FORMULA STUDENT UK EV ENERGY METER SPECIFICATIONS

REVISION HISTORY

VERSION	DATE	CHANGES	AUTHOR
1.0	24/06/2021	Initial release	AS
2.0	27/05/2022	Review for FS2022, addition of logger LV connector pinout, typo fixes, branding	AS

INTRODUCTION

At the competition event all EV teams that pass scrutineering will be issued with an Energy Meter for installation into their vehicle. These are calibrated by the manufacturer in advance of every Formula Student event. This document explains how to install the Energy Meter and how to connect the sensors to an EV HV setup.

The purpose of the energy meter is to measure and log TS voltage and current during dynamic events. After each dynamic event run the EV scrutineers will read the data and verify that neither 600V has been exceeded or 80kW has been consumed by the tractive system. A filter is applied to the voltage reading prior to analysis to smooth very short-term spikes or noise.

Teams must under no circumstances remove a data stick or attempt to analyse the data or otherwise piggyback or reverse engineer the Energy Meter system. Any tampering with the logging equipment will result in an investigation that could lead to deletion of times or disqualification.

This document is always superseded by the published official FS Rules and FS UK Supplementary Rules if there are any inconsistencies in the supplied information.

POST-RUN ANALYSIS

After each run of Acceleration and Sprint, and on completion of Endurance in parc-ferme, the EV scrutineering team will require access to the datalogger memory stick. The teams will be asked to switch off TS, and then LV, and the data stick will be read by the event scrutineer on a dedicated analysis laptop.

As per the FS rules section D9.4, if a voltage or power violation has occurred, the scrutineering team will alert the event captain and the team's fastest run will be disqualified regardless of which run registered the violation. Any subsequent violations will remove their next fastest times, and so on.

As per D9.4.3 violations and associated data may be made public. However, teams will not be permitted to view the results of a run analysis until after the final event results have been classified. The intention is for the team to use their own systems and sensors to rectify the any thresholds or parameters and should not gain an insight or knowledge of performance from the official monitoring system.

ENERGY METER EQUIPMENT

DATALOGGER

There are two versions of the energy meter kits. In both setups the datalogger and memory stick is identical and the sensor sets are equivalent and accurate to sufficiently detect violations in the dynamics log traces. The data logger is a modified GEMS DA3 unit for Formula Student use.

The datalogger unit measures 60x63x33mm with no cables attached, a clearance of at least 60mm is required to insert and remove the data stick.

The datalogger must be installed securely in a location that is easily accessible by the scrutineers and where a memory stick can be removed and inserted without having to move any vehicle panels or enclosures. See rule EV 4.6.2. If a datalogger is damaged or a datastick is unseated due to the location or mounting method of the equipment, this is deemed as a violation as data was unable to be read on demand by the scrutineers and the teams are penalised as described above, losing their fastest time for each violation.

The datalogger must be provided with a reliable and clean LV connection at 12V DC. In previous competitions variable LV supply voltage has shown to cause instability of the logger and subsequently incomplete run logs. In this situation, where the logger is issued in working order and observed to be good under normal conditions, the teams will be found in violation and subject to that event's fastest run disqualification, as per rule D9.4.4 and D9.4.2

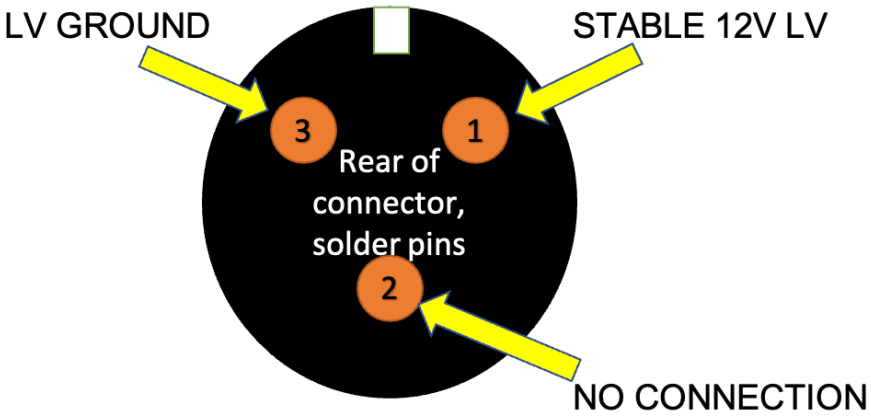
It is acceptable to mount the logger using cable ties, or if necessary, using suitably affixed hook and loop fixing tape.

ANCILLARY KIT

The Energy Meter kits will be provided with a set of each of the ancillary connectors for terminating the sensor cables where necessary. This includes:

- A Binder subminiature connector part number 09-9747-70-03 (solder termination) for the 12V LV DC power supply
- A Molex mini-fit junior female connector housing part number 39-01-2020 for the HV sense wires
- 2x Molex mini-fit female pins part number 39-00-0038 for terminating the HV sense wires (crimp termination).

