voltage below maximum level.
7	Battery high voltage protection	I	Battery voltage or capacitor voltage is above a user definable maximum battery level for a user definable time.	Investigate and reduce battery voltage below user defined maximum level.
7	Motor low voltage protection	I	Capacitor voltage has entered the motor low voltage cutback region defined in 4612 _h .	Increase battery voltage above start of motor low voltage cutback region.
7	Motor high voltage protection	I	Capacitor voltage has entered the motor high voltage cutback region defined in 4612 _h .	Reduce battery voltage below start of motor high voltage cutback region.
7	Controller high voltage protection with line contactor open.	S	Battery voltage or capacitor voltage is above the maximum level allowed for the controller with line contactor open.	Isolate controller and investigate high battery voltage
7	Battery voltage below critical level for controller.	S	Battery voltage is below the absolute minimum voltage at which the controller hardware is guaranteed to operate.	Increase battery voltage.
7	Precharge failure	VS	Capacitor voltage is less than 5V after pre-charge operation is complete.	Check controller wiring to ensure there are no short circuits between B+ and B-.

LED flashes	Fault	Level	Set conditions	Operator action
8	Controller too hot	I	Controller has reduced power to motor(s) below maximum specified by user settings due to controller over temperature.	Remove loading to allow controller to cool down.
8	Controller too cold	I	Controller has reduced power to motor(s) below maximum specified by user settings due to controller under temperature.	Allow controller to warm up to normal operating temperature.
8	Motor over temperature	I	Controller has reduced power to motor(s) below maximum specified by user settings due to motor over temperature.	Reduce load to motor to allow it to cool down.
8	Motor too cold	I	Motor thermistor reports less than -30°C.	Allow motor to warm up. Check motor thermistor.
8	Heatsink over temperature	VS	Heatsink temperature measurement has exceed absolute maximum for controller and system has powered down.	Remove loading to allow controller to cool down.
10	Pre-Operational	I	Controller is in pre-operational state.	Use DVT to put controller into operational state.
10	I/O initializing	I	Controller has not received all configured RPDOs within 5s of power up.	Check CANbus wiring and PDO configuration.
10	RPDO Timeout	I / DI / S	One or more RPDOs have not been received within 3s at power up or within 500ms during operation.	Check CANbus wiring and PDO configuration.
11	Encoder fault	VS	Speed measurement input wire-off is detected. Or encoder signals out of range or misaligned.	Check encoder wiring. Calibrate analogue encoder signals for sin/cos.
11	Over current	VS	Software has detected an over current condition	Check motor load and wiring. Check motor parameters are correct.
11	Current Control fault	VS	Software is unable to control currents on PMAC motor.	Check motor load and wiring. Check motor parameters are correct.
12	Communication error	S	Unrecoverable network communication error has been detected.	Check CANbus wiring and CANopen configuration.
13	Internal software or hardware fault	RTB	Software run time error captured or hardware variant not recognised.	

LED flashes	Fault	Level	Set conditions	Operator action
13	Current sensor auto-zero fault	RTB	Current sensor voltage out of range with no current.	
13	DSP parameter error	RTB	Motor parameter written to while motor control is operational.	Recycle keyswitch to allow parameters to be reloaded correctly.
14	3 rd Party Anonymous Node EMCY received	I / DS / RTB	3 rd party node has transmitted an EMCY message.	Check CANbus wiring and 3 rd party node status.
15	Vehicle service required	I	Vehicle service interval has expired.	Service vehicle and reset service hours.

Table 7 Fault identification

Fault list

Use DVT to access the Fault list. If you don't have DVT you can use any configuration tool as follows:

1. Object 5300_h gives information about all active faults. Read sub-index 1 to get the number of active faults. Write to sub-index 2 to select one of the active faults (0 = highest priority) and read back sub-index 3 to read the fault ID at that index.
3. Object 5610_h can be used to read a text description of the fault. Write the fault ID to sub-index 1 and read back the fault description from sub-index 2.

Upgrading the controller software

It is possible to field update the firmware of the Gen4 controller , typically using Sevcon's DVT configuration tool.

Please contact Sevcon for assistance with this process.

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM III

Document 3: Annexes a la memòria

Annex I.4 – Annex I.7

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



ESCOLA TÈCNICA SUPERIOR
D'ENGINYERIA QUÍMICA
Universitat Rovira i Virgili

etsEQ

I.4.- Radiador AUSTIN MINI 1000





RADIADOR AUSTIN MINI 1000

Referencia: AX-RAD022

~~277,19 €~~ 249,47 € 10% de descuento

Impuestos incluidos

RADIADOR AUSTIN MINI 1000



Cantidad

1

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▼

AÑADIR AL CARRITO

Compartir

Descripción

Detalles del producto

Radiador de aluminio para Austin Mini 1000. Fabricado íntegramente con una aleación de aluminio aeronáutico mas resistente y ligero que el aluminio estándar, soldaduras TIG realizadas a mano con pruebas finales de estanqueidad. Medidas, soportes y anclajes iguales que el radiador de origen (en las versiones de mas capacidad, las medidas pueden variar sin necesidad de hacer adaptaciones). Los radiadores de aluminio proporcionan un 12-25% mas de rendimiento térmico respecto a los radiadores estándar (de iguales dimensiones). Para mas información no dude en ponerse en contacto con nosotros.

DIMENSIONES TOTALES: **380 x 280 x 50mm**
DIMENSIONES PANEL: **255 x 270 x 45mm**
ORIFICIO TERMOCONTACTO: **NO**

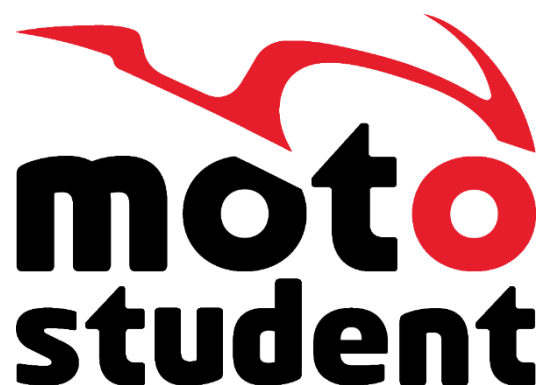
4 OTROS PRODUCTOS EN LA MISMA CATEGORÍA:



I.5.- Reglament MotoStudent 2022-2023



VII



INTERNATIONAL COMPETITION

2022 - 2023

Competition Regulations

Rev. 12/2021



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SECTION A

ADMINISTRATIVE REGULATIONS

ARTICLE 1: INTRODUCTION TO MOTOSTUDENT COMPETITION

A.1.1 MotoStudent Objectives

A.1.1.1 | MotoStudent is a university challenge between student teams, that must design and develop a competition motorbike project (electric or petrol) which will be evaluated and tested in a Final Event to be held at the MotorLand Aragón facilities in Alcañiz (Teruel), Spain.

A.1.1.2 | MotoStudent is an education advanced program that prepares undergraduate and graduate students in a variety of fields related with the mobility sector, focusing on the professionals that will drive the future of innovation, by challenging them with a real MotorSport project. Through the different phases on which the teams will be involved they will develop their talent on areas that include:

- Project Management with acumen on economic aspects and budget targets, marketing, resource management, document analysis and preparation, and milestones competition.
- Develop a real prototype under the given rules, with special focus on the industry and MotorSport basis.
- Compete, work and collaborate within the Team and with other worldwide university teams.

A.1.2 Event Promoter

A.1.2.1 | The MotoStudent Competition, promoted by the Moto Engineering Foundation (hereinafter MEF) and TechnoPark MotorLand, both entities are part of the Competition Organization, responsible for its full development.

A.1.2.2 | The Organization has the right to adapt and modify the Competition Rules & Regulations as well as any other official document, committing itself to communicating to the participating teams with sufficient time for the proper development of the activities of the Competition.

A.1.3 Competition categories

The MotoStudent Competition has two different categories:

- MotoStudent Petrol

- MotoStudent Electric

- A.1.3.1 | The MotoStudent Petrol Category is characterized by using an internal combustion engine as the propulsion method. The regulations relating to the MotoStudent Petrol Category are defined throughout these Rules and Regulations in their corresponding sections.
- A.1.3.2 | The MotoStudent Electric Category is characterized by using a 100% electric system as a propulsion method. The regulations regarding the MotoStudent Electric Category are defined throughout these Rules and Regulations in their corresponding sections.
- A.1.3.3 | Each Category will be developed in parallel and independently with its evaluation and corresponding score, as well as the tests and milestones to be fulfilled throughout the Competition, including the Final Event.

A.1.4 Phases of the Competition

The projects and prototypes presented will be judged and assessed in a series of different tests, divided into two different phases, called MS1 Phase and MS2 Phase.

- A.1.4.1 | The different stages to which the projects will be submitted will be:

STAGE	SCORING
Special and Administrative Milestones	No*
Scrutineering	No
MS1 Phase: Project	Yes
MS2 Phase: Dynamic tests	Yes

* It can apply penalties on the global score.

- A.1.4.2 | All participating teams, with the purpose to be evaluated, must have exceeded the minimum level required in each of the stages.
- A.1.4.3 | The requirements to be met in the different stages are detailed in the following parts of this Regulations:
- General Milestones: Section A, Article 6.
 - Scrutineering: Section E
 - MS1 Phase: Section F

- MS2 Phase: Section G

A.1.5 Awards and scores

Based on the results of the different Phases, the Organization will give a series of awards.

A.1.5.1 The MS1 Phase specific awards are detailed in Art.F.6.3 of these Regulations.

A.1.5.2 The MS2 Phase specific awards are detailed in Article 9 of Section G of these Regulations.

A.1.5.3 In addition to the specific awards of each Phase and category, the following general prizes will be awarded:

- Best MotoStudent: Awarded to the team that obtains the maximum score in the sum of the results of the MS1 + MS2 Phases.
- Best Rookie team: Awarded to the newly incorporated team (representing a university not registered in any of the previous editions of MotoStudent) that obtains the maximum score in the sum of the results of the MS1 + MS2 Phases.

A.1.5.4 Summary of the Competition awards:

MotoStudent Petrol	MotoStudent Electric
MS1 Phase	
Best MS1 Project	Best MS1 Project
Best Design Project	Best Design Project
Best Innovation	Best Innovation
Best Innovation Red Bull MotoBoost	
MS2 Phase	
1st Classified	1st Classified
2nd Classified	2nd Classified
3rd Classified	3rd Classified
General Awards	
Best MotoStudent	Best MotoStudent
Best Rookie Team	Best Rookie Team

A.1.5.5 The economic and material value of each prize will be published by the Organization to all registered teams.

A.1.5.6 In case of a tie of the score between two or more teams in the overall classification of the General Awards, the final classification position will be based on the score

of each team in the MS1 Phase, with the team with the highest MS1 score remaining ahead.

A.1.6 Entries

MotoStudent accepts registrations from teams of students representing universities around the world.

A.1.6.1 The registration period starts on January 17, 2022. The registration process shall be formalized through the website of the Competition: www.motostudent.com.

A.1.6.2 The entry fee for a team amounts to 3,895.00€ (VAT included). This fee covers the entry of the 7 compulsory team members. Each additional team member must pay an additional fee of 265.00€ (VAT included).

A.1.6.3 For a team, or a team member, to be considered as registered, it must have paid the corresponding registration fees.

A.1.6.4 The number of available places for teams is limited to 104 teams among both categories. These vacancies will be covered by order of registration (including the payment of the registration fee). Teams that have not paid the registration fees will not be considered as registered, therefore it will not be possible to reserve their place for the Competition.

A.1.6.5 The payment of the registration fee includes:

- The rights to participate at the VII Edition of the MotoStudent International Competition as an official team, having therefore a certificate of being an official registered team member or tutor.

- The MotoStudent Kit that includes common compulsory parts for all teams that must be installed in the prototype. The shipping cost of the Kit is also included. There are not included the duties or special taxes of the destination countries, states or other areas.

- "Full Access" passes to restricted areas and the corresponding insurance during the Final Event in 2023, exclusively for registered team members:

- Access to briefings.
- Access to MS1 presentation rooms, either physical or virtual.
- Access to the Work Zone of Pit Lane and Pit Wall.

- Access to the Photo Opportunity.
- Access to the track for the recognition of the teams prior to MS2 tests.
- Access to Technical Box (Scrutineering Area) (2 members per team).
- Access to the Starting Grid before the races.
- Free access to the MS1 Awards Ceremony.
- Access to the MS2 Podiums.
- In general, access to the specific areas of the Competition that require the presence of participating students.
- Bracelets of registration, which will allow the manipulation of the prototype. The manipulation of the prototypes by people not officially registered in the Competition will not be allowed during the Final Event.
- Registered students will be included in the MotoStudent employment and training exchange, through which they will have access to specialized on-site or online training courses, as well as the opportunity to access exclusive job offers from the main companies in the sector.
- Access to Challenges in partnership with external companies such as the Red Bull MotoBoost KTM Call Challenge.
- The right of access to services, supplies, discounts and opportunities offered by the Organization of the Competition and the collaborating companies.

A.1.6.6 | The entry fees of the Competition are not refundable. If for any reason outside the Organization, the Competition has to be interrupted, canceled, or a variation in the scheduled terms has been determined (such as the dates of the Final Event), the Organization reserves the right not to return the amount totally or partially of these registration fees.

A.1.7 Official publications and Event information

All official communications, Regulations, annexes, etc. will be published on the official website of the Competition: www.motostudent.com

A.1.7.1 | Teams are required to read, understand and be familiar with all publications that the Organization makes.

- A.1.7.2 | The Organization may use the email system or other electronic means to send news and information about the Competition. To do this, each team will present at least two official email addresses to receive communications:
- Faculty advisor/s email address
 - Team or team leader email address
- A.1.7.3 | Any official communication issued by the Organization will have the same officiality as the present Regulations of the Competition and, therefore, the teams will have the same compliance obligation.

A.1.8 Official languages

The Official languages of the Competition will be the following (in order of priority):

- 1st English
 - 2nd Spanish
- A.1.8.1 | Official publications and documents will be published in English. The Organization will also be able to publish such documentation in Spanish, although it reserves the right not to do so if it deems it convenient.
- A.1.8.2 | The communications between the participating teams and the Organization must be made in one of the two official languages indicated at Art. A.1.8.
- A.1.8.3 | In the event of any conflict between the English or Spanish version, it will be the English version which will prevail. This rule will apply to any official document published by the Organization throughout the Competition.

A.1.9 Official time

The Official time of the Competition is the one in force in mainland Spain:

- Winter Schedule: CET (UTC+1)
- Summer Schedule: CEST (UTC+2)

ARTICLE 2: APPLICATION OF THE MOTOSTUDENT REGULATIONS

A.2.1 Ambiguities in the Regulations

The possible ambiguities or questions about the meaning or intention of the Competition Regulations will only be resolved by the MotoStudent Organization.

A.2.2 Validity of the Regulations

The Regulations of the MotoStudent Competition published on the website www.motostudent.com, including its possible future versions, are the only Regulations valid for the VII MotoStudent International Competition 2022-2023.

A.2.2.1 | The Regulations from past editions (I, II, III, IV, V or VI Edition) of the MotoStudent Competition will not be valid for the VII MotoStudent International Competition 2022-2023.

A.2.2.2 | For any situation or sports infraction not included in this MotoStudent Regulations or in another official communication of the Organization, the RFME Sporting Regulations of the Spanish Speed Championship (ESBK) 2023 will regulate the procedure to be followed.

A.2.3 Compliance of the Regulations

By taking part in the MotoStudent Competition, the team, the team members as individuals, the faculty advisors (tutors), riders and any other university staff member accept and must comply with all the rules imposed by the Organization both in the Competition Regulations and in subsequent official documents, as well as the rules of the sports complex where the Final Event will take place.

A.2.4 Penalties for non-compliance with Regulations

The Organization has the right to sanction all those teams that do not comply with aspects of the Competition Regulations and established schedules, as well as those teams that demonstrate unsportsmanlike behavior, or may endanger persons and facilities.

A.2.4.1 | The Organization shall establish sanctions according to the following criteria:

- Minor infraction: Penalty of 10 points in the test or phase to be evaluated.
- Serious infraction: Exclusion of the phase to evaluate. Depending on the seriousness of the fault, the Organization may even exclude the team from the Competition.

- Sports penalties in the MS2 Phase: to be determined by the Race Direction

A.2.4.2 | It is considered as minor infraction timely breach of the defined schedule, delivery of documentation (with the exception of deliverable milestones involving specific penalties), specific non-compliance of paddock and pit lane rules, or similar acts.

A.2.4.3 | It is considered as serious infraction repetitive breach of the cases set out in the Article A.2.4.2 once it has been already warned to the team, disobedience to orders given by the Organization or Race Direction, unsportsmanlike or aggressive behavior, acts prejudicial to the people attending, etc.

A.2.4.4 | During dynamic tests of the MS2 Phase on the racetrack, the Race Direction may apply the relevant penalties for noncompliance with sports regulations. These penalties may be accompanied by score penalties.

A.2.5 Right to claims and impugnments

Any team has the right to protest and suggest. The Organization will review any doubt, breach or penalty presented by the official method.

A.2.5.1 | Claim: A team can file a claim based on any disagreement with any action by the Organization, either in the scoring of the Competition or other official action that can be considered as causing damage to its team.

A.2.5.2 | Impugnment: Any team may lodge a protest against another participating team if they observe any breach of the Competition Regulations or improper conduct.

A.2.5.3 | Every protest and/or complaint must be submitted to the Organization following the presentation format reflected in Annex 1 of Section J of these Regulations, stating the article of the Regulations which is considered to have been breached, with enough proof to be verified. The protests and complains prior to the Final Event may be sent scanned or digitally signed by email to faq@motostudent.com, while protests and complaints during the Final Event must be submitted in writing to the Organization.

A.2.5.4 | To make a claim or an impugnment, the applicant team must deposit 50 points on the score of the Phase or test to protest and €800. If the Organization approves the resolution in favor of the applicant team, the 50 points and €800 will be given back to the applicant team, if not, and the protest is refused, the team will lose the 50 points and €800.

- A.2.5.5 | Period of presentation: Claims or impugnments related to any aspect of the tests developed during the Final Event, must be submitted within a maximum of 30 minutes after the publication of the results of the test affected.
- A.2.5.6 | The Organization will be responsible for the final decision on the protest. This decision will be final and cannot be appealed.
- A.2.5.7 | Only in the purely sporting field it will be possible to request an appeal procedure: As it is stated in Article 119 of the RFME Sporting Regulations, any participant may appeal to penalties imposed or decisions taken by the Organizing Committee and the Race Direction to the Disciplinary Court of the RFME. Any appeal may be presented in writing, signed by the interested party and accompanied by a deposit of 800€. The right for appeal expires after fifteen days, including post terms, from the communication of the resolution.
- A.2.5.8 | As it is stated in the RFME Sporting Regulations, in its article 119, at the request of a team it is possible to lodge appeals to the FIM, through the RFME, being the only one to judge the opportunity of the formulated appeal, being able to refuse the process without being obliged to explain the causes and reasons that induce it. The right of appeal does not imply the suspension of the penalty or sanction; however, when RFME accedes to raise an appeal to the FIM, the appellant may obtain, prior to the appropriate request, that the appeal may lead to the temporary suspension of the decision, but in this case, it must submit, together with the appeal, the guaranteed deposit stipulated by the FIM.

A.2.6 Right of confiscation

The Organization reserves the right to confiscate or hold during the Final Event any prototype, component, tool or rider equipment at its discretion that considers non-complying with the Competition Regulations.

- A.2.6.1 | Any material confiscated by the Organization in the Final Event will be returned to its owner team at the end of the Final Event.

A.2.7 Changes to the Regulations of the Competition

The MotoStudent Organization has the right to change the Competition Regulations, as well as the Official Calendar of the Competition, if it considers it necessary. Any change to the Regulations, will be added in Section I: Modifications' glossary, and will be published on the official website.

- A.2.7.1 | The Organization Committee will announce the changes to the Regulations through the means considered as most appropriate to make the changes known. Regardless of the means used, the most updated Rules and Regulations document will always be the one published on the website of the Competition.

ARTICLE 3: PARTICIPATION REQUIREMENTS

A.3.1 Eligibility

The Competition has a purely academic objective, being a multidisciplinary project with a great importance in the areas of engineering, economics, marketing and project management. Although the project is based on the development and manufacture of a racing motorcycle prototype, it is not a conventional speed championship. Therefore, eligibility is limited to active university students (enrolled in a university in the academic years 2021-2022 and/or 2022-2023), or students at Vocational Training schools/colleges (including the latter within a team with the university as a holder).

Only students from either universities and/or Vocational Training schools/colleges whose main activity is not training in the field of motor racing in any of its forms are allowed.

- A.3.1.1 | There is no limit in the number of teams set for each University. Each University may submit as many teams as they like for any category of the Competition.
- A.3.1.2 | Each registered team can only submit one project and one prototype.

A.3.2 Liability Waiver

All participants, including students and tutors, must sign a liability waiver when entering the Competition. The rest of the people attending the Final Event with the teams will be considered as general public.

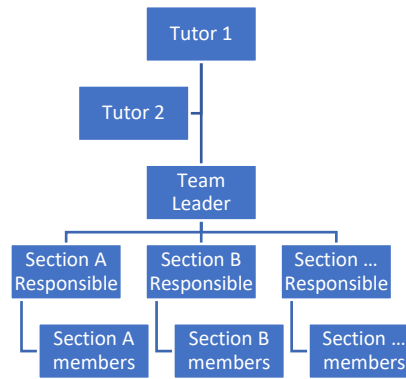


MotorSport can be dangerous

A.3.3 Heads of the team: Faculty Advisor and Team Leader

Each team must designate one or two faculty advisors, who will be recognized as "Tutors" of the team, as well as a delegate student enrolled in the team, who will be recognized as "Team Leader".

- A.3.3.1 | The Faculty Advisors should accompany the team during the Final Event and will be considered as the highest responsible person for the team. Should the Faculty Advisors not be able to attend the Final Event, the responsibility will be delegated to the Team Leader as the maximum responsible of the team.
- A.3.3.2 | Faculty Advisors may advise their teams on general engineering and theoretical aspects of their projects, but in no case may design any part of the prototype, or take part in the development of any document or presentation.
- A.3.3.3 | Faculty Advisors are not allowed to assemble or manufacture any component of the prototype.
- A.3.3.4 | The internal hierarchy of the teams is the responsibility of the internal organization of each team, but it is advisable to establish the following hierarchical order in the taking of decisions or actions:



Recommended team structure

- A.3.3.5 | At least one of the Faculty Advisors must be able to represent the University in administrative terms over the three semesters of the Competition.
- A.3.3.6 | The Team Leader will have the same rights and obligations as the rest of enrolled students, but he/she will act as a communication link with the Organization and representation of the team in the absence of the Faculty Advisors.
- A.3.3.7 | If there are any changes in the figure of the Faculty Advisors or Team Leader, for justified reasons, it should be communicated as soon as possible to the Organization to take into account the new positions.

A.3.4 Participants

Teams and team members registered in the Competition will be considered as "participants of the Competition" from the moment they enter until the end of the Final Event.

- A.3.4.1 | Each team will have at least 7 participants.
- A.3.4.2 | Every university team participating in MotoStudent must include in their team name the name of the University or College they belong to.
- A.3.4.3 | Each participating team will be associated with an identification bike number, between 1 and 99. This number will be given at the election of each team, by order of Registration in the Competition. The numbers 1, 2 and 3 will be exclusively reserved for the teams representing the finalist universities in the first, second and third place respectively in the global ranking MS1 + MS2 of the VI MotoStudent International Competition 2019-2021.
- A.3.4.4 | Students from Training Centers (enrolled in the Vocational Training Center in the 2021-2022 and/or 2022-2023 academic year) can also be part of the team. To do this, the team must present a proof of agreement agreed between the Training Center and the participating University.

- A.3.4.5 | The consideration of the Competition and its compatibility with the curriculum will be decision of each University. The represented University has no obligation of including MotoStudent Competition in its curriculum, not even as free-elective formation.
- A.3.4.6 | To participate at the Competition, in the academic aspect students must be enrolled in 2021-2022 and/or 2022-2023 courses, regardless of the percentage of subjects or credits passed.
- A.3.4.7 | All students must be over 18 years old at the beginning of the Final Event.

A.3.5 Cancellations and replacements

- A.3.5.1 | The modification of team members, tutors, rider or team leader will entail the payment of an administrative fee for management expenses, according to Art.A.3.7., and will only be accepted up to 15 days before the Final Event.
- A.3.5.2 | Any team member who has taken benefit of its registration in MotoStudent (as challenges access, formation, winners of any price with personal rewards, etc.), will block its place and its modification will not be allowed.
- A.3.5.3 | The entry fees of student are not reimbursable, even if they are cancelled.
- A.3.5.4 | All the modifications on the participating students must be communicated to the Organization by the tutor or the team leader, through the email address of registrations (registry@motostudent.com) or through the means that the Organization provides for the management of members.

A.3.6 Insurances

The registered universities must integrate the work carried out in the training curriculum so that the participation in the MotoStudent Competition is included in the activities covered by the school insurance.

- A.3.6.1 | The Organization will have a private liability insurance that will cover all team members, as a guarantee against any accident that could occur during the Final Event at the facilities of the MotorLand Aragón Speed Circuit. Physical damage to team members, if they arise from their work in the box, will not be covered by this insurance. To do this, teams must ensure the coverage of their school insurance and, if not covered, hire one on their own.

- A.3.6.2 | The Event will have the necessary medical and security means in terms of sporting requirements.
- A.3.6.3 | The Organization is not liable for material or physical damage that may be caused during the development or handling of the prototype by each team.

A.3.7 Administrative procedures and fees

The administrative procedures requested by the teams to the Organization of the Competition, and that are not part of the development of the milestones and activities of MotoStudent, will entail standard administrative fees for management expenses of € 30 (VAT included). Some examples of administrative procedures are:

- Issuance of certificates and other justification documents (excluding those issued generically by the Organization).
- Issuance of duplicates of documentation.
- Modification of each given team data: designation of tutor and team leader, team name and/or university, etc.
- Management of parcels, shipments, and storage of prototypes and other team elements for the MotoStudent Final Event.

ARTICLE 4: MANUFACTURING THE MOTORBIKE

A.4.1 Prototype manufacturing

The motorbikes taking part in MotoStudent must be created, designed and assembled by the students registered in the team without the direct involvement of professional engineers, race engineers, professional mechanics, etc. The team commits to this by signing the document in accordance with the Organization and the Regulations of the Competition.

A.4.2 MotoStudent Kit

The Organization will provide all teams with a Kit including all parts that are compulsory to be installed in the prototypes. The technical regulations regarding this Kit are defined in sections B, C and D of this Regulations.

- A.4.2.1 | The shipping cost of the MotoStudent Kit to the facilities indicated by the teams will be covered by the Organization. However, each team will be responsible for

the taxes and duties derived from the import policies of the country, zone or region to which the Kits are sent.

- A.4.2.2 | The teams must be informed previously to the sending of the Kits about tariff policies and logistical limits derived from the shipping destination to avoid retentions of the material, telling the Organization about special requirements in case of being necessary.
- A.4.2.3 | It is possible that, depending on the country where the team is located, the shipment of any of the components included in the MotoStudent Kit is not allowed. In this case, the Organization will contact the team to find alternative solutions for the management of these components.
- A.4.2.4 | The parts included in the MotoStudent Kit for both categories should only be used for the development of their own prototypes for the VII MotoStudent Edition and their participation in it, being strictly forbidden to give them other applications outside of this one.

ARTICLE 5: PARTICULARITIES FOR NON-EUROPEAN TEAMS

A.5.1 Transport and import of the prototype

Shipments and imports of prototypes and material must comply with all relevant requirements regarding transportation, import and export established by Spanish laws and regulations

- A.5.1.1 | Is recommended to manage the delivery and customs clearance as a temporary importation with a specialized company.
- A.5.1.2 | In no case the Organization or the management company of the Speed Circuit will be the recipient of the transport, nor will it manage the reception of the prototype.
- A.5.1.23 | The prototype must be sent in sufficient time to avoid delays that prevent the prototype from being available in time to compete in the Final Event.
- A.5.1.4 | The data for the shipment to the place of the Final Event will be:
- Addressee: Team or University name.
 - Address: MotorLand Aragón - Circuito de Velocidad, Ctra. TE-V-7033 km.1, 44600 Alcañiz – Teruel (Spain)
 - Contact phone: Team's contact phone

A.5.2 Visa

The registration documents in the MotoStudent Competition and other participation accreditations of the team in the Competition can be used as justification or demonstration to issue the visa, in case of requiring it.

The Organization recommends non-EU teams to ensure all aspects of the visa and travel in general as soon as possible to avoid unexpected incidents.

All the information and doubts about the requirements to travel to Spain are included in the website of the Ministry of Foreign Affairs and Cooperation of the Government of Spain: www.exteriores.gob.es

- A.5.2.1 The Organization will not grant any type of visa or invitation letter, nor will it intervene with any organism, embassy, or consulate to resolve any question regarding the visa of the members of each team.

ARTICLE 6: COMPETITION CALENDAR

A.6.1 Official deadlines and calendar

The MotoStudent International Competition takes place during three semesters over the period 2022-2023. During this period there are some milestones that all teams must meet to complement the final evaluation of the Competition. The following Calendar shows the main deadlines of the Competition:

Period	DATE Start End	2022												2023											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Team Registration	17/01/2022 until full quota																								
MS1 Delivery 1: Chapter A – Concept development	01/09/2022 30/09/2022																								
MSE Special Milestone 1: Electric Scheme	01/10/2022 31/10/2022																								
MSE Special Milestone 2: Battery Pack specs	01/11/2022 31/11/2022																								
MS1 Delivery 2: Chapter B – Product design	01/01/2023 31/01/2023																								
MS1 Special Milestone 1: Final Design	01/01/2023 31/01/2023																								
MS1 Delivery 3: Chapter D – Innovation	01/03/2023 31/03/2023																								
MS1 Delivery 4: Chapter E – Management Plan	01/04/2023 31/04/2023																								
MSE Special Milestone 3: Battery Pack assembly	01/03/2023 30/04/2023																								
MS1 Delivery 6: MS1 presentations	01/04/2023 30/04/2023																								
MS1 Special Milestone 2: State Report	01/04/2023 30/04/2023																								
MSE Special Milestone 4: Electric Powertrain Test	01/05/2023 30/06/2023																								
MS1 Delivery 5: Chapter C – Prototyping and testing	01/06/2023 30/06/2023																								
MS1 Delivery 6: MS1 presentations	01/06/2023 30/06/2023																								
Admin Milestone 1: Data Accreditations	01/08/2023 31/08/2023																								
Admin Milestone 2: Rider Data	01/09/2023 30/09/2023																								
Final Event	Autum 2023																								

A.6.2 Team Registration Period

The Team Registration period is open at 17/01/2022 until all available places have been filled.

A.6.3 Administrative Milestones

The Milestones of an administrative nature indicated in the Competition Calendar of Art. A.6.1 are described below.

A.6.3.1 | Admin Milestone 1: Data for accreditations (From 01/08/2023 to 31/08/2023):
Documentation and pictures for access passes during the Final Event

A.6.3.2 | Admin Milestone 2: Rider data (From 01/09/2023 to 30/09/2023): Rider data to present (name, ID, racing career, number of license and other federative data).

A.6.3.3 | If Administrative Milestones are not delivered on time due to a late registration, its delivery will be accepted up to the date MotoStudent Organization set at the time of team registration.

A.6.4 MotoStudent Electric Category specific Milestones

A series of specific milestones will be required for equipment of the MotoStudent Electric Category in order to guarantee the safety of the prototypes and compliance with the Technical Regulations. Detailed descriptions are found in Art.D.13.1.1.

A.6.4.1 | MSE Special Milestone 1: Electric scheme (From 01/10/2022 to 31/10/2022):
Aspects related to the electrical design of the prototype and complete electrical diagram.

A.6.4.2 | MSE Special Milestone 2: Battery pack specs (From 01/12/2022 to 31/12/2022):
Design and electrical and mechanical configuration of the battery pack.

A.6.4.3 | MSE Special Milestone 3: Battery pack assembly (From 01/03/2023 to 30/04/2023): Description of the physical assembly of the battery pack.

A.6.4.4 | MSE Special Milestone 4: Electric powertrain test (From 01/05/2023 to 30/06/2023): Functional test description of the electric propulsion system.

A.6.4.5 | If any MSE Special Milestone is not delivered on time due to a late registration, its delivery will be accepted in the first 15 days after the team registration.

A.6.5 MS1 Special Milestones for Electric & Petrol categories

- A.6.5.1 | MS1 Special Milestone 1: Final Design (From 01/01/2023 to 31/01/2023): 3D file in STEP format with the final design in a single “part” file.
- A.6.5.2 | MS1 Special Milestone 2: State Report (From 01/04/2023 to 30/04/2023): The present state for each system of the prototype will be described on a sheet with a picture of present situation up to date.

A.6.6 MS1 Project Deliveries

Teams will deliver the different parts that will make up their MS1 Project.

- A.6.6.1 | MS1 Delivery 1: Chapter A – Concept development (From 01/09/2022 to 30/09/2022): See Art. F.2.2.
- A.6.6.2 | MS1 Delivery 2: Chapter B – Product design (From 01/01/2023 to 31/01/2023): See Art. F.2.3.
- A.6.6.3 | MS1 Delivery 3: Chapter D – Innovation (From 01/03/2023 to 31/03/2023): See Art. F.2.5.
- A.6.6.4 | MS1 Delivery 4: Chapter E - Management Plan (From 01/03/2023 to 31/03/2023): See Art. F.2.6.
- A.6.6.5 | MS1 Delivery 5: Chapter C – Prototyping and testing (From 01/06/2023 to 30/06/2023): See Art. F.2.4.
- A.6.6.6 | MS1 Delivery 6: MS1 presentations (From 01/06/2023 to 30/06/2023): See Article 4, section F of this Regulation

A.6.7 Final Event

The Final Event will take place in Autumn 2023 at the MotorLand Aragón Speed Circuit. The specific date and time of tests and activities will be published by the Organization.

A.6.8 Penalties for delays in official deadlines

The deadlines stipulated in the Competition Calendar (see Art. A.6.1) must be met. In case of delay, penalties will be applied:

- A.6.8.1 | The delay in the delivery of each Admin Milestone will entail the following penalty: [1 MS1 point + 1 MS2 point] for each day of delay (Max 20 points → 10 MS1 + 10 MS2).
- A.6.8.2 | The delay in the delivery of each MSE Special Milestone will entail the following penalty: [1 MS1 point + 1 MS2 point] per day of delay (Max. 20 points → 10 MS1 + 10 MS2). Delivery of the MSE Special Milestones more than 10 days after the deadline may also entail the established in Art. D.13.1.2.
- A.6.8.3 | The delay in the delivery of each MS1 Special Milestone will entail the following penalty: 2 MS1 points per day of delay (Max. 20 points).
- A.6.8.4 | The delay in the delivery of each MS1 Phase Milestone will entail 2 points of penalty in the corresponding chapter of the MS1 project (A, B, C, D or E) per day of delay (max 20 points). Deliveries after more than 10 days from the deadline will not be evaluated and will, therefore, be given 0 points.
- A.6.8.5 | Penalties accumulated to the MS1 Phase in the delay of the Admin Milestones and/or MSE Special Milestones will be distributed over the scores given by the expert jury over the MS1 Deliveries (A, B, C, D and E chapters) in the proportion in which each part represents over the total of 400 points, as stated in Art.F.6.3.
- A.6.8.6 | Penalties accumulated affecting the MS2 Phase in the delay of the milestones will be applied to the final score of the MS2 Phase.
- A.6.8.7 | The minimum score in each of the parts or scoring events in the Competition cannot be less than 0 points.

ARTICLE 7: COMUNICATION BETWEEN TEAMS AND ORGANIZATION

A.7.1 Publication of questions: Frequently Asked Questions (FAQ)

By sending a question to the Organization, teams accept that the Organization can partially or totally reproduce the question and the official response in the FAQ Database, available to all registered teams through the official platforms.

- A.7.1.1 | FAQ Database will collect the common doubts regarding the MotoStudent Competition sent by the teams, and will be updated by the Organization
- A.7.1.2 | Registered teams must read the updates of the FAQ Database, which will have the same officiality as the present Regulations.

A.7.2 Types of questions

The Organization will answer all the questions that are not described in the Competition Regulations or in the FAQ Database.

- A.7.2.1 | The Organization may not answer a question whose answer is clearly reflected in the Competition Rules, FAQ Registration or any other official document

A.7.3 Consultation procedure

All questions addressed to the Organization must be sent through the platform established by the Organization for that purpose and must comply with the following format:

- Full name of the person asking the question.
- Category (MotoStudent Electric / MotoStudent Petrol).
- Bike number.
- Team Name.
- Affected article/s of the Regulations or FAQ number affected.
- Question.

- A.7.3.1 | It is recommended to not attach any picture, drawing or file which exceeds 500KB in size.

- A.7.3.2 | The Organization will not answer queries whose response is clearly reflected in the Competition Regulations, FAQ Database or any other official document.

- A.7.3.3 | The Organization will not solve any doubts by telephone. All questions must be submitted and solved using the consultation procedure defined in this article.

A.7.4 Response time

The Organization undertakes to answer all questions as soon as possible. Considering the fact that some questions may need more time to be answered due to the complexity or need for external consultation, the estimated maximum response time will be 15 natural days.

SECTION B

GENERAL TECHNICAL REGULATIONS

ARTICLE 1: TECHNICAL REQUIREMENTS OF THE PROTOTYPE AND RESTRICTIONS

B.1.1 Introduction to Technical Regulations

The prototypes presented to compete in MotoStudent must be self-designed.

- B.1.1.1 | The design and manufacture of the presented prototypes must comply with the rules imposed by these Regulations in order to participate in the scoring phases of Competition.
- B.1.1.2 | The prototypes must maintain all the specifications required in the Technical Regulations during all the tests of the Final Event. The Organization may review the correct compliance with the Regulations at any time during the Final Event.
- B.1.1.3 | Any failure to comply with the technical requirements and restrictions should be corrected and re-inspected before the prototype can participate in any test during the Final Event.
- B.1.1.4 | The rules reflected in this Section B of the Regulations equally affects both the "MotoStudent Petrol" and the "MotoStudent Electric" categories of the Competition, except for the articles where are indicated special requirements for a specific Category.

B.1.2 Changes and repairs

Once the scrutineering (see Section E) has been passed and the prototype has been validated for the MotoStudent Competition, any change not explicitly permitted without the supervision of the Technical Staff of the Organization will be strictly forbidden. Before carrying out any modification, the Organization must be informed, which must approve it and re-inspect the prototype after it has been applied.

Changes allowed after the Scrutineering that do not involve supervision by the Organization are:

- Secondary transmission adjustment
- Brake system adjustment
- Changes and adjustments in the data recording systems
- Tire pressure adjustment
- Refilling fluids

- General set-up adjustments
- Engine set-up adjustments

Should a prototype need to be repaired, the repair must be approved by the Organization. Once it has been repaired, the Organization must give the approval to let the prototype return to the Competition after checking it.

B.1.3 Other Competitions

The present General Technical Regulations have been created exclusively for the MotoStudent Competition, so prototypes manufactured according to the specifications indicated on these Regulations do not have to adhere to the requirements of other speed competitions outside MotoStudent. The Organization is not responsible for the use that the different teams can make with the prototypes presented at MotoStudent in other competitions.

B.1.4 MotoStudent Kit

B.1.4.1 The MotoStudent Kit for the teams registered in the "MotoStudent Petrol" Category includes the following components:

- Internal combustion engine
- 1 set of front and rear slick tires
- Brake calipers and pumps (To be confirmed, here in after TBC)

B.1.4.2 The MotoStudent Kit for the teams registered in the "MotoStudent Electric" Category includes the following components:

- Electric motor
- Insulation Monitoring Device (IMD)
- 1 set of front and rear slick tires
- Brake calipers and pumps (TBC)

B.1.4.3 The components included in the MotoStudent Kit will incorporate an identification mark. This marking must remain intact, since it will be reviewed by the Technical

Staff of the Organization in the Final Event. In case of breakage or damage of these markings, the teams should contact the Organization to determine a solution.

B.1.4.4 It is not possible to cover with paint or stickers any identification mark of the components supplied by the Organization.

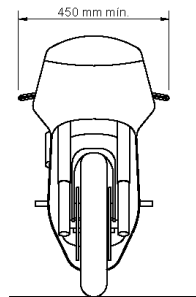
B.1.4.5 Any technical question regarding the components included in the MotoStudent Kit should be channelled through the Organization. Direct contact between the participating teams and the supplying companies for technical issues related to the MotoStudent Kit is prohibited.

ARTICLE 2: GENERAL DESIGN REQUIREMENTS

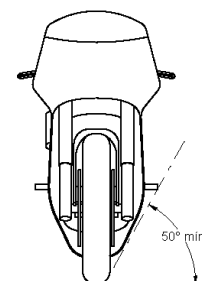
B.2.1 Dimensions

The dimensions of the prototype are free, except for the following basic requirements

B.2.1.1 The minimum width between the ends of the semi-handlebars must be 450mm.

