# *Contents*

**For racing and off highway use only**

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



6 June, 2003

# Introduction

Thankyou 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*

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

Note that the M48 uses the M4 drawings unless there is a specific M48 drawing.

### *Tech Notes*

- Traction Control
- Boost Control
- Idle Speed Control
- Closed Loop Lambda Control
- Wide Band Lambda Sensor
- Others

# Overview

The ***MoTeC*** M4, M48 & M8 are powerful and compact programmable Engine Management Systems or Engine Control Units (ECUs)

## *M4 ECU*

The M4 ECU has 4 Fuel Injector outputs and is referred to as a ***4 Group Engine Management System***.

## *M48 ECU*

The M48 ECU has 8 Fuel Injector outputs and is referred to as an ***8 Group Engine Management System*** but is otherwise similar to the M4 ECU, except for the following :

- Two Ignition outputs instead of four.
- Two PWM (Pulse Width Modulated) Auxiliary Outputs and 2 Switched Auxiliary Outputs instead of 4 PWM Auxiliary Outputs.
- No individual cylinder tables (Still does individual cylinder trims).

## *M8 ECU*

The M8 ECU has 8 Fuel Injector outputs and is also referred to as an ***8 Group Engine Management System***.

The M8 has additional inputs and outputs compared to the M4 & M48.

# *Options*

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

The options may be enabled at any time by entering an enabling password using the ***MoTeC*** **ENABLE** Software.

The passwords may be purchased from ***MoTeC***.

- The M4 or M8 Software Update Unit (SUU) is required to enable the options. The SUU must be connected between the ECU and the Computer Interface Cable. (The M4 SUU is also used for the M48).

## *Advanced Tuning Option (M4 and M48 Only)*

Allows access to the Advanced Tuning features, which include :

Traction Control & Launch Control, Narrow Band or Wide Band Lambda Control, Gear Change Ignition Cut, Individual Cylinder Tuning for Fuel and Ignition, Boost Enhancement, Wheel Speed Measurement, Programmable Load Sites, Warning Alarms, User definable Air Pressure, Air Temp, Engine Temp and other compensations for Fuel and Ignition, Nitrous Oxide, Dual RPM Limit, Sensor Calibration Tables, Odd Fire Engine capability and more.

- Advanced Tuning is standard on the M8 ECU.
- The Advanced Tuning setup parameter must also be set to enable Advanced Tuning.

## *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 by the ***MoTeC*** **INTERPRET** Software.

On the M4 and M48 ECUs the Data Logging option is enabled for an evaluation period of 6 hrs (engine running time).

## *Wide Band Lambda Option*

Allows Wide Band Lambda (Air Fuel Ratio) measurement, which may be used for data logging or closed loop control of the Air Fuel Ratio. The measurement is fully temperature compensated and will accurately measure ratios of 0.75 to 1.2 Lambda (11:1 to 18:1) when used with the ***MoTeC*** wide band exhaust gas sensor.

The M8 ECU has two Lambda Inputs whereas the M4 and M48 have one.

On the M4 and M48 ECUs the Wide Band Lambda option is enabled for a evaluation period of 6 hrs (engine running time).

# *Calibration & Setup*

## *Calibration Tables*

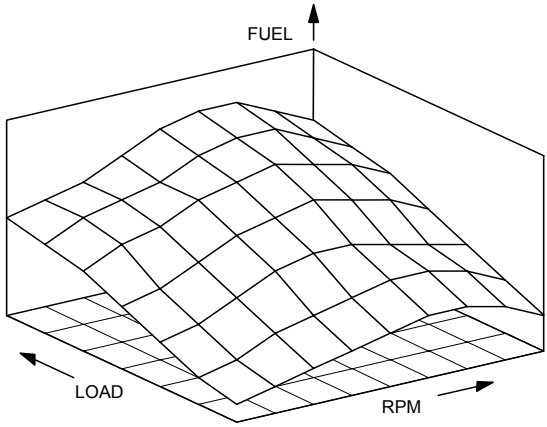
The Calibration Tables determine how the output devices should be controlled for various sensor readings. For example the fuel calibration table determines the base injector pulse width for all combinations of RPM and

Load. Various other calibration tables will also affect the fuel injector pulse width.

A typical 3 dimensional fuel calibration table is shown below.

| | RPM | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **LOAD** | **0** | **500** | **1000** | **1500** | **2000** | **2500** | **3000** | **3500** | **4000** | **4500** | **5000** | **5500** | **6000** | **6500** | **7000** |
| **100** | 38.0 | 40.0 | 41.0 | 43.0 | 45.5 | 55.0 | 53.0 | 55.0 | 56.5 | 58.0 | 59.5 | 60.5 | 62.0 | 64.0 | 62.0 |
| **90** | 38.0 | 39.0 | 40.0 | 42.0 | 42.0 | 50.0 | 50.5 | 51.0 | 52.5 | 52.5 | 55.5 | 57.5 | 59.5 | 61.5 | 59.5 |
| **80** | 38.0 | 39.0 | 39.5 | 41.5 | 40.5 | 45.5 | 48.0 | 45.5 | 46.5 | 49.0 | 51.5 | 53.5 | 55.5 | 56.0 | 55.5 |
| **70** | 38.0 | 38.5 | 39.0 | 40.0 | 38.5 | 42.5 | 43.5 | 43.0 | 43.0 | 43.5 | 46.5 | 44.5 | 44.0 | 44.5 | 44.0 |
| **60** | 38.0 | 38.0 | 39.0 | 39.5 | 37.5 | 38.0 | 41.0 | 41.0 | 41.5 | 41.0 | 43.5 | 42.5 | 41.5 | 42.0 | 41.5 |
| **50** | 38.0 | 38.0 | 38.5 | 39.0 | 37.0 | 36.0 | 39.0 | 39.5 | 39.0 | 40.0 | 41.0 | 39.0 | 38.0 | 38.0 | 38.0 |
| **40** | 32.0 | 31.5 | 32.0 | 33.0 | 32.0 | 31.0 | 33.0 | 34.0 | 33.5 | 34.5 | 35.5 | 34.5 | 33.5 | 33.5 | 33.5 |
| **30** | 25.5 | 26.0 | 25.5 | 27.0 | 26.0 | 27.0 | 28.0 | 29.0 | 28.5 | 28.0 | 28.0 | 28.0 | 28.0 | 27.0 | 28.0 |
| **20** | 20.5 | 21.0 | 29.5 | 20.5 | 21.5 | 22.5 | 22.5 | 25.5 | 27.5 | 27.0 | 26.0 | 27.0 | 26.0 | 25.0 | 26.0 |
| **10** | 18.0 | 17.5 | 17.0 | 18.5 | 18.5 | 19.5 | 19.5 | 22.0 | 24.0 | 24.5 | 24.5 | 24.5 | 24.5 | 22.5 | 24.5 |
| **0** | 14.0 | 14.0 | 14.5 | 15.0 | 15.5 | 16.5 | 18.0 | 20.0 | 20.0 | 21.0 | 20.5 | 20.0 | 20.0 | 19.5 | 20.0 |

The calibration tables may be represented graphically as shown below.




