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**For racing and off highway use only**

**Not legal on emissions controlled vehicles unless appropriately certified**

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While every effort is taken to ensure correctness, no responsibility will be taken for the consequences of any inaccuracies or omissions in this manual.

7 November, 2003

# Introduction

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Thank you for purchasing a **MoTeC** Engine Management System.

This manual will help you understand the installation and calibration requirements of your **MoTeC** Engine Management System.

## ***Additional Documentation***

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Additional documentation is available in the form of ***Drawings*** and ***Tech Notes***. Please consult your local **MoTeC** distributor for details.

### ***Drawing Categories***

- Accessories
- ECUs
- Looms
- Ignition Modules
- Combined Module & Trigger Systems
- Trigger Systems
- Valves
- Sensors
- Miscellaneous

### ***Tech Notes***

- Traction Control
- Boost Control
- Idle Speed Control
- Closed Loop Lambda Control
- Wideband Lambda Sensor
- Others



# Overview

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The **MoTeC** M400, M600, M800 & M880 ECU's are powerful and compact programmable Engine Management Systems or Engine Control Units (ECUs).

## ECU Models

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The different ECU's are characterised by the following features:

### **M400**

- 4 injector outputs
- 4 ignition outputs
- Waterproof plastic connector with gold plated contacts
- 512kByte logging memory (option)
- 1 wideband lambda input (option)
- Other optional functions include: Traction Control , Boost Enhancement (Anti-lag), Hi/Lo Injection, Gear Change Ignition Cut, CAM Control, Drive by Wire.

### **M600**

- 6 injector outputs
- 6 ignition outputs
- Waterproof plastic connector with gold plated contacts
- 512kByte logging memory (option)
- 2 wideband lambda inputs (option)
- Other optional functions include: Traction Control , Boost Enhancement (Anti-lag), Hi/Lo Injection, Gear Change Ignition Cut, CAM Control, Drive by Wire.

### **M800**

- 8 injector outputs standard
- 12 injector outputs (option, occupies 4 ignition outputs)
- 6 ignition outputs
- Waterproof plastic connector with gold plated contacts
- 1MByte logging memory (option)
- 2 wideband lambda inputs (option)

- Other optional functions include: Traction Control , Boost Enhancement (Anti-lag), Hi/Lo Injection, Gear Change Ignition Cut, CAM Control, Drive by Wire, Pro Analysis, Telemetry, Multi Pulse Injection, Servo Motor Control.

### **M880**

- 8 injector outputs standard
- 12 injector outputs (option, occupies 4 ignition outputs)
- 6 ignition outputs
- Military style Autosport connector
- 4MByte logging memory (option)
- 2 wideband lambda inputs (option)
- Other optional functions include: Traction Control , Boost Enhancement (Anti-lag), Hi/Lo Injection, Gear Change Ignition Cut, CAM Control, Drive by Wire, Pro Analysis, Telemetry, Multi Pulse Injection, Servo Motor Control.

### **Options**

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A number of options are available which allow the ECU to be configured for a particular need and can also be updated later if necessary.

The options may be enabled at any time by entering an enable password.

#### **Data Logging Option**

Allows logging of the ECU sensors and operating parameters to the internal data logging memory. The logged data may then be analysed in graphical format using the free **MoTeC Interpreter** Software.

#### **Pro Analysis**

Enables more advanced functions in the data logging analysis software such as multiple graph overlays, XY plots, maths functions, advanced track map analysis. (Available on M800 & M880 only).

#### **Wideband Lambda Option (Single or Dual)**

Allows Wideband Lambda (Air Fuel Ratio) measurement, which may be used for data logging or closed loop control of the Air Fuel Ratio. The ECU is compatible with Bosch LSU or NTK wideband lambda sensors, it is not

compatible with the Bosch 4 wire LSM sensor. (Dual Lambda not available on M400)

## ***Telemetry***

Enables the ECU to send telemetry data via a radio to the pits. The data can be viewed in graphical format using the **MoTeC Telemetry Monitor** program. (Available on M800 & M880 only).

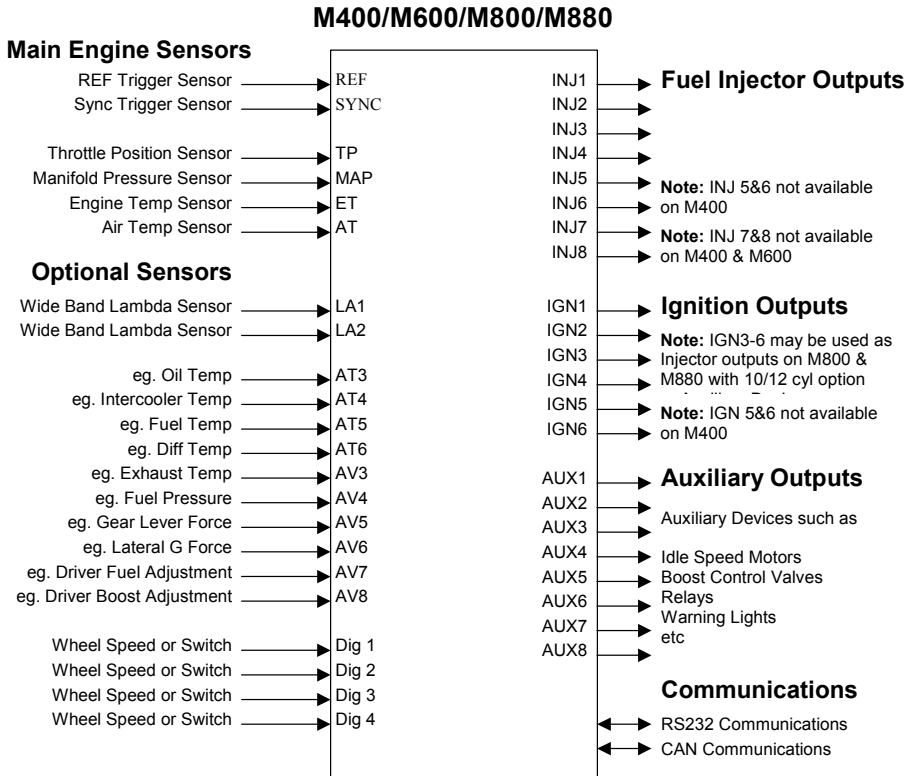
## ***Other***

Other options include CAM Control, Drive by Wire, Traction Control, Overrun Boost Enhancement (Anti-lag), Gear Change Ignition Cut, Hi/Lo Injection, Servo Motor Control (M800 & M880 only) & Multi-pulse Injection (M800 & M880 only).

## ECU Inputs & Outputs

The **ECU** analyses signals from the sensors, then controls the Fuel Injectors, Ignition System and other auxiliary devices according to the Calibration and Setup Data which is stored in the ECUs programmable memory.

The Inputs and Outputs are shown below.



### Main Engine Sensors

The Main Engine Sensors are required for correct operation of the ECU.

The engine RPM is derived from the REF trigger sensor.

The SYNC trigger sensor is required to synchronise the Fuel and Ignition to the correct engine cycle for sequential injection and correct firing of multicoil ignition systems.



The Throttle Position, Manifold Pressure, Air Temp and Engine Temp are used as inputs to the various calibration tables.

## ***Optional Sensors***

The Optional Sensors are not required for basic operation of the ECU.

The Lambda Inputs may be used for wideband air fuel ratio measurement or wideband or narrow band closed loop lambda control.

The Digital Inputs may be used for wheel speed measurement or to activate functions such as Dual RPM Limit, or Nitrous.

The other inputs may be used for data logging (eg. Exhaust Gas Temp, Gear Box Temp, Driver Boost adjustment etc) or for special calibration features.

## ***Fuel Injector Outputs***

### ***M400***

Up to four injectors may be driven fully sequentially including very low ohm types (0.5 ohms).

### ***M600***

Up to six injectors may be driven fully sequentially including very low ohm types (0.5 ohms).

### ***M800 & M880***

Up to twelve injectors may be driven fully sequentially by the ECU if the injectors are high resistance types (12 ohms or greater), otherwise up to eight injectors may be driven fully sequentially including very low ohm types (0.5 ohms).

- Four of the Ignition Outputs are used for full sequential 12 cylinder operation.
- Twelve cylinder engines may also be driven as six groups of 2 injectors which leaves all six Ignition outputs available for wasted spark ignition.
- Outputs not used for Fuel Injection may be used as Auxiliary Outputs.

## ***Ignition Outputs***

The Ignition Outputs may be used to drive many different types of ignition systems, which are detailed in the various ignition system drawings.

### **M400**

Up to four ignition outputs are available for multi coil applications.

### **M600**

Up to six ignition outputs are available for multi coil applications.

### **M800 & M800**

Up to 6 ignition outputs are available for multi coil applications.

- Outputs not used for ignition may be used as Auxiliary Outputs.
- Up to 8 coils may be driven from one Ignition Output using a **MoTeC** CDI8 or **MoTeC** Ignition Expander .
- Up to 12 coils may be driven from two Ignition Outputs using two **MoTeC** CDI8's or two **MoTeC** Ignition Expanders.

### **Auxiliary Outputs**

The ECUs have eight Auxiliary Outputs that may be used for :

Turbo Waste Gate Control, Idle Speed Control, Gear Change Light, Driver Warning Alarm, Tacho Output, Fuel Pump Control, Thematic Fan Control, Fuel Used Signal, Air Conditioner Fan Control, Air Conditioner Clutch Control, RPM / Load Activated Output, or other functions.

### **CAN Communications**

The CAN Communications system is a high speed network communications system that allows multiple devices to be connected and communicate with each other.

The CAN connection is used for all communications with the PC via the **ECU Manager** software which includes; calibration, diagnostics checking, retrieving the logged data, firmware upgrading and enabling options.

CAN may be used to communicate with the **MoTeC** ADL Dash Logger.

CAN will also be used to communicate with future **MoTeC** devices.

### **RS232 Serial Communications**

Optionally used to communicate with the **MoTeC** ADL Dash Logger. In this case the ADL is effectively picking up Telemetry data from the ECU. (Note that CAN communications may also be used to connect to the ADL)

Used for Telemetry Output (M800 & M880 only).

## Calibration & Setup

### Calibration Tables

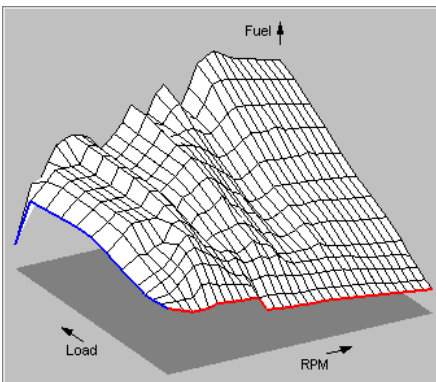
The Calibration Tables determine how the output devices should be controlled for various sensor readings. For example the fuel calibration table determines the base injector pulse width for all combinations of RPM and Load. Other calibration tables will also affect the fuel injector pulse width such as Air Temperature compensation and Engine Temperature compensation.

The ECU determines the amount of fuel to inject by first calculating the RPM and Load then extracting the corresponding value from the table. If the RPM and Load do not match an RPM and LOAD point exactly then the values from the closest sites are mathematically interpolated to arrive at an intermediate value.

A typical 3 dimensional fuel calibration table is shown below.

Fuel Main (% of IPU)		RPM	0	500	750	1000	1250	1500
Load %	50.0		35.0	40.5	44.0	44.0	44.0	44.0
	40.0		32.5	39.5	44.0	44.0	44.0	44.0
	30.0		29.5	35.0	34.5	37.0	38.0	46.0
	20.0		27.0	31.0	32.5	36.0	42.0	46.0
	15.0		25.5	29.5	31.5	35.5	40.5	42.5
	10.0		25.5	26.5	29.5	33.5	37.0	37.5
	5.0		26.0	25.5	25.5	25.5	30.5	30.5
	0.0		26.5	23.5	22.0	22.0	22.0	23.5

The calibration tables may also be represented graphically as shown below.



## Setup Parameters

The Setup Parameters allow the ECU to be configured for almost any engine. The Setup Parameters include Number of Cylinders, Ignition Type, Sensor Types, Injector Current, Auxiliary Output Functions etc.

- The Setup Parameters must be correct before attempting to start the engine.

## ECU Functions

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The ECU's can perform a large number of functions in addition to the normal Fuel and Ignition control capabilities including Hi /Lo injection, Individual Cylinder tables for Fuel and Ignition, Rotary ignition split and various sensor compensations

The functions are setup using **ECU Manager** either in the **Functions** menu, the **Digital Input Functions** menu or the **Auxiliary Output Functions** menu.

Help on each function is available from within **ECU Manager** by pressing the F1 key when the appropriate screen is shown.

Tech Notes are available from **MoTeC** on the more complicated functions such as Traction Control.

Note that some functions may not be available depending on the ECU Model and options.

The functions are as follows:

### Functions

The following functions are setup in the **Functions** menu

- Boost Control \*\*
- Warning Alarms \*\*
- Gear Detection \*
- Overrun Fuel Cut
- Ground Sped Limiting \*
- Gear Change Ignition Cut \*
- Boost Enhancement (Antilag) \*
- Lambda Control
- Traction Control \*

\* must also be setup in the Digital Input Functions

\*\* must also be setup in the Auxiliary Output Functions

### **Digital Input Functions**

The following functions are setup in the **Digital Input Functions** menu

- Speed Measurement
- Period Measurement
- Pulse Measurement
- Dual RPM Limit
- Air Conditioner Request
- Nitrous
- Nitrous + Dual RPM Limit
- Ignition Switch
- Brake
- Logging Enable
- Clutch
- Beacon
- Power Steering
- Cam Position
- Telemetry Control
- Mass Air Flow Frequency Measurement
- RPM Speed Limiting

### **Auxiliary Output Functions**

The following functions are setup in the **Auxiliary Output Functions** menu

- Idle Speed Control
- Aux Table Controlled Output
- Tacho Signal
- Drive by Wire Control
- Drive by Wire with Idle Speed Control
- Stepper Idle Speed Control
- Fuel Pump Control
- Thematic Fan Control
- Air Conditioner Fan Control
- Air Conditioner Clutch Control
- RPM / Load Table Output
- Gear Change Light Output
- Fuel Used Pulse Output
- Slip Warning Output
- Alternator Control
- Spray Bars Output
- Status Output

- DC Servo Motor Control
- Cam Control
- Power Hold Output
- Servo Stepper Motor Control
- Fuel Pressure Control





## MoTeC Software

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The following software is available. Note that the same software is used for all ECU models.

**ECU Manager:** Used for calibration, setup, diagnostics, output testing, upgrading, unloading the logged data and enabling ECU options.

**Interpreter:** Used to analyse the logged data.

**Telemetry Monitor:** Used to show real time telemetry data.

## PC Requirements

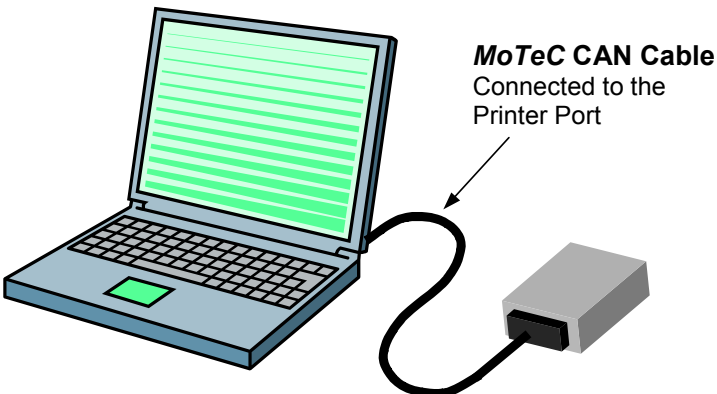
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- IBM PC compatible.
- 200 MHz Pentium or faster.
- The PC must have a 25 pin printer port (parallel port) for connection of the **MoTeC CAN Cable**.
- Operating System: Windows 95, 98, ME, NT4, 2000, XP.