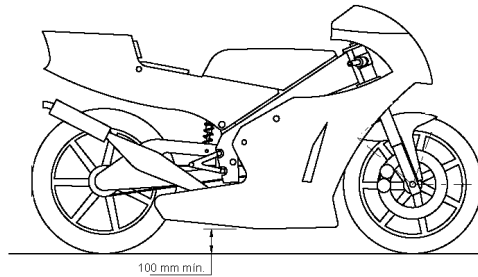


B.2.1.2 The minimum tilt angle of the prototype without any of its elements (except the tires) touching the road surface must be 50°. This measurement will be made with an unloaded prototype (without the rider) but fully equipped, fluids included, for its correct operation.

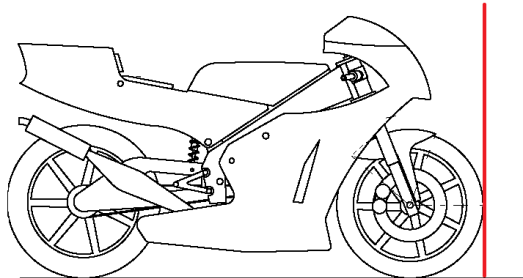


B.2.1.3 The minimum distance between the prototype in upright position and the road surface must be of at least 100mm in rest situation. This measurement will be done

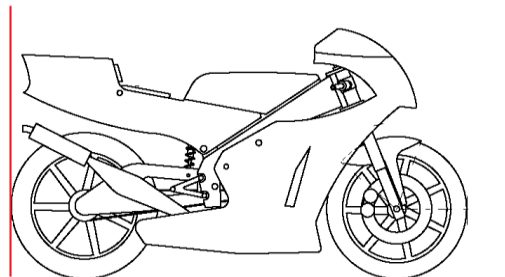
with the prototype unloaded (without the rider), but with all the equipment and liquids for its operation.



- B.2.1.4 Front limit: No element of the prototype shall protrude from the front vertical line drawn tangentially with respect to the external circumference of the front tire.

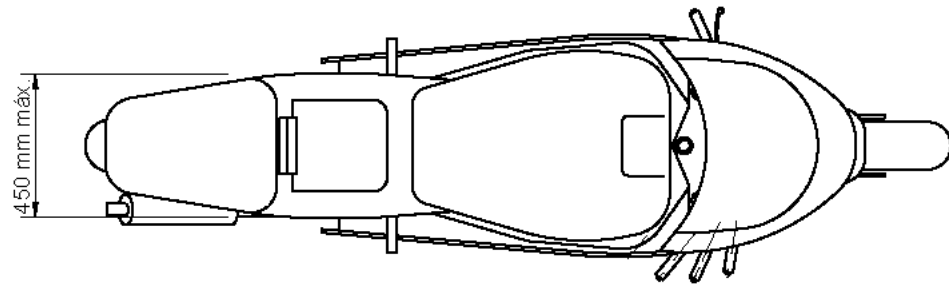


- B.2.1.5 Rear limit: No element of the prototype shall protrude from the vertical line drawn tangentially with respect to the external circumference of the rear tire.

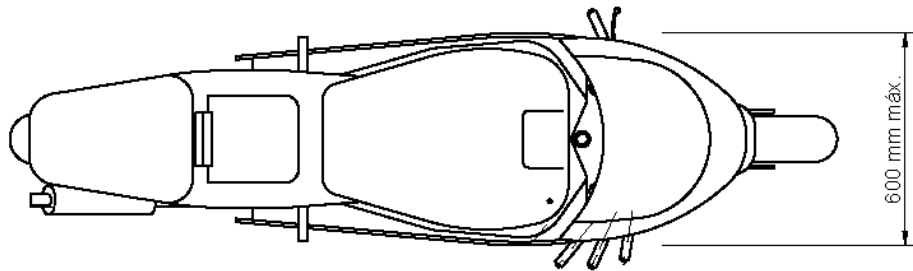


- B.2.1.6 The tire tread shall have a minimum clearance of 15mm along its outer circumference to any part of the prototype in any position and with any geometry set-up.

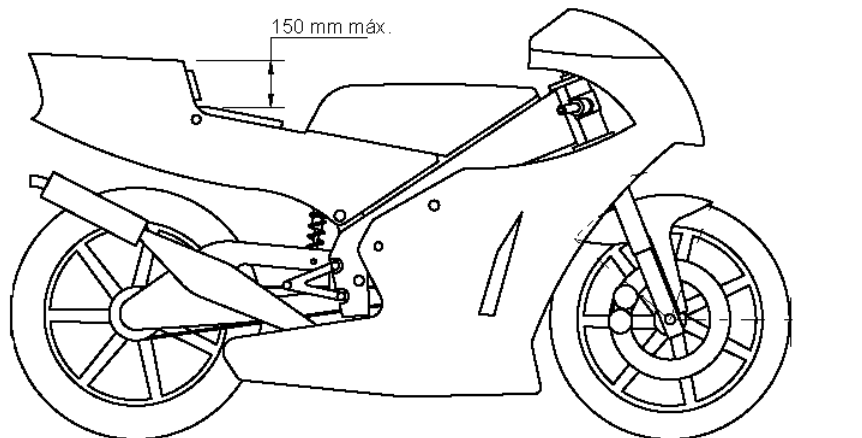
- B.2.1.7 The maximum width of the saddle must not exceed 450mm. No other element of the prototype shall protrude from this width from the saddle to the rear except for the exhaust system for prototypes of the “MotoStudent Petrol” Category.



- B.2.1.8 The maximum width of the fairing shall be 600mm.



- B.2.1.9 The maximum height difference between the height of the saddle and the highest part of the tail shall be 150mm.



B.2.2 Weight

- B.2.2.1 The total minimum weight of the prototype without the rider shall be 95kg for both categories, including all fluids that may be necessary for the correct operation of the prototype.
- B.2.2.2 The weight of the complete prototype shall not be below the minimum weight indicated in Art. B.2.2.1. at any time during the Final Event.

B.2.2.3	The use of ballast to reach the minimum weight of the prototype is allowed. In case of using it, the ballast must be declared to the Technical Staff during scrutineering.
B.2.2.4	In case of installation of mobile ballast, it must be properly fixed to the chassis so it cannot become detached from the prototype in case of shock or fall. It can be installed by zip ties or screwed.

ARTICLE 3: FRAME

B.3.1 Design

The use of a commercial frame is not allowed, not even a modified unit. It must be a self-designed frame prototype.

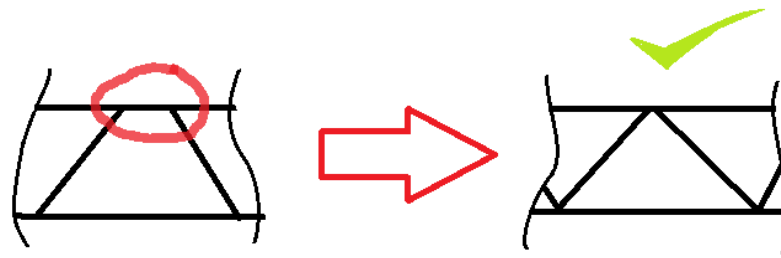
The main frame, the subframe and the swingarm are included in this article.

B.3.1.1	There are no restrictions in the type of design or materials of the frame, swingarm or subframe, provided that the result complies with the rules imposed by these Regulations.
B.3.1.2	In case of doubt about the safety of the frame design submitted, the Organization may request a safety justification report that includes analysis using the finite element method, simulations or other demonstration tests.
B.3.1.3	Frame must be designed in such a way that all elements of the engine, fuel and combustion intake, and electrical and electronic control and safety systems, including battery packs, are protected in case of a fall, especially in case of lateral fall.

B.3.2 Welding and unions

Welding of structural elements by any means is permitted, but the final structure must be consistent.

B.3.2.1	Structures of jalousie type must search the correct triangulation in the nodes of the structure.



Example of correct triangulation

B.3.3 Crash protectors

B.3.3.1 It is mandatory to use protection caps made of nylon, fiber or materials of similar hardness, to protect the chassis and propulsion system laterally in case of fall.

B.3.3.2 The chassis crash protectors are mandatory. They may be installed both inside and outside the fairing, and properly fixed to the frame, to protect the entire frame and propulsion system in case of crash.

Wheel axles, handlebars ends or other locations are also allowed to have crash protectors, assuring that they protect laterally the entire frame and propulsion system in case of crash.



Example of crash protector

ARTICLE 4: FAIRING

B.4.1 General requirements

B.4.1.1 All edges and finishes of the fairing must be rounded. Minimum radius 1mm.

B.4.1.2 The fairing cannot cover the rider sideways, except for the forearms (this exception is only applicable in minimum aerodynamic resistance position of the rider).

B.4.1.3 There are no restrictions regarding the manufacturing material of the fairing.

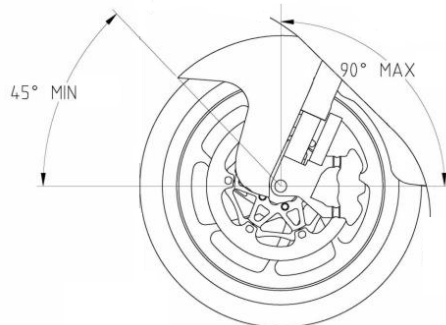
- B.4.1.4 | It is allowed to install any aerodynamic device (wings, fins, bulges, etc.) protruding from the fairing or bodywork, if they do not exceed the maximum dimensions stated in this Regulations and are correctly fixed to the fairing.
- B.4.1.5 | Any leading edge of the aerodynamic devices will have a minimum external radius of 2.5 mm.
- B.4.1.6 | Any aerodynamic device will have a maximum deflection of 10mm in any point, when a 50N vertical load is applied in the downward direction. In case of doubt regarding track safety due to the use of wings or other aerodynamic elements, the decision of the Technical Staff of the Organization will be final.
- B.4.1.7 | Mobile wings or other mobile aerodynamic elements are allowed.

B.4.2 Lower fairing

- B.4.2.1 | The lower fairing must be manufactured to contain, in case of an incident, at least the half of the liquids (fuel excluded) of the prototype, with a minimum of 2.5 liters of liquid.
- B.4.2.2 | The lower fairing must include a hole with a diameter of 25mm located in the lowest part of the fairing. This hole must remain closed with a cap in dry conditions and may only be opened in case of rain.

B.4.3 Mudguards

- B.4.3.1 | The use of front and rear mudguards is compulsory.
- B.4.3.2 | Front mudguard cannot cover more than 135° of the wheel circumference measured from the rear part of the tire; the origin of the angle being on the horizontal line crossing the wheel shaft. Anchor points of the mudguards to the front fork, fork or brake discs covers may exceed this restriction.



- B.4.3.3 | The rear rim cannot be covered in more than 180°.

B.4.4 | Protection against trapping

- B.4.4.1** | If by means of its design, the swingarm does not cover the inferior part of the chain or transmission belt, a guard must be fitted in such a way as to prevent trapping between the lower drive chain run and the final drive sprocket.



Example of “Shark fin”

ARTICLE 5: HANDLEBARS AND FOOTRESTS**B.5.1** | **Handlebars and manual controls**

- B.5.1.1** | The use of handlebars or semi-handlebars made of light alloys, such as magnesium or titanium is not allowed.
- B.5.1.2** | The supports of the handlebar or semi-handlebar must be designed so as to minimise the risk of a fracture in case of a crash.
- B.5.1.3** | Minimum radius of 2 mm must be used at the parts that constitute the handlebars and their anchorages.
- B.5.1.4** | The throttle grip must include an auto return feature in order to make sure that the throttle will be shut down whenever the rider lets it go.
- B.5.1.5** | The manual lever for clutch (in case of including it) is for free choice, provided the distance between the pivot point and the outer end do not exceed 200mm and edges and terminations are rounded.
- B.5.1.6** | Installation of a front brake lever protection is mandatory. This protector must protect the lever from being accidentally activated in case of contact with another prototype.



Examples of front brake lever protections

- B.5.1.7 | The electric ignition or start button must be located on the handlebar.

B.5.2 Footrests and their controls

- B.5.2.1 | The footrests can be fixed or “folding in case of crash” type. In case of folding type these must be fitted with a device that will make them return to their normal position as well as avoid any easy folding during the race. In rest position without the rider, footrests must be unfolded.
- B.5.2.2 | The end of each footrest must present round ends, until a minimum spherical radius of 8mm.
- B.5.2.3 | It is recommended the installation of a cap at the outer end of footrests, made of aluminum, plastic, Teflon or any other equivalent material in terms of strength, permanently fixed.
- B.5.2.4 | The footrests must be fitted with side protections to avoid the rider's boot to interfere with mobile elements such as the chain or the rear tire.
- B.5.2.5 | The choice of rear brake pedal is free.
- B.5.2.6 | The choice of the gear shift pedal (in case of having one) is free.

ARTICLE 6: BRAKE SYSTEM

The prototype must be fitted with a single-disc hydraulic-driven brake system both in the front and in the rear shaft.

B.6.1 Command and control

- B.6.1.1 | Combined brake systems are not allowed. The front and rear systems must be completely independent of each other.
- B.6.1.2 | The braking system for the front wheel should be commanded by a hand lever installed next to the throttle grip on the right handlebar.
- B.6.1.3 | The braking system for the rear wheel must be commanded by foot by a cam system installed in the area of the right footrest.

B.6.2 Discs

- B.6.2.1 | The brake discs are free-choice.
- B.6.2.2 | The brake discs must be made of steel alloys. The use of carbon or ceramic compound brake discs is strictly forbidden.
- B.6.2.3 | The use of discs with inner ventilation is forbidden.
- B.6.2.4 | Brake discs must be installed on front and rear rims.
- B.6.2.5 | Installation of brake disc spacers between the rim and the disc is permitted.

B.6.3 Brake calipers

The use of the brake calipers provided by the Organization, both for the front and the rear shaft, is compulsory. (TBC)

- B.6.3.1 | The rear brake caliper must be installed with at least one anchoring element directly fixed to the swingarm.
- B.6.3.2 | It is allowed to mount the rear caliper over a non-fixed support system placed by the rear wheel axle, provided that the system has at least one direct fixing for the swingarm, as indicated in Art. B.6.3.1.
- B.6.3.3 | The front and rear brake pads are free-choice.
- B.6.3.4 | The pins of the front and rear brake pads can be changed. Quick change systems are allowed.
- B.6.3.5 | No supplementary cooling pipes conducting fresh air to the caliper are allowed.

- B.6.3.6 | The modification of the body of the brake calipers provided by the Organization is forbidden. The realization of recesses or chamfers is not allowed. Therefore, teams must choose or adapt anchorages for proper installation of the supplied calipers.

B.6.4 Brake pumps

The use of the brake pumps provided by the Organization, both for the front and the rear shaft, is compulsory. (TBC)

- B.6.4.1 | The activation lever for the front brake pump cannot be replaced or modified.

B.6.5 Brake ducts

- B.6.5.1 | Brake hoses are free-choice.

- B.6.5.2 | The passage of the hoses for the front brake caliper must be made ahead the lower steering plate.

- B.6.5.3 | Quick connectors on the brake hoses are allowed.

B.6.6 ABS System

The use of an anti-block system (ABS) is not allowed.

B.6.7 Brake fluid

The hydraulic fluid of the brake system is free-choice.

ARTICLE 7: SUSPENSION SYSTEM

Suspension systems are free configuration, except for the rules set forth below.

B.7.1 General aspects

- B.7.1.1 | All active or semi-active suspension systems and/or electronic controls of any type for the suspension, including those that control the height adjustment are forbidden.

B.7.1.2 | The settings of the suspension can only be made manually and by means of mechanic/hydraulic adjustments.

B.7.1.3 | The Organization shall not accept the participation of a prototype which suspension system is determined to be dangerous for the participation in track tests.

B.7.2 Front suspension

B.7.2.1 | Front suspension system of any kind is permitted: conventional fork, inverted fork, telelever, duolever, front swingarm, etc. Both commercial and self-designed / modified systems are allowed.

B.7.2.2 | The front suspension assembly may have mechanical or hydraulic adjustment systems, such as spring preload, compression, extension or rebound regulation.

B.7.3 Rear suspension

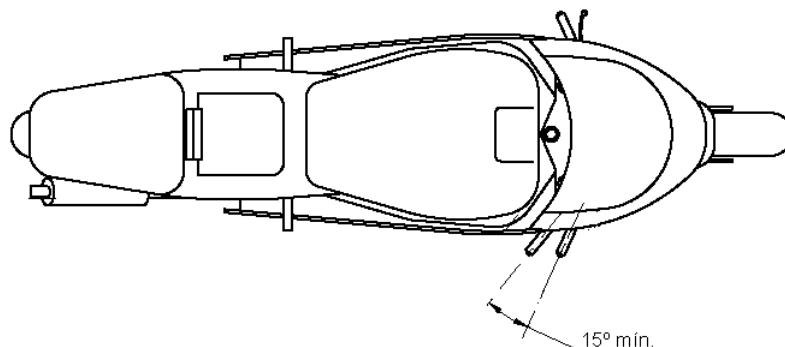
B.7.3.1 | Rear suspension system of any kind is permitted. Both commercial and self-designed / modified systems are allowed.

B.7.3.2 | The rear suspension assembly may have mechanical or hydraulic adjustment systems, such as spring preload regulation, compression, extension or rebound regulation.

ARTICLE 8: STEERING SYSTEM

B.8.1 Restrictions and geometry

B.8.1.1 | The minimum turning angle of the steering must be 15° measured on either side of the longitudinal axis of the prototype.



B.8.1.2 | The turning angle must be limited with stoppers on both sides. These stoppers should be made of nylon, aluminum or materials of similar hardness. Neither the chassis, nor any other part of the prototype may act as a steering stopper.

B.8.1.3 | There must not be any element interfering in a tolerance of 30mm around the handles of the handlebars and actuators, all along the steering stroke. The aim is to avoid damage to the hands and fingers of the rider in case of a crash.

B.8.2 Steering dampers

B.8.2.1 | The use of steering dampers is allowed.

B.8.2.2 | The settings of the steering dampers can only be made manually and by means of mechanic/hydraulic adjustments.

B.8.2.3 | The steering damper cannot act as a device that limits the turning angle.

ARTICLE 9: RIMS AND TIRES

B.9.1 Rims

Rims will be freely chosen by each team.

B.9.1.1 | The sizes of the rims (considering areas enabled for the tires fitment) must be:

- Front rim: 2.5" x 17"
- Rear rim: 3.5" x 17"

B.9.1.2 | Rims made of composites (like carbon fiber or reinforced glass fiber) are forbidden. Rims must be made of steel, aluminium or magnesium.

B.9.1.3 | The use of nylon protectors at the ends of the shafts for possible crashes is allowed. These protectors must be rounded, with a diameter that is equal or larger than the used shaft.

B.9.1.4 | The ends of the wheel shafts cannot protrude more than 30mm from their housing. Possible nylon protectors are not considered in this measure (see Art. B.9.1.3).

B.9.2 Tires

Only those tires supplied by the Official Tire Supplier of the respective competition year can be used at MotoStudent. The Organization will supply a set (front and rear) of dry-condition slicks to each team within the MotoStudent Kit.

The technical information regarding the official tire set will be sent to all teams participating in the Competition.

- B.9.2.1 | Should the team wish to have more tires for dry conditions they will be able to purchase them through the Organization. Wet tires will only be available for purchase during the Final Event, and limited to two sets per team. The tire mounting during the Final Event will be limited to 1 additional dry set to the supplied before, and/or 2 wet tire sets.
- B.9.2.2 | The use of tire warmers is allowed.

ARTICLE 10: ELECTRONIC SYSTEMS

B.10.1 Riding assistance electronic systems

- B.10.1.1 | It is forbidden to use electronic control or assistance systems that provide for a clear riding advantage, such as traction control, ABS, anti-wheelie systems, etc.

B.10.2 Rider information systems

- B.10.2.1 | The information systems and alerts in the dashboard for the rider are freely configurable.

B.10.3 Data recording systems

Data recording systems are permitted. These systems can acquire data relative to motor/engine parameters, motorcycle dynamics and rider behavior.

- B.10.3.1 | The use of all types of sensors is allowed, provided that its installation does not affect any rule of these Technical Regulations.
- B.10.3.2 | The live reading systems of telemetry are prohibited. The data acquisition may only be read at the stops in box. Direct download of data is allowed using a wired connection or a wireless one (e.g. Bluetooth or WIFI) as long as the connection and data download is only made during stops in box.

B.10.3.3 | All components and wiring of the data acquisition system must be properly fixed and placed in safe areas.

B.10.3.4 | MotoStudent Organization may request totally or partially the acquired data to any team at any time along the competition if it deems it appropriate, with special attention to the powertrain data.

B.10.4 Transponder

Prior to performing the MS2 tests during the Final Event, the Organization will supply a transponder to all the teams to be installed on the prototype.

B.10.4.1 | Transponder will have a rental price of 25€, not included in the MotoStudent registration fee.

B.10.4.2 | The transponder must be properly fixed using zip ties on the left suspension bottle of the front fork, focused towards the outside of the prototype, and in an easily accessible area. In case the design of the prototype does not allow this placement, the Technical Staff of the Organization will indicate to the team the correct location.

B.10.5 On-board cameras

For the use of on-board cameras during the tests, teams must request permission previously to the Competition Organization.

B.10.5.1 | The installation of on-board cameras during MS2 tests must be approved by both the Technical Staff of the Organization and by the Race Direction.

B.10.5.2 | The installation of on-board cameras will only be possible during the dynamic tests 1, 2 and 3 of the MS2 Phase. On-board cameras are not allowed to be installed during practice sessions and races.

B.10.5.3 | In case of installing on-board cameras for the tests described in Art. B.10.5.2, the Technical Staff of the Organization must verify and authorize beforehand the correct installation.

B.10.6 Rear Safety Light

All motorcycles must have a functioning red light mounted at the rear of the machine for rain or low visibility conditions. The team must ensure that the light is switched on any time the motorcycle is on the track or being ridden in the pit-

line whenever a rain tyre is fitted on the motorcycle. All lights must comply with the following:

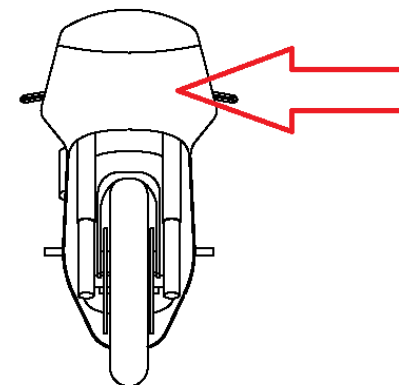
- a) Lighting direction must be parallel to the motorcycle running direction, and be clearly visible from the rear at least 15 degrees to both left and right sides of the prototype centre line.
- b) The rear light must be mounted near the end of the seat/rear fairing and approximately on the machine centre line, in a position approved by the Organization. In case of dispute over the mounting position or visibility, the decision of the Organization will be final.
- c) Power output/luminosity equivalent to approximately: 10 – 15W (incandescent), 0.6 – 5 W (LED).
- d) The output must be continuous - no flashing safety light whilst on track, flashing is allowed in the pit lane when pit limiter is active.
- e) Safety light power supply may be separated from the motorcycle.
- f) The Organization has the right to refuse any light system not satisfying this safety purpose.

ARTICLE 11: IDENTIFICATION, ADVERTISING AND COMPETITION NUMBERS

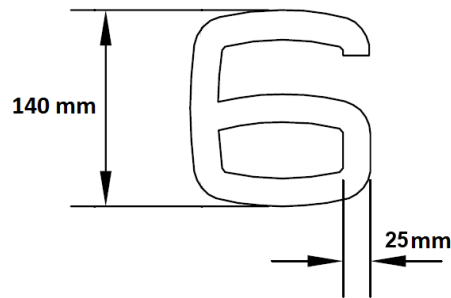
B.11.1 Bike Numbers

Each prototype must include 3 identifying bike numbers on its fairing, according to the bike number assigned to each team as stated in Art. A.3.4.3.

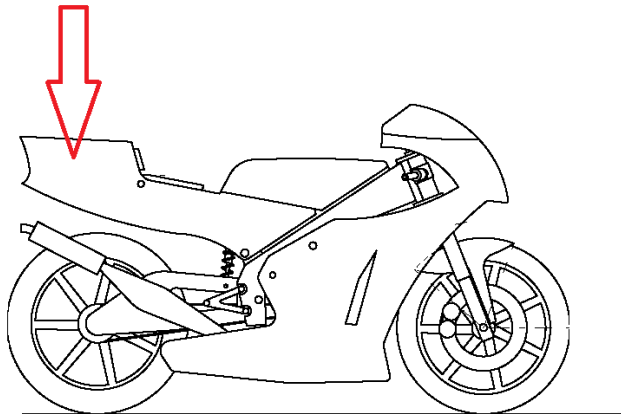
- B.11.1.1 The front number must be placed on the front part of the fairing. It may be located in the central part or lopsided, provided that it is perfectly readable.



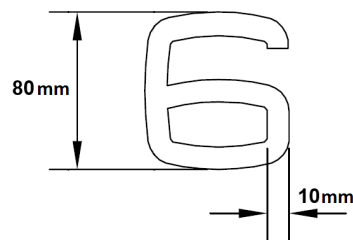
- B.11.1.2 In the front number, the minimum dimension of each character must be 140mm in height and the minimum stroke width of each character must be 25mm. The minimum distance between characters must be 10mm.



- B.11.1.3 A bike number must be placed on either side, on the rear side of the fairing (tail). The location for the numbers on each side of the motorcycle can be on the lower rear portion of the main fairing near the bottom, or on the rear side of the fairing (tail).



- B.11.1.4 In the side numbers, the minimum dimension of each character must be 80mm in height and the minimum stroke width of each character must be 10mm. The minimum distance between characters must be 5mm.



- B.11.1.5 The numbers must be totally black color. No combination of colors is allowed.
- B.11.1.6 The font used for bike numbers is free, as long as the Technical Staff of the Organization considers it readable. The inclusion of graphics or logos in the number is not allowed.
- B.11.1.7 The background behind the numbers should be a continuous homogeneous white area, and shall cover an area encompassing at least 25 mm around the numbers

B.11.2 Identification

B.11.2.1 The name of the represented university, its logo or its initials must appear on all prototypes, occupying an area with a minimum height and width of 100mm.

B.11.2.2 There must be a space on the left external side (considering riding direction) of the frame for the scrutineering stickers. The stickers must be visible with the fairing mounted and directly stuck to the frame. The Organization will place 3 rectangular labels with a maximum size of 3 x 3 cm.



Examples of scrutineering stickers

B.11.2.3 Every prototype must have an identifying number engraved in the frame. The said number/code will be provided by the Organization and engraved by the team on the left side of the prototype. The engraved identifying number must be perfectly visible with the fairing fitted.

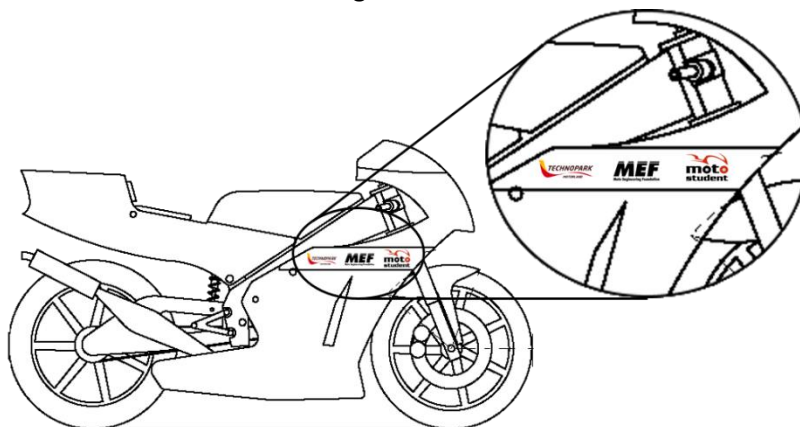
B.11.3 Competition Logos and Advertising

B.11.3.1 In the final design of the prototype, all participating teams must include in the upper part of the side fairing a strip which must meet the following specifications:

- The strip should be white.
- The MotoStudent, MEF and TechnoPark MotorLand logos must be included on the strip in the original colors. The design of these logos will be previously provided by the Organization to all teams.
- This strip must cross from the rear of the side fairing to the front. The minimum height of this white strip will be 70mm and the length will be defined by the chosen design of fairing. The tilt angle is free, although it is recommended to position it as horizontally as possible.
- The logos should be arranged in symmetrical order on both sides, in the order of the guiding figure shown below. From the front to the rear must

follow the order MotoStudent - MEF - TechnoPark MotorLand on both sides.

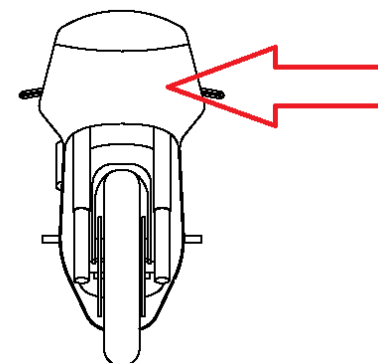
- The minimum width of the logos will be 50mm.



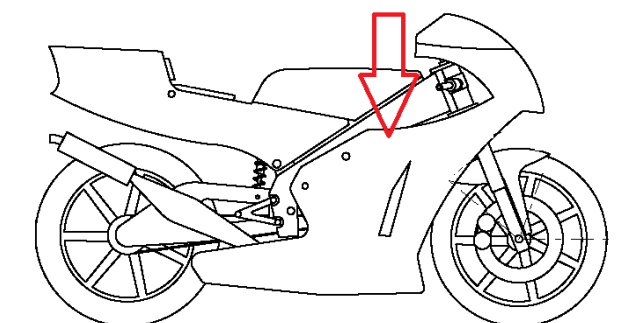
White stripe with compulsory logos

B.11.3.2 Apart from the stripe indicated in Art.B.11.3.1, three spaces should be available to include stickers that will be fixed by the Organization during the Final Event. These stickers will have a maximum area of 150mm wide x 100mm high and will be provided by the Organization. Its location will be:

- A sticker in the front part of the fairing, near the front number, under the windscreen.



- A sticker on each side of the fairing at the top front zone.



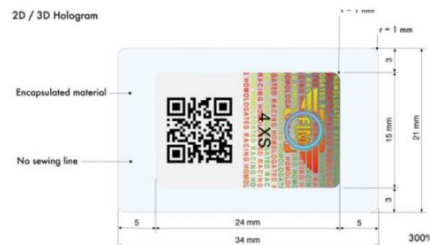
- B.11.3.3 | In case of not following the spaces stated in this article for the Organization stickers, the Organization will decide to place them where it considers more convenient, without caring if it is placed under any existing logo, promotional sticker or fairing element, without giving the chance to the team to appeal or change them.
- B.11.3.4 | Is strictly forbidden to include advertising of alcoholic drinks or tobacco on the prototype or any other corporate environment of the team.
- B.11.3.5 | Is strictly forbidden to include advertising or other messages that violate human dignity (violence, intolerance, xenophobia, racism, etc.), or that may offend the sensibilities of some people, both on the prototype as in any other corporate environment of the team. Likewise, the Organization reserves the right to review and analyze the advertising content and ban it if it is considered appropriate

ARTICLE 12: RIDER EQUIPMENT

B.12.1 Helmet

- B.12.1.1 | The rider must wear a homologated helmet, according to the following homologations:

a) FHRPhe-01



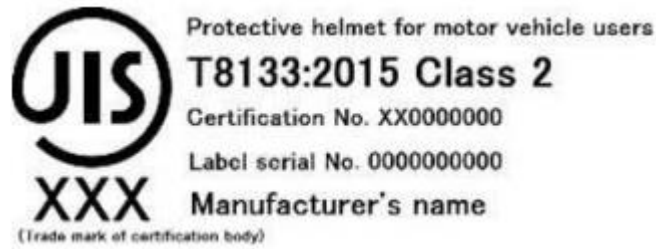
b) ECE 22-05 "P" or ECE 22.06



c) SNELL M 2015 o MD2020D o 2020R



d) JIS T 8133:2015



- B.12.1.2 | The use of disposable screen covers is allowed (tear-off).
- B.12.1.3 | The screen must be made of a shatterproof material.
- B.12.1.4 | Riders must wear a helmet which is in good condition, provides a good fit and is properly fastened during all MS2 tests.

B.12.2 Safety clothing

- B.12.2.1 | The rider must be fitted with a whole one-piece suit, preferably made of leather or other great resistance material, which cover full torso and extremities, and provides special protection of elbows and knees.



- B.12.2.2 | Use of back and chest protector is mandatory
- B.12.2.3 | Use of boots of leather or similar material protection is mandatory.
- B.12.2.4 | Use of leather gloves with fingers protection is mandatory.
- B.12.2.5 | The use of underwear homologated for competition is recommended. This underwear must not be made of a synthetic material which might melt and cause damage to the riders' skin.

SECTION C

SPECIFIC TECHNICAL REGULATIONS FOR THE CATEGORY "MOTOSTUDENT PETROL"

ARTICLE 1: ENGINE

The Organization will supply an internal combustion engine which will be common for the teams entered in the “MotoStudent Petrol” Category.

The engine supplied has passed rigorous quality control checks prior to its shipment, and its design has been tested on road racing competition. As it will be mounted on an external bench and/or prototype without OEM parts, the Organization will assume no responsibility for any damage the engine may suffer during its use or test.

C.1.1 Sealing

The use of the engine provided by the Organization is compulsory. The engine provided by the Organization will be sealed and it is strictly forbidden to manipulate it. Any broken or damaged seal shall be reason to declare a technical nonconformity.

- C.1.1.1 | In case of breakdown or malfunction of any internal part to which the team is not allowed to access, the team shall inform the Organization, who shall take the convenient steps.

C.1.2 Engine technical specifications

Technical information about the engine will be published and sent by the Organization to all the teams registered in the Competition.

- C.1.2.1 | The engine supplied by the Organization will have a displacement between 240cc and 340cc.
- C.1.2.2 | The engine supplied by the Organization shall have an internal liquid cooling system.

C.1.3 Crankcase, cylinder head and engine block

- C.1.3.1 | External and internal modifications of the engine assembly are not allowed.
- C.1.3.2 | Modifications in the engine block are not allowed, not even in its anchorages. The frame supports for the engine should be designed according to its original geometry.

- C.1.3.3 | Modifications in the original cooling ducts supplied with the engine are not allowed. The external cooling system should be developed according to the original cooling ducts of the engine.
- C.1.3.4 | Modifications in the intake and exhaust housing supplied with the engine are not allowed. Intake and exhaust systems should be developed according to the original geometry and dimensions of the engine.
- C.1.3.5 | The installation of protective engine covers or cases is allowed, provided that their installation does not involve the structural modification of the engine, being able to use the original screw housings of the engine covers or carters as anchoring. In no case shall the protective cases cover the Organization seals or labels, nor any identifying reference engraved on the engine.
- C.1.3.6 | The original oil pump integrated in the engine block cannot be modified.
- C.1.3.7 | The original water pump integrated in the engine block cannot be modified.

C.1.4 Modifications

- C.1.4.1 | Any change or modification on the engine that is not specified in these Regulations is not allowed.
- C.1.4.2 | In case of a dispute about these changes, the decision of the Organization will be final.

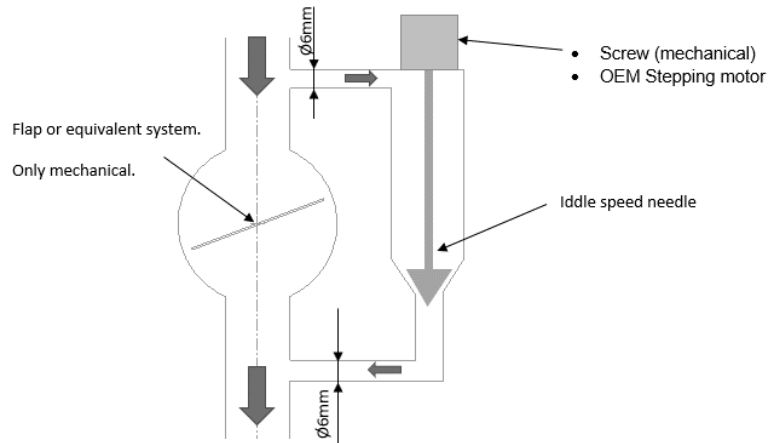
ARTICLE 2: AIR INTAKE SYSTEM

C.2.1 Intake pipes

- | The composition, dimension and position of the air intake pipes are free, provided that they comply with the dimensional requirements of the general dimensions of the prototype.
- C.2.1.1 | It is not allowed to install mobile devices in the intake system before the intake valves of the combustion chamber, except for the carburetor or the injector-throttle body.
- C.2.1.2 | The presence of an air-fuel mix and recycled engine gases is only allowed in the intake pipes. The additional injection of other elements, such as ethanol, methanol, water, etc. is not allowed.

C.2.2 Intake flap

- C.2.2.1 Only one flap or an equivalent mechanical system is allowed, to be activated only by mechanical means (e.g. cable) handled by the rider. A bypass could be implemented for controlling the idle speed of the engine. It could be commanded both mechanical or electronic, using the original stepping motor supplied with the KTM throttle body and directly connected to the KTM ECU . The maximum diameter of the inlet and outlet of the bypass would be 6mm. No other mobile elements are allowed in the intake pipe.



- C.2.2.2 "Ride by wire" systems are not allowed.
- C.2.2.3 In case of commanding system failure, it must be ensured that the flap or equivalent system gets closed.

C.2.3 Overpressure systems

The use of "turbo" systems to increase the gas pressure in the intake is forbidden. It is only allowed to make use of the aerodynamics of the vehicle movement by means of air intakes.

C.2.4 Airbox and air filtering

The design of the airbox is free, except for the rules set forth below.

- C.2.4.1 Airbox with air filter is mandatory.
- C.2.4.2 The air box must have a minimum volume (volume TBA).
- C.2.4.3 The air filter is free choice and must have a minimum filtering capacity of 3mm.

C.2.5 Recycling of gases

It is allowed the recycling of breather gases of the engine.

- C.2.5.1 | The installation of a closed gas recycling system that directs the excess gases from the engine block to the intake system is allowed. These engine breathing lines can pass through a filtration and oil capture tank.
- C.2.5.2 | In case that the recycling system indicated in Art.C.2.5.1 is not installed, a breathing duct must be installed to discharge the remains of oil in a tank of at least 200cc, specifically installed for this function.
- C.2.5.3 | Under no circumstances shall the breather gases without previous oil residues filtration be discharged directly on the track or on any part of the prototype not indicated in this article.

ARTICLE 3: FUEL SUPPLY SYSTEM

C.3.1 Fuel tank

- C.3.1.1 | Fuel tanks, regardless their design or manufacturing material, should be full filled with mousse type flame retardant foam (preferably Explosafe, ExploStop or similar foam).



Example of flame retardant foam

- C.3.1.2 | It is mandatory to install a breathing duct in the fuel tank to prevent possible overpressures. This duct should be provided with a retention valve that allows the free circulation of air (fuel gases) but blocks the circulation of liquids (fuel), to avoid spills of gasoline in case of an accident. The exit of the breathing tubes must be done in a recovery container specific for this use, which must have a minimum capacity of 250cc.
- C.3.1.3 | In case of "non-metallic" fuel tanks (made of carbon fiber, aramid fiber, fiberglass, polymeric materials, etc.) the installation of a second additional internal deposit of rubber or resin is mandatory. If the non-metallic tanks have FIM approval

(demonstrable with the corresponding FIM label), the installation of this internal bladder is not mandatory. The purpose of this inner safety bladder is to prevent spillage of fuel to the outside in the event of tank breakage.

C.3.1.4 | The lowest part of the fuel tank must be above the height of the engine intake valves.

C.3.1.5 | The fuel tank cap must be fitted with a threaded opening/closing system. Lockable caps are forbidden.

C.3.1.6 | The fuel tank cap must ensure a watertight seal, which prevents the possibility of fuel leaks in the event of a fall.

C.3.2 Fuel pipes

All fuel pipes going from the tank to the carburettor or to the injection system must be fitted with at least one self-closing valve (quick connector), so that if the tank becomes detached from the motorcycle it will be the connector that gets disconnected and no other connections of the pipe. The strength needed to open the connector must be, maximum, 50% of the strength needed to loosen any other connection or breakage of the pipe material.



Example of self-closing quick connector

C.3.3 Injection system

C.3.3.1 | Replacement or modification of the original fuel supply system of the supplied engine is allowed. Either carburetion or injection systems are allowed.

C.3.3.2 | The fuel injector must be installed before the admission valves of the cylinder. Direct injection into the combustion chamber is not allowed.

C.3.3.3 | It is only allowed to install one injector.

C.3.3.4 | It is only allowed to install one fuel pump. There are no restrictions on the type of pump to be installed.

C.3.4 Fuel cooling

The artificial cooling of the fuel is not allowed. Only the aerodynamic design may be used for cooling the fuel system.

C.3.5 Fuel pressure

The fuel pressure must not be over 5 bar (To be confirmed) in any part of the supply circuit.

C.3.5.1 | The refueling operation must be done from a non-pressurized recipient.

C.3.5.2 | It is forbidden to artificially pressurize the fuel tank.

ARTICLE 4: FUEL AND LUBRICANTS

C.4.1 Fuel

The fuel set for the Competition must be unleaded 98 octanes (or less). During the Final Event, only the Official Fuel distributed by the Organization may be used.

The technical information and sales prices of the Official Fuel will be published by the Organization to all teams

C.4.1.1 | Any alteration of the fuel with additives or any other treatment is forbidden.