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.

## *2D Calibration Tables*

2D calibration tables have 3 load sites only : Light Load, Full Load and Boost. 2D calibration is not as precise as 3D calibration, a more accurate result will be obtained using 3D calibration.

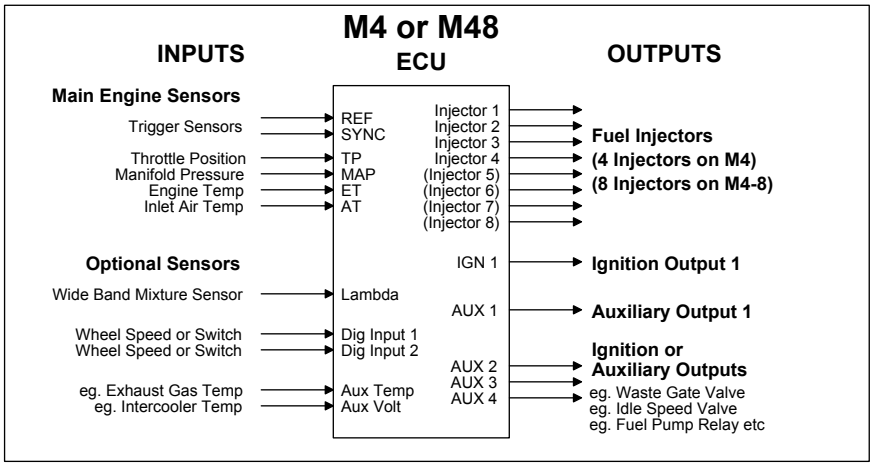
## *Setup Parameters*

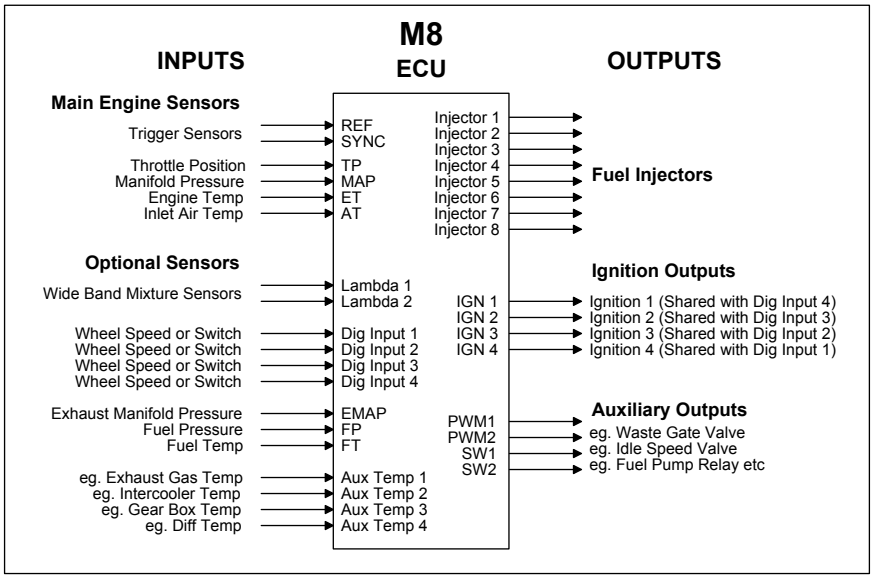
The Setup Parameters allow the ECU to be configured for almost any engine. The Setup Parameters include Number of Cylinders, Ignition Type, Sensor Types, Injector Current, Auxiliary Output Functions etc.

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

# *ECU 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.






## *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 for Sequential Injection or Multi Coil 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 Digital Inputs may be used for wheel speed measurement or to activate functions such as Dual RPM Limit, or Nitrous. (Advanced Tuning Only)

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

The other inputs may be used for data logging or for special calibration features.

# Fuel Injector Outputs

### M4 ECU

Up to four groups of injectors may be driven by the ECU.

On engines with more than 4 cylinders 2 or more injectors must be driven in parallel as follows :

6 cyl 3 groups of 2 injectors (Outputs 1, 2 and 3)
8 cyl 4 groups of 2 injectors
12 cyl 4 groups of 3 injectors

- The Injector current must be doubled or trebled as appropriate.

### M48 & M8 ECU

Up to eight groups of injectors may be driven by the ECU.

On 12 cylinder engines the injectors must be driven as 6 groups of 2 injectors in which case the Injector current must be doubled.

# Ignition Outputs

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

### M4 ECU

Up to 4 ignition outputs are available for multi coil applications.

- Ignition Outputs 2, 3 & 4 are shared with Auxiliary Outputs 2, 3 & 4.
- Outputs not used for ignition may be used as Auxiliary Outputs.

### M48 ECU

Two ignition outputs only.

### M8 ECU

Up to 4 ignition outputs are available for multi coil applications.

- Ignition Outputs 2, 3 & 4 are shared with Digital Inputs 1, 2 & 3.
- Any pins not used as Ignition Outputs may be used as Digital Inputs.

### *All ECUs*

All ECUs may drive up to 8 coils when used with the ***MoTeC*** Ignition Expander.

## *Auxiliary Outputs*

The Auxiliary Outputs may be used for :

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

### *M4 & M48*

The ECU has four Auxiliary Outputs which may be used as follows :

#### *Standard Tuning*

Auxiliary Output 1 : User definable.
Auxiliary Output 2 : Tacho Output on M48, not used on M4.
Auxiliary Output 3 : Tacho Output on M4, not used on M48.
Auxiliary Output 4 : Fuel Pump Control.

#### *Advanced Tuning*

All Auxiliary Outputs are user definable.

- Note that Auxiliary Outputs 3 and 4 on the M48 ECU cannot be used for PWM functions such as turbo waste gate control or idle speed control.

### *M8*

All Auxiliary Outputs are user definable.

- Note that the two Switched Outputs cannot be used for PWM functions such as turbo waste gate control or idle speed control.

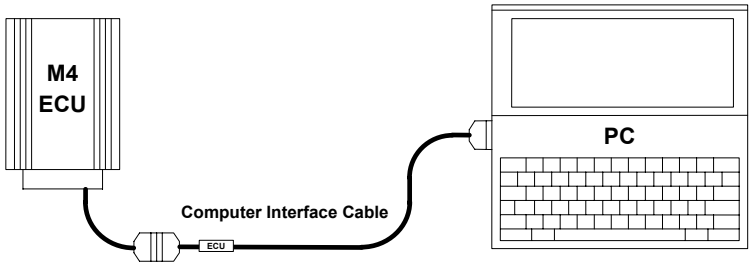
# *MoTeC* Software

The ***MoTeC*** Software is a collection of software programs that allow the user to perform various tasks such as Calibration, Setup, Diagnostics, Data logging Analysis, Upgrading etc.

- The software will only run on an IBM PC compatible computer.
- Different software is required for all three types of ECU.

