Emerald K3

Engine management system
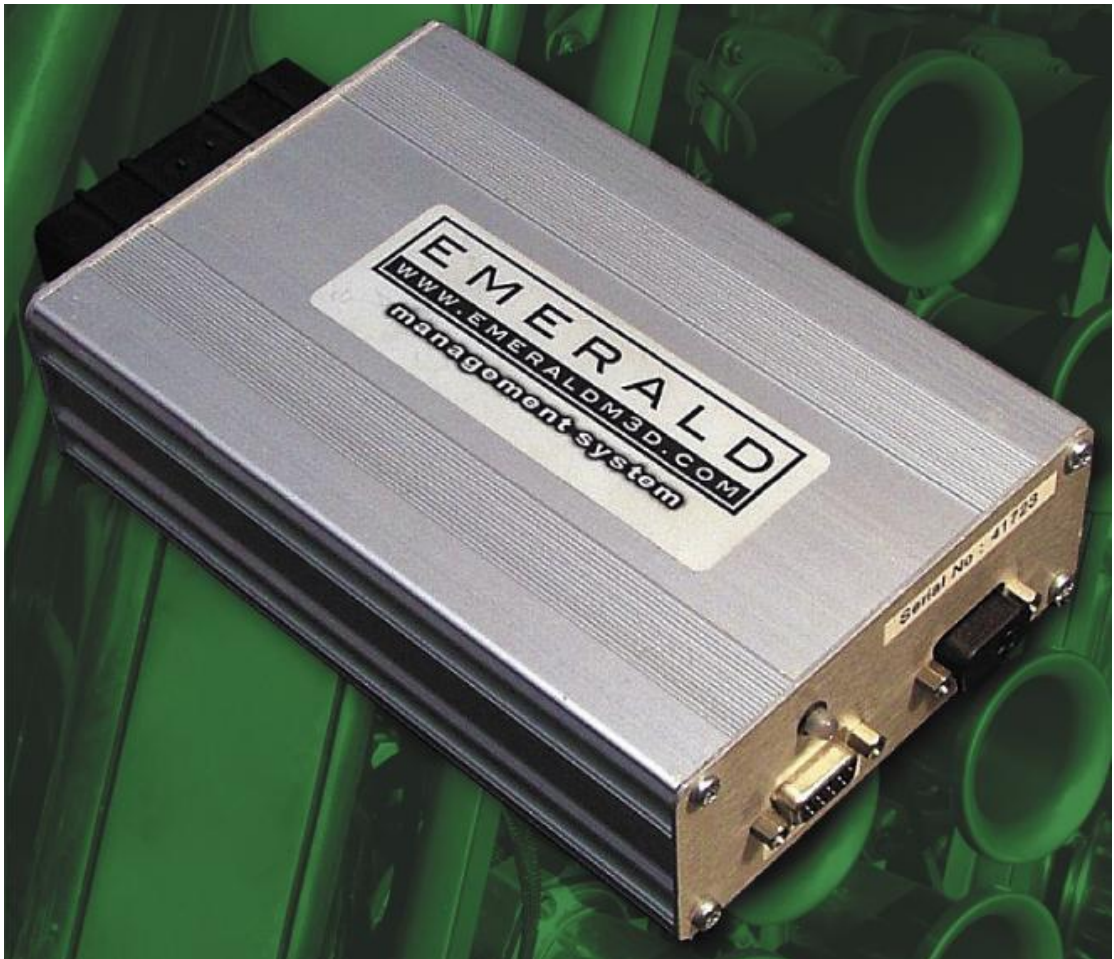
Operating manual
v0.57

Contents

Software installation

The Emerald K3 Windows mapping software is written in 32-bit code, which means it needs to be operated through MS Windows 95 or later.

Compatible operating systems:

- Windows 95, 98, Me, 2000, NT, XP

Minimum PC requirements:

This is really dictated by the requirements of Windows itself. The absolute minimum recommended PC specification is :

- 486DX 66MHz
- 32MB RAM
- CD-ROM
- RS-232 or USB port (USB to serial adapter can be used)

Install from CD

The software files are supplied in a single installation file on a CD-ROM. They must be uncompressed and installed onto your PC before use.

To install the mapping control software, insert the Emerald K3 CD in to the PC's CD-ROM drive. The install process should start automatically within several seconds.

If the CD Auto-run function on your PC does not automatically start then use Windows Explorer to navigate to your CD drive and view the contents of the Emerald K3 CD-ROM. Double click the 'setup.exe' file to start the installation process.

Follow the on screen instructions. Before the files are installed, you will be asked for a location for these files. The default location is **C:\Program Files\Emerald K3**. Select the **Next** button to continue or enter another location of your choosing.

When the files have been successfully installed click the **finish** button to return to Windows.

A shortcut icon will be placed on the desktop and also in the Programs/Emerald K3 directory accessed through the Start menu. Use either of these icons to start the Emerald K3 software.

Starting the software

Double click the 'Emerald K3 v1.00' desktop shortcut icon or click the shortcut from the Start / Emerald K3 menu.

As the Emerald K3 software starts, you will be asked which serial communications port you are going to use to connect to the ECU. A drop down list of available com ports are displayed in the 'Select Port' window.
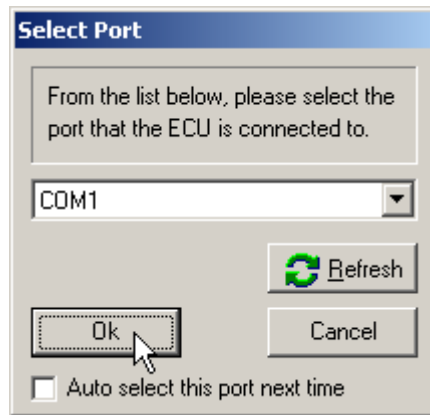
From the drop down list select the serial port you are going to use to connect to the ECU. Click the 'ok' button when you are happy with your selection.

If you have a known working port selection you can select the 'Auto select this port next time' check box before click the 'ok' button. This saves you from having to go through this port selection process each time the software is loaded. If you need to change this port selection at a later date just click 'Comms port' from the 'Comms' menu in the main software and you will be presented with this same 'Select Port' window.

Click the 'Refresh' button to instruct the software to rescan and update the comms port list. You can use this feature to update the list after inserting a USB-serial adapter without having to close and restart the Emerald K3 software.

In order to establish a communications link with the ECU:

- Use the supplied serial communications lead and **_not_** a generic RS-232 lead.

- Use a valid serial communications port or USB-serial adapter.

- The ECU must be powered via pin 11 (+12v via ignition switch).

Software

Introduction

Once the software has started and the com port selection has been accepted you will be presented by the main window of the Emerald K3 operating software.

