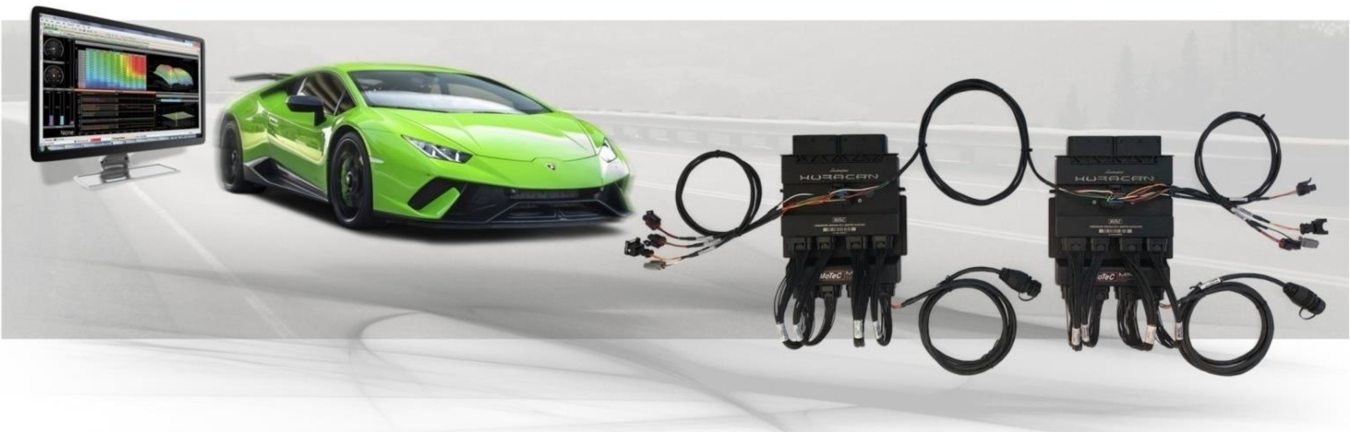

# M1 Lamborghini Huracan User Guide also suitable for Audi R8



02 September 2021

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# OVERVIEW

The information in this document is to assist users of the Lamborghini Huracan Plug-In Kit to get started with installation and initial tuning. Ongoing developments make this document subject to change.

The kit is also perfectly suited for the Audi R8 MY16+ (gen 2) vehicles. However, for simplicity the name Huracan will be used throughout this document to refer to the vehicle.

# KIT CONTENTS

## Hardware

**13142** - M142 ECU x 2
**61432** - M142 Lamborghini Huracan 2014 Adaptor Kit
**61404** - M1 Adaptor 250mm 26w Key 1 Stub Loom x 2
**61405** - M1 Adaptor 250mm 26w Key 3 Stub Loom x 2
**61406** - M1 Adaptor 250mm 34w Key 1 Stub Loom x 2
**61407** - M1 Adaptor 250mm 34w Key 2 Stub Loom x 2
**61433** - M142 Lamborghini Huracan 2014 Breakout Loom
**61434** - M142 Lamborghini Huracan 2014 Adaptor Master Box
**61436** - M142 Lamborghini Huracan 2014 Adaptor Slave Box

## Firmware Licences

**23390** – M1 Licence - Lamborghini Huracan 2014 Master
**23391** – M1 Licence - Lamborghini Huracan 2014 Slave

These Licences are required to run the Lamborghini Huracan 2014 Master and Slave M1 Packages in the M142 ECUs.

**Notes:**

- **Adaptor boxes:** The Master and Slave adaptor boxes look identical, however they are not interchangeable. They are clearly labelled Master and Slave. The licensing ensures the correct functioning of each ECU.
- **Lambda:** Inside each adaptor box is an LTC 4.9 device to connect the OE lambda sensors. See Lambda for configuration.

# DUAL ECU OPERATION

The Lamborghini Huracan Plug-In Kit contains two M142 ECUs. This mimics the OE ECU configuration and allows for a neat installation and ample I/O.

The Master ECU controls Bank 1 (RH side), while the Slave ECU controls Bank 2 (LH side). The Master ECU also drives additional items not related to an individual bank, like fuel pump and cooling fans. See Appendix: M142 ECU and Break Out Pinout for a detailed breakdown.

Using two ECUs requires some additional steps while tuning, as M1 Tune has been designed to update a single ECU at a time. For this reason, the ECUs are configured in a Master and Slave arrangement. The majority of tuning and calculations are performed in the Master ECU with commands to the Slave ECU sent via a dedicated CAN bus (in the OE loom).

All common tuning operations are carried out in the Master ECU. Only few setup items need to be adjusted in the Slave ECU. After initial installation the Slave ECU will rarely need to be adjusted.

The following lists every setup or tuning object that needs to be carried out in the Slave ECU. Anything not mentioned here is setup and tuned in the Master ECU only, as if it was a single ECU running the engine.

**Note:** If a group name is listed, this refers to all child objects in the group.

Most items listed below have been configured in the base calibration files available on MoTeC online. They do not need adjusting. They are listed here only for completeness.

## Paired Setup

This tuning must match in Master and Slave ECUs. If adjusted in the Master, the matching change needs to be made in the Slave.

Alternative Fuel Mode (only the mode parameter, all other flex fuel tuning is in the Master)
CAN Bus 2 Mode - should be set to 500kbps
CAN Bus 3 Mode - should be set to 1Mbps
Boost Actuator Frequency
Driver Switch 1
ECU Battery
Engine Speed Reference
Engine Speed Pin
Engine Run Switch
Exhaust Lambda Bank 2 Collector
Exhaust Lambda Cylinder 6 to 10 (if fitted)
Fuel Used Primary/Secondary Correction
Fuel Timing Primary Limit Margin
Fuel Timing Secondary Edge and Cycle Delay
Fuel Flow Sensors
Fuel Film (entire system)
Fuel Pressure Default
Fuel Pressure Regulator
Fuel Pressure Sensor (could have different sensors though)
Fuel Injector Primary and Secondary (except Secondary Contribution)
Fuel Output
Huracan CAN Bus - should be set to CAN Bus 2
Huracan Inter ECU CAN Bus - should be set to CAN Bus 3
Ignition Timing Limit Advance and Retard
Ignition Coil
Ignition Driver
Ignition Restrike
Ignition Output
Knock (almost entire system)
Throttle Servo Dead Band
Throttle Servo Zero

## Unpaired Setup

Tuning that exists in both ECUs but could be tuned differently in each ECU depending on application.

CAN Bus 1 Mode
E8XX

ECU Acceleration
ECU Receive
RS232 Baud Rate

## Slave Only Setup and Tuning

**Note:** Items marked with * should mirror Bank 1 or Cylinder 1 to 5 settings in the Master ECU

Airbox Mass Flow Bank 2
Boost Pressure Bank 2
Boost Actuator Bank 2 Output Resource
Boost Actuator Bank 2 Output 2 Resource
Boost Servo Bank 2 group*
Brake Vacuum Pump Relay
Engine Piston Cooling Solenoid
Exhaust Pressure Bank 2*
Exhaust Temperature Bank 2 Collector*
Exhaust Temperature Cylinder 6 to 10*
Exhaust Sound Actuator
Exhaust Camshaft Bank 2*
Fuel Pressure Direct Bank 2*
Fuel Purge Solenoid
Fuel Cylinder 6 to 10 Primary and Secondary Output Resources*
Gear Request Up and Down output setup (Tuning in Master ECU)
Huracan Engine Mount Solenoid output setup
Huracan Secondary Air Pressure Bank 2*
Ignition Cylinder 6 to 10 Resources*
Inlet Air Temperature Bank 2*
Inlet Manifold Pressure Bank 2*
Inlet Camshaft Bank 2 (Aim tuned in Master ECU)*
Throttle Servo Bank 2*
Wastegate Bank 2 Position*

## Methods of Dual ECU Tuning

While the ECUs look identical, they are not interchangeable. The licensing ensures only the correct package can be sent to each ECU, preventing any mix-up.

**Mirror Tuning Method**

This method uses a live setup to only one ECU and uses the other package to compare items.

- Open Slave package
- Open Master package as a compare
- Click *Tools > Migrate Data*
- Directly migrate all items in the above **Paired Setup** list that have different tuning
- Drag and drop Bank 1 into Bank 2 for any item in the **Slave Only Setup and Tuning** marked with * that have been tuned
- Save the Slave package and send to the Slave ECU

**Simultaneous Tuning Method**

This method uses a live setup with simultaneous connections to both ECUs.

- Use a standard Ethernet network switch or router to connect both ECUs and the PC onto one network.
- Open M1 Tune. This will lock the workspace.
- Open a second instance of M1 Tune. An error will be reported that the workspace cannot be accessed. This can be resolved by ensuring the second instance of M1 Tune uses a different workspace, either an existing one or a newly created one.
- Connect each ECU to its own instance of M1 Tune.
- Switch between the instances of M1 Tune, to tune both ECUs simultaneous.
  **Tip:** Parameter and Tables can be copied between the instances of M1 Tune using the context menus (right click).

**Logging and Diagnostics**

The important channels for diagnostics and logging existing in the Slave ECU are transferred via CAN bus to the Master ECU, for example, sensor result and diagnostic channels.

In addition, a dataset is send from Slave to Master ECU for logging purposes only. These channels are not used for control in the Master ECU. Currently the dataset contains:

- Knock Cylinder n Level A/B/C/D channels (200Hz update, 20 channels)
- Ignition Cylinder n Trim Knock (50Hz update, 5 channel)
- Fuel Cylinder n Trim Knock (50Hz update, 5 channels)

To disable this in order to save CPU usage and CAN bandwidth between ECUs, set *Huracan Inter ECU CAN Log Channels* parameter to *Disabled*.

Data exchange between the ECUs is performed with some reduction in resolution and update rate. These have been carefully chosen and will generally be sufficient. All important information is available from the Master ECU logging. In most cases it will not be necessary to connect to the Slave ECU to collect logging. However, for some diagnostic operations, it may be necessary to connect to the Slave ECU for live data analysis.

**Note:** the Slave ECU is supplied with the standard level 1 logging, but it is not intended to be used for any particular purpose.

## INSTALLATION

**Figure 1: Tools required to install the kit**

## Hardware

The Master and Slave adaptor boxes look identical, however are different internally. They are clearly labelled Master and Slave.

Similar the Master and Slave ECUs look identical. The correct ECU must be identified by relating the ECU serial number to the Master or Slave licence. The licence information provided separately.

1. Assemble both Master and Slave ECUs and adaptor boxes and the four stub looms to connect each ECU and adaptor. The connector with Ethernet cable is fitted to the ECU connector D.
2. Power off the car.
3. Remove the engine bay side covers, disconnect the engine harness connectors and remove both OE ECUs.
4. Fit the breakout loom roughly into position, loom running from side to side tied in, in front of the engine. This loom is symmetrical; it can be fitted either way around.
5. Although each ECU plus adaptor box assembly will fit in either side of the vehicle, it's important to ensure the Master is fitted on the right hand side (Bank 1) and the Slave on the left hand side (Bank 2).
   ***Left and right defined as sitting in the vehicle facing forward.***
6. Fit right hand side of breakout loom to the E connector on top of the Master adaptor box.
7. Fit Master ECU and adaptor box assembly to right hand side using the OE mounting brackets, slide and clip in.
8. Plug in the OE engine loom connectors.
9. Fit left hand side breakout loom to the E connector on top of the Slave adaptor box.
10. Fit Slave ECU and adaptor box assembly to left hand side using the OE mounting brackets, slide and clip in.
11. Plug in the OE engine loom connectors.
12. Finish routing and tying up the breakout loom, connect to additional sensors (if fitted) and fit Ethernet connections in a convenient location.
    **Tip:** run both Ethernet cables to one side of the engine bay, or find a passageway into the cabin.