C.4.1.2 | At any time during the Final Event, the Organization may require samples of fuel. In case of not using the Official Fuel, the team can be disqualified from the test in process or even from the Competition.

C.4.1.3 | It should be taken into account that the composition of the fuel will comply with the chemical requirements established in the European Union. Non-EU countries may find different chemical composition of lubricants, so it is recommended to take this factor into account when setting up and adjusting the prototype.

C.4.2 Engine lubricating oil

The lubricating oil to be used is free-choice.

C.4.2.1 | The installation of radiators to cool the oil is not allowed.

ARTICLE 5: COOLING SYSTEM

C.5.1 Cooling systems

- C.5.1.1 | The design and manufacturing of the external cooling system is free.
- C.5.1.2 | The number, position, size and composition of the cooling liquid radiators are free-choice, provided that they comply with the dimensional requirements of the general dimensions of the prototype.

C.5.2 Cooling fluids

- C.5.2.1 | Only distilled water may be used as cooling fluid.
- C.5.2.2 | The use of additives in the distilled water is forbidden.

ARTICLE 6: EXHAUST SYSTEM

C.6.1 Exhaust system design

- C.6.1.1 | The exhaust system design is free, provided that it complies with the general dimensional requirements of the prototype and the noise regulations.
- C.6.1.2 | No mobile parts are allowed in the exhausts starting from the exhaust valves of the engine (i.e. additional valves, deflectors, etc.).
- C.6.1.3 | The use of a lambda sensor is compulsory, it can be used both for active and/or passive engine tuning. In case of passive engine tuning, recorded data may be required by the Organization at any time.
- C.6.1.4 | Maximum lambda value must be (value to be announced).

C.6.2 Noise

The maximum noise level allowed for the exhaust is 105 dB/A measured statically at 6,000 RPM.

No tolerance will be applied unless after a race session. After a race session it will be applied a tolerance of +3dB/A.

ARTICLE 7: TRANSMISSION SYSTEM

C.7.1 Clutch

The original clutch type should be maintained.

C.7.1.1 | Clutch disks can be replaced.

C.7.1.2 | Clutch springs can be replaced.

C.7.1.3 | Clutch basket can be replaced.

C.7.1.4 | The installation of clutch systems with limited slip (anti-skid or anti-bounce type) is allowed.

C.7.2 Gearbox

The original gearbox is integrated in the supplied engine and shares the lubrication system with the engine itself.

C.7.2.1 | The original gearbox cannot be replaced or modified.

C.7.2.2 | External quickshift type systems are allowed.

C.7.3 Secondary transmission

C.7.3.2 | Only secondary transmission systems by chain are allowed.

C.7.3.2 | The original output pinion of the gearbox included in the engine can be replaced. The variation of geometry and number of teeth is allowed.

C.7.3.3 | The rear wheel sprocket and the chain are free-choice.

ARTICLE 8: ELECTRIC INSTALLATION

C.8.1 ECU

It is only allowed the use of an Electronic Control Unit (ECU) of the engine homologated by the MotoStudent Organization. List of homologated ECUs will be published.

C.8.1.6 | Under no circumstances may the signal from the sensors integrated in the engine be distorted to exceed the engine speed limit (rpm) set by the manufacturer (TBA).

The limit of revolutions may be verified by the Technical Staff of the Organization at any time during the Final Event.

C.8.1.7 | Under no circumstances may the base ignition map be modified.

C.8.2 Battery

It is compulsory to install a battery with an operating voltage of between 8V and 18V.

C.8.3 Electric installation

C.8.3.1 | The configuration of the electric installation by the teams is free.

C.8.3.2 | The use of commercial installations is allowed.

C.8.3.3 | The type of cable, the design and the wiring are for free configuration, provided that they are properly insulated.

C.8.3.4 | The connector type is free. Teams should bear in mind that the electric functioning of the prototype must also be guaranteed in wet conditions.

C.8.3.5 | The use of commercial components is allowed (coil, batteries, regulators, connectors, etc.).

C.8.3.6 | All prototypes must fit a safety stop button on the left-hand side of the handlebar. This button must be highlighted in red to be easily locatable in case of emergency. The stop button should stop the engine when it is activated.

C.8.3.7 | Only the use of one ignition coil is allowed.

C.8.3.8 | The electrical installation must be perfectly integrated into the whole of the prototype. It is forbidden leaving distances larger than 15cm of wires unfixed.

C.8.3.9 | The length of the cable must be the proper one, so that it is forbidden to coil the excess cable length.

C.8.3.10 | It is recommended to remove the electrical installation as much as possible from the hot spots of the engine, as well as cooling and exhaust systems. Under no circumstances may the electric cables and components be in direct contact with parts of the prototype that reach high temperatures.

C.8.4 Start system

- C.8.4.1 | The cancellation of the electric start system integrated in the Official Engine is forbidden.
- C.8.4.2 | In the event of a fault in the electric starter motor, during the start procedure of the race session will not be allowed to start the engine with external starters. Only in the event of a breakdown will it be possible to start the prototype by pushing.

SECTION D

SPECIFIC TECHNICAL REGULATIONS FOR THE CATEGORY “MOTOSTUDENT ELECTRIC”

ARTICLE 1: DEFINITIONS AND GENERAL ASPECTS**D.1.1 High Voltage - HV, Low Voltage - LV, Volts Direct Current – VDC.**

Any circuit with a potential difference above 40 VDC, will be part of the High Voltage (HV) system of the prototype. Below this voltage, it will be considered as part of the Low Voltage (LV) system.

D.1.1.1 | The maximum permitted voltage of the HV system shall be 126 VDC.

D.1.1.2 | The use of software elements to control the maximum voltage is allowed.

D.1.1.3 | HV cables must be shielded.

D.1.2 High Voltage System – HVS

The High Voltage System (HVS) is made-up of all the electric pieces that form part of the motor, controller, accumulator or any other electric part connected to them. The HVS shall be a High Voltage (HV) system according to the specifications of Art. D.1.1 of these Regulations.

D.1.2.1 | The HVS must be electrically separated from the prototype chassis or ground.

D.1.2.2 | The accumulator of the HVS is defined as any cell, battery or supercapacitor (or a group of them), able to store electric energy for the electric propulsion system.

D.1.2.3 | The HVS must have a controller device fitted in between the motor and the accumulator, so that there cannot be a direct connection between the motor and the accumulator.

D.1.2.4 | It is compulsory to place clearly visible labels indicating danger on housings or areas near the components working with High Voltage (HV). These labels must include the text "HIGH VOLTAGE".



D.1.2.5 | The dashboard must be fitted with a display showing the voltage between terminals in the HVS at any given time. The voltage of the HVS may be measured by the Technical Staff of the Organization in order to check whether or not the value shown on the display corresponds to the real voltage value of the HVS.

D.1.3 Ground Low Voltage System – GLVS

The Ground Low Voltage System (GLVS) is made-up of any circuit or electrical part of the prototype (chassis) and hence is not part of the HVS.

- D.1.3.1 | The GLVS must be a LV system, with a voltage below 40 VDC.

D.1.4 Insulation between HVS and GLVS

- D.1.4.1 | The HVS and the GLVS shall be galvanically separated.
- D.1.4.2 | Should a DC/DC converter be used; it will have to comply with this specification.

ARTICLE 2: ELECTRIC MOTOR AND POWER DEMAND

The Organization will provide a common electric motor for the teams registered at the MotoStudent Electric Category

The motor supplied has passed rigorous quality control checks prior to its shipment, and its design has been tested on road racing competition or similar situations. As it will be mounted on an external bench and/or prototype with and/or without OEM parts, the Organization will assume no responsibility for any damage the motor may suffer during its use or test.

D.2.1 Sealing

The use of the motor provided by the Organization is compulsory. The Organization will provide a sealed motor and it is absolutely forbidden to manipulate it. Any broken or damaged seal will be reason for technical non-conformity.

In case of breakdown or malfunction of any internal part, the access to which is forbidden, please contact the Organization to let them take the appropriate measures.

D.2.2 Electric motor technical specifications

The technical information about the electric motor will be published by the Organization to all the teams registered in the Competition.

- D.2.2.1 | The motor supplied by the Organization cannot be modified structurally, not even in its anchors, outer casings or cooling / ventilation system.

D.2.3 Energy regeneration

Energy regeneration is allowed using the motor as a generator during braking.

D.2.4 Throttle potentiometer

It is compulsory to include a throttle potentiometer which is controlled from the right-side handlebar of the prototype. The signal of the potentiometer shall be used to configure the demand of torque or speed from the motor.

- D.2.4.1 | It is allowed to configure the motor brake with the same potentiometer, mapping it in a range below the acceleration range.

ARTICLE 3: ENERGY STORAGE

D.3.1 Permitted storage systems

Any type of battery may be used as energy storage system, except for molten salt batteries (thermal batteries) and fuel cells.

- D.3.1.1 | The use of supercapacitors is allowed
- D.3.1.2 | The voltage supplied by the batteries shall be a maximum of 126 VDC, as described in Art. D.1.1.
- D.3.1.3 | The connection diagram used (cells in series and in parallel) must be submitted to the Organization.

D.3.2 Battery container

All battery cells and supercapacitors that are part of the accumulator must be installed inside a battery container or case.

- D.3.2.1 | The use of several battery containers is allowed. Each one of them must comply with the same prescriptions established for a single battery container.

D.3.2.2 | If the battery container is not easily accessible, the Organization may request pictures of its layout and assembly at any time.

D.3.2.3 | A detailed description of the accumulation system shall be submitted before proceeding with its assembly. Also, it will be obligatory the submission of pictures of the different phases of the assembly of the accumulator, showing all the parts installed. Failure to comply with either of these two requirements may result in the exclusion of the prototype for the MS2 Phase of the Competition (see Art.D.13.1.1).

D.3.3 Electrical configuration of the accumulator

D.3.3.1 | If the container is made of an electricity conducting material, the terminals of the cells or supercapacitors must be correctly protected and insulated with an electrically insulating material.

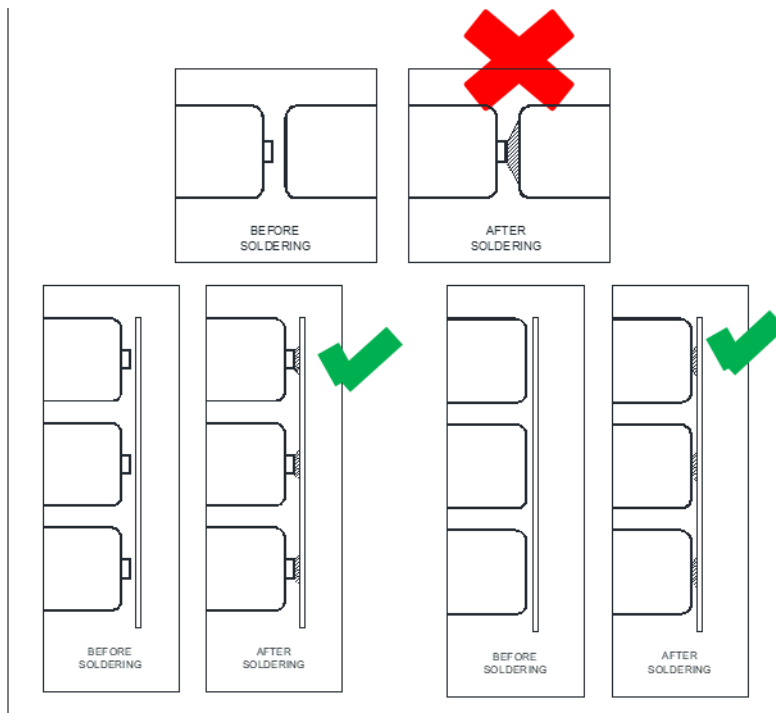
D.3.3.2 | If the container is made of an electrically conductive material (metals, carbon fiber, etc.), the body of the cells cannot be directly in contact with the inner wall of the crankcase and an insulation material must be placed between them. Prismatic cells with a rigid insulating housing are excluded from this requirement.

D.3.3.3 | Each container must include at least one fuse inside whose rated current must be below the cutting limit of the contactor.

D.3.3.4 | Each container must include, at least, a normally open (NO-type) line contactor, installed in the positive terminal of the accumulator.

D.3.3.5 | The closing of the line contactor, and consequently the presence of High Voltage (HV) at the exit of the accumulator, must be signalled by means of a red-light signal located on the dashboard, according to the standards given in Art. D.10.1.1.

D.3.3.6 | It is not allowed the direct connection between cell terminals by means of welding or soldering. Indirect welding or soldering is permitted through a conductive material (plates, plates, cables, fusible wire). The welding or soldering of the BMS conductors to the terminals is allowed. In the case of "pouch" type cells, direct welding between their plates is allowed, if they are available.



D.3.4 Mechanical configuration of the accumulator

- D.3.4.1 The battery containers must be built with a mechanically resistant material and be installed correctly anchored to the frame.
- D.3.4.2 The battery container may be part of the frame of the prototype, provided that it complies with the appropriate stiffness and resistance conditions.
- D.3.4.3 The battery containers that are not part of the frame must be protected against side impacts by the prototype frame.
- D.3.4.4 The cells must be duly protected and fixed to avoid any relative movement (horizontally and vertically) inside the container.
- D.3.4.5 The only communication holes allowed between the inside and the outside of the container are those needed to pass duly insulated conducting cables and those that serve for cooling and ventilation.
- D.3.4.6 Ventilation openings cannot cover a complete side of the container.
- D.3.4.7 Ventilation openings must include some type of filtering element in order to avoid the entry of dust, particles and liquids into the container.
- D.3.4.8 Should a container be completely and tightly sealed; it must include an escape valve to prevent the gas concentration from reaching critical pressure.

- D.3.4.9 | The use or adaptation of commercially available containers or cases is allowed, provided that they comply with the characteristics established in this article.

D.3.5 Battery Management System – BMS

- D.3.5.1 | The installation of a battery management system (BMS) is compulsory
- D.3.5.2 | The BMS must read the voltage of each cell in order to keep the cells within the voltage limits established by the manufacturer.
- D.3.5.3 | The BMS must read the temperature of the cells in their hottest point by means of a compatible temperature sensor. It will be compulsory to read the temperature of at least 4 installed cells, with at least two of them being those corresponding to areas where higher temperatures are expected to be reached.
- D.3.5.4 | Should a cell balancing passive system be used (non-compulsory), resistances used must be capable of dissipating the energy corresponding to the balancing, in such a way that during the balancing period, the temperature indicated by the manufacturer of the resistor (or the BMS) is not overpassed, and does not affect the battery cells or printed circuits nearby.
- D.3.5.5 | To improve the balancing speed, it is allowed to activate the artificial cooling of the battery container during the balancing process.
- D.3.5.6 | The BMS system must deactivate the vehicle traction if the voltage of one of the cells is discharged to the critical minimum voltage or if the critical maximum temperature of the cell is exceeded, according to the values indicated by the manufacturer. This deactivation is compulsory and must happen at the same time as the contactor of the battery accumulator opens. (See diagram in Art. D.6.1.2).
- D.3.5.7 | In addition to the conditions set-out in Art. D.3.5.6, it is allowed to progressively limit the electric power delivered to the motor until being equal to zero in the critical voltage point of the cell or the maximum temperature of the cell.
- D.3.5.8 | The BMS must also deactivate the recharge system when the maximum voltage or temperature levels of the cell are reached. This deactivation may be progressive and/or prompt.

ARTICLE 4: CONTROLLER

D.4.1 Motor controller or motor variator

The motor controller or motor variator is the hardware device that controls the speed and torque of an electric motor.

The controller is part of the HVS and can be part of the GLVS.

- D.4.1.1 | It is allowed to use any type of commercially available controller.
- D.4.1.2 | It is allowed to develop the controller or to adapt any commercially available device.
- D.4.1.3 | The hardware components shall be compatible with the working voltage and current values.
- D.4.1.4 | The controller must comply with all the prescriptions that may apply to it in these Technical Regulations.

D.4.2 Control software

The configuration of the control software of the motor is free. Both commercially available and own developed software tools may be used for this purpose.

- D.4.2.1 | The management map for the propulsion system is freely configurable.
- D.4.2.2 | The implementation of different management maps is allowed.

ARTICLE 5: GENERAL ASPECTS OF THE HIGH VOLTAGE SYSTEM (HVS)

D.5.1 Separation of the HVS and the GLVS

- D.5.1.1 | The HVS and the GLVS must be physically separated.
- D.5.1.2 | There cannot be any contact between the HVS and the frame of the prototype or any metallic part that is exposed to the outside.
- D.5.1.3 | If any part or piece of the HVS and the GLVS must be together inside a container, they must respect the minimum separation distance according to the table below, except in the exceptional cases described in Art. D.5.1.4 and Art. D.5.1.5:

HVS Voltage	Separation distance
< 100 VDC	10 mm
≥ 100 VDC	20 mm

D.5.1.4 | Distances indicated in Art. D.5.1.3 shall not apply if the components of the HVS and the GLVS are separated by a humidity insulating barrier with a temperature resistance degree of 150 °C or higher

D.5.1.5 | If some parts or pieces of the HVS and the GLVS should be installed in the same PCB board, they shall be placed in clearly differentiated areas, marked as such on the board. They shall be separated by at least 6.4 mm over the surface, 3.2 mm through the air and 2 mm if they are under coating (these distances may not be respected in cases of optocouplers with a rated voltage equal or higher than the voltage of the HVS).

D.5.2 Positioning of the HVS

All components of the HVS must be located inside a reinforced structure that ensures their integrity in case of a crash.

D.5.2.1 | The frame of the prototype may be considered as a protective structure of the HVS, provided that the design and the construction fully protect the system in case of a crash, provided that the requirements indicated in Art. D.3.4 is met.

D.5.3 Grounding

All metal parts of the prototype that may be able to conduct electricity because they are located less than 100 mm from the HVS or the GLVS must be grounded to the prototype.

D.5.4 Insulation and cabling

All components of the HVS must be duly insulated and protected against direct contact.

D.5.4.1 | The protection of the HVS must be granted, so that it becomes impossible to access the HVS connections with a cylindrical probe of 100 mm in length and 6 mm in diameter.

D.5.4.2 | The HVS connections must be encapsulated in insulating components.

D.5.4.3 | The cables or conductors pertaining to the HVS must be orange, or clearly marked with orange, and non-flammable grade UL-94 V0, FAR25 or equivalent.

D.5.5 Precharge circuit

It is mandatory to install a precharge circuit before the closing of the accumulator contactor.

D.5.5.1	The minimum precharge level must reach 90% of the real voltage of the accumulator, and / or 10 V of maximum voltage difference between terminals.
D.5.5.2	When the disconnection circuit described in Art.D.6.1 opens, the precharge circuit must open as well, so that any new activation manoeuvre of the disconnection circuit always leads to the previous precharging manoeuvre.

D.5.6 HVS activation warning

A red warning light that will remain on while the HVS is active shall be installed, while the contactor of the accumulator is closed.

ARTICLE 6: DISCONNECTION SYSTEMS AND CIRCUITS

D.6.1 HVS disconnection circuit

The disconnection circuit manages the opening and closing of the line contactor.

D.6.1.1	The disconnection circuit will consist of, at least: - A Tractive System Master Switch (TSMS). - An emergency shut-down button. - An insulation monitoring device (IMD). - The disconnection system managed by the BMS.
D.6.1.2	The disconnection system must follow one of the systems described below: - Disconnection system with contactor directly controlled by the disconnection circuit:

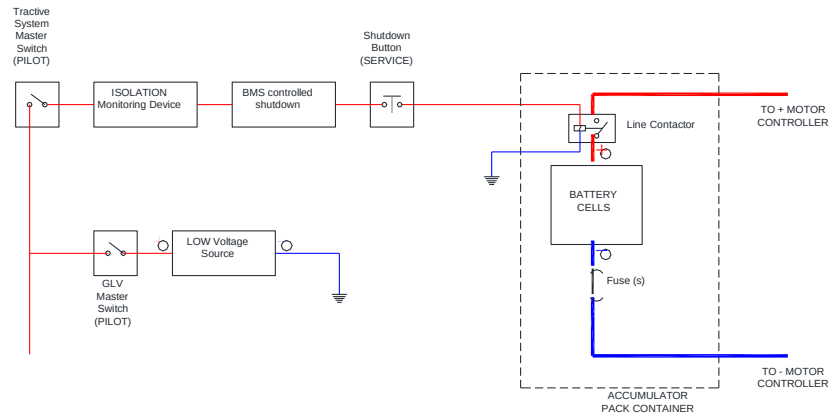


Diagram 1: Contactor directly controlled by the disconnection circuit

- Disconnection system with contactor directly controlled by the controller:

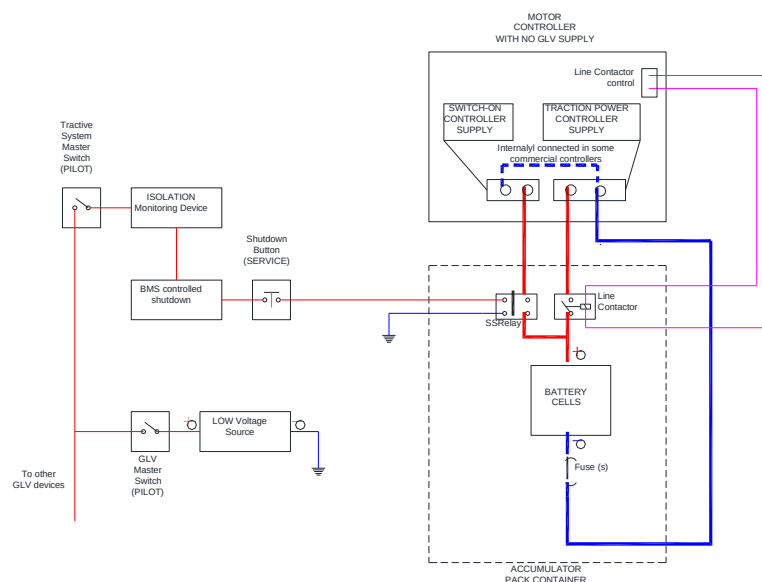


Diagram 2: Contactor directly controlled by the controller

- D.6.1.3 Should the coil of the contactor of the battery accumulator be controlled directly by the motor controller (or any other device), the disconnection circuit has to ensure the shut-down of the controller (or the respective device) and consequently the shut-down of the contactor coil, being its opening guaranteed as described in diagram D.6.1.2.
- D.6.1.4 Once the disconnection circuit is open (contactor open) as a consequence of the action of any of the designated devices (TSMS, emergency shut-down button, BMS or IMD), the system will remain in “not ready to ride” condition and the rider will have to reactivate it manually and voluntarily (e.g. restarting the controller), before the disconnection circuit closes again.

D.6.2 Disconnection of the GLVS

To make sure that the GLVS is able to turn on and off independently, a Grounded Low Voltage Master Switch (GLVMS) must be installed.

D.6.3 Type of switches

- D.6.3.1 The emergency shut-down button(s) must be red mushroom-type push-rotary (press to open and turn to close) buttons.



Example of emergency button

- D.6.3.2 The TSMS must be rotary-type

D.6.4 Deactivation of the DC/DC converter

- D.6.4.1 Should a DC/DC converter be used as LV energy source, the complete disconnection of the converter must be ensured to avoid self-consumption.

D.6.5 Insulation Monitoring Device (IMD)

The Organization will provide an insulation monitoring device (IMD) BENDER included in the MotoStudent Kit to ensure a proper electrical isolation between the HVS and the chassis of the prototype

- D.6.5.1 The installation of this insulation monitoring device is mandatory.
- D.6.5.2 The proper working of the Insulation Monitoring Device will be checked during the Static Scrutineering, as indicated in Art. E.5.1 of these Regulations.

ARTICLE 7: FUSES

D.7.1 HV Fuses

The circuit on the HV side must be protected by at least one fuse, according to the conditions stated in Art. D.3.3.3.

- D.7.1.1 | The rated current of the fuse shall be lower than the calculated shortcut current, and higher than the maximum service current.
- D.7.1.2 | If several cell strings are mounted in parallel, each of these strings must be protected with an own independent fuse.
- D.7.1.3 | The fuse or fuses must be installed inside the battery container or case.

ARTICLE 8: ACCUMULATOR RECHARGING

D.8.1. Chargers

- D.8.1.1 | All types of chargers with a rated power minor or equal to 22 kW are permitted (maximum 32 rated amps in three-phase network side configuration).
- D.8.1.2 | Serial or parallel configurations of different chargers are permitted provided that the total sum of the unit powers of the chargers does not exceed the power indicated in Art. D.8.1.1.
- D.8.1.3 | The charger must be fitted with a respective ground conductor which must be duly connected to the case of the charger.

D.8.2 Mains connection

The mains connection can be single-phase (230 VAC, 50 Hz) or three-phase (400 VAC, 50 Hz).

- D.8.2.1 | The connection of the ground conductor to the socket base is compulsory.

D.8.3 Connection to the prototype

The connection between charger and prototype must comply with specific minimum safety conditions.

- D.8.3.1 | The charging connector located on the prototype must be fitted with an automatic or manual shut-down system.
- D.8.3.2 | The conductors of the recharging connector present on the prototype must be inaccessible when the connector is closed.
- D.8.3.3 | The charging connector of the prototype must have a tightness degree of IP-65 when closed.
- D.8.3.4 | The charging connector must be located in a protected area of the prototype to prevent damages due to possible crashes, contacts or impacts.

D.8.4 Charging process

The charging process of the accumulators must be carried out in a safe way.

- D.8.4.1 | During the recharging process of the prototype during the Final Event it will be compulsory to have at least one team member present, who is familiar with every detail of the recharging process.
- D.8.4.2 | The team member in charge of the recharging process must be prepared to face any kind of action during the process (manual disconnection, deactivation, etc.) in order to insulate the prototype from the mains in case of any contingency.
- D.8.4.3 | Each team must have its own fire extinguisher with a minimum capacity of 2kg for electric fire (extinguishing agent CO2 or similar), and it must be located at a distance of less than 2m from the prototype during the recharging manoeuvre. It is also highly recommended to have a pair of High Voltage insulating gloves.
- D.8.4.4 | The BMS must be fitted with a recharge control device, as described in Art. D.3.5.

ARTICLE 9: GENERAL INSTALLATION AND WIRING

D.9.1 General insulation

- D.9.1.1 | All conducting wires and connectors must be covered with insulating material, except for direct ground connections.

- D.9.1.2 | The areas, elements and systems with a high electric risk must be correctly protected against possible contact and manipulations. It is recommended to install rigid insulating housings for a higher protection.

D.9.2 Dimensioning

- D.9.2.1 | All conducting wires and connectors must be correctly dimensioned according to the requested current levels.

D.9.3 Protection against humidity

- D.9.3.1 | The components of the propulsion system shall be highly protected against humidity. The recommended protection degree is IP-65.

D.9.4 Wiring

- D.9.4.1 | The wire length must be exact, and therefore it is not allowed to roll excessive wire lengths.
- D.9.4.2 | The passage of the electric installation through possible hot points must be avoided as far as possible.
- D.9.4.3 | The electric installation must be perfectly well integrated into the prototype assembly, and the distance between wire fixing points shall not be longer than 15 cm.
- D.9.4.4 | Any possible interference between the electric installation and any mechanic system of the prototype must be taken into account and avoided, in any possible geometry range (during the complete route of the steering, suspensions, etc.).

ARTICLE 10: CONTROL AND CONTROL DEVICES

D.10.1 Dashboard

The dashboard shall be perfectly visible for the rider in riding position.

- D.10.1.1 | The dashboard must include a red warning light that must be lit when the HVS is activated, as indicated in Art. D.5.6.

- D.10.1.2 | The dashboard must have a display showing the voltage between HVS terminals at all times, as established in Art. D.1.2.5.

D.10.2 Control devices

The rider must be able to activate, reactivate or reset the electric propulsion system completely, without the help of other people and without the need to get off the prototype, from the standard riding position.

D.10.3 Emergency shut-down button

This article affects the emergency shut-down button(s) described in Art. D.6.1 of these Regulations.

- D.10.3.1 | The emergency shut-down button must be installed in a place in which it is protected against a crash or accidental contact by the rider, but at the same time accessible and recognisable for the sport marshals.
- D.10.3.2 | The emergency shut-down button must not be installed on any quick-removable component, such as the fairing. It should be installed preferably on supports that are fixed to the frame.
- D.10.3.3 | If the emergency shut-down button is installed on the side of the prototype there must be two buttons, one on either side.
- D.10.3.4 | The installed emergency shut-down button or buttons must be red and "press to open and rotate to close", as described in Art. D.6.3.1.

ARTICLE 11: TRANSMISSION SYSTEM

D.11.1 Types of transmission

- D.11.1.1 | Any type of primary transmission system is allowed: gearbox, CVT variator, etc.
- D.11.1.2 | Direct transmission between the output shaft of the motor and the rear wheel is allowed.
- D.11.1.3 | There are no limitations on the installation of clutch elements between components of the transmission system.

D.11.2 Secondary transmission

- D.11.2.1 | There is no limitation regarding the type of secondary transmission used: chains, belt, etc.
- D.11.2.2 | Any element of the transmission that might imply a trapping risk for the rider must be covered with a rigid housing fixed by mechanic means.

ARTICLE 12: COOLING SYSTEM

D.12.1 Overview of the cooling systems

- D.12.1.1 | The design of the cooling system for the different components is freely configurable.
- D.12.1.2 | The cooling of components is allowed both by air and by liquid cooling systems.

D.12.2 Air cooling systems

- D.12.2.1 | The cooling by means of aerodynamic air conduction is permitted.
- D.12.2.2 | Forced-air cooling by means of fans or other methods of air impulsion or extraction is allowed.

D.12.3 Liquid cooling systems

- D.12.3.1 | Only distilled water may be used as cooling liquid.
- D.12.3.2 | The use of additives in the distilled water is forbidden.
- D.12.3.3 | The number, location, size and composition of the cooling liquid radiators are free, provided that they comply with the dimensional requirements of the overall dimensions of the prototype.
- D.12.3.4 | The installation of a liquid cooling system for the motor, by means of external cases is allowed. These cases cannot modify the motor and must be easily removable. It is forbidden that the cases cover totally or partially any of the seals and/or stickers from the Organization.

ARTICLE 13: DOCUMENTATION OF THE PROTOTYPE

D.13.1 Documents to be submitted

The Organization will require to the teams of the MotoStudent Electric Category, throughout the Competition, to submit documentation about the electric propulsion system. The Organization will establish a series of mandatory documentation deliveries, reflected in the Official Competition Calendar indicated in Art. A.6.1, in which information will be requested regarding the electric propulsion system.

D.13.1.1 The specific milestones for the teams of the MotoStudent Electric Category will be:

- MSE Special Milestone 1: Electric scheme (From 01/10/2022 to 31/10/2022): Complete electric scheme (HVS, LVS, BMS, cells electric scheme), including all active and passive parts.

- MSE Special Milestone 2: Battery pack specs (From 01/12/2022 to 31/12/2022): General description of the energy accumulator, including 3D design of the container, cells, mechanical protections, list of electrical components (identification of all elements of the electrical diagram: commercial names, measures and location in the prototype). Connection diagram used in the accumulator (series and parallel cells), total number of cells and rated and maximum voltages of the complete accumulator. Data sheet of the cells or supercapacitors used.

- MSE Special Milestone 3: Battery pack assembly (From 01/03/2023 to 30/04/2023): Presentation of the assembly of the batteries' container with diagrams and pictures of its assembly and wiring. Pictures of the definite set assembled.

- MSE Special Milestone 4: Electric powertrain test (From 01/05/2023 to 30/06/2023): Video of the electric powertrain in operation, with the final components that will be installed on the prototype (although it is still in the testing phase).

D.13.1.2 Failure to submit the documentation requested by the Organization (or submitting it more than 10 natural days after the deadline) might result in the non-compliance of the Static Scrutineering, and therefore, the exclusion of the teams from the MS1 and MS2 Phases.

D.13.1.3 For safety reasons, the Technical Staff of the Organization may require technical information additional to that described in this article if it considers it for the inspection of one or more specific prototypes.

SECTION E

SCRUTINEERING

ARTICLE 1: OBJECTIVE AND METHODOLOGY

E.1.1 Objective

The objective of the scrutineering is to check that the prototypes that have been presented to the Competition by the participating teams comply with the specifications in terms of performance and safety as established in the Technical Regulations (Sections B, C and D), as well as checking that the chosen rider is eligible to take part in the MS2 Phase of the Competition

E.1.1.1 | The scrutineering will not score towards the MotoStudent Competition, but it may entail the exclusion if any deviation from the Regulations is detected or if the prototype is not considered as safe enough to take part in the tests.

E.1.1.2 | The scrutineering will be carried out by experienced scrutineers and qualified Technical Staff of the Organization.

E.1.1.3 | In case of dispute over the non-compliance of the rules stated in the Technical Regulations, or the safety of the prototype on track, the decision of the Technical Staff of the Organization will be final.

E.1.2 Responsibility of the teams

Teams are responsible for making sure that their prototype complies with all the rules established in the Competition Technical Regulations.

E.1.2.1 | When presenting the prototype for Scrutineering, the team acknowledges that they have made sure that the prototype complies with the Regulations established by the Organization.

E.1.3 Procedure

The Scrutineering consists of three stages:

- Administrative Check.
- Static Scrutineering.
- Dynamic Safety Check.

ARTICLE 2: ADMINISTRATIVE CHECK

E.2.1 Process

Teams, at the beginning of the Final Event, must perform the Administrative Check, in which the Organization will confirm the registration of the team and the total fulfillment of the federative requirements of the rider. Once these aspects have been approved, the corresponding Administrative Check sticker will be placed on the prototype, and the team will be able to proceed to the next scrutineering stage.



Administrative Check sticker example

- E.2.1.1 | The Administrative Check will be carried out in the Paddock General Office.
- E.2.1.2 | Teams will not be able to access the Static Scrutineering without having passed the Administrative Check.
- E.2.1.3 | In case the rider attends to the Final Event later than the team, the team will also have to pass the Administrative Check, having the rider to complete the signature and confirmation when he/she arrives to the Event.

ARTICLE 3: STATIC SCRUTINEERING – GENERAL TECHNICAL CHECKS

E.3.1 Process

The Static Scrutineering consists on a series of checks on the prototype to verify its compliance with the Competition Technical Regulations and its safety. Rider clothing will be also verified in order to check if it is appropriate to take part in the MS2 Phase.

- E.3.1.1 | Scrutineering checks described in this article affect the prototypes presented for both the "MotoStudent Petrol" and "MotoStudent Electric" Categories.

E.3.2 Development

The prototype and the rider clothing will be checked by the Technical Staff following all the rules described in the Competition Technical Regulations.

- E.3.2.1 | Teams can have as many spare parts (any part or component of the prototype) as they consider. These spare parts must be presented to the Organization together with the prototype in order to verify them.

- E.3.2.2 | The Static Scrutineering will be carried out in the Technical Control Area.

- E.3.2.3 | The prototype must be presented under appropriate conditions to participate in the MS2 Phase, strictly complying with all the rules indicated in the Competition Technical Regulations.

- E.3.2.4 | Using components not verified by the Organization during the Static Scrutineering will entail the immediate exclusion of the team from the Competition.

- E.3.2.5 | Only 2 Team Members can access the Technical Control Area during Static Scrutineering. These members will be the responsible of transporting the prototype and some kind of support that allows it to be presented in static position for its examination.

E.3.3 Structure check bench

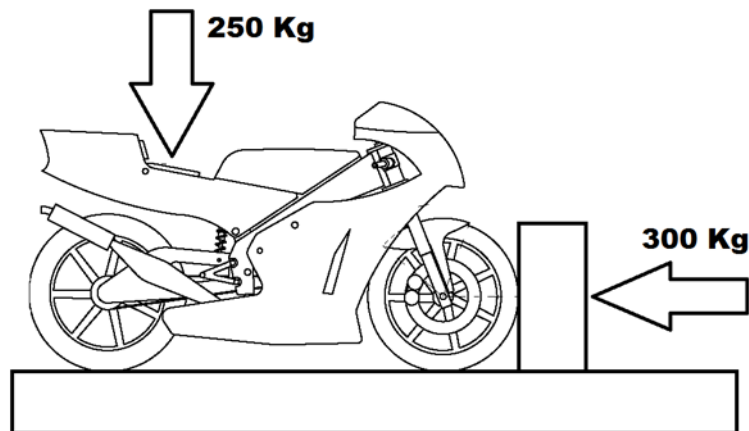
If the Organization considers it necessary, the prototype can be subjected to horizontal and vertical forces on the check bench in order to verify the rigidity of the frame, the correct assembly and behaviour of suspensions.

E.3.3.1 The following forces will be applied on the prototype:

- Progressive horizontal load on the front wheel: 300 kg
- Progressive vertical load on the saddle: 250 kg

E.3.3.2 These loads will be applied alternately and progressively, verifying that in compression situation there is no interference between elements, as well as that all the systems that integrate the structure of the prototype work properly. When removing the force, the scrutineers will verify that the original geometry has not undergone deformations, nor that no crack has appeared in the structural components or joining elements. In order for the prototype to be considered fit in this test, must comply with the provisions described.

E.3.3.3 Graphic description of the test:



Forces Diagram

E.3.4 Brake check

The correct behaviour of the front and rear brakes is going to be checked on a roller brake tester.



Brake check

E.3.4.1 In order for the prototype to be considered as apt at this check, it shall provide brake strength values above the following figures:

- Front shaft: 0.30 kN
- Rear shaft: 0.25 kN

E.3.4.2 In order for the prototype to be able to meet the braking values, it is recommended to carry out the brake check with the brake pads and brake discs with a slight pre-working. Certain disc assemblies and pads newly installed may give efficiency problems due to coatings, adaptations between surfaces, etc.

E.3.5 Approval

E.3.5.1 If the prototype passes the Static Scrutineering, it will be marked with the respective sticker and allowed to access the Dynamic Safety Check.



Example of approval sticker

ARTICLE 4: STATIC SCRUTINEERING - SPECIFIC TECHNICAL CHECKS OF THE “MOTOSTUDENT PETROL” CATEGORY

This article affects only the prototypes presented for the "MotoStudent Petrol" Category of the Competition, using an internal combustion engine. The checks described below will be carried out during the Static Scrutineering.

E.4.1 Exhaust noise check

The exhaust noise will be measured.

E.4.1.1 | The maximum permitted exhaust noise is stated in Art. C.6.2. of the Technical Regulations.

E.4.1.2 | The noise will be measured at approx. 50 cm from the exhaust exit, in the flow direction of exhaust gas, in a place with no walls or obstacles within 3 meters around the exhaust exit.

ARTICLE 5: STATIC SCRUTINEERING - SPECIFIC TECHNICAL CHECKS OF THE "MOTOSTUDENT ELECTRIC" CATEGORY

This article affects only the prototypes presented for the "MotoStudent Electric" Category of the Competition. The checks described below will be carried out during the Static Scrutineering.

E.5.1 Insulation Monitoring Device Check

A check will be carried out in order to verify the correct working of the insulation monitoring device (IMD) defined in Art. D.6.5 of these Regulations.

E.5.1.1 | During the check, a 50 k Ω resistance will be placed between the HV side and the frame in order to verify the correct electric insulation.

E.5.1.2 | In order for a prototype to pass the check, the disconnection circuit should open not later than 30 seconds after the resistance has been connected to the prototype.

E.5.2 Insulation Measurement Check

A check will be carried out in order to verify the correct insulation between HVS and GLV.

E.5.2.1 | During the test, the insulation between HVS and GLVS will be measured.

- E.5.2.2 | In order for a prototype to pass the check and take part in the Competition, the value measured between both systems must be equal or higher than 100 kΩ.

E.5.3 Disconnection Circuit Check

A check will be carried out in order to verify the correct working of the disconnection circuit.

- E.5.3.1 | The correct working of the Main Switch and of the Emergency Shut-Down Button will be checked. Shutting down any of them must open the contactors of the battery accumulator.
- E.5.3.2 | When shutting down these switches, the voltage shown on the display of the dashboard must be zero.

E.5.4 Rain Check

The Organization may carry out a rain check to verify the correct insulation of the electric propulsion system in rainy conditions.

- E.5.4.1 | The prototype must have passed the Insulation Monitoring Device Check, Insulation Measurement Check and the Disconnection Circuit Check in order to access the Rain Check.
- E.5.4.2 | During this check, the prototype must be connected, with the drive wheel raised without contact on the ground (on a stand) and in a "non-ready-to-ride" situation.
- E.5.4.3 | Water will be projected simulating the effect of fine rain over the prototype in different directions for a minimum period of 60 seconds. Under no circumstances will high pressure jets be projected towards the prototype.
- E.5.4.4 | The check shall be approved if the IMD has not act during the minimum 60 seconds of spray or during the next 60 seconds after the spray has ended. The minimum total duration of the check will therefore be 120 sec.
- E.5.4.5 | The Technical Staff will also verify that there is no accumulation of water in areas at risk for the electrical system.
- E.5.4.6 | It is recommended to carry appropriated means to dry the prototype after the check.

ARTICLE 6: DYNAMIC SAFETY CHECK

E.6.1 Process

The Dynamic Safety Check stage consists of a series of on-track verifications on the prototypes made by professional riders of the Organization. The verifications described in this article affect the prototypes presented for both the "MotoStudent Petrol" and the "MotoStudent Electric" Categories.