## *Connecting a PC to the ECU*

The PC must be connected to the ECU via the ***MoTeC*** **Computer Interface Cable** as shown below. The cable must be connected the right way around (one end is labelled ECU), the other end must be connected to the PC connector marked COM1. The cable is a special cable that contains electronic circuitry, a standard cable will not work.




## *DOS Prompt*

The ***MoTeC*** Software must run from the DOS prompt.

| | |
|---|---|
| ***DOS*** | If using a menu program, first exit to DOS |
| ***Windows 3.1*** | First exit to the DOS prompt as follows :<br>From the Program Manager menu select ***File - Exit***. |
| ***Windows 95*** | First start an MS-DOS box as follows :<br>Select : ***Start - Programs - MS-DOS Prompt*** |

# *Software Installation*

The ***MoTeC*** Software must be installed on to the PC hard disk.

To install the software place the ***MoTeC*** Software Disk into the floppy disk drive.

From the DOS prompt type **A:INSTALL** then press **Enter**. The software will be automatically installed onto the hard disk.

A separate 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*

Start the ***MoTeC*** Software from the DOS prompt [ ***C:***\ ] by typing **MOTEC** then press **Enter**, this will start the ***MoTeC*** **Program Integrator**.

If the software doesn't start it may be necessary to change to the MOTEC directory first by typing **CD \MOTEC** then press **Enter**.

The ***MoTeC*** **Program Integrator** lists all the available software programs. To start the required program select it from the menu using the up and down arrow keys then press **Enter**.

To exit the ***MoTeC*** **Program Integrator** and return to DOS, hold down the **Alt** key then press **X**.

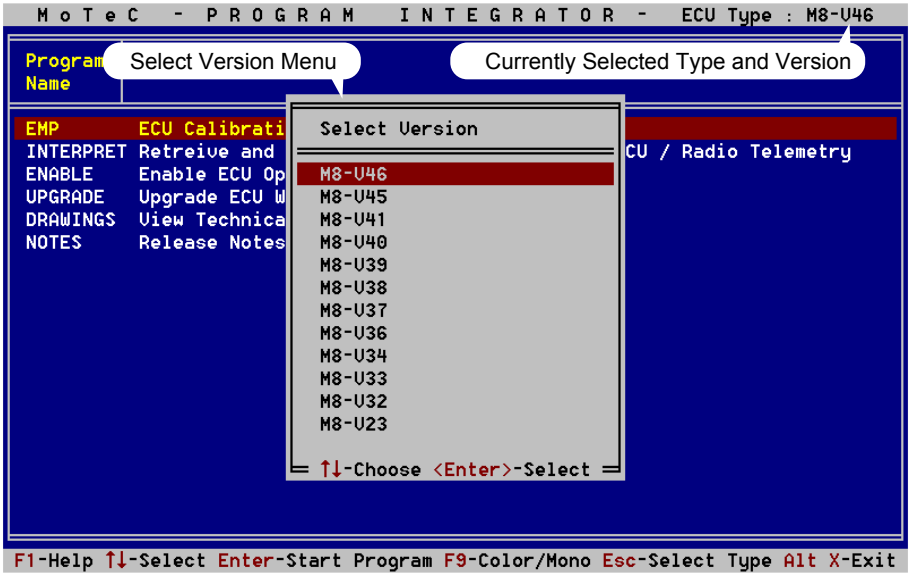
- If using a monochrome screen press the **F9** key to change the screen colours between colour and black and white.
- When using Windows 95 it is best to run the software in a full screen rather than a window. (Press **Alt** and **Enter**)

# *Software Versions*

The software will only work with an ECU that is the same type (M4, M48 or M8) and is running the matching software version.

If multiple versions of the software are installed on the PC a list of the available ECU types and versions will be displayed when the ***MoTeC*** **Program Integrator** is started. The appropriate ECU type and version may then be

chosen. The currently selected ECU type and version are shown at the top right of the screen as shown below.




To check which version of the software a particular ECU is running, start the latest version of the E.M.P. Software. If the ECU is not the correct type or the ECU software version does not match, then a screen will be displayed that will show the current ECU type and version.

To change to another ECU type or version press the **Esc** key while in the ***MoTeC* Program Integrator**, this will re-display the ***Select Version*** menu. The appropriate ECU type and version may then be chosen.

The ECU software version contains an extra digit which may be ignored. For example ECU versions 4.60, 4.61 etc are all compatible with PC software version 4.6 (V46).

If the PC does not contain the matching version then the matching version of the PC software must be installed onto the PC or the ECU must be upgraded to an available version.

# *E.M.P Software*

The ***MoTeC* Engine Management Program (E.M.P.)** is used for Calibration, Setup and Diagnostics.

E.M.P. includes the following features :

- Storage of the Calibration Data on disk.
- Transfer of any Calibration Data File from the PC into any ECU.
- 3 Dimensional Graphing of the Calibration Data.
- Viewing of all sensor readings and other ECU operating parameters.
- Injector, Ignition & Aux Output testing while the engine is stopped.
- Extensive Help (Press the F1 key).

The E.M.P. Software is covered in more detail later in this manual.

# *Data Logging*

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* E.M.P.** Software. This is done in the ***Misc Setup*** or ***Data Logging Setup*** menus depending on the software version.

The logged data can be extracted from the ECU using the ***MoTeC* INTERPRET** Software or by using the ***MoTeC* GETLOG** Software depending on the software version.

- The M4 & M48 ECUs will remember the logged data even if the ECU power is turned off. The M8 ECU requires power to be maintained to the ECU until the logged data has been extracted.
- 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.

## *Data Logging Analysis*

The ***MoTeC* INTERPRET** Software may be used to analyse the logged data.

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

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

# *Upgrading*

The ***ECU Control Software*** controls the function of the ECU. Upgrading the control software allows the latest features to be added to any ECU.

When the ECU control software is upgraded the ECU calibration data must also be upgraded so that it compatible with the new ECU software.

The ***MoTeC*** **UPGRADE** Software is used to upgrade the ECU control software and calibration data.

## *Upgrade ECU*

To upgrade the ECU select ***Upgrade ECU*** from the UPGRADE Software menu. This will send the new ECU control software to the ECU and automatically convert the existing ECU calibration data.

- To upgrade the software the M4 or M8 Software Update Unit (SUU) is required. The SUU must be connected between the ECU and the Computer Interface Cable. (The M4 SUU is also used for the M48).

## *Convert Files*

The UPGRADE software is also used to convert any old calibration files so that they are compatible with the new software version, select ***Convert Files*** from the menu.

Calibration files may be converted between the M4 and M48 or vice versa but M8 files cannot be converted to or from M4 or M48 files.

## *Software Version Release Notes*

The changes between the various software versions may be viewed using the ***MoTeC*** **NOTES** Software.

# Installation

## *Throttle Position or MAP Load Sensing*

The load point for the fuel and ignition calibration tables may be based on the Throttle Position sensor or the MAP (Manifold Pressure) sensor.