## Connecting a PC to the ECU

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The PC must be connected to the ECU by a **MoTeC CAN Cable**. Note that the ECU must be wired with the mating connector.



## ***Installing the Software***

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The **MoTeC** Software must be installed on to the PC hard disk before it can be used.

The main software required is the **ECU Manager** software, if Data Analysis is required then the **Interpreter** software should also be installed, if telemetry is required then the **Telemetry Monitor** software should be installed.

The software can be downloaded from the **MoTeC** web site at [www.motec.com.au](http://www.motec.com.au), or is available on CD.

**MoTeC** is continually updating the software and newer versions may be downloaded from the web site at no charge.

To install the software after downloading from the web double click on the downloaded file and follow the instructions.

Note that a separate folder (directory) is automatically created for each version of the software. Old versions are kept so that they may be used if necessary.

- Do not change the **MoTeC** directory structure or move the software to a different directory, otherwise the software will not operate correctly.

## ***Starting the Software***

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To start the **MoTeC** Software double click the appropriate icon on the desktop or select the appropriate program from the Start menu. For example: Start / Programs / MoTeC / M400 M600 M800 / ECU Manager 2.1

## ***ECU Manager Software***

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The **ECU Manager software** is covered in more detail later in this manual.

## ***Data Logging***

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Data Logging allows the ECU operational data to be recorded in a memory chip inside the ECU, the data may then be extracted for analysis on a PC. Data logging is extremely useful for checking mixture readings, sensor readings, diagnostics errors and other operating information.

The items to be logged and the logging rates must be setup using the **MoTeC ECU Manager** software. This is done in the **Data Logging Setup** screens.

The ECU will remember the logged data even if the ECU power is turned off.

- If the logging memory becomes full the oldest data is overwritten so that the most recent data is always available.
- The ECU must have the **Logging** option to perform data logging.

## **Pro Analysis**

If the **Pro Analysis** option is enabled then advanced analysis options such as Track maps, multiple graph overlays, XY plots, maths functions, advanced track map analysis. (Available on M800 & M880 only).

## **Unloading the Logged Data**

The logged data can be extracted by connecting the **MoTeC** CAN Cable to the ECU and selecting **Utilities | Get Logged Data** from the **ECU Manager** menu.

## **Data Logging Analysis**

The **MoTeC Interpreter** software may be used to analyse the logged data.

The **Interpreter** software is supplied separately to the **ECU Manager** software.

The **Interpreter** software makes it easy to analyse mixture readings and other sensor readings by presenting the data in various graphical formats.

Refer to the **Interpreter** help screen for more detail.

## **Telemetry**

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The **MoTeC Telemetry Monitor** software may be used to view live information from the ECU via a radio link.

The **Telemetry Monitor** software is supplied separately to the **ECU Manager** software.

The **Telemetry Monitor** software shows the ECU data in various graphical forms including dial gauges, bar graphs and chart recorders.



# Installation

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## ***Throttle Position or MAP Load Sensing***

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The load point for the fuel and ignition calibration tables may be based on any defined load measuring sensor.

The most commonly used are the Throttle Position sensor or the MAP (Manifold Pressure) sensor.

Mass Air flow (MAF) sensors are also used particularly where regulations state that the sensors cannot be changed from the factory fitted sensors.

### ***Turbo Charged Engines***

Normally use Manifold Pressure load sensing (connect the MAP sensor to the inlet manifold).

A Throttle Position sensor is optional and will be used for acceleration enrichment if fitted.

### ***Normally Aspirated Engines***

#### ***3D Fuel and Ignition Tables***

Normally use Throttle Position load sensing.

The MAP sensor may be used to compensate for barometric pressure changes by venting it to atmospheric pressure.

- If Idle Speed Control is used then the MAP sensor should be connected to the plenum or Manifold Pressure load sensing should be used. This is required so that the fuel is varied as the idle speed control valve opens and closes.

## Sensors

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### Throttle Position Sensor

The Throttle Position sensor must be a potentiometer type, older switch types are not suitable. The sensor will produce a voltage proportional to the angle of the throttle plate.

Throttle sensors generally have a dead band at either end and must be pre-loaded to avoid the dead band.

The Setup Parameters **TPHI** and **TPLO** must be set to indicate the fully closed and fully open positions. These parameters must be reset any time the sensor is moved or replaced. It is very important to set these parameters with the butterfly in exactly the same place each time.

The resistance element inside the sensor may wear due to vibration in high performance engines which can cause erratic readings. It is best to replace the throttle position sensor periodically.

Avoid high pressure washing as this may penetrate the seals and damage the sensor.

For wiring details refer to the appropriate **MoTeC** drawing.

### MAP Sensor

The MAP (Manifold Absolute Pressure) sensor measures Absolute Pressure (ie. pressure relative to a vacuum).

0 kPa Absolute = Complete Vacuum

100 kPa = 1 Bar = 14.5 PSI

Atmospheric Pressure at sea level is approximately 100 to 102 kPa, depending on the day.

MAP sensors normally produce a voltage between 0 and 5V, depending on the pressure.

The pressure sensor may be used to measure the inlet manifold pressure or to measure the barometric pressure depending on the Load Sensing arrangement detailed earlier.

The ECU Sensor Setup parameters must be set to indicate the type and pressure range of the sensor.

Avoid severe vibration of the sensor as this can cause fluctuations in the reading. Do not mount rigidly to the engine. Normally the pressure sensor is mounted to the vehicle body.

### ***If used for Manifold Pressure Sensing***

For normally aspirated engines use a 100 kPa sensor.

For turbo charged engines a 300 kPa absolute sensor will measure up to 200 kPa (29 psi) of boost (above Atmospheric). If higher boost will be achieved a sensor with a higher pressure range will be needed.

The sensor should be connected to the inlet manifold plenum via a short hose (less than 1m). The sensor should be mounted above the level of the plenum with the port facing down to avoid moisture accumulating on the sensor element. The hose should run downwards all the way to the plenum.

The plenum take off point should be at a position that best represents the average manifold pressure and has minimal pressure pulsations. A small restrictor may be needed at the manifold end of the hose to help reduce pressure pulsations. The take off point should not be teed in with other items such as idle speed control valves as they can affect the pressure reading.

### ***If used for Barometric Pressure Sensing***

Use a 105 kPa sensor.

Vent the sensor to the atmosphere with the port facing down.

Avoid mounting at a point where air buffeting occurs, any pressure fluctuations will directly affect the mixture.

It may be desirable to sense the pressure at the air intake as the pressure may vary due to aerodynamic effects.

### ***Air Temp Sensor***

The Air Temperature sensor is mainly used to correct for air density change due to air temperature variation.

The sensor contains a temperature dependant resistor and is designed for high speed response in an air flow.

The Air Temp sensor must be placed to measure the air temperature before the butterfly (and after the inter cooler on turbo charged engines).

Avoid placing the sensor too close to the stand-off vapour in a multi-runner manifold as this will cool the sensor and give a false reading.

The ECU Sensor Setup parameters must be set to indicate the particular type of sensor.

### ***Engine Temp Sensor***

The Engine Temperature sensor is mainly used for cold start enrichment.

The sensor contains a temperature dependant resistor and is designed for water immersion.

The ECU Sensor Setup parameters must be set to indicate the particular type of sensor.

### ***Trigger Sensors (REF & SYNC)***

The trigger sensors supply the necessary timing information to the ECU so that it knows when to fire the fuel injectors and ignition system. Normally two sensors are used, REF and SYNC.

Many different types of trigger sensors and chopper patterns may be used.

The wiring and ECU setup information for the trigger sensors are specific to the particular system. Refer to the appropriate **MotEC** drawing.

Home made sensor systems often cause problems. Do not use Chrome molly for chopper disks as it is a non magnetic material. Runout of the disk, imperfections and bolt heads are also potential sources of problems. Where possible it is best to use the manufacturers trigger system.

### ***REF Sensor***

Supplies the crank position information.

Some sensors supply one pulse per Top Dead Centre (4 pulses per engine revolution on a V8), others supply as many as 360 pulses per engine rev.

The Engine RPM is derived directly from this signal.

### ***SYNC Sensor***

Used to indicate each engine cycle, which is required for sequential injection and multi coil operation.

Generally supplies one pulse per engine cycle (ie: once every 2 revs on a 4 stroke engine).

- On some special trigger systems the ECU can be synchronised using the REF sensor only (eg. Ford Narrow Tooth)



## ***REF / SYNC Alignment***

Most modern distributors supply both REF and SYNC signals in which case the alignment is pre-set.

When using separate REF and SYNC sensors the alignment of the two sensors relative to one another is critical. Ensure that the sensors are aligned correctly for the type of trigger system being used. Refer to the appropriate drawing. Allow for any slop in the distributor drive system if the SYNC signal is derived from the distributor.

## ***Exhaust Gas Sensor (Lambda Sensor)***

The ECU may optionally use a wideband exhaust gas sensor for data logging or closed loop control of the Air Fuel Ratio.

The ECU is compatible with the Bosch LSU wideband sensor and the NTK wideband sensor. These sensors are different to the sensors used on previous model ECUs.

Note that the sensor heater must be connected to these sensors at all times and must be controlled by the ECU by connecting it to one of the Auxiliary Outputs.

The sensor should preferably be placed within 0.5 m of the collector pipe on a normally aspirated engine or 0.5 m of the turbo on a turbo charged engine. If placed too close to the exhaust outlet the reading may be effected by the outside oxygen.

The sensor can be contaminated by exhaust manifold sealant - use an exhaust gas sensor friendly sealant.

The lifetime of the Sensor will be significantly reduced by leaded fuels.

Refer to the **MoTeC** Tech Notes and Drawings for more details.

## ***Wiring***

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### ***Wiring Drawings***

Refer to the Loom wiring diagram for the loom wiring details. Refer to the drawings at the back of this manual for more general wiring details.

The wiring details for the REF and SYNC Trigger Sensors and the Ignition Module are specific to the type of sensors and Ignition system. **MoTeC** can provide wiring diagrams for most Trigger Sensors and Ignition systems.

## ***Wiring Reliability***

The wiring is critical for reliable operation of the ECU. The following points will help to ensure that the wiring is reliable.

### ***Ground Wiring***

One of the most common wiring problems is poor ground wiring.

The ground wire must be grounded properly to the engine block. There should be no paint or anodising between the ground wire and the engine block. Temporary wiring is likely to cause problems, use a proper eyelet terminal that is securely crimped to the ground wire. Studs fixed in place by Loctite® can also cause a problem as the Loctite® becomes an insulator. These comments apply to both the ECU ground wire and the Ignition system ground wire.

The ground wire must be at least 12# (3.3 mm<sup>2</sup>) and must be kept as short as possible.

### ***Power Wiring***

The power wire must be wired by the shortest path possible to the battery via a 30 Amp relay and a 20 Amp fuse. The relay and fuse must be in good condition and the wires must be crimped securely to the appropriate terminals. The relay should be activated by the Ignition Switch. The ECU power must NOT be fed directly from the Ignition switch because it probably wont handle the required current.

The power wire must be at least 12# (3.3 mm<sup>2</sup>) and must be kept as short as possible.

### ***Spark Plug Leads***

The spark plug leads can cause interference in the ECU wiring. Keep the ECU wires away from the plug leads wherever possible (at least 100mm). If it is necessary to cross the plug leads, cross at right angles.

### ***Terminal Crimping***

Use the correct crimping tool for each type of terminal. Do a pull test on a sample wire and terminal to verify that the crimp is sound. In theory the wire should break before the wire pulls out of the crimp.

Most crimp tools are only designed for a certain range of wire sizes so be sure to test the crimp with the particular wire size being used.

Soldering the terminal is a last resort if the correct crimping tool is not available. Soldering will cause a stress point where the solder wicks up the wire which is likely to fracture unless all movement is avoided. Solder flux can also cause corrosion and may affect the contacts.

### ***Terminal Damage***

The various connector terminals are easily damaged if probes are inserted into them. Do not insert probes of any kind into the terminals. If checking a circuit for continuity gently touch the side of the terminals only, or preferably attach a mating connector.

### ***Wire Splicing***

Preferably use a crimp splice. If soldering a wire splice, wire movement near the joint must be avoided otherwise a fracture may occur at the stress point created by the solder. Use heatshrink sleeving to insulate and provide support to the wires.

### ***Wire Strain***

Avoid pulling the wires tight at the connectors.

### ***Wire Movement***

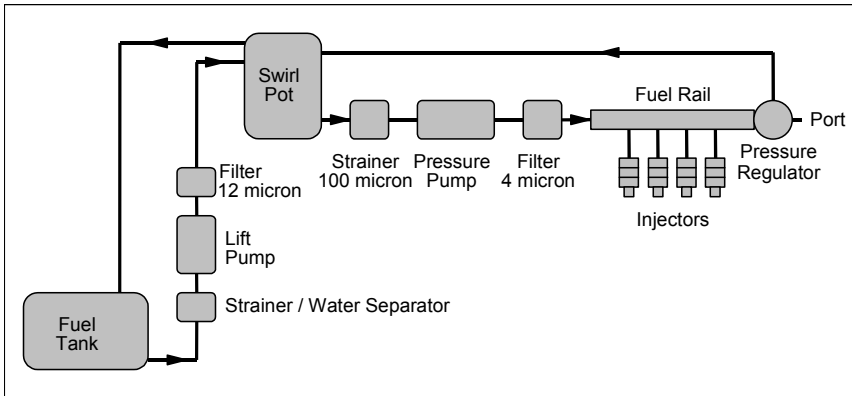
Avoid wire fatigue by tying the wires down close to the connectors.

### ***Heat***

Keep the ECU wires away from the exhaust system.

## ***Fuel System***

An ideal race fuel system is shown below



### ***Lift Pump***

The Lift Pump is a low pressure pump designed to lift the fuel from the fuel tank to the swirl pot (header tank).

The Lift Pump must be capable of flowing enough fuel for full power operation.

### ***Swirl Pot***

The swirl pot (header tank) maintains a reserve of fuel to avoid fuel starvation to the engine during cornering and acceleration. Fuel starvation can also cause damage to the pressure pump as it relies on the fuel for cooling, lubrication and speed limiting.

The swirl pot also forms a header tank for the pressure pump since the pressure pump is not capable of lifting the fuel from the tank if the tank is lower than the pump. Place the swirl pot at the same level, or higher than the pressure pump.

### ***Pressure Pump***

The Pressure Pump is a high pressure pump that must be capable of delivering the required amount of fuel at the correct pressure at full power.

It is very important that the pump is capable of maintaining the correct fuel pressure at full power otherwise the engine could be damaged due to a lean mixture.

A 600 hp engine requires a flow rate of approximately 250 lb/hr for petrol or gasoline.

### **Notes**

- The pressure pump must be lower than the outlet of the swirl pot.
- Prime the pump with fuel before use.
- The pumps flow capability is dependant on the required pressure, the flow capability of the pump will be less at higher pressures. A small pump will maintain correct pressure at light load but will not maintain correct pressure as the flow requirement increases.
- On boosted engines the pressure required from the pump increases with boost pressure because the regulator maintains constant pressure above manifold pressure.
- Avoid running the pump dry as this may destroy the pump.

### **Filters**

The filters are necessary to ensure that the fuel pump is not damaged and to ensure that the injectors do not become blocked.

- The strainer before the pressure pump is essential to prevent the pump from seizing. A strainer is used because the pressure pump won't suck through a paper filter.

### **Fuel Lines**

The fuel feed lines must be high pressure type and should be at least 8mm (5/16 inch) diameter. The return lines should also be at least 8mm (5/16 inch) diameter to ensure that the fuel is easily returned to the tank.

Use proper high pressure hose clamps to ensure that the lines do not blow off under pressure.

Keep the fuel lines as cool as possible to avoid fuel vaporisation. The temperature of the fuel will also affect the mixture due to the change in fuel density.

