MoTeC

M1 Flex Fuel

USER GUIDE

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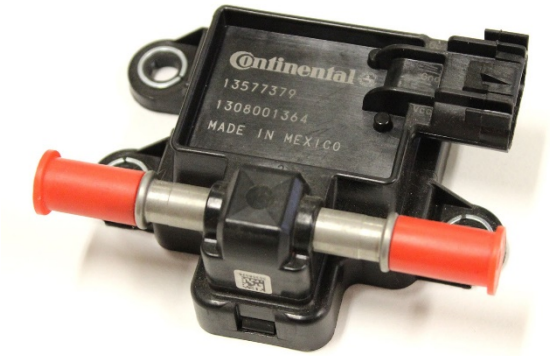
OVERVIEW

The following document describes the MoTeC M1 Flex Fuel Package and the basic tuning process.

The Flex Fuel functionality is designed to work with a mixture of two fuels, for example, using petrol and E85 in the one fuel system. It is necessary in this instance to install a “Flex Fuel” sensor so that the ECU has an accurate measurement of the fuel composition being supplied from the fuel tank and injected into the engine.



WHY FLEX FUEL?

Allows for the use of ethanol blended fuel and non-ethanol blended fuel, with the M1 using the Fuel Composition Sensor to vary the tuning calibration based on the sensed Fuel Composition.

WHAT IS NEEDED?

Fuel Composition Sensor

The Continental 13577379 short arm sensor is recommended as these sensors have been tested and calibrated at MoTeC. There is a drop down calibration available in M1 Tune for this specific sensor. Other sensors can be used with a custom calibration. It is recommended to independently confirm that the actual Fuel Composition matches that of the Fuel Composition sensor, if a custom calibration is being used.

An M1 Package with the Flex Fuel Functionality

This was introduced in the February 2016 release with the following version numbers:

GPA – 01.07.0002

GPR – 01.07.0002

GPR-DI – 01.05.0002

GPRP – 01.01.0005

GPRP-DI – 01.01.0001

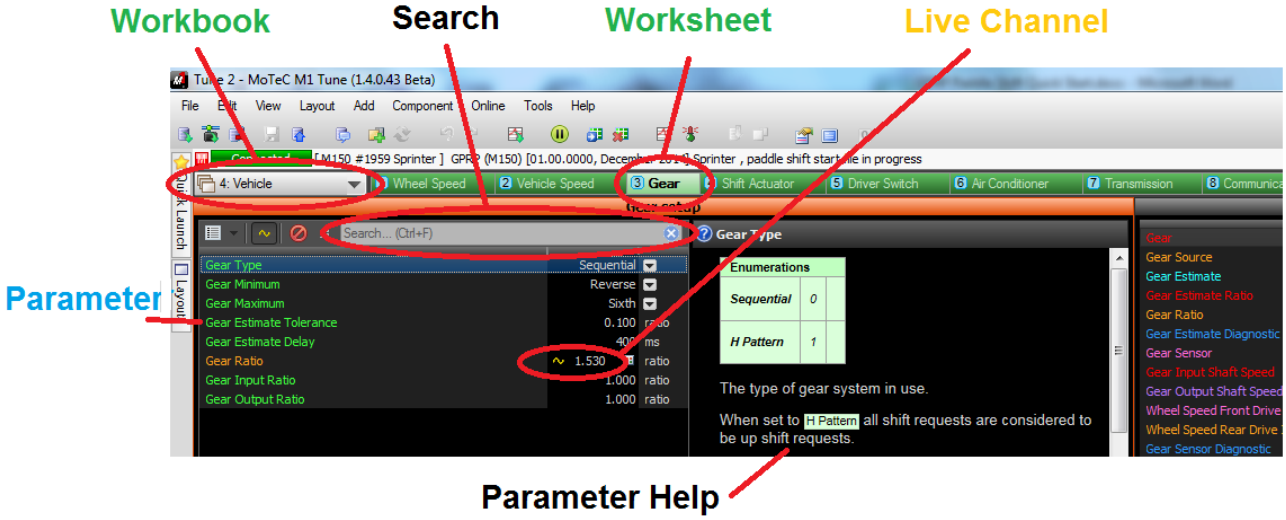
OPERATION

Flex Fuel: The actual fuel in use is a blend between Fuel Properties and Alternative Fuel Properties as reported by the Fuel Composition Sensor. The fuel is used on primary and secondary injectors.

Secondary Fuel: The alternative fuel is used on the secondary injectors only. The main fuel defined in Fuel Properties is used on the primary injectors only. No blend occurs. Overall cylinder fuel volumes are calculated assuming use of the main fuel only. Subsequently, Fuel Injector Secondary Contribution Main defines the ratio of fuel volume replaced from the primary injectors. The fuel volumes and pulse widths of the secondary injectors are then calculated using Alternative Fuel Temperature and Alternative Fuel Pressure instead of Fuel Pressure and Fuel Temperature, scaled with the different stoichiometric values of both fuels. As a result, no change in measured lambda values should be noticeable when changing the secondary contribution. If necessary, Alternative Fuel Contribution Efficiency can be used to finetune the secondary fuel volume amount to achieve an exact match of lambda values.