Screen minimise
Screen maximise
Software exit

Main menu

Main window page control

ECU communications/connection status

Data logger recording status

Current map status

Green = Map 1
Red = Map 2
Yellow = Map 3
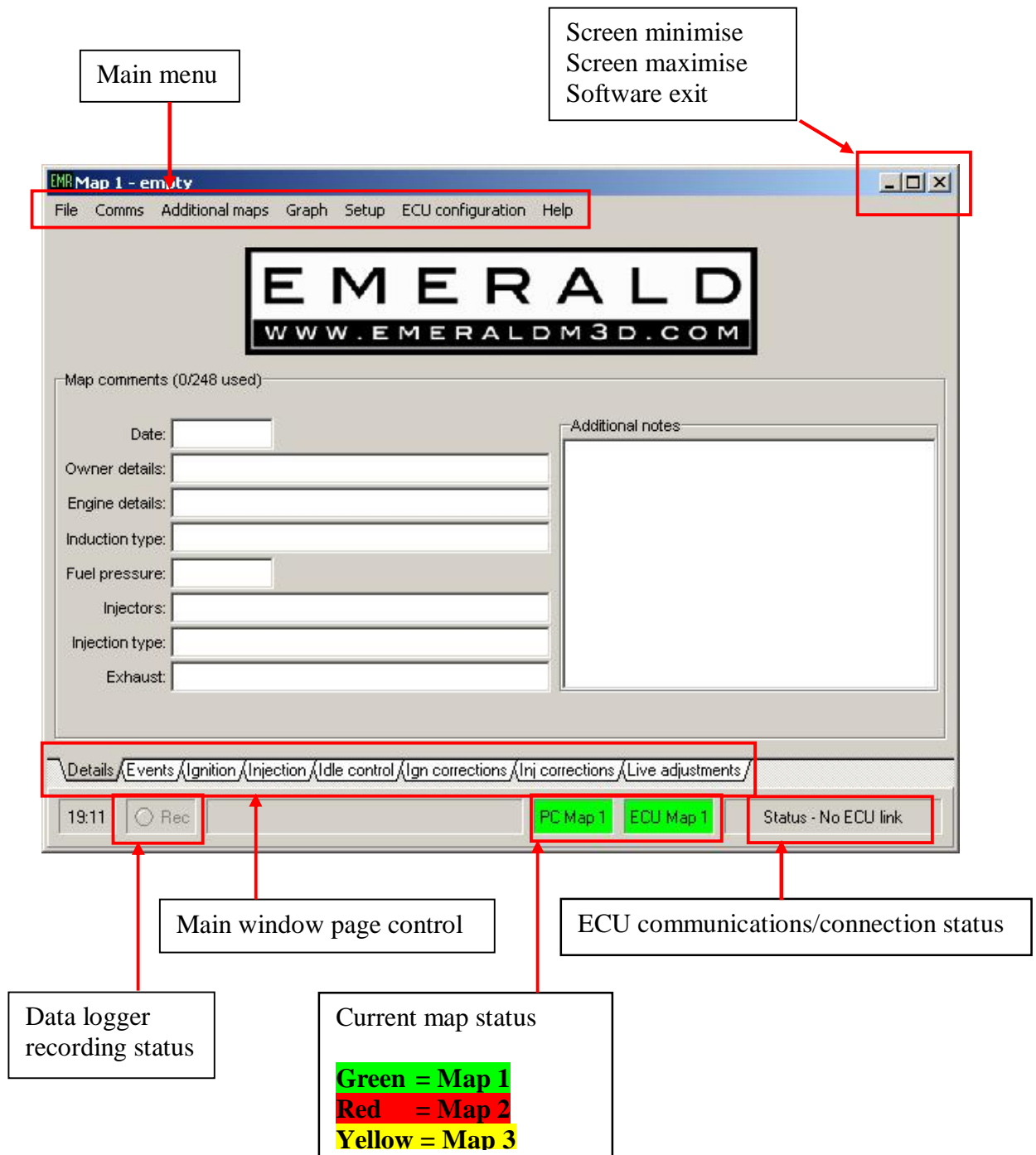
The Emerald K3 mapping software centres on a paged main window. This window gives quick access to the most commonly accessed parts of the maps. Other map tables and settings are accessed through the main menu.

There are 8 pages to the main menu. Each page has a function key shortcut. To switch to the desired page just click the appropriate 'Tab' or press the appropriate function key.
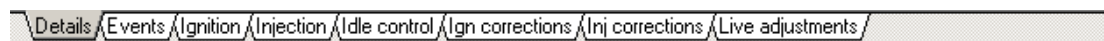
Main window page control

Function key short cuts

F1….Details screen

F2….Events screen

F3….Main ignition table

F4….Main injection table

F5….Idle control settings

F6….Air temperature correction settings

F7….Coolant temperature correction settings

F8….Live adjustments

F12…Data-logger

As with most Windows software, the mouse pointer is the primary input device but this is not always convenient especially when mapping from a laptop.

Where possible we have provided additional keyboard shortcuts as well as retaining the standard windows keyboard controls to make the software as easy and quick as possible to operate.

Details (F1)

When the software is first started this is the screen you are first presented with.

Use this screen to keep notes that relate to your map. Make the notes as detailed as possible as this information may be useful when tracking engine & map changes over time. These notes can also be very helpful if you wish to pass this map to another Emerald ECU user.

Map comments

Each map can contain up to 248 characters in the details section. These details will be stored in map files saved to disk or programmed into the ECU. The number of characters used out of the maximum of 248 is shown at the top of the map comments section.

The detail fields are arranged to help remind you which details may be important to record. Use the additional notes text box to store any other information.

Events (F2)

This page contains a number of commonly accessed settings.

These settings are grouped into 5 areas, RPM events, Tacho telltale, Main cooling fan control, cooling fan control 2 and overrun fuel cut off.

RPM events

To change one of 'RPM events' highlight the setting you want to change and increase or decrease the Rpm number by pressing the up/down arrow keys. With each key press, the number will change in 50rpm steps. Holding the arrow key down will rapidly change the value. To change these values with the mouse pointer, simply click on the appropriate up/down arrow button beside the value you want to change.

Note: The RPM events have a minimum setting of 2,000rpm.

When the engine rpm has reached the 'Shiftlight' rpm, the ECU shiftlight output will switch to earth and, if fitted, will illuminate a dashboard mounted warning lamp. Normally this is used to indicate a maximum safe rpm or a desired change up point.

Once the 'Soft-cut rev limiter' rpm has been reached engine power will be reduced with a combination of ignition retard and spark cut. Although this rev-limiter does *reduce* engine power it is still possible for the engine to continue accelerating and over-rev.

When the 'Hard-cut rev limiter' rpm is reached, all ignition sparks and fuel pulses will stop until the engine rpm falls below this rpm setting. It is possible for the engine to exceed this rpm setting by mechanically over-revving the engine even though the engine is effectively switched off, i.e. when down-changing too early.

Tacho telltale

The ECU records the maximum attained engine speed. When the ECU is connected this *Max recorded RPM* value is shown here. Click the *Clear* button to reset this telltale to the default of 2,000rpm.

The ECU can also display this maximum rpm reading through the car's tacho if the *Tacho driver* is ON. Click the On/Off button to change the *Tacho driver* status. With the ignition on, the engine not running for at least 5 seconds, and the *Tacho driver* set to ON, the ECU will drive the tacho to display this maximum rpm telltale reading. While displaying the telltale you can reset it back to the default of 2,000rpm by cranking/starting. To retain the telltale reading switch the ignition off. The engine should be started within 5 seconds of ignition to ensure the telltale reading is not reset.

Main cooling fan control

The ECU has a dedicated cooling fan control output that is activated by the engine's coolant temperature. This 7output switches to earth when active. The cooling fan control output should only be used to switch a relay and not directly wired to the cooling fan motor itself. Having separate 'On' and 'Off' settings means you can set the temperature at which the cooling fan switches on and also the temperature the engine must cool down to before switching the fan off.

The air temperature switch will not be used in most cases, only certain ECU versions will have this function enabled. This function can have various uses, e.g. for switching on a charge cooler when the inlet air temperature reaches a given threshold.

To adjust these on/off values press *TAB* to activate to desired setting and then use the up/down arrow keys to change the setting.

Cooling fan control 2

This is an additional temperature-activated control that can be configured to switch any spare output to earth according to air, coolant or aux temperature inputs.

This function differs from the main cooling fan control with the additional *Switched by* setting which determines the temperature sensor measurement used.

The output that this function will switch to earth when activated is determined by the *Cooling fan 2* setting in the *Output channels* page of the ECU configurations.

Cut-off all fuel if… (overrun cut-off)

These settings are used by the ECU to determine the overrun condition. When overrun is detected the ECU will cut off all fuel. If enabled, the overrun fuel cut off function is activated when the engine rpm is above the *Engine speed above* threshold AND the throttle number is below the *Throttle-pot number below* threshold. Once activated the overrun fuel cut function will remain active until the throttle is opened beyond the set threshold or the engine rpm is at or below the target idle rpm.

Ignition map (F3)

The ignition map is a 16 load site x 32 speed site 'look up table', each cell is a number that is an ignition timing value in degrees BTDC (before top dead center).

The speed (rpm) sites, columns 0 to 31, are arranged from left to right starting at 0 rpm. The rpm that each speed site relates to is shown in the cells shaded yellow.

The load sites, rows 0 to 15, are arranged from top to bottom with the lowest load site at the top.

As rpm & throttle position change, the ECU looks at the cell for these speed/load conditions to determine the ignition timing. If the current engine speed or load condition falls between the sites in the map then the value is interpolated between the nearest sites i.e. the two nearest speed sites and two nearest load sites. By calculating an interpolated setting, there is no step in value as a load or speed condition crosses a site boundary.

The startup timing is a separate value from the main map. While cranking, the main map is ignored and the timing is determined by the *startup timing* value (regardless of load). When the engine speed has risen above 500 rpm, the software switches to the ignition map to determine ignition timing, the software will **not** use the startup timing value again unless the engine has completely stalled or the ECU is reset.

