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Final Design of Intelligent Energy FCM

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Towards a standardised fuel cell module

Table of Contents

1 Introduction

Intelligent Energy Ltd. contributes to the StasHH project with the design, development, manufacturing, and tested delivery of an Fuel cell system (FCS) with an fuel cell module (FCM) sized to fit inside the BB standard size definition.

The IE-Drive HD is a hydrogen fuelled PEM fuel cell power unit, packaged for a heavy-duty automotive requirement, ready for multi-sample design validation in small fleet and test conditions. It is intended to provide range extension and/or hybrid power for a heavy-duty powertrain, such as truck or bus, with net peak output of 110kW.

The IE-Drive HD consists of 4 fundamental assemblies (FCM, air filter, thermal module, and exhaust module) with components between interfaces supporting the operation of the system. The StasHH standard size definition of BB has been selected for the IE-Drive HD FCM. The complete IE-Drive HD system will be supplied to the StasHH project for testing.

2 WP3 standard overview

The following sub-sections provide an overview of the WP3 standard definition, which is necessary to verify the compliance of the FCM design according to the StasHH definitions. The exact and binding requirements are listed in the official documents. A minimum power output of 30 kW (Beginning of life, BOL) of the FCM is mandatory for the StasHH standard.

2.1 Standard size definition

Three series of FC boxes were defined within the standard: A, B, and C series. For the A-series a doubling in the height direction is possible, which will be denoted with the subscript AA. The B-series allows for doubling or tripling in height direction denoted with the subscript BB and BBB respectively. The dimensions of the boxes can be found in Table 1 and the following tolerances in all directions are tolerated: +0/-100 mm.

Table 1: dimensions FC module A, B and C

StasHH	Length / mm	Width / mm	Height / mm	Expected PEM kW
A	1.020	700	340	50
AA	1.020	700	680	110
AAA	1.020	700	1020	160
B	1.360	700	340	70
BB	1.360	700	680	145
BBB	1.360	700	1.020	220
C	1.700	700	340	90

The respective volumes of the different sizes are as follows:

- A external volume is max. 0.243 m^3
  AA external volume is max. 0.486 m^3
  AAA external volume is max. 0.729 m^3
- B external volume is max. 0.324 m^3
  BB external volume is max. 0.647 m^3
  BBB external volume is max. 0.971 m^3
- C external volume is max. 0.405 m^3

A visual representation of the A to C series boxes including the multiple sizes is shown in Figure 1.

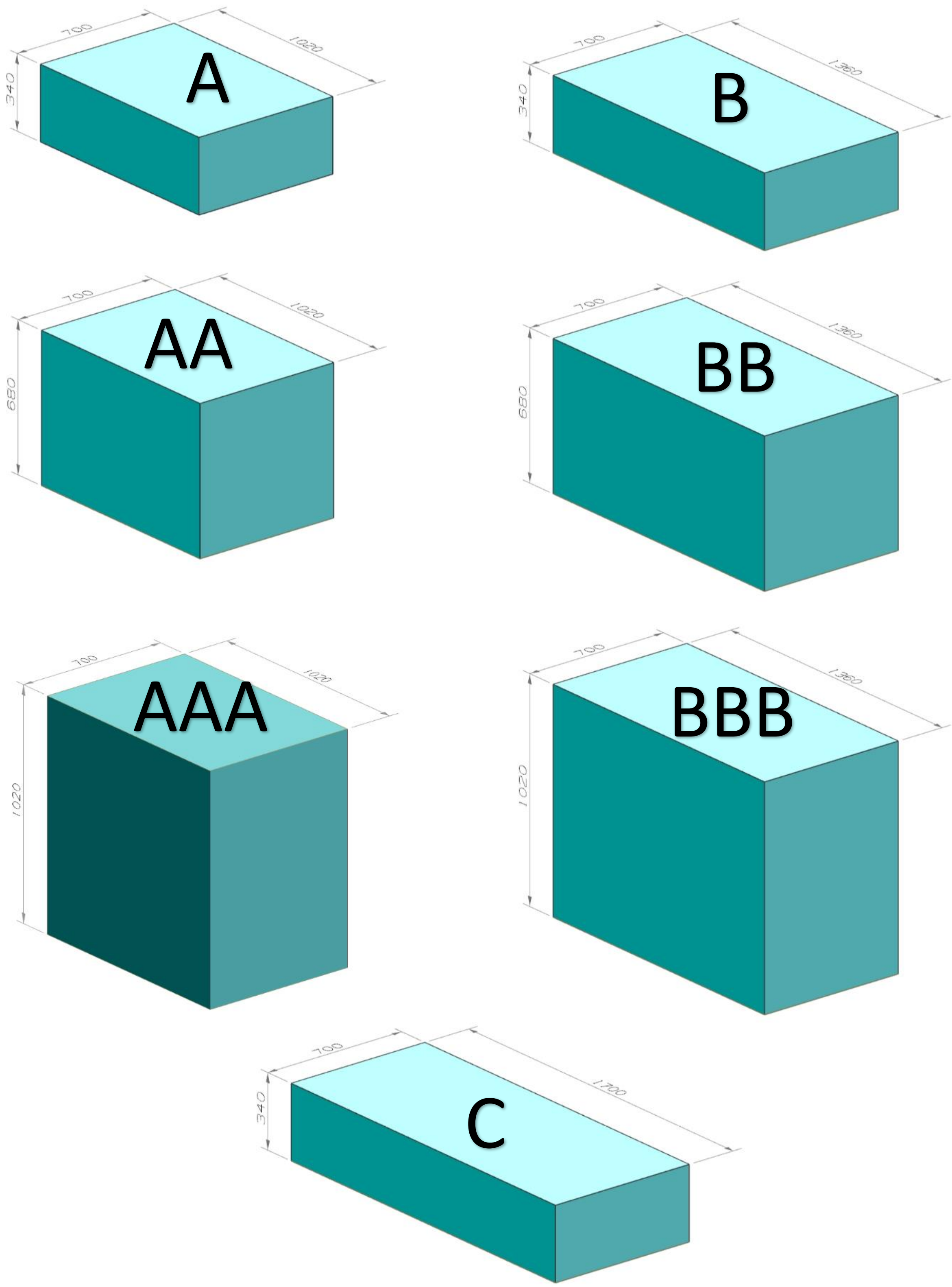


Figure 1: FC modules A, B and C

The orientation of all FC boxes is fixed according to the Length x Width x Height definition except for the A(A) boxes which can be orientated optionally on its side. This is not a StasHH requirement. The optional orientation on the side is shown in Figure 2

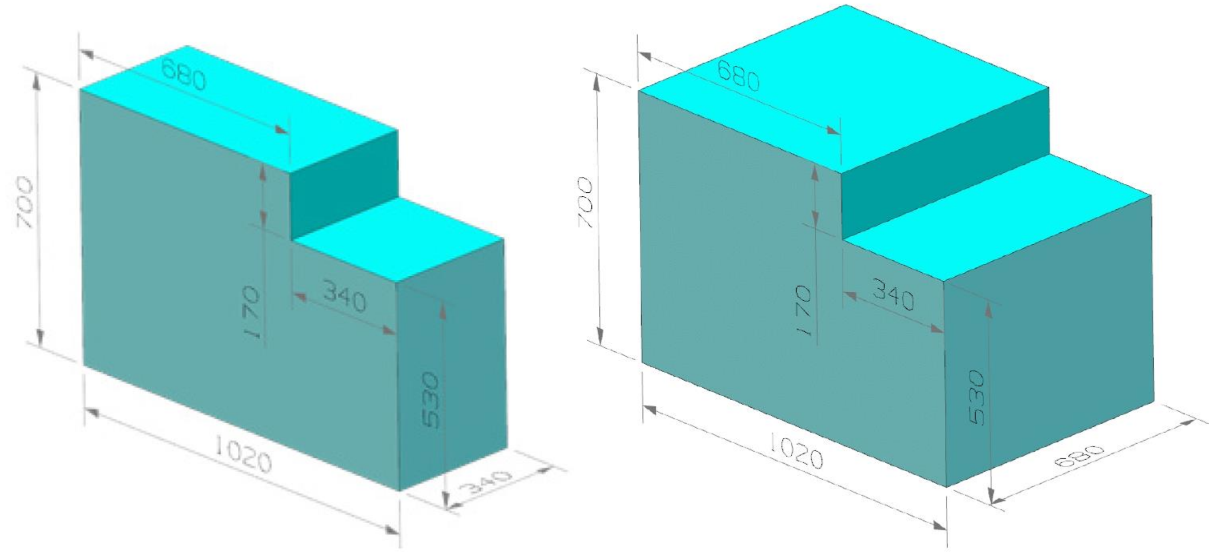


Figure 2: A and AA on their side

2.2 Standard interface definition

The interface areas and requirements for the pneumatic, hydraulic, and electronic connections are defined in the following.

2.2.1 Interface area

The interface area can be on two different sides. At least all pneumatic and hydraulic connections are within this interface area (except eventually the drain or (box) ventilation). Sides are defined with FC module in horizontal position:

1. In corner 3, on the L x H side FC module. See Figure 3. The dimensions of the interface area will be max. 340mm x $Depth_{main}$ x Module Height
2. In corner 4, on the W x H side FC module. See Figure 3. The dimensions of the interface area will be max. 700mm x $Depth_{main}$ x Module Height

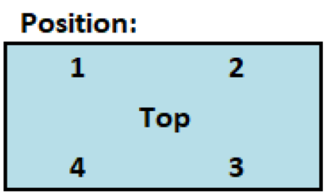


Figure 3: Top view of FCM for interface area definition

"$Depth_{main}$" or "D_{main}" is defined as the minimum depth needed to stay within the overall FC module volume (defined in D3.2), with connected male and female connectors.