USING THIS DOCUMENT

Parameters and tables are listed as the actual name in the GPRP Package and are represented in blue in this document. The location of parameter and tables are listed as the specific Worksheet on a specific Workbook and are listed in green. Parameters and tables are where the user must enter setup information. A specific parameter or table can be found using the search box at the top of each calibrate box on a Worksheet. A live channel is the direct feedback from a sensor or function calculation, this can be a sensor reading like air pressure or an enumerated result of a state group or diagnostic group and will be listed in orange.



Help for a specific parameter of table will appear whenever that parameter or table is highlighted by clicking on it. The help can also be accessed by pressing “F1” or by going to “Help” – “Firmware Help”.

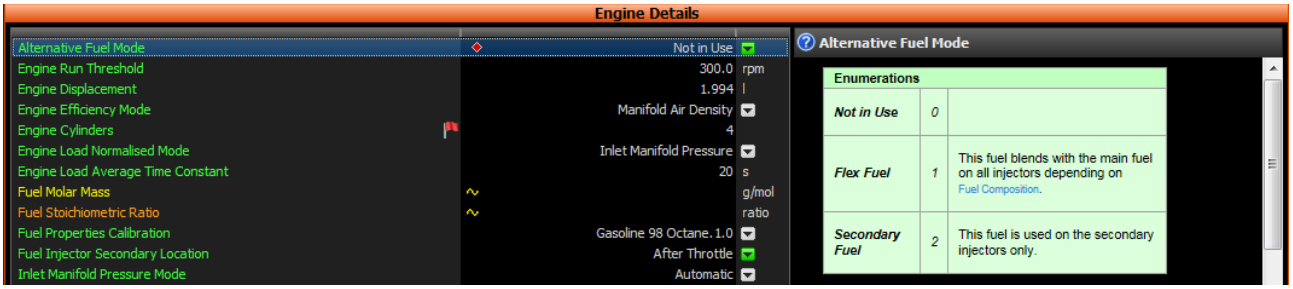
Any parameter or table with a green “Q” next to it can be set by pressing the “Q” button. The parameter or table cell will be set to the current value read by the ECU.

NOTE: Due to updates in ECU Packages some items in the following document may move to a different Worksheet. If you are unable to locate some parameters/tables it is possible to use the Search in an All Calibrate Worksheet, these will be in most Workbooks.

FLEX FUEL CONFIGURATION

Alternative Fuel Mode

To expose the Alternative Fuel properties, a mode will need to be chosen using the Alternative Fuel Mode drop down list. The setting is in the Initial Setup Workbook on the Engine Details Worksheet.

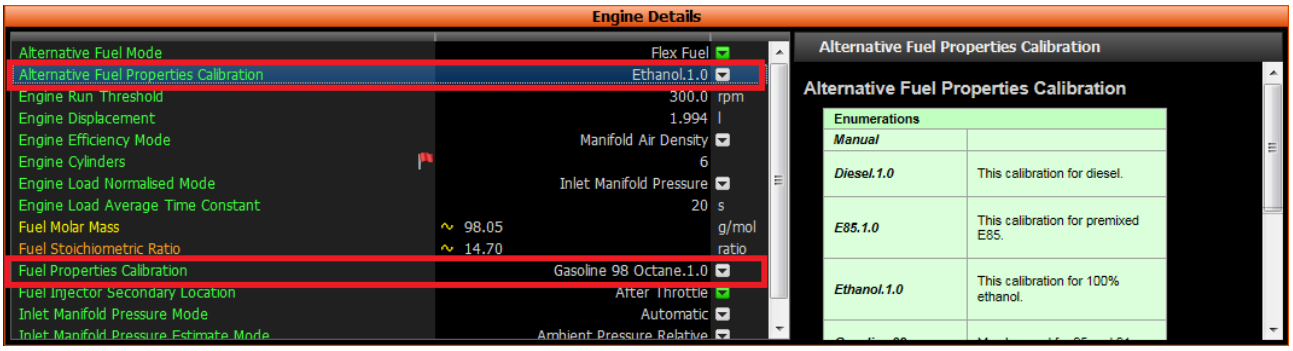


The three options are:

- Not in Use: When using only one consistent type of fuel, e.g. always petrol **or** always E85 and never a blend of the two.
- Flex Fuel: When using a mixture of two different fuels in one fuel tank. A sensor is used to determine the composition of the fuel to be injected into the engine. Generally, the system is designed around the common Flex Fuel sensors available.
- Secondary Fuel: When using two completely separate fuel systems with separate injectors, pumps, fuel rails for each fuel type. A separate fuel pressure sensor is highly recommended for both systems. Function not described in this document.