Each cell has a range of -30° to 60° BTDC.

Map editing

See the *map editing* section on page 11 of this manual for further information on how this table can be manipulated.

Injection map (F4)

The injection map functions much the same as the ignition map. **Note** that there is no startup value – the injector pulse width duration is taken from the main injection map at all times.

The injection map values determine how long the injectors are switched for. The values can range from 0 to 255. As with the ignition map, the final injection value is fully interpolated by calculating between cells according to current engine speed & load conditions.

Map editing

The injection and ignition map tables share a common layout. These maps also reference a common load site and speed site configuration.

The values in these maps can be changed in various ways. Use the cursor arrow keys to highlight the cell of interest. Press enter to bring up the **insert data** window as shown below.

You are reminded of the speed/load site of the cell you have selected and also the current map value. If you want to change the value of this cell type in the new value and press **enter** (or select OK). Pressing the **Escape** key or selecting **cancel** will return you to the map unchanged.

An alternative way to change individual map values is to use the + and – keys. These will increase/decrease the currently highlighted map cell by 1 unit.

By blocking a map area (using the drag mouse method or press & hold the shift key while moving the cursor with the arrow keys) you are able to change the value of more than one site at a time. With an area of the map highlighted, the + and – keys can be used to increase/decrease those values by 1 unit. Pressing **enter** with an area selected will bring up the **block map function** window.
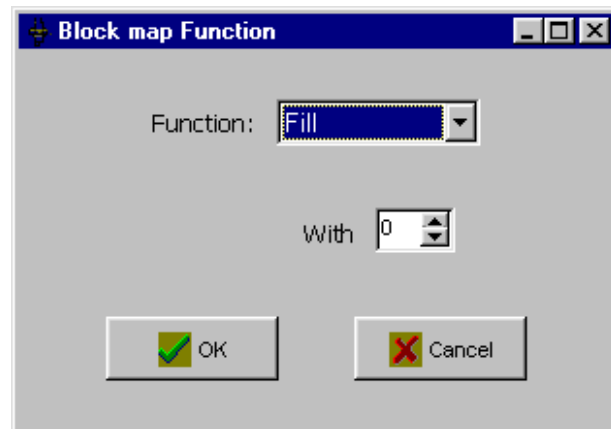
The available functions are *Fill with*, *Add* or *Subtract*. The injection table also has *Increase* and *Decrease* functions in the drop down list. Use the up/down arrow keys to select the desired function (or use mouse). Press **tab** to select the value to fill, add or subtract, type in the value. Press **enter** to perform the function or press **escape** to abort.

Calculate (interpolate) function

The PC software can be used to calculate the map settings between cells in the table. This can be a very useful aid to speed up the mapping process.

Example

Two cells have been mapped, one at load site 5 and one at load site 7. The *calculate* function can be used to 'guess' the setting at load site 6 by interpolating between sites 5 & 7. The highlighted/selected area of the table determines the end points or corners within which the cells will be adjusted. For this example block a column between sites 5 & 7 and press the 'C' (**C**alculate) key. The numbers changed by this function will be highlighted blue with the original mapped numbers being red. It is a good idea to re-check these 'guessed' sites when mapping on a dyno or rolling road.

The software will calculate over any number of load or speed sites using the end points of the highlighted block with linear interpolation between sites. You often find that there are areas of the map that you do need to map every site, e.g. around very light throttle where a small change in throttle angle results in a large change in air-flow. It is usually slow progress when starting a map, this function allows you to map a few sites and quickly get a sensible map into shape by filling in the gaps… you can then go over calculated sites to check/fine tune them.

Below is an example using this function - load sites 3 & 5 where mapped (numbers highlighted red). You can see that the number at load site 4 is obviously too high. The *calculate* function is used to replace the number at load site 4 with one that is between the values of load sites 3 & 5.

2	83	80
3	93	90
4	105	95
5	99	96
6	100	97

1. Load sites 3 & 5 mapped

2	83	80
3	93	90
4	105	95
5	99	96
6	100	97

2. Block column

1	70	65	61	53	46	41	42
2	83						
3	93						
4	105						
5	99						
6	100						
7	101						

Confirm

Interpolate column
Part of the map will be overwriten, Continue?

OK   Cancel

3. Press 'C' to calculate between sites 3 & 5
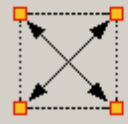
2	83	80
3	93	90
4	96	95
5	99	96
6	100	97

Result, calculated/interpolated value at load site 4

The calculate function can be used on a larger area of cells where the four outer corners are used to calculate the surrounded cells. You can set how the calculation function proceeds. The options are row by row, column by column or four corner interpolation.

Block interpolate function

Select interpolation method

Four corner ⦿
Rows ○
Columns ○

OK   Cancel

Idle control (F5)

A number of settings that affect how the ECU detects and controls the engine idle speed are grouped here in the *Idle control* page.

Conditions that enable idle control

Settings

- *Throttle-pot number below*
  Throttle position threshold. If the throttle is opened beyond this point the function is de-activated.

- *Engine speed below*
  Engine speed threshold. If the engine rpm increases beyond this point the function is de-activated.

When both the *Throttle-pot number below* AND the *Engine speed below* statements are true the ECU will enable the idle control mode. Idle control mode will activate any enabled idle control function. The live throttle-pot number can be viewed in the *Live adjustments* screen, the *throttle position sensor setup* screen or the *diag data* screen.

As a general starting point the *Throttle-pot number below* value should be set to 8 units above the value read whilst the engine is idling and the *Engine speed* below value should be set to 200 rpm above the hot idle speed.

Idle stabilisation using ignition advance

Settings

- *Enabled*
  Idle stabilisation function on/off control.

- *Max idle ignition trim*
  The maximum amount of advance this function can add to the base advance in order to maintain the desired idle speed.

- *Update rate*
  The update rate sets how often this idle stabilisation function is called to update the ignition advance. This value is the number of ignition events between function calls. The practical range for this setting is 1 (fast) to 25 (slow).

Once the idle control mode condition has been determined the *idle stabilisation using ignition timing function*, if enabled, will be activated. When enabled and activated the function will have control over the ignition advance and will use this in an attempt to hold the engine speed at that dictated by the *Target idle rpm*. This function will not reduce the ignition advance to a value lower than 0.0° BTDC if the idle speed is too high.

In certain conditions advancing the ignition timing alone is not enough to increase the idle speed to reach the target rpm. Without the *Max idle ignition trim* value the function would continue to advance the ignition until it was too far advanced to run and the engine would stall. Unless an air bypass valve is also used in conjunction with this function it may not be possible for the target rpm to be reached.

As this function name suggests, it should only really be relied on to provide stabilisation or fine control of the idle speed. An air bypass valve would normally be used to provide a slow responding coarse idle speed adjustment, with the stabilisation function providing a rapid responding fine idle speed adjustment. Many applications will not have an air bypass valve so this stabilisation function can be used on its own to give a good improvement to the idle quality under varying conditions.

Tip. If you intend to use this idle stabilisation function it is a good idea to leave it disabled until the mapping work is finished. Set the idle speed ignition timing in the base map fairly retarded, e.g. 0° – 10°, and set the hot idle speed to the desired idle speed using the idle control screw. By maximising the air flow/cylinder filling at idle, the idle stabilisation function will be most effective.

Target idle rpm

The ECU uses this table and the current engine coolant temperature to determine the desired idle speed.

To adjust the table values click/highlight a cell or range of cells and use the **plus (+)** key to increase by 10 rpm and use the **minus (-)** key to decrease by 10 rpm. If more than two cells are highlighted, the *Calculate* function (press 'C') can be used to interpolate between values.

Idle control using Air Bypass Valve

Settings

- *Motor control mode*
  - *Off*
    IACV control disabled

  - *Manual (fixed position)*
    IACV position is controlled by the user. Use the PageUp, PageDown and Home keys to adjust the IACV position from the *Live adjustments* screen.

  - *Mapped*
    IACV position is controlled by the ECU according to the position table found in the *Idle Air Control* screen via the *Additional maps* menu.

- *Update every..*
  This setting determines how often the IACV position is updated. The interval between position changes can range from 0mS (fastest) to 2550mS (slowest). A setting of around 100mS suits most systems.

The *Idle control using Air Bypass Valve* settings determine the way the air bypass motor, if fitted to the engine, is controlled. With the *Motor control mode* set to "off" the ECU will completely disable any outputs associated

with the control of the IACV (idle air control valve) and any corrections to the maps from related look-up tables will be ignored.