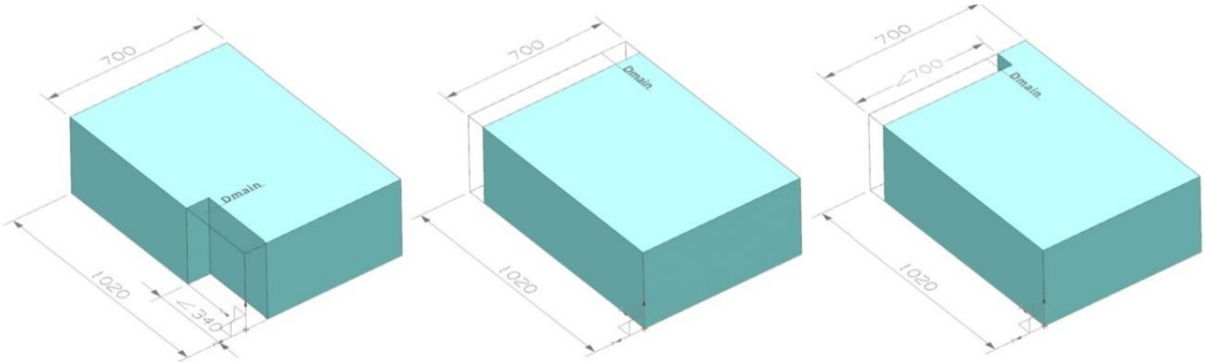


Figure 4: FCM interface areas possibility (1st side)

The size definitions of the interfacial areas can also be found in a tabulated manner in Table 2

Table 2: Dimensions FC module interface areas (1st side)

Interface 1st side	Length / mm	Depth / mm	Height / mm
A			340
AA			680
AAA			1.020
B	Max. 340	≥D_{main}^{x}	340
BB			680
BBB			1.020
C			340

Interface 1st side	Length / mm	Depth / mm	Height / mm
A			340
AA			680
AAA			1.020
B	Max. 700	≥D_{main}^{x}	340
BB			680
BBB			1.020
C			340

*Depth is min. Depth needed to stay within overall FC module volume with connected interfaces

Optionally, a second interface area can be utilized under the following conditions:

3. The main side complies with 1. with depth “Dmain”, and the second side complies with 2. with depth “Dsub”

OR

4. The main side complies with 2. with depth “Dmain”, and the second side complies with 1. with depth “Dsub”
5. Both connections areas are mechanically redundant, i.e., all pneumatic and hydraulic connections are on both sides (except eventually the drain or (box) ventilation)

“$Depth_{sub}$” or “D_{sub}” is defined as the minimum depth needed to stay within the overall FC module volume, with not connected male or female connectors.

Table 3: Dimensions of FC module interface areas (optional 2nd side)

Interface 2nd side	Length or width / mm	Depth / mm	Height / mm
A	Max. 340 or 700	$\geq D_{sub}^{x}$	340
AA			680
AAA			1.020
B			340
BB			680
BBB			1.020
C			340

An exemplary image of the optional second interface area is depicted in

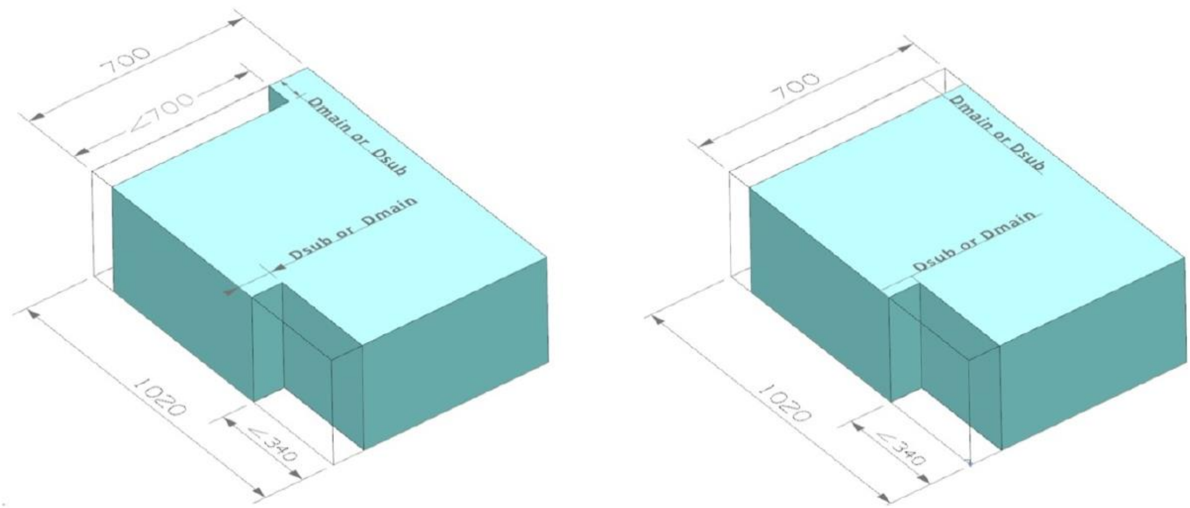


Figure 5: Example of FC module interface area with 1st side and optional 2nd side

2.2.2 Hydraulic, pneumatic, and electrical interfaces

All hydraulic and pneumatic interfaces must comply with the following conditions:

- All the pneumatic and hydraulic connections, excluding the optional drain or (box) ventilation, are positioned in the defined interfaces areas
- The connections' principle will be fixed for all FCMs, but can be different depending on usage. For example, for air this can be a hose, for hydrogen a pipe. See The electrical and I/O communication can be positioned anywhere within the chosen overall dimensions of A, B and C.

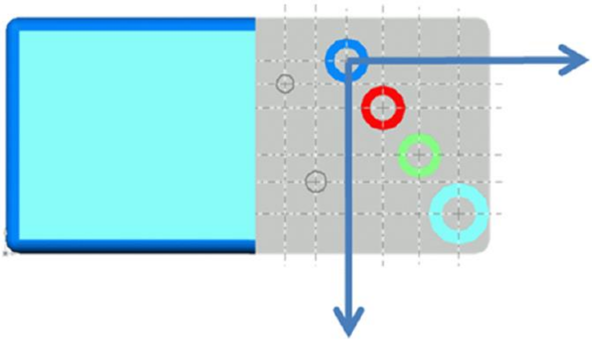
- Table 4
- The connection size ranges (in mm) are defined, but will vary with the power range of the FC module The electrical and I/O communication can be positioned anywhere within the chosen overall dimensions of A, B and C.

- Table 4.
- The electrical and I/O communication can be positioned anywhere within the chosen overall dimensions of A, B and C.

Table 4: Hydraulic and pneumatic interfaces of FC modules

	Interfaces	Inner diameter / mm Nominal power				Remark
		≤ 70 kW	71 - ≤ 100 kW	101 - ≤ 130 kW	131 - ≤ 160 kW	
Hydrogen	Pipe fitting	6-8	8-12	12-16	16-20	6-22 bar
Air	Nozzle + Hose	30-60	45-75	60-90	75-105	
Steam	Nozzle + Hose	30-60	45-75	60-90	75-105	
Drain	Nozzle + Hose	6-8	8-12	12-16	16-20	optional
Cooling FC	Nozzle + Hose	20-40	30-50	40-60	50-70	In/Out
Cooling -E	Nozzle + Hose	15-35	20-40	25-45	30-50	Optional
Breather	Banjo	M14x1.5	M14x1.5	M14x1.5	Tbd	Optional
Ventilation	Nozzle + Hose	20-40	20-40	20-40	20-40	Optional

An additional condition for the main hydraulic and pneumatic connections is that they may not interfere in the horizontal and vertical directions, see Figure 6.



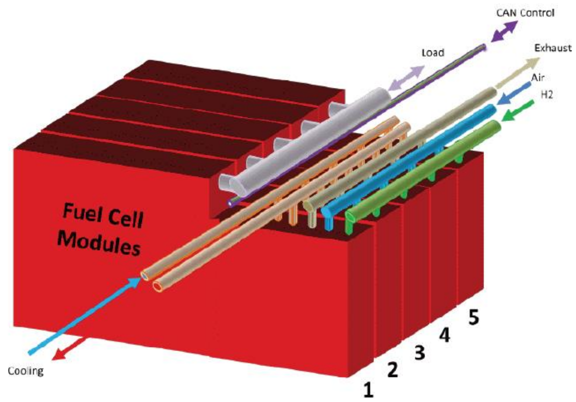


Figure 6: Non-interfering hydraulic and pneumatic connections

2.2.3 Low and high voltage connectors

Within StasHH the pins for the LV and HV connection are specified but not the specific connector.

High voltage connector:

The connector must have two pins, plus and minus. Additionally, it must withstand the maximum FCM voltage and current. Connectors, already utilized in heavy-duty applications are preferred.

Low voltage connector:

The LV connector must withstand up to 100 A and cable lugs are suggested.

2.3 Standard API definition

2.3.1 Physical connector

For the physical connector for the communication with the FCM only the pins are specified and not the connector itself. It is proposed to use an 18 pin connector to include additional functions of needed. The connector shall at least have an ingress protection level of IP54 with a proposed pinout, depicted in Figure 7.

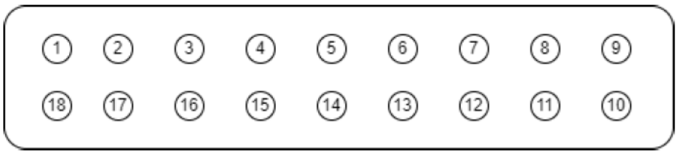


Figure 7: Pinout

The physical connector shall have enough pins to transfer all electrical signals needed and must fulfil the requirements resulting from the working environment or use case of the application.

The following pins must be included in the connector:

1. CAN ground
2. CAN high
3. CAN low
4. OPTIONAL shield
5. Wakeup signal
6. Emergency stop

The following optional pins are also specified:

7. OPTIONAL HVIL in
8. OPTIONAL HVIL out
9. OPTIONAL 24V
10. OPTIONAL ground for LV power
11. OPTIONAL CAN high for DC/DC or secondary FCM
12. OPTIONAL CAN low for DC/DC or secondary FCM
13. OPTIONAL CAN high manufacturer specific diagnostic bus
14. OPTIONAL CAN low manufacturer specific diagnostic bus

The remaining pins 15 to 18 are intended for future use and additionally deployments

2.3.2 State machine

The state machine shall at least contain the following states:

- Idle:
  In this state the FCM has LV power sufficient to activate the FCCU. This state corresponds to “Power on” in J1939. Periodic counter messages are transmitted
- Standby:

No HV output power but necessary subsystems are powered and ready such that it can start producing output within a short time. Error and diagnostic messages can be sent

- Starting:
  FCM is transitioning from standby to running state. Power is ramping up and HV bus is enabled – Module can consume and provide energy
- Running:
  FCM is active and delivering power. Power may be limited due to derating which will be indicated by FCM
- Stopping:
  FCM is ramping down and returning to standby state. HV bus must be enabled during shut-down procedures.
- Error:
  Error state must be enabled from any other state. FCM shall be brought in a safe state

Proprietary substates can be defined by the FCM manufacturers.

For further information see D3.4 document.