## Firmware

### ECU Power

The ECU power is held on when the ignition is on, when M1 Tune is connected to either the Master or Slave ECU or for a short time after the ignition is turned off.

### Load Initial Firmware

**Important:** The following procedure is only required if the ECUs have not been preloaded with the Huracan firmware.

To load the initial firmware the ECU needs to be powered, however when turning the ignition on, other OE devices register a fault code because the ECU cannot transmit any CAN data. As a 'trick' to power the ECU without turning the ignition on, use the automatic power up that occurs for a short time when a door is opened. This will power the ECU and allow PC communications with the ECU with the ignition switched off. Regularly opening and closing the door at least once every 10s will keep the ECU powered and ensures uninterrupted transfer for the initial firmware loading.

This work around is only required once. For any additional firmware loading or tuning of one ECU, the other ECU will hold the power on for both ECUs until M1 Tune is disconnected.

1. Ensure the provided Master and Slave licences are preloaded on the PC
2. Ensure both M142 ECUs are fitted and the car is powered off
3. Connect the PC Ethernet cable to the Master ECU
4. **Open** the Huracan Master package in M1 Tune
5. Open the car door and click **Send package**
6. Enter the ECU serial number that appears as the connected device
7. Click **OK**
8. While the package is transmitting, open and close the car door regularly (at least once every 10 s) to ensure the ECU stays powered on
9. When the firmware is loaded and M1 Tune is still connected to the Master ECU, close the Master package and open the Slave package
10. Move the Ethernet connection to the Slave ECU
11. Repeat steps 5 - 8 to send the package to the Slave ECU

Once the Slave firmware is loaded the process is complete.

**Note:** If the firmware send fails due to the power turning off, just restart the process. The ECU will recover from this state.

## Wiring

Refer also the pinout listed in Breakout Connector E

The breakout connectors on each adaptor box provide a convenient location to wire additional inputs and outputs.

The breakout connectors also carry 5 share wires where outputs from the Slave ECU are shared to the Master ECU. **These must not be altered**.

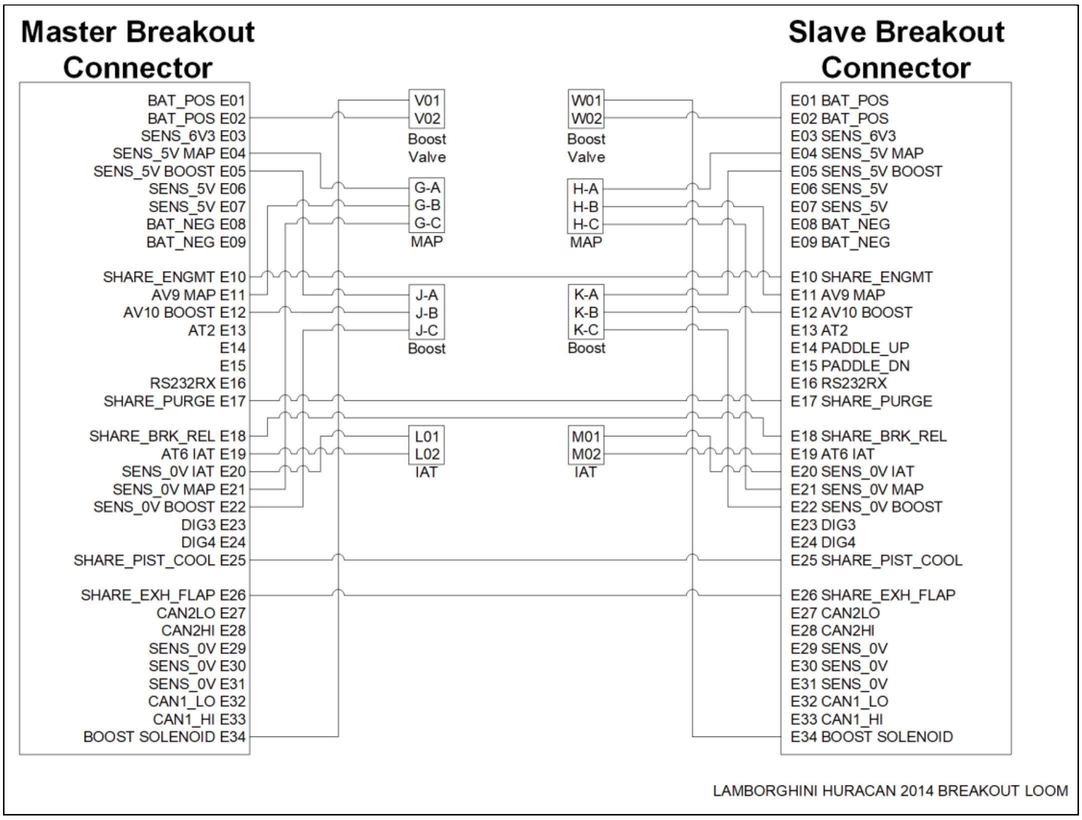



**Figure 2: Breakout Loom Schematic**

### Breakout Connector E - Intended Functionality

**Note:** Bank N refers to respectively Bank 1 for Master and Bank 2 for Slave.

- Inlet Manifold Pressure Sensor Bank N
- Boost Pressure Sensor Bank N
- Inlet Air Temperature Sensor Bank N
- Boost Control Solenoid Output Bank N
- Gear Shift Up (Slave ECU only)
- Gear Shift Down (Slave ECU only)
- Optional GPS (Master ECU only)
- Optional Power/CAN breakout for MoTeC Dash Displays (Master ECU only)

### Breakout Connector E - Spare Pins

- Spare 12 V, ground, 5 V and 0 V pins
- Spare inputs AT2, Dig3, Dig4 (typically driver switches)

Other spare pins can be made available by wiring into the stub looms between ECU and adaptor box. After all E-connector functions are used, there are spare pins in both Master and Slave ECU.

**Master and Slave ECU Connectors - Spare Pins**

- AV inputs 11, 12, 13, 14, 15, 16
- LA_NB1, LA_NB2
- HB 8
- LS Inj 6 (Master ECU only)

## Wiring for ECU Gear Shifting

**Note:** The wiring is different for Lamborghini Huracan models and Audi R8 models as the shift paddles are setup differently in the vehicles.

Gear shifts can be triggered by the M1 ECU when in manual shift mode based on Engine Speed, Throttle Position and Driver Switch setting. This allows for fully automatic gear shifting (up and down) and precise tuneability of the gear shift points for circuit or drag racing and street driving. See Transmission Control Module Integration to setup ECU gear shifting.

The Slave ECU is wired to the shift paddles to trigger the gear shifts. Wires can be spliced to the back of the OE TCM2 control unit harness connector located next to the Slave ECU.
**Important:** don't use the pins on the Master ECU adaptor.

**Huracan**

- Wire from Slave Breakout Connector E14 (Up Shift Paddle), splice to the OE TCM2 pin T81-12 (B12) violet/yellow wire.
- Wire from Slave Breakout Connector E15 (Down Shift Paddle), splice to the OE TCM2 pin T81-25 (B25) violet/red wire.

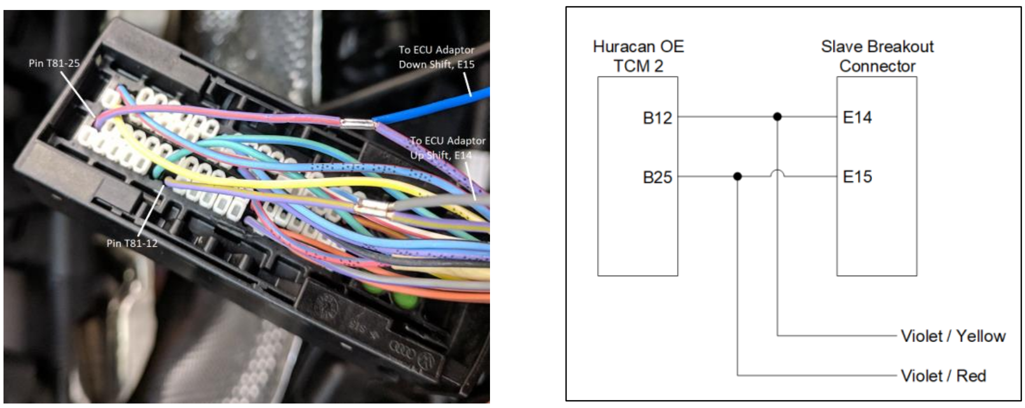



**Figure 3: TCM2 on the 81 pin connector, loom side with back shell removed showing wire spliced in.**

**Audi R8**

- Connect a 7.6k ohm resistor to Slave Breakout Connector E14 (Up Shift Paddle)
- Connect a 2.7k ohm resistor to Slave Breakout Connector E15 (Down Shift Paddle)
- Splice the free end of the two resistors together and splice to pin OE TCM2 pin T81-79 (B79) blue/white wire.

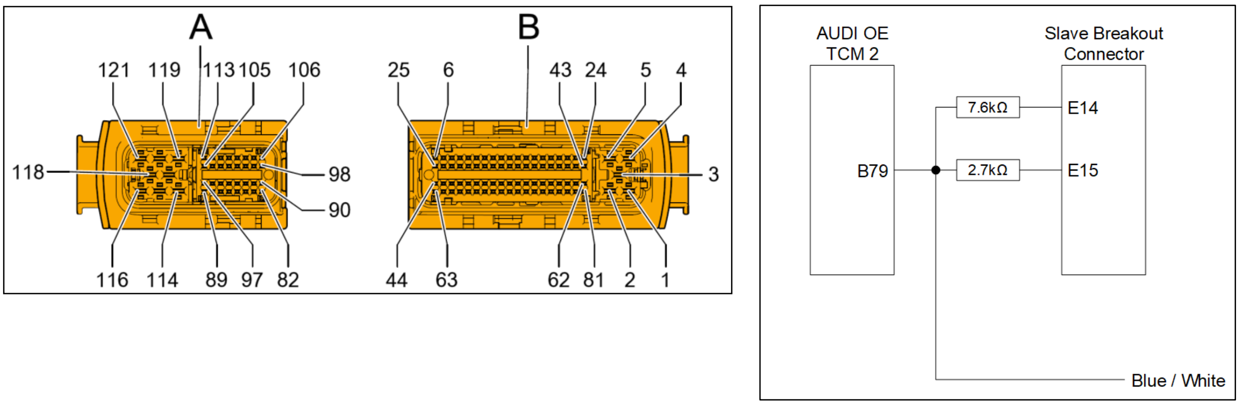



**Figure 4: TCM2 loom connector pin numbering (pin side)**

**Gear Shifting Set Up:**

- Calibrate in Master ECU the Gear Request, Gear Automatic and Gear Shift groups.
- Calibrate in Slave ECU the Gear Request group.

Configuration:

- Gear Request Up Output Resource on the Slave ECU is configured to Ignition Low Side 7.
- Gear Request Down Output Resource on the Slave ECU is configured to Ignition Low Side 8.
- Gear Automatic Mode in the Master ECU is configured to Enabled.