With the *Motor control mode* set to "Manual (fixed position)" the IACV position can be controlled directly from the keyboard when in the *Live adjustments* (F8) screen. The ECU will keep track of the motor position even after the ECU has powered down.

With the *Motor control mode* set to "Mapped" the IACV position is controlled by the ECU only - the keyboard control of the motor is disabled. The IACV position is now determined by the look-up table found in the *Additional maps – Idle Air Control* screen.

Ignition corrections (F6)
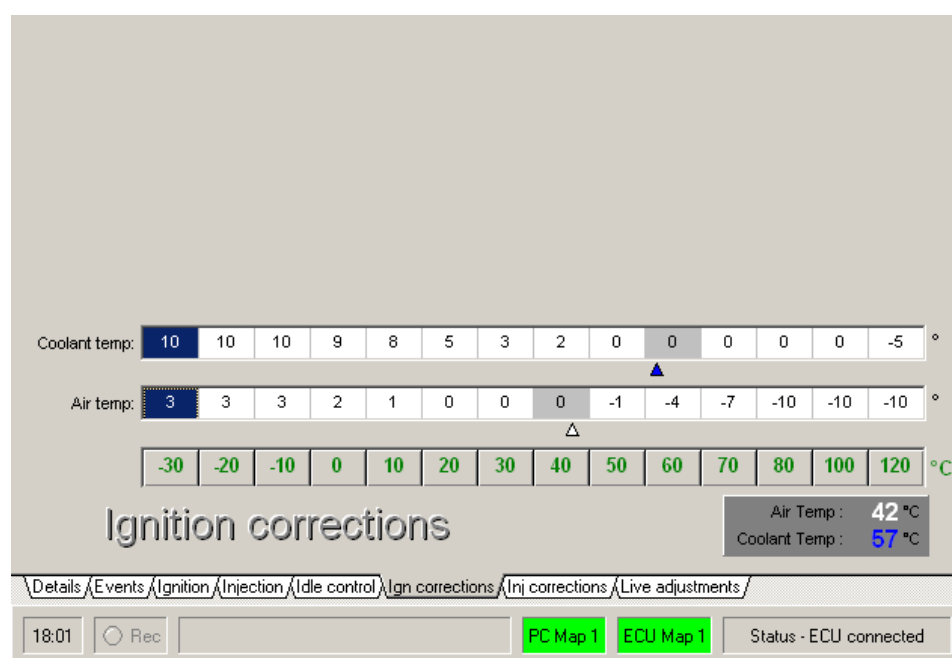
The change in inlet air density effectively changes the cylinder filling so the ignition timing requirements will change slightly. Also with increasing inlet temperature there is more chance of detonation/pinking due to increasing cylinder temperatures. It is common to retard the ignition slightly as the inlet temperature increases, as a safety measure to protect the engine.

At lower engine temperatures there is usually less risk of detonation. The ignition can often be advanced to improve response, warm-up and help with idle control.

The injection correction and ignition correction values displayed in the *Readings* panel on the *Live adjustments* screen will show the actual correction applied to the ignition. The correction value displayed is a combined value taking into account air temperature corrections, coolant temperature corrections and pressure compensations.

Keyboard controls

To adjust the table values click/highlight a cell or range of cells and use the **plus (+)** key to increase by 1 unit and use the **minus (-)** key to decrease by 1 unit. If more than two cells are highlighted the *Calculate* function (press 'C') can be used to interpolate between values.

Injection corrections (F7)

To aid cold start and cold running the ECU has a number of temperature-related fuelling correction settings that it refers to.

Initial Inj Prime

This table sets a one-shot injection priming pulse that is activated the moment engine rotation is detected. The priming pulse is used to wet the inlet manifold to help speed the engine start-up time.

Cranking enrichment

Due to low air speed during and high fuel drop-out during cranking the fuelling needs to be increased. This table increases the fuelling according to engine temperature and also how many times the engine has rotated (engine turns). The engine turns counter is reset to 1 at ignition on and will not increase until the engine rpm has increased above 500 rpm. Once above 500 rpm (engine started) the engine-turns input is used to decay the cranking enrichment away over time. The engine-turns axis of this table is adjustable. Right-click the engine-turns column to access the adjustment.

Coolant temp

When the engine is cold, fuel drop-out is high and fuel atomisation is poor, which leads to poor combustion and a lean mixture. This correction table is used to adjust the fuelling for cold engine running. This table can also be used to increase fuelling at higher than normal engine temperatures to provide some protection against the increased risk of detonation.

Air temp

The density of the inlet charge varies with inlet air temperature. This varying density changes the amount of oxygen trapped in the cylinder and will therefore change the air fuel mixture ratio. For every increase of 10°C of inlet temperature the density of the air is reduced by approximately 3%, therefore the fuel injected will need to be reduced by the same percentage in order to maintain a constant air/fuel mixture ratio.

A standard temperature of 20° C is often used. At this temperature there is no correction to the fuelling. Below this temperature the fuelling is increased and above it the fuelling is reduced.

Coolant correction mapping

Keyboard controls

To adjust the table values click/highlight a cell or range of cells and use the **plus (+)** key to increase by 1 unit and use the **minus (-)** key to decrease by 1 unit. If more than two cells are highlighted the *Calculate* function (press 'C') can be used to interpolate between values.

Tip. *Don't spend too much time fine tuning these enrichment tables until you have finished mapping the main injection table for your application - these injection correction tables are applied to the main injection table. Also, it is very easy to be confused into adjusting the wrong coolant injection correction table. The **Injection** table value is applied to the main map at all times whereas the **Cranking Enrichment** table value is only applied during cranking and for a few seconds after.*

Once the injection has been mapped, start with a fully cold engine. If you have difficulties starting the engine check the condition of the spark plugs. They may have become fouled if the mixture is far too rich - replace/clean if necessary. While cranking you can increase/reduce the fuelling from the *Live adjustments* screen by using the fuel trim keys. When the engine is up and running clear any trim and allow any cranking enrichment remaining to fade away. This may take a few seconds.

Check how the engine runs and revs. If the mixture is over-lean you will normally notice a poor pickup response when you open the throttle, or 'spitting' in the inlet. If the mixture is over-rich you will often have black smoke from the exhaust, the spark plugs will have a tendency to foul and if excessively rich the engine will be sound rough when the throttle is opened. Use the fuel trim keys from *Live adjustments* screen and check for an improvement. If you need to make a change to the mixture, note the temperature and stop the engine. Increase or decrease the value in the *Coolant temp* correction table at that temperature site. Re-program the ECU with the changes and repeat the process.

Note: Keep a careful eye on the water temperature as you adjust the enrichment. The engine heats up quite quickly and you might find yourself adding fuel at a given temperature, not having noticed that the engine has moved on. This process may take some time and need a few attempts with a cold engine to get the correction table spot on.

If a wideband lambda sensor is fitted allow time for it to warm up before making any fuelling adjustments. Engine design usually dictates the fuelling level required during warm-up. As a rough guide, aim for a fuelling level of around 12.5:1 AFR (lambda 0.85) at the coldest temperatures, gradually moving towards the normal idle fuelling as the engine warms.

Live adjustments (F8)

This page displays the current live information the ECU is working with. This information shows you the engine data inputs that the ECU has measured and also the mapping information that results from these inputs.

The page is split up into 5 titled panels to make the information easier to understand.

Readings

The most important engine data needed during mapping is displayed in this area.

- o *Engine rpm*
  The engine rpm measured by the ECU is displayed here. Until engine rotation is recognised 0 rpm will be displayed.

- o *Speed site*
  The main injection/ignition tables have 32 columns. The speed site value is the column that the ECU is currently looking at. This value is determined by the engine rpm and the speed site configuration.

- o *Load site*
  The main injection/ignition tables have 16 rows. The load site value is the row that the ECU is currently looking at. This value is determined by the main load sensor (throttle position sensor or MAP sensor) and the load site configuration.

- o *Air temp*
  The air temperature as measured by the ECU.

o *Coolant temp*
The engine coolant temperature as measured by the ECU.