Fuel and Alternative Fuel Properties

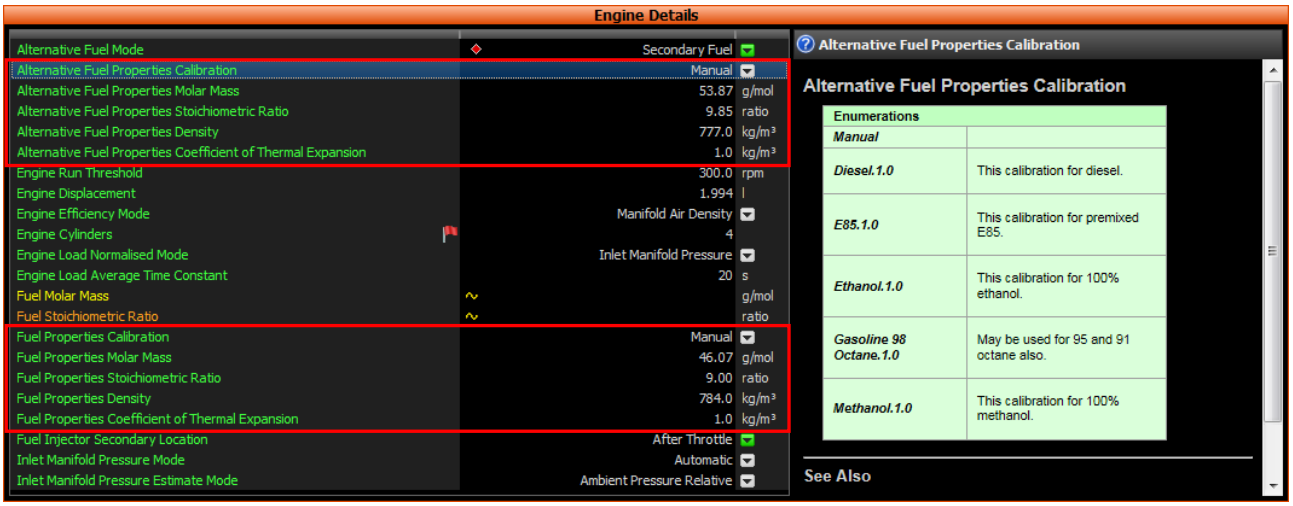
To start with, the ECU must know the properties of both types of fuel to be used. The Fuel Properties Calibration and Alternative Fuel Properties Calibration must be set correctly for each fuel. The fuel properties settings are common to both the Flex Fuel and Secondary Fuel functions.



NOTE: If E85 is used as the Alternative Fuel it must be specified as 100% Ethanol. The Flex Fuel sensor itself will specify the Ethanol content as 85%.

- Alternative Fuel Properties Calibration and Fuel Properties Calibration– MoTeC will add different types of common fuel to a drop down list to avoid having to enter each value for the fuels details. A "Manual" setting will always be available for uncommon or custom fuels.

For a Manual fuel calibration:



- Fuel Properties Molar Mass – Used to find the volume of gas occupied from a given mass of fuel at STP.
- Fuel Properties Stoichiometric Ratio – Stoichiometric air/fuel ratio by mass
- Fuel Properties Density – Fuel A density at 25deg Celsius
- Fuel Properties Coefficient of Thermal Expansion – Fuel density correction for temperature

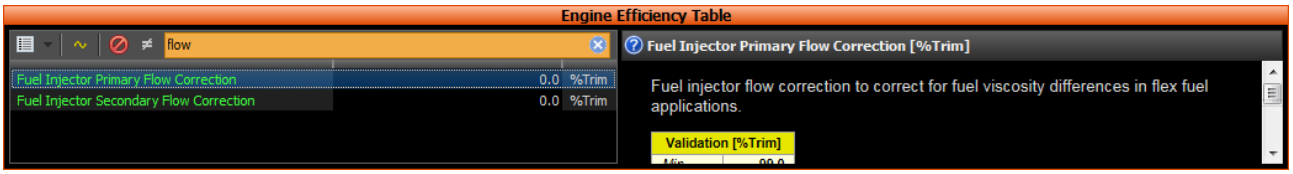
Flex Fuel Setup

The following section describes the setup of a Flex Fuel system using a Flex Fuel sensor and considers that a mixture of two fuels is injected through one common fuel system. This common fuel system would generally consist of a single set of injectors (one per cylinder) with one fuel tank, one fuel pressure regulator and one fuel pressure sensor.

The ECU can use this same fuel system with two injectors per cylinder; the staged injection system for a common fuel type is not detailed in this document.