2.3.3 Messages

In the following the messages that are used in the communication between the application ECU and FCCU are listed:

- State machine control
- State machine feedback
- Emergency stop request
- Reference power value
- FCM actual current and voltage
- Power limits
- Voltage limits
- High voltage bus information
- FCM temperature
- Time and date
- Ambient conditions
- Vehicle speed
- FCM gas leakage
- Alarm messages

For a generic description of the messages including a mapping to a J1939 message, please refer to the official D3.4 document.

3 Design of IE DRIVE HD

The IE-Drive HD product has been targeted at the heavy-duty automotive, bus and truck market. It is intended that the IE-Drive HD is used in an application in conjunction with a high voltage (HV) battery with the FCS acting in a range extending and/or hybrid power supply function. The StasHH standard size definition BB has been targeted for the FCM part of the IE-Drive HD FCS product. The outer dimensions of FCM are, length 1244mm, width 698mm, and height of 520mm, meeting the BB requirements.

3.1 Key technical specifications

The mandatory key technical specifications are listed in table 5.

Requirement	StasHH requirement	FCM
Service life / h	> 15,000	15,000[a]
Geographical heights / m	< 3,000m with derating	1000m without derate, derated up to 3000m
IP class	> IP54	IP67 excluding air intakes, and exhausts.
Low voltage / V	24DC	24 DC
High voltage output / V	160 – 850 DC	250 – 400 DC NO DCDC supplied
Operational ambient temperature / °C	-25 to 45	-20 to +65[b]
Conductivity glycol / µS/cm	< 6 (ASTM D 1125)	NA
H_2 input pressure / bar	6 - 22	6 – 12 bar absolute
Hydrogen quality	ISO 14687 or SAE J2719	grade D as per ISO 14687-2:2012 or purer.

Table 5: Mandatory technical specifications of FCM according to StasHH

Deviations:

a. The target design life to EoL condition, across a realistic duty cycle

b. Initial testing to -20°C, with design to -40°C on longer product timeframe

Additional technical specifications of FCM are listed in Table 6 below.

Requirement	FCM
Net continuous system power output P_{net} BOL / kW	110
Net continuous system power output P_{net} EOL / kW	Not disclosed
Weight / kg	285 for the FCM
DC/DC included in FCM / -	HV DCDC not included in the FCM
Peak system efficiency / %	Not disclosed
System efficiency at P_{net} BOL	Not disclosed
System efficiency at P_{net} EOL	Not disclosed
Gravimetric system power density @ BOL / kW/ton	Not disclosed
Volumetric system power density @ BOL / kW/m³	Not disclosed

Table 6: Additional optional StasHH key technical specifications of FCM.

3.2 Exterior design

The external design of the IE-Drive HD FCM is shown in Figure 8 below. The face of the FCM which has the fluidic interfaces has been defined as the "front face". The FCM face which has the electrical connections and the cut out on the top face has been defined as the "rear face". The underside of the FCM has a fuse access panel.

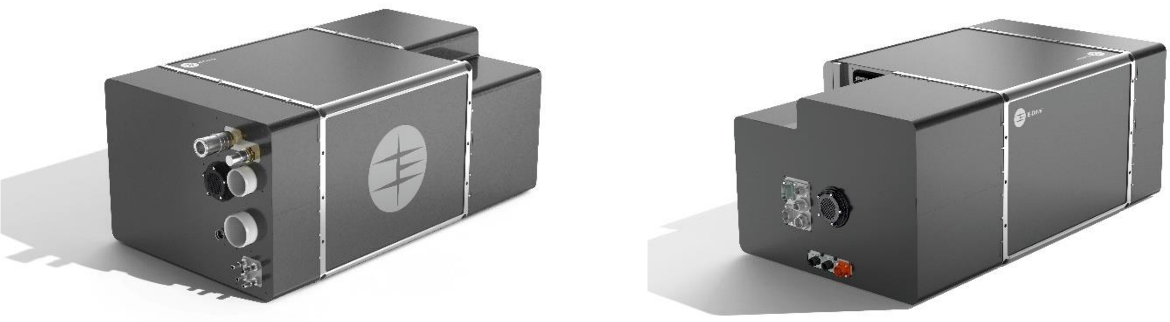


Figure 8: Rendering of the IE-Drive HD FCM.

3.3 Outer Dimensions of the FCM and location of interfaces

The following figures (Figure 9, Figure 10, Figure 11, Figure 12, and Figure 13) provide the external dimensions of the FCM as well as the locations of each of the interfaces. The connector location dimensions are measured to the connector centre point.

Figure 12 shows the overall FCM height to be 520mm. Intelligent Energy acknowledge that this value is less than the 680 minimum stipulated in the standard. However, this design has been carefully considered and deliberate to allow close coupling of an external DC-DC (supplied by others) to the FCM, for example. This box dimension will not be increased before FCM delivery to the StasHH project and therefore volumetric power density is enhanced.

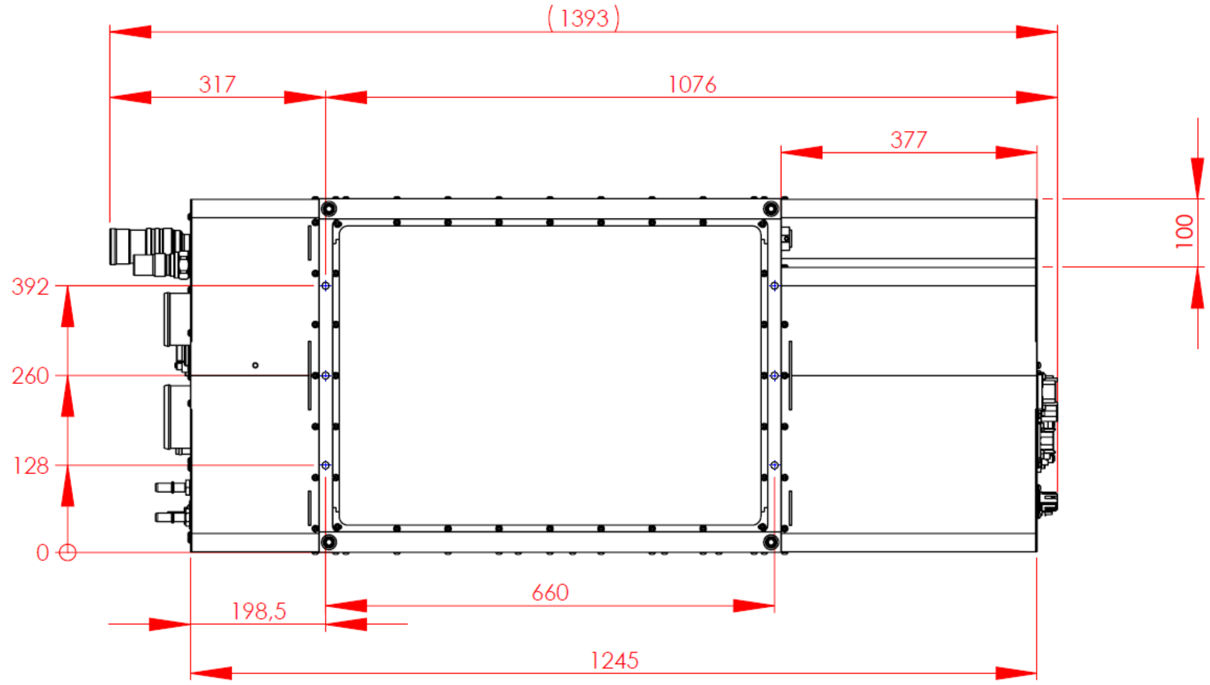


Figure 9: IE-Drive HD FCM side view.

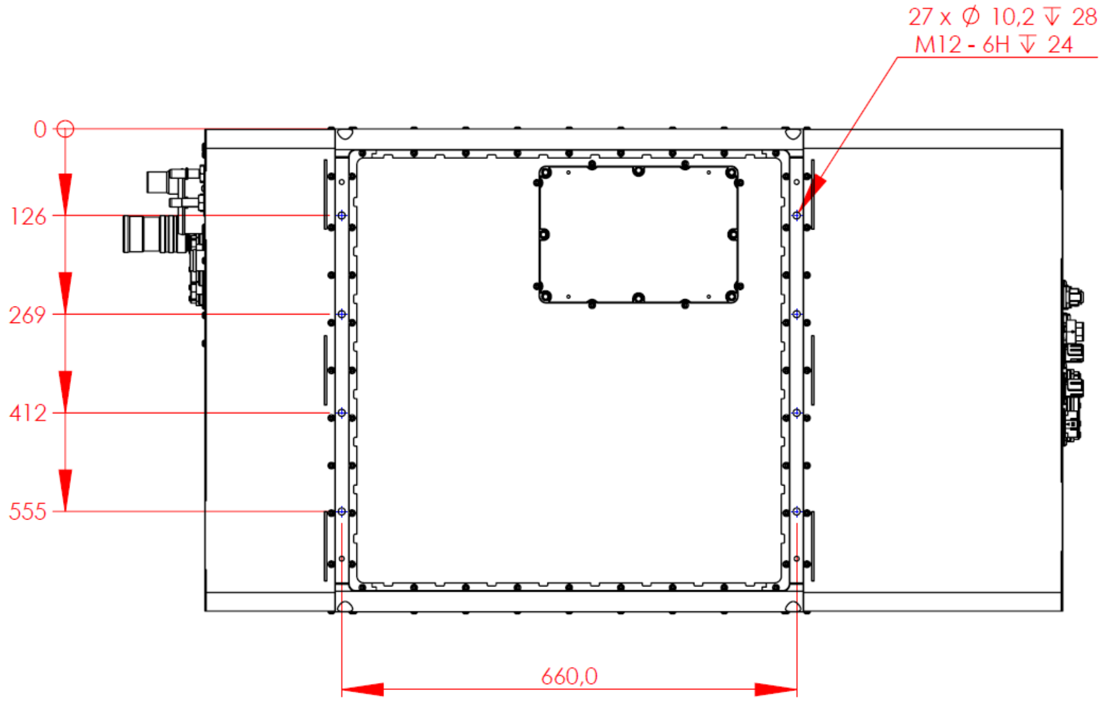


Figure 10: IE-Drive HD FCM underside view.