Note: The air/coolant temperature display will also highlight a detected sensor fault. The conditions that determine the fault condition are set in the ECU configuration. The ECU will substitute the faulty input with a user adjustable temperature reading. The substituted temperature reading is displayed and highlighted red to show that a fault has been detected…

Coolant Temp : **100** °C

o *Throttle*
The throttle position as measured by the ECU.

o *MAP pressure*
The inlet manifold or barometric pressure. Assuming the ECU has been configured to read a pressure sensor a reading of ~0.00 bar/0.0 psi/100 KPa should be displayed if the engine is not running.

o *Battery voltage*
The voltage supplying the ECU. The displayed voltage should indicate approximately 12.5–14.5 volts when the alternator is charging. If the battery voltage is showing higher or lower than this, the alternator condition should be checked. Also the battery voltage can be monitored while cranking. A very low voltage may seriously impair the performance of the coil/injectors etc. and make starting difficult. A battery voltage of 9–10 volts while cranking is normal and there needs to be a minimum of 6v for the ECU to operate.

o *IAC pos*
The current position of the Idle Air Control Valve (if fitted). The colour of this number also indicates when the ECU has determined that the engine is idling. The *IAC pos* value is coloured red to indicate idle control mode is active otherwise it is coloured green. The engine rpm and the throttle pot number are used by the ECU to determine if the engine is idling, these settings are found in the *Idle control* screen (F5).
Depending on the current motor control mode the IACV motor can be moved manually from the keyboard from the *Live adjustments* screen. Pressing home will move the motor to the fully closed position (IAC pos: 0). Pressing the Page Up or Page Down keys (PgUp/PgDn) will open/close the valve by one step. Pressing the shift key at the same time as PgUp/PgDn will move the motor in steps of 10.

o *Ignition correction*
The total ignition trim applied to the basic ignition timing (as determined by the ignition map, speed site & load site). This trim is the result of the air, coolant and pressure compensation tables.

o *Injection correction*
The total injection trim applied to the basic fuelling as a result of the air, coolant, cranking and pressure compensation tables.

o *Site target*
The cross on the target shows the level of interpolation between speed/load sites. With the cross in the middle of the target there is no interpolation between sites. The injection/ignition values are only determined by the one map cell as indicated by the current speed and load sites. As the rpm increases slightly the cross will move to the right showing that the ECU is interpolating between the current site and the map cell at the next speed site. The cross will move vertically to indicate interpolation with sites above/below the current load site.
This is a very useful mapping aid. You want to have the target as close to the middle as possible so you know that you are just adjusting that one particular site and the actual injection/ignition output is not also being affected by another map cell value. When you press enter to store a trimmed map value only the one cell at the current speed/load site is changed. Ensuring that you have the cross in the centre at that time means the new untrimmed map will produce the same injection/ignition output as the previously trimmed map.

User selectable readings

There are four user selectable readings on the live adjustments screen. Click a reading box to select from a drop down list of available readings that can be displayed.
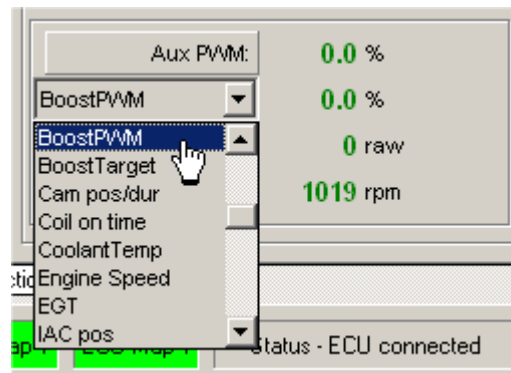
Map trim 1

From the Live Adjustments screen you are able to apply an adjustment/trim to two maps at the same time. The two maps selected for adjustment are set by the Map trim 1 and Map trim 2 panels.

By default Map trim 1 panel is assigned to the ignition map.

Hold the ALT key and tap the '1' key to cycle through the other map option available.
Ignition→Injection→Boost PWM→INJ position→PWM→VVT position.

Although the following text assumes that Map trim 1 is set to adjust the ignition map, the same info also applies to the other map options.

The basic value determined by the map selected (in this case, the ignition map) and referenced by the speed/load sites, is displayed in the first box titled "map advance". The ignition timing can be advanced or retarded in 1° steps from the keyboard when this live adjustments screen is showing. The current trim that has been applied by you is shown in the box titled "ignition trim" and is coloured red. The trimmed advance box shows you the result of the basic ignition advance and the trimmed advance.

Keyboard controls

The ***zero (0)***, ***minus (-)***, ***plus (+)*** and ***Enter*** keys (on main keyboard, not numeric keypad) are used to control this trim while the engine is running.

- ***Zero (0)***
  Clears the current trim. ECU returns to the normal mapped value.

- ***Minus (-)***
  Reduces (trims) the mapped value by 1 unit for each tap of the key. In this case the ignition timing is retarded in 1° steps.

- ***Plus (+)***
  Increases (trims) the mapped value by 1 unit for each tap of the key. In this case the ignition timing is advanced in 1° steps.

Tip: It is always a good idea to save the current map stored in the ECU to disk before you make any changes. This way can you always re-install the original settings if you lose your way. To retrieve the current map stored in the ECU, select the 'Read ECU' item from the 'Comms' drop down menu. To store this map to disk select 'Save Map File' from the 'File' drop down menu.

Map trim 2

From the Live Adjustments screen you are able to apply an adjustment/trim to two maps at the same time. The two maps selected for adjustment are set by the Map trim 1 and Map trim 2 panels.

By default Map trim 2 panel is assigned to the injection map.
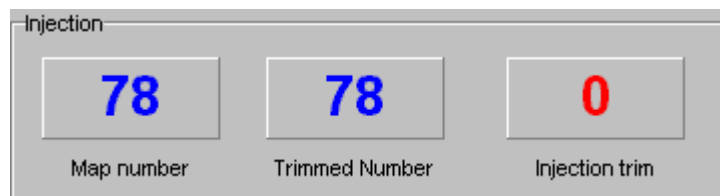
Hold the ALT key and tap the '1' key to cycle through the other map option available. *Ignition→Injection→Boost PWM→INJ position→PWM→VVT position*.

The basic value determined by the map selected (in this case, the injection map) and referenced by the speed/load sites, is displayed in the first box titled "map number". The fuelling can be increased or reduced in 1 unit steps from the keyboard when this live adjustments screen is showing. The current trim that has been applied by you is shown in the box titled Injection trim and is coloured red. The trimmed number box displays the result of the basic Map number and the Injection trim.

Keyboard controls

The *1*, *2*, *3* and **Enter** keys (on main keyboard, not numeric keypad) are used to control this trim while the engine is running.

o *1*

Clears the current trim. ECU returns to the normal mapped value.

o *2*

Reduces (trims) the mapped value by 1 unit for each tap of the key. In this case the fuelling is increased in steps of 1 unit.

o *3*

Increases (trims) the mapped value by 1 unit for each tap of the key. In this case the fuelling is reduced in steps of 1 units.

o **Enter**

A trimmed map value can be stored while the engine is running by pressing the **Enter** key. The ECU's own map is updated as well as the map in the PC. The cell in the relevant table is coloured red to help identify the cells that have been mapped.

Tip:Iit is always a good idea to save the current map stored in the ECU to disk before you make any changes. This way can you always re-install the original settings if you lose your way. To retrieve the current map stored in the ECU, select the 'Read ECU' item from the 'Comms' drop down menu. To store this map to disk select 'Save Map File' from the 'File' drop down menu.

Lambda / Fuelling

Information relating to fuelling is grouped in this panel.
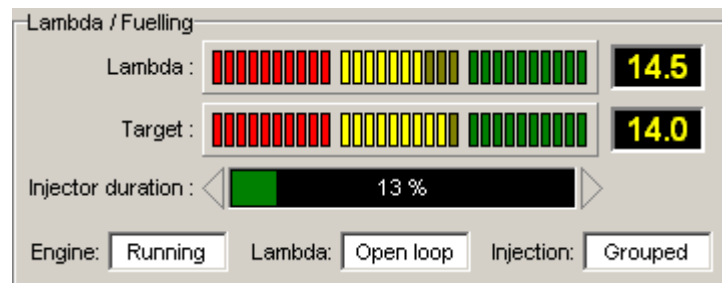
- o *Lambda*
  A graphical and numerical display of the lambda sensor AFR signal.

- o *Target*

- o A graphical and numerical display of the target AFR as determined by the **Target AFR** table.