Fuel Flow Correction (Flex Fuel Mode)

The Flow Correction number is used to adjust fuel volume based on the viscosity of the alternative fuel being injected. The Flow Correction channel is only used when Flex Fuel is chosen as the Alternative Fuel Mode. The Flow Correction will automatically be 0% when the primary fuel is being injected, e.g. straight petrol. When the full amount of Alternative fuel is being injected, e.g. straight E85, the full Flow Correction is applied. The number is automatically scaled when a combination is used, e.g. E50. The user only needs to enter the flow correction for the Alternative Fuel.



- Fuel Injector Primary Flow Correction – flow correction for primary injector for the Alternative fuel type.
- Fuel Injector Secondary Flow Correction – flow correction for secondary injector if using flex fuel and staged injectors.

MoTeC uses injector test fluid that mimics the flow properties of petrol. The tuner should consider petrol to be the primary fuel and E85 to be the Alternative Fuel so that a properly tested Flow Correction number can be used correctly in the software.

If an unknown fuel is being used for the Alternative Fuel, the tuner will need to perform their own testing to establish a Flow Correction number. To test for unknown fuels:

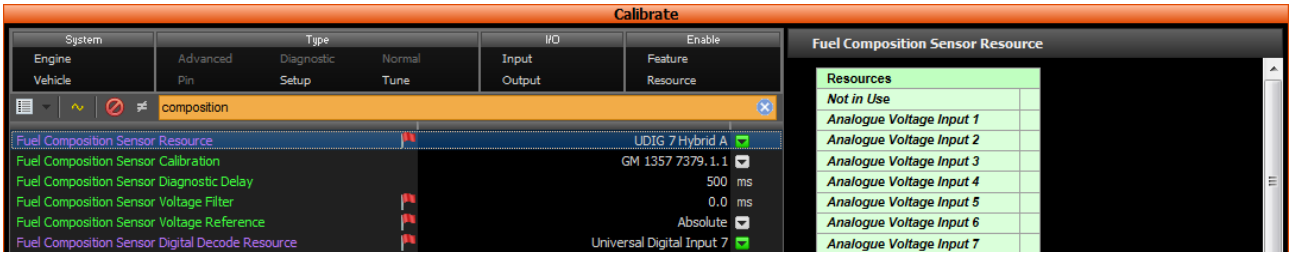
- The engine should be properly tuned on petrol so that the Lambda sensor reading matches the Fuel Mixture Aim
- The fuel should then be changed to the Alternative fuel (all fuel properties must be filled out)
- Run the engine at a load site that was correctly tuned on the primary fuel
- The Flow Correction can be altered until the Lambda again matches the Mixture Aim

With the Flow Correction number set correctly for the Alternative Fuel there should be no reason to change the main Efficiency table no matter what the composition of the Primary and Alternative Fuel.

NOTE: Flow Correction numbers may vary between two different injectors for a given fuel like E85. The flow correction must be changed/checked if the injectors are changed at any time after initial tuning.

FLEX FUEL SENSOR: FUEL COMPOSITION

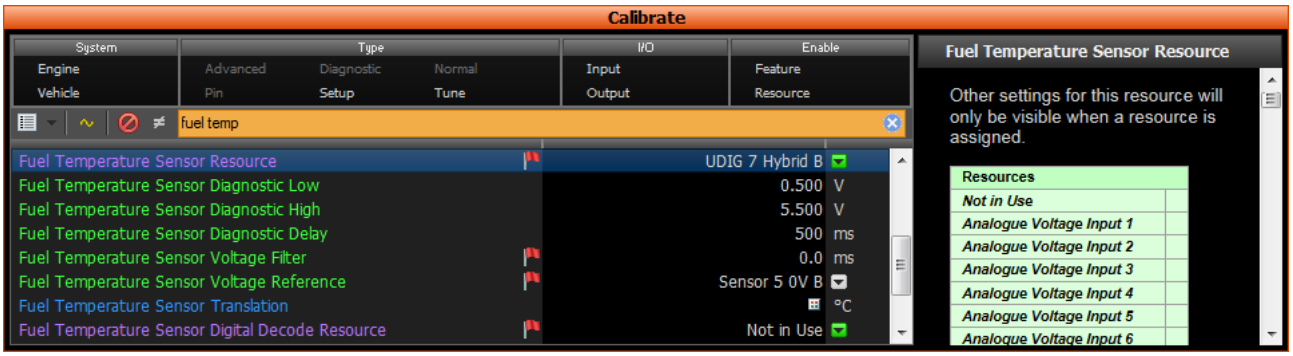
The MoTeC ECU can use Analogue Voltage, Digital and CAN inputs for Flex Fuel to measure Fuel Composition. Generally, customers will be using digital sensors like those commonly supplied.