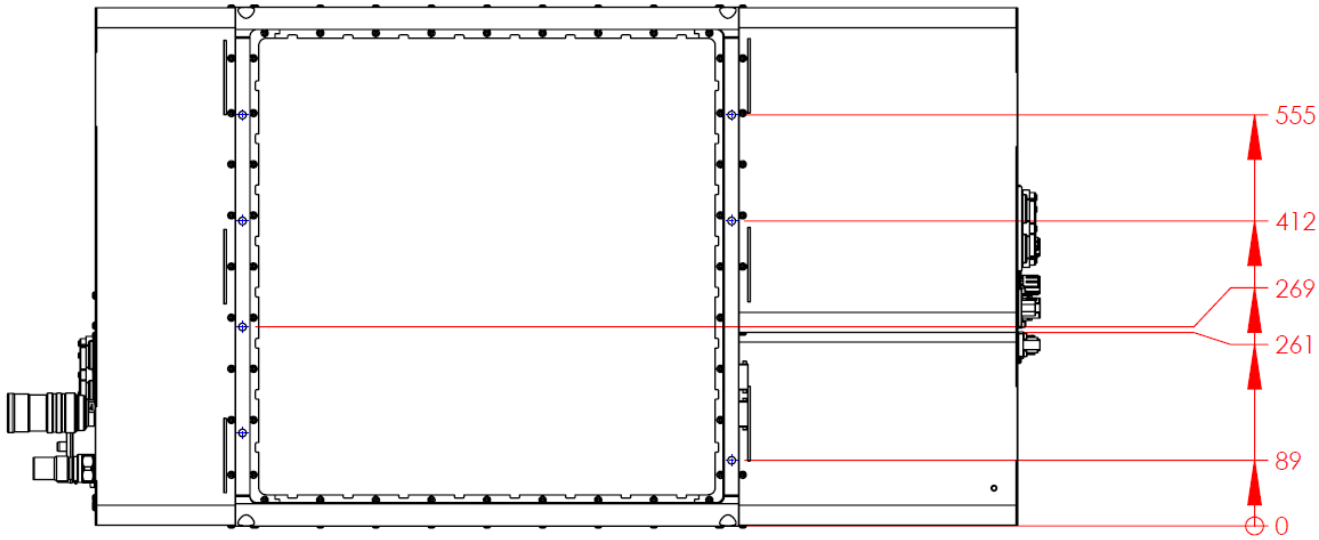


Figure 11:IE-Drive HD FCM top view.

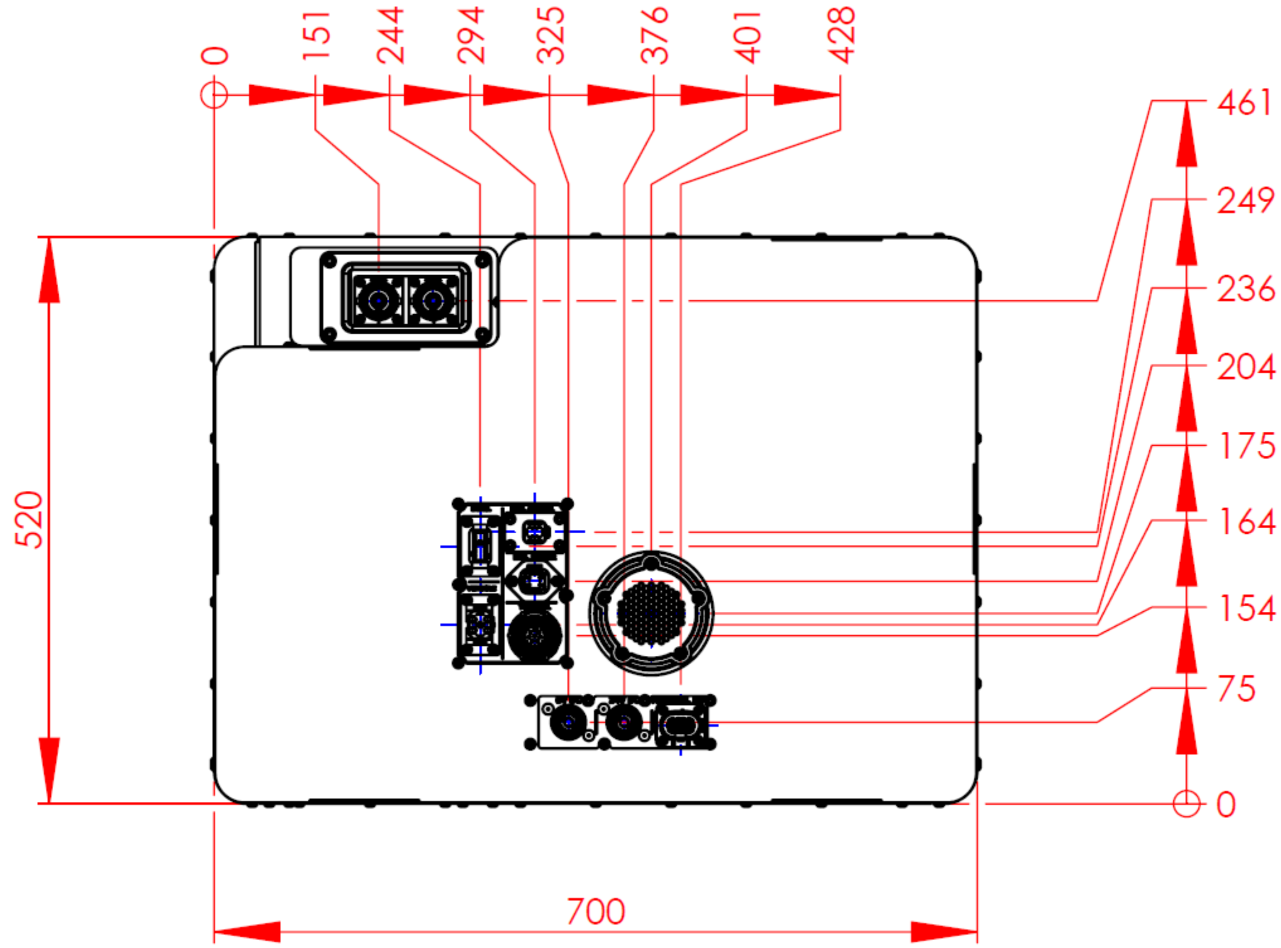


Figure 12: IE-Drive HD FCM rear view.

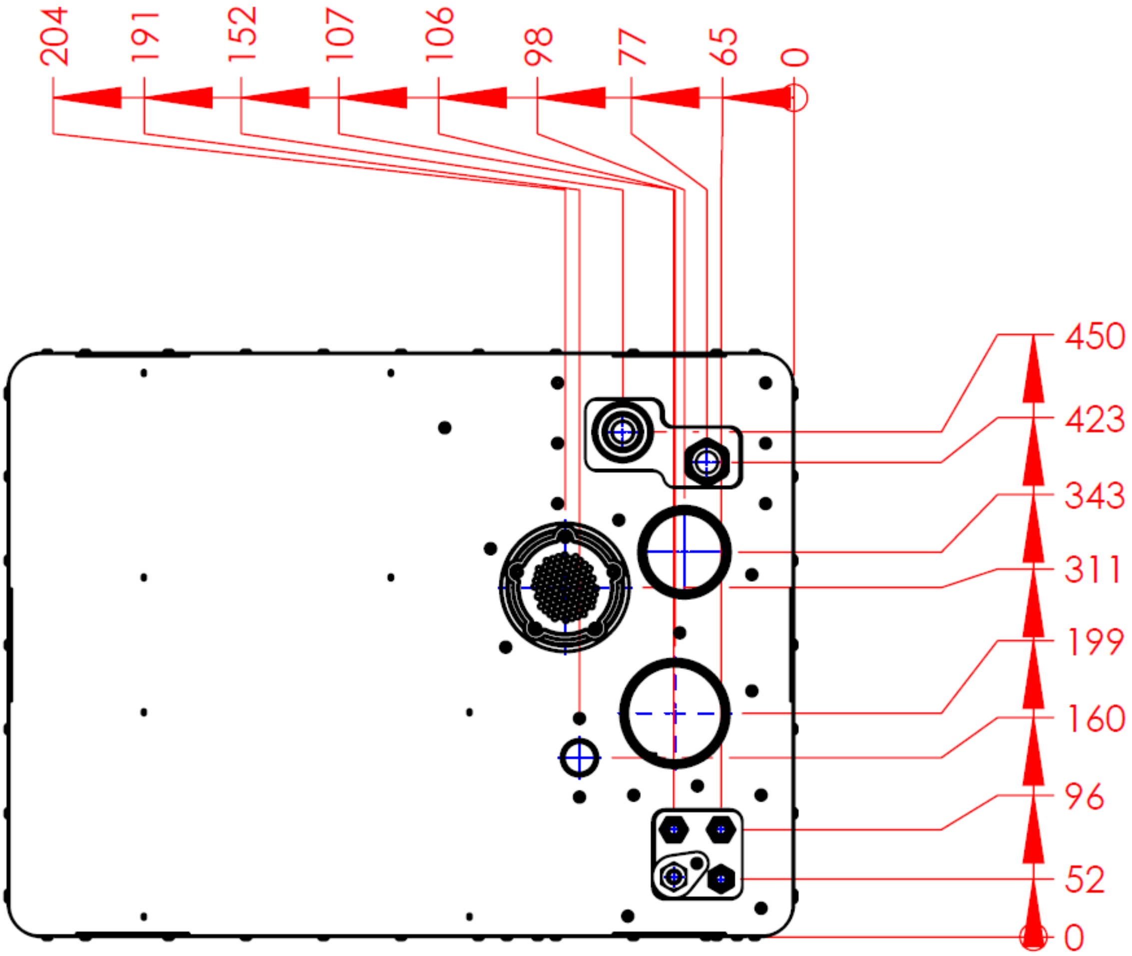


Figure 13: IE-Drive HD FCM front view.

3.4 Module Pictures

Pictures of the modules built for testing are shown in Figure 14 & 15.

3.5 Fuel Cell Module

The FCM is the primary component within the IE-DRIVE HD system. It contains the PEM fuel cell stack, most of the FCS BoP and the control systems associated with operating the fuel cell. The module uses hydrogen and air and converts it to unregulated DC output. Additionally, it acts as the central interface between all other assemblies.