- o *Injector duration*
  The injection duration bar shows you how hard the injectors are being worked. The ECU calculates the percentage of the available time the injectors are on for (duration %) and this is displayed in the duration bar. At the extremes of injector duration i.e. very short or long opening pulse, the duration bar changes colour as a warning. Below 10% duration, the bar will turn yellow. Above 85% duration the bar will turn red and at, or above, 100% the triangular led to the right of the bar will flash red/yellow.

- o *Engine*
  This status box displays the current engine running mode. The modes displayed are *stopped, cranking, idling, running, over boost, overrun, Rev Limit and Over boost*.

- o *Lambda*
  This box displays the current status of the ECU's lambda control function. The status indicates the following lambda control modes: *Warm up…, Open loop, Closed loop, Adaptive and Error.*

- o *Injection*
  The injection status indicates the following injection control modes: *Grouped, Sequential and Double INJ.*

Connecting a lambda sensor

What is a lambda sensor?

A lambda sensor, also known as an oxygen or O_2 sensor, is an electronic device that measures the residual oxygen in the exhaust gas. The lambda sensor outputs a signal proportional to the air-fuel ratio. This signal can be used by the ECU for data-logging, display or closed-loop-controlled fuelling purposes.

Lambda sensors fall into two main groups, narrow-band and wide-band.

A narrow-band sensor can only accurately determine if the mixture is at lambda 1, richer than lambda 1 or leaner than lambda 1. This information is fine for most engine management systems that only need to regulate the fuelling at lambda 1 in order for a catalytic converter to work efficiently.

A wideband sensor can provide precise air-fuel mixture information from very rich to very lean. This information is far more useful for tuning and allows the Emerald K3 to run a closed-loop fuelling system that targets any air-fuel ratio that can vary with engine speed and load.

Lambda sensor input illustration

There are a number of options/settings that determine where the ECU looks for a lambda signal and how that signal is translated into a meaningful AFR reading.
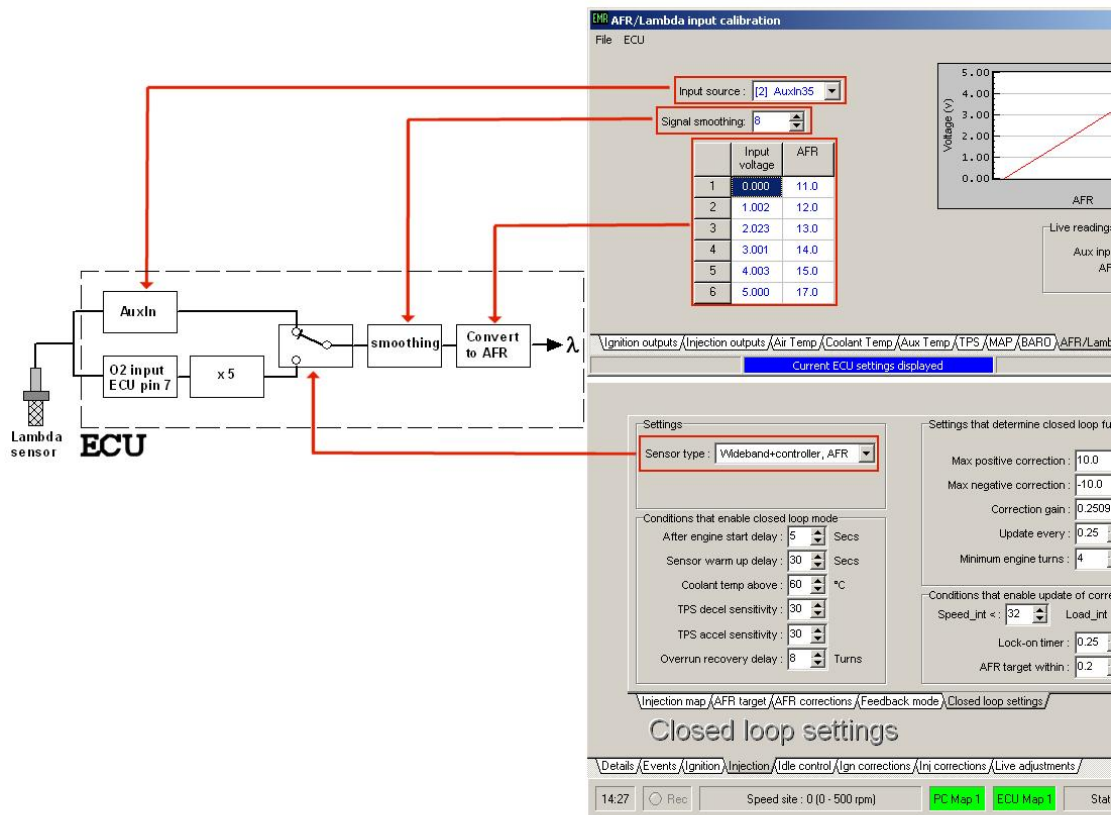
The *Input source* configuration setting and *Sensor type* map settings determine where the ECU will look for a lambda sensor signal.

The lambda sensor signal is smoothed (averaged) over time and the level of smoothing is set by *Signal smoothing* value. If *Signal smoothing* is set too high the signal response will be slow. If set too low the lambda signal may appear noisy and can affect the closed loop fuelling stability.

Narrow band lambda sensors

These sensors can be found in most cars manufactured since the mid 1980's. The most common type, the Zirconia sensor, can be a 1, 2, 3 or 4 wire device depending on the signal ground & heater configuration. Of these sensors the 4-wire is the preferred narrow band sensor type as it has a heater and also a separate signal earth return. The wiring convention for a typical Bosch 4-wire sensor is…

Bosch sensor Wire colour	Function	Note
White	Heater, +12v supply	Heater wires are not polarity sensitive
White	Heater, earth	
Black	Output signal	To ECU pin 7
Grey	Signal earth return	To ECU pin 18

Narrow band lambda sensors can be thought of as switches whose output changes suddenly as the air-fuel ratio crosses the stoichiometric point. This point is known as lambda 1 and for normal petrol this equates to an AFR of ~14.7:1. Narrow band sensors do not provide accurate information either side of lambda 1 as the output is affected by exhaust gas temperature. For this reason narrow band sensors should really only be used for simple diagnostics and closed loop control at lambda 1.

Using a narrow band lambda sensor

The Emerald K3 ECU has a dedicated narrow band lambda sensor input. This input, main connector pin 7, is only used to read the 0-1v signal from a Zirconia type narrow band sensor.

It is possible to connect a narrow band sensor to any spare analogue input but the ECU must be configured to read the lambda/AFR signal from this specific input.

If a narrow band sensor is wired to the dedicated input ECU pin 7 the *Sensor type* setting in the main map should be set to 'Simple O2 sensor'. When set this way the ECU will read the signal from pin 7, rescale it to 0-5v by multiplying by 5 and then convert to AFR using the voltage-AFR conversion table. The voltage-AFR conversion table is part of the ECU configuration and can be accessed via the menu 'ECU configuration | AFR Lambda input'.

Note: when set to 'Simple O2 sensor' the ECU will only look at pin 7 to read the lambda signal, the *Input source* setting in the AFR/Lambda input configuration screen is ignored. Also, if a narrow band sensor is connected to another spare analogue input (e.g. AuxIn10) then you must set the *Sensor type* to 'Wideband+controller, AFR' and configure the voltage-AFR conversion table to suit the 0-1v input range.

Example AFR/Lambda input table for a narrow-band lambda sensor
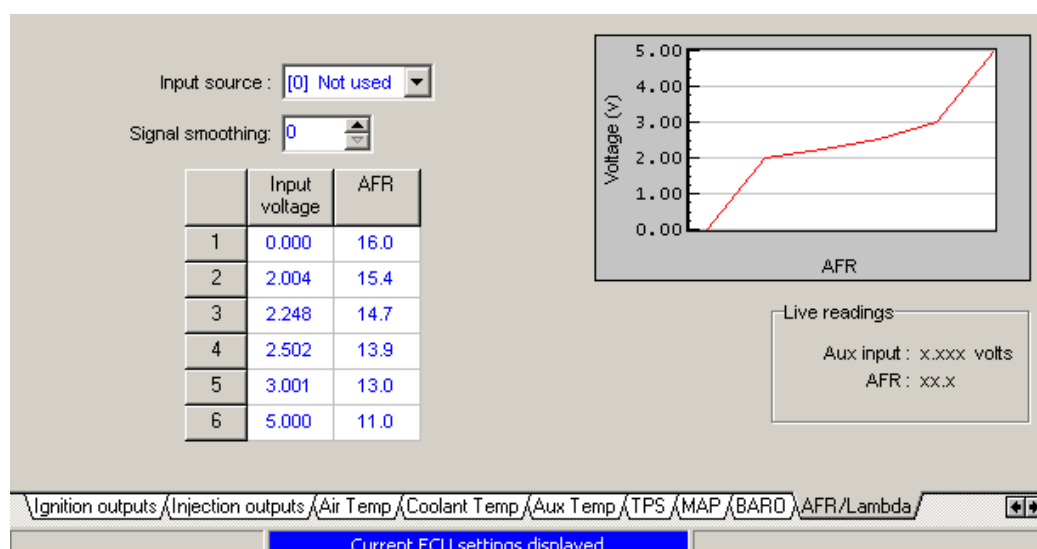
Note: The input voltage column is the actual narrow band signal voltage multiplied by 5.