- Fuel Composition Sensor Resource – The input for a digital sensor is defined as a UGIG X Hybrid A. This needs to reflect the UDIG input used, e.g. UDIG 7 in the example above.
- Fuel Composition Sensor Digital Decode Resource – this setting needs to match the UDIG number for the Fuel Composition Sensor Resource
- Fuel Composition Sensor Calibration – Some of the common sensors will be in the drop down list. There is also a manual calibration for other sensors.
- Fuel Composition Diagnostic Delay – The delay time the ECU will wait before a sensor is declared in fault when the input voltage goes out of range.
- Fuel Composition Sensor Voltage Filter – Filter time constant used to apply some smoothing to the channel reading. This value should be kept as low as possible.
- Fuel Composition Sensor Voltage Reference – Specifies the 5v output used to power the sensor. Use a setting of Absolute if the sensor is not ratiometric.

FLEX FUEL SENSOR: FUEL TEMPERATURE

The common flex fuel sensors will also provide fuel temperature as part of its digital reading. Only one digital input is needed to get both the composition and temperature readings.

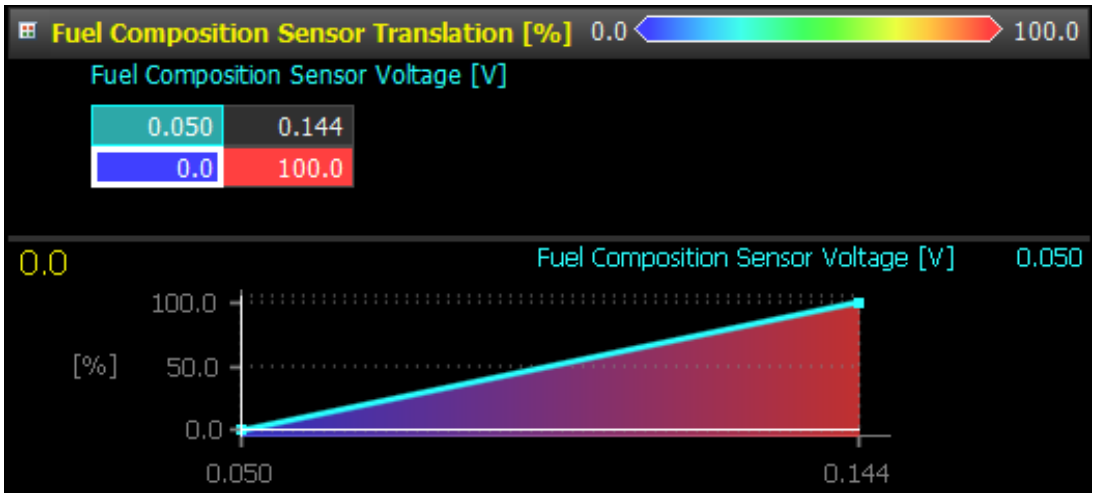


- Fuel Temperature Sensor Resource: If using the flex fuel sensor, a UDIG X Hybrid B can be used if the UDIG input has already been set up for the Fuel Composition channel. It is still possible to use a separate fluid type sensor as well.
- Fuel Temperature Sensor Diagnostic Low: Sensor voltage below which the sensor channel will be in error. The above example is suitable for the digital Flex Fuel sensor.
- Fuel Temperature Sensor Diagnostic High: Sensor voltage above which the sensor channel will be in error. The example above is suitable for the digital Flex Fuel sensor.

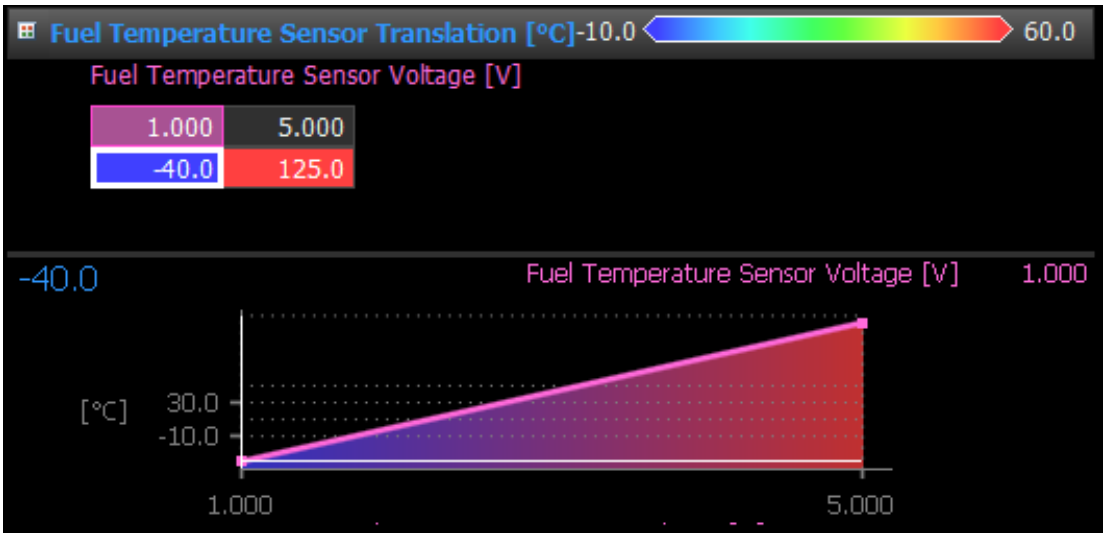
- Fuel Temperature Sensor Diagnostic Delay: Sensor reading needs to be outside of the Fuel Temperature Sensor Diagnostic Low and Fuel Temperature Sensor Diagnostic High range for this time before it is flagged as in fault.
- Fuel Temperature Sensor Voltage Filter: Can be used to smooth noisy signals. The minimum possible filtering value is recommended.
- Fuel Temperature Sensor Voltage Reference: Specifies which 5v power supply is used for the sensor. For Analogue Temperature inputs see ECU Package help for more detail.
- Fuel Temperature Sensor Translation: Translates sensor input into temperature. See below for GM 1357 7379 digital sensor.
- Fuel Temperature Sensor Digital Decode Resource: If the UDIG X has already been specified for the Fuel Composition channel and the temperature channel is form the same sensor this does not need to be specified.