Avoid fire risk by ensuring that all hoses and fittings are in good condition and installed correctly.

## ***Fuel Rails***

The fuel rails must be free of any debris that could block the injectors. Welded fuel rails can often cause a problem unless they have been properly treated to remove all scale and debris and even then they may corrode and cause problems. Aluminium fuel rails mounted directly on the injectors are recommended as they do not suffer these problems.

The fuel rails must have sufficient volume to minimise fuel pressure pulsation and resonance problems.

## ***Fuel Pressure Regulator***

The fuel pressure regulator maintains constant fuel pressure to the injectors which is necessary to ensure constant metering of the fuel. Any variation in the fuel pressure will cause a corresponding mixture change.

The fuel pressure regulator should be mounted at the end of the fuel rail so that fuel is always flowing through the rail. This helps to avoid vapour locks.

Adjustable pressure regulators are available.

## ***If using Manifold Pressure Load Sensing***

Connect the regulator port to the plenum as this ensures that constant pressure is maintained across the injectors.

Note that this will cause the fuel pressure required from the pump to increase as the manifold pressure increases.

## ***If using Throttle Position Load Sensing***

Leave the regulator port open to the atmosphere, unless the MAP sensor is connected to the manifold as is recommended when using idle speed control, in which case the regulator port should be connected to the manifold.

## ***Fuel Injectors***

The fuel injectors meter the fuel by opening for a short but defined time once per engine cycle (sequential operation).

The injectors must be wired in the firing order of the engine.

## ***Sizing***

The size of the injector determines the maximum amount of fuel that can be delivered to the engine.

As a rule of thumb the engine will require about 5cc per minute per horse power for petrol or gasoline. For alcohol a higher flow rate is required.

For example : A 600 hp V8 will require each injector to flow at least  
 $600 \text{ hp} \times 5 \text{ cc/min/hp} / 8 \text{ injectors} = 600 \times 5 / 8 = 275 \text{ cc/min}$ .

Note that the flow rate of any particular injector is dependant on the fuel pressure applied to it.

Sometimes oversize injectors are used to maintain lower duty cycles, since high duty cycles reduce the effect of sequential injection, since the injectors are turned on for most of the time. However this can affect idle fuelling as the injector may have trouble delivering small amounts of fuel.

### ***Flow Rate Matching***

The flow rate of injectors can vary between injectors of the same type. It is advisable to match the flow rates of injectors by testing each injector on a flow bench.

### ***Fuel Pressure***

The fuel pressure applied to the injector will directly affect the amount of fuel that the injector delivers. Doubling the pressure however only increases the fuel flow by about 1.4 times.

Most injectors will only operate correctly over a certain range of fuel pressures. If the pressure is too low then the fuel may not atomise properly. If the pressure is too high then the injectors may not turn off fully. Many injectors will operate correctly at 2.5 bar (29 psi) and some will operate up to 5 bar (73 psi).

### ***Current***

Different injectors require different operating currents. The ECU injector drives must be programmed to suit the injector using the Injector Current setup parameter.

### ***Pulse Width***

The amount of time that the injector spends open during each injection pulse is called the Injector **Pulse Width** and is measured in milliseconds (thousandths of a second), abbreviated as **msec**.

The injector pulse width is controlled by the ECU according to the ECUs calibration data.

## ***Duty Cycle***

The Injector **Duty Cycle** is a measure of the ratio of the time the injector is open (pulse width) to the available time per engine cycle. For example if the injectors were on for half the available time then the duty cycle would be 50%.

The maximum allowable duty cycle is about 85 percent, beyond this the injector does not have time to open and close and is therefore open continuously and cannot deliver more fuel.

The ECU will set a Diagnostics Error if the duty cycle exceeds the maximum allowed duty cycle.

## ***Ignition System***

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### ***Ignition System Types***

Many different types of ignition systems are available with some better suited to different applications than others.

#### ***CDI Distributed***

CDI systems are suited to high revving engines with 8 or more cylinders and are generally capable of at least 12,000 RPM on an 8 cylinder. CDIs are also good at firing fouled plugs.

#### ***HEI Distributed***

High Energy Inductive (HEI) distributed ignition systems are generally limited to about 8000 RPM on an 8 cylinder engine but will run a 6cylinder to 11,000 RPM and a 4 cylinder to 15,000 RPM.

Most modern road cars run HEI ignition systems that are equally well suited to high performance engines as long as the above RPM restrictions are observed.

#### ***Multi Coil (HEI or CDI)***

HEI or CDI multi coil systems will generally run any engine to 15,000 RPM.

Two types of Multi Coil systems are possible :



### **Coil per plug**

One coil for each spark plug, fired sequentially.

### **Double Ended Wasted Spark**

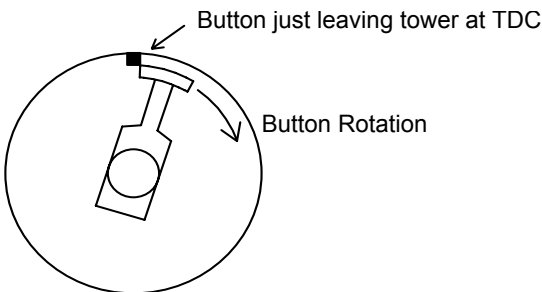
Double ended coils have two high tension towers and fire two plugs at the same time, one on the compression stroke and the other on the exhaust stroke. Each coil is fired sequentially twice per engine cycle and must feed the appropriate two cylinders.

## **Ignition System Wiring & Setup**

The wiring and setup parameters are specific to the particular ignition system. Refer to the appropriate **MoTeC** Ignition System or Ignition Module drawing.

### **Distributor Button Alignment**

If using a distributor, the button must be aligned so that it is leaving the tower at Top Dead Centre for that cylinder.



The button must be a wide tip type to cater for a wide range of advance points since the advance is changed electronically rather than mechanically.

Make sure that the button still overlaps the tower at the maximum advance point.

The distributor should have no mechanical or vacuum advance as this is provided by the ECU.

### **Spark Plug Leads**

The spark plug leads should be high quality Inductive Suppression leads such as Magnicor® leads and must be in good condition.

- Do not use wire leads as they can cause interference.

- Do not use resistive suppression leads as they will reduce the spark energy.

## ***Auxiliary Valves***

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The ECU can control various auxiliary valves such as Idle Speed or Turbo Boost control valves.

Refer to the appropriate **MoTeC** drawing for setup and wiring details. Refer also to any relevant Tech Notes.

## ***ECU Mounting***

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The ECU should be mounted in an area where the internal temperature of the ECU will not exceed 85 °C, generally this is in the passenger compartment. Allow for adequate air circulation around the ECU. The ECU internal temperature may be viewed using the **ECU Manager** software or it may be recorded using the data logging.

Mount so as to minimise vibration, this will help to prolong the ECUs life.

## ***ECU Cleaning***

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Avoid high pressure washing or degreasing of the ECU.

# Initial Setup

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Before attempting to start the engine the setup parameters must be correct.

Use the **MoTeC ECU Manager software** to adjust the setup parameters.

Preferably start with a calibration file from a similar engine as this will make setup faster and easier.

## Main Setup

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### Injectors

Injector Scaling (IJPU)

Injector Current

Injector Battery Compensation

Refer to the **ECU Manager** help screens for details.

### Calculation Methods

Efficiency Calculation Method.

Load Calculation Method.

Refer to the **ECU Manager** help screens for details.

### Load Sites Selection

Selects the range of load points to suit the selected sensors' operational range. For example 0 to 100 for a Throttle position sensor.

Refer to the **ECU Manager** help screens for details.

### Number of Cylinders

**CYLS** 4 Stroke engines : use positive numbers eg. 8 for 8 cyl.

2 Stroke engines : use negative numbers eg. -2 for 2 cyl.

Rotary engines : use -2 for 2 rotor and -3 for 3 rotor.

### Trigger Setup

Ref / Sync Mode (REF)

Crank Reference Teeth (CRT)  
Crank Index Position (CRIP)

These parameters are dependant on the type of trigger system. Refer to the appropriate **MoTeC** Trigger drawing, or Ignition System drawing.

Note that the trigger sensor type (Hall / Mag, Edges etc) must be setup in the Sensor Setup screens.

### ***Ignition***

Ignition Type (IGN)  
Number of Coils (COIL)  
Ignition Dwell Time (DELL)  
Ignition Delay Time

These parameters are dependant on the type of Ignition Module. Refer to the appropriate **MoTeC** Ignition Module drawing, or Ignition System drawing.

## ***Sensor Setup***

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### ***Throttle Position Sensor Hi / Lo***

**TPLO** Throttle Position LO (Closed Throttle)

**TPHI** Throttle Position HI (Wide Open Throttle)

The Throttle HI and LO points must be set every time the throttle position sensor is moved or replaced so that the throttle can be correctly scaled between 0 and 100%.

### ***REF/SYNC Sensor Setup***

The REF/SYNC setup parameters must be set to suit the trigger sensors. Refer to the **MoTeC** Trigger drawings for details.

### ***Sensor Calibrations***

The sensors calibrations must be set to suit the connected sensors. Refer to the **ECU Manager** help screens for details.

## ***Input / Output Functions***

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Setup any essential Input / Output functions.

It may be best to start with any non essential functions turned off (eg. Idle Speed Control, Dual RPM Limit etc).

Refer to the *ECU Manager* help screens for details.

## ***Other Functions***

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Ensure any other functions such as Boost Control, Traction Control etc are all set appropriately.

It may be best to start with any non essential functions turned off (eg. Traction Control, Lambda Control etc).

Refer to the *ECU Manager* help screens for details.



# Initial Calibration

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Before attempting to start the engine the calibration tables should be initialised to sensible values.

Use the **MoTeC ECU Manager software** to initialise the ECU calibration tables.

Preferably start with a calibration file from a similar engine as this will make initial calibration faster and easier.

Clear any \*s from the tables by selecting **Clear \*s** from the **ECU Manager software Tools Menu** (Press the **F9** key). The \*s indicate values that have been set correctly, which is inappropriate at this stage.

## Fuel Tables

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### Fuel - Main Table

Check the Fuel - Main Table.

The table should be smooth.

In general turbo tables look quite different from throttle position tables, so it is best to start with a table from a similar engine.

### Fuel - Air Temp

Check the Fuel - Air Temp compensation table.

Typically the following table can be used :

-40	-30	-20	-10	0	10	20	30	40	50	60	70	80+
10	9	8	6	4	2	0	-2	-4	-6	-8	-10	-12

### Fuel - Engine Temp

The Fuel - Engine Temp compensation table may be used instead of the cold start warm up parameter.

If using Engine Temp compensation the following table can be used :

-10	0	10	20	30	40	50	60	70	80	90	100	110+
60	50	40	30	20	10	5	2	0	0	0	0	5

## ***Fuel - MAP***

Check the Fuel - MAP compensation table.

The fuel must be increased by 100% every 100 kPa increase in air pressure.

Normally the MAP table should contain the following values, with a straight line increase between values.

0 kPa	100 kPa	200 kPa	300 kPa	400 kPa	500 kPa
-100	0	100	200	300	400

This table is equally applicable whether the MAP sensor is used for barometric pressure measurement or for manifold pressure measurement.

Note that the higher pressure sites will only be available if a high pressure MAP sensor is used.

## ***Fuel - Cold Start***

Start with the typical values listed in the help.

## ***Fuel - Acceleration Enrichment***

Start with the typical values listed in the help.

Generally acceleration enrichment is not required above 4000 RPM.

## ***Other Fuel Compensation Tables***

Typically all other compensation tables should be set to zero.

## ***Ignition Tables***

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### ***Ignition - Main Table***

The table should be smooth.

Make sure that the Ignition - Main Table is initialised with a conservative curve for the particular engine, not too advanced and not too retarded.

### ***Ignition - Air Temp***

Check the Ignition - Air Temp compensation table.

Typically the following table can be used :



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-20	-10	0	10	20	30	40	50	60	70	80	90	100+
-12	-9	-6	-3	0	0	0	0	-3	-6	-9	-12	-15

### ***Other Ignition Compensation Tables***

Typically all other ignition compensation tables should be set to zero.



# Initial Starting Procedure

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The **ECU Manager software** should be used to assist during starting.

The **ECU Manager software** allows all diagnostics errors and sensor readings to be checked and allows the injectors, ignition system and auxiliary outputs to be tested while the engine is stopped. The calibration tables and setup parameters should also be checked.

## Pre Start Checks

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### Calibration Tables & Setup Parameters

Check that all Setup Parameters have been set appropriately.

Check that all calibration tables have sensible values in them.

Check that any advanced functions such as Traction Control are turned off.

### Power to the ECU

If the ECU has power then the **ECU Manager software** should indicate that the ECU is connected (At the bottom left corner of the screen)

### Diagnostic Errors

Before starting the engine check the diagnostics errors on the **ECU Manager : Diagnostics Errors** screen. Any errors must be rectified before starting the Engine.

To clear any non current errors press the **Enter** key on the PC while viewing the **Diagnostics Errors** screen.

- Note that the Diagnostic Errors are lost if the ECU power is turned off.

### Sensor Errors

If an error is shown for a sensor that is not fitted the sensor should be disabled by setting the sensor setup number to zero.

Sensor Errors may be due to bad wiring to the Sensor (either short circuit or open circuit).

## ***Test the Sensors***

Before starting the engine test that all sensors are giving sensible readings by viewing their values on the **ECU Manager : View** screen. Vary the sensor readings if possible to check for correct operation.

Check that the Throttle Position Sensor varies smoothly from 0 to 100% when moved from fully closed to fully open. Note that the **TPHI** and **TPLO** setup parameters must have been set correctly for correct operation of the Throttle Position sensor.

The MAP sensor should read barometric pressure when the engine is stopped (approximately 100 to 102 kPa at sea level depending on the day).

The Engine Temp and Air Temp sensors must give correct readings.

## ***Test the Ignition***

Use the **ECU Manager : Ignition Test** (On the **Utilities** menu) to ensure that the Ignition System is functioning correctly.

- Some special ignition systems do not work in the Ignition Test screen. eg. Mazda Series 4 & 5 and other direct fire ignition systems.
- If the Ignition System is wired via the Fuel Pump relay then the ignition test will not work unless this relay is activated.
- It will be necessary to place a spark plug on the lead from the ignition coil if the ignition system uses a distributor.

## ***Test the Injectors***

Use the **ECU Manager : Injector Test** (on the **Utilities** menu) to ensure that all injectors are working and that they are wired in the correct firing order for sequential operation.

**WARNING:** Ensure that the fuel pump is off during this test.

## ***Initial Cranking***

Crank the engine without fuel pressure and check the RPM reading.

Check that the RPM reading is sensible, if the RPM is too high or too low or is erratic then the Setup may be incorrect or there may be a problem with the REF sensor signal. If there is no RPM reading then the REF sensor is not working.

Check that no REF or SYNC Diagnostic Errors occur during constant cranking. Diagnostic errors may occur as cranking winds up, this is OK, but the errors need to be cleared by pressing the **Enter** key while viewing the **ECU Manager : Diagnostics Errors** screen, so that constant cranking may be checked for errors. Diagnostic errors may occur as cranking winds down, this is also OK.

## ***Cranking Ignition Timing***

Check that the Ignition Timing is correct during constant cranking.

This can best be done in the Crank Index Position setup screen under the ignition menu. While in this screen the ignition timing will stay fixed at the value set under 'Test Advance'. This allows the CRIP to be adjusted if necessary until the timing matches the Test Advance.

- Dial back timing lights such as the Snap-On® brand may not work correctly at cranking - use a traditional timing light.
- For some trigger modes (one tooth per firing) the Ignition Timing is set by the sensor position only. In this case the ECU only controls the timing above 500 RPM.
- If the spark is going to the wrong cylinder on a Direct Fire Ignition then the ignition may be wired incorrectly or the **CRIP** (Crank Index Position) setup parameter may be out by a multiple of the angle between cylinders.