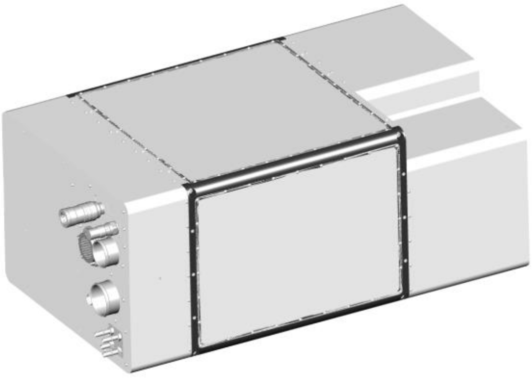


Figure 14: IE-Drive HD FCM front orientation view.

Figure 14 above shows the unit in an upwards orientation. The front of the FCM is deemed as the end face displayed. The rear is deemed as the end face not shown with a cut out on the top face. The rearward orientation of the fuel cell module is shown below in figure 15:

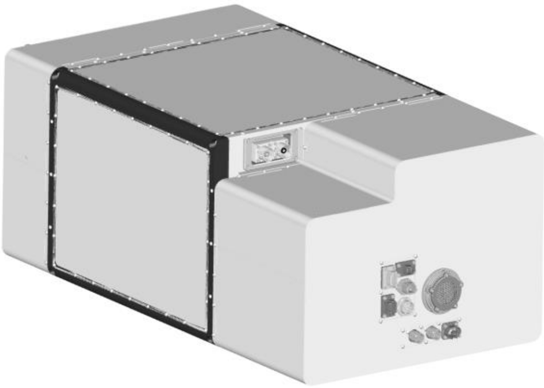


Figure 15: IE-Drive HD FCM rear orientation view.

The unit has been designed with ease of interface connection in mind. All fluidic connections to the fuel cell application are secured on the front of the unit. All electrical connections to the fuel cell application are secured on the rear of the unit.

3.6 Air Filter

External to the FCM, a filter and ducting are provided, where the filter element is considered to be a serviceable item. Depending on the specific integration, ducting will be supplied by the fuel cell application to allow the free flowing of ambient air to the intake of the air filter housing. A representation of the air filter is shown below:

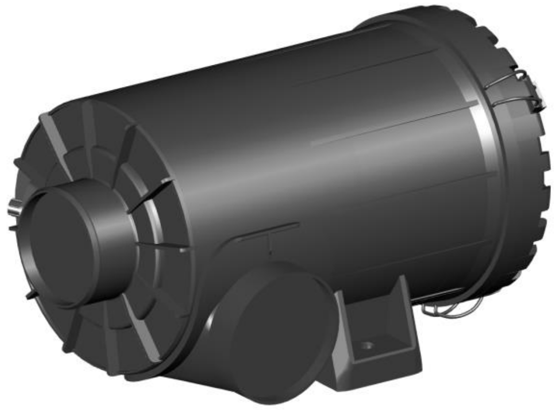


Figure 16: IE-Drive HD air filter & housing.

3.7 Thermal Module

The thermal module rejects heat from the IE-Drive HD FCS and recovers water from the exhaust stream. It consists of a forced cooled condenser and water separator. The remaining exhaust air is vented to atmosphere through the exhaust module. A representation of the thermal module is shown below in figure 17. The module also includes additional sub-assemblies for the conversion and distribution of power for the cooling fans.

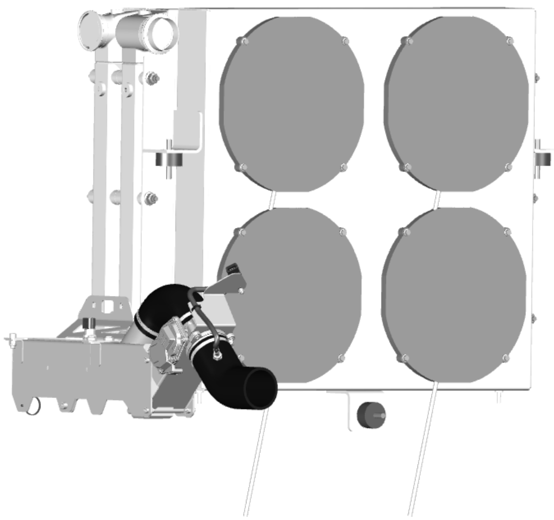


Figure 17: IE-Drive HD thermal module.

3.8 Exhaust Module

A representation of the exhaust module is shown in Figure 14. This module exhausts waste gases and fluids from the IE-Drive HD system, consisting of a dilution blower, a dilution chamber, and an exhaust outlet to atmosphere. As it combines anode and cathode waste gases, hydrogen sensing is included to permit a safe level of tailpipe hydrogen emission from the FCS. Depending on the application there may be ducting from the exhaust module to the outer envelope of the application.

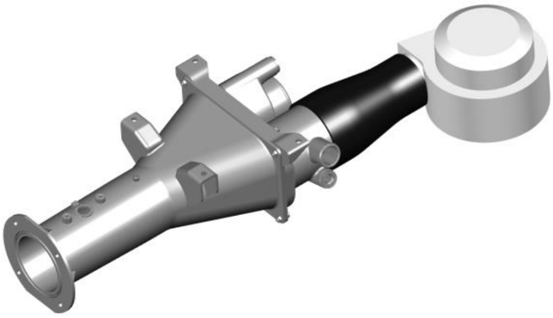


Figure 14: IE -Drive HD exhaust module.

3.9 DCDC

The IE-Drive HD does not include a HV DCDC between the output of the fuel cell stack and the connection to the host platform, as depicted in the boundary diagram. A DCDC is not provided as this allows for greater flexibility on the application side, as an appropriate DCDC can be optimised for the specific application.

3.10 FCS including, FCM, air filter, thermal module, and exhaust module

The FCS including the FCM, air filter, thermal module, and exhaust module can be seen in Figure 15 below.

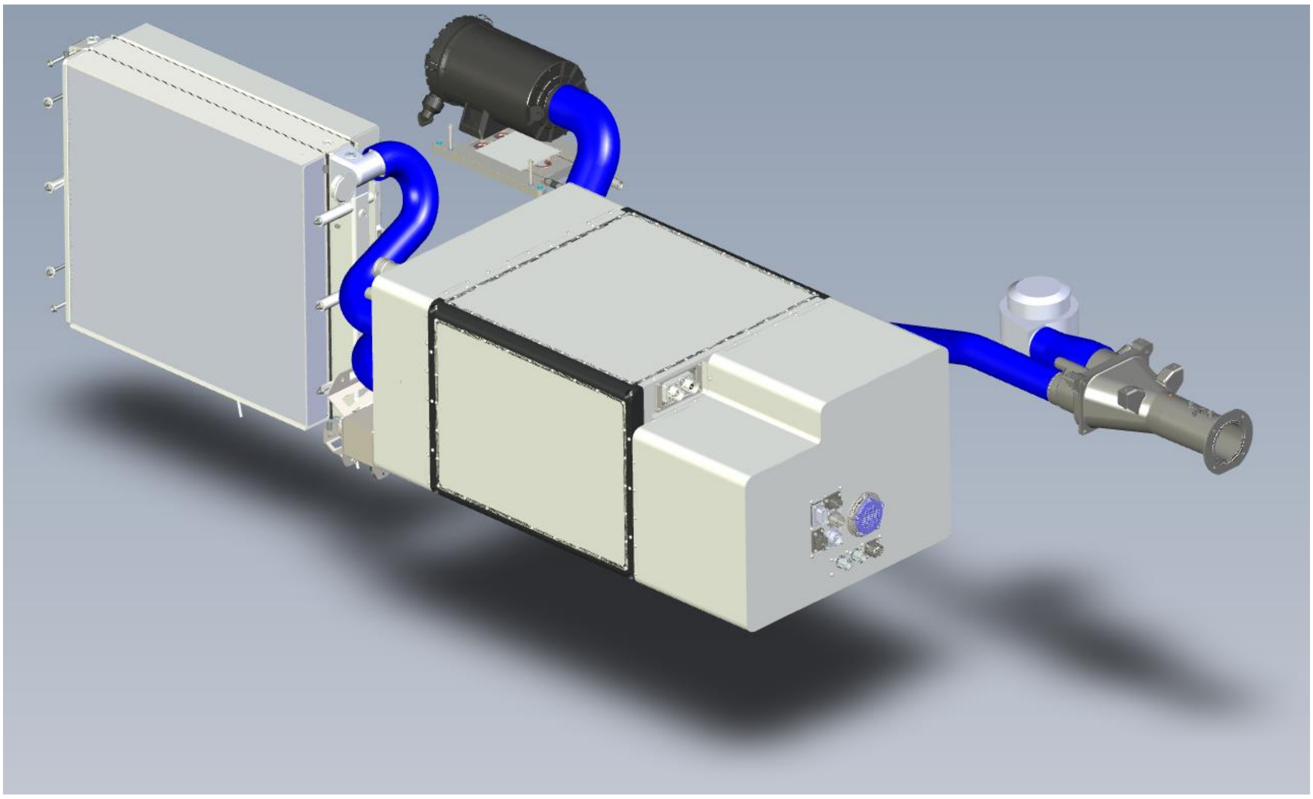


Figure 15: IE-Drive HD consisting of; FCM, air filter, thermal module, and exhaust module.

3.11 Interface specification and area

In this section the hydraulic, pneumatic, and electrical interfaces are discussed. The location on the FCM, medium of transport, and type of connector used for each interface are discussed.

3.11.1 Interface area including hydraulic and pneumatic interfaces

For ease of reference Figure and Figure identify which hydraulic or pneumatic interface is which. For each interface, the medium which is to be transferred and the physical connector.