GM 1357 7379 Flex Fuel Sensor Translation Table

For Flex Fuel composition, the below table can be used although it is recommended to use the automatic calibration from the drop down list.



At the time of writing the fuel temperature sensor calibration does not have a drop down list. Below is the recommended translation table for the temperature reading.



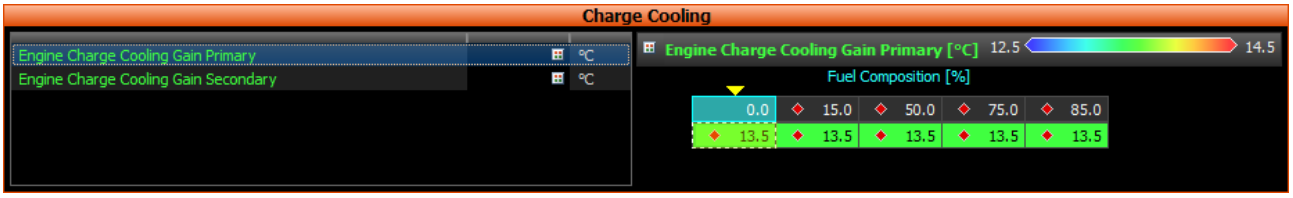
EFFICIENCY TABLE TUNING

The main Efficiency table should only need to be tuned for the primary fuel; there is no need for individual tables for each fuel. As the M1's fuel model is able to cope with the two different fuels and any mixture of the two it is now more important to make sure the efficiency table is tuned so that the actual exhaust Lambda (sensor) reading matches the Fuel Mixture Aim. Any deviation in Lambda sensor reading from the Mixture Aim Main will be amplified with a higher use of the alternate fuel.

Once the Engine Efficiency table has been tuned accurately the Lambda reading should follow the Mixture Aim very closely no matter what the composition of fuel.

Engine Charge Cooling Gain Primary

The Engine Charge Cooling Gain is used in the fuel model of the M1 ECU to account for the cooling effect fuel vapour has on the air in the engine intake. The charge cooling effect should be tested at the early stages of tuning. Engine Charge Cooling Gain is found on the Fuel Mixture Aim Worksheet in the Tuning Workbook.