## ***Starting***

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### ***Fuel System***

Power up the fuel pumps and check the fuel system for leaks before attempting to start the engine.

### ***Fuel Overall Trim***

Use the **FUEL - Overall Trim** to vary the mixture when trying to start the engine to see if the engine needs more or less fuel, this ensures that the mixture is varied equally for all RPM and Load points.

Establish how much trim the engine needs on average then trim this out by adjusting the setup parameter **IJPU** (Injector Pulse Width Scaling), or by using the **Overall Trim Table** item in the Tools Menu.

## ***If the Engine won't start***

- Check for correct fuel pressure.
- Check for fouled plugs.
- Re-check for diagnostics errors.
- Re-check the Ignition Timing with a Timing Light.
- Check the setup parameters against the drawings.
- Check that the ignition is wired in the correct firing order.
- Check that the ignition is firing on the compression stroke, not the exhaust stroke.

## ***After Start Checks***

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### ***Ignition Timing Check***

Check the Ignition Timing with a Timing Light to ensure that the actual Ignition Timing corresponds to the ECU Ignition Timing as shown on the **ECU Manager : View** screen. Check the timing at high and low RPM to ensure that it is correct at all revs. If the timing is correct at one RPM but incorrect at another RPM and the REF sensor is a magnetic type then the trigger edge may be incorrect or the sensor may be wired in the wrong polarity.

Adjust the setup parameter **CRIP** (Crank Index Position) to correct for small variations in the REF sensor positioning.

Adjust the **Ignition - Individual Cylinder Trim** for cylinder number 1 and verify that it changes the ignition timing for cylinder number 1 rather than any other cylinder, if not then the **CRIP** is incorrect and needs to be adjusted by multiples of the angle between cylinders.

### ***Fuel Pressure***

Check that correct fuel pressure is maintained under all load conditions.

### ***Operational Diagnostics Errors***

After the engine has started check for diagnostics errors.

To clear any non current errors press the **Enter** key while viewing the **ECU Manager : Diagnostics Errors** screen.

The following operational errors may occur in a new installation.

## **Injector Errors**

**Open** The Injector is open circuit - check the wiring.

**Short** The Injector is short circuit - check the wiring.

**Peak** The Injector peak current was not reached.

Possible causes :

- The Injector Current Setup Parameter **IJCU** is set too high.
- The battery voltage is too low.

## **Over Duty**

The injector duty cycle is too high, typically the duty cycle should not exceed 85%.

If the injectors exceed their maximum duty then larger injectors or higher fuel pressure is needed.

## **REF / SYNC Errors**

The possible causes of the various errors are detailed below :

### **REF Error**

Too many REF pulses have occurred between SYNC pulses.

Possible causes :

- A bad REF signal has caused extra pulses or a SYNC pulse has been missed - check voltage levels with a scope.
- Bad REF / SYNC alignment.
- Incorrect Setup

### **No REF**

Two SYNC signals have occurred without a REF signal.

Possible causes :

- If the RPM is 0 then there is no signal - check the wiring and sensor voltage levels with a scope.
- If RPM is not 0 then a bad SYNC signal has caused extra pulses - check voltage levels with a scope.
- If RPM is low then the REF and SYNC signals may have been swapped.
- Incorrect Setup

**SYNC Error**

The SYNC signal has occurred before expected.

Possible causes :

- A bad SYNC signal has caused extra SYNC pulses - check voltage levels with a scope.
- A bad REF signal has caused missing REF pulses - check voltage levels with a scope.
- Bad REF / SYNC alignment.
- Incorrect Setup

**No SYNC**

Two or more consecutive SYNC pulses are missing.

Possible causes :

- No SYNC signal - check the wiring and SYNC sensor voltage levels with a scope.
- A bad REF signal has caused many extra pulses - check voltage levels with a scope.
- Incorrect Setup

**Multiple REF / SYNC Errors**

Multiple REF / SYNC errors may occur, often the first error to occur is the correct error.

Multiple errors may also occur due to incorrect Setup.



## Calibration

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The Calibration Tables determine how the output devices should be controlled for various sensor readings. For example the **Fuel - Main Table** determines the pulse width for the Fuel Injectors for all combinations of RPM and Load.

The **ECU Manager** software should be used to adjust the various calibration tables to suit the engine.

## Warning Alarms

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Set the Warning Alarms to warn if the engine temperature goes too high. (The warning alarms may be set in the functions menu).

## Ensure that the engine is “On Site”

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The engine must be “On Site” for changes to the table values to affect the tuning, this means that the engine must be operating at the same RPM and Load as the currently selected site in the calibration table.

Note that when the engine RPM (or Load) is between table sites the current fuel value (or Ignition value etc) is effected by the sites to either side. For this reason when adjusting the calibration values it is important that the engine RPM and Load are centred on the current adjustment site to ensure that the values from the adjacent sites have minimal influence on the value being adjusted. Use the Target (at the left of the table) to ensure that the engine operating point is centred on the site being adjusted.

During initial tuning, if large adjustments are required to a particular site ensure that the sites around it are also adjusted to a similar value so that the adjacent sites have minimal influence.

Use the **SPACEBAR** key to quickly move the adjustment cursor to the engines current operating point.

## Site Tables

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The RPM and Load sites for the various calibration tables may be modified in the **Setup Sites** screen.

A number of site tables are available which affect different calibration tables. Use the help to check which calibration tables are effected by which site tables.

To insert or delete sites use the **Tools menu** (press the **F9** key). When sites are inserted or deleted the calibration tables may be adjusted so that the new sites do not affect the tuning.

## Dyno

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The alternator should be connected while tuning the engine to ensure that the injectors are working at normal operating voltage.

The exhaust system should be the same as that in the vehicle as it will effect the engine tuning.

On multi runner intake manifolds the air box should be fitted as it is an integral part of the intake system and will effect the engine tuning.

The fuel pressure is critical to the injector flow and should be monitored during dyno tuning. Incorrect fuel pressure will result in incorrect tuning. Note that on turbo engines the fuel pressure will vary as the manifold pressure varies because the regulator maintains a fixed pressure above manifold pressure.

## Fuel - Main Table

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The **Fuel - Main Table** allows adjustment of the fuel at various RPM and Load points.

Work through all the table values systematically so that all points are adjusted for the correct Air Fuel Ratio reading.

Use **extreme caution** when adjusting the fuel to ensure that the engine does not run lean at high loads. It is best to start rich. A temperature compensated wideband Air Fuel Ratio Meter is essential to ensure correct air fuel ratio.

- If the engine is missing for any reason (including over rich) the sensor may falsely read lean due to the oxygen in the unburnt mixture.

The Air Fuel Ratio should be adjusted according to the engine load and the desired results, e.g. power, economy, emissions etc. At high loads the mixture should be approximately 0.89 Lambda for maximum power. On turbo charged engines a richer mixture may be required to reduce exhaust temperatures and help avoid knocking. At lighter loads the mixture may be adjusted for best emissions (1.00 Lambda) or best economy (1.05 Lambda).

The cranking (starting) fuel may be adjusted by adjusting the 0 RPM load sites. Typically more fuel is required at cranking than at idle RPM.

The **Quick Lambda** feature may be used to quickly adjust each table value with one key stroke (Press the **Q** key). The adjustment is made to the value closest to the current engine operating point. The Quick Lambda feature may only be used if the ECU is directly measuring the lambda reading. The desired lambda value must be set in the **Functions - Lambda Control Table**.

If the maximum value in the table falls below 60 then the setup parameter **IJPU** should be decreased to increase the table values. This ensures that the table has sufficiently fine resolution. Similarly if the table values reach the maximum of 99.5 the **IJPU** setup parameter should be increased to decrease the table values.

Use the **F5** key to change quickly between the Fuel - Main Table and the Ignition - Main Table.

Use the **F6** key to change quickly between the Fuel - Main Table and Fuel - Timing Table.

Use the **View - Fuel** Screens to check that all the fuel trims and compensations are correct (Press the **V** key).

Refer to the **ECU Manager** software help for more details (Press **F1**).

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## Ignition - Main Table

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The **Ignition - Main Table** allows adjustment of the Ignition Timing at various RPM and Load points.

Start with a conservative curve for the particular engine, not too advanced and not too retarded.

Use **extreme caution** when adjusting the Ignition Timing to ensure that the engine does not knock due to excessive advance. Re-check the Ignition Timing with a Timing Light to ensure that the what the ECU thinks is the ignition advance is in fact the actual advance.

The Ignition Timing should be adjusted for maximum torque without knocking, by increasing the advance until the torque stops increasing. Make sure there is at least 3 or 4 degrees margin to the knock limit.

Too much retard will cause excessive exhaust gas temperature.

At idle a more retarded ignition setting is desirable (approximately 10 to 15 degrees). This makes the idle speed less sensitive to load changes. Also the ignition should be flat over the idle RPM range so that timing variations do not cause the engine to hunt, since variations in the timing will vary the engine torque.

The **Quick Lambda** feature may also be used from the Ignition Main Table, which allows ignition timing adjustments to be made while also maintaining correct mixture readings.

Use the **View - Ignition** Screen to check that all the fuel trims and compensations are correct (Press the **V** key).

Refer to the **ECU Manager** software help for more details (Press **F1**).

## ***Fuel - Injection Timing***

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The **Fuel - Injection Timing** table allows adjustment of the Fuel End of Injection Timing at various RPM points and optionally at various Load points.

This table is only effective if the injectors are fired sequentially.

Adjusting the Injection Timing ensures that the fuel is injected at the optimum point in the engine cycle, so that the engine makes best use of the fuel. In theory the fuel should end injection at a point where all the fuel will be sucked into the current induction stroke, therefore the end of injection point should be some time before the intake valve closes. The optimum point depends on the engine RPM and load.

Torque, economy, emissions and idle quality are all effected by the Injection Timing.

At high duty cycles the Injection Timing will have minimal influence since the injectors are on for most of the engine cycle.

Refer to the **ECU Manager** software help for more details (Press **F1**).

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## ***Fuel - Cold Start***

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The ***Cold Start*** parameters may be adjusted after the ***Fuel - Main Table*** has been adjusted and the 0 RPM sites have been adjusted for good hot starting.

Refer to the ***ECU Manager*** software help for more details (Press **F1**).

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## ***Other Calibration Tables***

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The other calibration tables may be adjusted as necessary.

Refer to the ***ECU Manager*** software help for more details (Press **F1**).

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## ***Data Logging & Road Testing***

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The calibration must be verified on the road This is best done by logging the air fuel ratio and other sensors and checking them using the ***MoTeC Interpreter*** software.

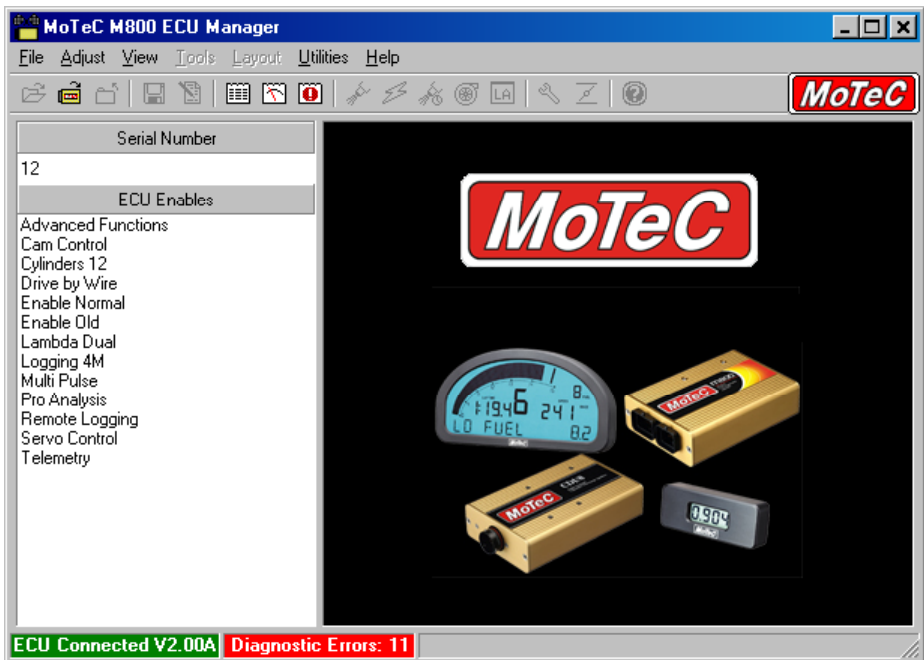
Data Logging is also very useful for identifying unexpected problems such as an incorrect air temperature reading due to fuel vapour cooling the sensor or excessive air temperature due to hot air entering the intake system.

Data logging may also be used to verify and fine tune the operation of the various advanced functions such as traction control.

The light load and overrun calibration must also be completed on the road as these areas cannot be adjusted on a dyno.



# ECU Manager Software



## Introduction

The following is an overview of the main concepts of the **ECU Manager** software. More detailed information is available from the online help.

The **ECU Manager** software is used for :

- Calibration and Setup
- Sending calibration files to the ECU
- Viewing Sensor readings
- Viewing Diagnostics information
- Testing the Outputs
- Unloading the logged data
- Upgrading the ECU firmware
- Enabling ECU options.

## **PC Requirements**

See the **MoTeC Software** section earlier in this manual.

## **Connecting a PC to the ECU**

See the **MoTeC Software** section earlier in this manual.

## **Installing the Software**

See the **MoTeC Software** section earlier in this manual.

This topic covers information that may be helpful for users that have previously used the **MoTeC EMP Software**, which **ECU Manager** supersedes.

## **For EMP Users**

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### **Windows**

The main difference between **ECU Manager** and the old EMP software is that it is a full Windows application. This has allowed a significant number of improvements to be made, the most obvious being the improved graphical user interface.

### **Familiarity**

The operation of **ECU Manager** is very similar to EMP, including most keyboard shortcuts such as: **F5** to switch between Fuel and Ignition and **V** to show the view screen.

The **Adjust** menu item is the same as the EMP *Select Screen* menu and may still be activated by pressing the **Esc** key. Pressing the **Esc** key has the advantage of highlighting the currently selected screen item which often makes navigation to the next screen easier.

All the adjustment screens should be familiar so there is no need to relearn how to configure the ECU.

The **Tools** menu replaces the old **Function** menu and may still be activated by pressing the **F9** key.

### **Communications**

All communication is done using the **MoTeC CAN Cable** (No need for both a Serial Cable and a CAN Cable).



This also allows the configuration to be sent and retrieved much faster.

## ***Making Adjustments***

To enter adjust mode select **Open File** or **Open ECU** from the **Adjust** or **File** menus. This is equivalent to selecting Adjust from the EMP main menu.

The usual keys are used for making adjustment: **Arrow** keys to move around, **PgUp** and **PgDn** for making changes, **Enter** to set the value.

## ***Screen Layouts***

A major new feature of ECU Manager is that multiple screen layouts can be created by the user to suit the users preference and the task at hand.

See the topic on Layouts for more detail.

## ***Utility Programs***

The utility programs such as *Upgrade* and *Enable ECU Options* are built in to **ECU Manager** rather than being separate programs and may be selected from the **Utilities** menu.

Note that **Convert Files** is selected from the **File** menu.

## ***Notes***

Note that because the **F10** key is used to access the menu (as dictated by Windows) the old **F10** function of *Copy Site up and Right* has been reassigned to the **F11** key.

## ***Basics***

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### ***Starting ECU Manager***

To start **ECU Manager** double click the icon on the desktop or select **ECU Manager** from the Start menu, for example: Start / Programs / MoTeC / M400 M600 M800 / ECU Manager 2.1.

Note that the desktop icon will start the latest version of ECU Manager.

### ***Online Help***

Online help is available in two forms:

Context sensitive help is available by pressing **F1** or clicking on the help button, this shows help that is relevant to the current screen.