Wideband lambda sensors

These sensors are more complex than conventional narrow band sensors. They can be used to provide accurate Air-Fuel Ratio information over a wide range of mixtures, typically lambda 0.7 to >1.5 (10.3:1 to >22:1 AFR). The most common type of wideband sensor is the Bosch LSU 4.x. These sensors are 5-wire devices and cannot be wired directly to the Emerald K3 ECU - a dedicated controller is required.

The wideband controller interfaces with the sensor and provides mixture information via an analogue 0-5v or a digital data link.

Using a wideband lambda sensor

Although the K3 cannot directly control a wideband lambda sensor it can read a 0-5v analogue signal that relates to AFR/lambda. Many wideband lambda sensor controllers produce a 0-5v signal for use with ECU's or data-loggers.

This AFR data can be recorded in the Emerald data-logger, displayed in the live adjustments screen and used by the ECU for closed loop and/or adaptive fuelling functions.

The 0-5v signal is converted to meaningful AFR value by a user adjustable look-up table in the ECU configuration. This table must be set to match the AFR/voltage of your lambda signal conditioning unit. The *Sensor type* setting in the map must also be set to 'Wideband+controller, AFR'.

Note: If the *Sensor type* is set to 'Simple O2 sensor' the ECU will only read the signal from the dedicated narrow band sensor input, pin 7, regardless of the ECU configuration settings.

Emerald K3 to Innovate LC-1 connection example

An Innovate LC-1 is used in this example but the principles can be applied to many other wideband lambda controllers.

The Innovate LC-1 manual should be read carefully before installation.
It is absolutely essential that the correct sensor calibration routine is followed - this is detailed in the Innovate manual.

<u>Wiring</u>

LC-1	Function	Wire to..
Red	+12v supply	Ignition controlled +12v
Blue	Heater ground	Good chassis ground or battery (-) terminal
White	System ground	**Join** with Green wire to ECU pin 30
Yellow	Analogue out 1 (narrow band lambda signal)	ECU connection not required
Brown	Analogue out 2 (AFR signal)	Any spare analogue ECU input via an inline resistor. (see **note 2**). AuxIn35 (ECU pin 35) is used in this example.
Green	Analogue ground	**Join** with White wire to ECU pin 30
Black	Calibration wire	Calibration button
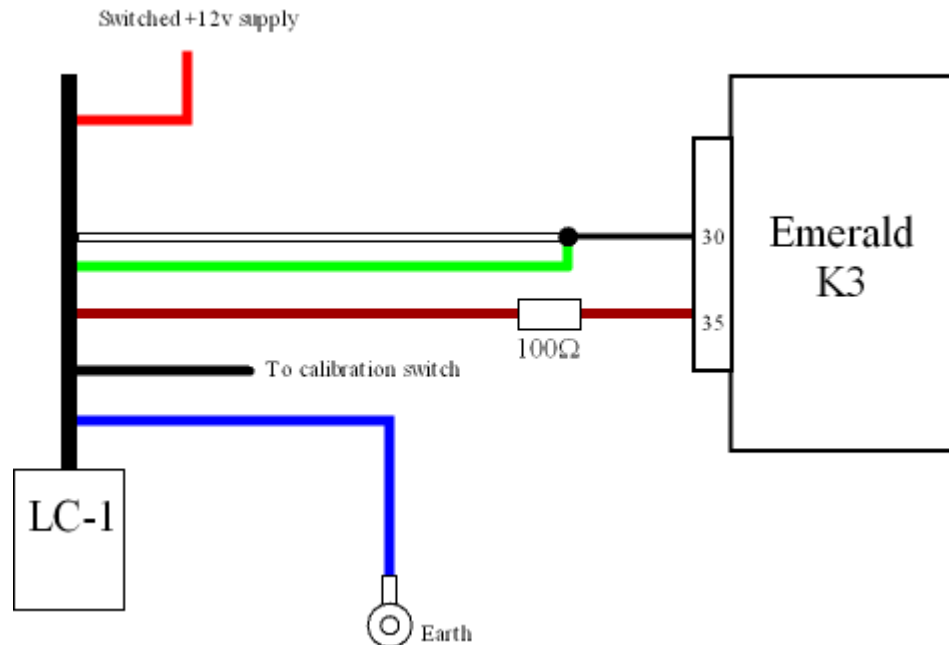
Note :

Wide band AFR signal. A 100Ω resistor* should be fitted inline between the brown analogue out 2 wire and the ECU analogue input pin (AuxIn35, pin 35 in this example).

*The LC-1 outputs are quite sensitive and can become unstable if connected to a capacitive load. The inline resistor buffers the LC-1 from the ECU input signal filters.

LC-1 configuration

The LC-1 output configuration should match the Emerald K3 input configuration.

We recommend narrowing the AFR range so the 0-5v signal spans a more useful 11.0:1 to 16.0:1. Doing this will mean any noise or voltage offset errors have less of an impact on the AFR readings.
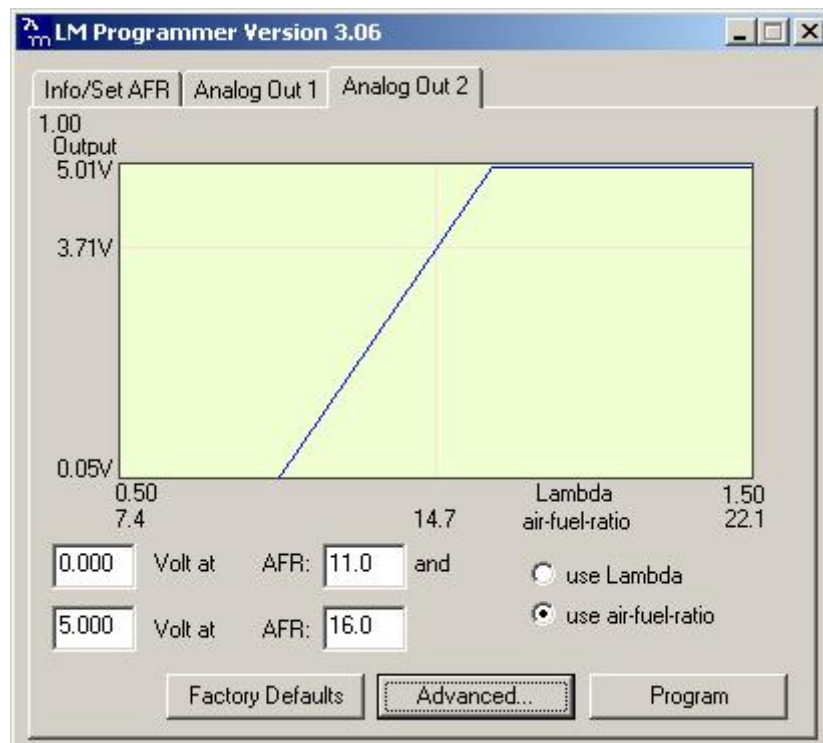
If the AFR signal appears to be noisy you may find setting the LC-1's output response speed to '1/3 sec' helps…
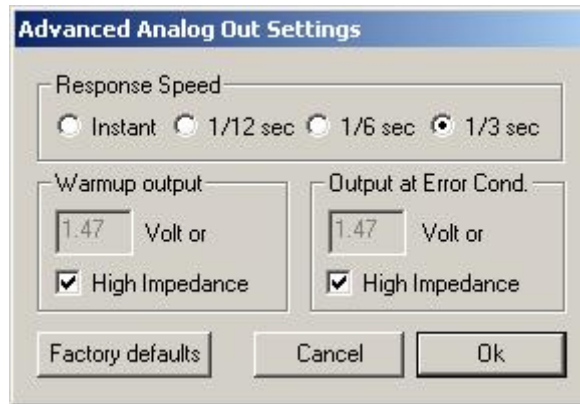
K3 AFR/Lambda input calibration

Any spare analogue input on the ECU can be used to read the LC-1 analogue AFR signal. AuxIn35 is often spare and is used for this example.