E.6.2 Procedure

An Official Rider from the Organization will carry out a series of dynamic tests on the track to check the correct working of the prototype.

In order for the prototype to be approved for the participation in MotoStudent it shall comply with the following:

- E.6.2.1 | The prototype must start up and move under its own power.
- E.6.2.2 | The prototype must brake correctly both when riding softly and sportively.
- E.6.2.3 | The prototype must be able to carry out a series of turns at different speeds.
- E.6.2.4 | The Official Rider will determine if the prototype meets the basic safety requirements to participate in the Competition.

E.6.3 Lap around the track

Once checked the different aspects, the Official Rider of the Organization may make a complete lap around the Speed Racing Track in order to check the on-track behaviour of the prototype.

E.6.4 Approval

- E.6.4.1 | If the prototype passes the Dynamic Safety Check, it will be marked with the respective sticker and the team will be able to take part in the MS2 Phase.



Example of approval sticker

ARTICLE 7: RECTIFICATION IN CASE OF PROBLEMS

E.7.1 Rectification time

- E.7.1.1 | If the prototype is considered as "not approved" after any of the Scrutineering stages, the Organization will provide a time period to allow the team to rectify the failures detected by the Organization in their own box. After this period of time the prototype shall be presented again at the scrutineering to verify whether it complies with the Regulations.
- E.7.1.2 | No prototype will be accepted in MS2 Phase without having passed the Scrutineering stages within the established timetables. Motostudent Organization reserves the right of not to admit for scrutineering any prototype once the scrutineering scheduled has been finished.

SECTION F

MS1 REGULATIONS

ARTICLE 1: OBJECTIVES

The MS1 Phase is designed to guide the teams to develop, in a project management structured configuration, the prototype. It shows the evolution line of the MotoStudent project by any team along the Competition development. The participant teams must show to the Jury and Organization the complete process of the prototype design and development, and a theoretical project of a racing team creation.

The MS1 Phase is specially focused in assessing the engineering skills of the teams. It is not about who has the best means, but about who makes the best use of the means they have.

Therefore, MS1 phase will give to the participant students the opportunity to apply the knowledge acquired during their education in a “real” professional project, showing the aspects and difficulties that a professional project can entail, and how must be performed the process in all its stages, from the creation and development of the product, until its final completion launched into the real scenario.

F.1.1 Project MS1 Scenario

To perform the MS1 Project, the teams must work as what they are, a university racing team competing in MotoStudent, developing a real prototype, the product, under a project management structure, with its final participation in the VII Edition of the MotoStudent International Competition.

The participating teams must be prepared to present to the Jury and Organization the complete project, along any of its phase such as Design, Development of the Prototype, Manufacture of the prototype and how they manage to make it form an economical point of view, that will participate in the VII International MotoStudent Competition.

F.1.2 Overviews of the MS1 Project

The MS1 Project must include the design, development and manufacture of the prototype (racing motorcycle) developed by the team for its participation in the VII Edition of the MotoStudent International Competition, and it will also include the management plan followed by the team to its completion.

ARTICLE 2: PROJECT STRUCTURING

F.2.1 Project Chapters

The basic Design and Development process is organized and structured to consider all the necessary aspects that make the prototype to comply with the needs for which it has been devised. Therefore, the obligatory chapters to be included in the MS1 Project are defined below.

F.2.1.1 The MS1 Project must include the following chapters:

A.- Concept development

B.- Product design.

C.- Prototyping and testing

D.- Innovation

E.- Management plan

F.2.2 Chapter A: Concept development

The first stage shall consider the MS1 Project scenario and the targets intended to be achieved. This chapter must answer to two fundamental aspects:

- *How the prototype has to perform?*

- *Which are the design constraints and requirements to comply with?*

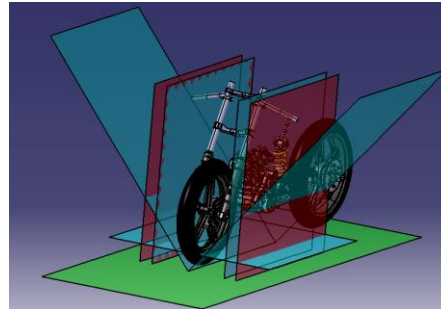
F.2.2.1 The following design aspects and conditions must be considered:

A.1.- Preliminary Analysis

A.1.1.- Competition Regulations Analysis:

Brief analysis of the technical requirements contained on this document. A list of applicable requirements to the complete prototype, and their degree of compliance at the end of this stage (i.e. minimum weight estimation and the % of compliance compared with the value given the Regulations). These requirements are additional to those initially considered at the Design Conditions.

Functional requirements based on Rules and Regulations			
	Requirement	Value	
1	Minimum width between semi-handlebars external limit	450 mm	Parts
2	minimum lean angle	50°	Assembly
3	free distance from any point to floor with compressed suspensions.	100mm	Assembly



Requirements coming directly from the Rules

A.1.2.- Team Know-how: Comprehensive list of available skills and gaps:

- Human resources, with organization chart. Which profiles are needed to accomplish the project, how many people for each profile, and when they are needed.
- Components and systems pre-dimensioning methodologies.

A.1.3.- Comprehensive list of team resources:

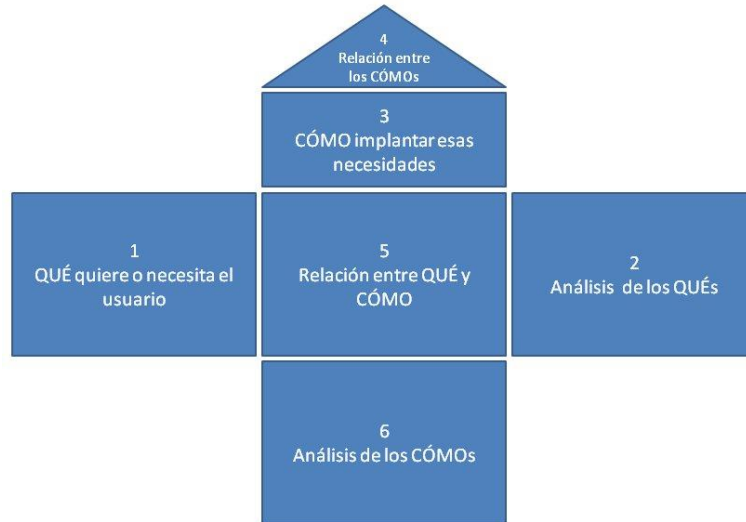
- SW tools needed and their availability.
- HW tools needed and their availability.
- Availability and size of workshop.
- Transportation means.
- Personal safety means.

A.1.4.- Comprehensive list of methods and lessons learned from previous projects:

Rookies without previous experience will develop here a benchmarking of similar motorcycles.

A.2.- Definition of the product

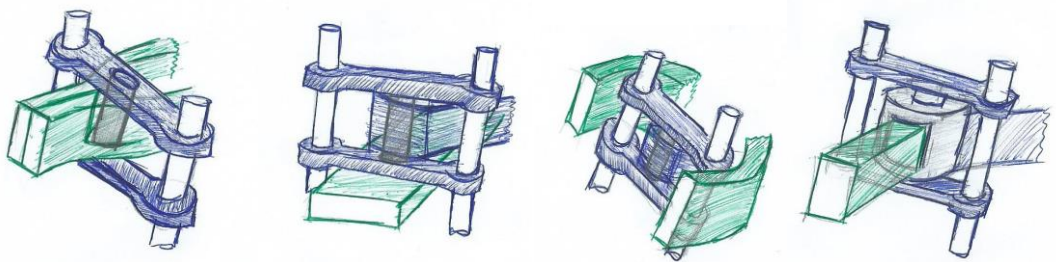
The purpose of the stage is to verify whether an idea is technically feasible. Taking into account all design inputs (refer to Art. F.2.2.1), teams must take several decisions in order to define team and prototype concepts with which they compete subsequently: modes of use, geometry, materials, structural elements, commercial components; not getting into constructive details beyond those strictly needed to define a design basis that will comply with the function and the requirements. A QFD matrix is recommended as an example of helping technique.

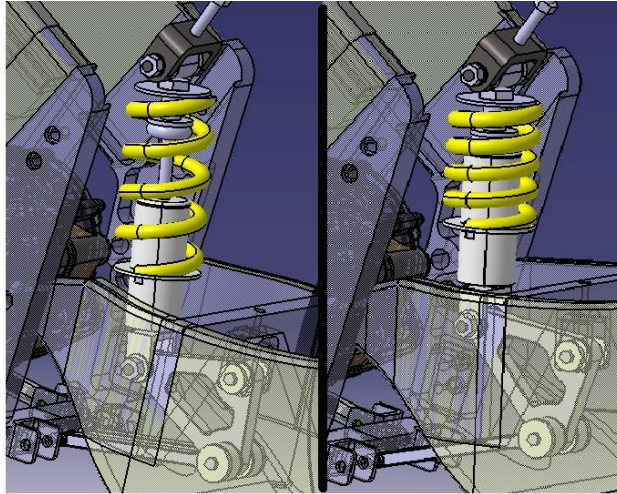


QFD schematic

A.2.1.- Trade-off for the functional systems:

At this stage the analysis of the different design alternatives for the functional systems that conform the prototype must be carried out (refer to Art. F.2.2.1/A.3.2). It will be assessed that solutions developed internally by the teams have been taken into account.





Examples of alternatives selection

A.2.2.- Failure Mode and Effects Analysis (FMEA):

A FMEA of the design and the technical risks assessments has to be deployed. This is a very relevant driver in order to perform right design decisions and will be specifically analysed. Especial care has to be put on getting to a minimum the H&S risks.

A.2.3.- A “Make or Buy” decision for all the parts of the prototype:

A “Make or Buy” decision for the parts of the bike. That is, what is going to be manufactured internally with the means the team has, and what is going to be outsourced.

On this chapter, you will relate the whole bill of materials (BOM) for the complete motorbike, including the precise definition and justification for all the commercial components that added to those manufactured, makes you possible to assemble the prototype.

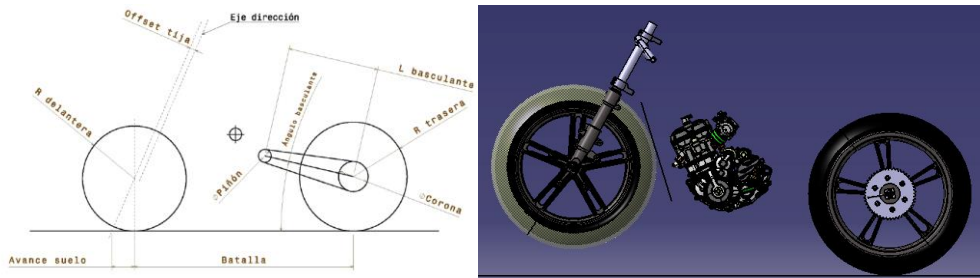
A.2.3.1. Purchase description for commercial components:

For those components that a manufacturing drawing is not needed for, a complete technical file must be provided, or an interfaces and requirements specification. Interfaces are not only mechanical (geometry, fits...), but may also be electrical or even communication protocols.

A.3.- Design Requirement Specifications

A.3.1.- Design Requirement Specifications for the complete vehicle:

Design targets. Components and systems pre-dimensioning methodologies. Geometrical and dimensional restrictions and rider integration. A draft Plan. In this chapter, it is recommended to identify and control some parameters in order to monitor along the Project development whether the initial design targets are being met or not. Some recommended examples for these parameters are; raised position of the center of gravity (CoG), minimum prototype weight, ergonomics dimensions, performance, etc.



Examples of design targets.

As minimum design targets, teams must fill the template provided by the MotoStudent Organization through the MotoStudent Private Area, and include it in the project.

A.3.2.- Design Requirement Specifications for generic systems:

Functional generic systems that conform the prototype:

- Structure
- Powertrain
- Suspension
- Wheels
- Brakes
- Aerodynamics
- Others / Ancillaries

Requirement specifications that will apply to each of the main systems. Either for those to be manufactured (Make) or purchased (Buy).

	Centered Fuel tank output	Easy access	Airbox available volume	Ergonomics	Fuel waves	Safety
Centered Fuel tank output	1	1/3	3	3	1	1/4
Easy access	3	1	2	6	2	1
Airbox available volume	1/3	1/2	1	4	3	1/5
ergonomics	1/3	1/6	1/4	1	1/2	1/8
Fuel waves	1	1/2	1/3	2	1	1/7
Safety	4	1	5	8	7	1

Example of comparison matrix for the functional requirements of a petrol tank

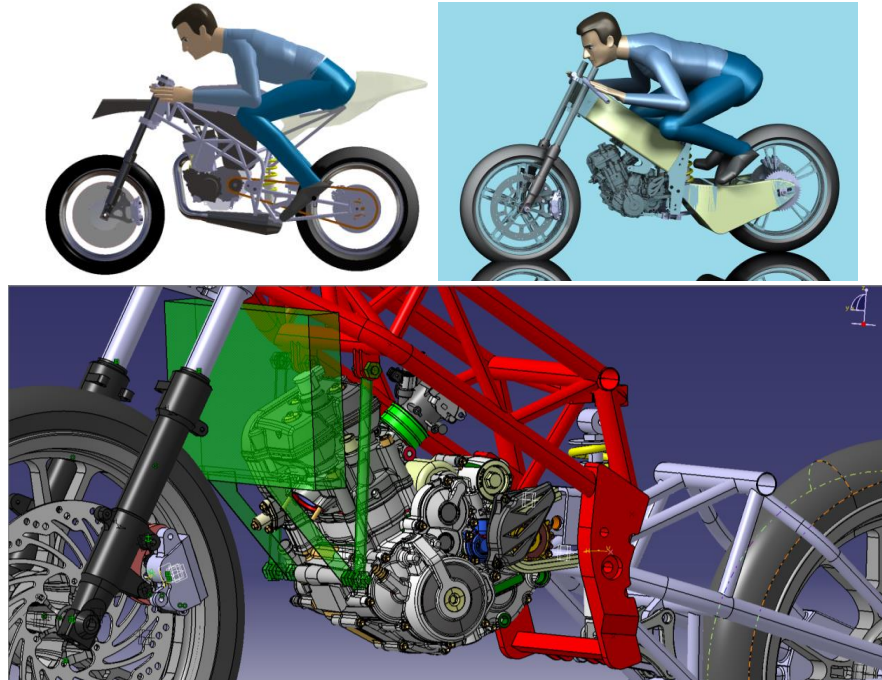
	Exhaust final design	Available airbox volume	Easy access	Easy to tune	Ergonomics	Reliability	Cooling	Pressure drop in cooling system	Vibrations	Pressure drop in ducts	Propper Airbox flux	Wiring space
Exhaust final design	1	5	1	1	4	3	1/3	1	1/2	1	3	8
Available airbox volume	1/5	1	1/6	1/6	2	1	1/5	1/4	1/3	1/5	1/8	2
Easy access	1	6	1	1	5	3	1/4	1/3	3	1/4	2	9
Easy to tune	1	6	1	1	6	5	1/3	1/3	5	1/4	3	8
Ergonomics	1/4	1/2	1/5	1/6	1	1/6	1/8	1/9	1/2	1/3	1/3	3
Reliability	1/3	1	1/3	1/5	6	1	1/6	1/4	1	1/7	1/6	4
Cooling	3	5	4	3	8	6	1	4	6	1	1	8
Pressure drop in cooling system	1	4	3	3	9	4	1/4	1	2	1	1	9
low vibrations	2	3	1/3	1/5	2	1	1/6	1/2	1	1/3	1/4	7
Pressure drop in ducts	1	5	4	4	3	7	1	1	3	1	5	9
Propper Airbox flux	1/3	8	1/2	1/3	3	6	1	1	4	1/5	1	8
Wiring space	1/8	1/2	1/9	1/8	1/3	1/4	1/8	1/9	1/7	1/9	1/8	1

Example of comparison matrix for the functional requirements of the intake, airbox and exhaust

A.4.- Geometrical Model

A.4.1.- A draft design model (3D/2D):

Basic drawings showing geometric constraints, interfaces and basic geometry. Minimum for this point are front, top and side view of the final prototype without fairings.



F.2.2.2 Each chapter of the MS1 Design Project (Chapter A, B and C) may have a free number of pages, provided that the total final number of the complete MS1 Design Project does not exceed 120 pages (from page 121 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.

F.2.2.3 Assessments Chapter A:

Total MS1 Project Delivery sums up 400 points. Chapter A provides up to 50 points out of them.

These will be distributed as follows:

Item	Score (max)
A.1.1.- Competition Regulations Analysis	5
A.1.2.- Team Know-how: Comprehensive list of available skills and gaps	5
A.1.3.- Comprehensive list of team resources	5
A.1.4.- Comprehensive list of methods and lessons learned from previous projects	5
A.2.1.- Trade-off for the functional systems	5
A.2.2.- Failure Mode and Effects Analysis (FMEA)	5

A.2.3.- A “Make or Buy” decision for all the parts of the prototype	5
A.3.1.- Design Requirement Specifications for the complete vehicle:	5
A.3.2.- Design Requirement Specifications for generic systems	5
A.4.1.- A draft design model (3D/2D)	5

The assessment is done therefore on the analysis the team does of their own means, and how they are going to use it to develop their bike. Technical feasibility should be assured as one of the results of this stage.

F.2.3 Chapter B: Product design

With the approach from Chapter A “Concept development”, the purpose of the “Product design” stage is the sizing and optimization of the components, so the motorbike would comply with the design objective with a minimum level of safety and integrity.

This chapter will be divided into two different group of documents that must be delivered:

- Chapter B definition in PDF format, with the information described from B.1. to B.3., below.
- Manufacturing drawings in PDF format, with the information described in B.4. These pages will not be taken into account for the pages’ limitation.

Product Design is performed, assessed and reported down to the level of Component and Part, thus, the detail design for all the bike elements is frozen. Product Design Structure is defined down to the lowest levels. Only modifications for a safety reason will be allowed from this delivery on, and all of them must be justified in Chapter C.

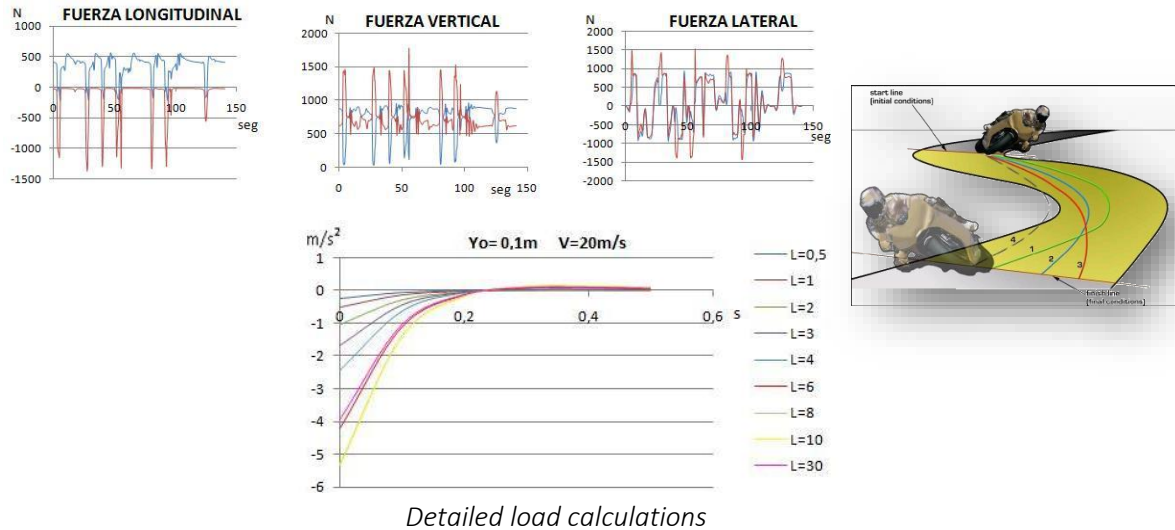
Product Assembly Process and Subsystems and Components Manufacturing Processes are frozen, the Control plans established and the Process associated tooling specified and designed.

F.2.3.1 The structural integrity of the prototype components under the loading defined in Chapter A that is going to be subjected to, is ensured in this Chapter.

F.2.3.2 The whole documentation needed to build the prototype shall be generated. This Chapter shall include, as a minimum, the following information:

B.1.- Detailed dynamic and static loads calculations

At the Conceptual Design Phase, the loads that will dimension the structural components should have been defined. Usually, static load cases are considered, as the efforts the motorbike will be subjected to at the static technical verifications test bench; stationary cases (with constant acceleration values), as braking or cornering; or transient cases of certain riding conditions that can potentially affect to the motorbike or rider integrity.



Independently of the simulation tools that the team has access to, the team has to be conscious of the precision of their calculation tools. Thus, loads application factors, which represent this precision, can be selected correctly.

*****Please, consider that a person will be riding the vehicle.*****

In the Detailed Design phase, a review of the adequacy of the selected load cases is needed. You are requested to make your calculations for the following situations:

B.1.1.- MS2 Static Loads

Simulation of loads that will be applied during Technical Scrutineering.

B.1.2.- Loads at maximum Braking

Special attention must be paid at the front spindle, front suspension and steering system.

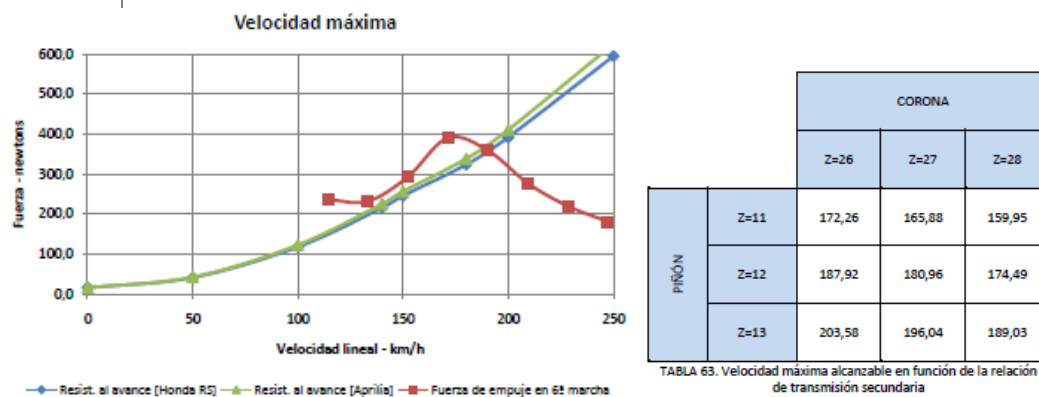
B.1.3.- Loads at maximum Acceleration

Particular attention must also be paid to key points such as the rear suspension system, swingarm, and rear wheel axle, in order to safely manage these forces.

B.1.4.- Loads at cornering and transient events

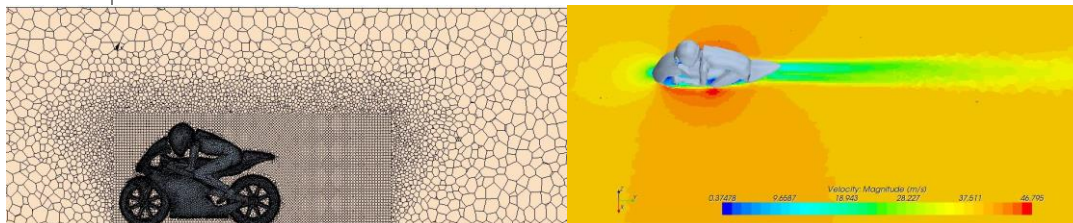
Loads involved when cornering as a combination of braking at the entrance and accelerating on the exit of the curves, must be in consideration. What is happening to the bike at maximum lean angle and what loads will be present on the structure.

B.1.5.- Aerodynamic Loads



Maximum speed calculations

If available, numeric simulations are recommended. Empirical simulations are also convenient, especially if they have been verified by the team previously. The data about MotorLand racetrack are available in the Rules.



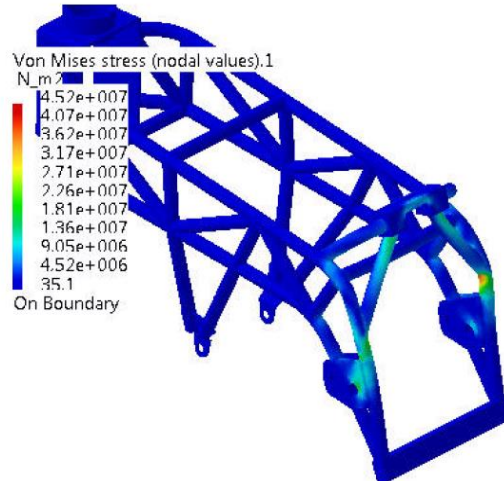
CFD calculations for the complete bike

There might be several analysis loops until a final configuration is selected, that will provide the final loading cases for the components design.

B.2.- Structural calculations

From the Conceptual Design generated in Phase A of the Project and taking in consideration those loads calculated on the precedent paragraphs, a model for each component manufactured, has to be developed in this phase.

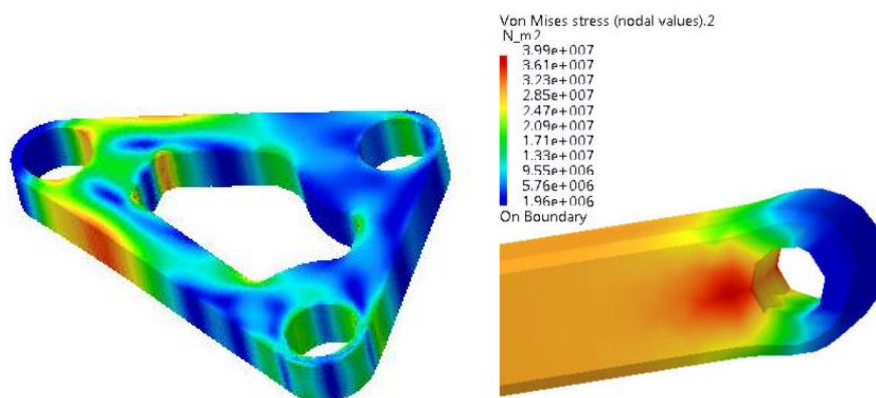
The most common tool for this is Finite Elements, but this is not a compulsory requirement. There are some components of lower complexity that can be calculated with analytical methodologies (i.e. some bolted joints can be analysed this way).

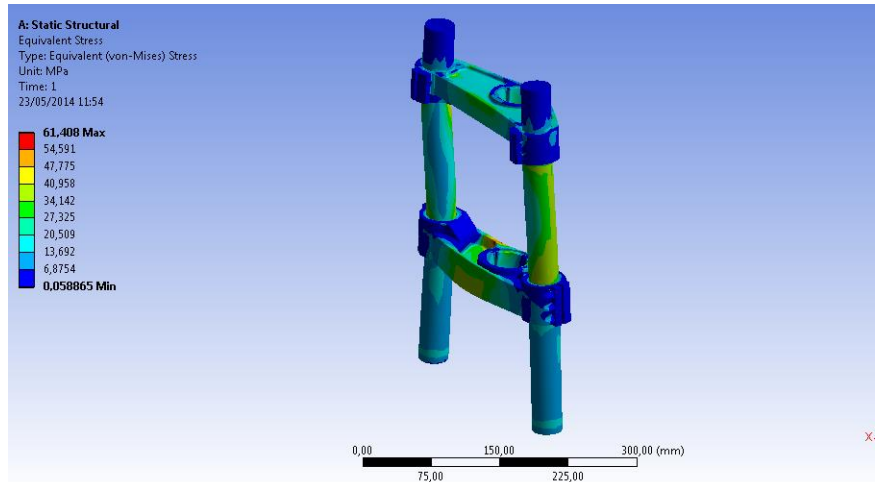


Finite element analysis for a Trellis-type frame

B.2.1.- Stress and Deformations on main structural parts:

Calculations will not be restricted to your project manufactured components and parts. Frame, swing-arm and subshassis are mandatory but other important parts must be considered, as well. Joints and load transmission elements shall also be checked. Yokes, Shafts, bolts, friction joints, must be sized according to the application they are in. 'Buy' components that are structurally compromised shall be checked too.





Stress calculations for different joining parts

B.2.2.- Strength and Stiffness calculations:

Calculations shall be performed and justified here for main structural parts, considering as an input, the loading cases previously commented.

B.2.3.- Calculations of safety margins:

Safety margins should be achieved, so vehicle integrity is assured. Engineering function is to minimize the check-error cycle. The most exhaustive, reliable and efficient the calculations are, the most efficient regarding time, manufacturing and test the prototype manufacturing is, and the sooner the serial production starts. The effort in this phase is put in value avoiding issues in future stages.

B.3.- Prototype Systems Design Calculations

B.3.1.- Powertrain

Calculations related to the power developed by the engine must be analyzed.

B.3.2.- Transmission and Wheels

Develop of the speed from the engine to the ground, type of transmission used and its torque and grip analysis.

B.3.3.- Suspension and Steering

Calculations on how the suspension will change along the curve affecting the geometry and how the behavior of the prototype will change using different settings.

B.3.4.- Braking

Specific calculations of the brake actuation in terms of efforts, hydraulic system and its efficiency (fading and manage of heat generated).

B.3.5.- Cooling and Thermodynamics calculations:

Cooling and venting systems dimensioning is key to keep motorbike working conditions constant and within limits. Worst ambient temperatures, vehicle speed and possible transients foreseen in the design phase must be taken into account. Although non-compulsory, a CFD analysis is recommended for the complete vehicle, to dimension channels, coolers and any other elements contained in the design. Analytic models are also available, that might be useful, specifically if they are correlated with experience. Otherwise, this has to be taken into account to be verified at the Validation stage, although this usually takes more cost.

From the health and safety point of view, surfaces that might develop high temperatures must be identified in this stage, in order to design adequate protections to avoid potential burns for the rider and whoever may touch the bike for maintenance or adjusting purposes.

B.3.6.- Dashboard and Control instruments.

Explanation of the control instruments and how to be displayed to the driver in order to assure the control of all the motorcycles as a system.

B.4.- Manufacturing assemblies and Parts Drawings, and Electric Diagram

An additional PDF file must be delivered with drawings related to all assemblies, subassemblies and parts being design and manufactured by the team for the prototype. Also, electric diagram for both categories must be included.

Both for manufacturing subcontracting or for manufacturing with internal means, final and detailed parts documentation are needed. Starting from a 3D model is recommended, where potential issues with interferences and fits should have been previously solved, and the compliance with requirements and restrictions from the Rules should also have been checked. Once the 3D is considered final, manufacturing drawings can be produced. It is not recommended to publish manufacturing documents if the 3D model is not completely finished, as further modifications might not be transmitted to final parts.

All assembly and manufacturing drawings must be included.

Nomenclature for parts and assemblies must be as follows:

An alphanumeric reference assigned by the team that identifies each part or element. The following format must be used:

System	Assembly	Subassembly	Part
00	-AA-	111	-222

- System: The whole prototype will be broken down into the following 7 systems:
 - 01 – Structure
 - 02 – Powertrain
 - 03 – Suspension
 - 04 – Wheels
 - 05 – Brakes
 - 06 – Aerodynamics
 - 07 – Others
- Assembly: Level set immediately below systems.
- Subassembly: Level set immediately below assemblies.
- Part: The number of the part pertaining the subassembly. Numbering must be ascending. For subassemblies, the part number must be 000.

Each assembly and subassembly drawing must include its bill of materials and parts/subassemblies must be referenced with balloons.

Commercial parts must also be named and included in the bill of materials (BOM).

3D models will only be accepted as manufacturing documents for fiber parts, or as an extra for additive fabrication parts.

3D models for fiber parts will not be delivered.

Electric schemes must be included, irrespective of whether they have also been delivered in other milestones.

F.2.3.3 Each chapter of the MS1 Design Project (Chapter A, B and C) may have a free number of pages, provided that the total final number of the complete MS1 Design Project does not exceed 120 pages (from page 121 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.

F.2.3.4 | Assessment of Chapter B

Total MS1 Project Delivery sums up 400 points. Chapter B provides up to 90 points out of them.

Item	Score (max)
B.1.1.- MS2 Static Loads	5
B.1.2.- Loads at maximum braking	5
B.1.3.- Loads at maximum acceleration	5
B.1.4.- Loads at cornering and transient events	5
B.1.5.- Aerodynamic loads	5
B.2.1.- Stress and Deformations on main structural parts	10
B.2.2.- Strength and Stiffness calculations	10
B.2.3.- Calculations of safety margins	5
B.3.1.- Powertrain	5
B.3.2.- Transmission and Wheels	5
B.3.3.- Suspension and Steering	5
B.3.4.- Braking	5
B.3.5.- Cooling and Thermodynamics calculations	5
B.3.6.- Dashboard and Control instruments	5
B.4.- Manufacturing assemblies and Parts Drawings, and Electric Diagram	10

These will be distributed as follows:

F.2.4 Chapter C: Prototyping and testing

Prototyping the model is the real manufacturing process based in the ideas shown in Chapters A and B of the MS1 Project. The team shall manufacture, purchase, assembly and test all the designed components in order to achieve an integrated and feasible motorcycle prototype.

F.2.4.1 “Chapter C: Prototyping and testing” of the MS1 Project shall reflect the degree of correlation between of the simulations, designs and calculations made in Chapters A and B with the real working conditions of the prototype.

F.2.4.2 Chapter C shall include a report with the description and results of the different tests made during the manufacturing, assembly and settings of the prototype.

The tests to be done can be, as an example:

- Component bench testing in dedicated check benches.
- Complete vehicle testing in bench: check bench, wind tunnel, loading rigs, etc.

- Complete vehicle testing on a track: a report with the different tests on a track with rider.
- Previous testing of compulsory Scrutineering as published in Section E of this Regulation, which will take place on the Final Event.
- Previous testing of compulsory Dynamic Tests from MS2 Phase as published in Section G of this Regulation, which will take place on the Final Event.
- Changes justification between the initial project and the final prototype.

F.2.4.3 As a consequence of this process of manufacturing and testing, some prototype re-designs might happen. These shall be justified and documented during this stage.

F.2.4.4 The final target of this stage is to get into the track a competitive and fully functional prototype.

F.2.4.5 Regarding the indicated conditions, the minimum sections to be included in Chapter C: Prototyping and testing, must be:

C.1.- Deviation description report

Where all issues detected at the time of manufacturing the prototype that might cause minor design or performance changes described and estimated on the Chapters A and B of the MS1 Project shall be recorded. These changes shall be developed and justified.

C.1.1.- Deviations' report

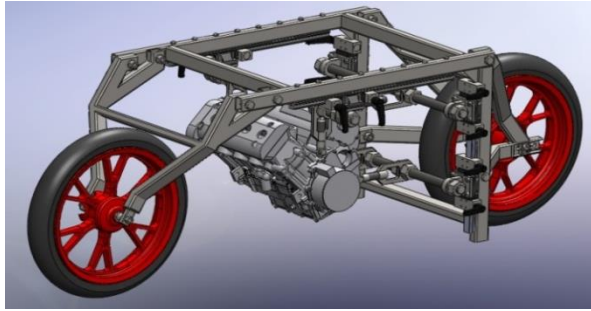
Template from MS1 Chapter A.3.1. must be filled again with the real values measured on the prototype.

C.2.- Validation report

Where the results of any test performed during the prototype development and manufacturing shall be shown, including:

C.2.1.- Validation tests made on components or systems

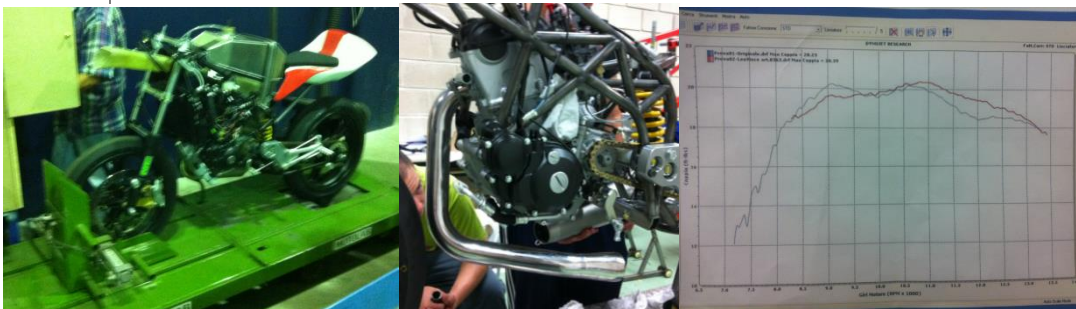
Tests made on components or subsystems: the test specification and the results obtained. Lessons Learned and reworks if applicable.



Engine separate testing

C.2.2. Validation tests made on the whole motorbike in a test bench

Tests made on the complete bike on the test bench: the test specification and the results obtained. Lessons Learned and reworks if applicable.



Testing a complete prototype in a bench

C.2.3.- Validation tests made on the whole motorbike on a racetrack.

C.2.4.- Verification tests

Checks to ensure the compliance with all requirements reproduced in the Technical Regulations, Chapter E and G specially. Performance tests to ensure the desired behaviour at MS2 dynamic tests, etc.

Final validation plan and prototyping, in order to ensure the right future integration of the components and their performance.

A Validation Plan must be designed in order to check the compliance of all those requirements that were not able to be fully confirmed in the detailed design phase. Again, it is needed to take into account the consequences of a design mistake and verify all the parameters where some uncertainty is not clarified yet. Especially when the FMEA reflected critical risks regarding safety issues.

A good validation plan must target the correlation of the verified values (stress, stiffness, temperatures...), with the results coming from the numerical or analytical models used in the design. This allows that for future designs, the calculation models are more precise, and the design process more efficient.

The proper integration of the components must also be assured, and the required performance. Although the complete Prototype will be assembled and started up during Validation Stage, certain items could be separately tested at this stage, in order to optimize their design in this phase, so their validation plan should be developed during Chapter B (as an example, a front fork can be tested in a dynamic bench, or an engine in a specific engine bench, even though the frame is not available yet).

C.3.- Prototype maintenance program

C.3.1.- Maintenance Service Program of the prototype

This program will establish those operations due to “mileage” and “time of use”, should be performed on the bike to assure the optimal performance of all its systems.

- Engine (manufacturer instructions)
- Electrical system
- Chassis
- Transmission
- Suspension
- Brakes
- Cooling system
- Software updating

F.2.4.6 Each chapter of the MS1 Design Project (Chapter A, B and C) may have a free number of pages, provided that the total final number of the complete MS1 Design Project does not exceed 120 pages (from page 121 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.

F.2.4.7 Assessment of Chapter C:

Total MS1 Project Delivery sums up 400 points. Chapter C provides up to 60 points out of them.

These will be distributed as follows:

Item	Score (max)
C.1.1.- Deviations' report	10
C.2.1.- Validation tests made on components or systems.	10
C.2.2.- Validation tests made on the whole motorbike in a test bench	10
C.2.3.- Validation tests made on the whole motorbike on a racetrack	10
C.2.4.- Verification tests	10
C.3.1.- Maintenance Service Program of the prototype	10

F.2.5 Chapter D: Innovation

The objective of this chapter is to evaluate the creative capacity and imaginative talent of the MotoStudent teams, and more especially from the formal aspect of the process than what the innovation represents by itself. The final prototype must include an innovation in its development, so it must assume the technical feasibility of its manufacturing.

Innovating represents a challenge in itself, representing the act or process of introducing new ideas, devices or methods. It etymologically refers to the fact of "making new".

The innovative solutions adopted can be mainly of two types:

- Tactical: this innovation refers to a product or technical solution, and covers the final result, where an object constitutes the invention.
- Operational: this innovation refers to a process, where the importance is taken by the ordered sequence of elements used to obtain a different or better-quality result.

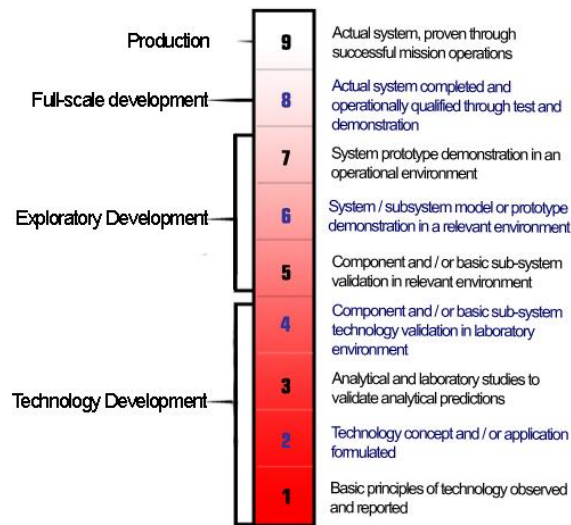
Therefore, the innovation presented can be a pure innovation in itself or a novel combination of known or existing resources, elements or components.

F.2.5.1 The innovation scenario is driven by the Red Bull MotoBoost challenge, so that all proposed innovations by the teams should face a solution to the given scenario, which be announced shortly.

F.2.5.2 All prototype presented must incorporate an innovative solution.

F.2.5.3 In the same way, the developed innovation must contain a minimum degree of technological maturity. The levels of technology readiness can be measured by several methods, using the following scale allows to evaluate its maturity degree:

R&D - Technology Readiness Mapping



All innovative projects must achieve level 7, as they will be implemented in the real prototype and in real use conditions, but the starting level shall be analyzed, and the development effort (cost and time), dedicated to each case.

F.2.5.4 The innovation included in the prototype must comply with the instructions described in the Technical Regulations of the Competition.