General help is available from the **Help** menu.

## Main Menu



The Main Menu is used to access all of the features of the **ECU Manager** software.

Select a menu item by using the mouse or use the keyboard by holding down the **Alt** key followed by the keys corresponding to the underlined letter of the menu items to be selected. For example to select **File | Exit** hold down the **Alt** key then press **F** then **X**. Alternatively press the **F10** key then use the arrow keys and the **Enter** key to select the desired menu item.

## Unavailable Menu Items

Note that some menu items may be unavailable if the ECU is not connected or a file is not opened.

Unavailable items appear grey.

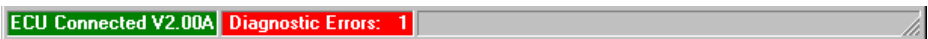
## Button Bar (Toolbar)



The Button Bar provides an alternative way of activating some of the commonly used items on the main menu. To find out what each item does hold the mouse pointer over the button of interest until a hint appears.

Note that some items will not be available depending on whether the ECU is connected and if a calibration file is open.

## Status Bar



The bottom line on the screen is called the Status Bar and shows the following:

- ECU Status: Connected or NOT Connected (if the ECU is connected the ECU firmware version is also shown). If the ECU is not connected the

reason that it is not connected is shown where the Diagnostics Errors are normally shown.

- The number of diagnostics errors (if the ECU is connected)

## **Calibration Files**

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**ECU Manager** records the ECU calibration and setup data in files that are stored on the PC hard disk, this ensures that a permanent record of the data is kept. The files also record comments to allow easy identification of each file. Any file may be sent to any ECU which will totally re-configure the ECU according to the calibration and setup data contained in the file.

### **Creating a New Calibration File**

To create a new calibration file open an existing file and save it to a new file by selecting **Save As** from the **File** menu.

### **Sending a Calibration File to the ECU**

To send a calibration file to the ECU select **Send File to ECU** from the **File** menu. Note that the ECU must be connected to the PC using a **MoTeC** CAN Cable.

### **Changing the Comments**

To change the file comments select **Edit Comments** from the **File** menu.

## **Versions & Upgrading**

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**MoTeC** is continually updating the software and newer versions may be downloaded from the web site at no charge ( [www.motec.com.au](http://www.motec.com.au) )

The software consists of the **ECU Manager** software that runs on the PC and the control software (firmware) that runs inside the ECU.

The ECU firmware may be updated at any time by the user which allows the latest features to be used.

The **ECU Manager** version may be viewed by selecting **About** from the **Help** menu.

The ECU firmware version is shown on the **ECU Manager** status line when the ECU is connected.

### ***Matching Versions***

The version of **ECU Manager** and the version of the firmware in the ECU must match in order to be able to communicate with each other.

To communicate with an ECU that has older firmware in it, either the matching **ECU Manager** software must be used or the ECU firmware must be upgraded to match the version of **ECU Manager** on the PC.

### ***Upgrading the ECU***

To upgrade the ECU firmware select **Upgrade ECU Version** from the **Utilities** menu. This will send the new firmware to the ECU and automatically convert the calibration data in the ECU to ensure it is compatible with the new firmware.

### ***Calibration File Versions***

The calibration files that are stored on the PC must also match the version of software being used.

To ensure that older version calibration files are not rendered useless the older version calibration files may be converted in order to be used with the new version of the software. To convert older files select **Convert** from the **File** menu.

Calibration files may also be converted from some older ECU models (M4, M48 & M8).

### ***Minor Version Updates***

Minor version updates do not require the calibration data to be converted but still require the firmware to be sent to the ECU by selecting **Upgrade ECU Version** from the **Utilities** menu.

Minor updates usually contain bug fixes or minor enhancements.

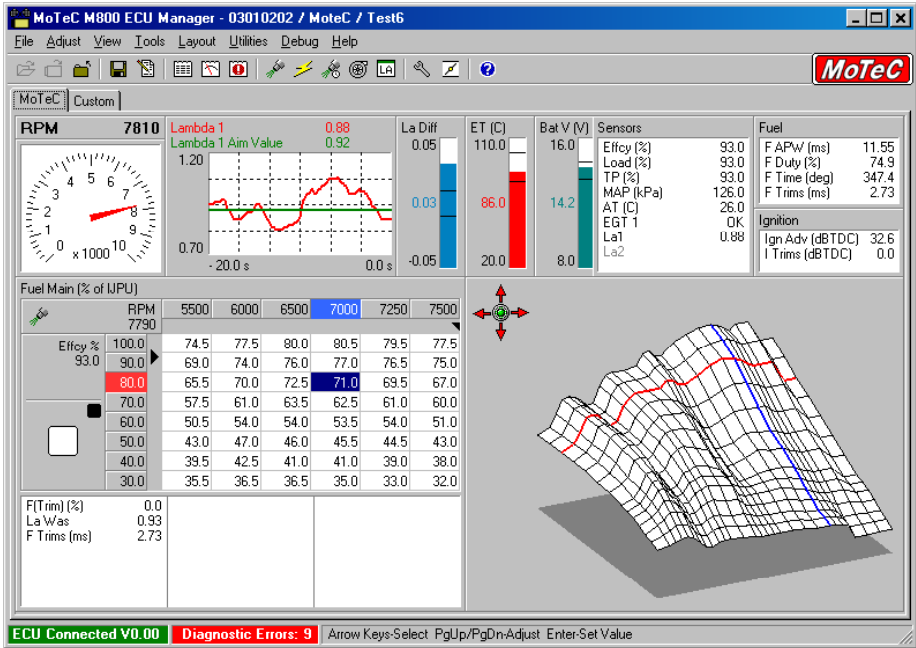
A minor update is one where the number before the decimal point and immediately after do not change, for example 2.10A, 2.10C, 2.11A are all minor updates of version 2.1.

### ***Software Version Release Notes***

The changes between the various software versions may be viewed by selecting **Release Notes** from the **Help** menu.

## Screen Layouts

The screen layouts are completely user definable and may be optimised to suit the user's preference, the screen resolution and the task to be performed. For example it may be useful to have screen layouts to suit different types of engines or to perform particular tasks such as CAM Control or individual Cylinder tuning.



The image above shows one possible screen layout that suits an 800x600 screen.

## Layout Pages

Separate layouts may be defined on separate pages. A number of pages may be loaded at once and may then be selected by clicking on the tabs at the top of the pages or by pressing the **Tab** or the **Ctrl+Tab** keys.

The layout pages are saved to files. To open, close or create new pages, select the appropriate menu item from the **Layout** menu.

## Layout Objects

To add an object to the layout page select **Add** from the **Layout** menu or right click on an empty space in the layout page and select **Add**.

To change the properties (settings) of any object right click on the object and select **Properties**.

To delete an object right click on the object and select **Delete**.

## Adjust Tables and Adjust Graph Objects

In order to make adjustments the layout page must contain an Adjust Table or an Adjust Graph or both.

Note that only one Adjust Table and one Adjust Graph are allowed per page.

### Adjust Tables

Adjust Tables show the values for the currently selected table and allow adjustments to be made. They also show axis indicators and a target to help positioning of the engine operating point.

Fuel Main [% of IJPU]		4500	4750	5000	5250	5500	5750
RPM 5500						▼	
Effic % 79.0	100.0	66.0	57.0	54.0	62.0	72.0	74.5
	90.0	62.0	55.0	53.0	59.0	67.5	68.5
	80.0	55.0	52.0	51.0	54.5	58.5	61.0
	70.0	49.0	45.5	46.0	48.0	51.0	53.5
	60.0	44.0	40.5	39.5	42.0	45.0	45.5
	50.0	39.5	34.5	34.5	36.0	39.0	39.0
	40.0	35.0	31.0	31.0	33.0	35.5	34.0
	30.0	31.0	28.0	28.0	29.5	32.0	30.0

### Adjust Graphs

The table values may also be shown graphically in an Adjust Graph.

The graph may be rotated if necessary by clicking on the rotation buttons or by holding down the **Ctrl** key while using the arrow keys.

### Graph Table

If there is no graph displayed the table object may be switched between table mode and graph mode by pressing the **G** key.

## ***Y Axis Reversing***

On certain graphs it may be desirable to reverse the Y axis so that the graph surface is easier to see.

To do this select *Reverse Y-Axis* on the *Tools* menu or press the *Y* key.

## ***Making Adjustments***

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### ***On Line / Offline***

Changes may be made directly to the ECU (Online) or to a file (Off line).

#### ***Online (ECU Connected)***

To make changes directly to the ECU, connect the ECU then select **Open** ECU from the **File** menu.

When the ECU is opened the calibration data is first retrieved from the ECU then matched to a file. If the ECU data does not match an existing file then a new file will be created, at which point an Engine Description and Comment should be entered to describe the file.

Changes to the ECU are also saved to this file when the ECU is closed.

#### ***Offline (ECU not Connected)***

To make changes to a file with the ECU offline select **Open** from the **File** menu.

The file may be sent to the ECU at a latter date by selecting **Send File to ECU** from the **File** menu.

### ***Closing the ECU or File***

When the changes are completed the ECU or file should be closed by selecting **Close** from the **File** menu, this will ensure that changes are saved to the associated file.

### ***Warning Alarms***

If the Warning Alarms have been set then a warning screen will be displayed if any sensor goes outside its alarm limits. This can be particularly useful for automatically monitoring engine temperature during a dyno session. The alarms can be configured in the **Functions** table.

### ***Help***

Context sensitive help is available by pressing **F1** or clicking on the help button, this shows help that is relevant to the current screen.

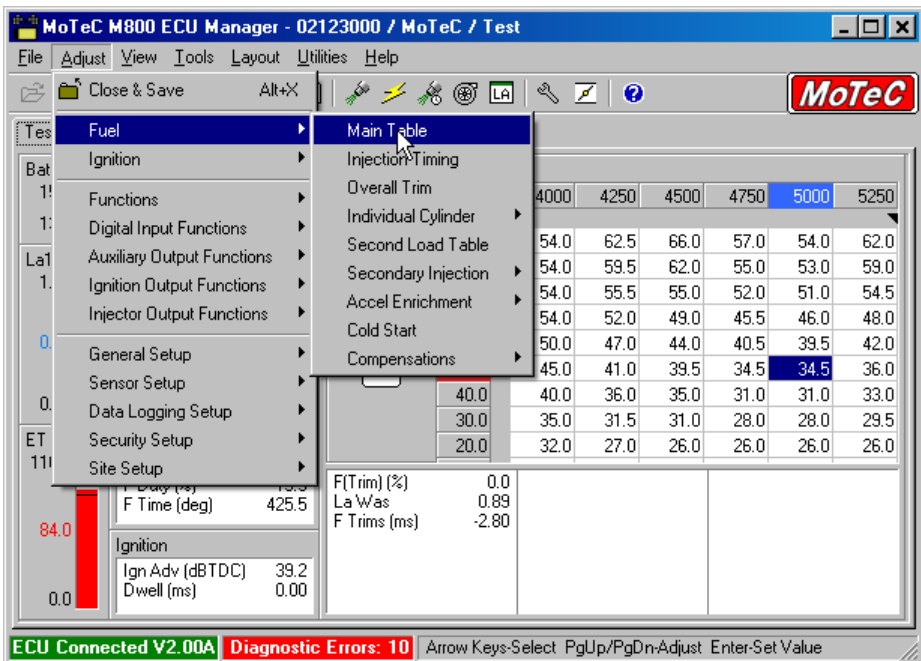


## Selecting the Adjust Table

Once a file or the ECU has been opened the appropriate table or setup screen may be selected from the **Adjust** menu by using the mouse or the keyboard.

To select the **Adjust** menu using the keyboard hold down the **Alt** key followed by the **A** key then use the arrow keys and the **Enter** key to make a selection.

Alternatively the **Adjust** menu may be displayed by pressing the **Esc** key. This has the advantage that it shows the **Adjust** menu with the current table selected which often makes it easier to select the next table.



## Fuel / Ignition Toggle (F5 key)

The **F5** key will quickly toggle the screen between the current Fuel table and the corresponding Ignition table or vice versa.

## F6, F7, F8 Key Assignment

The **F6**, **F7**, or **F8** keys may be assigned to any table by pressing **Alt+F6**, **Alt+F7** or **Alt+F8**. This assigns the current table to the **F6**, **F7** or **F8** keys which allows that table to be returned to quickly.

## Changing Table Values

### Selecting the Item to be Adjusted

The cursor selects the table value that may be adjusted.

The cursor may be moved using the arrow keys, or by pressing the **Space Bar** which will automatically move the cursor to the current engine operating point.

Note that the table does not show all values at once. To view the additional values move the adjustment cursor to the edges of the table using the arrow keys, this will cause the table to scroll and show the hidden values.

### Make sure the Engine is “On Site”

For adjustments to affect the current engine operation the engine operating point must be at the centre of the selected site. The Adjust Table object provides Indicators and a Target to assist in this.

Fuel Main (% of IJPU)		RPM	4250	4500	4750	5000	5250	5500
		5310						
Effic % 78.0	90.0		59.5	62.0	55.0	53.0	59.0	67.5
	80.0		55.5	55.0	52.0	51.0	54.5	58.5
	70.0		52.0	49.0	45.5	46.0	48.0	51.0
	60.0		47.0	44.0	40.5	39.5	42.0	45.0
	50.0		41.0	39.5	34.5	34.5	36.0	39.0
	40.0		36.0	35.0	31.0	31.0	33.0	35.5
	30.0		31.5	31.0	28.0	28.0	29.5	32.0
	20.0		27.0	26.0	26.0	26.0	26.0	27.5

### Table Indicators

Indicators are shown at the top and side of the table (the black triangles). The indicators show the current engine operating point and therefore indicate which table value (or values) the ECU is currently using. The indicators must point to the same site as the adjustment cursor for any adjustments to change the current engine tuning.

The site that is closest to the current operating point is also indicated by a red rectangle.

### Table Target

A target is shown at the left of the table. This allows more accurate positioning of the engine operating point.

For best calibration the indicator should be within or close to the centre rectangle, this ensures that the ECU tuning is determined mainly by the site being adjusted and not by the adjacent sites.

### ***Up / Down Adjustment***

Up or Down adjustments may be made to the selected table value using the **PgUp** and **PgDn** keys.

- Fast adjustments may be made by holding the **Ctrl** key down while pressing the **PgUp** or **PgDn** keys. This will increment the value by ten times the normal amount.
- If the **PgUp** or **PgDn** keys are held down the value will continue to change until the key is released.

### ***Locking in the New Value***

When the desired adjustment has been made the new value must be locked in ("Set") by pressing the **Enter** key, this stores the new adjustment in the ECUs programmable memory.

- If the cursor is moved before pressing the **Enter** key the value will revert to its previous unadjusted value.

### ***Direct Entry***

The table values may also be entered directly using the number keys followed by the **Enter** key.

### ***Maths Operations***

Mathematical operations may be performed on the currently selected value or the WHOLE table or a BLOCK within a table.

To perform a maths function enter the value followed by an operation key (+, -, \*, /), for example **2.5+** will add 2.5 to the current table value.

To apply the maths operation to the whole table type a **T** before pressing the operation key, for example: **2.5T+** will add 2.5 to the whole table.

### ***Block Operations***

To mark a block hold down the shift key while pressing the arrow keys then perform a maths operation.

### **Quick Lambda**

The Quick Lambda feature allows the **Fuel - Main Table** values to be adjusted to the correct lambda by simply pressing the **Q** key. This feature uses the Wideband Lambda reading and the value from the **Lambda Table** to calculate the new fuel table value.

The Lambda Table may be accessed by pressing the **F8** key.

- Note that this feature requires a Wideband Lambda sensor or meter to be connected to the ECU.