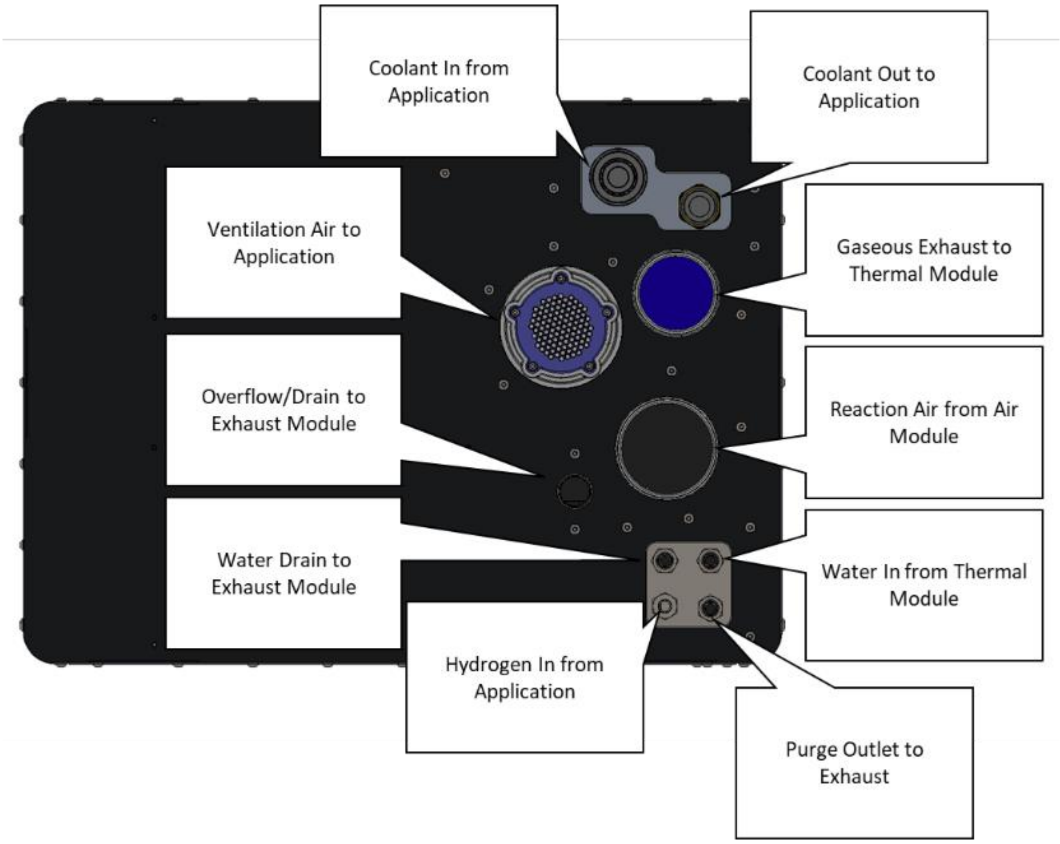


Figure 20: FCM hydraulic and pneumatic connections identified.

Interface location is based on a combination of the best package inside the FCM enclosure and to comply to external interface requirements driven from common underpinning commercial requirements placed upon Intelligent Energy.

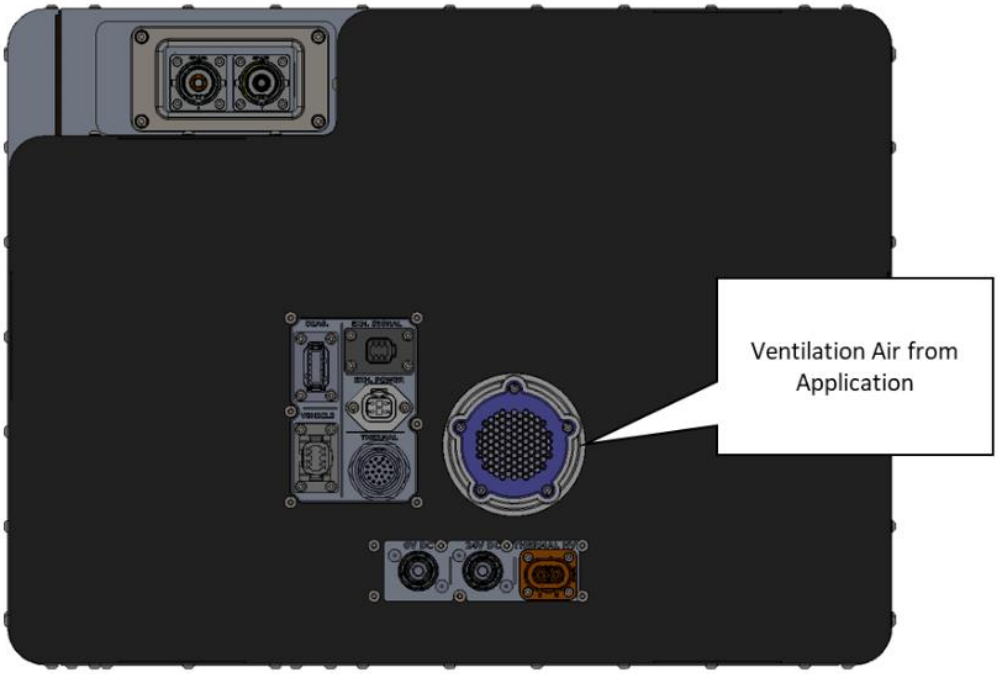


Figure 21: Ventilation air inlet location identified.

Interface	Interface Type	Connection on Product	Connection to Product
Hydrogen in from Application	Hydrogen gas	SS-8-TA-1-8ST 1/2"OD	1/2" Swagelok Tube Fitting (316L Stainless Steel) Example Hose (Application Specific): SS-FM8TA8SL8-18
Reaction Air from Air Module	Air	Hose Fitting, 92mm	92 mm ID hose
Gaseous Exhaust to Thermal Module	Deionised Water Oxygen depleted air	Hose Fitting, 76.2mm	76.2mm ID hose
Water Drain to Exhaust Module	Deionised water	Coupling,1/2" SAE J2044 male	Coupling,1/2" SAE J2044 female
Water in from Thermal Module	Deionised water	Coupling,1/2" SAE J2044 male	Coupling,1/2" SAE J2044 female
Overflow / Drain to Exhaust Module	Deionised water	Hose Fitting, 30mm	30mm ID hose
Coolant in from Application	50/50 water glycol mix	Exact hose tail (nozzle) and hose size to be confirmed in D4.19 in M24	
Coolant Out to Application	50/50 water glycol mix		
Ventilation Air from Application	Atmospheric air	Filtered port	NA
Ventilation Air to Application	Atmospheric air and hydrogen	Filtered port	NA
Purge Outlet to Exhaust	Hydrogen	Coupling,1/2" SAE J2044 male	Coupling,1/2" SAE J2044 female

Table 7: Specifications of hydraulic and pneumatic interfaces.

4 Electrical interfaces

Within this chapter the electrical interfaces and specification of the connectors are summarised. For the relative location of each of the electrical interfaces on the FCM, these are detailed in section 4.

4.1 LV connection to application

The IE-Drive HD has two LV power connections to the host application.

4.1.1 24 Volt from application connector

For LV power to the FCM a 24V connection is presented to the host application. The location of the 24V from application connector on the FCM is shown in the Figure below. The pin assignments of the connector are defined in the Table 8 below.

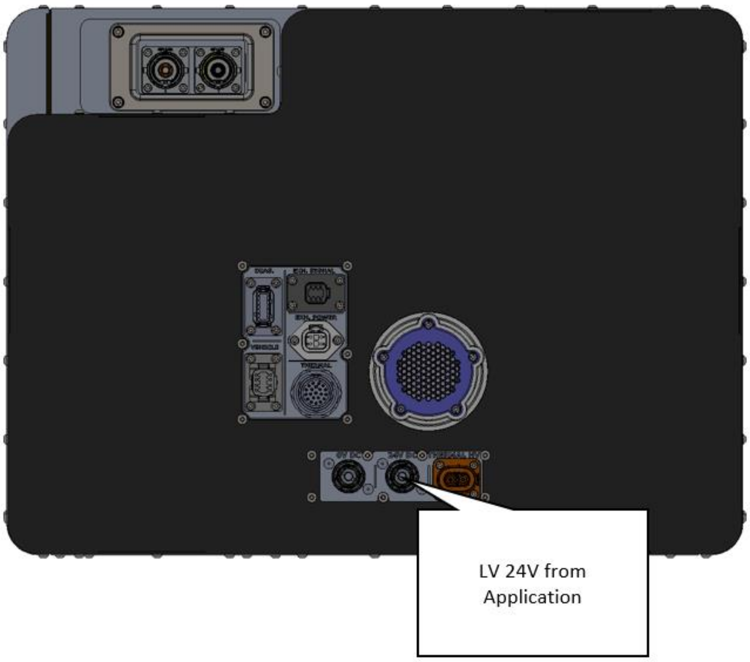


Figure 22: Location of 24V LV connector on FCM.

24V Connector		
System Interface		TE DTSK04-1-08PC
Mating Connector		TE DTSK06-1-08SC
Posn	Wire (mm^2)	Function
1	RD 25 FLRY-B	Vehicle 24V Supply

Table 8: 24V LV connector pin assignment.

4.1.2 LV 0 Volt from application

For a 0-Volt connection to the FCSM a 0-Volt connection is presented to the host application. The location of the LV 0-Volt application connector on the FCM is shown in Figure below. The pin assignments of the connector are defined in the Table 9 below.

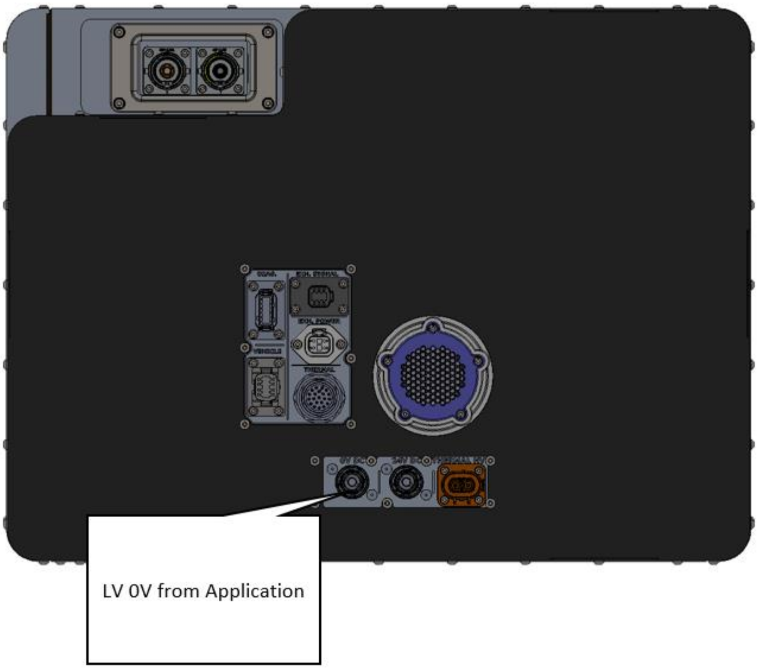


Figure 23: Location of 0V LV connector on FCM.

0V Application Connector		
System Interface		TE DTSK04-1-08PC
Mating Connector		TE DTSK06-1-08SC
Posn	Wire (mm^2)	Function
1	BK 25 FLRY-B	0V Ground to Vehicle Chassis/Ground

Table 9: 0V LV connector pin assignment.