F.2.5.5 The innovation project development must include, as minimum, the following sections:

D.0.- Tittle of the innovation and a brief summary that will be published.

D.1.- Preface or starting condition

It is requested to explain in this chapter the origin of the innovation and the need to be solved with, as well as the improvement obtained with its implementation. The solution and its contribution to solve a certain problem must be explained.

D.2.- State of the Art and infringement risk

When a design project is launched, the possibility of the use in the final product must be assessed. A benchmarking investigation of similar solutions is needed, and the risk of patent or utility models infringement must be taken. Sometimes, the modification of the solution in a non-optimal way is needed to avoid an already granted patent, as an example.

Once the infringement risk is identified, the mitigation strategy must be established. It may consist in search for another solution, or modifications of the existing one.

D.3.- Research process

Following the previous analysis of innovation, needs and global market competitions, opportunities, social changes, and the environment dynamics will be detected, thus contrasting the proposed solution with the market and existing technology knowledge, and detecting by this method the possible innovation gaps.

The expenditures and investments dedicated to the innovation development must be explained in this chapter. Any subsidies that might be applicable have to be included here.

D.4.- Proof of concept

Once the innovation and the target have been identified, the development and analysis of its phases will be described, detail design and prototyping of the innovation, as well as the valuations or test of the product.

D.5.- Drawings and simulations

All needed to to justify the technical feasibility of the innovation must be developed with the same standard that the rest of the motorcycle (as in Chapters A to C), as it will be used in the real prototype.

D.6.- Market viability

A study of the possibility of introduction in the market of racing motorcycles, street bikes or in other related technological variants, from the point of view of technical development and manufacturing feasibility and acceptance or readiness to this new technology by potential customers.

D.7.- Conclusions

Assessment on the ratio between the development effort and the expected benefits of the application of the innovative solution.

F.2.5.6 Chapter D of the MS1 Project should not exceed 40 pages (from page 41 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.

F.2.5.7 Assessment of Chapter D:

Total MS1 Project Delivery sums up 400 points. Chapter D provides up to 100 points out of them.

These will be distributed as follows:

Item	Score (max)
D.1.- Preface or starting condition	15
D.2.- State of the Art and infringement risk	15
D.3.- Research process	15
D.4.- Proof of concept	15
D.5.- Drawings and simulations	20
D.6.- Market viability	15
D.7.- Conclusions	5

F.2.6 Chapter E: Management plan

The Management plan shall reproduce a report whereby the business model of the cost unit is developed to fulfil the real scenario about the development of the prototype as reflected in the Art.F.1.1.

The Management plan should focus mainly on the project targets, based on the new product introduction plan methodology, considering terms such as the cost, product and how to achieve them from an economical point of view, all of this would be integrated in the Product Profile.

F.2.6.1 All figures shown in this report should refer to the real numbers that the team is facing up, not including taxes and fees so that the values should be the net cost. The official currency unit is the Euro (€) and the exchange rates to be applied must be the official rate change at the end of the year 2021.

F.2.6.2 The minimum sections to be developed in “Chapter E: Management Plan” of the MS1 Project will be:

E.1.- Marketing plan

This section should answer to the following questions:

- What is the strategy? Answering why and for what reason you are doing it.
- What is the product mission? Answering how the product will be perceived by a third party.
- How is the market design?

The sequence to elaborate a Marketing plan is the following:

E.1.1.- Executive summary:

Preliminary vision of the team where to show the profile and goals of the organization. Must include a number of key points:

- Team information: Name, organizational hierarchy, promoters, trajectory, etc.
- Team goals: Mission and vision. Market Benchmarking and key targets, taking into account the given requirements and the team requirements.

Tells who you are and what you do.

E.1.2.- SWOT analysis:

Analysis of the current situation and diagnosis, listing the strengths and weaknesses (internal analysis) and opportunities and threats (external analysis, related to the market conditions) of the project. The out coming result must be actions that permit to the team be directed towards the right targets, either material, production needs, investments cost and present trends. An internal and external analysis of the team must be carried out to capture the conclusions derived from this analysis in the SWOT matrix.

E.1.3.- Goals and strategic plans (based on the previous analysis):

Main objectives of the team defining the product profile and the strategies to achieve them. Once established those, the Action Plans (tactical and operational planning that will make it possible to achieve the targets) must be specified.

E.1.4.- Action Plans:

Based them on the stablished goals and strategies in the previous point.

E.1.5.- Measurement and feedback:

Design in order to check the degree of compliance of the set targets.

E.2.- Economic & Financial Plan

The economic plan should work two aspects: the cost structure and the targets on it, and the financial plan, how to achieve the needs of the team, based on real cost and income showing the viability of the project.

The key financial aspects are the material cost, production cost and investment cost, so that the team can control the cost, set targets and how to achieve them, with the final emphasis of demonstrating the feasibility. The plan should be based on the following parts:

E.2.1.- Income report:

All income received and its justification must be detailed, including donations (monetary or in kind). The estimate of future income for this Edition should also be included (example, planned or agreed sponsors for the Final Event).

E.2.2. Prototype costs:

The costs of the realization of the prototype must be detailed as the following scheme

PROTOTYPE DETAIL COST							
Item Nr.	Manufacturing Part Number	Part Name	Make / Buy	Manufacturer Name	Quantity	Unit Cost	Total Cost
001	01-FR-001-001	Frame	Make	TEAM	3	4050,82 €	12152,46 €
002	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...

- Item Nr: Numerical order of the part in the table.
- Manufacturing Part Number: The same alphanumeric reference as in Chapter B.
- Part Name: Unique name for each part, subassembly or assembly.
- Make / Buy: Identification of whether the part, subassembly or assembly has been purchased from an external manufacturer or is self-designed and produced, the case of sponsoring it should be considered as Buy and the cost should be the market real cost.
- Manufacturer Name: Name of the part, subassembly or assembly manufacturer.
- Quantity: Amount of each item.
- Unit Cost: Cost of each element.
- Total Cost: Total cost of the element. It is the result of multiplying the unit cost by the quantity

E.2.3. Final Event costs:

The costs derived from attending the VII MotoStudent Final Event (or their estimate) must be added, including the cost of logistics, accommodation, spare parts, etc.

E.2.4. Results report:

Graphically the team must present as minimum the product profile, the targets to comply in either financial or technical sides, the financing target achieved and the economic result of the team, where its expenses and income are interpreted.

F.2.6.3 Chapter E of the MS1 Project should not exceed 40 pages (from page 41 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.

F.2.6.4 Assessment of Chapter E:

Total MS1 Project Delivery sums up 400 points. Chapter E provides up to 100 points out of them.

These will be distributed as follows:

Item	Score (max)
E.1.1.- Executive summary	5
E.1.2.- SWOT analysis	15
E.1.3.- Goals and strategic plans	10
E.1.4.- Action Plans	20
E.1.5.- Measurement and feedback	5
E.2.1.- Income report	10
E.2.2.- Prototype Cost	20
E.2.3.- Final Event Cost	5
E.2.4.- Results report	10

ARTICLE 3: DEADLINES AND SUBMISSION OF THE PROJECT

F.3.1 Deadlines Calendar

According to the Competition Calendar, defined in Art. A.6.1 of these Regulations, each chapter of the MS1 Project shall be submitted in digital format to the Organization at the established milestones.

F.3.1.1	These deliveries <u>must be complete and definitive</u> and will be evaluated in order to contribute to the final score.
F.3.1.2	The established milestones correspond to the delivery of the different chapters that integrate the MS1 Project and should be sent to the Organization within the deadlines reflected in the Calendar of Art.A.6.1.
F.3.1.3	Only officially registered Team members at the time of each delivery will be recognized as authors.
F.3.2 Documentation submission format	
F.3.2.1	Each chapter of the MS1 Project must be delivered in digital format within the established deadlines.
F.3.2.2	Each chapter of the MS1 Project should not exceed the pages limit set on each Chapter, the total final number of the complete MS1 Project will not exceed 200 pages (from page 201 onwards it will not be evaluated), including any type of annex, cover, index, drawings, etc.
F.3.2.3	The MS1 Project must be delivered in A4 format, in both cases digitally and in the printed hard copy given to the organization at the registration time of the team in the Final Event. A DIN A4 sheet will be considered one page, although it will also be considered as a single page a DIN A3 sheet, when its use is exclusively for the delivery of drawings.
F.3.2.4	The pages of each chapter must be numbered, including sub-index, sub-pages or annexes. The numbering format should reflect the chapter to which each page corresponds, i.e. A1, A2, A3..., B1, B2, B3... For the main cover and general index, it will not be necessary to reflect this numbering, but the total limitation of 200 pages also applies to them and should be taken into account.
F.3.2.5	Each one of the delivered chapters (A, B, C, D and E) must include its own sub-cover and sub-index.
F.3.2.6	Together with the deliveries of the MS1 Project in PDF-format, teams could include CAD-files in .STEP format and videos they may seem fit. Any document or drawing in PDF-format, images or other aspects that may be contained within the parts of the MS1 Project shall not be accepted as an attachment.
F.3.2.7	The format used must be the following: - Indentation: - Left: 3cm

- Right: 3cm
- Upper: 2.5cm
- Lower: 2.5cm

- Line-spaced: 1.5

- Paragraphs spacing
 - Previous: 0 points
 - Below: 6 points

- Font type: Arial

- Size: 11 (except titles, sub-titles and tables)

F.3.2.8 | At the time of registration of the team in the Final Event, a copy of the complete MS1 Project must be submitted to the Organization in a USB memory stick. The given copy must include all chapters already submitted in digital format to the Organization as stated in the MS1 delivery dates of the Calendar.

F.3.2.9 | Projects can be delivered in Spanish or English as both are Official Languages.

F.3.3 Changes or modifications after delivery

F.3.3.1 | No change or modification will be allowed on the delivered documentation.

ARTICLE 4: PRESENTATION IN FRONT OF THE JURY

For the evaluation of the MS1 Phase of the Competition, two presentations should be performed:

- MotoStudent Pitch prior to the Final Event on a Virtual basis
- MS1 Finals in front of the jury, during Final Event

The weight of the presentations' assessments in the total scoring (according to Article F.6.2), is 100 points. This assessment includes Pitch and Finals presentations. MS1 Presentations will be assessed by a professional expert Jury from the different areas of the Industry, Innovation, Automotive and MotorSport.

F.4.1 MotoStudent Pitch

The first presentation, nominated as "MotoStudent Pitch", will present a general introduction of the MS1 Project.

MotoStudent Pitch will be a general introduction of the MS1 Project. It is a short exhibition to sell your product to a group of potential investors. As time is limited, the exhibition must focus in the strengths of your product, to attract the attention of the jury, taking into account all the fields that are shown in the assessment table which is shown below.

F.4.1.1	The exhibition must be formal as if it was directed to a group of investors.
F.4.1.2	The "MotoStudent Pitch" presentation will have a maximum time of 20 minutes (15' of exhibition + 5' for questions by the jury). Every extra minute in the presentation will involve a 2 points penalization.
F.4.1.3	This presentation will be recorded by Teams in mp4 format and delivered to the MotoStudent Organization in the MS1 Delivery 6: MS1 Presentations.
F.4.1.4	Each exposition shall be made by a maximum of 3 students, all of them officially registered in the current Competition.
F.4.1.5	All speakers must introduce themselves at the beginning of the presentation, telling its name and surname, and show to the camera an ID card with photography to proof its identity. Plase, make sure that the document is readable before submitting the video.
F.4.1.6	Any speaker not identified at the beginning of the presentation or not declared in "speakers declaration form" will be considered as an extra speaker, therefore, the presentation will score zero points.
F.4.1.7	The introduction menctioned in Article F.4.1.5 will not be considered as part of the presentation, therefore, it will not be taken into account for maximum times refered in Articles F.4.1.2.
F.4.1.8	Embedded videos including narrator are not allowed, those videos may have music but all explanations must be done by a visible speaker (in order to avoid non declared speakers), for example, using a small window for the speaker during the video, both on the same screen.
F.4.1.9	Dubbing during the presentation is not allowed. In case of dubbing, it will be applied a minor infraction.
F.4.1.10	MS Pitch assessments:

Total MS1 Presentations sums up 100 points. MS Pitch provides up to 60 points out of them.

These will be distributed as follows:

<i>Topics to be Assessed:</i>	<i>Score (max)</i>
<i>Concept development & Design</i>	<i>20</i>
<i>Prototype & Testing</i>	<i>10</i>
<i>Innovation</i>	<i>15</i>
<i>Management Plan</i>	<i>15</i>

For each of these topics, the following aspects of the presentation will be assessed:

- Clarity of the message and knowledge of the topic.
- Quality of the graphic materials used during presentation.
- Accuracy of the prototype with respect to the overall Project.
- Quality of the answers to the questions of the Jury.

F.4.2 MS1 Finals

The second presentation, nominated as “MS1 Finals”, will reflect all sections of the MS1 Project in a more detailed way than in the “MotoStudent Pitch” presentation, and will take place during the Final Event.

This presentation is the crowning moment of MS1 and this presentation must show to the jury the process of the project. It should be focused on the deviations from the original concept to the built prototype, a demonstration of the innovation applied on the prototype and costs justifications of the prototype.

- F.4.2.1 | The exhibition must be formal.
- F.4.2.2 | The “MS1 Finals” presentation will be with the prototype in front of the jury and will have a maximum time of 35 minutes (30’ of exhibition + 5’ for questions by the jury).
- F.4.2.3 | Each exposition shall be made by a maximum of 3 students, all of them officially registered in the current Competition. The rest of the registered team members may stay on these as attendance, but no external public is allowed.
- F.4.2.4 | The presenting students may use a digital presentation as support, to do so the Organization will provide a projector or screen.

- F.4.2.5 | To do the exposition, the presenting students must carry their own laptop and VGA and HDMI wiring.
- F.4.2.6 | Teams must carry by themselves to the presentation room their own digital presentation file stored in an USB external storage device.
- F.4.2.7 | The digital presentation may include images and videos. Included narration in videos is forbidden, speakers must explain the video content, if necessary.
- F.4.2.8 | The jury, if estimates as appropriate, could ask to specific listeners present at the presentation room to assess the degree of involvement of the team.
- F.4.2.9 | Teams must comply with the arrival order and the opening scheduled hours of the presentations. If not, a minor infraction will be applied to the final score.
- F.4.2.10 | MS Finals assessments:
- Total MS1 Presentations sums up 100 points. MS Finals provides up to 40 points out of them.

These will be distributed as follows:

<i>Topics to be Assessed:</i>	<i>Score (max)</i>
CONCEPT & DESIGN DEVIATIONS	10
INNOVATION DEMONSTRATION	20
BUDGETS DEVIATIONS	10

F.4.3 Presentation methodology

- F.4.3.1 | No confidentiality restrictions from the teams are allowed along the MS1 Phase. If due to the nature of the project a team does not want to show any aspect of the prototype or project, the scoring of the corresponding chapter of the project and presentation will be zero, it is responsibility of the team to protect and patent any confidential aspect in order to be public. Since MotoStudent is an academic open project and it involves internal and external juries, the Organization does not accept any responsibility on the projects disclosure.
- F.4.3.2 | During the presentation will be allowed to show parts or elements which the students consider as adequate for a better explanation, as well as using other means of dissemination as the digital presentation (i.e. leaflets, schemes, etc.).

ARTICLE 5: DOCUMENTATION OF THE PROTOTYPE

F.5.1 Documents to be submitted

The Organization will require to the teams, throughout the Competition, to submit documentation about the prototype status. The Organization will establish a series of mandatory documentation deliveries, reflected in the Official Competition Calendar indicated in Art. A.6.1, in which information will be requested regarding the prototype status.

F.5.1.1 The special milestones for the Electric and Petrol teams will be:

-MS1 Special Milestone 1: Final design (From 01/01/2023 to 31/01/2023): Teams will submit their final prototype design in a single 3D file in STEP format. This file will include the whole prototype without fairings in a single part.

- MS1 Special Milestone 2: State Report (From 01/04/2020 to 30/04/2020): The present state for each system of the prototype will be described on a sheet with a picture of present situation up to date. It must include a brief description of the present state for all systems described in Chapter B.4. A picture of the whole prototype must be sent to check the current status.

ARTICLE 6: ASSESSMENTS

F.6.1 Evaluation

F.6.1.1 The MS1 Phase will be assessed by a professional expert Jury from the different areas of the Industry, Innovation, Automotive and MotorSport.

F.6.2 Scoring

The MS1 phase will be assessed based on a total of 500 achievable points, which will be distributed as follows:

MS1 Deliveries	Score
A. Concept development	50
B. Product design	90
C. Prototyping and testing	60
D. Innovation	100
E. Management plan	100
Final Event Presentations	Score
MotoStudent Pitch	60
MS1 Finals	40

TOTAL

500

- F.6.2.1 | The assessment by the jury will be final.
- F.6.2.2 | In the event of a tie, the Organization will apply the tie-breaker methodology that it considers and justifies.
- F.6.2.3 | If a team along the MS1 Phase does not score 200 points or over, the team will have to carry with a Handicap during the final race at the MS2 Phase, as established in Art. G.8.4.

Award		Part	MS1 Deliveries	MotoStudent Pitch	MS1 Finals	TOTAL
Best MS1 Project	Best Design	A	50	30	10	240
		B	90			
		C	60			
	Best Innovation	D	100	15	20	135
		E	100	15	10	125
TOTAL			400	60	40	500

F.6.3 Awards

The MS1 Phase will grant, for each Category, the following awards:

- F.6.3.1 | The award for the “Best MS1 Project” will be awarded to the team, from each Category, that achieves the best overall score in the MS1 Phase.
- F.6.3.2 | The award for the “Best Design” will be awarded to the team, from each Category, that achieves the best score after adding the results of chapters A, B and C (A: Concept development, B: Product design, C: Prototyping and testing).
- F.6.3.3 | The award for the “Best Innovation Red Bull MotoBoost” will be awarded for the team that achieves the best score in “Chapter D: Innovation” from both categories, it be also awarded two accessits “Best Innovation” to the team, from each Category, that achieves the best score in “Chapter D: Innovation” on their Category.
- F.6.3.4 | The Organization reserves the right to add new awards throughout the development of the Competition.

SECTION G

MS2 REGULATIONS

ARTICLE 1: GOALS AND CONDITIONS

The MS2 Phase consists of a series of tests aimed at assessing the dynamic behavior and the performance of the manufactured prototype.

G.1.1 Requirements

To take part in MS2 Phase, the Organization imposes a series of requirements indicated below.

- G.1.1.1 | The prototypes must have passed the Scrutineering (Section E) to participate in the MS2 Phase and must be presented in suitable conditions to take part in the dynamic tests. The Technical Staff of the Organization can check the conditions of the prototypes at any times.

G.1.2 MS2 Sports Committee

The MS2 Phase will be controlled and managed by the MS2 Sports Committee, which will be formed, at least, by the following official positions:

- Competition General Manager
- Competition Sport Director
- Race Director
- Race Director Assistant
- Sporting Jury (Officials' coordinators)
- Timekeeping Director
- Competition Technical Director
- Chief Scrutineer

ARTICLE 2: RIDER

Each team must nominate a rider who will be in charge of riding the prototype during the MS2 Phase tests. In order to equalize advantages between teams, and since the goal of MotoStudent is to evaluate the prototype and the engineering

work done by the teams, the Organization has taken the following considerations about the chosen rider:

G.2.1 Rider eligibility

G.2.1.1 | The rider is considered as a team member from the moment he/she is approved by the Organization, and he/she shall have the same rights and obligations as any other team member, except for the academic requirements, which are not applicable to him/her.

G.2.1.2 | The rider does not need to pay any entry fee for the Competition.

G.2.1.3 | The rider must be 18 years or older at the day of start of the 2023 Final Event.

G.2.1.4 | The participation of riders who have raced since 2013 (included) in any event listed on FIM Calendar, of the following disciplines, will not be allowed:

- Circuit Racing
- Motocross
- Enduro
- Rallies
- Track Racing

In this exception is included any rider who has participated as a Wild Card, or replacement rider one event or more, in any of these disciplines.
The participation in previous editions of MotoStudent is excepted from this article.

G.2.1.5 | A student can federate or be federated, and participate as a rider. However, if he/she is not registered as a team member he/she will be able to ride the prototype, but not to manipulate it as mechanic or team member. If such student wants to become a rider and also to manipulate the prototype as a team member, he must be registered and pay the required fees to do so.

G.2.1.6 | Each rider will be enrolled in a specific team, and may only participate with that team in the Category where he is exclusively registered. The same rider cannot be shared between different teams, even those that represent the same university, even if they participate in different categories.

G.2.1.7 | The rider is obliged to attend the briefing sessions prior to the tests of the MS2 Phase, as well as to meet with the Organization if required.

- G.2.1.8 | In case of retirement of the rider during the Final Event (either by medical leave or by other force majeure) it will not be possible to assign a substitute rider to complete the MS2 Phase.

G.2.2 Rider Federative requirements

- G.2.2.1 | The rider must prove to be federated in order to take part in the Final Event. To do so, he/she must be covered by a Federative License of an Official Motorcycling Federation that allows its participation in a FIM International Competition such as MotoStudent. Moto track day insurances or other federation licenses that do not cover the characteristics of International FIM Competition will not be valid for participation in MotoStudent.

- G.2.2.2 | Riders participating in MotoStudent must comply the following documentation*:

- RFME:
 - Homologated RFME license
 - Or
 - One Event homologated RFME License
- FIM
 - FIM International Racing Meetings Annual license.
 - Or
 - FIM International Racing Meetings- One event license.
 - Or
 - FIM Superbike/Supersport world championship license.
 - Or
 - FIM World Endurance Championship.
- Others:
 - **For FIM Europe Countries only**: National license + Start Permission.

* These federative requirements may vary according to the conditions imposed by the motorcycle federations involved (FIM, RFME y FARAM) for the 2023 season.

- G.2.2.3 | Teams can process temporary licenses for their riders online through any of the following federations:
- Spanish Riders: Aragonese Motorcycling Federation (www.faram.es).

- Spanish and Non-Spanish Riders: Royal Spanish Motorcycling Federation (www.rfme.com).

G.2.3 Communication with the rider

Radio or any other communication between the team and the rider during the MS2 Phase tests is forbidden.

- G.2.3.1 | The communication between the team and the rider is only allowed by means of a board shown on the Pit Wall and only during the Free Practice, Warm Up, Qualifying and Race sessions.
- G.2.3.2 | The information board must be light, with a maximum size of 1m in width and 1.5m in height.
- G.2.3.3 | The information board must be shown by only one team member, who must hold the board firmly in order to avoid the board from crashing onto the track.
- G.2.3.4 | The information board can only be shown when the rider passes the Finish Straight, and afterwards it must be stored in the pit lane wall, never on the track surface.

ARTICLE 3: SPORT BEHAVIOUR

G.3.1 Weather conditions

The Organization reserves the right to modify schedules and even assessment methods due to weather unforeseen events.

- G.3.1.1 | In case of rain the Organization may establish three different rain levels:
 - Light
 - Moderate
 - Intense
- G.3.1.2 | If the Organization establishes "light" rain: both MotoStudent Petrol and MotoStudent Electric Categories teams will be able to carry out the MS2 Phase tests, but it may become advisable to use wet weather tires.
- G.3.1.3 | If the Organization establishes "moderate" rain: both MotoStudent Petrol and MotoStudent Electric Categories teams will be able to carry out the MS2 Phase tests, but will be compulsory to use wet weather tires.

G.3.1.4 | If the Organization establishes "intense" rain: it will not be possible to carry out the MS2 Phase tests for any category and all prototypes that are outside their respective Box must return to it immediately.

G.3.1.5 | In case of "intense" rain, the Organization will decide and notify the participants if a test is cancelled or postponed.

G.3.1.6 | For any other situation or unforeseen weather, the MS2 Sport Committee will decide and announce if there is any postponement or cancellation.

G.3.2 Access to the track

Prototypes must access to the track through the exits enabled by the Organization for each test.

G.3.3 Behavior on the track:

G.3.3.1 | Any manoeuvre of a rider in the opposite direction of the race is strictly forbidden

G.3.3.2 | In the event of an accident or breakdown, the rider must immediately take his prototype **off-track**, in a place where it does not represent any danger to the normal development of the Competition and always out of the path of the rest of the riders.

G.3.3.3 | On the track, it is forbidden for anyone to approach a prototype stopped at the circuit, with the exception of the rider himself, the Race Director, his deputies, the marshals or Technical Staff.

G.3.3.4 | The Race Director may stop a prototype whose rider had committed an infraction. A black flag with the bike number will indicate to the rider that he/she must stop. If the rider does not stop after two laps, the Race Director will communicate the Team Leader to order his/her prototype to stop immediately. The reasons for this decision will be communicated to the Team Leader.

G.3.3.5 | The Race Director or any marshal post (only at the request of the Race Director) may indicate a rider to leave the track if the prototype has mechanical problems that could put him/herself or others in danger. A black flag with an orange circle and the bike number would be shown to a rider in all marshal posts to stop immediately, without completing the lap.

G.3.4 Behavior at the Pit Lane

- G.3.4.1 | The speed limit throughout the Pit Lane is set up to 60kmph
- G.3.4.2 | During the development of the competition, only people with the proper accreditation may be in the Pit Lane. The Organization will be able to evict from these zones all those persons whose stay is not duly justified.
- G.3.4.3 | In case of oil or any other liquid spillage from a prototype in the Pit Lane soil (work zone), it will not be allowed to start up that prototype before the affected area and prototype are completely cleaned.
- G.3.4.4 | To start the engine up and get to the track, in case the automatic start device of the engine does not work, two people may help the rider pushing the prototype up to the Pit Lane exit. Additional batteries are not allowed to start the prototype.
- G.3.4.5 | If a rider going out from his/her Box, has a problem in the prototype before the exit of the Pit Lane, can return to the Box with the engine/motor off through the work zone and accompanied by a Pit Lane marshal.
- G.3.4.6 | During pit stops only registered team members can manipulate the prototype. Failure to comply with this rule may result in the exclusion of the team.
- G.3.4.7 | During pit stops a maximum of 3 people (rider included) may manipulate the prototype. Any contact with the prototype will be considered as manipulation (even if the rider stays on it, although he/she does not intervene).
- G.3.4.8 | If the work is done inside the Box, the number of registered team members working on the prototype is not limited. During the race sessions, introducing the prototype inside the Box will mean the exclusion of the team from that session.
- G.3.4.9 | Oil or other liquids exchange and cleaning must be done over a recipient and inside the Box. After this operation the team must ensure that the area remains perfectly clean.

G.3.5 Signals with flags

The following flag code will be used to alert the riders during the course of the MS2 Phase tests:

- Red flag: interruption of the session.
- Black flag: immediate stop of the indicated bike number. The rider will not be allowed to get back to the track.

- Black flag with orange circle: immediate stop of the indicated bike number due to a technical problem. The rider may get back provided the technical problem is solved.
- Yellow flag: imminent hazard onto track. Forbidden to overtake.
 - 1 flag: hazard out of the track.
 - 2 flags: hazard on the track.
- Yellow and red striped flag: the grip on that section of the track may be affected.
- White flag with a diagonal red cross: rain drops in that section of the track.
- Green Flag: track is clear. End of the overtaking prohibition.
- Blue Flag: shown to a slow rider who is going to be overtaken by a faster one/s. The slow rider must give way to the faster ones.

G.3.5.1 | Any infraction or ignorance of the signals may be penalized.

G.3.6 Regulations priority order

Any situation or infraction not contemplated in the MotoStudent Regulations, will be ruled by the RFME Sporting Regulations of 2023 speed competitions.

Current RFME Sporting Regulations can be found on the following link:

<http://www.rfme.com/web/pagina/36>

ARTICLE 4: DYNAMIC TESTS

G.4.1 Objectives and procedure

The dynamic tests consist of a series of exercises prepared to demonstrate and evaluate the behavior and performance of the prototypes.

G.4.1.1 | MS2 dynamic tests described in this Section correspond to the two categories of the Competition: "MotoStudent Petrol" and "MotoStudent Electric". Each Category will have its own separate score.

- G.4.1.2 | The dynamic tests on the track will be carried out by the rider presented by the team.
- G.4.1.3 | The dimensions, speed, schedules, and measurement indicated in this article may vary and change in the Final Event, if the Organization so had to determine it for any reason.
- G.4.1.4 | The dynamic tests referred below as “Test 1: Brake Test”, “Test 2: Gymkhana” and “Test 3: Acceleration” may be performed twice, taking the best score of the two as the valid for the team.

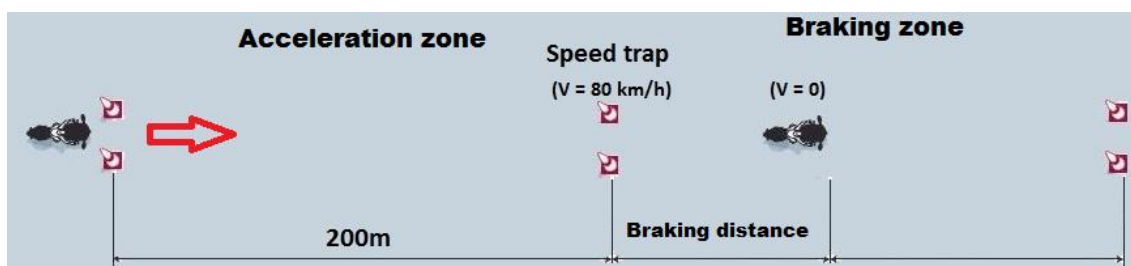
G.4.2 Test 1: Brake Test

The brake test will consist in an evaluation of the distance needed to bring the prototype to a complete stop from a minimum speed of 80 km/h.

- G.4.2.1 | The start will be given by lowering a flag or similar signal by a sport marshal at the starting point.
- G.4.2.2 | The rider will have a maximum time of 10 seconds from the marshal signal to start the test. In case of not starting in this time the rider will be excluded from the test.
- G.4.2.3 | The test will be carried out on a straight with a total length of 350m.
- G.4.2.4 | The maximum track length available for the prototype to reach a speed equal or higher than 80 km/h is 200m. The Organization will fit the specific point with a speed measurement device to verify that the speed has been reached.
- G.4.2.5 | After passing the end mark of the acceleration straight (speed trap point), the rider will have to try to stop the prototype in the shortest possible distance.
- G.4.2.6 | The marshals will measure the point of the vertical tangent of the front tire (foremost part of the prototype).
- G.4.2.7 | The distance between the point described in Art. G.4.2.6 and the speed trap will be considered as the braking distance for the assessment of the test result.
- G.4.2.8 | The score of the braking test will be assigned after recording the braking distance of all teams.
- G.4.2.9 | The score of the test will be assigned according to the classification of the distances obtained (from lowest to highest distance) based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	80	18 th	33	35 th	16
2 nd	75	19 th	32	36 th	15
3 rd	70	20 th	31	37 th	14
4 th	65	21 st	30	38 th	13
5 th	61	22 nd	29	39 th	12
6 th	57	23 rd	28	40 th	11
7 th	53	24 th	27	41 st	10
8 th	50	25 th	26	42 nd	9
9 th	47	26 th	25	43 rd	8
10 th	44	27 th	24	44 th	7
11 th	42	28 th	23	45 th	6
12 th	40	29 th	22	46 th	5
13 th	38	30 th	21	47 th	4
14 th	37	31 st	20	48 th	3
15 th	36	32 nd	19	49 th	2
16 th	35	33 rd	18	50 th	1
17 th	34	34 th	17	...	1

G.4.2.10 | Graphic description of the test.



Graphic description of Test 1: Brake Test

G.4.2.11 | If the speed at the speed trap is lower than 80 km/h, the following penalties will be applied, which will be added to the achieved braking distance.

Speed (km/h)	Penalty
79	+ 4 m
78	+ 6 m
77	+ 8 m
76	+ 10 m
75	+ 12 m
70-74	+ 20 m
<70	Null result

G.4.3 Test 2: Gymkhana

The second test will consist of a small-timed gymkhana.

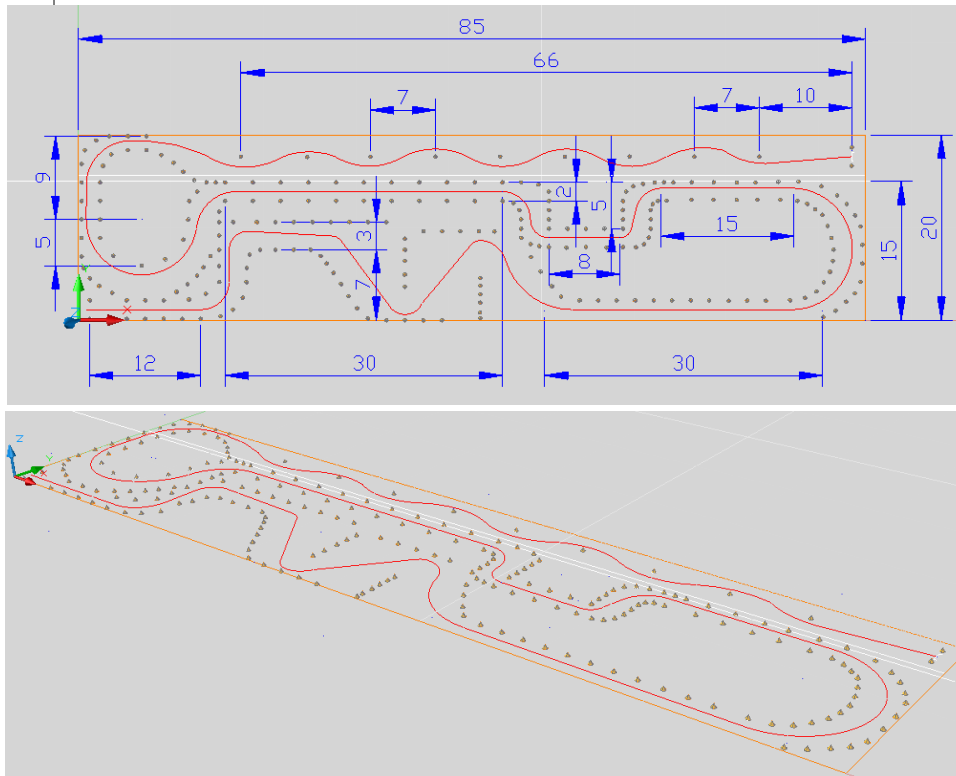
- G.4.3.1 The start will be given by lowering a flag or similar signal by a sport marshal at the starting point.
- G.4.3.2 The rider will have a maximum time of 10 seconds from the marshal signal to start the test. In case of not starting in this time the rider will be excluded from the test.
- G.4.3.3 The time needed to cover the complete route will be recorded by means of cells at the start and finish points.
- G.4.3.4 The table below shows the penalties for failures. They are time penalties that will be added to the total time of the test.

Failure	Penalty
Moving or pulling cones	+ 5 seconds / cone
Moving or pulling more than 5 cones	Null test
Not exceeding cones in the correct side	+ 10 seconds / cone
Not exceeding more than 3 cones in the correct side	Null test

- G.4.3.5 The score of the test will be assigned according to the ranking of times obtained (from lowest to highest time) based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	60	18 th	31	35 th	14
2 nd	55	19 th	30	36 th	13
3 rd	52	20 th	29	37 th	12
4 th	50	21 st	28	38 th	11
5 th	48	22 nd	27	39 th	10
6 th	46	23 rd	26	40 th	9
7 th	44	24 th	25	41 st	9
8 th	42	25 th	24	42 nd	8
9 th	40	26 th	23	43 rd	8
10 th	39	27 th	22	44 th	7
11 th	38	28 th	21	45 th	6
12 th	37	29 th	20	46 th	5
13 th	36	30 th	19	47 th	4
14 th	35	31 st	18	48 th	3
15 th	34	32 nd	17	49 th	2
16 th	33	33 rd	16	50 th	1
17 th	32	34 th	15	...	1

G.4.3.6 | Graphic description of the test:



Graphic description of Test 2: Gymkhana / * Measures indicated in meters (m)

G.4.3.7 | Dimensions and geometries indicated in the images in Art. G.4.3.6 are indicative, so they may suffer slight variations in the approach of the test during the Final Event.

G.4.4 Test 3: Acceleration

During this test, the maximum acceleration of each prototype from a complete stop on a 150m-long straight will be measured.

G.4.4.1 | The start will be given by lowering a flag or similar signal.

G.4.4.2 | The rider must try to complete the 150m of the track in the least possible time (maximum acceleration).

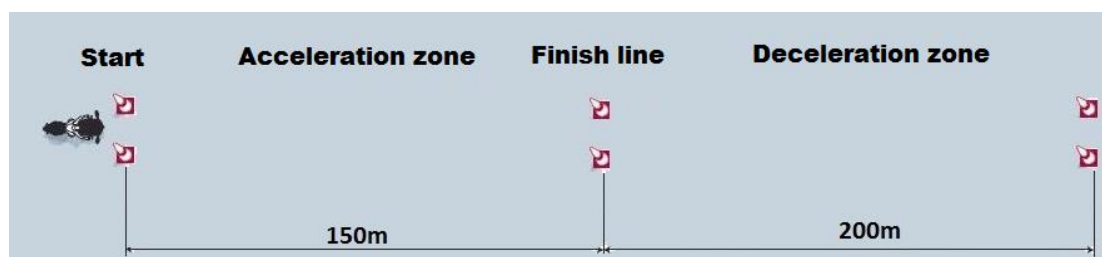
G.4.4.3 | The time needed to complete the route from the start to the finish point will be recorded by Organization.

G.4.4.4 | The rider will have a maximum time of 10 seconds from the marshal signal to start the test. In case of not starting in this time the rider will be excluded from the test.

G.4.4.5 | The score of the test will be assigned according to the ranking of times obtained (from lowest to highest time) based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	80	18 th	33	35 th	16
2 nd	75	19 th	32	36 th	15
3 rd	70	20 th	31	37 th	14
4 th	65	21 st	30	38 th	13
5 th	61	22 nd	29	39 th	12
6 th	57	23 rd	28	40 th	11
7 th	53	24 th	27	41 st	10
8 th	50	25 th	26	42 nd	9
9 th	47	26 th	25	43 rd	8
10 th	44	27 th	24	44 th	7
11 th	42	28 th	23	45 th	6
12 th	40	29 th	22	46 th	5
13 th	38	30 th	21	47 th	4
14 th	37	31 st	20	48 th	3
15 th	36	32 nd	19	49 th	2
16 th	35	33 rd	18	50 th	1
17 th	34	34 th	17	...	1

G.4.4.7 | Graphic description of the test.



Graphic description of Test 3: Acceleration

ARTICLE 5: FREE PRACTICE SESSIONS

Free Practice sessions will be held in the FIM Grand Prix International layout of MotorLand Aragón, with a length of 5.077,65m. Such tracing is represented in Annex 2 of Section J of these Regulations.

G.5.1 Development of the sessions

The teams will have 2 rounds of 20-minute free practice sessions on the racetrack, named "Free Practice 1" and "Free Practice 2". Two courses for the "MotoStudent

Petrol" Category and other two for the "MotoStudent Electric" Category will take place independently.

- G.5.1.1 | After these 20 minutes a chequered flag will be shown at the finish line and no prototype will be allowed to access the track. The prototypes that are on the track and take the chequered flag must leave the track after the following lap.
- G.5.1.2 | In case the maximum number of prototypes capable of competing in any of the Categories exceeds the maximum allowed limit of prototypes on the track, the Organization will establish two groups for the performance of the Free Practice sessions.
- G.5.1.3 | During the "Free Practice 1" session, the test "Test 4: Vmax in Speed Trap" of the MS2 Phase will be developed and scored.
- G.5.1.4 | During the "Free Practice 2" session, the test "Test 5: Regularity" of the MS2 Phase will be developed and scored.

G.5.2 Test 4: $V_{\max}$ in Speed Trap

This test consists in achieving the maximum speed at a specific point of the racetrack during "Free Practice 1" session.

- G.5.2.1 | The Organization will place a speed measurement device at the Speed Trap point. The location of the Speed Trap will be communicated to the teams during the Final Event.
- G.5.2.2 | Any passage through the Speed Trap point during the entire "Free Practice 1" session, including laps without passing through the finish line (with entry and/or exit from Pit Lane), will be considered suitable for the result of this test.
- G.5.2.3 | Once the "Free Practice 1" session is over, the maximum speed registered by each team through the Speed Trap will be considered to create the test score. The final score of the test will be assigned according to the classification of the maximum speeds obtained (from highest to lowest speed) for each team, based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	30	18 th	10	35 th	7
2 nd	28	19 th	10	36 th	6
3 rd	26	20 th	10	37 th	6
4 th	24	21 st	9	38 th	6
5 th	22	22 nd	9	39 th	6
6 th	20	23 rd	9	40 th	6
7 th	19	24 th	9	41 st	5

8 th	18	25 th	9	42 nd	5
9 th	17	26 th	8	43 rd	5
10 th	16	27 th	8	44 th	5
11 th	15	28 th	8	45 th	5
12 th	14	29 th	8	46 th	4
13 th	13	30 th	8	47 th	4
14 th	12	31 st	7	48 th	4
15 th	11	32 nd	7	49 th	4
16 th	10	33 rd	7	50 th	4
17 th	10	34 th	7	...	1

G.5.3 Test 5: Regularity

This test consists of achieving the greatest regularity of times in a given sector of the Circuit, taking as reference 3 different laps in the "Free Practice 2" session.