## M1 CAN Bus Allocation

Each ECU has 3 CAN busses. They are pre-wired in this kit and allocated as follows:

| | Bus 1 | Bus 2 | Bus 3 |
|---|---|---|---|
| Master ECU | User CAN bus (e.g. Colour Displays, PDMs) | OE powertrain bus<br>Master and Slave linked | Inter ECU and LTC bus<br>Master and Slave linked |
| Slave ECU | Reserved | | |
| Messaging | Includes M1 General 0x640, 0x650, 0x660, 0x670 CAN | Mimics that of the OE ECUs to provide full integration of engine and vehicle functions | Information exchange between the Master and Slave ECUs<br>No interaction with the vehicle |
| Baud Speed | As required | 500 kbps | 1 Mbps |
| Connection | Breakout Connector E32, 33 | Breakout Connector E27, 28 and ECU harness connector 91/79, 91/80 | ECU harness connector 91/77, 91/60 |

# COMMON MODIFICATIONS

While many components may be changed to achieve better performance, some combinations are more likely to deliver improvements with minimal re-tuning from the installer, tuner, or customer.

In general, OE fuel injection components are suitable for improved performance. However, when they reach their capability limits (for example, inadequate injector flow), these can be replaced with higher performance alternative components.

MoTeC has conducted many tests to characterise components for optimal performance within the M1 environment. This is particularly relevant in regard to our comprehensive, precise and highly repeatable injection calibration testing, which allows for fuel pressure and supply voltage variations. Each injector for which we supply data has been subject to 400 tests.

MoTeC's recommends choosing components from our list of suitable options when selecting alternative parts.

Each component listed below includes the settings which should be adjusted or checked with M1 Tune. Clicking on these settings within M1 Tune, displays operational help relevant to the item.

## MAF (Mass Air Flow) Sensor

The MAF sensor signal can be used for fuelling. The OE MAF sensor provides an adequate measurement range for the naturally aspirated engine. If the sensor is placed in a housing with a larger diameter it is necessary to adjust the sensor calibration.

Optionally the MAF sensors may be removed and replaced by MAP sensors for fuelling.

## MAP (Manifold Absolute Pressure), Air Temperature and Boost Sensors

### Unmodified engine installation

Fitting additional sensors to the engine is up to the installer. For a standard car (non turbo), no additional sensors are necessary. It is possible to use the original MAF sensors for engine load. However, fitting at least one MAP sensor is recommended.

A common installation for operation of the vehicle with this Plug-In Kit allows for the following additional sensors connected to the Master and Slave Breakout Boxes

- Inlet manifold pressure sensor for bank 1 and bank 2
- Inlet air temperature sensor for bank 1 and bank 2

Common connectors are provided on the included breakout loom. For air temperature sensors a DTM2F connector is provided and for pressure sensor round Packard Metri-pack connectors are provided. When choosing sensors with different connectors, the provided connectors need to be modified as required.

Possible options for this sensor installation are:

1. MoTeC Part no. 53010 - a Bosch integrated temperature and pressure sensor (TMAP sensor) that operates from 20 to 300 kPa and -20 to 130 °C.

2. External pressure sensors and air temperature sensors.
   Suitable air temperature sensors with MoTeC calibration include:
   - Bosch 0 280 130 039 - JGM 280 039
   - Bosch 0 280 130 060 - JGM 280 060

- Delphi 1261 4717 - MoTeC Part no. 54012
- Delphi 2503 7225 - MoTeC Part no. 54001
- KA NPT2
- KA NTC2
- KA NTC2F

**Boosted engine installation**

Boost control is included in this product to accommodate the likely addition of turbochargers to the engine.

Turbocharged engines require the installation of boost pressure sensors in addition to the sensors recommended for unmodified engines for correct functioning of the boost and torque control. To fit all recommended sensors may require removal of the inlet manifold.

A common installation for this Plug-In Kit for turbocharged engines consists of the following additional sensors connected to the Master and Slave breakout boxes:

Inlet manifold pressure Bank 1 and 2 – as per unmodified engine
Inlet air temperature Bank 1 and 2 – as per unmodified engine
Boost pressure Bank 1 and 2

MAP sensors should be fitted to the plenum of each bank and must cover the full range of boost down to high vacuum. For higher boost levels TI (Honeywell) sensors are suggested.

Boost pressure sensors should ideally be fitted pre-throttle in the boost pipework and must cover the full range of boost pressures needed. Correct choice and installation of these sensors is critically important for successful running of the Package. Boost sensors must be absolute or sealed gauge type sensors (gauge sensors are not supported). Sensors don't need a range below ambient pressure (vacuum).

For boost pressure sensors, Packard Metri-Pack connectors are provided in the break out loom, one for each bank.

If boost control is facilitated by means of servo actuators or CO2 style solenoids rather than typical boost valves, email MoTeC for additional information on connecting and configuring these devices.

## Turbo and Wastegate

Any suitable turbo and wastegate combination may be used.

**Note:** If a turbocharger kit is added, exhaust pressure can cause some error in the lambda reading. To prevent this, the lambda sensor should be moved to the turbo dump pipe.

**Turbo and Wastegate Set Up**

- The settings in the Boost group will need adjusting
- In addition, the settings in Boost Servo or Wastegate groups may also need adjusting depending on the wastegate type

## Fuel Injection

Typically only port injectors will be changed as availability of DI injectors is limited.

**Fuel Injection Set Up**

- The settings in the Fuel Injector group must be adjusted. If accurate injector calibrations are used, only minor re-tuning may be necessary.

## Throttle Bodies

Any throttle body with direct actuation of the DC servo can be used, including those with digital SENT throttle position sensors.

**Throttle Bodies Set Up**

The settings in the following groups must be tuned:

- Throttle Servo
- Throttle Mass Flow Area Factor
- Throttle Area

## Inlet Manifold and Plenum Chamber

If the OE inlet manifold is changed, this can have a small effect on the Torque Control System.

**Inlet Manifold and Plenum Chamber Set Up**

The settings in the following groups must be adjusted:

- Inlet Manifold Volume set to the new manifold volume.
- Inlet Manifold Pumping Gain set by testing the response of a changing torque limit.
- A change in the manifold will also likely change the engine's pumping efficiency so re-tuning of fuel and ignition should be carried out.

## Fuel Pumps

The M1 Package has flexible configuration to allow switched, PWM or closed loop PWM control of up to 5 separate fuel pumps. An external driver module such as MoTeC Dual Half Bridge (DHB) may be used for high current PWM control.

**Fuel Pumps Set Up**

The settings in the following groups must be adjusted:

- Fuel Pump
- Fuel Pressure Control
- Alternative Fuel Pump

Please refer to the Help in the Package for more information

## Intercooler

Water-to-air intercoolers are commonly fitted when turbo charging the engine.

**Intercooler Set Up**

The settings in the Intercooler Coolant group must be configured to control the cooling of the intercooler water.

# VEHICLE INTEGRATION

## Torque Control

The ECU firmware uses a torque modelling and control system. As the engine does not have a dedicated torque sensor, a torque measurement is derived from air flow into the engine which has a reasonably accurate and linear relationship to the torque the engine produces. Using torque is useful as it is relatable to other vehicle systems, like the clutch or to vehicle acceleration. Engine cylinder cut events or ignition timing changes are also relatable to a reduction in torque and so using torque allows multiple methods of controlling torque to be integrated together.

As torque is related to air flow, all throttle commanded positions are derived from the Torque Aim system. For example, the Throttle Pedal does not set the Throttle Position, but it sets a Torque Aim. This allows the throttle to give a more linear and consistent response.

The Direct Shift Gearbox (DSG) Transmission Control Module (TCM) interfaces with the ECU via CAN and requests torque reductions for seamless gear shifting. This is achieved through a combination of ignition retard and fuel cut in a manner similar to the OE control system.

The torque control system requires relatively accurate calibrations of all sensors and injectors for a naturally accurate torque model and torque control without additional complex tuning.

### Torque Control Tuning

The torque control system uses a mathematical model of engine mass air flow and uses a linear scaling from air flow to engine power with compensations.

This means the majority of the torque control system is tuned by tuning the Engine Efficiency table (air pumping efficiency of the engine) when the fuelling is tuned via the Lambda measurement.

Additional is required for the torque losses in friction and driving engine ancillaries and is applied as an offset. For more information, see Help in M1 Tune for Torque Ideal Correction.

For torque control, the throttle is moved to a position based on the model of throttle mass air flow to achieve the desired engine torque. Additional tuning required for this to function correctly is performed in the Throttle Area table. This single axis table provides the ECU with the relationship between butterfly position and opening area. This can be tuned by matching *Inlet Manifold Pressure Bank n Sensor* to *Inlet Manifold Pressure Modelled*. Increasing the *Throttle Area* value results in a higher air flow value in the throttle mass flow model. More air flowing into the manifold increases the modelled manifold pressure.

**Important:** Ensure when tuning this table that the values are always ascending. The control will malfunction if this is not maintained.

**Tip:** This can be tuned via the Quick tune function (keyboard shortcut **Q**) on the *Throttle Area* table.

**Tip:** To tune an exact *Throttle Area* table site, use the *Throttle Servo Test Static* function. This limits the position of the throttle while the engine is running. Ensure the pedal is pressed sufficiently to reach the Test position.

## Reference Mode

The M1 reference mode in this Package is locked to this engine variant.

## Vehicle On/Off Switch

Vehicle On/Off sense is via Driver Switch 1 which is linked to Engine Run Switch.

This is controlled by pressing the Engine Start button and operates the same as OE.

Also, the M1 ECU will be powered whenever the vehicle is 'active', e.g. when the door is open and self-powers down after some time, around 30s.

**Note:** The M1 ECU will remain powered on while it is connected to M1 Tune even if the vehicle is turned off.

Resetting the M1 while the vehicle is on will interrupt the CAN communications on the vehicle CAN bus causing other CAN modules to display errors on the dash. To avoid this, turn the vehicle off before resetting the M1 ECU or sending a new package/tuning update to the ECU.

## Vehicle Model Selection

The kit supports all models of Huracan and Audi R8 (Gen 2) vehicles, however there are some differences between models. The main differences between Huracan and Audi R8 are the driver display and controls like cruise control switches and drive mode selection. Ensure the correct model is selected for your vehicle so that the ECU integrates correctly.

For RWD vehicles ensure the Vehicle Drive Type is set to 'Rear'. For AWD vehicles, this must be set to 'All Rear Bias'.

## Cruise Control

Information to follow later.

## Drive Mode Switch

**Huracan:**

The drive mode switch selects between Strada, Sport and Corsa drive mode.

**Audi R8:**

The drive mode switch selects between Comfort, Auto, Dynamic and individual modes. Individual mode follows the mode set for the Engine in the Individual setup as Comfort, Auto or Dynamic.
A separate button on the steering wheel selects Performance mode. This overrides the Comfort, Auto or Dynamic setting.

The drive mode is reported in the Huracan Driver Mode channel. To change the ECUs maps or behaviour based on the vehicles drive mode, select drive mode in the driver switch index parameters and map as required to the driver switch functions. There are many options available to provide control to the preferred behaviour.

## Additional Driver Switches

Three additional driver switches with 0-9 positions are accessible using the cruise control buttons and switch position. They are displayed on the driver display utilising the tacho and redline indicators.

When in switch setting mode, the tacho red line indicator shows which switch is being changed, 2000 rpm for switch 2, 3000 rpm for switch 3 or 4000 rpm for switch 4. The tacho shows the switch setting, 0 rpm for position 0 and 9000 rpm for position 9.

The result of the switch settings can be seen in Huracan Driver Switch 2, 3 and 4 channels. These can be selected on any Driver Switch Index to link to other subsystems, for example change torque limits, traction control, or enable anti lag.

The settings are retained when the ECU is powered off, however are cleared if the ECU firmware is updated (values reset to zero).

The Huracan and Audi R8 have different controls for setting cruise control and so have different methods for accessing the switch setting mode.