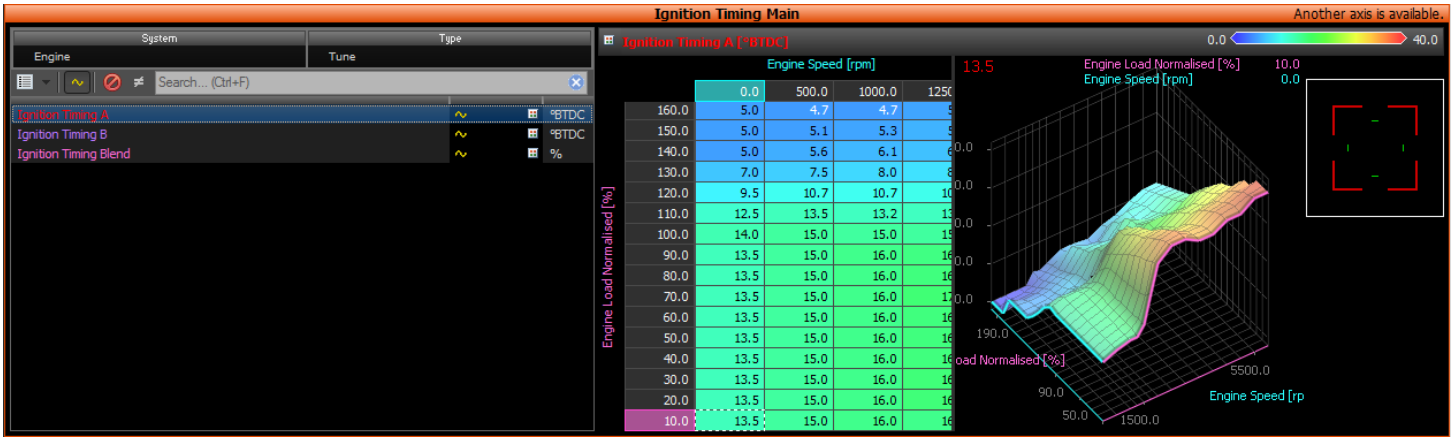


To test charge cooling effects:

- Run the engine at one light load site with a Mixture Aim of 1.0La.
- Tune the Efficiency Table load site until the Lambda reading matches the Mixture Aim.
- Change the Mixture Aim to a much richer aim, e.g. 0.85. The ECU will automatically change the calculated fuel volume to follow the Mixture Aim. The Lambda sensor reading should follow the new requested Mixture Aim without needing to change the Efficiency Table.
- If the Lambda reading does not achieve the new Mixture Aim do not adjust the Engine Efficiency table, instead adjust the Engine Charge Cooling Gain. A larger number will make the Lambda reading richer, while a smaller number will make it leaner.
- Checks should be made for different Fuel Compositions.

IGNITION TIMING

The ignition timing tables will generally be very different from the Primary Fuel to the Alternative Fuel. There is a separate Ignition Timing table for each fuel. It is highly recommended that the timing tables be fully tuned on each fuel, e.g. one completely tuned table for pure 98 octane petrol and one for pure E85.

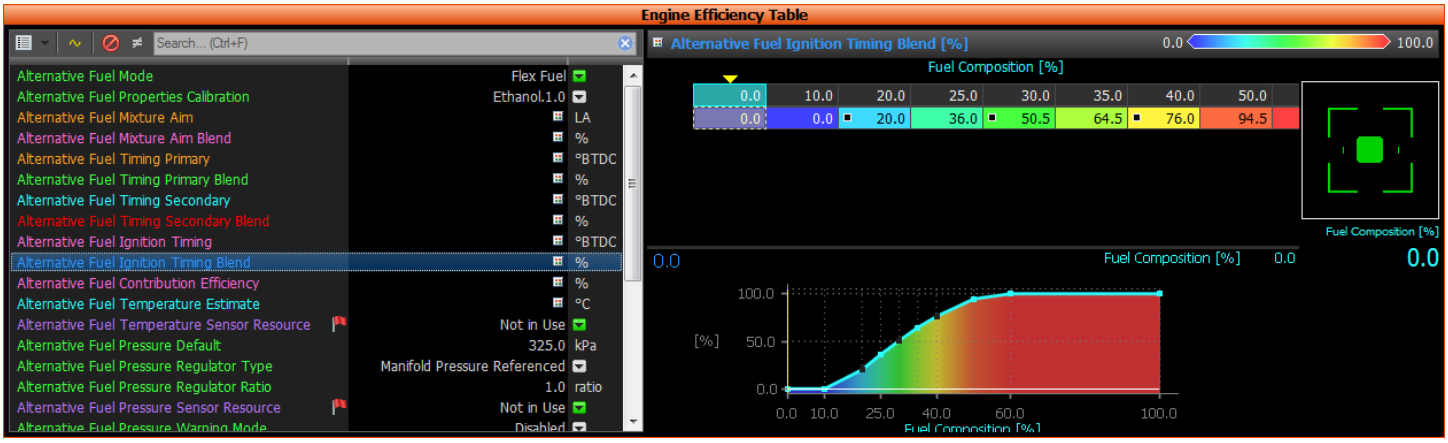


- Ignition Timing Main – Ignition timing table relating to the primary fuel
- Alternative Fuel Ignition Timing – Ignition timing table relating to the Alternative Fuel

The Ignition Timing Main is in the Tuning Workbook on the Ignition Worksheet. The Alternative Fuel Ignition Timing is in the Tuning Workbook on the Flex Fuel Worksheet.

Ignition Timing Blend

The Ignition Timing Blend table is used to decide which ignition table is to be used and by how much. The Ignition Timing Blend table can be found on the Tuning Workbook on the Flex Fuel Worksheet.



In the example above the X axis of the Ignition Timing Blend table is "Fuel Composition", this is a measurement directly from the Fuel Composition channel, in most cases this will be a "Flex Fuel" sensor. E85 fuel (85% Ethanol, 15% Petrol) will give a reading of 85% on the Fuel Composition Axis so it is convenient to have an axis site to represent this.