4.2 LV connection between the FCM and other FCS modules

The IE-Drive HD has been designed with a FCM and supporting modules. To reduce the integration burden on the application the FCM has interfaces which provide power and communication to the supporting FCM modules.

4.2.1 Thermal module connector

The thermal module connector facilitates communication and LV power from the FCM to the FCS thermal module and the high voltage interlock signal (HVIL). The location of the thermal module connector on the FCM is shown in the Figure below. The pin assignments of the connector are defined in the

Table 10 below.

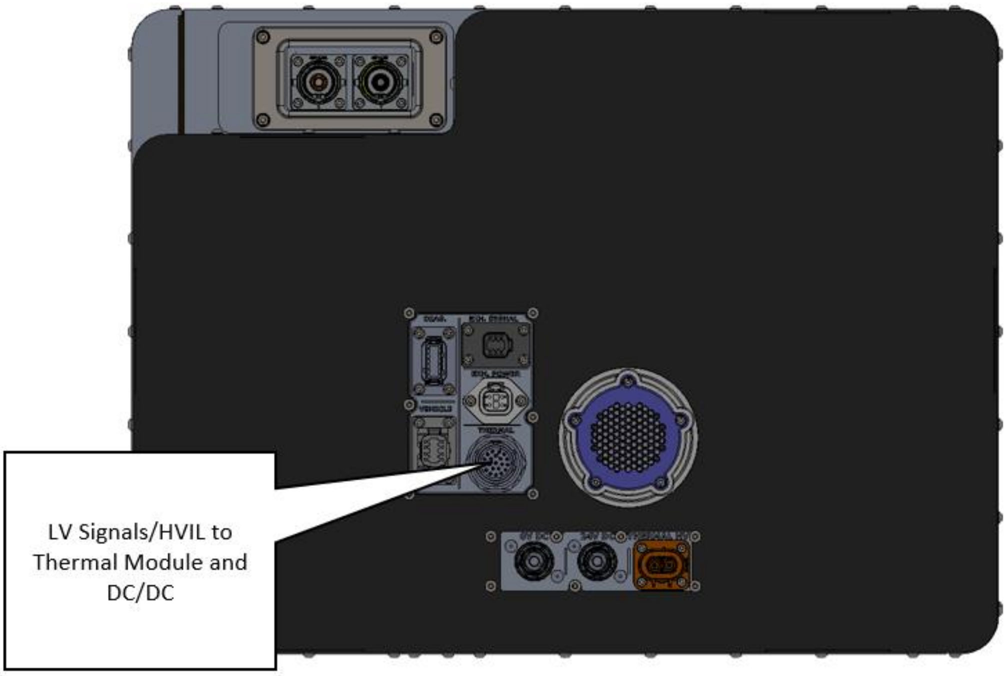


Figure 24: Location of Thermal module LV connector on FCM.

Thermal Connector		
System Interface		TE HD34-18-21PN
Mating Connector		TE HD36-18-21SN
Posn	Wire (mm^2)	Function
1	YL 0.5 FLRY-B	Pressure Sensor 5V Supply
2	GY 0.5 FLRY-B	Pressure Sensor Signal
3	GN 0.5 FLRY-B	5V Sensor Return
4	GY 0.5 FLRY-B	Temperature Sensor Signal
5	YL 0.5 FLRY-B	Valve 5V Supply
6	GN 0.5 FLRY-B	Valve 5V Return
7	GY 0.5 FLRY-B	Valve Tacho Signal
8	RD 0.5 FLRY-B	Valve 24V Supply
9	BK 0.5 FLRY-B	Valve 0V Ground
10	GY 0.5 FLRY-B	Pressure Sensor Signal
11	-	-
12	-	-
13	VT 0.5 FLRY-B	HVIL In
14	VT 0.5 FLRY-B	HVIL Out
15	VT 0.5 FLRY-B	Hex Fan PWM Signal
16	VT 0.5 FLRY-B	Hex Fan PWM Signal
17	BN 0.5 FLRY-B	Private CAN High
18	BU 0.5 FLRY-B	Private CAN Low
19	-	-
20	-	-
21	-	-

Table 10: Thermal module LV connector pin assignment.

4.2.2 Exhaust module LV connector

The exhaust module connector supplies sensor power to the exhaust module as well as enabling communication between the exhaust module and the FCM. The location of the Exhaust module LV connector on the FCM is shown in the Figure below. The pin assignments of the connector are defined in Table 11 below.

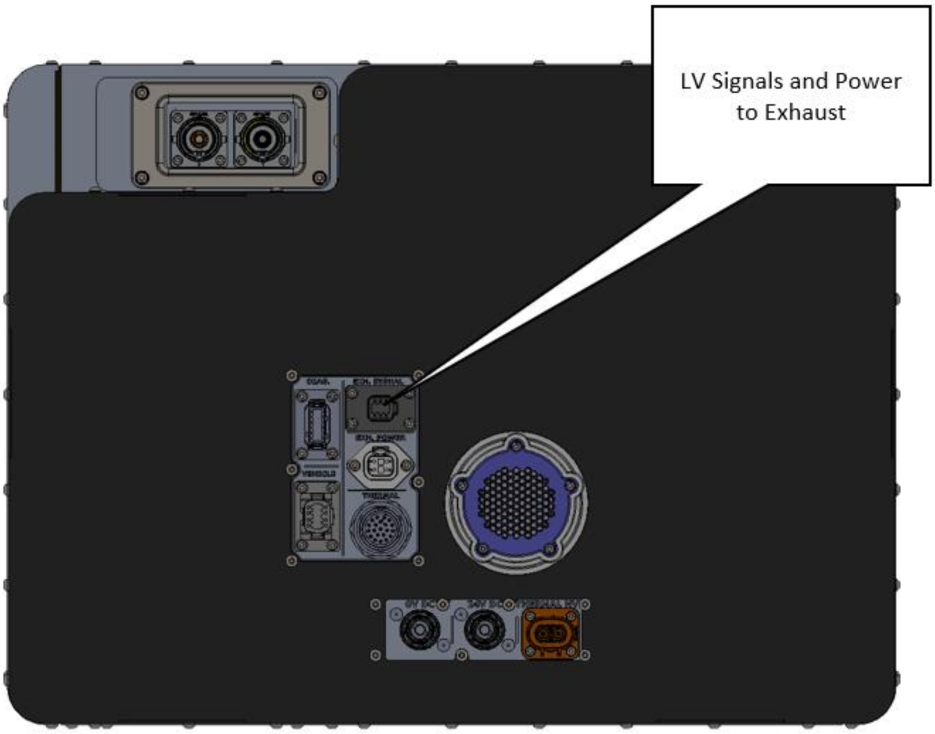


Figure 25: Location of Exhaust module LV connector on FCM.

Exhaust module LV connector		
System Interface		TE DT04-6P-L012
Mating Connector		TE DT06-6S
Posn	Wire (mm^2)	Function
1	BN 0.5 FLRY-B	Public CAN High
2	BU 0.5 FLRY-B	Public CAN Low
3	RD 0.5 FLRY-B	Hydrogen Sensor 24V Supply
4	BK 0.5 FLRY-B	Hydrogen Sensor 0V Ground
5	-	-
6	-	-

Table 11: Exhaust module LV connector pin assignment.

4.2.3 Exhaust module power connector

The exhaust module power connector supplies power from the FCS to the exhaust module for dilution purposes. The location of the exhaust module power connector on the FCM is shown in Figure below. The pin assignments of the connector are defined in the Table 12 below.

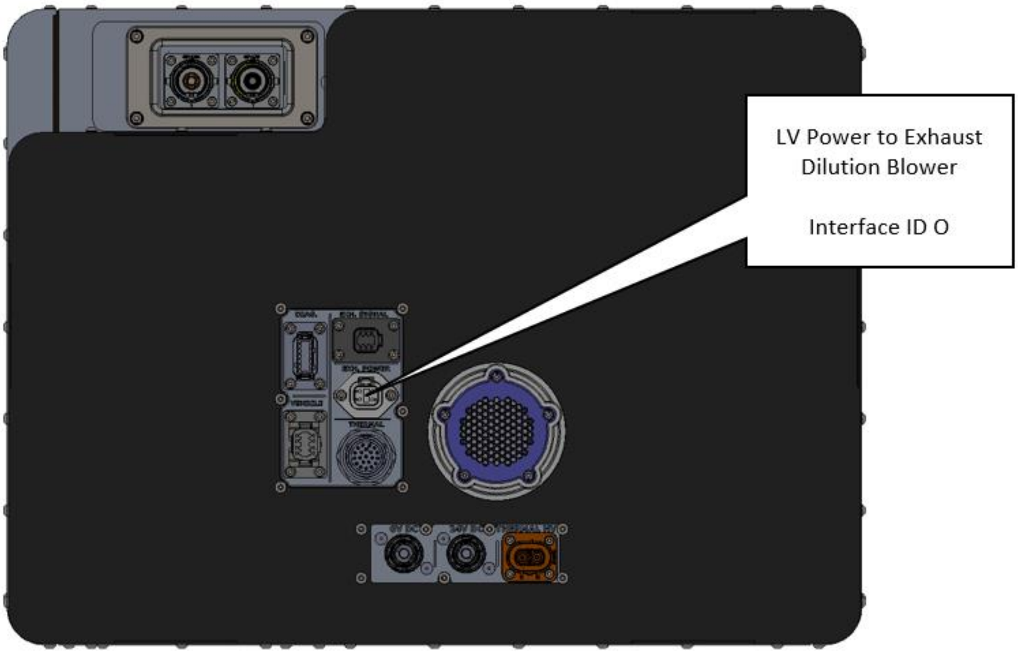


Figure 26: Location of exhaust module LV connector on FCM.

Exhaust Power Connector		
System Interface		TE DTP04-4P-L012
Mating Connector		TE DTP06-4S
Posn	Wire (mm^2)	Function
1	RD 2.5 FLRY-B	Exhaust Dilution Fan 12V Supply
2	BK 2.5 FLRY-B	Exhaust Dilution Fan 0V Ground
3	-	-
4	-	-

Table 12: Exhaust module LV connector pin assignment.

5 HV Connections

The IE-Drive HD FCM has HV connections to the application platform as well as to the FCS Thermal module. The relative location of the HV connectors on the FCM are detailed in section 5.

5.1 HV to/from application

The FCS has a bidirectional HV interface with the platform application. During start up and shutdown power is drawn from the platform application. While running the FCS provides power to the platform application. The location of the HV to/from application connector on the FCM is shown in the Figure 27 below. The pin assignments of the connector are defined in Table 13 below.