### *Turbo Charged Engines*

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.

Partial barometric pressure compensation will be achieved using the MAP sensor only. For improved compensation an additional pressure sensor must be connected to the **Aux V** input on M4 & M48 (**EMAP** on M8) and the load calculation method should be selected as ***MAP / Aux V*** for M4 & M48 (***MAP / EMAP*** for M8). This additional sensor should be vented to atmospheric pressure.

### *Normally Aspirated Engines*

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

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.

#### *2D Fuel and Ignition Tables*

Use Manifold Pressure load sensing, see Turbo Charged Engines above. Not suitable for multi-runner engines, engines with erratic pressure readings, or very low vacuum.

# *Sensors*

## *Throttle Position Sensor*

The Throttle Position sensor must produce a voltage between 0 and 5 volts, proportional to the angle of the throttle plate. Switch types are not suitable.

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 set 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, this 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.

The sensor produces 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 used 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 100 kPa or 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. Generally 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 boltheads 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 rev 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 (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 preset.

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 wide band exhaust gas sensor for data logging or closed loop control of the Air Fuel Ratio.

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 sealants, use exhaust gas sensor friendly sealants.

The sensor must reach correct operating temperature (>400 °C) before useful readings can be taken which may take a number of minutes depending on the engine load. The sensor has an internal heater which adds about 200 °C to the sensor temperature.

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

At the end of the sensors life it becomes slow to respond and won't read richer than about 0.85 Lambda.

Refer to the ***MoTeC*** Wide Band Lambda Sensor Tech Note for more details.

Refer to the ***MoTeC*** Wide Band Lambda Sensor Drawing for wiring and ECU setup details.

# *Wiring*

## *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 $mm^2$) and must 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 $mm^2$) 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). Where 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*

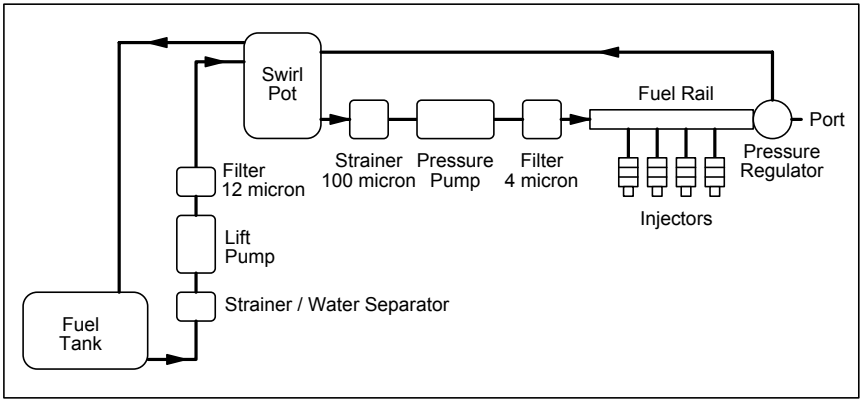
Avoid wire fatigue by tying the wires down close to the connectors.

### *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.

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, 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 either once per engine rev or once per engine cycle in the case of sequential operation.

### *Group Fire Operation*

All injectors are fired together once per engine rev or in two groups 180 degrees apart once per engine rev.

### *Sequential Operation*

The injectors are fired once per engine cycle and must be wired in the firing order of the engine.

Sequential operation can improve torque, fuel economy, emissions and idle quality.

Sequential operation requires a SYNC trigger signal.

### *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 hp x 5 cc/min/hp / 8 injectors = 600 x 5 / 8 = 275 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 rev or engine cycle. For example if the injectors where 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

## Ignition System Types

Many different types of ignition systems are available and some suit different jobs better 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*

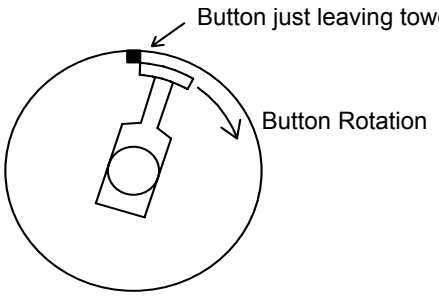
Double ended coils have two high tension towers and fire two plugs at the same time, one on the compression stroke and the other on the exhaust stroke. Each coil is fired sequentially twice per engine cycle and must feed the appropriate two cylinders.

## *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

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

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 E.M.P. 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*

Avoid high pressure washing or degreasing of the ECU.

# Initial Setup

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

Use the ***MoTeC* E.M.P. 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*

### *Injectors*

***IJPU*** Injector Pulse width scaling
***IJCU*** Current per injector output
***IJbc*** Injector Battery Voltage Compensation
***IJOP*** Injector Operating Mode (M4 & M48 Only)

Refer to the E.M.P. help screens for details.

### *Calculation Methods*

***EFF*** Efficiency Point Calculation Method. (Advanced Tuning Only)
**LOAd** Load Point Calculation Method.

Refer to the E.M.P. help screens for details.

### *Load Sites Selection*

**Ld S** Selects the range of load points to suit the manifold pressure range.

Refer to the E.M.P. 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 Types*

**rESn** Ref Sensor Type (M4 & M48 only)

**SYSn** Sync Sensor Type (M4 & M48 only)
***rEF*** Ref / Sync Mode
***crt*** Crank Reference Teeth
***criP*** Crank Index Position

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

### *Ignition*

***ign*** Ignition System Type
***COIL*** Number of Coils
***dELL*** Ignition Dwell Time
***dLY*** Ignition System Delay

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

## *Miscellaneous Setup*

All parameters must be set appropriately. (Advanced Tuning only)

Refer to the E.M.P. help screens for details.

## *Sensor Setup*

### *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%.

### *Sensor Selections*

The Air Temp, Engine Temp, MAP and other sensor types must be selected in the sensor setup.

Any unused sensor inputs should be turned off.

Refer to the E.M.P. help screens for details.

## *RPM Limit*

The RPM Limit and associated parameters should be set appropriately.

Refer to the E.M.P. help screens for details.

## *Input / Output & Misc Functions*

Setup any essential Input / Output or Misc functions.

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

Refer to the E.M.P. help screens for details.

# Initial Calibration

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

Use the ***MoTeC*** **E.M.P.** 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.

Graph the tables so that any unusual points can be easily identified (Press the **G** key).

Clear any *s from the tables by selecting ***Clear *s*** from the E.M.P. Software ***Function Menu*** (Press the **F9** key). The *s indicate values that have been set correctly, which is inappropriate at this stage.

## *Fuel Tables*

### *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 wise to start with a table from a similar engine.

### *Fuel - Air Temp*

Check the Fuel - Air Temp compensation table (Advanced Tuning only).

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 (Advanced Tuning only).

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 (Advanced Tuning only).

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.

## Other Fuel Compensation Tables

Typically all other compensation tables should bet set to zero.

# Ignition Tables

## 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 (Advanced Tuning only).

Typically the following table can be used :

| -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 bet set to zero.