For an Ignition Timing Blend table value of 100, the Alternative Fuel Ignition Timing will set the Ignition timing. For a table value of 0, the Ignition Timing Main will set the ignition timing. For a table value of 50, the ignition timing will be halfway between the two as the ECU interpolates between the two ignition tables.

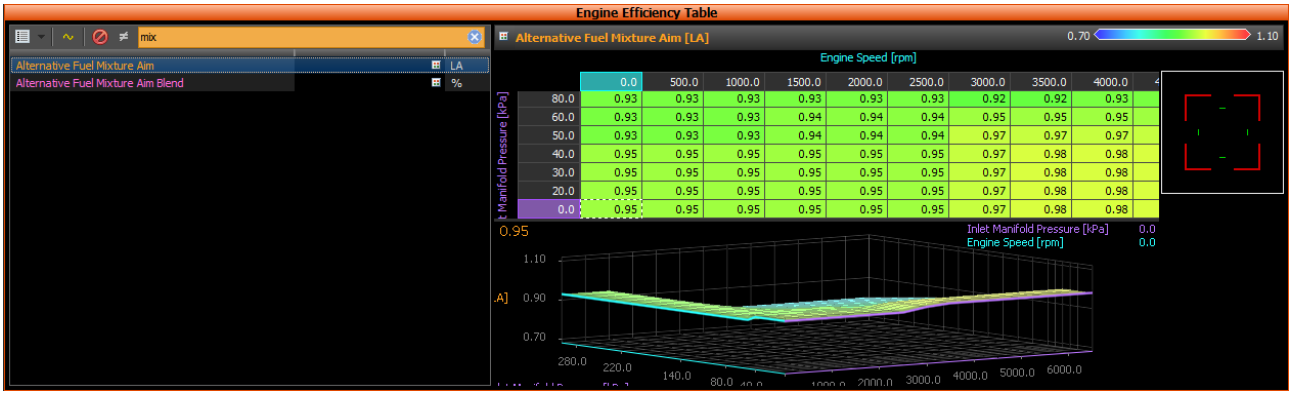
This table must be filled in with some starting values prior to tuning with the Alternative Fuel. As the table is controlled by the Fuel Composition channel (e.g. Flex Fuel sensor), when the Alternative Fuel is added to the fuel tank for tuning it is logical to use 100 in this blend table.

In the preceding example, an engine was tuned at several different fuel compositions between E85 and petrol. Engine Torque and the Knock Control system were used to determine what the blend of the two ignition tables should be for best performance at each composition.

NOTE: The table above is given as an example and may not be correct for different engine types.

ALTERNATIVE FUEL MIXTURE AIM AND BLEND

The Fuel Mixture Aim is altered with the Alternative Fuel Mixture Aim and Alternative Fuel Mixture Aim Blend tables. These two tables work in a similar way to the Alternative Fuel Ignition Timing and Ignition Timing Main tables. Using the Alternative Fuel Mixture Aim Blend table the ECU can automatically move the mixture aim between the two mixture aim tables based on the Fuel Composition channel reading.



OTHER ALTERNATIVE FUEL AND BLEND TABLES

The firmware also enables the tuner to adjust and blend for:

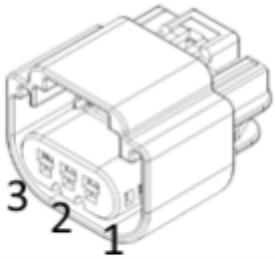
- Alternative Fuel Timing Primary – Different fuel end of injection timing based on Fuel Composition
- Alternative Fuel Timing Secondary – Different fuel end of injection timing for the secondary set of injectors when using staged injection
- Fuel Composition Boost Limit – Alter the boost limit based on Fuel Composition
- Engine Crank Fuel Volume Compensation – Alter the cranking fuel compensation based on Fuel Composition
- Engine Post Start Fuel Volume Compensation – Alter the post start fuelling based on Fuel Composition
- Engine Charge Cooling Gain Primary – Should be calibrated prior to tuning. See ECU Help
- Engine Charge Cooling Gain Secondary – Should be calibrated prior to tuning. See ECU Help
- Knock Threshold – Alter Knock Control threshold based on Fuel Composition
- Knock Trim Gain – Alter the amount of ignition timing reduction for Knock Control
- Knock Trim Limit – Alter maximum amount of ignition reduction for Knock Control

FUEL FILM

There is no specific setup in the Fuel Film function for Fuel Composition but it is recommended that the tuner check the effects of both fuels during tuning.

FLEX FUEL SENSOR WIRING

To wire in the most commonly used Continental sensors such as the 13577379 short arm sensor that MoTeC provides the calibration for, use the following information.



Pin	Description
1	Vcc - Battery 12V
2	GND - Battery Ground
3	Vout - Sensor Output