### **Set Indicators (\*)**

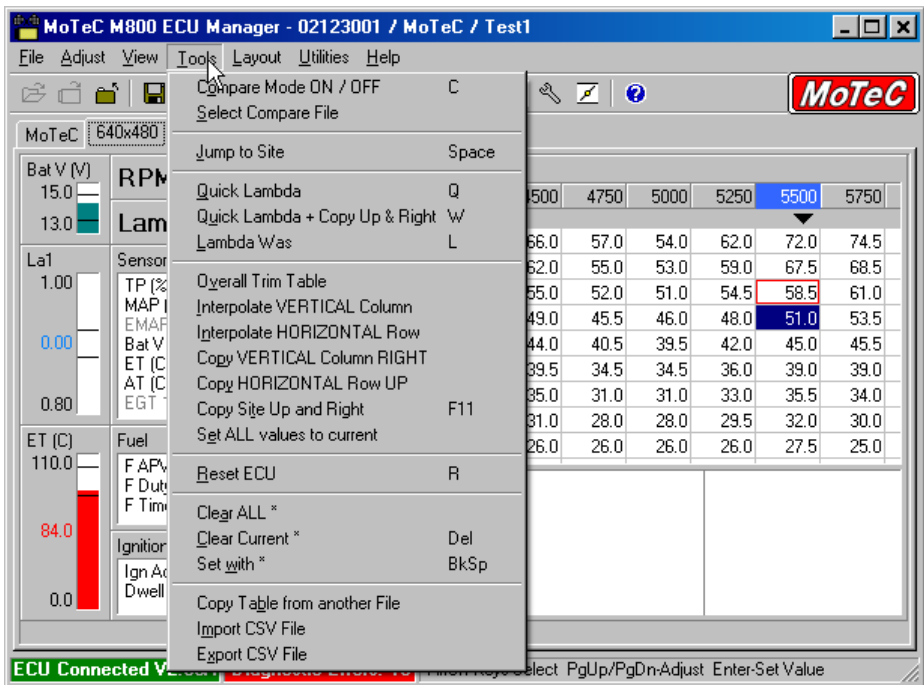
A \* will appear next to items that have been set, with the exception of tables that are dependent on the engine operating point where a \* will only appear if the engine operating point corresponds to the currently selected site. The \* indicates that the point has been tuned.

The \*'s may be cleared individually or all \*'s may be cleared at once. To clear an individual \* press the **Delete** key. To clear ALL \*'s select **Clear ALL \*'s** from the **Tools** menu.

## Tools

The Tools Menu allows selection of various functions as listed on the menu below.

The Tools Menu may also be displayed by pressing the **F9** key, in this case the previously selected item will be highlighted which makes it easier to do repetitive operations.



Note that the items on the menu will change depending on which adjust table is shown, for example Quick Lambda is not available for all tables

The letter to the right of some menu items is the “hot key”. Pressing this key will activate the item without selecting the Tools menu.

### Compare Mode On / Off

Turns **Compare Mode** on or off.

**Compare Mode** shows the difference between the current file and the selected comparison file.

When **Compare Mode** is turned on the selected compare file description is shown on the status line at the bottom of the screen.

The comparison file may be selected by choosing **Select Compare File** from the **Tools** menu.

When Compare Mode is turned on an icon will appear at the left of the Adjust Menu items that contain differences.

### **Select Compare File**

Selects the file used for **Compare Mode**.

### **Jump to Site**

Moves the Cursor block to the Site closest to the current engine operating point.

### **Quick Lambda**

Adjusts the fuel value to achieve the lambda value in the Wideband Lambda table. The Lambda Table may be accessed from the **Functions | Lambda Control** menu or by pressing the **F8** key.

The new fuel value is calculated by checking the difference between the Lambda sensor reading and the value in the Wideband Lambda Table.

The Lambda reading may be either Lambda 1, Lambda 2 or the Average of both, this is configured in the Wideband Lambda setup.

The engine must be operating near the centre of the site for the calculation to give correct results.

Quick Lambda may be used from the Fuel Main Table, Fuel Injection Timing Table, Ignition Main Table, Fuel Second Load Table & Fuel Individual Tables.

When used from the Fuel Main Table the cursor jumps to the closest site if the cursor is not on site.

When used from the Ignition main Table or Fuel Injection Timing Table the Fuel Main Table site closest to the current operating point is adjusted.

When used from the Fuel Second Load Table or the Fuel Individual Tables the change is made to that table rather than the Fuel Main Table.

### **Quick Lambda + Copy Up & Right**

As for Quick Lambda except that the new value is copied to the sites immediately above, right and diagonally above and right if the sites do not contain a \*.

## ***Lambda Was***

Adjusts the fuel table value by an appropriate amount by comparing the value entered by the user to the desired lambda value in the Lambda Table.

The value that is entered may be either the current lambda reading from a lambda meter if tuning online or the lambda reading from the logged data if tuning offline.

Note that if a lambda sensor is directly connected to the ECU then online tuning may be performed more easily using the Quick Lambda function.

## ***Overall Trim Table***

Trims the whole Table by the percentage indicated by the Overall Trim then sets the Overall Trim back to 0.

This is useful during initial tuning of the Fuel Main Table since an existing table can be used then trimmed to take into account variations in injector sizing etc. Note that it is better to change the IJPU setup parameter if large changes are required as this will ensure that the Table numbers maintain sufficient range and resolution i.e. ensures that the table numbers do not become too small or too large.

Note that during the interpolation the engine may run incorrectly. It is therefore best if the engine is stopped during the interpolation. If the engine is running a warning will be given before the interpolation is started.

## ***Interpolate Vertical Column***

Linearly interpolates the current Column between the Upper most value and the Lower most value leaving the Upper most value, the Lower most value and points marked with an \* unchanged.

Note that it may be necessary to use the **Backspace** key to mark the desired points with an \*.

## ***Interpolate Horizontal Row***

Linearly interpolates the current Row between the left most value and the right most value leaving the left most value, the right most value and any points marked with an \* unchanged.

Note that it may be necessary to use the **Backspace** key to mark the desired points with an \*.

**Copy Vertical Column Right**

Copies the data in the current Column to the Column immediately to its right.

**Copy Horizontal Row Up**

Copies the data in the current row to the row above.

**Copy Site Up And Right**

Copies the value of the current site to the sites immediately above, right and diagonally above and right if the sites do not contain an \*.

**Reverse Y-Axis**

Reverses the Y axis for the Graph or Table or both. This makes some graphs easier to see.

**Toggle Table Mode**

If a table is displayed and there is no graph displayed this will switch the table between table mode and graph mode.

**Set All Values To Current**

Set all values in the current table to the value of the current site.

**Reset ECU**

Resets the ECU. This can be useful if changes have been made to a setup item that requires the ECU to be reset, normally this does not happen until a different screen is selected.

**Clear All \***

Clears all \*'s in either the currently displayed table or all tables.

The \*'s are normally used to indicate which sites have been tuned.

**Clear Current \***

Clears the \* on the current site.

**Set with \***

Sets an \* on the current site whether or not the engine is currently at that site.



### ***Copy Table from Another File***

Copy a table from another calibration file into the current table.

Warning - The current table data will be overwritten.

### ***Import CSV File***

Read a CSV (Comma Separated Value) file into the current calibration table.

Normally the CSV file is one that has been written out from another configuration file, possibly for a different ECU type.

Warning - The current table data will be overwritten.

Note that the CSV file must be for the same type of table.

Note also that the site values are not imported therefore the site values must be the same as the sites in the CSV file for the table to have the same result.

### ***Export CSV File***

Write the current table to a CSV (Comma Separated Value) file.

May be used to transfer data between different ECU types or for use in a spreadsheet.

### ***Insert Site***

Insert a site to the left of the current site.

The new site value will be half way between the value of the current site the value of the site to the left.

(Available only in the Site setup screens)

### ***Delete Site***

Delete the current site.

(Available only in the Site setup screens)

## View Screen

The View Screen may be shown by pressing the **V** key or by selecting the desired view page from the **View** menu. The View Screen displays all the operating details of the ECU including:

- Sensor data
- Diagnostics errors
- Fuel injection detail including all trims and compensations
- Ignition detail including all trims and compensations
- Boost control detail
- Status information
- Output Status
- Internal Voltages etc

The screenshot shows the ViewScreen application window with the following data:

Trigger Sensors		Main Sensors		Gear Sensors	
RPM	5560	Bat V (V)	14.2	EGT 2 (C)	457
Max RPM (rpm)	19246	La1	C-1	EGT 3	
SyncPos (%)	50.0	La2	C-1	EGT 4	
Ref V (V)	4.86	TP (%)	79.0	TP2	
Sync V (V)	3.72	MAP (kPa)	46.5	TPD	
Ref Max (V)	4.86	EMAP		TPD2	
Ref Min (V)	0.28	ET (C)	84.0	ThRqdP (%)	0.0
SyncMax (V)	3.76	AT (C)	20.0	DCSvoP	
SyncMin (V)	3.71	ECU T (C)	46.7	StSvoP	
Sensor Supplies		MAF		User 1	
5V Aux (V)	5.00	BAP		User 2	
5V Eng (V)	4.97	FT (C)	40.0	User 3	
8V Aux (V)	7.94	FP		User 4	
8V Eng (V)	8.00	OT		G Lat	
		OP		G Long	
		Knock V		G Vert	
		EGT 1			
				Speed Sensors	
				Gnd Spd	0.0
				Drv Spd	0.0
				Speed 1	0
				Speed 2	0
				Speed 3	0
				Speed 4	0
				Slip	0.0
				Input Positions	
				SyncPos (deg)	0.0
				Din1Pos (deg)	0.0
				Din2Pos (deg)	0.0
				Din3Pos (deg)	0.0
				Din4Pos (deg)	0.0

Buttons at the bottom: Reset Errors, Reset Fuel Used, Reset Max RPM, Close, Help

The View Screen has a number of pages that may be accessed by pressing **Tab** while holding down the **Ctrl** key or by pressing the first letter of the screen name.

It also allows resetting of The Diagnostic Errors, Maximum RPM and the Fuel Used. The Diagnostic Errors Screen may be accessed directly by pressing the **F3** key.

Note that the view screen may be viewed with or without the ECU open (but only if the ECU is connected).

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## Testing the ECU Outputs

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The ECU Outputs (Fuel Injectors, Ignition Outputs and Auxiliary Outputs) may be tested by selecting **Test Outputs** from the **Utilities** menu.

This allows verification of the operation of the wiring and actuators. It is also very useful in checking that the injectors are wired in firing order.

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## ECU Password

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A password may be set in the ECU to stop unauthorised access to the ECU configuration data.

The password may be set by selecting **Adjust | Security Setup** from the main menu.

### Channel Locking

Note that the live channel information (RPM, Engine Temp) may still be viewed even when the password is set unless the particular channel has been locked using the Channel Locking feature.

Channels that have been locked cannot be viewed on the View screens or sent as Telemetry data once the ECU password has been set.

Channel locking may be set by selecting **Adjust | Security Setup** from the main menu.

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## File Encryption

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File Encryption allows a configuration file to be distributed to a customer without the customer being able to view the contents of the file.

An encrypted file can only be sent to an ECU that has its password set to the same value as the Encryption Number that was used to encrypt the file. An encrypted file cannot be sent to an ECU with no password.

The data in an encrypted file cannot be viewed.

The comments for an encrypted file are the same as those of the file from which it was created. The comments cannot be edited. It is possible to create files with the same comments so care needs to be taken to ensure the correct files are used. Any unnecessary files should be deleted.

## ***Enabling ECU Options***

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A number of options are available which allows the ECU to be configured for a particular need or updated later if necessary. The options include Data Logging, Wideband Lambda measurement, Drive by Wire and more.

The options may be enabled at any time by selecting ***Utilities | Enable ECU Options*** from the main menu and entering the enabling password.

## Keyboard Reference

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PgUp	Adjust Up
PgDn	Adjust Down
Ctrl + PgUp	Fast Adjust Up
Ctrl + PgDn	Fast Adjust Down
Shift + PgUp	Slow Adjust Up (Not available on all tables)
Shift + PgDn	Slow Adjust Down (Not available on all tables)
Enter	Set the adjusted Value
Alt+X	Close the ECU or File
Esc	Show the Adjust menu with the current screen item highlight
Tab	Select the next Layout page
Spacebar	Jump the cursor to the site closest to the current engine operating point.
F1	Show Help
F3	Show the Diagnostics Errors screen
F5	Toggle between the Fuel and Ignition screens
Alt+F6	Remember the current screen, Show it when F6 is pressed
Alt+F7	Remember the current screen, Show it when F7 is pressed
Alt+F8	Remember the current screen, Show it when F8 is pressed
F6	Select the Fuel Timing screen (or the Remembered screen)
F7	Select the Boost Limit screen (or the Remembered screen)
F8	Select the Lambda Table screen (or the Remembered screen)
F9	Show the Tools menu
F10	Select the main menu
F11	Copy site up and right
C	Turn Compare Mode Off / On
E	Edit the File Comments
G	Switch table between table mode and graph mode
L	Lambda Was
Q	Quick Lambda
W	Quick Lambda plus copy up and right
V	Show the last View screen
S	Show the sensors tab on view screen
Y	Reverse the Y axis on the table, graph or both.
Delete	Delete * at the current site
Backspace	Place * at the current site
Home	Select one of a number of default view angles for the graph.
Ctrl+Arrow	Change the view angle of the graph
Shift+Arrow	Mark a block on the table (mathematics may be applied to the block)
Ctrl+Shift+Arrow	Copy the current table value to an adjacent cell.

Alt+1...0

Select Individual Cyl 1...10 table (Only when an Individual Table is currently selected)

# Appendices

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## Appendix A: General Specifications

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### **Physical**

Case Size 147mm x 105mm x 40mm (5.8in x 4.1in x 1.6in)

Weight M400, M600, M800: 0.50 kg (1.10lb)

M880: 0.525kg (1.16 lb)

### **Power Supply**

Operating Voltage: 6 to 22 Volts DC

Operating Current: 0.5 Amps Max (excluding sensor and load currents)

Reverse Battery Protection via External Fuse

Battery Transient Protection

### **Operating Temperature**

Internal Temperature Range: -10 to 80°C (14 to 176°F)

Ambient Temperature Range: -10 to 70°C (14 to 158°F) typical, depending on output loading

## ***Appendix B: Sensor Supplies***

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### ***Maximum Current***

5V ENG Sensor Supply: 0.20 Amps Max

5V AUX Sensor Supply: 0.15 Amps Max

8V ENG Sensor Supply: 0.30 Amps Max

8V AUX Sensor Supply: 0.30 Amps Max

### ***Accuracy / Temp Drift***

5V ENG Sensor Supply:  $\pm 0.5\%$  max at 25°C + 100ppm/°C max

5V AUX Sensor Supply:  $\pm 0.5\%$  max at 25°C + 100ppm/°C max

8V ENG Sensor Supply:  $\pm 5\%$  max over entire temperature range

8V AUX Sensor Supply:  $\pm 5\%$  max over entire temperature range

### ***Protection***

Short to ground

Short to battery

Thermal overload



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## ***Appendix C: Input Characteristics***

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### ***Analog Voltage Inputs***

Suitable for: Potentiometers, Voltage output sensors & Variable resistance sensors.

- Note that variable resistance sensors require a pullup resistor to the 5V sensor supply. (Normally a 1000 ohm resistor is used)

Measurement Voltage Range: 0 to 15 V

- Note that voltages outside this range may affect the readings on other inputs.

Input Resistance: 100k ohms to 0V

Resolution: 3.74 mV

Filter: 150Hz 1<sup>st</sup> order

Measurement Method: Absolute

### ***Analog Temp Inputs***

Suitable for: 2 wire variable resistance sensors and some voltage output sensors.

- Note that some voltage output sensors may not be able to drive input resistance.

Measurement Voltage Range: 0 to 15 V

- Note that voltages outside this range may affect the readings on other inputs.

Input Resistance: 1000 ohms to the 5V sensor supply and 100k ohms to 0V.