**Huracan:**

- To access switch setting mode, when in Sport or Corsa drive modes, press the Cruise On/Off button to turn ON (latches down).
  Cruise control is not allowed in these drive modes, and the driver switch setting mode is entered instead.
- While the switch position is displayed,
  - press the cruise up or down buttons to change the switch setting.
  - press the Cruise On/Off button to turn OFF and press again quickly to turn back ON switch setting mode to cycle to the next switch setting shown on the redline indicator.
- To leave switch setting mode, press the Cruise On/Off button to turn OFF, or wait to time-out.

**Audi R8:**

- To access switch setting mode, use the cruise control stalk.
  With the stalk in the ON position, press and hold the Set button for 1sec to enter switch setting mode.
- While the switch position is displayed
  - Lift (accelerate) or lower (coast) the cruise stalk to change the switch setting.
  - Pull the cruise stalk forward (resume) to cycle to the next switch setting.
  - Press set again (short press) to exit switch setting mode, or wait to timeout.

The time after which the display will timeout can be adjusted in the Huracan Driver Display Timeout setting.

The number of switch settings and positions can be limited to simplify the mechanism for the driver. See Huracan Driver Maximum Setting and Maximum Switch settings.

For example, if Maximum Setting is Five, only switch position Zero to Five is available and if Maximum Switch is 3, then only Switch 2 and Switch 3 can be accessed.

## Check Engine Light

The detailed and user definable warning system built into the M1 firmware activates the CEL based on the Warning Severity channel.

## Cooling Fan Control

Each cooling fan is independently speed controlled by a PWM signal. To access this control in M1 Tune select *Coolant > Fan 1 > Duty Cycle > Coolant Temperature table* and *Coolant > Fan 2 > Duty Cycle > Coolant Temperature table*.

## Power and Torque Gauges

The Audi R8 can display power and torque gauges on the instrument cluster. When a modified engine makes significantly more power and torque than OE, the gauges scaling may be unsuitable.

To scale the power and torque gauges use the Huracan Meter Power Torque Scale parameter.

| Huracan Meter Power Torque Scale parameter | 100% torque gauge | 100% power gauge |
|---|---|---|
| 100% (equivalent to OE scaling) | 540 Nm | 396.6kW |
| 50% | 1080 Nm | 793.2 kW |

The Huracan Meter Power Torque Filter can smooth the movement of the gauges as desired.

## Oil Level Display and Warnings

The engine is fitted with an oil level sensor in the dry sump tank. The sensor has a digital output read by the ECU with an approximately 1sec update rate. The oil level reported by the sensor can change drastically depending on operating conditions, temperature, engine running or stopped, etc. For this reason, the Engine Oil Level Filtered channel is created and conditionally updated to give a more stable and reliable value to use for displaying the oil level on the OE cluster (Audi R8 only) and cluster tell-tales high oil and low oil level. The conditions for generating this channel are hard coded to perform similarly to the OE ECU, no settings are required.

The Sensor measures a distance from the bottom of the sensor to the oil level in the tank. This distance is converted to a percentage with the Min and Max setting so the Engine Oil Level reports 0% when at Min and 100% when at Max. The oil level sensor can be calibrated with the minimum and maximum oil levels.

The tell-tales are based on Engine Oil Level Filtered and the trigger levels can also be set.

Additionally, the Engine Oil Level Warning has separate level and time delay settings that are fully configurable. This reads the unfiltered Engine Oil Level and triggers the ‘Add Oil Immediately’ tell-tale on the dash as well as optionally setting the CEL, rev and torque limits. This is intended for very low oil level warning, like if a fast oil leak developed while driving, this could warn the driver before losing oil pressure.

## Additional Transmission Data

The ECU has the ability to request and log internal transmission data using the on board diagnostic (OBD) functionality used by a factory service tool. Each channel can be individually selected to be requested.

**Note:** The update rate of these channels is limited and selecting more channels updates slower.

The following data is currently available:

- Line Pressure
- Clutch A Pressure
- Clutch A Pressure Aim
- Clutch A Torque Aim
- Clutch A Temperature
- Clutch B Pressure
- Clutch B Pressure Aim
- Clutch B Torque Aim
- Clutch B Temperature

Future firmware updates will include additional available channels.

**Note:** A service tool connected to the OBD port will not be able to communicate with the TCM while the ECU is actively requesting OBD channels. The M1 ECU only requests data while the logging is running and to prevent simultaneously communication the logging can be set up conditionally. Another option is to turn off logging (using M1 Tune) before connecting a service tool.

## Engine Starter Control

The ECU controls the starter motor. The settings can be found in the *Huracan Start group*.

A request to start the engine comes from the body control module on CAN and wired signal. The ECU reads these signals and decides if it is safe the crank the engine. The engine cranks until the engine speed exceeds the *Huracan Start Engine Speed threshold*. Cranking is stopped if the engine fails to start after 5sec or if the starter button is pushed again to turn off the vehicle.

## Transmission Control Module Integration

The ECU interfaces directly with the Transmission Control Module (TCM) to achieve seamless gear shifting as per factory settings and correct clutch control for take-off and driving.

For upshift the TCM request a reduction in torque and the ECU delivers the reduced torque with a combination of retarding the ignition timing and cutting fuel injection, depending on the operating conditions at the time and ECU tuning.

For downshift, the TCM requests an engine speed and the ECU delivers the engine speed by opening the throttles and controlling the ignition timing to accelerate and hold the exact engine speed.

During these times the TCM controls the dual clutches to provide fast and smooth change of gear, but it can only do so with the correct torque and speed from the engine.

The systems in the ECU that perform the torque reductions and rev matching are fully tuneable. In some applications, preferred shift feel may be achieved by changing the tuning to give different torque than requested by the TCM. Or the requested torque can be ignored altogether and fully configured in the ECU using the *Gear Up Shift group.* See *Huracan TCM, Engine Speed Control, Gear Up Shift* and *Torque Reduction groups* and *Huracan Torque Translation, Huracan Throttle Pedal Translation* and *Huracan Engine Speed Translation tables*.

## Vehicle Dynamic Control (ABS) integration

The ECU receives data from the Vehicle Dynamic Control (ABS) module including:

- Wheel Hub Speeds x 4
- Vehicle Speed
- Brake Pressure
- Acceleration Lateral and Longitudinal
- Yaw Rate
- Diagnostic and State
- Torque Request

Sensor values are available on the relevant Sensor Source parameter by selecting OE CAN.

The individual wheel speeds are received as linear speed but converted to rotational speed using the *Huracan VDC Wheel Speed Circumference* setting. This is effectively the wheel circumference set in the VDC programming for standard wheels. If different sized wheels are fitted, do not alter this setting. Only change the *Wheel Speed Front/Rear Circumference* to correct the final *Wheel Speed* values.

Torque requests are made for traction and stability control. These values can be adhered to fully or partially or completely ignored, based on the *Huracan VDC Torque Limit Gain*. Ideally the torque limits are obeyed, however in some circumstances they can be too intrusive and an ECU based traction control that is fully tuneable can be used instead.

The ECU also transmits all required data to the VDC to keep it functioning and error free.

## Other Vehicle Specific Systems

### Air Conditioner

The ECU can request the air conditioner compressor to turn off or reduce cooling but does not directly control the air conditional compressor. The air conditioner reports the torque used by the compressor and the ECU includes this in the *Torque Ideal Correction* to compensate for idle control.

The following requests are used:

- Off - if Air Conditioner Clutch State is Off
- Reduced cooling - if Engine Speed is High
- Disabled - if Coolant Temperature Warning is Active

### Secondary Air Emissions System

This system is not controlled by the ECU, however the pressure sensors are read.

### Launch Control

The TCM command the ECU to enter launch mode when the brake pedal is released. To ensure the ECU works with the TCM to achieve a good launch this is the only trigger available. The command is reported in the *Huracan Launch Request* channel.

All other launch behaviour, like Engine Speed and Boost, is fully tuneable.

### Alternator

The Body Control Module (BCM) controls the alternator and reports the engine power consumed. The ECU includes this in the *Torque Ideal Correction* to compensate for idle control, e.g. when cooling fans are running or headlights are on adding demand to the electrical system. This has a scaling factor that can be tuned.

### Other Received Values

- Steering Angle
- Fuel Level
- Odometer
- Time and Date (rolled into a single Unix Time channel)

## Fuel Pump Control

The OE fuel pump is variable speed and located in the tank. The speed is controlled by a PWM signal from the ECU. Low pressure fuel (5 bar) is delivered to the port injectors and the high pressure fuel pumps inlet using the *Fuel Pressure Control* closed loop system.

**Fuel Pump Set Up**

The settings in the *Fuel Pressure Control group* must be configured.

## Coolant Pump Afterrun Control

Coolant circulation after the engine stops is controlled with respect to *Coolant Temperature* or *Engine Load Average.*

**Coolant Pump Set Up**

The settings in the *Coolant Pump Duty Cycle table* must be configured.

## Idle Control

The system operates on the same principle as other MotecM1 ECU firmwares using high response ignition timing control over lower response torque (throttle) control. Further idle control strategy improvements used in this firmware are for drivability and seamless entry and exit from idle control.

The air flow into the engine for idle control is defined as ‘engine power’ and uses a simple integral calculation. This has the following advantages:

- Engine power has a direct relation to the torque control system.
- Torque compensation for air conditioner, alternator and gearbox loads at idle are directly integrated.
- With the idle system controlling engine power, there is a natural proportional gain between engine speed and torque. For example, if the engine speed halves, the torque must double to maintain the same power generated.
- With a torque based pedal, the nominal amount of torque (air flow) required is learned and stored in the *Idle Torque Nominal* channel. This is integrated into the *Throttle Pedal Torque Aim* for seamless transition out of idle control when the throttle pedal is pressed.
- A dedicated Idle Feed Forward is no longer required. The effective feedforward for the idle control is tuned in the *Torque Ideal Correction* tables that are used to correct *Torque Generated* into flywheel torque.
  When the engine is running at a constant speed with no load placed on the flywheel, flywheel torque is zero Nm. The mechanical energy produced by the engine is completely used to overcome internal friction and driving ancillary loads like the oil pump, alternator, etc.
  The *Idle Control Power* system always targets zero kW of flywheel power and does not need its own feedforward tables. This zero torque is based on best ignition timing. When entering idle control, ignition timing is reduced from best ignition timing. This results in positive fly wheel power when idling ensuring negative torque to slow down the engine.
  Both the torque calculation and idle control need corrections for non-flywheel loads put on the engine. To do this the alternator, air conditioner and transmission systems are applied in the *Torque Ideal Correction*.

## Engine Overrun (and Throttle Damper)

The engine overrun system aims to softly transition into and out of fuel cut (full engine braking), without a noticeable bump.

*Throttle Pedal Damper* achieves the softening effect within the damper system.