## *Cold Start*

Start with the typical values listed in the help.

## *Acceleration Enrichment*

Start with the typical values listed in the help.

Generally acceleration enrichment is not required above 4000 RPM.

# Initial Starting Procedure

The E.M.P. Software should be used to assist during starting.

The E.M.P. Software allows all calibration tables and setup parameters to be checked, 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.

## *Pre Start Checks*

### *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 E.M.P. Software should indicate that the ECU is connected (At the top right corner of the screen)

### *Diagnostic Errors*

Before starting the engine check the diagnostics errors on the E.M.P. ***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 E.M.P ***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 Injectors

Use the E.M.P. ***Diagnostics - Injector Test*** 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.

## Test the Ignition

Use the E.M.P. ***Diagnostics - Ignition Test*** to ensure that the Ignition System is functioning correctly.

- Some special ignition systems do not work in the Diagnostics Ignition Test screen. eg. Mazda Series 4 & 5 and other DFI 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.

## 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 E.M.P. ***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.

- 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

## 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 Function 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

## 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 E.M.P. ***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 (requires the Advanced Tuning option) and verify that it changes the ignition timing for cylinder no 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 E.M.P. ***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

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 E.M.P. Software should be used to adjust the various calibration tables to suit the engine.

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 top left of the screen) 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 on the current site.

Graph the calibration data so that any unusual points may be seen and to smooth out areas that can't be tuned easily on the dyno. (Press the **G** key)

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

Set the Warning Alarms to warn if the engine temperature goes too high (Misc Functions menu)

## *Site Tables*

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 ***Function 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

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 dynoing. 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

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 wide band 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, 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 ***Misc Functions - Lambda Control Table***. (Requires Advanced Tuning).

If the maximum value in the table falls bellow 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 ***Trims*** Screen to check that all the fuel trims and compensations are correct (Press the **T** key).

Refer to the E.M.P. Software help for more details (Press **F1**).

# *Ignition - Main Table*

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 ***Trims*** Screen to check that all the ignition trims and compensations are correct (Press the **T** key).

Refer to the E.M.P. Software help for more details (Press **F1**).

# *Fuel - Injection Timing*

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 E.M.P. Software help for more details (Press **F1**).

# *Cold Start*

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 E.M.P. Software help for more details (Press **F1**).

# *Other Calibration Tables*

The other calibration tables may be adjusted as necessary.

Refer to the E.M.P. Software help for more details (Press **F1**).

# *Data Logging & Road Testing*

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*** **INTERPRET** Software.

Data Logging is also very useful for uncovering 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.

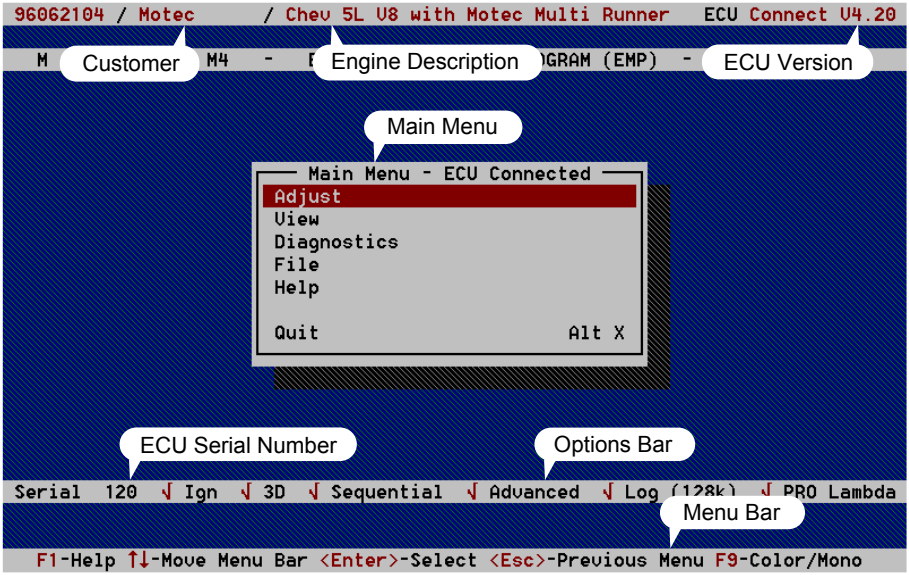
The light load and overrun calibration must also be completed on the road as these areas cannot be adjusted on a dyno.

# E.M.P. Software

The Engine Management Program (E.M.P.) is used for Setup, Calibration and Diagnostics of the ECU.

## *Main Screen*

When the E.M.P. Software is started the Main Screen will appear. If the ECU is connected the Main Screen will appear as shown below.




### *Status Line*

The top line on the screen is called the status line.

This line shows the following :

- The current file number (Automatically created)
- Customer (Entered when the file is created)
- Engine Description (Entered when the file is created)
- ECU Status : Connected or NOT Connected
- If the ECU is connected the ECU Software version is also shown.

## *Options Bar*

The options bar shows the ECU serial number and which options are currently enabled, a tick indicates that the option is enabled, an x indicates that the option is not enabled and an * indicates that the option is temporarily enabled during the evaluation period.

## *Menu Bar*

The bottom line is called the Menu Bar. This shows which key strokes are valid and what they do, or it gives special instructions.

Always look at this line to see what options are available.

# *Main Menu*

The ***Main Menu*** is used to select the desired operation. To select an item use the **Up** and **Down** Arrow keys then press the **Enter** key.

## *Adjust*

The ***Adjust*** item gives access to the various calibration and setup screens.

The calibration screens are detailed later in this document.

## *View*

The ***View*** item allows viewing of the engine data and sensor readings.

## *Diagnostics*

The ***Diagnostics*** item allows checking of the Diagnostics Errors and allows testing of Injectors, Ignition and Auxiliary Outputs while the engine is stopped.

## *File*

The ***File*** item gives access to the various file management functions.

Any file may be sent to any ECU by selecting ***Select File / Send Data to ECU*** from the File menu.

### *Help*

The ***Help*** item shows general help that is not necessarily available through the context sensitive help system.

### *Quit*

To exit the E.M.P. Software select the ***Quit*** item from the menu or hold down the **Alt** key then press **X**.

## *Context Sensitive Help*

Context Sensitive Help is available at most times and may be activated by pressing the **F1** Key.

"Context Sensitive" means that the help screen shows information relevant to the current screen or menu item.

## *Files*

E.M.P. 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 the calibration and setup data contained in the file.