Resolution: 3.74 mV

Filter: 150Hz 1<sup>st</sup> order

Measurement Method: Absolute

#### ***When used as Switch Inputs***

The Analog Temp Inputs may also be used as Switch Inputs

Trigger Levels: Programmable 0 to 15V

Hysteresis: Individually programmable high and low levels.

## **Lambda Inputs**

### **Wideband**

Sensor Type: NTK or Bosch LSU

Measurement Range : 0.70 to 32.0 Lambda

### **Narrow Band**

The LA1S and LA2S inputs may be used to measure the voltage of normal narrow band oxygen sensors.

Note: If closed loop control is to be used then an external 33k ohm bias resistor from the input to 0V is required to bias the input to stoichiometric (0.45V) while the sensor is cold.

### **Voltage Input**

The LA1S and LA2S inputs may be used as ordinary voltage inputs.

Specifications are the same as the Analog Voltage inputs except the inputs include a 220k ohm resistor to 5V.

## **Digital Inputs**

Suitable for : Switch to 0V, Logic signal & open collector device (eg Hall Switch)

Pullup Resistor : 4700 ohms to 5V

Voltage Range : 0 to 15V

Positive Trigger Threshold : 3.5 V max

Negative Threshold : 1.0 V min

Hysteresis : 0.5 V Min

Filter Time Constant : 22usec

Trigger Edge: Programmable

Measurement Methods: Switched, Speed / Frequency, Period, Pulse Width

## Appendix D: Auxiliary Output Characteristics

The following tables list the characteristics for the Auxiliary Outputs, including the Ignition and Injector Outputs when used as Auxiliary Outputs.

Output	Low Side Driver		High Side Driver		General	
	Nominal Max Current (A)	Min Current Limit (A)	Nominal Max Current (A)	Min Current Limit (A)	Fly-Back Voltage (V)	Max Freq (Hz)
AUX1	5	7 *	5	7	Recirculate	10000
AUX2	5	7 *	5	7	Recirculate	10000
AUX3	1	3	-	-	60V	10000
AUX4	1	3	-	-	60V	10000
AUX5	1	3	0.7	0.7 *	Recirculate	<b>200</b>
AUX6	1	3	0.7	0.7 *	Recirculate	<b>200</b>
AUX7	1	3	0.7	0.7 *	Recirculate	<b>200</b>
AUX8	1	3	0.7	0.7 *	Recirculate	<b>200</b>
IGN1	1	3	-	-	60V	5000
IGN2	1	3	-	-	60V	5000
IGN3	1	3	-	-	60V	5000
IGN4	1	3	-	-	60V	5000
IGN5	1	3	-	-	60V	5000
IGN6	1	3	-	-	60V	5000
INJ1	2	4	-	-	60V	5000
INJ2	2	4	-	-	60V	5000
INJ3	2	4	-	-	60V	5000
INJ4	2	4	-	-	60V	5000
INJ5	2	4	-	-	60V	5000
INJ6	2	4	-	-	60V	5000
INJ7	2	4	-	-	60V	5000
INJ8	2	4	-	-	60V	5000

Normally the current should not exceed the *Nominal Max Current* but in some circumstances it may exceed this value for a short period of time as long as it does not exceed the *Min Current Limit* and as long as the duty cycle is low. The limiting factor is thermal dissipation in the output driver.

The total maximum low side current should not exceed 15A.

The minimum frequency for all outputs is 15Hz (except when used as a switched output).

Items marked \* use a linear current limit, all other outputs shutdown at the current limit.

## ***Appendix E: Ignition Output Characteristics***

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Source Current: 20mA (Single Coil / Coil per Plug) / 40mA (Wasted Spark)

Source Voltage: 5.7V max at 20mA, 4.6V max at 40mA

Sink Current: 1 Amp max nominal (3 Amp current limit)

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## ***Appendix F: Injector Output Characteristics***

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The Injector outputs can operate in two modes: Peak and Hold mode and Saturated mode.

### ***Peak and Hold Mode***

This mode is normally required for low resistance injectors (5 ohms or less). This mode allows the injector current to build up to a high value to open the injector and is then reduced to minimise power dissipation in the injector. Normally this means that the ECU has to dissipate a large amount of power. **MoTeC** uses a switch mode technique to minimise power dissipation in the ECU. The opening current is referred to as the *Peak* current and the reduced current as the *Holding* current.

The peak current is fully programmable from 0 to 6 Amps and is suitable for very low ohm injectors including 0.5 ohms.

Holding Current: 25% of Peak Current

Flyback Voltage: 60V

Diagnostics: Open Circuit, Short to Battery, Peak current not reached.

### ***Saturated Drive Mode***

This mode is normally used for high resistance injectors (12 ohms or greater).

Nominal Maximum Current: 2 Amps

Current Limit: 4 Amps

Flyback Voltage: 60V

Diagnostics: Open Circuit, Short to Battery

### ***High / Low Injection***

The injector output characteristics may be set independently for High/Low injectors allowing two different types of injectors to be used.

## ***Appendix G: M880 Connector***

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### ***Mating Connector (for M880 only)***

Deutsch : AS6-18-35SN

### ***Wire***

Wire to suit connector : 22# Tefzel, Mil Spec : M22759/16-22

### ***Crimp Tool***

Crimp Tool : M22520/2-01

Positioner for Crimp Tool : M22520/2-07

- Note that the Crimp Contacts are type 22D (this is needed to set the crimp tool correctly)

### ***Wire Stripping Tool***

The following tool is recommended

Ideal Industries 45-2133 stripping tool with LB1195 wire stop.

### ***Heatshrink Boots***

Straight : Racychem 202K153, Hellermann 156-42-G

Right Angle : Racychem 222K153, Hellermann : 1156-4-G

## ***Appendix H: Wire Specifications***

### ***M22759/16 Wire Ratings (For Various Wire Gauges)***

Insulation Material : Tefzel

Conductor : Tin Plated Copper

Voltage Rating : 600 V

Maximum Temperature : 150 °C

Wire Gauge (AWG)	Cross Sectional Area (mm <sup>2</sup> )	Max Current at 100 °C Ambient (Amps)	Resistance ( ohm / m )	Resistance ( ohm / 1000 ft )
22	0.38	5	0.045	14
20	0.61	6	0.028	8.5
18	0.96	9	0.018	5.5
16	1.2	12	0.014	4.3
14	1.9	18	0.009	2.7
12	3.0	24	0.006	1.8

### ***Wire Stripping Tool***

The following tool is recommended

Ideal Industries 45-2133 stripping tool with LB1195 wire stop.

## Appendix J: CAN Wiring - Multiple Device

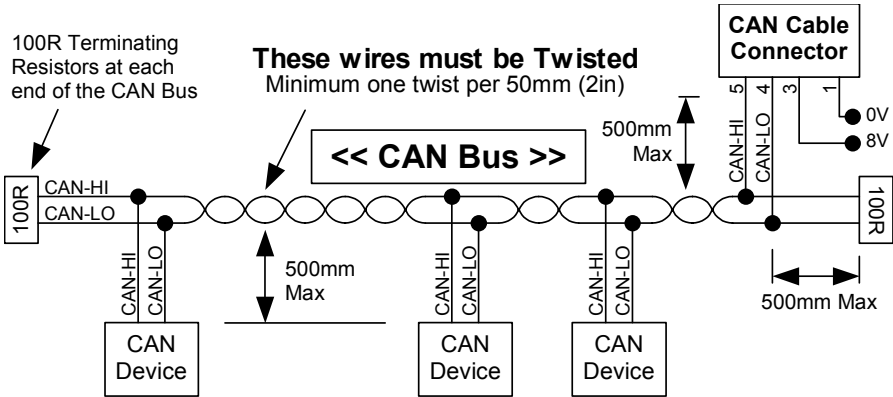
The CAN bus should consist of a twisted pair trunk with 100R (0.25Watt) terminating resistors at each end of the trunk.

The preferred cable for the trunk is 100R Data Cable but twisted 22# Tefzel is usually OK.

The maximum length of the bus is 16m (50ft) including the **MoTeC** CAN Cable (PC to CAN Bus Communications Cable)

CAN Devices (such as **MoTeC** ADL, BR2 etc) may be connected to the trunk with up to 500mm (20in) of twisted wire.

The connector for the CAN Communications Cable may also be connected to the trunk with up to 500mm (20in) of twisted wire and should be within 500mm of one end of the trunk. If desired two CAN Cable connectors may be used so that the **MoTeC** CAN Cable may be connected to either side of the vehicle. Both connectors must be within 500mm of each end of the trunk.



### Short CAN Bus

If the CAN Bus is less than 2m (7ft) long then a single termination resistor may be used. The resistor should be placed at the opposite end of the CAN Bus to the CAN Cable connector.

### Single Device

See Appendix K: CAN Bus Wiring - Single Device.

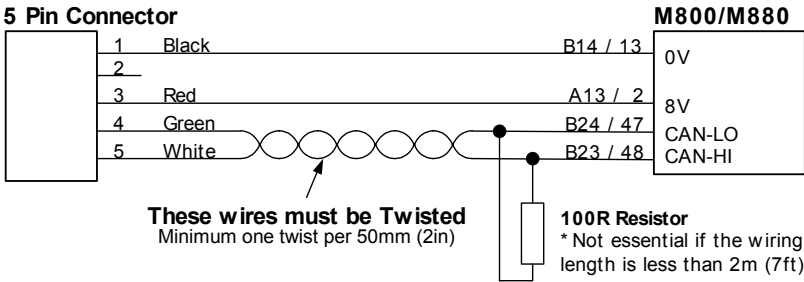


## Appendix K: CAN Bus Wiring - Single Device

When a single device (such as an ECU) is connected to the CAN bus then the wiring scheme shown below may be used to provide a connection point for the **MoTeC** CAN cable.

If the wiring length is less than 2m (7ft) then the terminating resistor is recommended but not essential.

If other devices are connected to the CAN bus a special wiring scheme is required, see Appendix J: CAN Wiring - Multiple Device.



### 5 Pin Connector Type :

- Deltron     716-0-0501     (Non Latching)
- Neutrik    NC5FDL1            (Latching)

## Appendix L: Pin list by Function

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M400

M600

M800

M880

Pin No	Pin No	Abrev	Description
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### Battery

A26	23,32,41	VBAT	Battery Positive
A10,A11	14,15,19	GND	Battery Negative

### Sensor Supplies

A12	3	8V-ENG	8V Engine Sensor Supply
A2	16	5V-ENG	5V Engine Sensor Supply
B16	27	0V-ENG	0V Engine Sensor Supply
A13	2	8V-AUX	8V Auxiliary Sensor and CAN Supply
A9	34	5V-AUX	5V Auxiliary Sensor Supply
B15	11	0V-AUX	0V Auxiliary Sensor Supply

### Auxiliary Outputs

A18	9	AUX1	Auxiliary Output 1
A1	8	AUX2	Auxiliary Output 2
A23	43	AUX3*	Auxiliary Output 3
A24	51	AUX4*	Auxiliary Output 4
A31	59	AUX5	Auxiliary Output 5
A32	65	AUX6	Auxiliary Output 6
A33	58	AUX7	Auxiliary Output 7
A34	64	AUX8	Auxiliary Output 8

### Ignition Outputs

A3	1	IGN1*	Ignition Output 1
A4	5	IGN2*	Ignition Output 2
A5	4	IGN3*	Ignition Output 3
A6	10	IGN4*	Ignition Output 4
A7	17	IGN5*	Ignition Output 5 (Not available on M400)
A8	25	IGN6*	Ignition Output 6 (Not available on M400)

### Injector Outputs

A19	33	INJ1	Injector Output 1
A20	50	INJ2	Injector Output 2

A21	63	INJ3	Injector Output 3
A22	66	INJ4	Injector Output 4
A27	24	INJ5	Injector Output 5 (Not available on M400)
A28	42	INJ6	Injector Output 6 (Not available on M400)
A29	57	INJ7	Injector Output 7 (Not available on M400 & M600)
A30	62	INJ8	Injector Output 8 (Not available on M400 & M600)

### **Analog Voltage Inputs**

A14	26	AV1	Analog Voltage Input 1
A15	18	AV2	Analog Voltage Input 2
A16	6	AV3	Analog Voltage Input 3
A17	7	AV4	Analog Voltage Input 4
A25	12	AV5	Analog Voltage Input 5
B20	36	AV6	Analog Voltage Input 6
B21	35	AV7	Analog Voltage Input 7
B22	44	AV8	Analog Voltage Input 8

### **Analog Temp Inputs**

B3	28	AT1	Analog Temperature Input 1
B4	38	AT2	Analog Temperature Input 2
B5	30	AT3	Analog Temperature Input 3
B6	39	AT4	Analog Temperature Input 4
B7	29	AT5	Analog Temperature Input 5
B19	37	AT6	Analog Temperature Input 6

### **Digital Inputs**

B8	46	DIG1	Digital Input 1
B9	45	DIG2	Digital Input 2
B10	52	DIG3	Digital Input 3
B11	53	DIG4	Digital Input 4

### **Trigger Inputs**

B1	49	REF	Crank Reference Timing Input
B2	56	SYNC	Cam Sync Timing Input

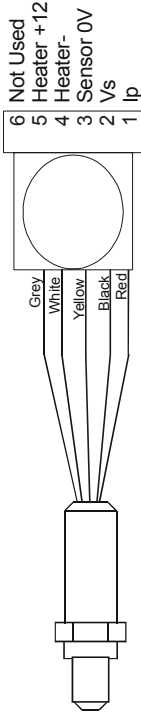
### **Lambda Inputs**

B26	60	LA1-P	Lambda1 Pump Current
B25	54	LA1-S	Lambda1 Sense Voltage
B13	61	LA2-P	Lambda2 Pump Current (Not available on M400)
B12	55	LA2-S	Lambda2 Sense Voltage (Not available on M400)

**Comms**

B17	40	TX-232	RS232 Transmit Data
B18	31	RX-232	RS232 Receive Data
B24	47	CAN-LO	Can Bus Low
B23	48	CAN-HI	Can Bus High
B14	13	0V-COM	0V Comms
A13	2	8V-AUX	8V Auxiliary Sensor and CAN Supply

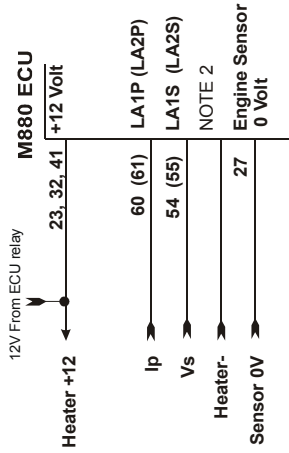
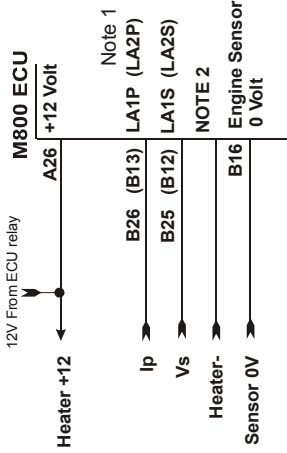
Note Outputs marked \* do not have a recirculation diode, see the Output Specifications for more detail.



**ECU Setup**

Ensure the following "Lambda Sensor" parameters are set.