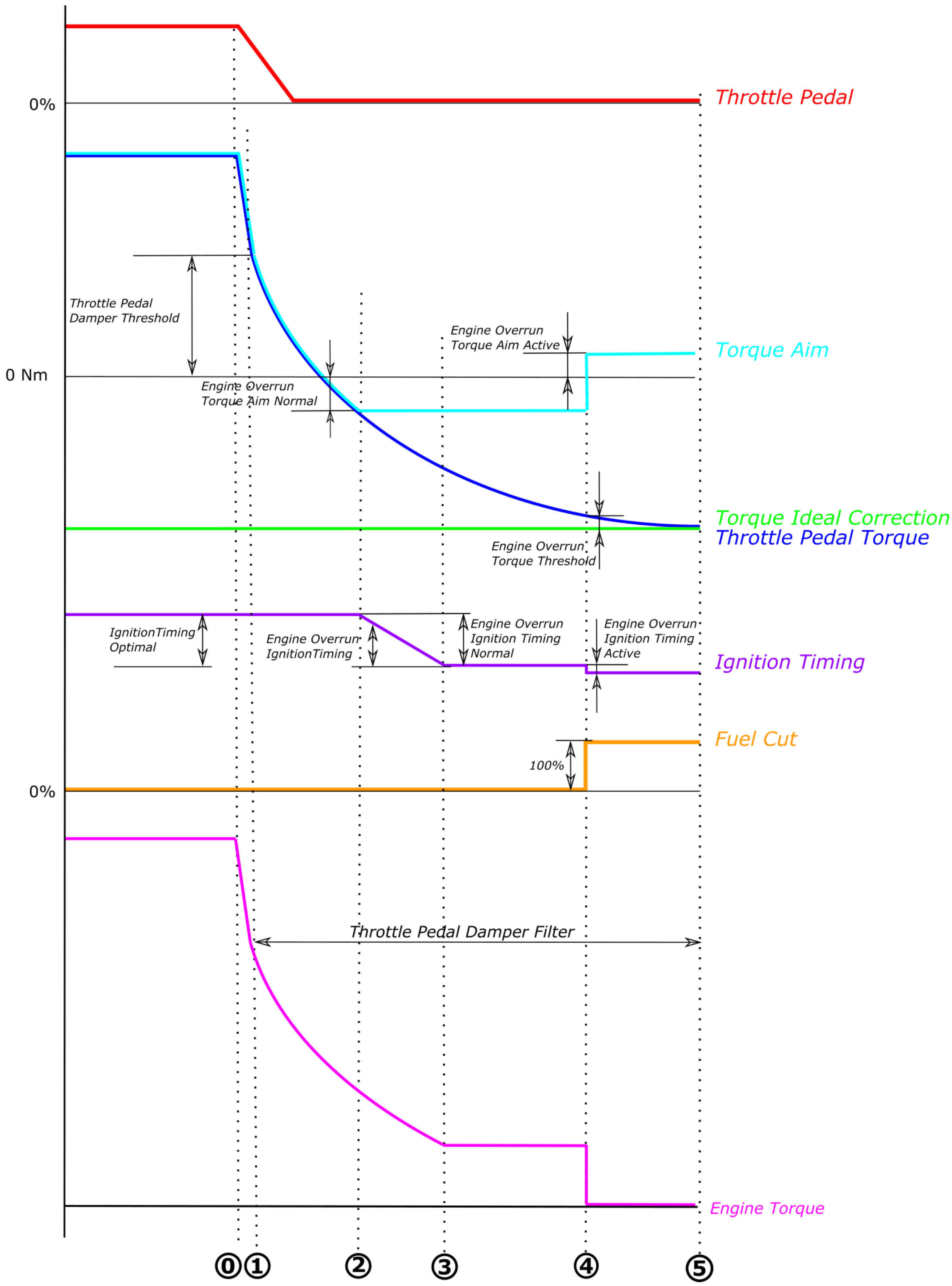
The system is fully tuneable to suit the driver's preference or vehicles application, but to make the appropriate adjustments it's important to understand how each tuning parameter affects the final engine torque.

The engine overrun system activates when the *Throttle Pedal* is at 0% and the engine speed is above *Idle Aim* speed (by the *Idle Activate Margin)*

The engine overrun system manages the reduction of engine torque to full engine braking in the following sequential steps:

- Reduce air inlet flow to minimum. The minimum *Torque Aim* is set by *Engine Overrun Torque Aim Normal* to maintain some air flow.
- Retard ignition. *Engine Overrun Ignition Timing Normal* is the minimum ignition timing (maximum retard) set by *Engine Overrun Ignition Timing.*
- Activate fuel cut, when *Throttle Pedal Torque* falls below *Engine Overrun Torque Threshold.*

The below diagram shows a time graph example of the transition into overrun cut (outside of idle control).



⓪ The driver lifts the **Throttle Pedal** to 0%, causing **Throttle Pedal Torque** to fall. While the **Throttle Pedal Torque** is above the *Throttle Pedal Damper Threshold* the value is unfiltered.

① Once below the *Throttle Pedal Damper Threshold*, filtering is applied so **Throttle Pedal Torque** falls with a curve. The total duration of the curve is set by *Throttle Pedal Damper Filter.*

**Torque Aim** follows this curve until it reaches *Engine Overrun Torque Aim Normal*.

② At this point the throttle is not closed any further. While **Throttle Pedal Torque** continues to fall, further reduction of **Engine Torque** is achieved with **Ignition Timing**. The timing is retarded from *Ignition Timing Optimal* (main table) to *Engine Overrun Ignition Timing*. This timing is calculated from the difference between **Torque Aim** and **Throttle Pedal Torque**.

③ The maximum amount of retard (minimum ignition timing) is limited by *Engine Overrun Ignition Timing Normal* and once this limit is reached, the **Engine Torque** will not be reduced further.

④ When the **Throttle Pedal Torque** falls further to below the *Engine Overrun Torque Threshold (*margin of **Torque Ideal Correction)***,* **Fuel Cut** is applied. Also at this time the **Torque Aim** is set to the *Engine Overrun Torque Aim Active* which is typically set higher than the *Engine Overrun Torque Aim Normal* setting for better downshift blip response (more air in the manifold). Also *Ignition Timing* is set to *Engine Overrun Ignition Timing Active*, typically set more retarded then *Normal*.

The reverse happens if the **Throttle Pedal** is pressed very lightly, requesting less **Throttle Pedal Torque** than the *Engine Overrun Torque Aim Normal.* **Fuel Cut** ends and **Ignition Timing** is controlled to deliver the requested **Engine Torque** but the throttle will not open until the **Throttle Pedal Torque** is greater than *Engine Overrun Torque Aim Normal*.

**Engine Overrun Settings Descriptions**

- *Engine Overrun Mode*, sets if fuel cut is used. ④ - ⑤
  **Note:** if fuel cut is not used the system still operates in the same way for ignition timing and torque aim.
- *Engine Overrun Torque Threshold*, effectively sets how long to wait after the throttle is lifted before fuel cut is started. This time is affected by the *Throttle Pedal Damper Filter* and *Throttle Pedal Damper Threshold*. These should be tuned first and data reviewed to set an appropriate threshold. Lower values wait longer.
- *Engine Overrun Torque Aim Active*, *Engine Overrun Torque Aim* when fuel cut is active affects downshift blip response and engine braking. If these are set too high the transition out of overrun on light pedal application may become rougher.
- *Engine Overrun Torque Aim Normal* is used before fuel cut is active. This sets the effective minimum throttle opening, and when torque control transitions from throttle to ignition timing control. If set too low, the engine will see high vacuum and may not recover from overrun cut as well. If set too high, ignition timing may be retarded at light load driving (lowering fuel efficiency).
- *Engine Overrun Ignition Timing Normal*, sets the maximum retard of *Engine Overrun Ignition Timing*. If set to high (advanced), torque may not be reduced enough to remove the 'bump' when fuel cut is activated. If set to low (retarded) the engine may misfire/pop. This must be balanced with the *Engine Overrun Torque Aim Normal* setting to provide the right amount of engine braking before fuel cut is started.
- *Throttle Pedal Damper Filter*, changes the time it takes for the *Throttle Pedal Torque* to fall/change. This affects how quickly the demanded torque falls and therefore how long it takes to fully move into fuel cut.
- *Throttle Pedal Damper Threshold* is a channel that defines when the above filter is applied. This is calculated by:

- *Throttle Pedal Damper Threshold Minimum* sets the minimum value for *Throttle Pedal Damper Threshold*. This is used when lifting the pedal from a cruise or low acceleration.
- *Throttle Pedal Damper Threshold Maximum* sets the maximum value for *Throttle Pedal Damper Threshold*. This is used when lifting the pedal from high acceleration. In this case, better feel for the transition into overrun can be achieved if starting the filtering of the *Throttle Pedal Torque* from a higher point so the acceleration to deceleration is not as sudden.
- *Throttle Pedal Damper Threshold Filter*, changes how long the throttle needs to be pressed before the *Threshold* transitions from *Minimum* to *Maximum*.
- *Throttle Pedal Damper Threshold Scale*, changes how far the throttle needs to be pressed before the *Threshold* transitions from *Minimum* to *Maximum*.

### Engine Speed Control

The Engine Speed Control system is used for rev matching on downshift (throttle blip). The system requests torque based on a simplified proportional control between limits. This opens the throttle to rev the engine, and once near the target engine speed the throttle is partially closed and held stable while the *Ignition Timing Control* system is utilised to accurately target the requested engine speed by retarding the ignition timing.

**Engine Speed Control Set Up**

The settings in both *Engine Speed Control* and *Ignition Timing Control* groups must be configured.

***Note***: *Ignition Timing Control* is used by multiple subsystems. The tables in the group have setting for each subsystem that uses this system. Only table values for *Engine Speed Control* should be adjusted for tuning the downshift engine speed matching.

### Other Control Systems

The following control systems mimic the OE vehicle operation:

- Intake Air Filter Bypass Control
- Purge Canister Control - both purge solenoids are wired together and thus operate simultaneously.
- Brake Vacuum Pump Control
- Exhaust Sound Control
- Electrohydraulic Engine Mount Control
- Piston Cooling Nozzle Control

## CALIBRATION / SETUP / TUNING

### Lambda

OE lambda sensors are Bosch LSU 4.9. Included inside each adaptor box is an LTC 4.9 component that uses all OE wiring for connection. The LTCs should be preconfigured to addresses 0x460 (Bank 1) and 0x461 (Bank 2).
If any LTC configuration needs to be changed, the LTC Manager software can be used. Connect via the ethernet connection of either M1 ECU and, in LTC Manager, select the gateway as the M1 ECU and CAN Bus 3 at 1 Mbit.

## Boost via Solenoid

**Boost via Solenoid Set Up**

The supplied breakout loom wires this sensor to the Slave ECU

Slave ECU - wired sensor

- Boost Pressure Bank 2 Sensor Resource set to Analogue Voltage Input 10
- Setup and calibration of Boost Pressure Bank 2 Sensor group details to match the sensor used.
- The sensor value appears in the Master ECU

## Sensor Calibrations

Any additional sensors fitted must have accurate calibrations.

**Kalman gain settings for alternate engine sensor configurations**

- Engine operating with pressure sensors fitted measuring air pressure in the inlet manifold plenum chamber.
  The supplied Tuning Base files are configured for this mode of operation and the Kalman gains should be set as follows:
    - Inlet Manifold Pressure Kalman Gain = 1000.0
    - Throttle Mass Flow Kalman Gain = 0.0
- Engine operating without manifold pressure (or boost pressure) sensors installed (non turbo only).
  The engine load is derived from Airbox Mass Flow and the Kalman gains should be set as follows:
    - Inlet Manifold Pressure Kalman Gain = 0.0 and
    - Throttle Mass Flow Kalman Gain = 1000.0.
- Intermediate gain values may also be used, where behaviour is biased towards manifold pressure or airbox mass flow depending on the load requirement and sensors fitted.

**Included Calibrations**

Included calibrations are for sensors fitted to a MY18 Lamborghini Huracan Performante (LP-640). Other supported model variations (Audi R8, LP-610) may have alternate sensor calibrations. Tuning base files will be updated as information becomes available.

**MAF (Mass Air Flow) Sensor**

If the standard sensor is placed in a housing with a larger diameter it is necessary to adjust the sensor calibration. For best accuracy, the sensor must be physically calibrated against a flow bench or reference sensor.
However, an approximate calibration can be achieved by using the squared ratio of cross-sectional areas of the original housing and the replacement housing.