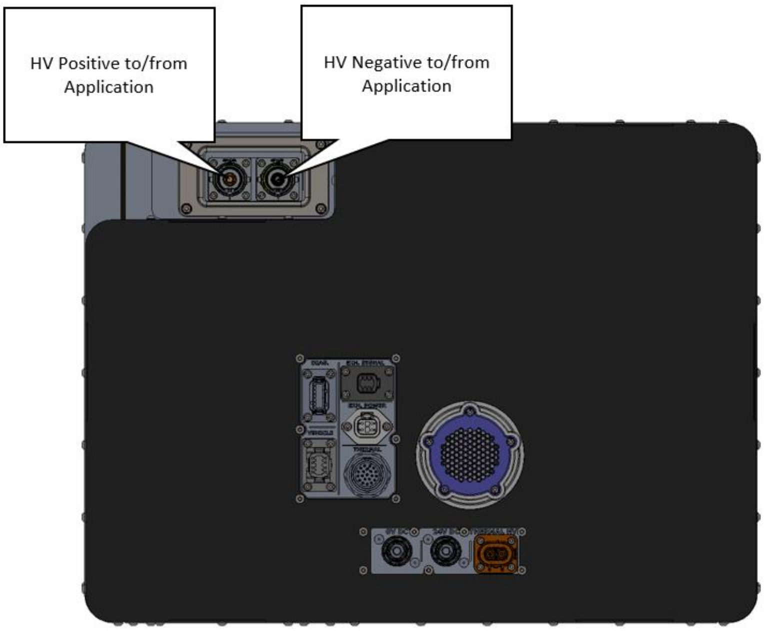


Figure 27: Location of HV to/from application connector on FCM.

HV Input/Output		
System Interface		95mm PowerLok G2 Male (Panel Mount) HV Positive: PL00X-501-10M8-2 HV Negative: PL00Y-501-10M8-2
Mating Connector		95mm PowerLok G2 Female (Plug) HV Positive: PL18X-501-95-2-5 HV Negative: PL18Y-501-95-2-5
Posn	Wire (mm^2)	Function
1	min 95 FHLR4GC13X	HV Input/Output positive
2	min 95FHLR4GC13X	HV Input/Output negative

Table 13: HV to/from application connector pin assignment.

5.2 HV from FCM to Thermal Module

The HV to Thermal Module connector supplies HV power from the FCM to the FCS thermal module. The location of the HV to Thermal module connector on the FCM is shown in Figure 28 below. The pin assignments of the connector are defined in Table 14 below.

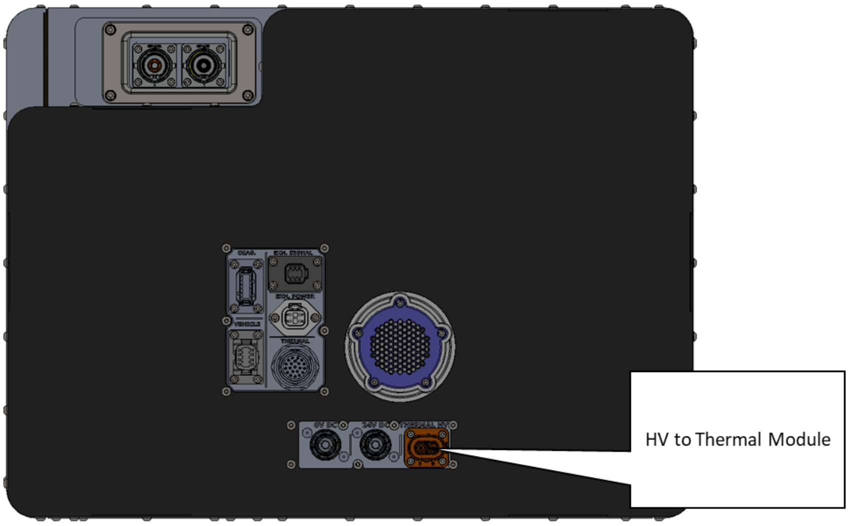


Figure 28: Location of HV to Thermal Module DCDC connector on FCM.

Thermal HV Connector		
System Interface		Amphenol ELR2A02
Mating Connector		Amphenol ELP2A02
Posn	Wire (mm^2)	Function
1	OR 4 FHLR	Thermal HV Supply
2	OR 4 FHLR	Thermal HV Ground

Table 14: HV to Thermal Module DCDC connector pin assignment.

6 Communication

There are two communication connectors on the FCM, one is intended for communication with the application and the other for diagnostics and servicing.

6.1 Application Connector

The vehicle connector is the means by which the Fuel Cell System (FCS) communicates with the host application. This connection has the equivalent functionality as specified in Section 6. The location of the Application connector on the FCM is shown in the Figure 29 below. The pin assignments of the connector are defined in Table 15 below.

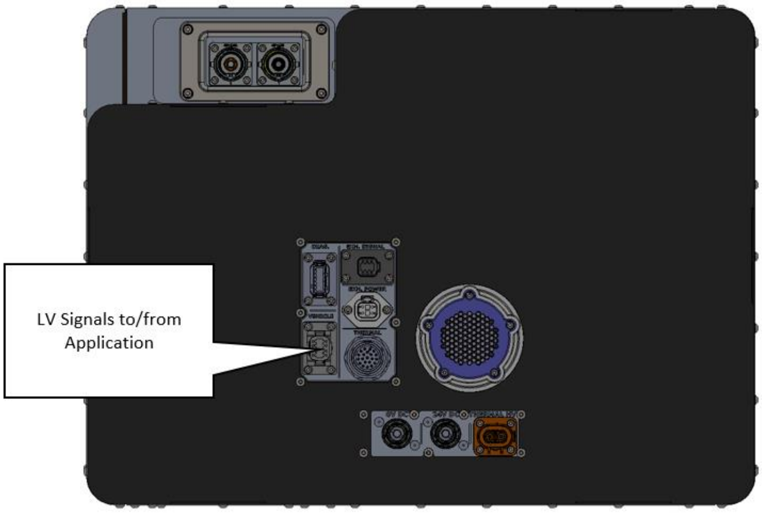


Figure 29: Location of Application LV connector on FCM.

Application Connector		
System Interface		TE DT04-08PB-L012
Mating Connector		TE DT06-08SB
Posn	Wire (mm²)	Function
1	RD 0.5 FLRY-B	Key Switch/KL15
2	BU 0.5 FLRY-B	E-Stop
3	BN 0.35 FLRY-B	Public CAN High
4	BU 0.35 FLRY-B	Public CAN Low
5	VT 0.5 FLRY-B	HVIL In
6	VT 0.5 FLRY-B	HVIL Out
7	RD 0.5 FLRY-B	Hydrogen Sensor 24V Supply
8	-	-

Table 15: Application LV connector pin assignment.

6.1.1 IE Diagnostic connector

The IE diagnostic connector is only intended for IE service personnel and designated 3rd parties. The location of the IE Diagnostic connector on the FCM is shown in the Figure 30 below. The pin assignments of the connector are defined in Table 16 below.

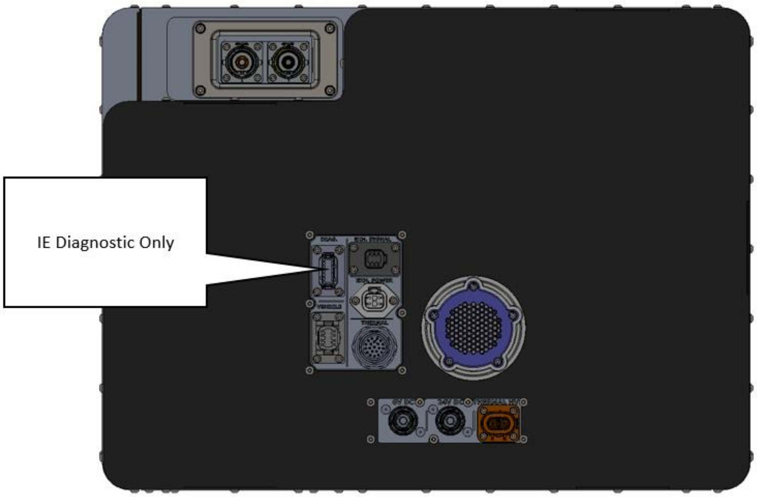


Figure 30: Location of IE Diagnostic connector on FCM.

DIAG Connector (Datalogger)		
System Interface		TE DTM04-12PA-L012
Mating Connector		TE DTM06-12SA
Posn	Wire (mm^2)	Function
1	VT 0.5 FLRY-B	Private
2	VT 0.5 FLRY-B	Private
3	VT 0.5 FLRY-B	Private
4	VT 0.5 FLRY-B	Private
5	BN 0.5 FLRY-B	Private
6	BU 0.5 FLRY-B	Private
7	BN 0.5 FLRY-B	Private
8	BU 0.5 FLRY-B	Private
9	BN 0.5 FLRY-B	Private
10	BU 0.5 FLRY-B	Private
11	RD 0.5 FLRY-B	Private
12	BK 0.5 FLRY-B	Private

Table 16: IE Diagnostic connector pin assignment.

7 API definition

The IE-Drive HD API is still under development and is intended to comply with StasHH deliverable D3.4. There may be some minor deviations from the prescribed state machine. However, a full description of operation will be supplied in the integration manual on delivery.

8 Customer – IE DRIVE Scope of Delivery

For integration of the IE-Drive HD in to the StasHH test environment the following articles supplied for testing and verification:

- An FCM.
- The supporting modules necessary for the operation of the FCM including air filter, thermal module, and exhaust module.
- Componentry between the FCS module interfaces to support the operation of the FCM.
- Mating halves for electrical connectors (including any necessary pins) for connection to the FCS test rig.
- Mating halves for fluidic connectors between the FCS and the test rig.
- Operation manual.
- Onsite integration support.
- Remote integration support available before delivery.

9 Compliance table

STASHH FCM Mandatory Requirements		
Requirements	**General**	**IE DRIVE HD100 expected compliance**
Service Life (hours)	>15000	Compliant
Geographic Height (m)	<3000m with derating	Compliant
IP (class)	>54	Compliant
Low Voltage (V)	24 VDC	Compliant
Output (V)	160 - 850 VDC	Compliant
Ambient T (C)	-25 to 45	Compliant
Hydrogen Input (bar)	6-22	Compliant
Hydrogen Quality	ISO 14687 (D), SAE J2719	Compliant

Table 17: STASHH FCM Mandatory Requirements