- G.5.3.1 | The time considered for the test score will be that of Sector 2 of the Speed Circuit. The details of the sector will be explained to the teams during the Final Event.
- G.5.3.2 | Any time measurement of Sector 2 during the entire "Free Practice 2" session, including laps without passing through the finish line (with entry and/or exit from Pit Lane), will be considered for the result of this test.
- G.5.3.3 | Once the "Free Practice 2" session is finished among the total time records for each team in Sector 2, the 3 most approximate time measurements will be taken. From these 3 measurements, the time difference between the fastest and the slowest measurement will be determined, which will be the value obtained by each team to apply the score.
- G.5.3.4 | The final score of the test will be applied according to the classification of the final time differences obtained by each team (from lowest to highest time) based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	30	18 th	10	35 th	7
2 nd	28	19 th	10	36 th	6
3 rd	26	20 th	10	37 th	6
4 th	24	21 st	9	38 th	6
5 th	22	22 nd	9	39 th	6
6 th	20	23 rd	9	40 th	6
7 th	19	24 th	9	41 st	5
8 th	18	25 th	9	42 nd	5
9 th	17	26 th	8	43 rd	5
10 th	16	27 th	8	44 th	5
11 th	15	28 th	8	45 th	5
12 th	14	29 th	8	46 th	4
13 th	13	30 th	8	47 th	4

14 th	12	31 st	7	48 th	4
15 th	11	32 nd	7	49 th	4
16 th	10	33 rd	7	50 th	4
17 th	10	34 th	7	...	1

- G.5.3.5 | Those measurements of Sector 2 that exceed 1'20" will not be considered as valid for the score.

ARTICLE 6: QUALIFYING SESSION

The Qualifying session will be held in the FIM International Grand Prix layout of MotorLand Aragón, with a length of 5,077.65m. That layout is represented in Annex 2 of Section J of these Regulations.

G.6.1 Session development

Teams will have a 20-minute timed practice session on the FIM International Grand Prix layout (see Annex 2 of section J). The "MotoStudent Petrol" qualifying session and the "MotoStudent Electric" qualifying session will take place independently.

- G.6.1.1 | After 20 minutes, the checkered flag will be shown on the finish line, and no prototype will be able to access the track. Prototypes that are on the track and pass through the checkered flag must leave the track on the next lap.
- G.6.1.2 | In case the maximum number of prototypes capable of competing in any of the categories exceeds the maximum allowed limit of prototypes on the track, the Organization will establish two groups for the Qualifying sessions.
- G.6.1.3 | The prototype that is making a timed lap at the end of the 20 minutes may complete the lap and the time taken on that lap will be considered as valid.
- G.6.1.4 | Based on Qualifying times, the fastest half, or the number that the Organization determines, of the teams will promote directly to Final Race. Only all other teams will take part in Play-Off Race for Final Race classification.
- G.6.1.5 | Lap times made by the prototypes in this session will be collected by the Organization, and will be those that define the classification for the starting grid in the final Race and the Play-Off Race.
- G.6.1.6 | During the Qualifying session, the "Test 6: Pole Position" test of the MS2 Phase will be developed and scored.

G.6.2 Test 6: Pole position

This test consists in obtaining the fastest lap time on the racetrack.

G.6.2.1 The times for this test will be recorded during the “Qualifying” session.

G.6.2.2 The test score will be awarded according to the classification of the lap times obtained (from lowest to highest time) based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	40	18 th	13	35 th	7
2 nd	36	19 th	13	36 th	6
3 rd	34	20 th	12	37 th	6
4 th	32	21 st	12	38 th	6
5 th	30	22 nd	11	39 th	5
6 th	28	23 rd	11	40 th	5
7 th	26	24 th	10	41 st	5
8 th	24	25 th	10	42 nd	4
9 th	22	26 th	10	43 rd	4
10 th	20	27 th	9	44 th	4
11 th	19	28 th	9	45 th	3
12 th	18	29 th	9	46 th	3
13 th	17	30 th	8	47 th	3
14 th	16	31 st	8	48 th	2
15 th	15	32 nd	8	49 th	2
16 th	14	33 rd	7	50 th	2
17 th	14	34 th	7	...	1

ARTICLE 7: FINAL RACE

It will run independently:

- The Final Race of the Category “MotoStudent Petrol”.
- The Final Race of the Category “MotoStudent Electric”.

Both Final Races will take place on FIM International Grand Prix Layout of MotorLand Aragón, with a length of 5.077,65m. Such tracing is represented in Annex 2 of Section J of this Regulations.

G.7.1 Play-Off Race

G.7.1.2 The starting grid order for the Play-Off Race will be determined according to the time rankings, ordered from fastest to slowest, obtained by the teams in the "Qualifying" sessions. Only not directly qualified teams for Final Race will participate in this race.

G.7.1.3 | Only the rider, tutor/s and registered students of each team will be able to access the starting grid. No other person can access if he is not a registered Team Member.

G.7.1.4 | The Play-Off Race for MotoStudent Petrol Category procedure will be configured as follows:

- Training lap from Pit Lane to starting grid.
- Countdown on the starting grid.
- Warm up lap to stop again on the starting grid.
- Play-Off Race, with start from static commanded by light.
- Return lap to Park Fermé.

G.7.1.4 | The Play-Off Race for MotoStudent Electric Category procedure will be configured as follows:

- Direct access from pit lane to starting grid (without formation lap).
- Countdown on the starting grid.
- Warm up lap to stop again on the starting grid.
- Play-Off Race, with start from static commanded by light.
- Return lap to Park Fermé.

G.7.1.5 | Number of laps for each Play-Off Race will be as follows:

Category	Number of laps for the Play-Off Race
MotoStudent Petrol	7
MotoStudent Electric	5

G.7.1.6 | After the Play-Off Race session, prototypes may be taken to Parc Fermé if the Organization considers it convenient to carry out the appropriate checks.

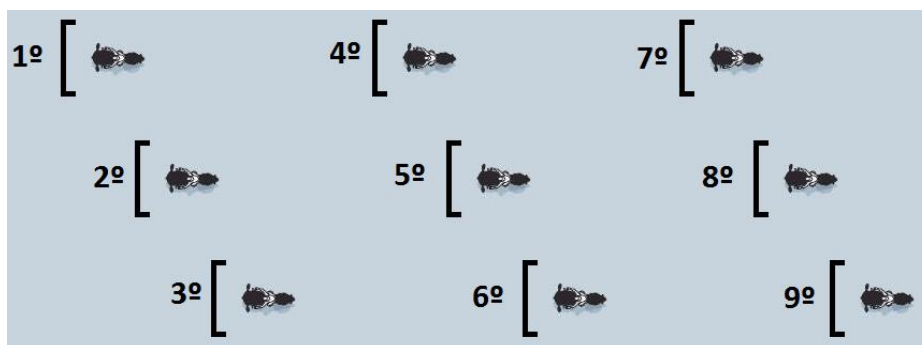
G.7.1.7 | 1st, 2nd and 3rd classified in Play-Off Race will progress to the Final Race.

G.7.1.8 The result of the Play-Off Race will be scoring from the last classified in the Final Race down until completing the total punctuation table, apart from the three teams classified to the Final Race, where their punctuation will depend on the Final Race results. This will affect to the scores in "Test 7: Best Race Lap" and "Test 8: Race Result".

G.7.1.7 The Organization reserves the right to change the number of admitted prototypes to qualify in the Play-Off Race, communicating it with enough time to the teams and always in favour of the safety of the participating riders. In no case may the Organization take decisions contrary to the requirements of FIM Homologation of the Speed Circuit.

G.7.2 Final Race session starting grid

The starting grid will have a formation of 3 prototypes per line, and all spaces from the starting line to the back will be filled.



G.7.2.1 For the MotoStudent Petrol category, the starting order will be established according to the ranking of the fastest times obtained by each prototype in the Qualifying session, having done Play-Off Race or not.

G.7.2.2 If the number of Teams is lower than 40, Play-Off race will be cancelled and all teams will access to the Final Race directly.

G.7.2.3 The Organization reserves the right not to admit teams that are considered as a safety risk for the race due to issues such as lap times or top speed.

G.7.2.4 Only the rider, tutor/s and the registered students of each team will be able to access the starting grid. No other person can access if he is not a registered Team Member.

G.7.2.5 It is allowed to introduce to the grid stands and basic hand tools necessary for pre-race assistance. Access to the grid is NOT allowed with any type of portable

generator. Heaters may be used to maintain the tire temperature, but they cannot be plugged in during grid formation.

G.7.3 Final Race development

G.7.3.1 The Final Race of the "MotoStudent Petrol" Category will be held for 9 laps (approximate distance of 45.7 Km).

G.7.3.2 The Final Race procedure for the "MotoStudent Petrol" Category will be configured as follows:

- Formation lap from Pit Lane to starting grid.
- Countdown on the starting grid.
- Warm up lap to stop again on the starting grid.
- Race (9 laps) with start from static commanded by light.
- Victory lap and return to Parc Fermé.

G.7.3.3 The Final Race of the "MotoStudent Electric" Category will be held for 6 laps (approximate distance of 30.5 Km).

G.7.3.4 The Final Race procedure for the "MotoStudent Electric" Category will be configured as follows:

- Direct access from pit lane to starting grid (without formation lap).
- Countdown on the grid.
- Warm up lap to stop again on the starting grid, a maximum time will be given for performing the warm up lap.
- Race (6 laps) with start from static commanded by light.
- Victory lap and return to Parc Fermé through "National" layout (2,379.12m).

G.7.3.5 The maximum time set for the warm-up lap will be 4' 30" from the start command. After this time all the prototypes that are not placed in the corresponding position of the starting grid should leave the track immediately, being able to be picked by the assistance services to take the exit from Pit Lane later.

G.7.3.6 | After the Final Race sessions, all prototypes must remain in Parc Fermé during the time that the Organization deems appropriate to carry out the appropriate checks.

G.7.3.7 | During the Play-Off Race and Final Race session, the "Test 7: Best Race Lap" and "Test 8: Race Result" will be developed and scored.

G.7.4 MS1 Handicaps

The result of the teams in the MS1 Phase of the Competition may have direct influence on the application of handicap stops during the Race session.

G.7.4.1 | If the total scoring of a team in the MS1 Phase is not equal or greater than 150 points, the team must make a time penalty applied to the time for race starting grid formation, not for Final Race access.

G.7.4.2 | The total penalty time is determined based on the total scoring obtained in the MS1 Phase:

Scoring intervals	Handicap time
150 > Puntuación MS1 ≥ 112	1"
112 > Puntuación MS1 ≥ 75	2"
75 > Puntuación MS1 ≥ 37	3"
37 > Puntuación MS1	5"

G.7.5 Test 7: Best Race Lap

During the Play-Off Race and Final Race sessions the race fast lap test will be evaluated.

G.7.5.1 | The Organization will record the best lap times of each team during the whole race.

G.7.5.2 | The test score is assigned according to the classification of the lap times obtained (from lowest to highest time), being the first teams, the ones participating in the Final Race, and the following ones the Play-Off Race teams, except from the three teams that promote to the Final Race, based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	30	16 th	10	31 st	5
2 nd	28	17 th	10	32 nd	5
3 rd	26	18 th	9	33 rd	4
4 th	24	19 th	9	34 th	4
5 th	22	20 th	9	35 th	4

6 th	20	21 st	8	36 th	3
7 th	19	22 nd	8	37 th	3
8 th	18	23 rd	8	38 th	3
9 th	17	24 th	7	39 th	2
10 th	16	25 th	7	40 th	2
11 th	15	26 th	7	41 st	2
12 th	14	27 th	6	42 nd	1
13 th	13	28 th	6	43 rd	1
14 th	12	29 th	6	44 th	1
15 th	11	30 th	5	...	0

G.7.6 Test 8: Race Result

The final race result (Play-Off Race and Final Race session) will determine the score of this test.

- G.7.6.1 The test scores will be assigned according to the race classification, being the first teams, the ones participating in the Final Race, and the following ones the Play-Off Race teams, except from the three teams that promote to the Final Race, based on the following criteria:

Rank	Score	Rank	Score	Rank	Score
1 st	150	16 th	65	31 st	20
2 nd	140	17 th	60	32 nd	18
3 rd	130	18 th	55	33 rd	16
4 th	125	19 th	50	34 th	14
5 th	120	20 th	45	35 th	12
6 th	115	21 st	40	36 th	10
7 th	110	22 nd	38	37 th	8
8 th	105	23 rd	36	38 th	7
9 th	100	24 th	34	39 th	6
10 th	95	25 th	32	40 th	5
11 th	90	26 th	30	41 st	4
12 th	85	27 th	28	42 nd	3
13 th	80	28 th	26	43 rd	2
14 th	75	29 th	24	44 th	1
15 th	70	30 th	22	...	0

ARTICLE 8: MS2 PHASE RESULTS

G.8.1 Scores

The distribution of sessions and scoring of the MS2 tests is summarized in the following table:

Session	Test	Scoring
Round 1 / Round 2	Test 1: Brake Test	80
	Test 2: Gymkhana	60

	Test 3: Acceleration	80
Free Practice 1	Test 4: $V_{\max}$ in speed trap	30
Free Practice 2	Test 5: Regularity	30
Qualifying	Test 6: Pole Position	40
Final Race > Play-Off Race	Test 7: Best Race Lap	30
	Test 8: Race Result	150
Total		500

G.8.1.1 If for reasons outside the Organization like adverse conditions and other possible reasons, it should cancel one or more of the scoring tests, the MS2 Sports Committee reserves the right to change the assignment of scores, with previous notification to the participating teams.

G.8.1.2 In case of a tie of the scores between two or more teams in the overall classification of the MS2 Phase, the final classification position will be based on the score of each team in the MS1 Phase, with the team with the highest MS1 score remaining ahead.

G.8.2 Awards

The top 3 teams of the MS2 Phase will be awarded with the following awards:

- 1st classified MS2
- 2nd classified MS2
- 3rd classified MS2

SECTION H

FINAL EVENT

ARTICLE 1: SCHEDULE

H.1.1 Official Schedules during the Final Event

The Organization will establish a series of schedules in which it will cite the teams to carry out the tests corresponding to the Scrutineering, MS1 Phase and MS2 Phase. These schedules will be published and sent to the teams prior to the Final Event.

- H.1.1.1 Failure to comply with the schedules set by the Organization for the Final Event will result in the team being penalized in the corresponding test, or even the exclusion of said test if, for operational reasons, it is considered under justified causes.
- H.1.1.2 In the MotoStudent Electric Category, a minimum of 40 minutes between tests will be guaranteed to facilitate battery recharges.
- H.1.1.3 The Organization reserves the right to make any changes to the schedule in the tests presented.

ARTICLE 2: AREAS AND FACILITIES DURING THE FINAL EVENT

The participating teams undertake to take care of the facilities where the Final Event will take place. Otherwise, the Organization will be entitled to apply sanctions or expel the offenders from the Competition.

H.2.1 Definition of areas

Annex 3 indicates the orientative distribution of the different areas of the Final Event described below. (to be confirmed)

- H.2.1.1 Start – Finish Straight: finish straight of the Grand Prix FIM International track of the MotorLand Aragon circuit. Apart from the start and finish point during the races, the straight will house dynamic test of the MS2 Phase of the Competition, as well as other parallel activities.
- H.2.1.2 Pit Lane: route that connects the circuit layout with the team Boxes. This area is restricted only to students, tutors and riders enrolled in the Competition. Public access to Pit Lane is prohibited.
- H.2.1.3 Pit Building: main building of the circuit. It has three floors:
 - Ground floor: houses the team Boxes, as well as bathrooms and showers.

- 1st floor: houses the presentation rooms, restaurant, services, bathrooms, terraces and briefing room.
- 2nd floor: public terraces.

The floors are connected by stairs through the towers A, B, C, D, E and F. Tower E has an elevator for handicapped.

H.2.1.4 | Public Terraces: distributed along the Pit Building, terraces are open to the public to watch the activities on track.

H.2.1.5 | Team Boxes: working Boxes for teams.

H.2.1.6 | Technical Control Area: Scrutineering area where the Organization will carry out the inspection of the participating prototypes (Static Scrutineering).

H.2.1.7 | MotoStudent General Office: main office of the Competition Organization to attend registered teams.

H.2.1.8 | Paddock General Office (PGO): Paddock offices where teams may be called by different organizational committees (MS1, MS2, Technical, Disciplinary, etc.) for issues related to complaints, irregularities, disciplinary applications, etc.

H.2.1.9 | MotoStudent Shop: official shop of the Organization. Payments in the shop during the Final Event may be made by cash (€) or by credit card. Credit cards accepted are:



H.2.1.10 | Tires Technical Service: service point for the supply and mounting of tires.

H.2.1.11 | Fuel Area: facility to supply the Official Fuel.

H.2.1.12 | Dynamic Area: Paddock area reserved for dynamic activities (Dynamic Safety Check, regulated practices area, ...).

H.2.1.13 | Parc Fermé: closed park.

H.2.1.14 | MotoStudent Arena: Paddock area where events like the MS1 Awards Ceremony, presentations and other activities will take place.

H.2.1.15 | Fan Zone: commercial and show area.

H.2.1.16 | Medical Center: medical attention center.

H.2.1.17 | Working Vehicles Parking: area reserved for the working vehicles, up to 8 meters long.

H.2.2 Installations of teams

H.2.2.1 | The Organization will enable and assign, free of charge, a work area (located inside a Box) to each team where they must carry out repairs and tuning of the prototype.

H.2.2.2 | The Boxes have 230V power sockets with European model plug or 230V industrial socket and three-phase 400V sockets. They are also equipped with a TV socket with access to live timing, compressed air, water connections and bathroom.

H.2.2.3 | Personal and transportation vehicles must be parked in the areas authorized for this purpose. Track and test areas can only be accessed by the Organization vehicles.

ARTICLE 3: PARTICIPANTS ACCREDITATION

H.3.1 Accreditation

When accessing the Final Event, the Organization will provide an accreditation pass and bracelet to each of the team members, rider, and tutor/s. This identification will serve as an indication to the Organization for the follow-up of the tests and interventions in the prototype.

H.3.1.1 | The accreditation passes and bracelets will be placed to the registered team members at the time of entering the Final Event, and they must wear them until it finishes.

H.3.1.2 | Passes and bracelets will only be given to officially registered members as part of the team. Any unregistered person accompanying the team will be considered a general public and, therefore, will not have the same privileges of access and activity as the registered students, detailed in Art. A.1.6.5.

ARTICLE 4: BEHAVIOR RULES

H.4.1 Behavior of the participants during the Final Event

To achieve a good coexistence during the Final Event the following actions are strictly prohibited:

- Cooking inside the Boxes and spaces not specifically allowed by the Organization.
- Sleeping inside the Boxes.
- Installing tents in spaces not specifically allowed by the Organization.
- Entry of pets in the Paddock.
- Smoking, lighting fires or depositing gas containers inside the Boxes.
- Parking an unauthorized vehicle inside the Paddock.
- The exchange of people and vehicles passes.
- Paint, drill, disassemble or misuse circuit facilities.

H.4.2 Authorized vehicles in Paddock

H.4.2.1 The prototype can only be moved by its own means during the tests, for the rest of the movements through the Paddock it must be pushed or moved with the engine/motor stopped.

H.4.2.2 Vehicle traffic through the Paddock is restricted only to vehicles of the Organization and the following light vehicles:

- Vehicles without motor (scooters, bicycles ...).
- Personal mobility vehicles (motorized scooter, assisted bicycle, ...).
- Scooters.

H.4.2.3 The circulation of any vehicle on the Pit Lane (except for prototypes) is strictly forbidden, except for the access of non-motorized vehicles during the time allowed for the track inspection.

H.4.2.4 The circulation of the vehicles indicated in Art. H.4.2.2 shall be governed by the following rules:

- No more than two people can travel.

- Children under 14 years old will not be able to drive any vehicle.
- Reckless driving inside the paddock is prohibited.
- The circulation of vehicles will be prohibited during the hours of silence (23:00 - 07:00 hours).
- The use of helmet is mandatory.

H.4.3 Prototype manipulation

For safety reasons, the manipulation of the prototype must meet the following rules. Failure to comply with these rules may result in a penalty or even expulsion from the Competition.

- H.4.3.1 | Repairs and manipulations on the prototype during the Final Event can only be made inside the Box of each team.
- H.4.3.2 | The transfer of the prototype outside the circuit facilities during the Final Event is allowed (e.g. for practices in karting circuit).

ARTICLE 5: COMMUNICATION

H.5.1 Contact with the Organization during the Final Event

The contact between the teams and the Organization during the Final Event must be carried out primarily through the MotoStudent General Office.

- H.5.1.1 | During the Final Event, any tutor, team leader or rider can be summoned by the Organization to report incidents. Teams must attend these appointments at the place indicated in a maximum period of 15 minutes from the corresponding notice.

H.5.2 Briefings

During the Final Event, the Organization will hold several briefings to explain the development of the Competition to teams, tutors and riders.

- H.5.2.1 | Team leaders, tutors or riders must attend the briefings to which they are summoned by the Organization. The non-attendance at these briefings without a justified cause will be penalized.

H.5.3 Communication of schedules and results

The Organization will communicate the schedules of tests and results through different means.

- H.5.3.1 | The Organization will publish on the bulletin board enabled in the Paddock the results obtained in each of the tests.
- H.5.3.2 | The timing results of “Free Practice”, “Qualifying” and “Race” sessions will be broadcast live by the internal TV signal of the circuit. In addition to being broadcast by screens in common facilities, all Boxes and the Pit Wall will have TV sockets to access the live timing broadcast.
- H.5.3.3 | The timing results of “Free Practice”, “Qualifying” and “Race” sessions will be broadcast live through the internet. The Organization will communicate to the teams the web platform to which they can access to follow live timing.
- H.5.3.4 | The final results obtained in each test may be published on the web once the Competition is over.

SECTION I

MODIFICATIONS GLOSSARY

EVERYTHING NOT PERMITTED AND SPECIFIED IN THESE REGULATIONS IS STRICTLY FORBIDDEN

SECTION J

ANNEXES

ANNEX 1: CLAIMS AND IMPUGNMENTS MODEL

Mr/Ms _____ with personal ID-number _____, as
Tutor/Team Leader of the team _____, representing University of
_____ with bike number _____ participant in the MotoStudent
_____ Category, hereby applies (*mark with X*):

☐ a **CLAIM** over the Organization of the VI MotoStudent International Competition:

☐ an **IMPUGNMENT** over team _____ with bike number _____:

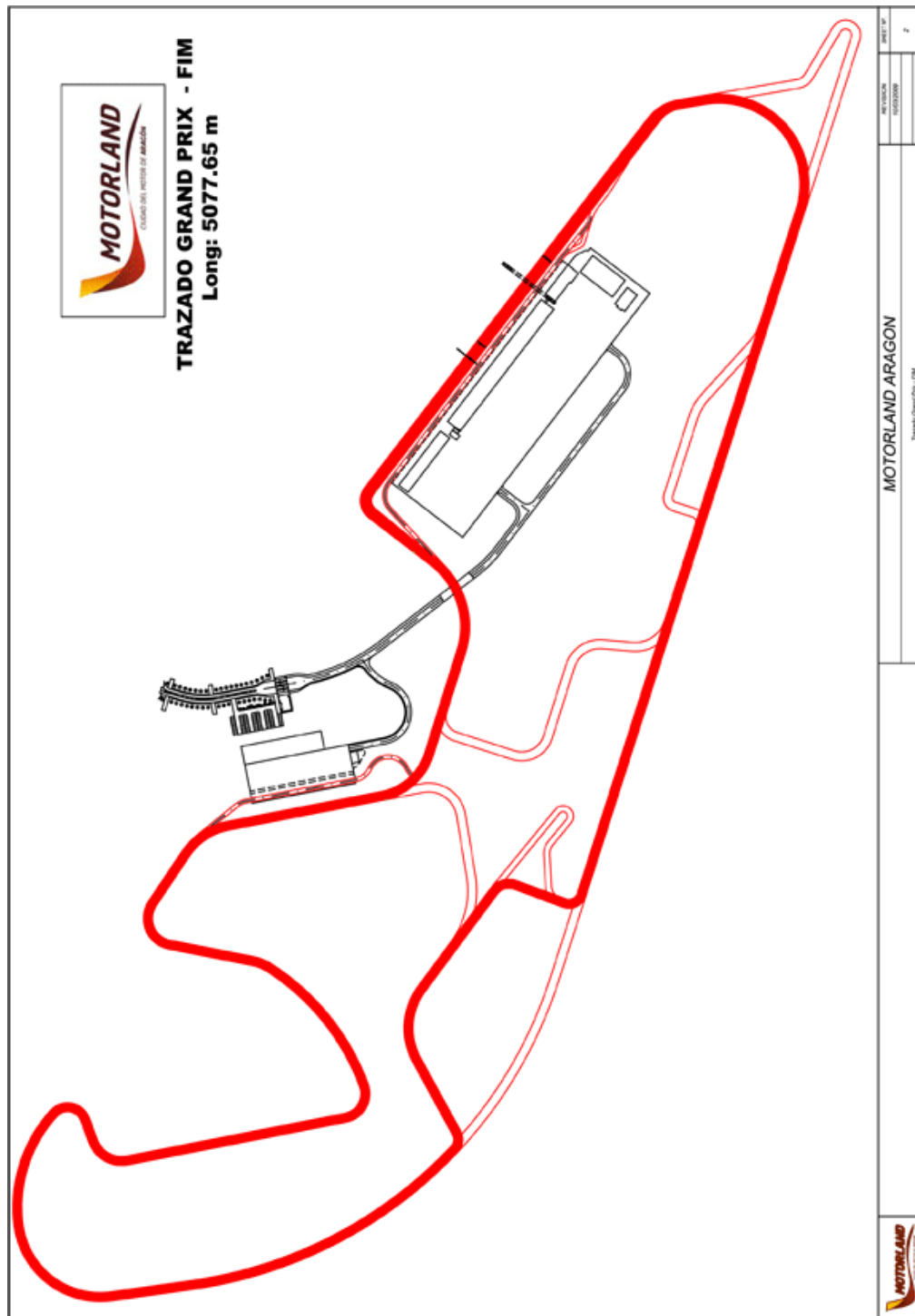
For that reason, it considers violated the Article _____ of the Competition Regulations where it stipulates:

Also provides the following evidences to be taken into account by the Organization when verifying this claim:

And for the record, signs this document in _____, on _____, _____ 20__

Mr/Ms. _____

ANNEX 2: TRACK LAYOUT



ANNEX 3: ORIENTATIVE FINAL EVENT MAP

(TBC)

I.6.- Abraçadora metàl·lica WÜRTH



ABRAZADERAS A4



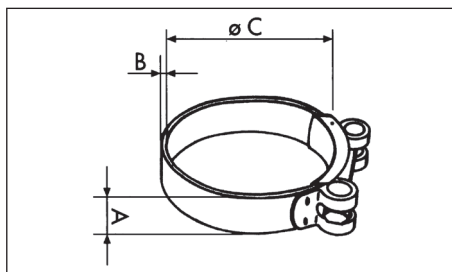
Fleje	Ø mm	Art. N°	U/E
9	8 - 16	0538 008 16	50/100
	12 - 22	0538 012 22	
	16 - 27	0538 016 27	
	25 - 40	0538 025 40	
	32 - 50	0538 032 50	

Fleje	Ø mm	Art. N°	U/E
12	16 - 27	0538 16 27	25/50
	20 - 32	0538 20 32	
	25 - 40	0538 25 40	
	35 - 50	0538 35 50	
	40 - 60	0538 40 60	
	50 - 70	0538 50 70	
	60 - 80	0538 60 80	
	70 - 90	0538 70 90	
	80 - 100	0538 80 100	
	90 - 100	0538 90 110	
	100 - 120	0538 100 120	

Datos técnicos

Material fleje: Acero inox A4 1.4401.
Material tornillo: Acero inox A4 1.4401
Ancho fleje: 9mm /12mm.
Cabeza tornillo: SW 7.

ABRAZADERA DE ALTA PRESIÓN A4



A mm	B mm	Ø mm	Ø tornillo	Art. N°	U/E
18	0,8	26 - 28	M5 x 35	0537 726 28	10
18	0,8	29 - 31	M5 x 35	0537 729 31	
18	0,8	32 - 35	M5 x 35	0537 732 35	
20	1	36 - 39	M6 x 50	0537 736 39	
20	1	40 - 43	M6 x 50	0537 740 43	
20	1	44 - 47	M6 x 50	0537 744 47	
20	1	48 - 51	M6 x 50	0537 748 51	
20	1	52 - 55	M6 x 60	0537 752 55	
20	1	56 - 59	M6 x 60	0537 756 59	
20	1	60 - 63	M6 x 60	0537 760 63	
25	1,5	64 - 67	M8 x 70	0537 764 67	
25	1,5	68 - 73	M8 x 70	0537 768 73	
25	1,5	74 - 79	M8 x 70	0537 774 79	
25	1,5	80 - 85	M8 x 70	0537 780 85	
25	1,5	86 - 91	M8 x 70	0537 786 91	
25	1,5	92 - 97	M8 x 70	0537 792 97	
25	1,5	98 - 103	M8 x 70	0537 798 103	

Con mordaza de apriete

- Para la sujeción de tubos, cables, mangueras, recipientes, etc.
- El ancho de la abrazadera proporciona una presión amplia sobre el material y evita daños en el mismo.
- La presión de apriete se distribuye proporcionalmente sobre toda la superficie de la abrazadera.
- Material: acero inoxidable AISI 316.

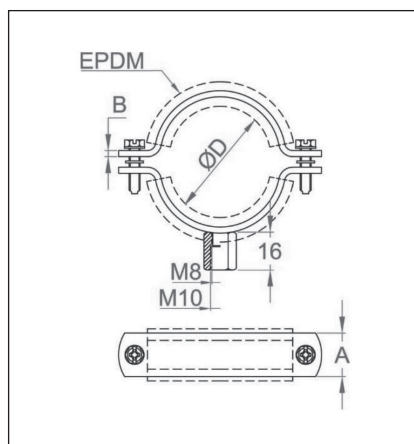
Aplicaciones

Conductos hidráulicos, conductos de alta presión, fabricación de maquinaria, automoción, etc.
Para industrias de alimentación (lácteas, bodegas, etc).
Instalaciones abiertas como depuradoras, complejos acuáticos, etc.

I.7.- Abraçadora isofònica WÜRTH



ABRAZADERA REFORZADA ISOFÓNICA M8/10



Abrazadera isofónica reforzada en acero galvanizado (según EN10051) y recubierta con goma EPDM (según DIN4109) para aislamiento, reducción del sonido y vibraciones.

- Tornillos laterales imperdibles gracias a la arandela de plástico que llevan incorporada.
- Reducción del sonido 18 dB (A).
- Resistencia a la temperatura -40 °C a +110 °C
- Carga máxima 2.000 N.
- Tuerca de sujeción soldada de M8+M10.
- Adecuada para tubos de acero, plástico, cobre y ventilación.
- Indicada para instalaciones de suministro de agua (ACS y AF), evacuación de agua (saneamiento), instalaciones térmicas (climatización, calefacción, ventilación), aire comprimido, instalaciones de gasóleo, etc.
- Cumple el Código Técnico de la Edificación, CTE, apartados Documentos Básicos HS y HR.

Campo de apriete (D) mm	Medida tubo mm	Medida (D) pulgadas	Carga máx. N	A x B mm	Art. Nº	U/E
15 - 19	18	3/8"	1.500	18,5x1,75	0543 209 019	50
20 - 25	22	1/2"			0543 209 025	
26 - 30	28	3/4"			0543 209 030	
32 - 36	35	1"			0543 209 036	
38 - 43	40	1 1/4"			0543 209 043	
47 - 51	48	1 1/2"			0543 209 051	25
53 - 56	54	-			0543 209 056	
60 - 64	60	2"			0543 209 064	
75 - 80	75	2 1/2"			0543 209 080	
81 - 86	83	-			0543 209 083	
87 - 92	90	3"			0543 209 092	
107 - 112	110	-	2.000	18,5x2,3	0543 209 112	
113 - 118	115	4"			0543 209 118	
125 - 130	125	4 1/2"			0543 209 130	
138 - 142	140	5"			0543 209 140	
148 - 152	150	-			0543 209 150	
159 - 166	160	6"			0543 209 166	
199 - 212	200	-			0543 209 212	
215 - 226	220	-			0543 209 220	
299 - 304	300	-			0543 209 300	
354 - 359	355	-			0543 209 355	
399 - 404	400	-			0543 209 400	

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM IV

Document 4: Plànols

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



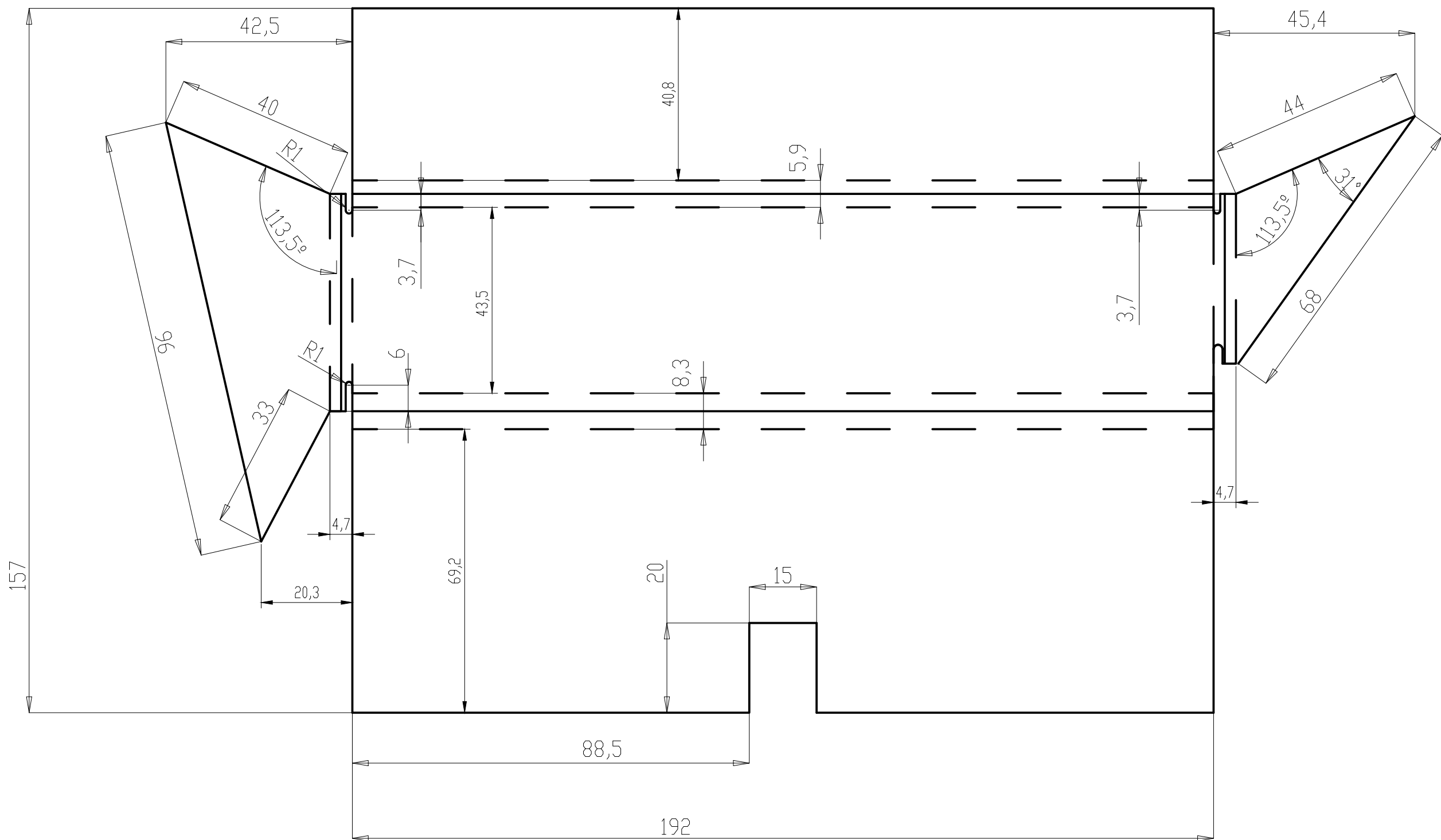
ESCOLA TÈCNICA SUPERIOR
D'ENGINYERIA QUÍMICA
Universitat Rovira i Virgili

etsEQ

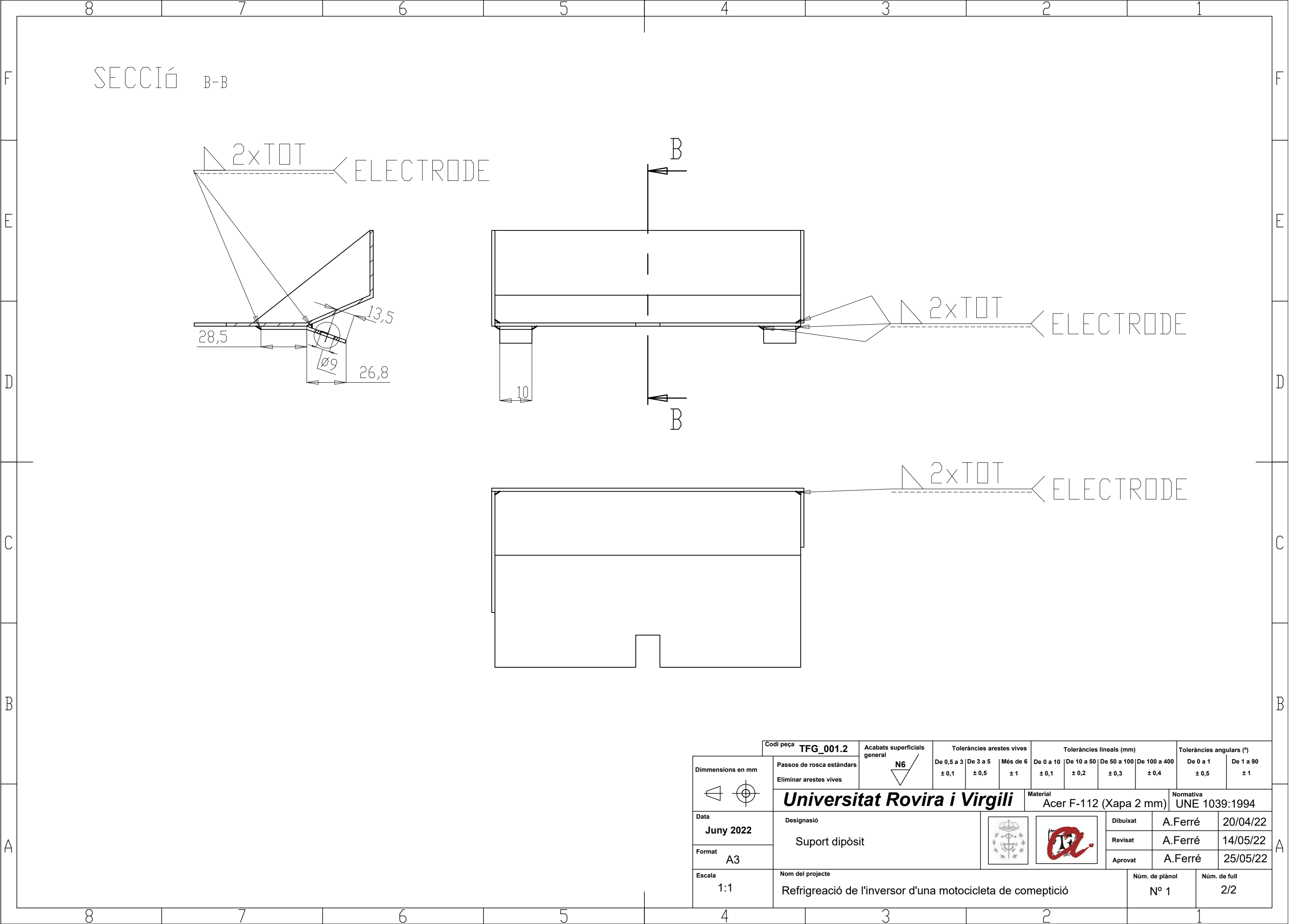
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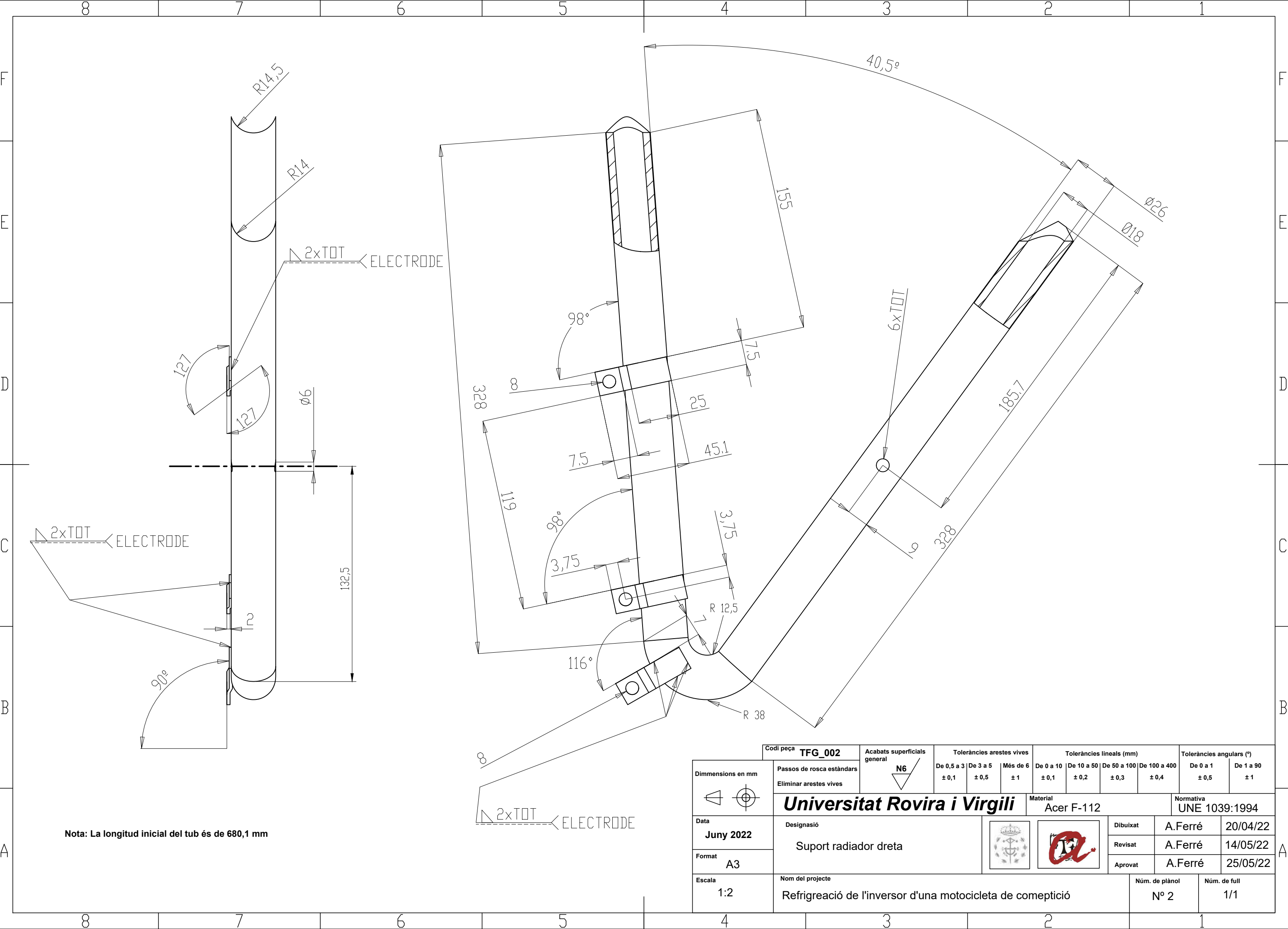
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1.- Plànol N°1.....	1
2.- Plànol N°2.....	3
3.- Plànol N°3.....	4
4.- Plànol N°4.....	5
5.- Plànol N°5.....	6
6.- Plànol N°6.....	7
7.- Plànol N°7.....	8
8.- Plànol N°8.....	9
9.- Plànol N°9.....	10
10.- Plànol N°10.....	11