*Example:*
*Standard housing is 64 mm, new housing is 80 mm.*
*Area ratio is (80/64)2 = 1.5625*
*resulting in 56% more flow at a given voltage reading*

## Throttle Servos

Throttle Servo - If your new throttle part number is not in the Throttle Servo Calibration list, please contact MoTeC for advice.

**Throttle Servo Set Up**

The settings in the following groups must be tuned:

- Throttle Servo
- Throttle Mass Flow Area Factor
- Throttle Area

**Throttle Bodies Set Up**

The settings in the following groups must be tuned:

- Throttle Mass Flow Area Factor - This parameter sets the maximum airflow factor of the throttle. It may be scaled by the change in throttle area from old throttle to new. For example, if increasing from 60 mm to 70 mm throttles, the Throttle Mass Flow Area Factor would be multiplied by 1.361.
- Throttle Area - This table sets the relationship between throttle position and throttle opening area. This is tuned by matching Inlet Manifold Pressure Bank N Sensor to Inlet Manifold Pressure Modelled. For low throttle opening and especially near idle, accuracy of this table is important, but also easy to tune. At higher throttle openings tuning becomes more difficult, but also much less important. Provided the shape of the table from the base tune is maintained, accurate torque control can be obtained for all throttle openings in a short time.
  **Tip:** A quick tuning function (keyboard shortcut **Q**)) is available for this table.

## Fuel

### Flex Fuel and Dual Fuel

MoTeC's M1 Flex Fuel User Guide (available at MoTeC.com.au) provides comprehensive information on adding flex fuel (variable ratio of gasoline and ethanol) or dual fuel (separate fuels on primary and secondary injectors) options to the engine.

### Fuel Type

The fuel type can be changed to one of a different chemistry like ethanol or methanol. Changing the fuel properties setting for the new fuel will adjust the fuel delivery to give close to the correct fuel mixture. Fine retuning of the Engine Efficiency table will also likely be required.

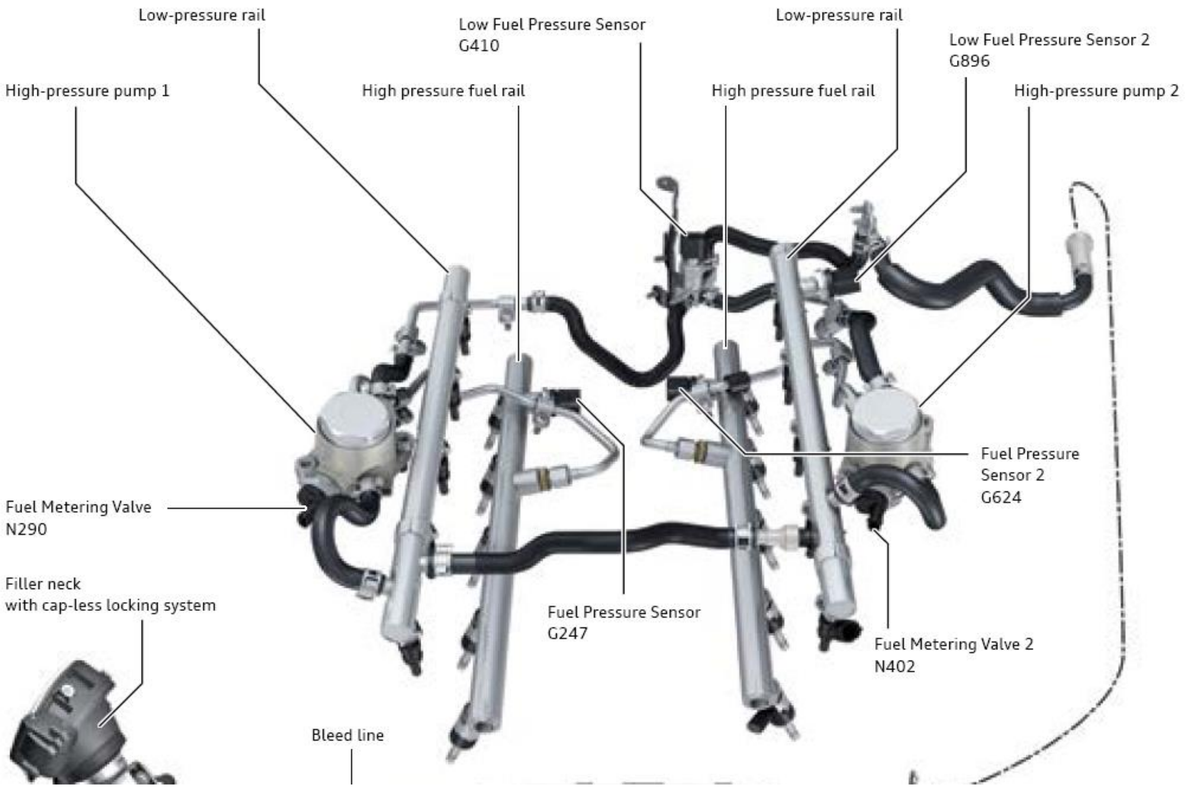
Changing the fuel type may require re-tuning of some systems to take advantage of a better quality fuel or for engine safety. For example ignition timing, fuel film, boost aim and knock control systems.

### Fuel Pressure

The Huracan engine has 4 factory fitted fuel pressure sensors, two high pressure sensors (located in each DI fuel rail), and two low pressure sensors.

One low pressure sensor is located in the bank 2 port injector fuel rail (G896), wired to bank 1 (Master) ECU. The other is located in the supply line to the DI fuel pumps (G410) and wired to the bank 2 (Slave) ECU.

**Note:** the workshop manual incorrectly shows the sensors are wired to the opposite ECUs.




The port injector rails are fed by the return line from each DI fuel pump and also have a line between the two. This means the fuel pressure for both rails is correctly sensed by the sensor in the bank 2 fuel rail wired to the Master ECU.

The DI fuel pump supply sensor normally reads the same as the rail pressure as fuel can pass through the DI pump to the port rails. However, at high port injector flow, due to some flow restriction, the port rail pressure can fall below the DI pump supply pressure.

The ECU firmware can be set up for multiple fuel system configurations.

**Fuel Pressure Sensors**

The *Fuel Pressure Sensor* is the wired sensor input into each M1 ECU. The ECUs use the *Fuel Pressure* channel for port (secondary) injector pressure compensation.

If the *Fuel Pressure Sensor* is not available in one ECU, but it is available in the other ECU, each ECU can use the other ECU's fuel pressure value automatically. For each ECU the value can always be seen in the channel *Huracan Bank n Fuel Pressure Sensor* channel.

Each ECU also has a *Fuel Pressure Auxiliary Sensor* input and if available this is used for the *Fuel Pressure Auxiliary* channel. If *Fuel Pressure Auxiliary Sensor* is only allocated in the Slave ECU, this value is also used in the Master ECU. The Slave ECU doesn't use the *Fuel Pressure Auxiliary* channel for control, so the Master ECUs value is not transferred back to the Slave ECU.

The Slave ECU's *Fuel Pressure Auxiliary Sensor* value can always be seen in the *Huracan Bank 2 Fuel Pressure Auxiliary Sensor* channel.

*Fuel Pressure Auxiliary* channel in the Master ECU can optionally be used as the closed loop feedback pressure sensor for the *Fuel Pressure Control* system, selected in *Fuel Pressure Control Injector Supply* parameter. Depending on any additional fuel pumps fitted, or if the DI pump fuel supply and port fuel supply is separated, the appropriate sensor can be selected to control the OE fuel pump speed. If closed loop fuel pressure control is used to supply both primary and secondary injectors, the *Fuel Pressure Control Injector Supply* must be set to either 'Both' or 'Both Auxiliary' depending on the feedback sensor used. It's recommended to use 'Both' (using *Fuel Pressure* as the feedback) so that the port injectors have a more stable pressure.

**Fuel Pressure Sensors Set Up**

For an unmodified fuel system

- Configure the Master ECU's *Fuel Pressure Sensor* to be used for *Fuel Pressure* in both ECUs so the correct port injection fuel pressure compensation is applied to both banks:
    - *Fuel Pressure Sensor Resource* in the Master ECU set to Analogue Voltage Input 8.
    - *Fuel Pressure Sensor Resource* in the Slave ECU set to Not in Use (unallocated).
- Configure the Slave ECU's *Fuel Pressure Auxiliary* value to be used in both ECUs:
    - *Fuel Pressure Auxiliary Sensor Resource* in the Slave ECU set to Analogue Voltage Input 8.
    - *Fuel Pressure Auxiliary Sensor Resource* in the Master ECU set to Not in Use

**Note:** The appropriate sensor setup and calibration also needs to be entered.

**Additional Fuel Pump**

The Huracan ECU firmware caters for 3 additional fuel pumps, *Fuel Pump Main*, *Fuel Pump Sub 1* and *Fuel Pump Sub 2*.

The main pump is used for priming and runs when the *Fuel Pump State* is Prime. The sub pumps do not prime.

The sub pumps can optionally be switched on with nitrous control.

Otherwise each pump has its own *Test* parameter and *Threshold*. The pump turns on when *Fuel Flow* exceeds the respective pumps *Threshold*. The pump turns off when the *Fuel Flow* falls below the respective pumps *Threshold - Fuel Pump Hysteresis* (common setting for all fuel pumps).

Normally the *Fuel Pump Main Threshold* would be set to 0 so that the pump is on whenever the engine is running, however if a manually switched pump or *Fuel Pressure Control Pump* is used, the threshold for the main pump may be raised.

The main pump also supports open loop PWM control based on Fuel Flow, staged or gradual.

**Combining additional pumps with the Huracan OE fuel pump**

The OE fuel pump is a brushless DC motor and has a dedicated controller. The ECU signals the controller to change the pump speed. This has fully variable control with fast response and good flow so keeping the OE pump is a good option. Aftermarket pumps can be added in parallel for additional flow.

The DI pumps may be isolated from the port rails, or kept combined.

If kept combined, the *Fuel Pressure Control* system can be tuned in a way so that when an additional pump is switched in, the OE pump slows down.

Since additional pumps are switched based on *Fuel Flow* and the *Fuel Pressure Control Feed Forward Main* table also has an axis of *Fuel Flow,* the *Feed Forward* table can step down in duty cycle at the *Fuel Flow* point where the additional pump/s switch in. This will not give perfect pressure control, but that is not necessary with the injector pressure compensation.

If the DI fuel pump supply pressure drops too low, the pumps will not fill correctly and DI fuel pressure may also fall. The exact specification is unknown at this time and will depend on many factors. Normal DI pump supply pressure is 5 bar.

**Fuel Pressure Control Closed Loop**

The Fuel Pressure Control system can be used open loop (PID gains set to 0 and use Feed Forward only), or closed loop using a fuel pressure sensor as feedback to adjust the pumps output duty cycle with the PID gains.

The OE fuel system includes an in-tank mechanical fuel pressure regulator (combined with the fuel filter), believed to be set to ~7 bar.

If using closed loop control and the aim pressure is set too high, the fuel pump may never be able to reach the aim fuel pressure as the fuel pressure regulator bleeds pressure off resulting in high pump speed heating the fuel. If aim pressure is kept below the regulator pressure, the closed loop system should be able to maintain the aim fuel pressure to any pressure below 7 bar with good efficiency.

Note that venturi pumps are used to fill the in-tank swirl pot. These use fuel pressure and flow from the main pump and will require some pressure to function correctly.