The polarity of the pins for the LV DC connection is as follows, viewed from the rear of the connector looking at the solder terminations:



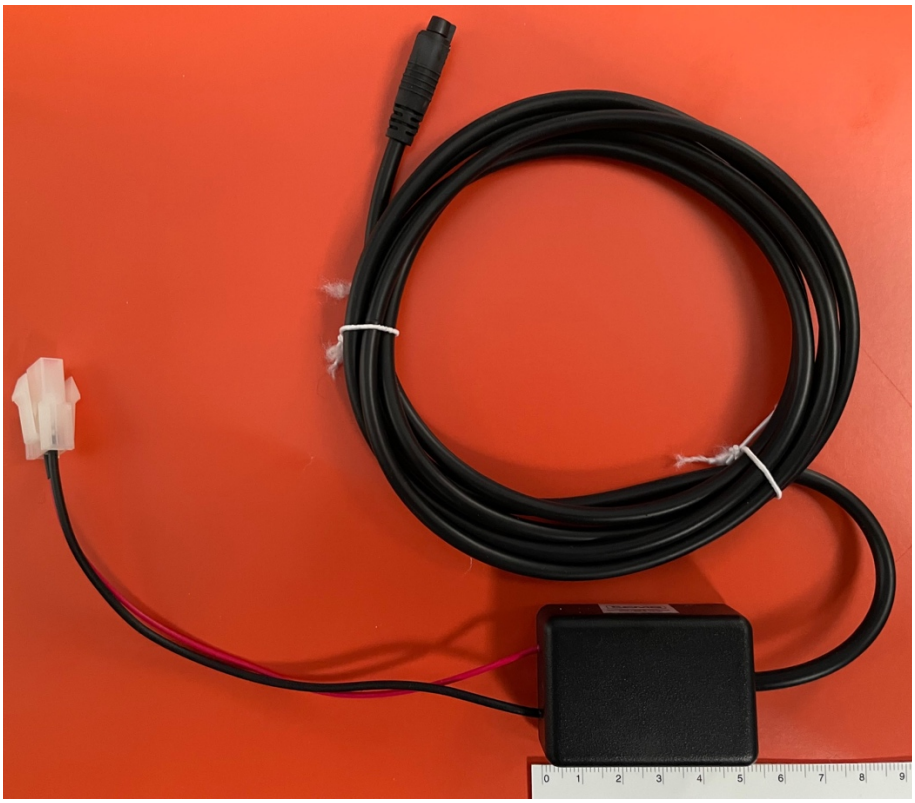
HV SENSOR

The HV sensor has two terminated connections as follows:

- A Binder connector that must be connected to the datalogger. On v1 kits this is colour coded Red. On v2 kits the connector is keyed uniquely.
- A Molex minifit junior male crimp housing for the interface to the vehicle TS system, refer to rule EV4.6.5.

HV Sensor in V1 Kits

Construction	Painted metallic enclosure, potted components
Dimensions	70x50x20mm
HV sensor input resistance	**57k Ohm**
Data cable length	2 metres
Logger connector housing diameter	9.5mm



HV Sensor in V2 Kits

Construction	ABS Plastic enclosure
Sensor Dimensions	50x35x20mm
HV sensor input resistance	**1.5M Ohm**
Data cable length	2 metres
Logger connector housing diameter	9.5mm

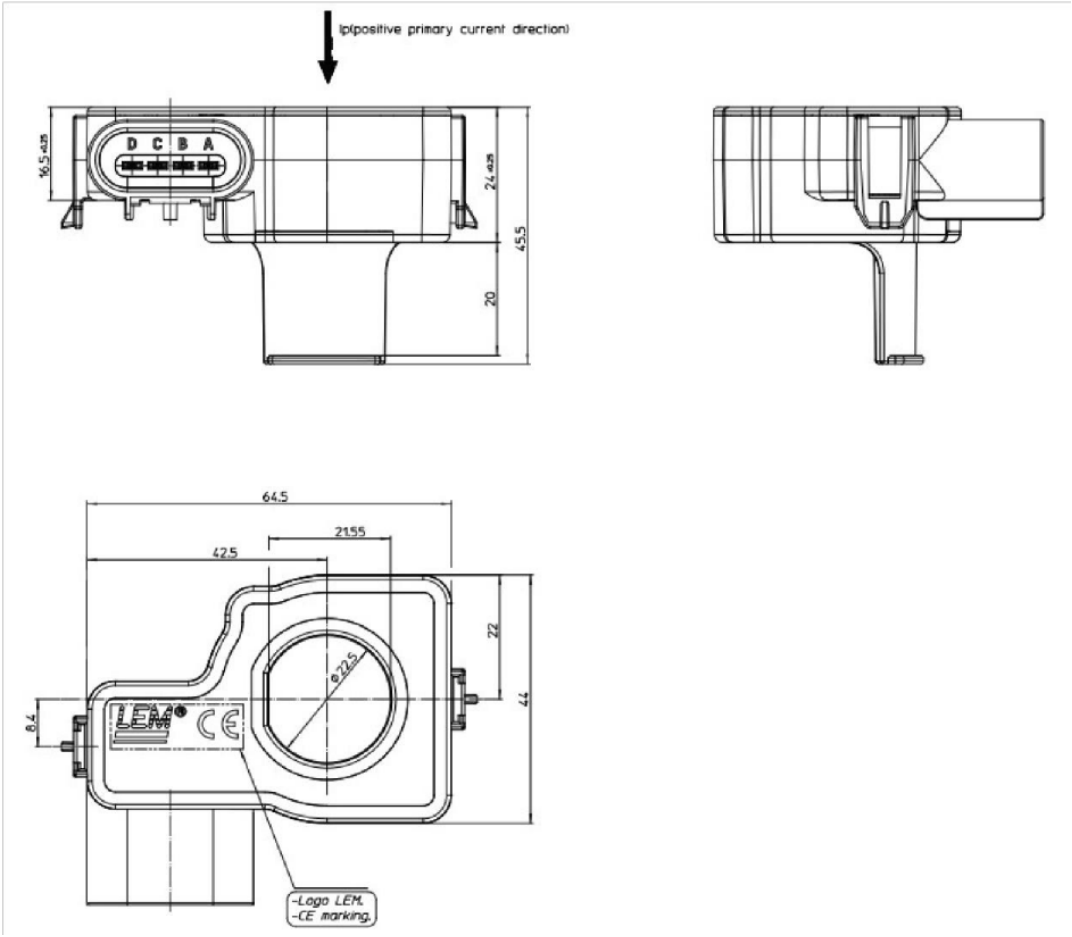
The team is responsible for locating the sensor body and running the sense line safely and securely. The team must be able to run the logger-side data cable back to the datalogger mounting position, outside of any HV enclosures.