SENSOR SETUP - CHANNEL ASSIGNMENTS - SCREEN 1	
La1	VALUE = 9
La2	VALUE = 10
SENSOR SETUP - SENSOR CALIBRATION	
La1 ( La2 )	VALUE = 38
SENSOR SETUP - LAMBDA SENSOR SETUP	
Type	VALUE = 1
Cal Number	VALUE = number engraved on sensor
Quick Lambda Mode	Will depend on how many sensors are used and channel assignments
INPUT/OUTPUT FUNCTIONS - AUXILIARY OUTPUT	
Aux Output	FUNCTION = 9

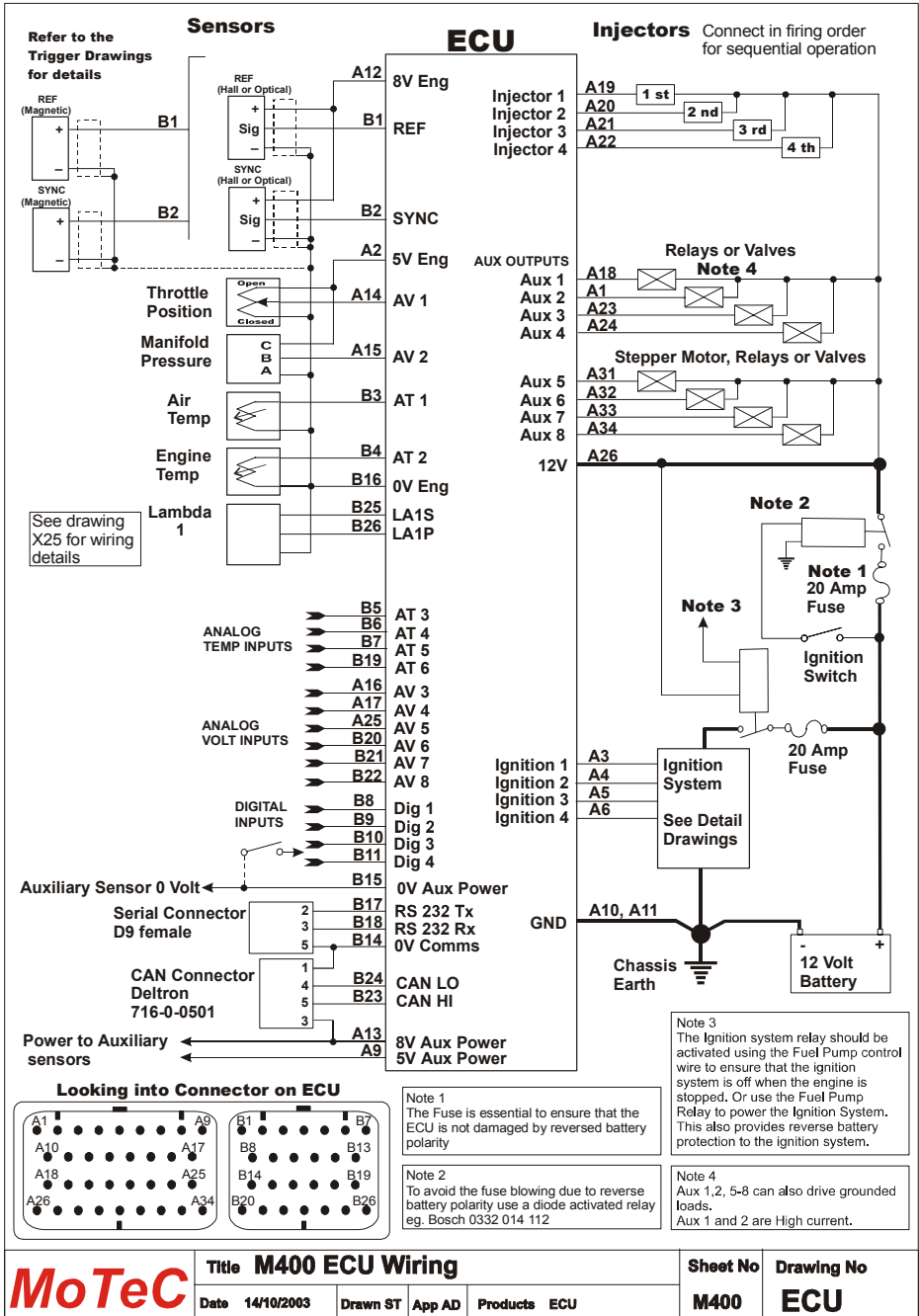


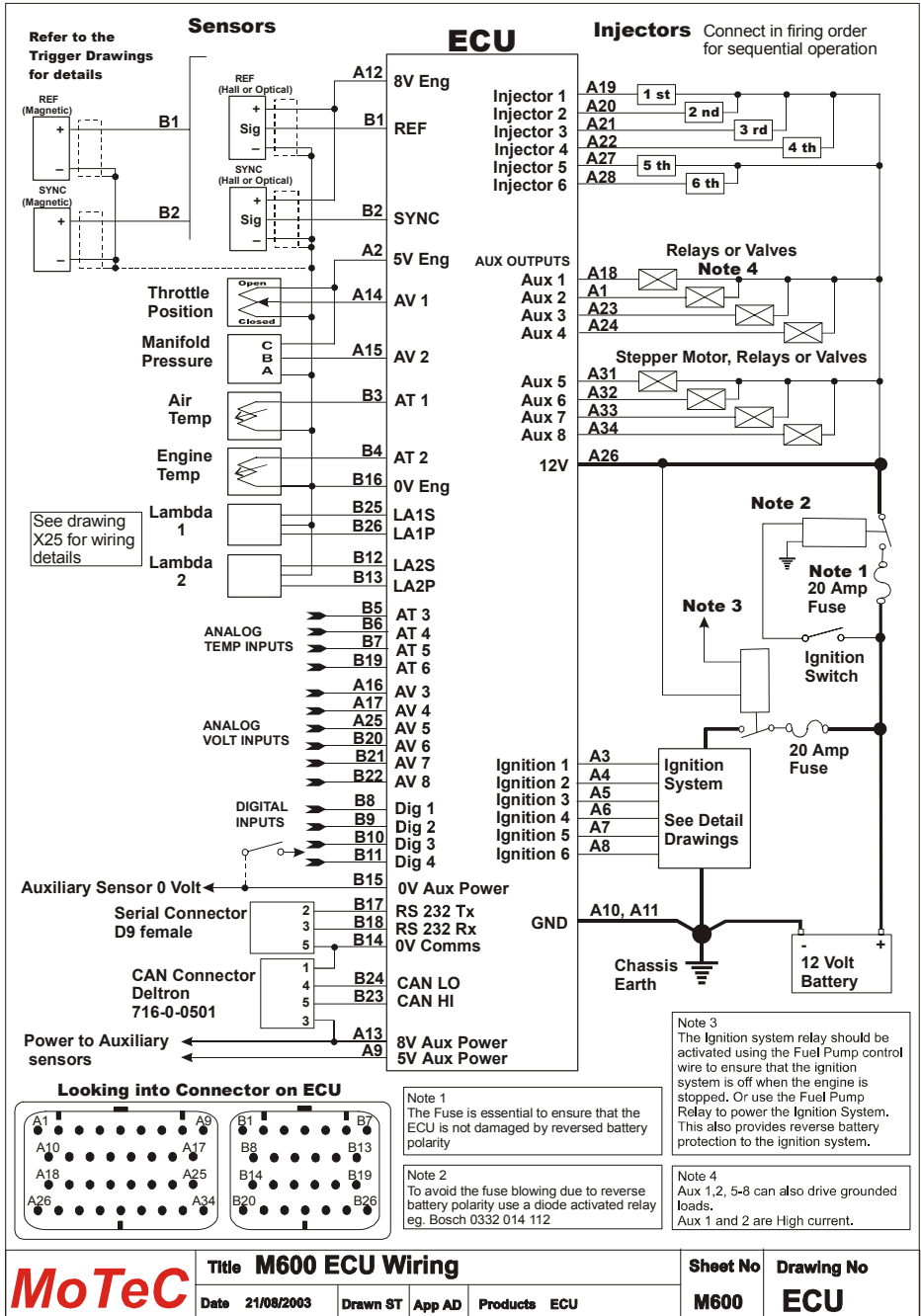
**Note 1**

Information in brackets ( ) indicates wiring for Lambda 2 input.

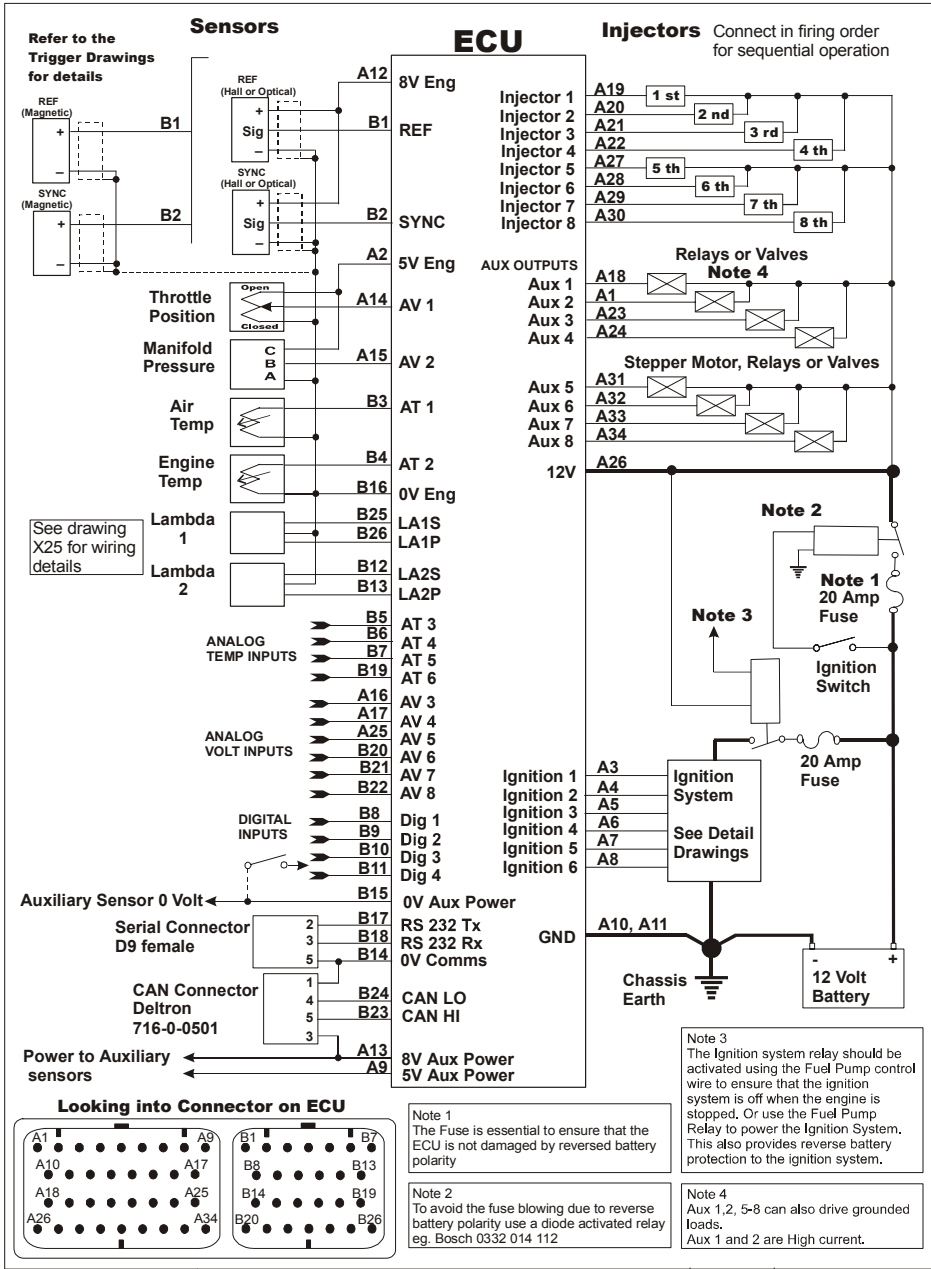
**Note 2**

Any AUX, Injector or Ignition output can be used for the Heater control.



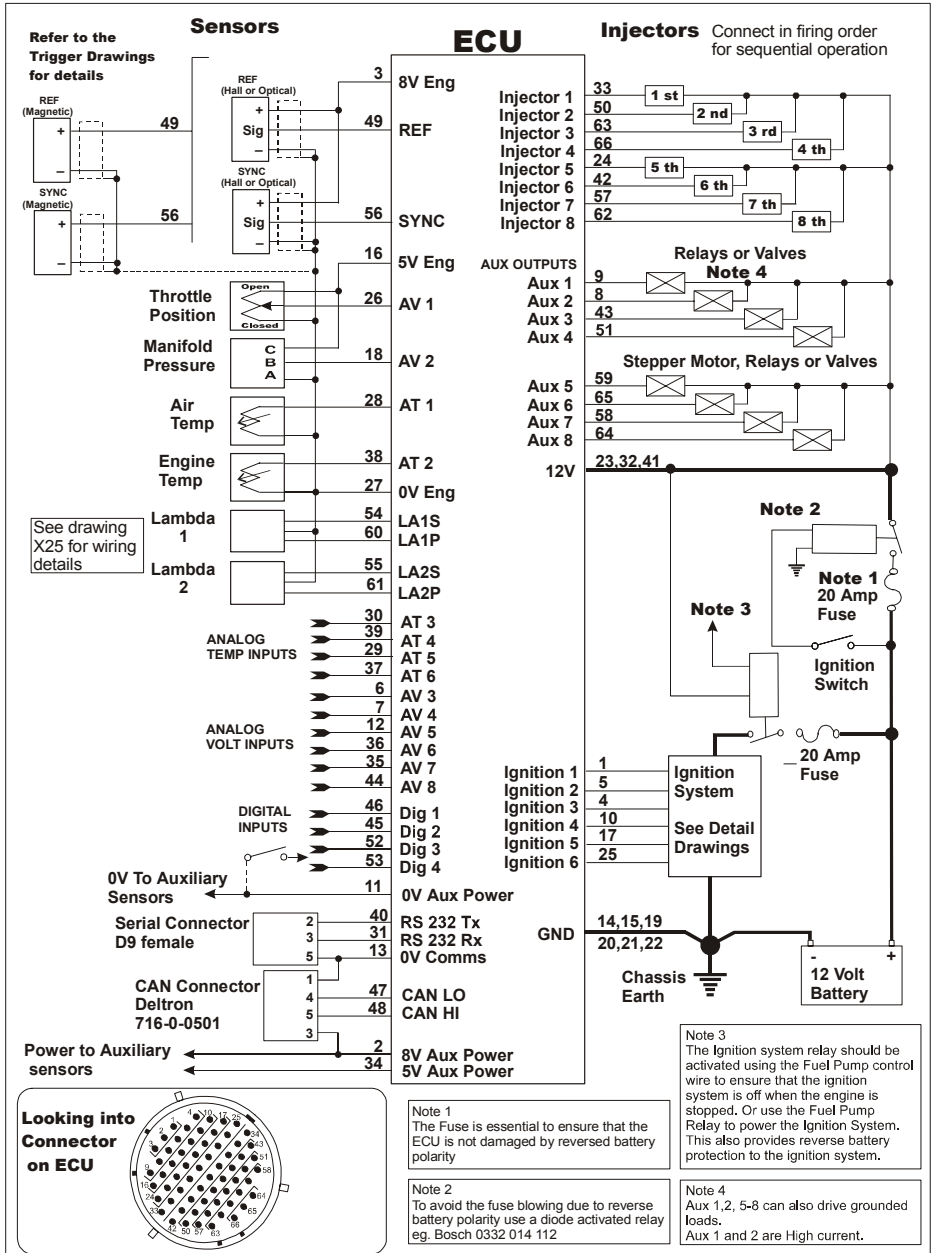


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	Date 21/08/2003	Drawn ST	App AD	Products ECU	<b>M600</b>	<b>ECU</b>



<b>MoTeC</b>	<b>Title M800 ECU Wiring</b>				<b>Sheet No</b>	<b>Drawing No</b>
	Date 21/08/2002	Drawn ST	App AD	Products ECU	<b>M800</b>	<b>ECU</b>





<b>MoTeC</b>	<b>Title M880 ECU Wiring</b>				<b>Sheet No</b>	<b>Drawing No</b>
	Date 22/08/2002	Drawn ST	App AD	Products ECU	<b>M880</b>	<b>ECU</b>