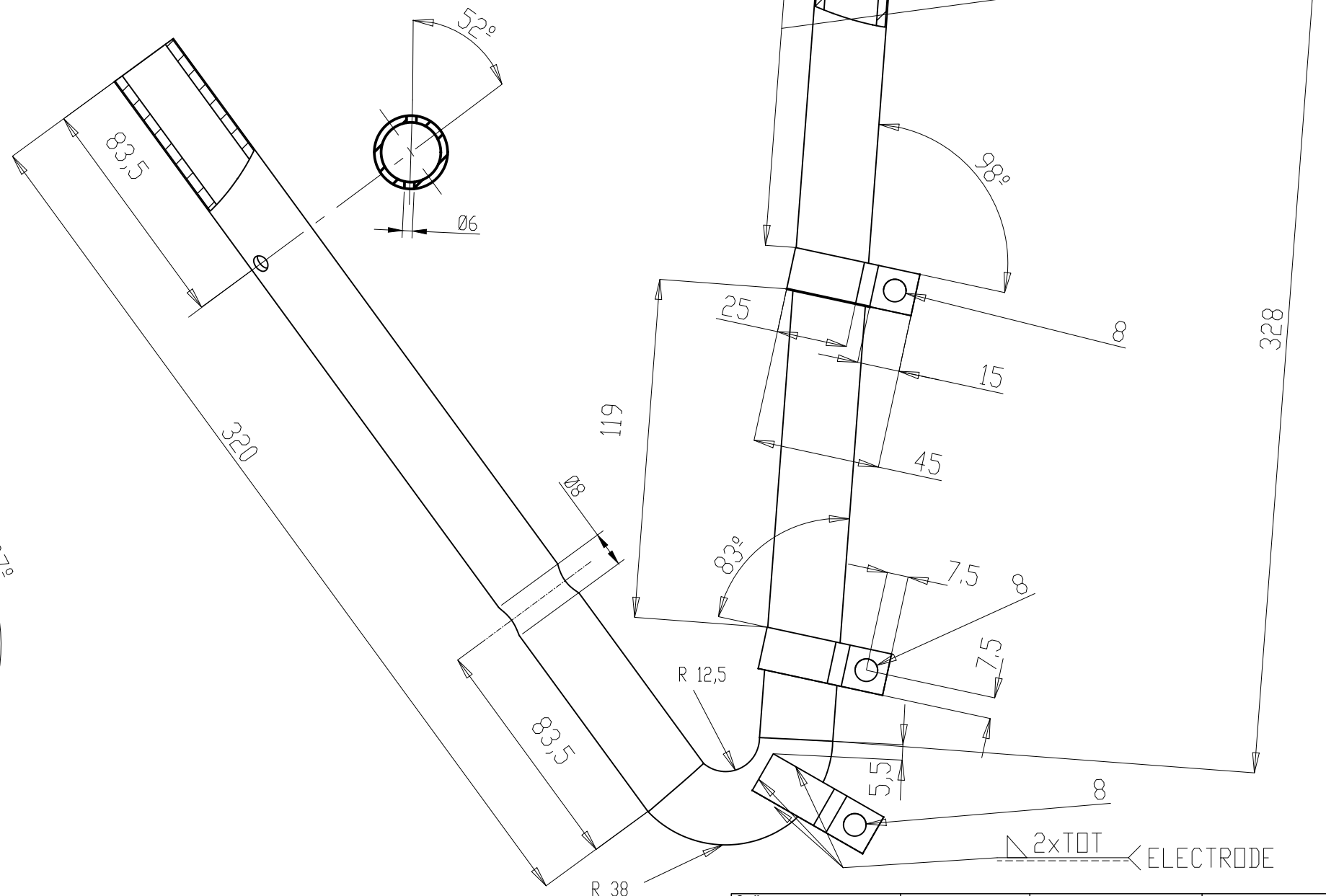
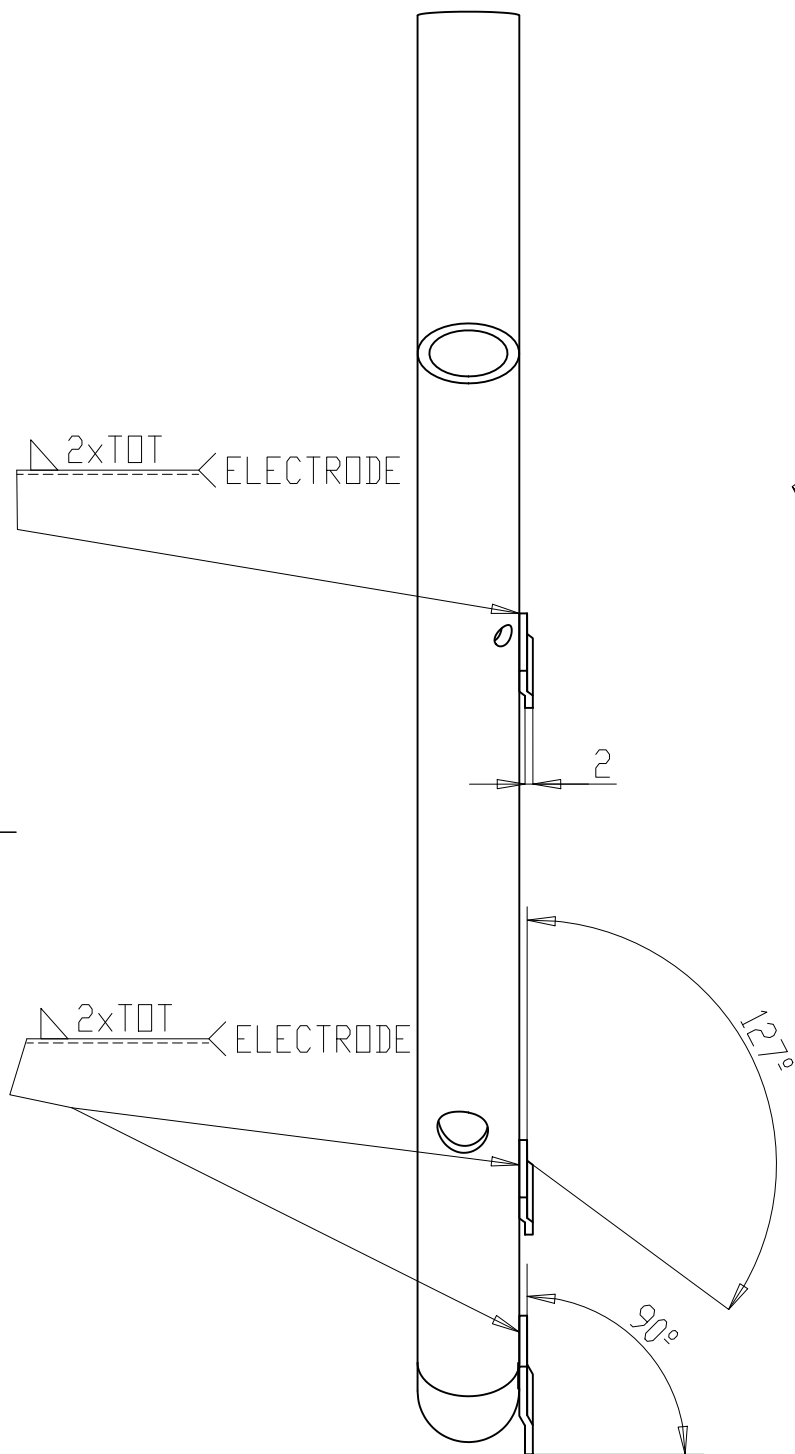


Codi peça TFG_001.1		Acabats superficials general N6		Toleràncies arestes vives De 0,5 a 3 ± 0,1			De 3 a 5 ± 0,5	Més de 6 ± 1	De 0 a 10 ± 0,1		De 10 a 50 ± 0,2		De 50 a 100 ± 0,3		De 100 a 400 ± 0,4		Toleràncies angulars (°) De 0 a 1 ± 0,5		De 1 a 90 ± 1		
Dimmensions en mm 		Passos de rosca estàndars Eliminar arestes vives		Universitat Rovira i Virgili																	
Data Juny 2022		Designació Suport dipòsit (desplagament xapa)								Material Acer F-112 (Xapa 2 mm)								Normativa UNE 1039:1994			
Format A3										Dibuixat		A.Ferré		20/04/22							
										Revisat		A.Ferré		14/05/22							
										Aprovat		A.Ferré		25/05/22							
Escala 1:1		Nom del projecte Refrigreació de l'inversor d'una motocicleta de comeptició										Núm. de plànol Nº 1		Núm. de full 1/2							



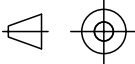


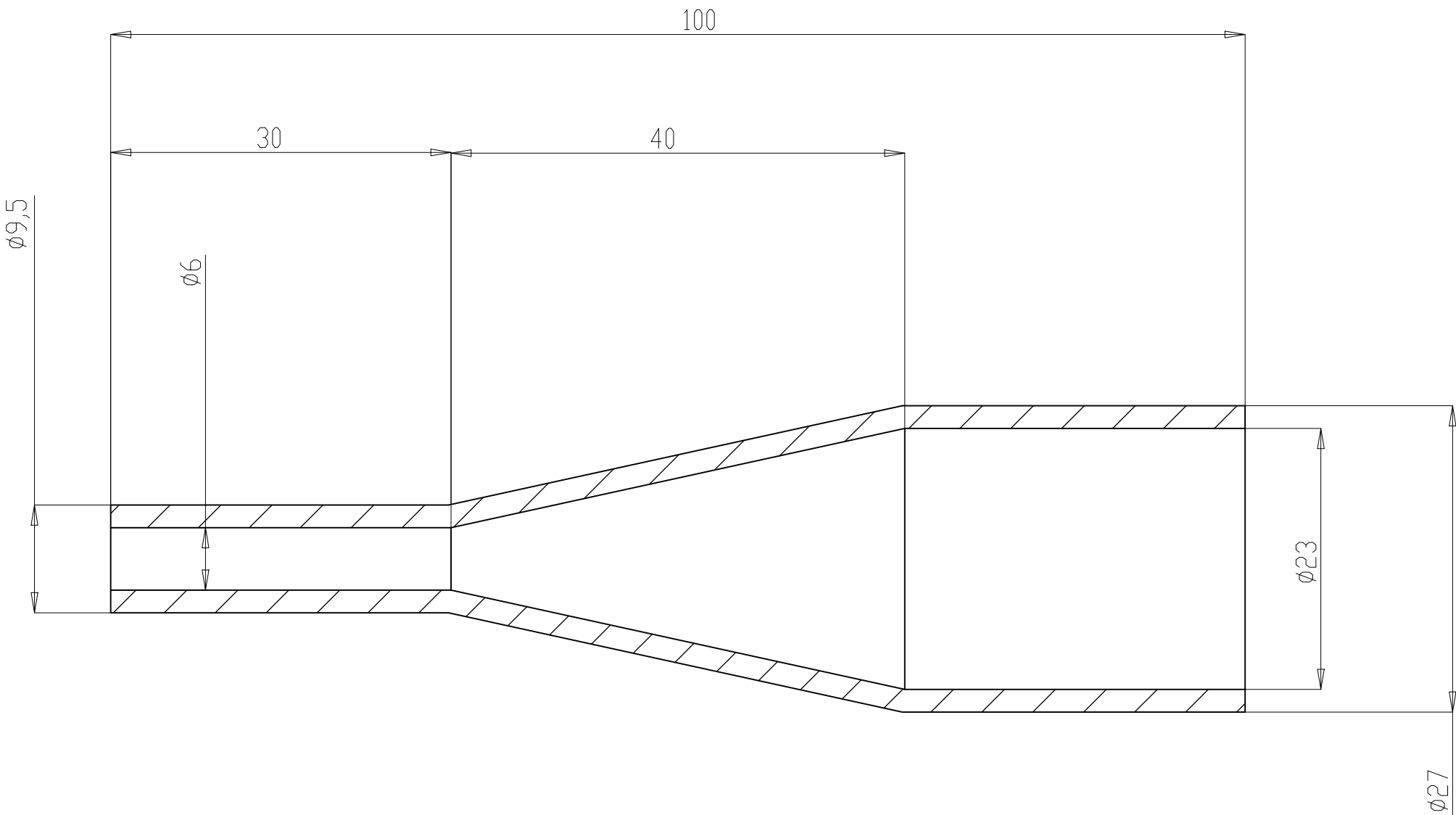
Codi peça TFG_002		Acabats superficials general N6		Toleràncies arestes vives			Toleràncies lineals (mm)				Toleràncies angulars (°)	
Dimmensions en mm		Passos de rosca estàndars		De 0,5 a 3	De 3 a 5	Més de 6	De 0 a 10	De 10 a 50	De 50 a 100	De 100 a 400	De 0 a 1	De 1 a 90
		Eliminar arestes vives		± 0,1	± 0,5	± 1	± 0,1	± 0,2	± 0,3	± 0,4	± 0,5	± 1
Data Juny 2022		Designació		Material				Normativa				
Format A3		Suport radiador dreta		Acer F-112				UNE 1039:1994				
Escala 1:2		Nom del projecte		Refrigreació de l'inversor d'una motocicleta de comeptició				Núm. de plànol		Núm. de full		
								Nº 2		1/1		



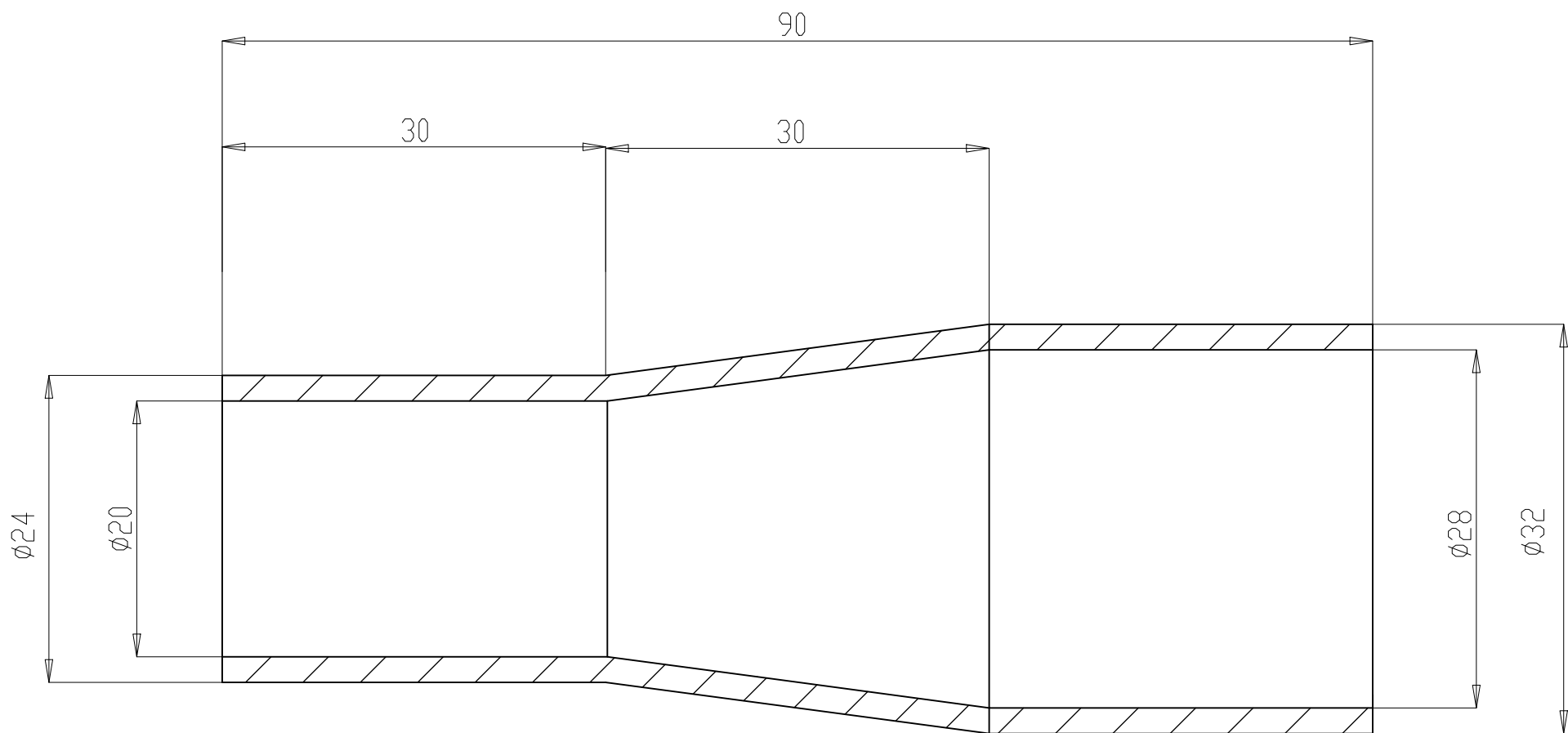
Nota: La longitud inicial del tub és de 670,1 mm

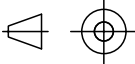
38

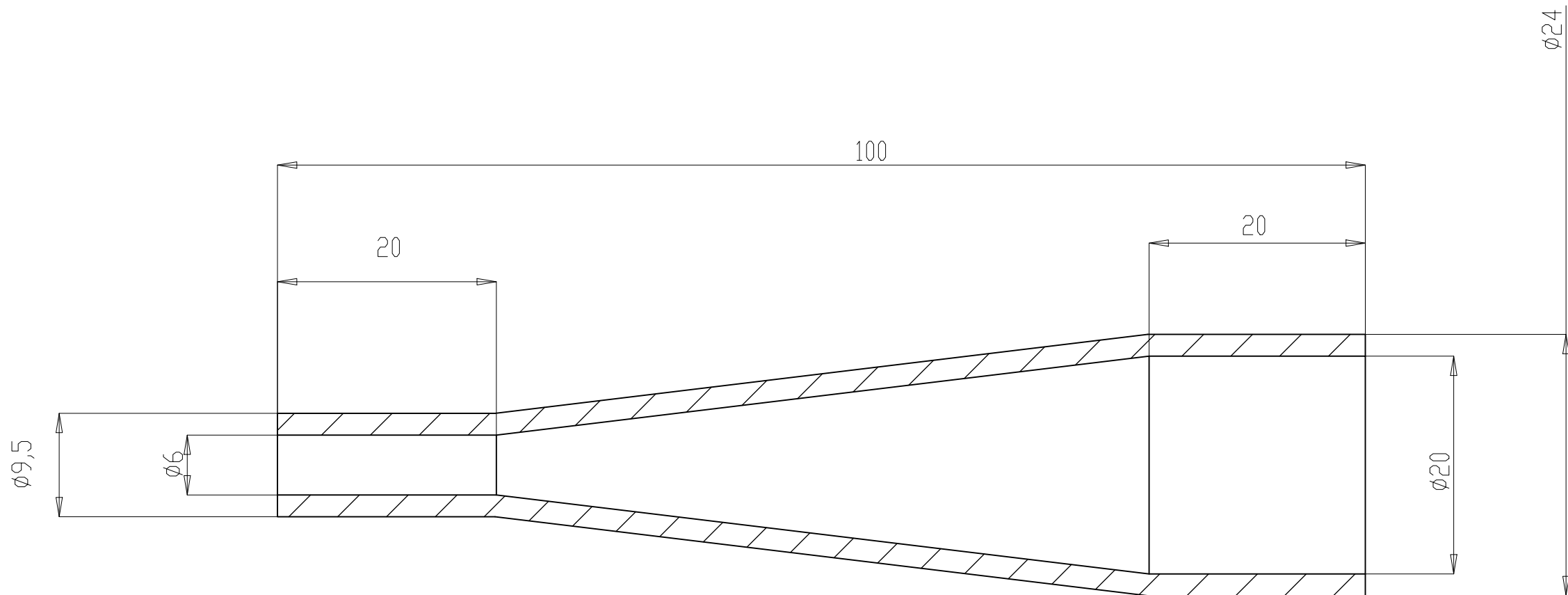
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Dimmensions en mm		Passos de rosca estàndars		De 0,5 a 3 ± 0,1	De 3 a 5 ± 0,5	Més de 6 ± 1	De 0 a 10 ± 0,1	De 10 a 50 ± 0,2	De 50 a 100 ± 0,3	De 100 a 400 ± 0,4	De 0 a 1 ± 0,5	De 1 a 90 ± 1
		Eliminar arestes vives										
Universitat Rovira i Virgili							Material Acer F-112				Normativa UNE 1039:1994	
Data Juny 2022		Designació Suport radiador esquerra				 		Dibuixat		A.Ferré	20/04/22	
Format A3								Revisat		A.Ferré	14/05/22	
								Aprovat		A.Ferré	25/05/22	
Escala 1:1		Nom del projecte Refrigreació de l'inversor d'una motocicleta de comeptició							Núm. de plànol Nº 3		Núm. de full 1/1	

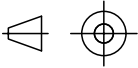


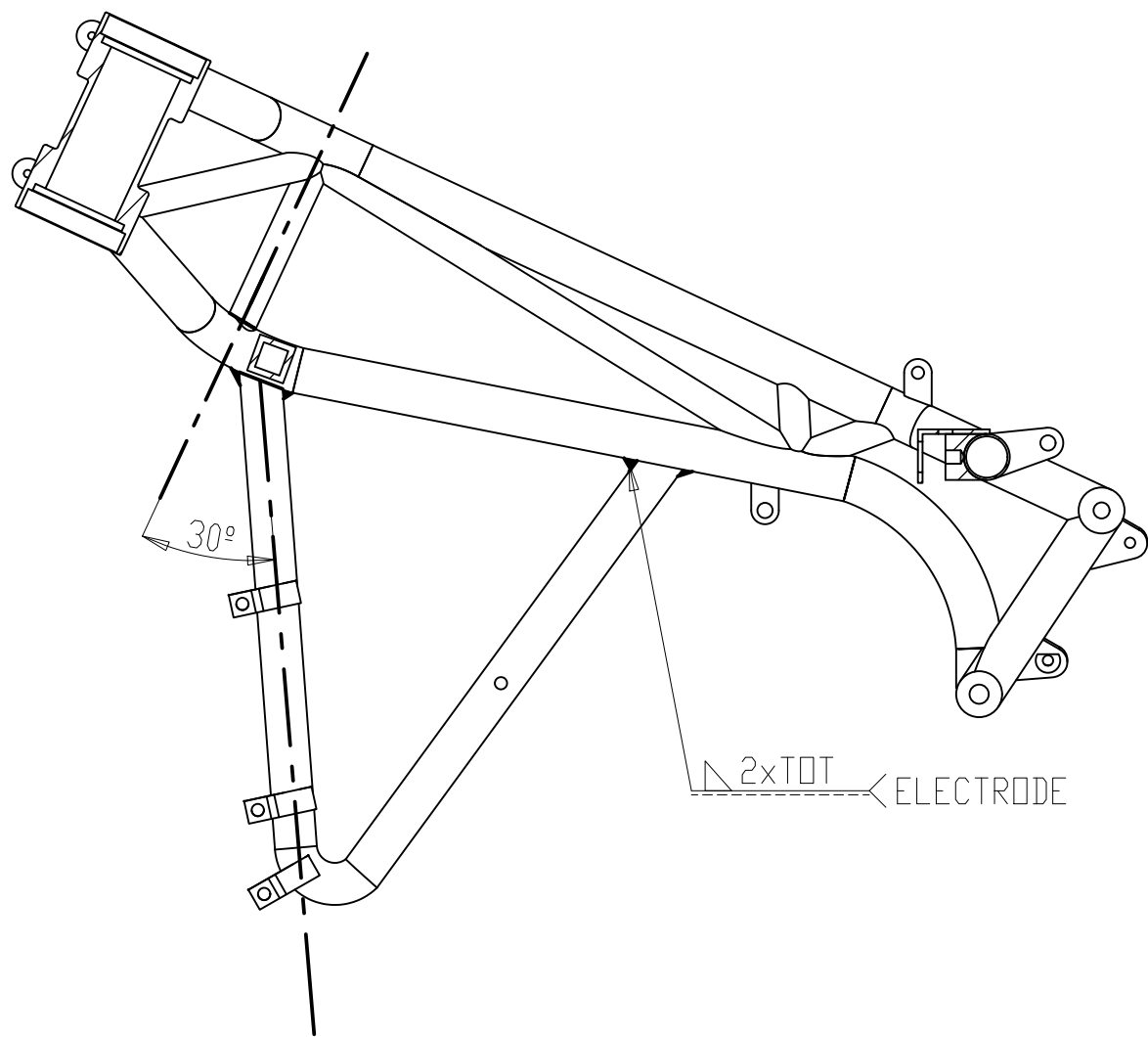
Dimmensions en mm	Codi peça	TFG_004			Acabats superficials general			Toleràncies arestes vives			Toleràncies lineals (mm)				Toleràncies angulars (°)			
	Passos de rosca estàndars				N6			De 0,5 a 3	De 3 a 5	Més de 6	De 0 a 10	De 10 a 50	De 50 a 100	De 100 a 400	De 0 a 1	De 1 a 90		
	Eliminar arestes vives							± 0,1	± 0,5	± 1	± 0,1	± 0,2	± 0,3	± 0,4	± 0,5	± 1		
	Universitat Rovira i Virgili							Material				Normativa						
						Acer inoxidable al Cr-Ni F-314				UNE 1039:1994								
Data	Juny 2022				Tovera radiador-dissipador								Dibuixat		A.Ferré		20/04/22	
Format	A3		Revisat										A.Ferré		14/05/22			
			Aprovat										A.Ferré		25/05/22			
Escala	2:1		Nom del projecte										Núm. de plànol		Núm. de full			
			Refrigreació de l'inversor d'una motocicleta de comeptició										Nº 4		1/1			



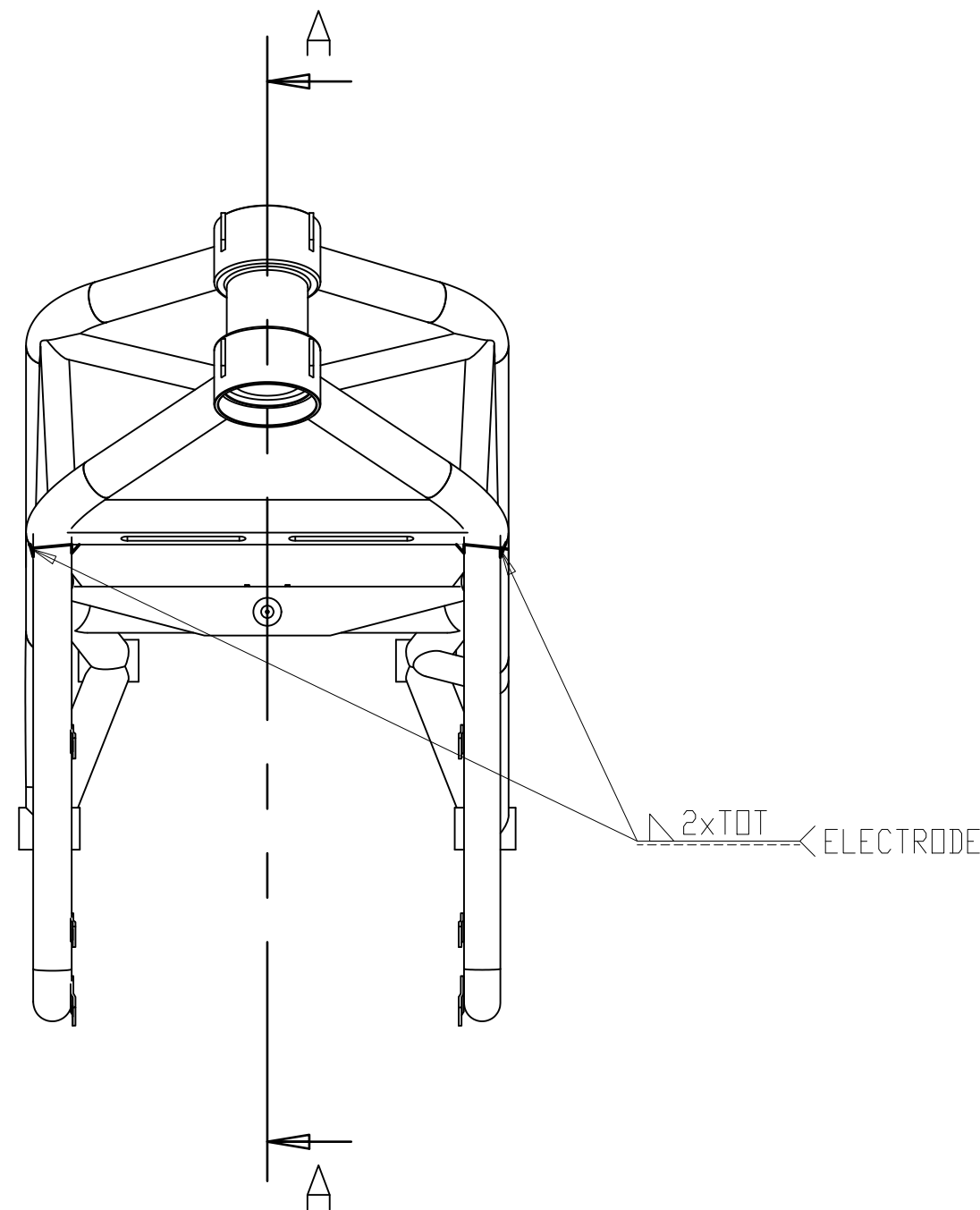
Codi peça		TFG_005		Acabats superficials general		Toleràncies arestes vives			Toleràncies lineals (mm)			Toleràncies angulars (°)			
Dimmensions en mm		Passos de rosca estàndars		N6		De 0,5 a 3	De 3 a 5	Més de 6	De 0 a 10	De 10 a 50	De 50 a 100	De 100 a 400	De 0 a 1	De 1 a 90	
		Eliminar arestes vives				± 0,1	± 0,5	± 1	± 0,1	± 0,2	± 0,3	± 0,4	± 0,5	± 1	
Universitat Rovira i Virgili									Material			Normativa			
									Acer inoxidable al Cr-Ni F-314			UNE 1039:1994			
Data		Designació								Dibuixat		A.Ferré		20/04/22	
Juny 2022		Tovera bomba-radiador								Revisat		A.Ferré		14/05/22	
Format										Aprovat		A.Ferré		25/05/22	
A3															
Escala		Nom del projecte									Núm. de plànol		Núm. de full		
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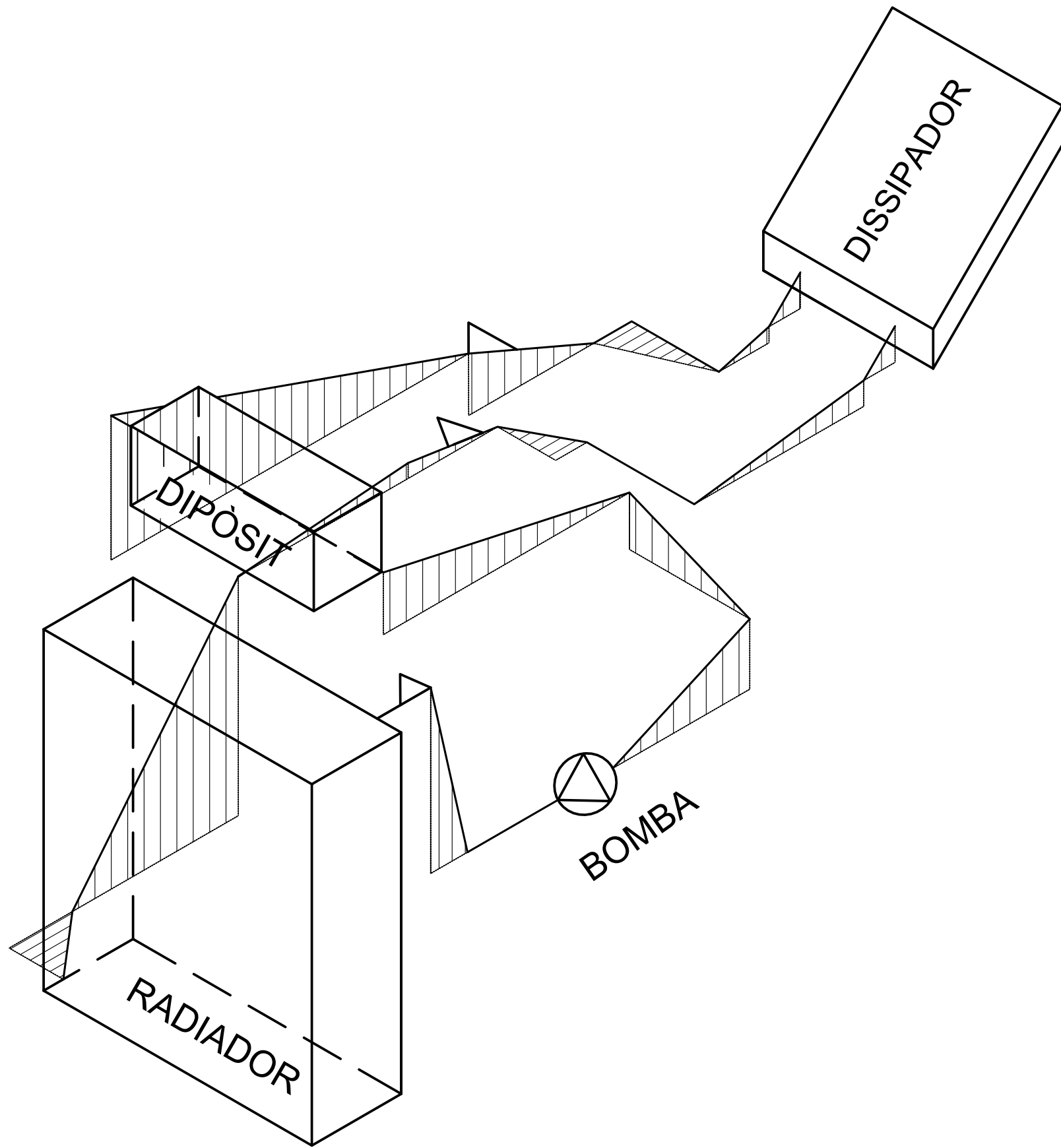
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Dimmensions en mm		Passos de rosca estàndars		N6		De 0,5 a 3	De 3 a 5	Més de 6	De 0 a 10	De 10 a 50	De 50 a 100	De 100 a 400	De 0 a 1	De 1 a 90	
		Eliminar arestes vives				± 0,1	± 0,5	± 1	± 0,1	± 0,2	± 0,3	± 0,4	± 0,5	± 1	
Universitat Rovira i Virgili									Material			Normativa			
									Acer inoxidable al Cr-Ni F-314			UNE 1039:1994			
Data		Designació								Dibuixat		A.Ferré		20/04/22	
Juny 2022		Tovera dissipador-dipòsit								Revisat		A.Ferré		14/05/22	
Format										Aprovat		A.Ferré		25/05/22	
A3															
Escala		Nom del projecte									Núm. de plànol		Núm. de full		
2:1		Refrigreació de l'inversor d'una motocicleta de comeptició									Nº 6		1/1		