## *Calibration and Setup*

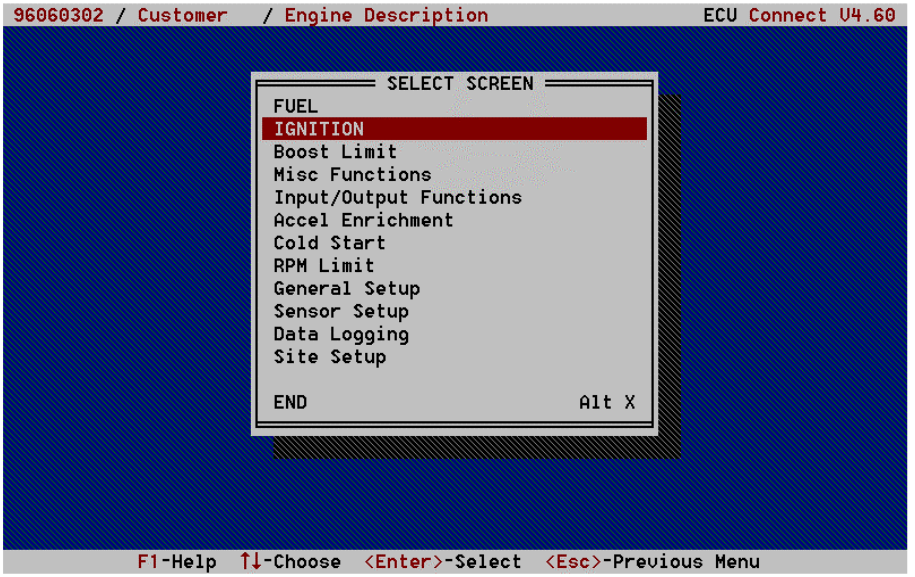
Selecting ***Adjust*** from the ***Main Menu*** allows adjustment of the ECU setup and calibration data.

### *File Matching*

Before entering the Adjust Screens 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.

## Selecting the Adjust Screen

The **Select Screen** menu will be displayed when entering the Adjust Screens so that the desired screen may be selected.




## Selecting a Different Screen

The Adjust Screen may be changed at any time by pressing the **Esc** key to re-display the **Select Screen** Menu.

## Exiting to the Main Menu

Press the **Esc** key to show the **Select Screen** Menu then select ***End***. Alternatively hold down the **Alt** key then press **X**.

Before exiting, any changes to the ECU calibration data may be saved to the original file or optionally to a new file which will leave the original file unchanged.

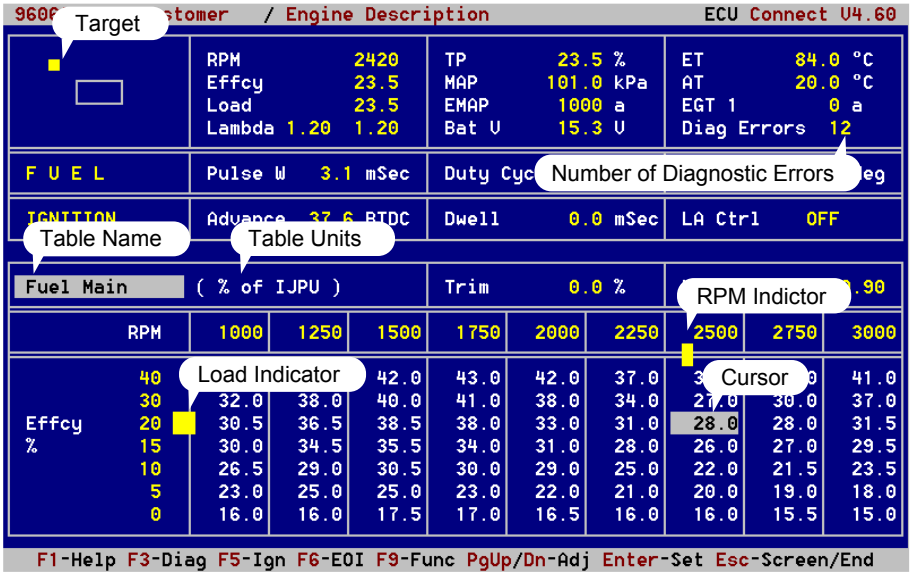
## File Only Edit Mode

If the ECU is NOT Connected the File Data may be adjusted directly, the changes can then be sent to the ECU at a later date.

- It is normally better to make changes with the ECU Connected.

# Calibration Screens

The FUEL - Main Table calibration screen is shown below, the other adjust screens are similar. Not all the calibration data can be seen at once, if the adjustment cursor is moved to the edges of the table the table will scroll.




## Sensor Readings

The calibration screens show basic sensor readings at the top of the screen, including RPM, Load Point, Throttle Position etc. The number of Diagnostic Errors is also shown, which should normally be zero. More detailed information may be shown by displaying the ***View*** screen (Press the **V** key).

## Selecting the Site to be Adjusted

The cursor shows which table value 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.

# *Making Adjustments*

## *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 pressing the **PgUp** or **PgDn** keys in conjunction with the **Ctrl** key. 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.

## *Setting the new Value*

When the desired adjustment has been made the new value must be "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.

## *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 Wide Band Lambda reading and the value from the ***Misc Functions - Lambda Control Table*** to calculate the new fuel table value. The adjustment is made to the value closest to the current engine operating point. (Requires Advanced Tuning).

This feature may be performed from the ***Fuel - Main Table*** or from the ***Ignition - Main Table***.

- This feature requires a Wide Band Lambda sensor or meter to be connected to the ECU.

## *Direct Entry*

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

Mathematical operations may also be performed on the currently selected value or to the whole table, Press the **F1** key while the direct entry screen is shown for details.

### *Set Indicators (*)*

An * will appear next to items that have been set, with the exception of tables that are dependent on the engine operating point where an * will only appear if the engine operating point corresponds to the currently selected site. The * indicates that the point has been correctly 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 ***Function Menu*** (Press the **F9** key).

## *Adjustment Concepts*

It is important to note that all adjustments are made directly to the ECU (if connected) rather than the File.

The File Data is only updated when exiting from the adjust screens back to the ***Main Menu***, it is therefore important to exit to the ***Main Menu*** after adjustments have been completed to ensure that the file is updated.

## *Graphical Indicators*

Graphical Indicators are shown at the top and side of the table.

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.

## *Target*

A Target is shown at the top left of the screen. This allows more accurate positioning of the engine operating point.

The indicator only moves if the engine is operating within the currently selected adjustment site.

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

## *Fuel / Ignition Toggle*

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

## *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.

Any alarm may be disabled by setting its limit value to zero.

## *Function Menu*

The Function Menu may be displayed by pressing the **F9** key.

The Function Menu allows selection of various functions such as :

- Compare Files
- Overall Trim Table
- Interpolate Vertical or Horizontal Column
- Copy Column Right
- Read Table from another File
- Many Others

Help is available on each item by positioning the selection bar on the item of interest and pressing the **F1** key.

## *Graph Table*

The calibration data may be graphed by pressing the **G** key or by selecting ***Graph*** from the Function Menu.

To change the view perspective press the **F8** key while viewing the graph.

## *View Screen*

The View Screen displays detailed engine and sensor data and allows resetting of the Maximum RPM and the Fuel Used.

The View Screen may be viewed by pressing the **V** key or by selecting ***Show View Screen*** from the Function Menu.

## *Trims Screen*

The Trims Screen displays a break down of various trims and compensations applied to the Fuel, Ignition and Boost.