The v1 HV sensor has a lower than ideal input resistance. This relatively low input resistance means that a small voltage drop occurs across the sensor, and this may have an effect on the vehicle's TS pre-charge behaviour. The input resistance is measured in an unconnected sensor at 57K Ohms. Teams must be aware of this characteristic when implementing pre-charge sensing, as behaviour may change by a proportionate scale once the HV sensor is attached. The v2 sensor has an ideal input resistance of approx. 1.5M Ohm and as such has negligible effect on the TS pre-charge sensing. V2 Kits will be supplied in preference however this is on a first come first served basis and teams will not have the opportunity to choose or to protest results based on the parameters of the supplied equipment.

CURRENT SENSOR

The v1 and v2 kits include an LEM automotive current sensor. v2 kits have a different model as the original sensor is no longer in production.

Current sensor in V1 kits: LEM DHAB S/15

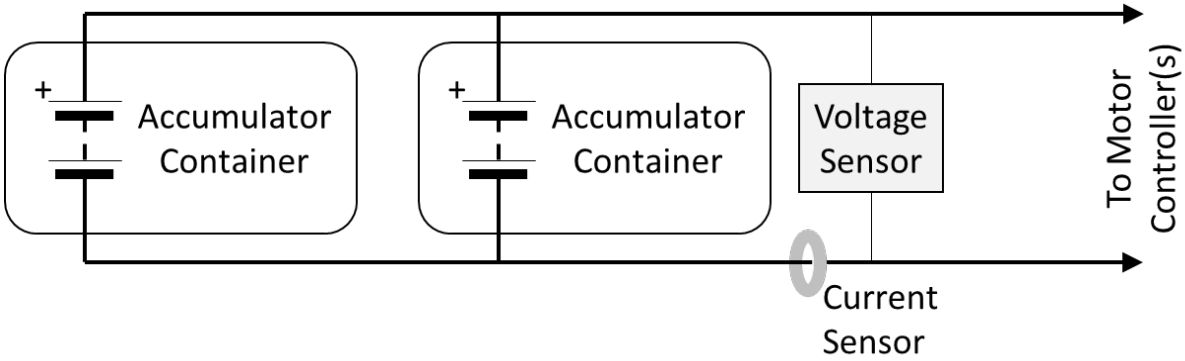


Current sensor in V2 Kits – LEM HTFS 400

CURRENT SENSOR MOUNTING

The current sensor must be oriented so that the primary forward current is in the following directions:

- V1: LEM DHAB S/15: Enters the sensor loop from the flush side and exits along the protruding channel.
- V2: LEM HTFS – Entering the sensor loop form the potted component side and exiting the flush silkscreened face.



It is recommended that the teams have a short removable section of unshielded HV cable on which to mount the current sensor. The sensor cores are not split and the internal diameter of the sensor is 21mm.

The sensors must be mounted on an UN-SHIELDED section of HV cable as the sensors will not detect the current Hall effect if the cables are shielded and grounded.

If a sensor is mounted on a shielded cable, resulting in the inability to calculate power consumption then the team will be found in violation as per rule D9.4.4

INSTALLATION VERIFICATION

Teams may request that data logs are verified in a static test, or for example after the brake test event, before competing in scored dynamic events. Availability of this opportunity is not guaranteed as EV scrutineers may not be available to assist, but requests will be accommodated where possible to ensure a working fleet of logger installations.