# CONTROL STRATEGIES

## New control strategies and tuning

Development of torque control strategies has been carried out for this project with the emphasis on improving driveability and some simplification of tuning.

**Throttle Pedal**

- Throttle Pedal Kickdown
  A detent can be felt in the Huracan's throttle pedal near to the floor. This is for the transmission kickdown functionality so that if full acceleration is needed, the transmission will automatically change down to the lowest gear possible for the current vehicle speed for maximum acceleration. Unlike in some vehicles, the kickdown is not an additional switch signal; the M1 ECU only 'knows' when the detent is exceeded from the pedal position.

> **Throttle Pedal Set Up**
>
> - Calibrate the 100% position of *Throttle Pedal Sensor* past the detent with throttle pressed hard to the floor.
> - Determine the value of Throttle Position Sensor where the detent is felt, typically at 88% of the pedal's travel. Enter this value into *Throttle Pedal Kickdown Threshold.*
>
> This threshold is used as a scaling factor so that *Throttle Pedal* value = 100% where the detent is felt. Also any position past the detent, *Throttle Pedal Kickdown State* will change to Active which is transmitted to the TCM to signal it to automatically change down gears.

- Throttle Pedal
  The result is linear to Throttle Pedal Sensor, but reaches 100% at the kickdown detent as described above. This is then used on the axis of the *Throttle Pedal Translation* table. This value is still used for subsystems that have a pedal threshold or similar but it is not used to control the *Throttle Aim* directly like other M1 firmwares.

- Throttle Pedal Damper
  Due to the large, responsive engine and relatively light chassis, the transition in and out of overrun, especially in a low gear at higher engine speed is quite jerky without any dampening of the throttle pedal.
  The dampening is fully tuneable and does not affect the overall response of the pedal. The damper is integrated with the *Engine Overrun* system and the full description of the damper detailed in that section.
- Throttle Pedal Translation
  This table is used to adjust the feel of the throttle pedal. The result of the table is used to find a percentage of *Torque Maximum.*
  **Note:** the values used in this table will give a different feel compared to the same values used in other M1 firmwares.
- Throttle Pedal Torque Aim
  The throttle control by pedal is performed via the torque control system. The *Throttle Pedal Translation* table result requests a percentage of *Torque Maximum* (torque if at 100% throttle position) for the given operating conditions (engine speed, boost pressure, etc.).
  **Note:** Throttle Pedal Translation in other M1 firmwares is different because it calculates a percentage of butterfly opening
  For example, at 2000 rpm and 100% throttle the engine might be capable of producing 400 Nm of torque. If the *Throttle Pedal Translation* is reduced to 50% by lifting the pedal, then the torque control system closes the throttle enough to produce 200 Nm, which may only be 15% *Throttle Position*.
  The advantage of this method is a linearisation of torque produced for the drivers demand in pedal travel and across the rev range. This improves drivability substantially on this large and responsive engine.
  This also allows better pedal integration with other subsystems that control or limit engine torque, for example, *Idle Control*, *Engine Overrun* fuel cut, *Cruise Control*, etc.
  Tip: When the engine is stopped the pedal drives the throttle aim directly for test purposes.
- Throttle Pedal Safety
  As the improved torque control system introduces many other sensors into the throttle control strategy, a safety net has been put in place. This safety net limits maximum throttle opening to *Throttle Pedal* x 2 + *Throttle Aim Safety* parameter.
  This means the throttle cannot open more than the safety value if the pedal is at 0%. The safety parameter would be typically set to a value that allows the engine to rev unloaded to approximately 5000 rpm.
  *Engine Speed Control* (downshift blipping), *Anti Lag* and *Cruise Control* systems do need to open the throttle wider. In this case the safety limit is overridden and additional safety controls are built into those systems.

# APPENDIX: M142 ECU AND BREAK OUT PINOUT

## M142 Connector A - 34 Way

Mating Connector: Tyco Superseal 34 Position Keying 2 (MoTeC #65067)

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| A01 | AT5 | Analogue Temperature Input 5 | 105-39 | Oil Pressure Switch / not used |
| A02 | AT6 | Analogue Temperature Input 6 | E19 | Inlet Air Temperature Bank 1 / Bank 2 |
| A03 | AV15 | Analogue Voltage Input 15 | | |
| A04 | AV16 | Analogue Voltage Input 16 | | |
| A05 | AV17 | Analogue Voltage Input 17 | 91-21 | Fuel Tank Pressure Sensor / not used |
| A06 | INJ_D1A_NEG | Direct Injector 1A - | 105-24 | Injector 1 Low / Injector 6 Low |
| A07 | INJ_D1A_POS | Direct Injector 1A + | 105-44 | Injector 1 Low / Injector 6 High |
| A08 | INJ_D1B_POS | Direct Injector 1B + | | Injector operation compromised if connected |
| A09 | INJ_D1B_NEG | Direct Injector 1B - | | Injector operation compromised if connected |
| A10 | SEN_5V0_C1 | Sensor 5.0V C | | |
| A11 | LA_NB1 | Lambda Narrow Input 1 | | |
| A12 | LA_NB2 | Lambda Narrow Input 2 | | |
| A13 | KNOCK3 | Knock Input 3 | 105-101 | Knock Sensor 2 / Knock Sensor 4 pin 1 |
| A14 | KNOCK4 | Knock Input 4 | 105-80 | Knock Sensor 2 / Knock Sensor 4 pin 2 |
| A15 | DIG2 | Digital Input 2 | 91-15 | Airbox Mass Flow Sensor Bank 1 / Bank 2 |
| A16 | DIG3 | Digital Input 3 | E23 | Spare DIG3 Input |
| A17 | DIG4 | Digital Input 4 | E24 | Spare DIG4 Input |
| A18 | SEN_5V0_C2 | Sensor 5.0V C | | |
| A19 | SEN_5V0_B2 | Sensor 5.0V B | 91-66 | Throttle Pedal Tracking 5V / not used |
| A20 | LIN | LIN Bus | | |
| A21 | RS232_RX | RS232 Receive | E16 | GPS Receive (optional) |
| A22 | RS232_TX | RS232 Transmit | | |
| A23 | DIG1 | Digital Input 1 | 105-16 | Exhaust Temperature Bank1 / Bank2 |
| A24 | BAT_NEG3 | Battery Negative | 91-01, 91-02, 91-04 | Chassis Ground |
| A25 | BAT_NEG4 | Battery Negative | 91-01, 91-02, 91-04 | Chassis Ground |
| A26 | SEN_0V_C1 | Sensor 0V C | | |
| A27 | SEN_0V_C2 | Sensor 0V C | | |
| A28 | CAN3_HI | CAN Bus 3 High | 91-60 | Inter-ECU CAN High, Internal LTC |
| A29 | CAN3_LO | CAN Bus 3 Low | 91-77 | Inter-ECU CAN Low, Internal LTC |
| A30 | CAN2_HI | CAN Bus 2 High | 91-79, E28 | CAN Powertrain High |
| A31 | CAN2_LO | CAN Bus 2 Low | 91-80, E27 | CAN Powertrain Low |
| A32 | BAT_NEG5 | Battery Negative | 91-01, 91-02, 91-04 | Chassis Ground |

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| A33 | SEN_0V_B2 | Sensor 0V B | 91-45, 91-46, 91-64, 91-69 | 0V Fuel Tank Pressure, Lift Pressure, Air Temp, Pedal Tracking, Oil Temp, Airbox Mass Flow / 0V Lift Pressure, Air Temp, Airbox Mass Flow |
| A34 | SEN_0V_A2 | Sensor 0V A | 91-81 | 0V Pedal Main |

**Important:**

* Master and Slave ECU pins and functions are largely the same. Slave pins and functionality is only listed if different from Master pin or functionality.

## M142 Connector B - 26 Way

Mating Connector: Tyco Superseal 26 Position Keying 3 (MoTeC #65068)

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| B01 | OUT_HB9 | Half Bridge Output 9 | 91-91 / 105-50 | Fuel Pump Control / Piston Cooling Spray Control |
| B02 | OUT_HB10 | Half Bridge Output 10 | 105-8 / 91-73 | Coolant Pump Control / Exhaust Flap Control |
| B03 | UDIG8 | Universal Digital Input 8 | 91-48 | Crank Request / not used |
| B04 | UDIG9 | Universal Digital Input 9 | 91-51 | Starter Solenoid Feedback / not used |
| B05 | UDIG10 | Universal Digital Input 10 | 91-50 | Ignition Switch Sense |
| B06 | UDIG11 | Universal Digital Input 11 | 91-30 | Brake Switch 2 / not used |
| B07 | UDIG12 | Universal Digital Input 12 | 91-29 | Brake Switch 1 / not used |
| B08 | INJ_LS5 | Low Side Injector 5 | 105-32 | Port Injector 5 / Port Injector 10 |
| B09 | INJ_LS3 | Low Side Injector 3 | 105-6 | Port Injector 3 / Port Injector 8 |
| B10 | AV9 | Analogue Voltage Input 9 | E11 | Inlet Manifold Pressure Sensor Bank 1 / Bank 2 |
| B11 | AV10 | Analogue Voltage Input 10 | E12 | Boost Pressure Sensor Bank 1 / Bank 2 |
| B12 | AV11 | Analogue Voltage Input 11 | | |
| B13 | BAT_POS | Battery Positive | 91-3, 91-5, 91-6 | Switched Power Source |
| B14 | INJ_LS6 | Low Side Injector 6 | - / E18, 91-71 | not used / Break Vacuum Pump Relay |
| B15 | INJ_LS4 | Low Side Injector 4 | 105-11 | Port Injector 4 / Port Injector 9 |
| B16 | AV12 | Analogue Voltage Input 12 | | |
| B17 | AV13 | Analogue Voltage Input 13 | | |
| B18 | AV14 | Analogue Voltage Input 14 | | |
| B19 | BAT_POS | Battery Positive | 91-3, 91-5, 91-6 | Switched Power Source |
| B20 | OUT_HB7 | Half Bridge Output 7 | 91-36 / E10, 105-12 | Radiator Fan Control Unit 2 / Engine Mount Solenoid Bank 1 and 2 |
| B21 | OUT_HB8 | Half Bridge Output 8 | | |
| B22 | INJ_D2A_NEG | Direct Injector 2A - | 105-2 | Injector 2 / Injector 7 Low |
| B23 | INJ_D2A_POS | Direct Injector 2A + | 105-65 | Injector 2 / Injector 7 High |
| B24 | INJ_D2B_POS | Direct Injector 2B + | | Injector operation compromised if connected |
| B25 | INJ_D2B_NEG | Direct Injector 2B - | | Injector operation compromised if connected |
| B26 | SEN_5V0_A | Sensor 5.0V A | 91-83 | 5V Throttle Pedal Main |

**Important:**

* Master and Slave ECU pins and functions are largely the same. Slave pins and functionality is only listed if different from Master pin or functionality.