The Trims Screen may be viewed by pressing the **T** key or by selecting ***Show Trims Screen*** from the Function Menu.

## *Diagnostic Errors Screen*

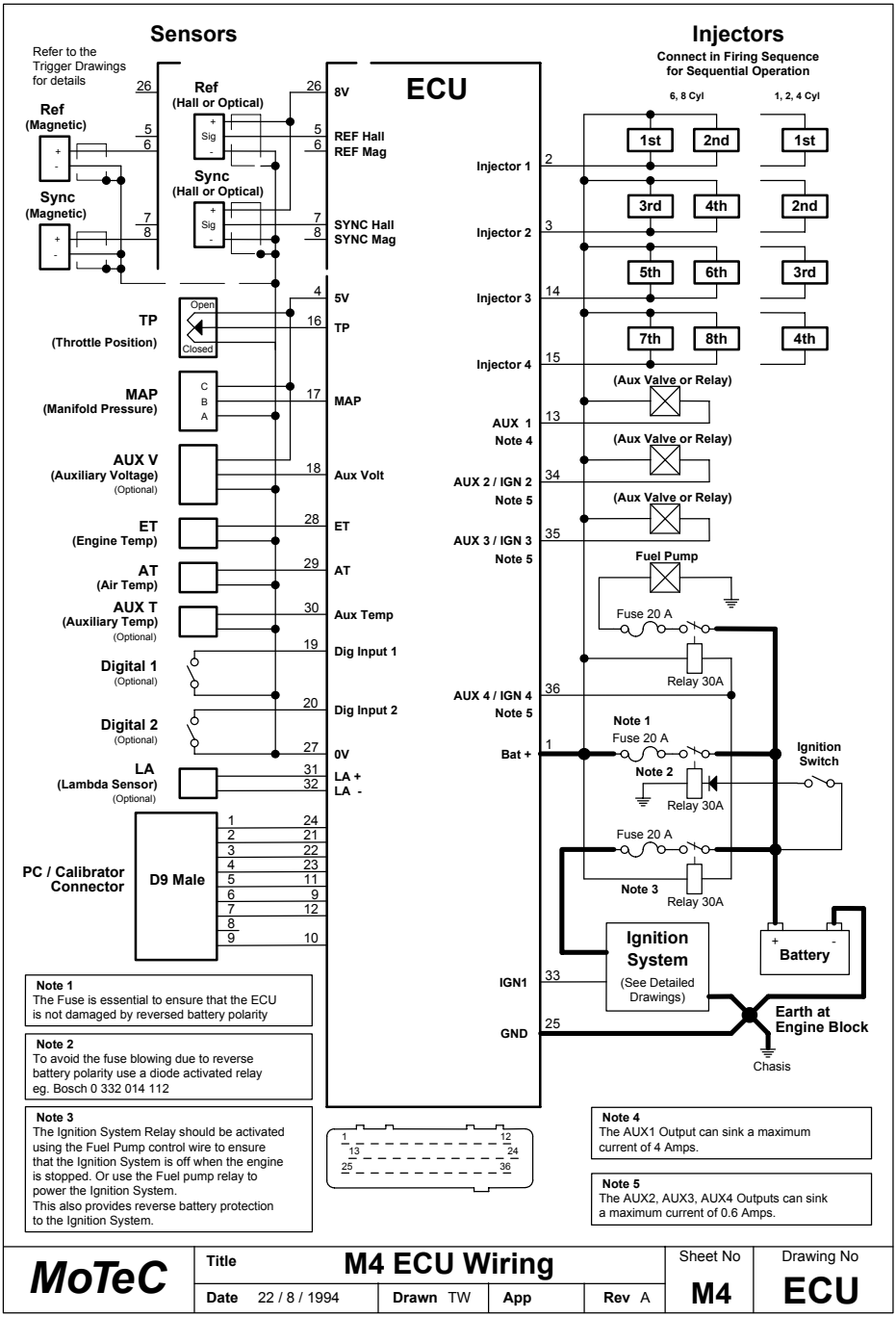
The Diagnostic Errors Screen may be viewed by pressing the **F3** key or by selecting ***Show Diagnostic Errors*** from the Function Menu.

To reset any non current errors press the **Enter** key.

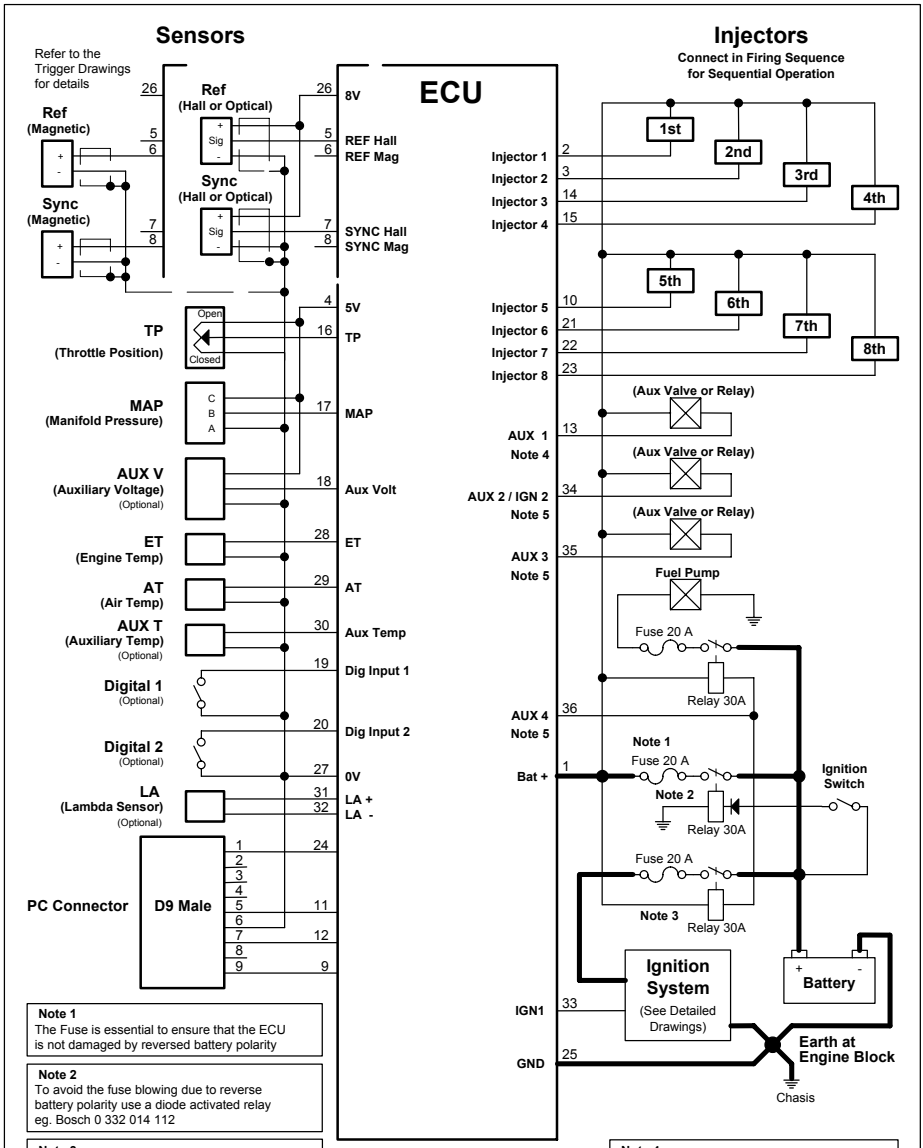
## *Keyboard Reference*

The main uses for the various keys are as follows :