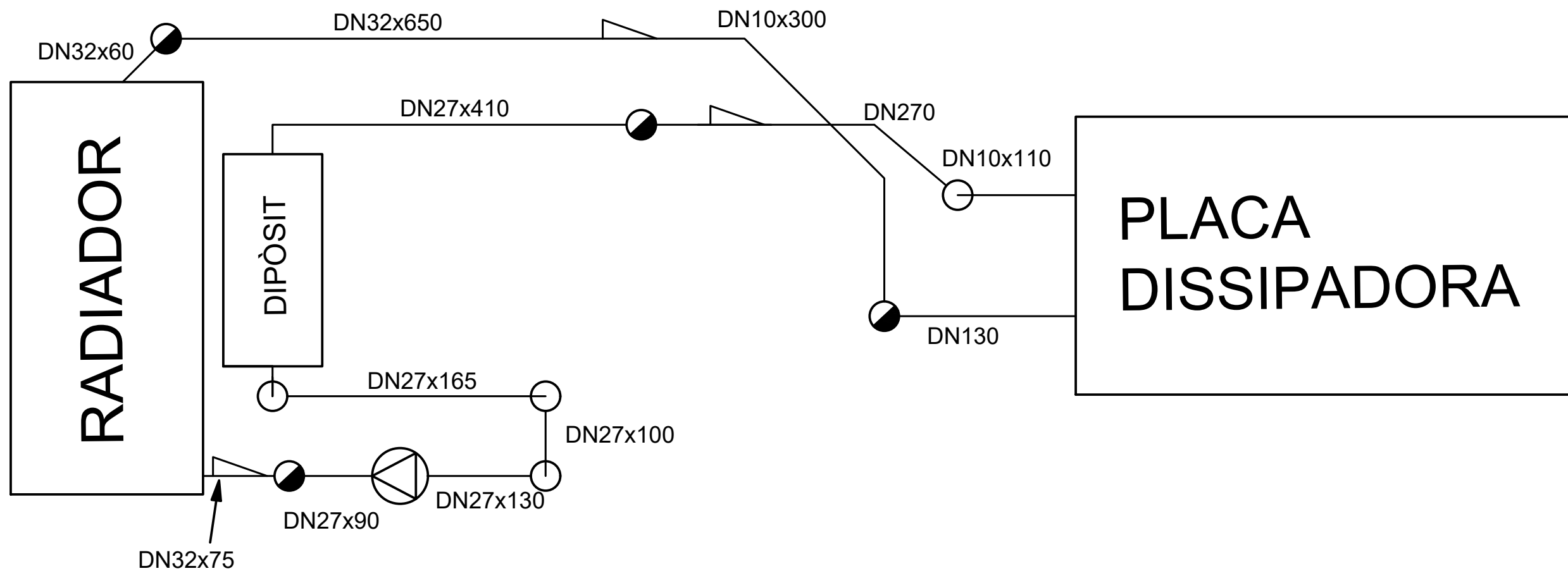
SECCIÓ A-A



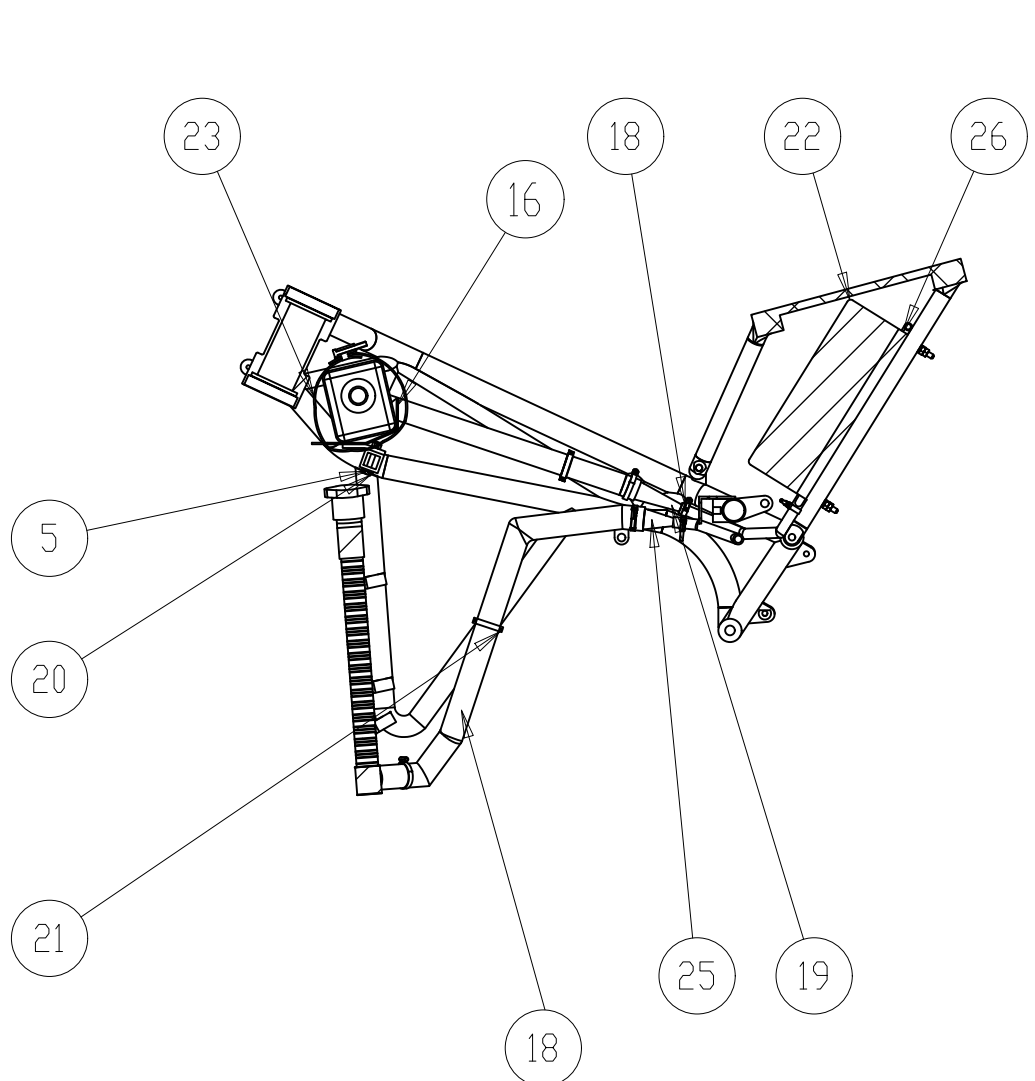
Codi peça TFG_007		Acabats superficials general N6		Toleràncies arestes vives De 0,5 a 3 De 3 a 5 Més de 6 ± 0,1 ± 0,5 ± 1			Toleràncies lineals (mm) De 0 a 10 De 10 a 50 De 50 a 100 De 100 a 400 ± 0,1 ± 0,2 ± 0,3 ± 0,4				Toleràncies angulars (°) De 0 a 1 De 1 a 90 ± 0,5 ± 1		
Dimmensions en mm 		Passos de rosca estàndars Eliminar arestes vives		Universitat Rovira i Virgili Material Acer inoxidable al Cr-Ni F-314 Normativa UNE 1039:1994									
Data Juny 2022		Designació Soldadures suports al xassís					Dibuixat		A.Ferré		20/04/22		
Format A3							Revisat		A.Ferré		14/05/22		
							Aprovat		A.Ferré		25/05/22		
Escala 1:5		Nom del projecte Refrigreació de l'inversor d'una motocicleta de comeptició						Núm. de plànol Nº 7		Núm. de full 1/1			



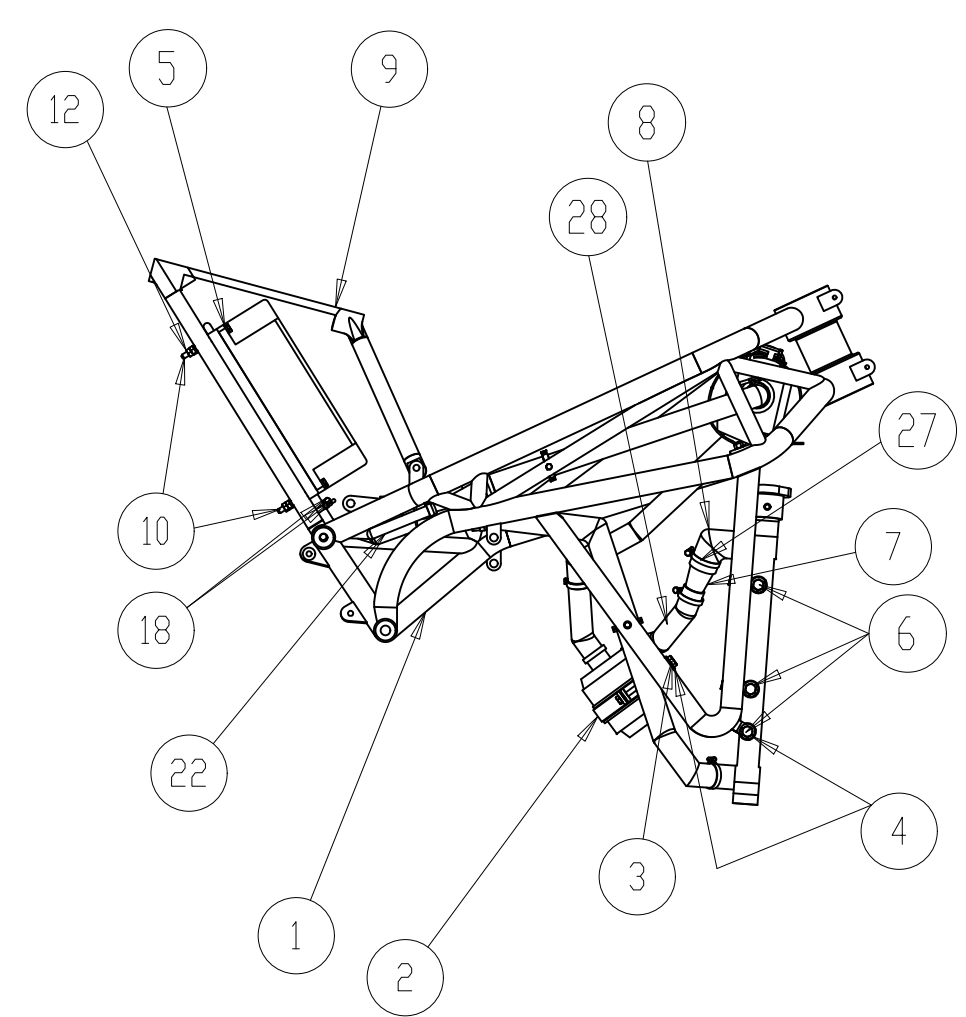
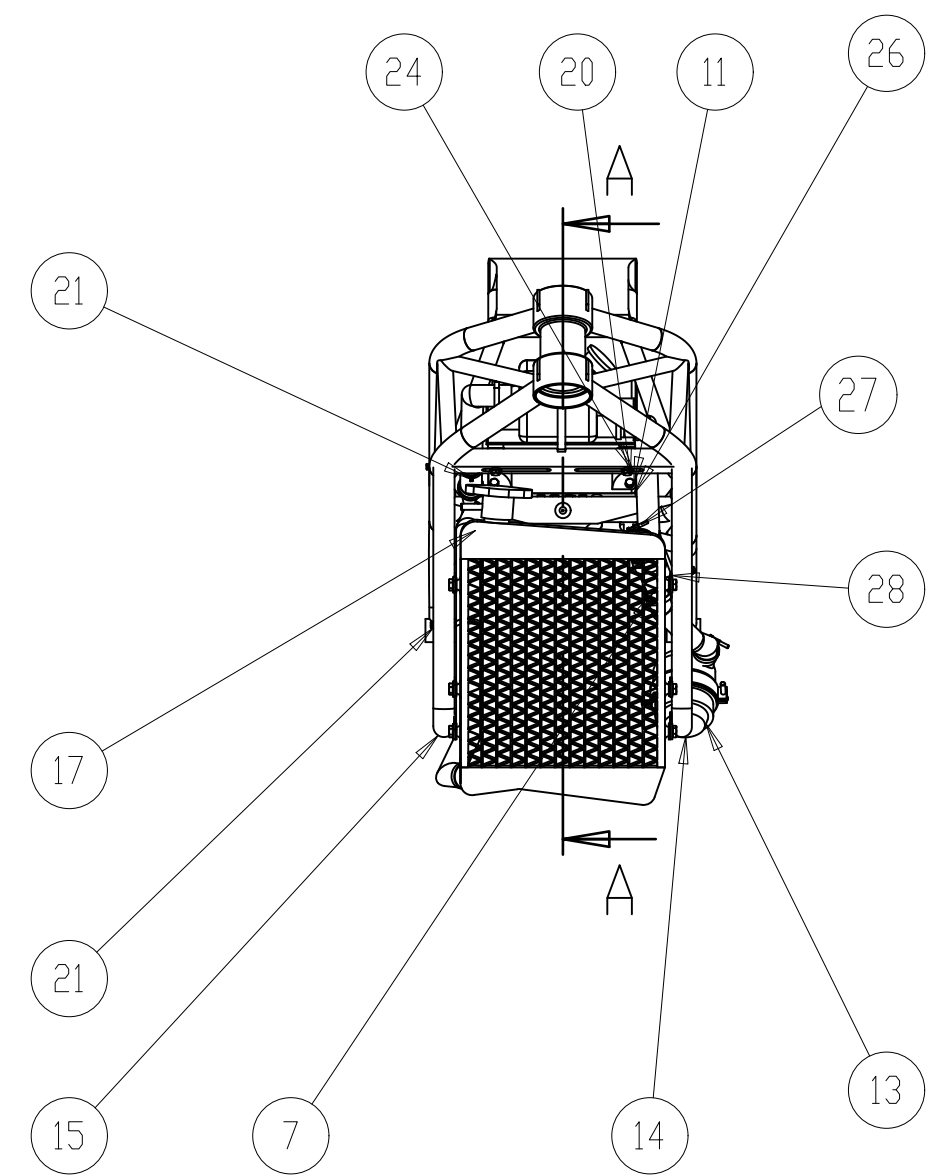
Dimmensions en mm		Universitat Rovira i Virgili			Material		Normativa				
					Acer inoxidable al Cr-Ni F-314		UNE 1039:1994				
Data		Designació		 		Dibuixat		A.Ferré		20/04/22	
Juny 2022						Revisat		A.Ferré		14/05/22	
Format						Aprovat		A.Ferré		25/05/22	
A3											
Escala		Nom del projecte					Núm. de plànol		Núm. de full		
N/A		Refrigreació de l'inversor d'una motocicleta de comeptició					Nº 8		1/1		



						Codi peça		TFG_009		
Dimmensions en mm		Universitat Rovira i Virgili			Material			Normativa		
					Acer inoxidable al Cr-Ni F-314			UNE 1039:1994		
Data		Designació							Dibuixat	
Juny 2022		Esquema 2D sistema hidràulic							A.Ferré	
									20/04/22	
Format									Revisat	
A3									A.Ferré	
									14/05/22	
									Aprovat	
									A.Ferré	
									25/05/22	
Escala		Nom del projecte					Núm. de plànol		Núm. de full	
N/A		Refrigreació de l'inversor d'una motocicleta de comeptició					Nº 9		1/1	



SECCIÓ A-A
ESCALA 1 : 10



27	Abraçadora DN31	2
26	Placa dissipadora líquida inverter Sevcon 6	1
25	Tovera radiador-dissipador	1
24	Tub sortida bomba	1
23	Abraçadora DN 105-110	1
22	Inversor Sevcon Gen 6	1
21	Abraçadora DN28	4
20	Cargol M6x30 DIN 933	2
19	Tovera dissipador-dipòsit	1
18	Tub sortida radiador	1
17	Radiador AUSTIN Mini 1.0 68	1
16	Suport dipòsit refrigerant	1
15	Barra suport esquerra	1
14	Barra suport dreta	1
13	Bomba BOSCH 0 392 024 041	1
12	Femella M6 DIN 934	1
11	Abraçadores DN10	4
10	Cargol M6x70 DIN 933	4
9	Conjunt sub-xassís	1
8	Tub entrada radiador	1
7	Tovera bomba-radiador	1
6	Cargol M8x25 DIN 933	1
5	Volandera plana M6 DIN 125	1
4	Volandera plana M8 DIN 125	7
3	Cargol M8x20 DIN 933	6
2	Abraçadora WÜRTH DN 79-85	1
1	Xassís	1
N.º ELEMENT	N.º DE PEÇA	QUANTITAT

Codi peça

TFG_010

Data

Juny 2022

Format

A2

Escala

1:10

Designació

Conjunt sistema de refrigeració

Nom del projecte

Refrigeració de l'inversor d'una motocicleta de competició

Núm. de plànol

Nº 10

Núm. de full

1/1

Dibuixat

A.Ferré

20/04/22

Revisat

A.Ferré

14/05/22

Aprobat

A.Ferré

25/05/22

Normativa aplicada
UNE 1039:1994

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM IV Document 5: Plec de Condicions

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



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Índex Plec de Condicions

DOCUMENT 5: PLEC DE CONDICIONS

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DOCUMENT 5: PLEC DE CONDICIONS

1.- Introducció i objecte

Amb la formulació del següent plec de condicions s'establiran les bases tècniques, facultatives, econòmiques i legals per a realitzar el projecte de càlcul i disseny del sistema del sistema de refrigeració d'un inversor d'una motocicleta de competició

L'objectiu del projecte és materialitzar tots els requeriments tècnics per a poder desenvolupar correctament els requeriments del promotor per solucionar les necessitats que aquest disposa, deixant clars per part del projectista els passos a seguir per al correcte desenvolupament i execució del projecte sol·licitat.



2.- Documents del projecte

A partir de la norma UNE 157001:2014, es regeixen els criteris generals per a elaboració de projectes. Aquesta sentència amb els següents apartats amb els que es basa el projecte:

- Índex general
- Memòria
- Annexes
- Plànols
- Plec de condicions
- Amidaments
- Pressupost

Dels mencionats en l'anterior llistat, cal diferenciar entre dos grups de documents:

Documents contractuals: Són tots aquells que estan incorporats al contracte i que siguin d'obligat compliment, excepte modificacions devidament autoritzades. Estan formats pels següents:

- Plànols
- Plec de condicions
- Pressupost

Documents de caràcter informatiu: Són els documents que només posseeixen caràcter purament informatius. Han de ser complement de la informació que el contractista ha d'adquirir directament i amb els seus propis medis. El conformen la resta de documents bàsics mencionats anteriorment.

3.- Condicions i normes de caràcter generalitzades

En aquest apartat es dictaran les condicions tècniques aplicades en el transcurs del projecte, que són normes d'obligat compliment cenyint-se a la normativa utilitzada. La responsabilitat del correcte compliment de la normativa recaurà i serà assumida pel projectista.

3.1.- Legislació vigent

La legislació vigent per a la realització d'aquest projecte ha estat tota la normativa redactada i expressada en el reglament de la competició MotoStudent. Si bé totes les especificacions tècniques generals i particulars queden ben redactades en dit document, de manera que no es fa èmfasi en altres supòsits fora d'aquest reglament.

3.2.- Condicions facultatives

Entenen coma condicionants facultatius tots aquells que regules les relacions entre la direcció d'obra i el contractista executor d'aquesta. Les possibles modificacions que es puguin fer durant l'execució del projecte seran prèviament consultades al director de l'obra o si no queda expressat amb prou exactitud, al projectista.

3.3.- Condicions econòmiques

Per a la execució del projecte s'estableix un import al document bàsic "Pressupost", a pagar per part del promotor al contractista, sent clarament exposat l'import total en l'apartat "Resum del pressupost".

Un altre qüestió a tenir en compte són les garanties i fiances que s'estableixen durant el període d'execució.

- Garantia: s'estableix una garantia sobre la estanqueïtat de les canonades emprades al projecte de 2 anys o 1.000 quilòmetres, sempre i quant l'ús de l'equip sigui correcte. Els possibles danys causats durant l'ús de l'equip es tenen contemplats en aquest apartat, sempre i quan es compleixin els requeriments mencionats anteriorment.

3.4.- Condicions legals

Pel que fa als accidents laborals i danys produïts a tercers durant la fase d'execució del projecte, corre a càrrec del contractista la bona pràctica de la de seguretat durant l'execució del projecte.

D'altra banda, les condicions que imposa el promotor per poder realitzar contractar són les següents:

- Durant l'execució del projecte, s'acorden jornades de treball de fins a 12 hores seguides en cas que el projecte no hagi arribat al 75% de la planificació 5 dies abans de la seva execució.

El dret per a rescissió del contracte es reservar per a les dues parts si no es compleixen les següents condicions:

- Per part del promotor, es reserva el dret de trencar el contracte amb el contractista si s'excedeix un 20% dels plaços d'entrega del projecte sense una causa major justificada. En cas que l'execució no tingui similituds o desviacions respecte el projectat i no es comentin ni mencionin, també és un motiu per poder rescindir el contracte per part del promotor.
- Per part del contractista, es reserva el dret de rescissió de contracte si el pagament del 50% de l'import total del projecte no és pagat 1 setmana abans de l'inici de l'execució del mateix. D'altra banda, si una setmana posterior a l'entrega del projecte, el promotor no realitza el pagament del 50% restant, també es considera una causa per poder trencar el contracte.

En cas que succeeixin successos de força major fora dels mencionats, també seran estudiats i poden ser causants de ruptures unilaterals de contracte.

4.- Preus i revisions

Tots els preus, revisions i imports a pagar per part del promotor del projectes es troben reflectits al document bàsic "Pressupost", exposant de forma clara els valors d'aquests.

La actualització dels preus es data al segon trimestre del 2022, tenint en compte els valors d'inflació actuals. Si el projecte es realitza fora d'aquest termini, els preus han de ser revisats i actualitzats a la data d'iniciació de l'execució del projecte. Si aquests no són actualitzats, el promotor no es fa càrrec de l'augment o disminució del preu total a data d'inici de l'execució del projecte.

5.- Indemnitzacions

Un cop designada l'execució i assignada a un contractista per a realitzar dirà execució, el promotor s'ha de fer càrrec del pagament de la meitat de l'import total de l'execució de l'obra, reflectit a l'apartat de resum de pressupost a la memòria. Si aquest fet no es realitza en els següents 15 dies posteriors a l'assignació, el contractista té el dret a recórrer la falta d'ingressos per via judicial i està exposat a cobrar una indemnització del 10% de l'import total per cada setmana de més que no es realitzi dit pagament.

D'altra banda, el contractista té de termini màxim fins a l'últim dia per a realitzar l'execució de l'obra segons la planificació marcada en l'apartat de planificació temporal, a menys que hi hagi una anomalia o qualsevol altre motiu de força major. En cas que es retardi la finalització de l'obra, les indemnitzacions seran adjudicades segons la falta de guanys o pèrdues produïdes al promotor, dictaminat per un jutge.

Per al pagament del total de l'import de l'execució del projecte, es permet fins a una setmana posterior al a la finalització de l'execució de l'obra per a realitzar el pagament per part del promotor. Si aquest no es realitza, la penalització a pagar per part del promotor al contractista serà del 20% de l'import total per cada setmana que es passi del termini acordat.

6.- Varis

6.1.- Ús de béns i serveis del promotor per part del contractista

Per a l'execució del projecte, el promotor posa a disposició els serveis per al contractista, sempre i quant se'n realitzi un bon ús i es retornin els serveis i béns prestats en condicions òptimes de tornar a utilitzar, a menys que esdevingui una causa de força major.

El promotor posa a disposició el servei del taller mecànic amb tots els seus serveis disponibles, com pàrquing que disposa el mateix taller per a l'estacionament dels vehicles, serveis de lavabos i farmaciola mèdica per a emergències. Al posar a disposició el taller, el promotor també posa a disposició el carro de les eines de mà que es disposen, amb les condicions anteriorment mencionades.

Els béns que el promotor posa a disposició del contractista són consumibles que es puguin trobar al taller, com lubricants, cintes adhesives...

7.- Activitats excloses del projecte

Les activitats citades a continuació no han estat avaluades ni s'han tingut en compte a l'hora de la realització del projecte ja que en surten del seu abast. D'aquesta manera, el projectista no es fa càrrec dels possibles problemes, danys i perjudicis que puguin aparèixer a l'executar aquestes activitats auxiliars no contemplades en dit projecte.

7.1.- Càlculs elèctrics

El càlcul, disseny i dimensionat del cablejat elèctric no corre a càrrec d'aquest projecte. Només es tenen en compte els valors de voltatge per a la selecció de la bomba, sense fer referència a cap normativa de xarxes de baixa tensió.

7.2.- Manteniment de l'equip

Les tasques de manteniment preventiu com de correctiu no entren en l'abast d'aquest projecte, de manera que qualsevol falla d'aquest tipus queda exclosa de resposta per part del projectista.

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM IV

Document 6: Amidaments

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



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Índex Amidaments

DOCUMENT 6: AMIDAMENTS

1.- Amidaments.....	1



AMIDAMENTS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UTS	LONGITUT	AMPLADA	ALÇADA	QUANTITAT
01	Capítol 1: Fabricació					
F-001	Ud Fabricació suport radiador dreta Fabricació del suport col·locat a la dreta que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís					
	Barra acer suport radiador dreta	1				1,00
						1,00
F-002	Ud Fabricació suport radiador esquerra Fabricació del suport col·locat a l'esquerra que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís					
	Barra acer suport radiador esquerra	1				1,00
						1,00
F-003	Ud Fabricació suport dipòsit Fabricació del suport del dipòsit amb xapa 2mm de gruix, tallat amb oxitall i soldat amb soldadura d'electrode revestit					
	Xapa acer 2mm F112 (200x200)	1				1,00
						1,00
F-004	Ud Fabricació tovera radiador-dissipador Fabricació de la tovera radiador-dissipador mitjançant un mecanitzat amb torn					
	Barra acer inoxidable al Cr-Ni F314 Ø35x200	1				1,00
						1,00
F-005	Ud Fabricació tovera bomba-radiador Fabricació de la tovera bomba-radiador mitjançant un mecanitzat amb torn					
	Barra acer inoxidable al Cr-Ni F314 Ø30x150	1				1,00
						1,00
F-006	Ud Fabricació tovera dissipador-dipòsit Fabricació de la tovera dissipador-dipòsit mitjançant un mecanitzat amb torn					
	Barra acer inoxidable al Cr-Ni F314 Ø30x150	1				1,00
						1,00

AMIDAMENTS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UTS	LONGITUT	AMPLADA	ALÇADA	QUANTITAT

02 Capítol 2: Muntatge mecànic

M-001 Ud Subjecció suports del radiador al xassís

Subjecció del suport del radiador al xassís mitjançant soldadura amb electrode revestit.

Unió barres dreta	1	1,00
Unió barra esquerra	1	1,00
		2,00

M-002 Ud Foradat xassís

Foradat de xassís mitjançant trepant portàtil.

Forats DN6 xassís	1	1,00
		1,00

M-003 Ud Muntatge suport dipòsit

Acollament suport del dipòsit, atornillat als colissos del xassís.

Muntatge suport dipòsit	1	1,00
		1,00

AMIDAMENTS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UTS	LONGITUT	AMPLADA	ALÇADA	QUANTITAT
03	Capítol 3: Sistema hidràulic					
SH-001	Ud Instal·lació bomba refrigerant Col·locació bomba refrigerant al xassís de la motocicleta, amb abraçadera i cargols.					
	Instal·lació conjunt bomba refrigeració	1				1,00
						1,00
SH-002	Ud Instal·lació dipòsit compensació Instal·lació del dipòsit al suport, acollat amb abraçadora metàl·lica.					
	Dipòsit DT Spare Parts 2.30046	1				1,00
						1,00
SH-003	Ud Instal·lació placa dissipadora Instal·lació de placa dissipadora sota de l'inversor, al colí de la motocicleta, atornillat amb cargols i doble femella de seguretat.					
	Placa dissipadora	1				1,00
						1,00
SH-004	Ud Instal·lació radiador Instal·lació del radiador al xassís, motjançant els suports prèviament muntats, amb subjectió amb cargols M8.					
	Radiador	1				1,00
						1,00
SH-005	Ud Instal·lació tubs DN10 Instal·lació de tubs de cautxú amb reforç tèxtil, acollats amb abraçadores pels seus extrems					
	Tub tovera radiador-dissipador	1				1,00
	Tub dissipador-tovera dipòsit	1				1,00
						2,00
SH-006	Ud Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs					
	Tub dissipador-tovera dissipador dipòsit	1				1,00
	Tub dipòsit-bomba	1				1,00
						2,00
SH-007	Ud Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems.					
	Tub bomba- tovera bomba radiador	1				1,00
						1,00
SH-008	Ud Instal·lació tubs DN37 Instal·lació de tubs de cautxú DI32 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs					
	Tub tovera bomba radiador-radiador	1				1,00
						1,00
SH-009	Ud Instal·lació tubs DN32 Instal·lació de tubs de cautxú DI27 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs.					
	Tub radiador-tovera radiador dissipador	1				1,00
						1,00

AMIDAMENTS

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	UTS	LONGITUT	AMPLADA	ALÇADA	QUANTITAT
SH-010	Ud Instal·lació de toveres Instal·lació de toveres a les reduccions i augments de diàmetre dels tubs.					
	Tovera radiador-dissipador	1				1,00
	Tovera bomba-radiador	1				1,00
	Tovera dissipador-dipòsit	1				1,00
						3,00
SH-011	Ud Instal·lació fluid refrigerant Instal·lació de fluid refrigerant (aigua destil·lada) per a omplir la totalitat del sistema hidràulic					
	Líquid refrigerant	1				1,00
						1,00
SH-012	Ud Verificació fugues i funcionament circuit Verificació del correcte funcionament del sistema i verificació de fugues.					
	Verificació fugues i funcionament circuit	1				1,00
						1,00

Treball de Fi de Grau

Enginyeria Mecànica



Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

VOLUM IV

Document 7: Pressupost

Autor: Arnau Ferré Queralt
Director: Héctor González Montarelo
Data: Juny 2022



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Índex Pressupost

DOCUMENT 7: PRESSUPOST

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4.- Resum de pressupost.....	12

QUADRE DE PREUS 1

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
01		Capítol 1: Fabricació	
F-01	Ud	Fabricació suport radiador dreta Fabricació del suport col·locat a la dreta que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	100,38
			CENT EUROS amb TRENTA-VUIT CÈNTIMS
F-02	Ud	Fabricació suport radiador esquerra Fabricació del suport col·locat a l'esquerra que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	100,38
			CENT EUROS amb TRENTA-VUIT CÈNTIMS
F-03	Ud	Fabricació suport dipòsit Fabricació del suport del dipòsit amb xapa 2mm de gruix, tallat amb oxitall i soldat amb soldadura d'electrode revestit	58,84
			CINQUANTA-VUIT EUROS amb VUITANTA-QUATRE CÈNTIMS
F-04	Ud	Fabricació tovera radiador-dissipador Fabricació de la tovera radiador-dissipador mitjançant un mecanitzat amb torn	47,06
			QUARANTA-SET EUROS amb SIS CÈNTIMS
F-05	Ud	Fabricació tovera bomba-radiador Fabricació de la tovera bomba-radiador mitjançant un mecanitzat amb torn	46,18
			QUARANTA-SIS EUROS amb DIVUIT CÈNTIMS
F-06	Ud	Fabricació tovera dissipador-dipòsit Fabricació de la tovera dissipador-dipòsit mitjançant un mecanitzat amb torn	46,18
			QUARANTA-SIS EUROS amb DIVUIT CÈNTIMS

QUADRE DE PREUS 1

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
02		Capítol 2: Muntatge mecànic	
M-01	Ud	Subjecció suports del radiador al xassís Subjecció del suport del radiador al xassís mitjançant soldadura amb electrode revestit.	22,50
M-02	Ud	Foradat xassís Foradat de xassís mitjançant trepant portàtil.	VINT-I-DOS EUROS amb CINQUANTA CÈNTIMS 19,25
M-03	Ud	Muntatge suport dipòsit Acollament suport del dipòsit, atornillat als colissos del xassís.	DINOU EUROS amb VINT-I-CINC CÈNTIMS 20,06
			VINT EUROS amb SIS CÈNTIMS

QUADRE DE PREUS 1

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
03		Capítol 3: Sistema hidràulic	
SH-001	Ud	Instal·lació bomba refrigerant Col·locació bomba refrigerant al xassís de la motocicleta, amb abraçadora i cargols.	287,59
SH-002	Ud	Instal·lació dipòsit compensació Instal·lació del dipòsit al suport, acollat amb abraçadora metàl·lica.	36,97
SH-003	Ud	Instal·lació placa dissipadora Instal·lació de placa dissipadora sota de l'inversor, al colí de la motocicleta, atornillat amb cargols i doble femella de seguretat.	173,06
SH-004	Ud	Instal·lació radiador Instal·lació del radiador al xassís, motjançant els suports prèviament muntats, amb subjecció amb cargols M8.	273,67
SH-005	Ud	Instal·lació tubs DN10 Instal·lació de tubs de cautxú amb reforç tèxtil, acollats amb abraçadores pels seus extrems	11,64
SH-006	Ud	Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs	22,48
SH-007	Ud	Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems.	18,93
SH-008	Ud	Instal·lació tubs DN37 Instal·lació de tubs de cautxú DI32 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs	20,01
SH-009	Ud	Instal·lació tubs DN32 Instal·lació de tubs de cautxú DI27 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs.	19,71
SH-010	Ud	Instal·lació de toveres Instal·lació de toveres a les reduccions i augments de diàmetre dels tubs.	2,91

QUADRE DE PREUS 1

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
			DOS EUROS amb NORANTA-UN CÈNTIMS
SH-011	Ud	Instal·lació fluid refrigerant Instal·lació de fluid refrigerant (aigua destil·lada) per a omplir la totalitat del sistema hidràulic	12,90
			DOTZE EUROS amb NORANTA CÈNTIMS
SH-012	Ud	Verificació fugues i funcionament circuit Verificació del correcte funcionament del sistema i verificació de fugues.	17,50
			DISSET EUROS amb CINQUANTA CÈNTIMS

QUADRE DE PREUS 2

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
01		Capítol 1: Fabricació	
F-01	Ud	Fabricació suport radiador dreta Fabricació del suport col·locat a la dreta que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	
		Mà d'obra.....	50,00
		Maquinària.....	25,25
		Materials.....	25,13
		TOTAL PARTIDA	100,38
F-02	Ud	Fabricació suport radiador esquerra Fabricació del suport col·locat a l'esquerra que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	
		Mà d'obra.....	50,00
		Maquinària.....	25,25
		Materials.....	25,13
		TOTAL PARTIDA	100,38
F-03	Ud	Fabricació suport dipòsit Fabricació del suport del dipòsit amb xapa 2mm de gruix, tallat amb oxitall i soldat amb soldadura d'electrode revestit	
		Mà d'obra.....	31,25
		Maquinària.....	15,25
		Materials.....	12,34
		TOTAL PARTIDA	58,84
F-04	Ud	Fabricació tovera radiador-dissipador Fabricació de la tovera radiador-dissipador mitjançant un mecanitzat amb torn	
		Mà d'obra.....	21,00
		Maquinària.....	9,25
		Materials.....	16,81
		TOTAL PARTIDA	47,06
F-05	Ud	Fabricació tovera bomba-radiador Fabricació de la tovera bomba-radiador mitjançant un mecanitzat amb torn	
		Mà d'obra.....	21,00
		Maquinària.....	9,25
		Materials.....	15,93
		TOTAL PARTIDA	46,18
F-06	Ud	Fabricació tovera dissipador-dipòsit Fabricació de la tovera dissipador-dipòsit mitjançant un mecanitzat amb torn	
		Mà d'obra.....	21,00
		Maquinària.....	9,25
		Materials.....	15,93
		TOTAL PARTIDA	46,18

QUADRE DE PREUS 2

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
02		Capítol 2: Muntatge mecànic	
M-01	Ud	Subjecció suports del radiador al xassís Subjecció del suport del radiador al xassís mitjançant soldadura amb electrode revestit.	
		Mà d'obra.....	15,00
		Maquinària.....	7,50
		TOTAL PARTIDA	22,50
M-02	Ud	Foradat xassís Foradat de xassís mitjançant trepant portàtil.	
		Mà d'obra.....	15,00
		Maquinària.....	4,25
		TOTAL PARTIDA	19,25
M-03	Ud	Muntatge suport dipòsit Acollament suport del dipòsit, atornillat als colissos del xassís.	
		Mà d'obra.....	15,00
		Maquinària.....	3,50
		Materials.....	1,56
		TOTAL PARTIDA	20,06

QUADRE DE PREUS 2

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM		PREU
03		Capítol 3: Sistema hidràulic		
SH-001	Ud	Instal·lació bomba refrigerant Col·locació bomba refrigreant al xassís de la motocicleta, amb abraçadora i cargols.		
			Mà d'obra.....	8,75
			Maquinària.....	2,00
			Materials.....	276,84
			TOTAL PARTIDA	287,59
SH-002	Ud	Instal·lació dipòsit compensació Instal·lació del dipòsit al suport, acollat amb abraçadora metàl·lica.		
			Mà d'obra.....	17,50
			Maquinària.....	3,75
			Materials.....	15,72
			TOTAL PARTIDA	36,97
SH-003	Ud	Instal·lació placa dissipadora Instal·lació de placa dissipadora sota de l'inversor, al colí de la motocicleta, atornillat amb cargols i doble femella de seguretat.		
			Mà d'obra.....	17,50
			Materials.....	155,56
			TOTAL PARTIDA	173,06
SH-004	Ud	Instal·lació radiador Instal·lació del radiador al xassís, motjançant els suports prèviament muntats, amb subjecció amb cargols M8.		
			Mà d'obra.....	17,50
			Maquinària.....	2,00
			Materials.....	254,17
			TOTAL PARTIDA	273,67
SH-005	Ud	Instal·lació tubs DN10 Instal·lació de tubs de cautxú amb reforç tèxtil, acollats amb abraçadores pels seus extrems		
			Mà d'obra.....	4,38
			Maquinària.....	2,00
			Materials.....	5,26
			TOTAL PARTIDA	11,64
SH-006	Ud	Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs		
			Mà d'obra.....	8,75
			Maquinària.....	2,00
			Materials.....	11,73
			TOTAL PARTIDA	22,48
SH-007	Ud	Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems.		
			Mà d'obra.....	8,75
			Maquinària.....	2,00
			Materials.....	8,18
			TOTAL PARTIDA	18,93

QUADRE DE PREUS 2

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	UT	RESUM	PREU
SH-008	Ud	Instal·lació tubs DN37 Instal·lació de tubs de cautxú DI32 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs	
		Mà d'obra.....	8,75
		Maquinària.....	2,00
		Materials.....	9,26
		TOTAL PARTIDA	20,01
SH-009	Ud	Instal·lació tubs DN32 Instal·lació de tubs de cautxú DI27 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs.	
		Mà d'obra.....	8,75
		Maquinària.....	2,00
		Materials.....	8,96
		TOTAL PARTIDA	19,71
SH-010	Ud	Instal·lació de toveres Instal·lació de toveres a les reduccions i augments de diàmetre dels tubs.	
		Mà d'obra.....	2,91
		TOTAL PARTIDA	2,91
SH-011	Ud	Instal·lació fluid refrigerant Instal·lació de fluid refrigerant (aigua destil·lada) per a omplir la totalitat del sistema hidràulic	
		Mà d'obra.....	8,75
		Materials.....	4,15
		TOTAL PARTIDA	12,90
SH-012	Ud	Verificació fugues i funcionament circuit Verificació del correcte funcionament del sistema i verificació de fugues.	
		Mà d'obra.....	17,50
		TOTAL PARTIDA	17,50

PRESSUPOST

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT	PREU	IMPORT
01	Capítol 1: Fabricació			
F-001	Ud Fabricació suport radiador dreta Fabricació del suport col·locat a la dreta que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	1,00	100,38	100,38
F-002	Ud Fabricació suport radiador esquerra Fabricació del suport col·locat a l'esquerra que suporta el radiador amb el xassís, amb elements soldats per la subjecció del propi xassís	1,00	100,38	100,38
F-003	Ud Fabricació suport dipòsit Fabricació del suport del dipòsit amb xapa 2mm de gruix, tallat amb oxitall i soldat amb soldadura d'electrode revestit	1,00	58,84	58,84
F-004	Ud Fabricació tovera radiador-dissipador Fabricació de la tovera radiador-dissipador mitjançant un mecanitzat amb torn	1,00	47,06	47,06
F-005	Ud Fabricació tovera bomba-radiador Fabricació de la tovera bomba-radiador mitjançant un mecanitzat amb torn	1,00	46,18	46,18
F-006	Ud Fabricació tovera dissipador-dipòsit Fabricació de la tovera dissipador-dipòsit mitjançant un mecanitzat amb torn	1,00	46,18	46,18
TOTAL 01.....				399,02

PRESSUPOST

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT	PREU	IMPORT
02	Capítol 2: Muntatge mecànic			
M-001	Ud Subjecció suports del radiador al xassís Subjecció del suport del radiador al xassís mitjançant soldadura amb electrode revestit.	2,00	22,50	45,00
M-002	Ud Foradat xassís Foradat de xassís mitjançant trepant portàtil.	1,00	19,25	19,25
M-003	Ud Muntatge suport dipòsit Acollament suport del dipòsit, atornillat als colissos del xassís.	1,00	20,06	20,06
TOTAL 02.....				84,31

PRESSUPOST

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CODI	RESUM	QUANTITAT	PREU	IMPORT
03	Capítol 3: Sistema hidràulic			
SH-001	Ud Instal·lació bomba refrigerant Col·locació bomba refrigerant al xassís de la motocicleta, amb abraçadera i cargols.	1,00	287,59	287,59
SH-002	Ud Instal·lació dipòsit compensació Instal·lació del dipòsit al suport, acollat amb abraçadora metàl·lica.	1,00	36,97	36,97
SH-003	Ud Instal·lació placa dissipadora Instal·lació de placa dissipadora sota de l'inversor, al colí de la motocicleta, atornillat amb cargols i doble femella de seguretat.	1,00	173,06	173,06
SH-004	Ud Instal·lació radiador Instal·lació del radiador al xassís, motjançant els suports prèviament muntats, amb subjecció amb cargols M8.	1,00	273,67	273,67
SH-005	Ud Instal·lació tubs DN10 Instal·lació de tubs de cautxú amb reforç tèxtil, acollats amb abraçadores pels seus extrems	2,00	11,64	23,28
SH-006	Ud Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs	2,00	22,48	44,96
SH-007	Ud Instal·lació tubs DN27 Instal·lació de tubs de cautxú DI24 amb reforç tèxtil, acollats amb abraçadores pels seus extrems.	1,00	18,93	18,93
SH-008	Ud Instal·lació tubs DN37 Instal·lació de tubs de cautxú DI32 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs	1,00	20,01	20,01
SH-009	Ud Instal·lació tubs DN32 Instal·lació de tubs de cautxú DI27 amb reforç tèxtil, acollats amb abraçadores pels seus extrems i subjectat al xassís amb abraçadores per tubs.	1,00	19,71	19,71
SH-010	Ud Instal·lació de toveres Instal·lació de toveres a les reduccions i augments de diàmetre dels tubs.	3,00	2,91	8,73
SH-011	Ud Instal·lació fluid refrigerant Instal·lació de fluid refrigerant (aigua destil·lada) per a omplir la totalitat del sistema hidràulic	1,00	12,90	12,90
SH-012	Ud Verificació fugues i funcionament circuit Verificació del correcte funcionament del sistema i verificació de fugues.	1,00	17,50	17,50
TOTAL 03.....				937,31
TOTAL.....				1.420,64

RESUM DE PRESSUPOST

Projecte de Disseny del sistema de refrigeració de l'inversor d'una motocicleta de competició

CAPÍTOL	RESUM	IMPORT	%
01	Capítol 1: Fabricació	399,02	28,09
02	Capítol 2: Muntatge mecànic	84,31	5,93
03	Capítol 3: Sistema hidràulic	937,31	65,98
		1.420,64	
PRESSUPOST D' EXECUCIÓ MATERIAL			
6,00 % Despeses generals		85,24	
13,00 % Benefici industrial		184,68	
Suma		269,92	
PRESSUPOST BASE DE LICITACIÓ SENSE IVA		1.690,56	
21% IVA		355,02	
PRESSUPOST BASE DE LICITACIÓ		2.045,58	

Puja el pressupost l'esmentada quantitat de DOS MIL QUARANTA-CINC EUROS amb CINQUANTA-VUIT CÈNTIMS

Alcover, 09 de juny de 2022.

Arnau Ferré Queralt