## M142 Connector C - 34 Way

Mating Connector C: Tyco Superseal 34 Position Keying 1 (MoTeC #65044)

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| C01 | OUT_HB2 | Half Bridge Output 2 | 105-66 | Throttle Servo Motor + Bank 1 / Bank 2 |
| C02 | SEN_5V0_A | Sensor 5.0V A | 105-20, 105-41 | 5V Cam 1,3, Fuel Pressure Direct, Secondary Air Pressure / Cam 2,4, Crank, Secondary Air Pressure |
| C03 | IGN_LS1 | Low Side Ignition 1 | 105-93 | Ignition 1 / Ignition 6 |
| C04 | IGN_LS2 | Low Side Ignition 2 | 105-94 | Ignition 2 / Ignition 8 |
| C05 | IGN_LS3 | Low Side Ignition 3 | 105-73 | Ignition 3 / Ignition 7 |
| C06 | IGN_LS4 | Low Side Ignition 4 | 105-91 | Ignition 4 / Ignition 9 |
| C07 | IGN_LS5 | Low Side Ignition 5 | 105-72 | Ignition 5 / Ignition 10 |
| C08 | IGN_LS6 | Low Side Ignition 6 | 105-86 | Fuel Pressure Direct Bank 1 Pump A / Bank 2 Pump A |
| C09 | SEN_5V0_B | Sensor 5.0V B | 105-42 | 5V Throttle Servo Position Bank 1 / Bank 2 |
| C10 | BAT_NEG1 | Battery Negative | 91-01, 91-02, 91-04 | Chassis Ground |
| C11 | BAT_NEG2 | Battery Negative | 91-01, 91-02, 91-04 | Chassis Ground |
| C12 | IGN_LS7 | Low Side Ignition 7 | 91-52, 91-70 / E14 | Starter Relay 1, Starter Relay 2 / Gear Shift Up |
| C13 | IGN_LS8 | Low Side Ignition 8 | 91-40 / E15 | Air Filter Bypass Solenoid / Gear Shift Down |
| C14 | AV1 | Analogue Voltage Input 1 | 105-103 | Throttle Servo Position Sensor - Main Bank 1 / Bank 2 |
| C15 | AV2 | Analogue Voltage Input 2 | 105-82 | Throttle Servo Position Sensor - Tracking Bank 1 / Bank 2 |
| C16 | AV3 | Analogue Voltage Input 3 | 91-82 | Throttle Pedal Sensor - Main / not used |
| C17 | AV4 | Analogue Voltage Input 4 | 91-65 | Throttle Pedal Sensor - Tracking / not used |
| C18 | OUT_HB1 | Half Bridge Output 1 | 105-88 | Throttle Servo Motor - Bank 1 / Bank 2 |
| C19 | INJ_D3A_POS | Direct Injector 3A + | 105-64 | Injector 3 High / Injector 8 High |
| C20 | INJ_D3B_POS | Direct Injector 3B + | | Injector operation compromised if connected |
| C21 | INJ_D4A_POS | Direct Injector 4A + | 105-43 | Injector 4 & 5 High / Injector 9 & 10 High |
| C22 | INJ_D4B_POS | Direct Injector 4B + | | Injector operation compromised if connected |
| C23 | INJ_LS1 | Low Side Injector 1 | 105-74 | Port Injector 1 / Port Injector 6 |
| C24 | INJ_LS2 | Low Side Injector 2 | 105-95 | Port Injector 2 / Port Injector 7 |
| C25 | AV5 | Analogue Voltage Input 5 | 105-59 | Fuel Pressure Direct Bank 1 / Bank 2 Sensor |
| C26 | BAT_POS | Battery Positive | 91-3, 91-5, 91-6 | Switched Power Source |
| C27 | INJ_D3A_NEG | Direct Injector 3A - | 105-46 | Injector 3 Low / Injector 8 Low |
| C28 | INJ_D3B_NEG | Direct Injector 3B - | | Injector operation compromised if connected |

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| C29 | INJ_D4A_NEG | Direct Injector 4A - | 105-23 | Injector 4 Low / Injector 9 Low |
| C30 | INJ_D4B_NEG | Direct Injector 4B - | 105-22 | Injector 5 Low / Injector 10 Low |
| C31 | OUT_HB3 | Half Bridge Output 3 | E34 | Turbo Wastegate Solenoid Bank 1 / Bank 2 |
| C32 | OUT_HB4 | Half Bridge Output 4 | 91-37 / E17, 91-23, 91-88 | Radiator Fan Control Unit 1 / Purge Solenoid Bank 1 and 2 |
| C33 | OUT_HB5 | Half Bridge Output 5 | 105-53 | Inlet Camshaft Control Solenoid Bank 1 / Bank 2 |
| C34 | OUT_HB6 | Half Bridge Output 6 | 105-9 | Exhaust Camshaft Control Solenoid Bank 1 / Bank 2 |

**Important:**

* Master and Slave ECU pins and functions are largely the same. Slave pins and functionality is only listed if different from Master pin or functionality.

## M142 Connector D - 26 Way

Mating Connector D: Tyco Superseal 26 Position Keying 1 (MoTeC #65045)

| Pin | Designation | Full Name | Master / Slave Pin* | Master / Slave Function* |
|---|---|---|---|---|
| D01 | UDIG1 | Universal Digital Input 1 | 105-18 | Crank Reference Position Sensor |
| D02 | UDIG2 | Universal Digital Input 2 | 105-36 | Inlet Camshaft Position Sensor Bank 1 / Bank 2 |
| D03 | AT1 | Analogue Temperature Input 1 | 105-105 | Coolant Temperature Sensor / not used |
| D04 | AT2 | Analogue Temperature Input 2 | E13 | Spare temperature or switch |
| D05 | AT3 | Analogue Temperature Input 3 | 91-11 | Airbox Mass Flow Temperature Sensor Bank 1 / Bank 2 |
| D06 | AT4 | Analogue Temperature Input 4 | 91-12 | Oil Temperature Sensor 2 / not used |
| D07 | KNOCK1 | Knock Input 1 | 105-79 | Knock Sensor 1 / Knock Sensor 3 pin 1 |
| D08 | UDIG3 | Universal Digital Input 3 | 105-15 | Exhaust Camshaft Position Sensor Bank 1 / Bank 2 |
| D09 | UDIG4 | Universal Digital Input 4 | 105-13 | Engine Oil Level and Temperature Sensor / not used |
| D10 | UDIG5 | Universal Digital Input 5 | 91-17 | Park Neutral Switch / not used |
| D11 | UDIG6 | Universal Digital Input 6 | 105-38 | Reduced Oil Pressure Switch / not used |
| D12 | BAT_BAK | Battery Backup | 91-86 | Permanent Power |
| D13 | KNOCK2 | Knock Input 2 | 105-100 | Knock Sensor 1 / Knock Sensor 3 pin 2 |
| D14 | UDIG7 | Universal Digital Input 7 | 91-34 | Cruise Cancel Switch / not used |
| D15 | SEN_0V_A | Sensor 0V A | 105-55, 105-76, 105-97 | 0V Cam Pos, Fuel Pressure Direct, Secondary Air Pressure, Coolant Temperature / 0V Crank, Cam Pos, Fuel Pressure Direct, Secondary Air Pressure |
| D16 | SEN_0V_B | Sensor 0V B | 105-102 | 0V Throttle Servo Position Bank 1 / Bank 2 |
| D17 | CAN1_HI | CAN Bus 1 High | E33 | Spare CAN High |
| D18 | CAN1_LO | CAN Bus 1 Low | E32 | Spare CAN Low |
| D19 | SEN_6V3 | Sensor 6.3V | E3 | 6.3V Sensor Supply |
| D20 | AV6 | Analogue Voltage Input 6 | 105-104 | SecondaryAir Pressure 1 / 2 Sensor |
| D21 | AV7 | Analogue Voltage Input 7 | Internal | Barometric Pressure Sensor Bank 1 Bank 1 |
| D22 | AV8 | Analogue Voltage Input 8 | 91-47 | Fuel Port Rail Pressure / Fuel Direct Injector Pump Lift Pressure |
| D23 | ETH_TX+ | Ethernet Transmit+ | | |
| D24 | ETH_TX- | Ethernet Transmit- | | |
| D25 | ETH_RX+ | Ethernet Receive+ | | |
| D26 | ETH_RX- | Ethernet Receive- | | |

**Important:**

* Master and Slave ECU pins and functions are largely the same. Slave pins and functionality is only listed if different from Master pin or functionality.

## Breakout Connector E

Mating Connector: Tyco Superseal 34 Position Keying 2 (MoTeC #65044)

| Pin | Designation | Full Name | M142 Pin# | Function |
|---|---|---|---|---|
| E01 | BAT_POS | Battery Positive | B13, B19, C26 | |
| E02 | BAT_POS | Battery Positive | B13, B19, C26 | Boost Solenoid Supply (optional) |
| E03 | SENS_6V3 | SEN_6V3 | D19 | |
| E04 | SENS_5V0_B2 | Sensor 5.0V B | A19 | 5V Supply MAP Sensor |
| E05 | SENS_5V0_B2 | Sensor 5.0V B | A19 | 5V Supply Boost Sensor |
| E06 | SENS_5V0_B2 | Sensor 5.0V B | A19 | |
| E07 | SENS_5V0_B2 | Sensor 5.0V B | A19 | |
| E08 | BAT_NEG | Battery Negative | A24, A25, A32, C10, C11 | |
| E09 | BAT_NEG | Battery Negative | A24, A25, A32, C10, C11 | |
| E10* | SHARE_ENGMT | Slave ECU Half Bridge Output 7 | B20 (Slave only) | Shared wiring between ECUs |
| E11 | AV9 | Analogue Voltage Input 9 | B10 | MAP Sensor Signal |
| E12 | AV10 | Analogue Voltage Input 10 | B11 | Boost Sensor Signal |
| E13 | AT2 | Analogue Temperature Input 2 | D04 | Spare |
| E14 | PADDLE_UP | Slave ECU Low Side Ignition 7 | C12 (Slave only) | Gear Shift Up (dedicated). Do not connect on Master. |
| E15 | PADDLE_DN | Slave ECU Low Side Ignition 8 | C13 (Slave only) | Gear Shift Down (dedicated). Do not connect on Master. |
| E16 | RS232RX | RS232 Receive | A21 | Usually for GPS. |
| E17* | SHARE_PURGE | Slave ECU Half Bridge Output 4 | C32 (Slave only) | Shared wiring between ECUs |
| E18* | SHARE_BRK_REL | Slave ECU Injector Low Side 6 | B14 (Slave only) | Shared wiring between ECUs |
| E19 | AT6 | Analogue Temperature Input 6 | A02 | Inlet Air Temperature Sensor Signal |
| E20 | SENS_0V_B2 | Sensor 0V B | D16 | 0V Inlet Air Temperature Sensor |
| E21 | SENS_0V_B2 | Sensor 0V B | D16 | 0V MAP Sensor |
| E22 | SENS_0V_B2 | Sensor 0V B | D16 | 0V Boost Sensor |
| E23 | DIG3 | Digital Input 3 | A16 | Spare |
| E24 | DIG4 | Digital Input 4 | A17 | Spare |
| E25* | SHARE_PIST_COOL | Slave ECU Half Bridge Output 9 | B01 (Slave only) | Shared wiring between ECUs |
| E26* | SHARE_EXH_FLAP | Slave ECU Half Bridge Output 10 | B02 (Slave only) | Shared wiring between ECUs |
| E27 | CAN2LO | CAN Bus 2 Low | A31 | OE Powertrain CAN Bus Low |
| E28 | CAN2HI | CAN Bus 2 High | A30 | OE Powertrain CAN Bus High |
| E29 | SENS_0V_B2 | Sensor 0V B | D16 | |
| E30 | SENS_0V_B2 | Sensor 0V B | D16 | |
| E31 | SENS_0V_B2 | Sensor 0V B | D16 | |
| E32 | CAN1LO | CAN Bus 1 Low | D18 | Spare CAN Bus Low |
| E33 | CAN1HI | CAN Bus 1 High | D17 | Spare CAN Bus High |
| E34 | OUT_HB3 | Half Bridge Output 3 | C31 | Boost Solenoid (optional) |

**Important:**

* These pins allow sharing of control functions from one ECU to the harness connector of the other ECU. Do not change this wiring.