| | |
|---|---|
| PgUp | Adjust Up |
| PgDn | Adjust Down |
| Enter | Set Value |
| Alt X | Exit |
| F1 | Show Help |
| F3 | Show Diagnostics Errors |
| F5 | Toggle between Fuel and Ignition screens |
| F6 | Toggle between Fuel Main and Fuel EOI screens |
| F7 | Toggle between Fuel Main and Boost Limit Main screens |
| F8 | Toggle between Fuel Main and Lambda Table screens |
| F9 | Show Function Menu |
| F10 | Copy site up and right |
| C | Compare Mode Off / On |
| E | Edit File Comments |
| G | Graph Table |
| L | Lambda Was |
| Q | Quick Lambda |
| S | Show Status Screen |
| T | Show Trims Screen |
| V | Show View Screen |
| Delete | Delete * at current site |
| Backspace | Place * at current site |




| MoTeC | Title | M4 ECU Wiring | | | Sheet No | Drawing No |
|---|---|---|---|---|---|---|
| | Date 22 / 8 / 1994 | Drawn TW | App | Rev A | M4 | ECU |




**Note 1**
The Fuse is essential to ensure that the ECU is not damaged by reversed battery polarity

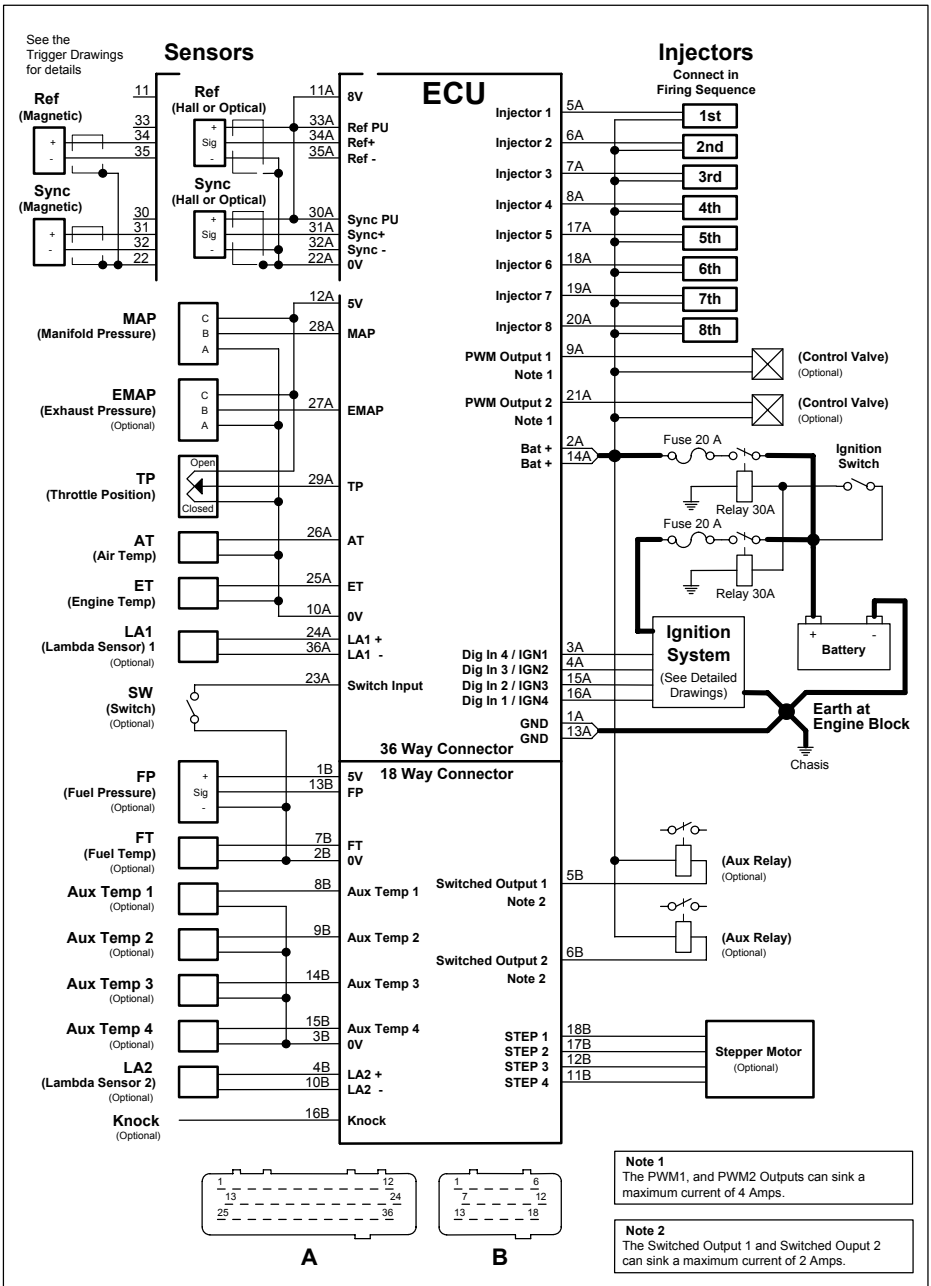
**Note 2**
To avoid the fuse blowing due to reverse battery polarity use a diode activated relay eg. Bosch 0 332 014 112

**Note 3**
The Ignition System Relay should be activated using the Fuel Pump control wire to ensure that the Ignition System is off when the engine is stopped. Or use the Fuel pump relay to power the Ignition System.
This also provides reverse battery protection to the Ignition System.

**Note 4**
The AUX1 Output can sink a maximum current of 4 Amps.

**Note 5**
The AUX2, AUX3, AUX4 Outputs can sink a maximum current of 0.6 Amps.

| MoTeC | Title | M48 ECU Wiring | | | Sheet No | Drawing No |
|---|---|---|---|---|---|---|
| | Date 15 / 1 / 1995 | Drawn TW | App | Rev A | M48 | ECU |




**Note 1**
The PWM1, and PWM2 Outputs can sink a maximum current of 4 Amps.

**Note 2**
The Switched Output 1 and Switched Ouput 2 can sink a maximum current of 2 Amps.

| MoTeC | Title | M8 ECU Wiring | | | Sheet No | Drawing No |
|---|---|---|---|---|---|---|
| | Date 17 / 1 / 1994 | Drawn TW | App | Rev B | M8 | ECU |