Note: *AuxIn7b, AuxIn8b and AuxIn9b inputs have built in pull-up resistors which make them unsuitable for connection to the 0-5v analogue signal from a wideband controller. Instead use AuxIn10, AuxIn34 , AuxIn35 or AuxIn36 but make sure the pull-up options for AuxIn10 or AuxIn35 are disabled.*

To convert from a voltage to an AFR value, a look up table is used. This table is accessed via the 'AFR/Lambda input' page of the 'ECU configuration'. Select the input source to suit the analogue input you wish to use and set the table to match the LC-1 output as shown below. The 'live readings' box will show the current voltage and AFR conversion readings, but note that the AFR readings will not be correct until the ECU has been updated with the new table settings.

Use the +/- keys to adjust the table values. You can highlight more than one cell and adjust them together. Hold shift while pressing the +/- keys to adjust in bigger steps.

AuxIn10 and AuxIn35 analogue inputs have switchable internal pull-up resistors. As we have used AuxIn35 in this example you must ensure that the pull-up resistor is switched off otherwise the analogue AFR signal will be distorted.

From the 'inputs' page of the 'ECU configuration' screen ensure that the pull-up for the used input is switched off.
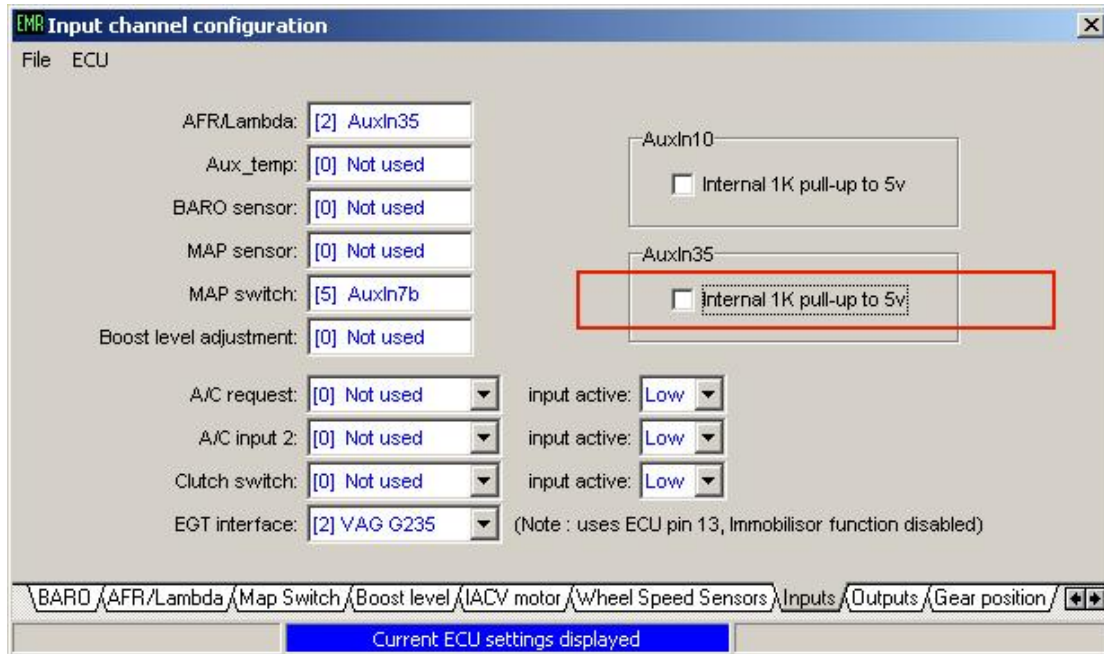
The 'inputs' screen confirms that the AFR/Lambda input has been set to AuxIn35 and that the AuxIn35 internal pull-up is switched off.

Update the ECU with these new settings by clicking 'Update ECU configuration' from the 'ECU' drop down menu.

The AFR information will now be displayed in the 'Live adjustments' screen as an LED bar display and in numerical form to the right of this.

The data-logger channel can also be set to record this AFR data by selecting 'AFR/Lambda' in the data-logger options screen.

Lambda - open loop/closed-loop/adaptive

Once the ECU has been wired and configured to read from a lambda sensor the information read can be used in a number of ways.

If set to open-loop control the lambda signal is only used for display and/or data-logging purposes.

Lambda display

The *Live adjustments* screen will show the lambda signal in the form of a 30 red/yellow/green LED style bar graph display as well as the numerical value.

This display can be very useful when mapping, it gives you a very quick indication of the exhaust mixture.

Live lambda reading

Lambda feedback mode

Target lambda reading
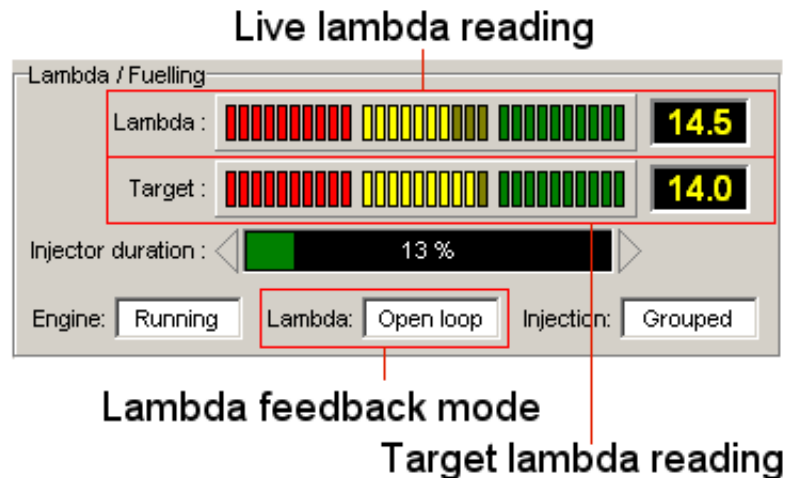
Live lambda reading

The centre point of the Lambda bar graph display represents an AFR of 14.7:1 (lambda 1), the far left an AFR of 16:1 (lambda 1.09) and the far right an AFR of 11:1 (lambda 0.75). The actual AFR value is also shown to the right of the lambda bar graph display.

Note: the *Lambda* display may not show an accurate reading until the sensor is up to full operating temperature. There are delay timer settings in the map are to allow for sensor warming.

Information relevant to the lambda display is also close by. The current *Target* AFR, as determined by the *Target AFR* map is displayed just below and the *Injector duration* bar shows you how hard the injectors are being worked. Refer to the *Live adjustments* section of the manual for more information.

Lambda feedback mode

The *Lambda* feedback mode will display the current status as reported by the ECU. Lambda feed back modes -

- Warm up…
- Open loop
- Closed loop
- Adaptive

Warm up…

Lambda sensors need to operate at a minimum temperature. Until they are up to working temperature the lambda sensors output cannot be relied upon to be accurate. The *After engine start delay* and *Sensor warm up delay* settings in the map are timers that delay any pending switch to closed loop or adaptive modes. While these timers are active the lambda feedback mode will display 'Warm up…'.

Open loop

Once the engine is running and the warm up timers have elapsed the feedback mode will switch to 'Open loop'. In open loop mode the lambda signal is just monitored and has no affect on the injection system or ECU operation.

Closed loop

When certain conditions are met the ECU can switch to 'Closed loop' mode. When in this mode the ECU will trim the fuelling in an attempt to attain the target set by the *AFR target table*.

Adaptive

When certain conditions are met the ECU can switch to the 'Adaptive' mode. This mode works in the same way as the close loop mode but corrections to the fuelling can be stored in the AFR corrections table.

Map settings

Settings relevant to the lambda closed loop and adaptive feedback modes are grouped together in the 'Injection' page of the main screen.

AFR target

TPS%	RPM	1,000	1,500	2,000	2,500	3,000	3,500	4,000	4,500	5,000
0	0	14.7	14.7	14.7	14.7	14.7	14.6	14.5	14.4	14.3
3	1	14.7	14.7	14.7	14.7	14.7	14.6	14.5	14.4	14.3
6	2	14.6	14.6	14.6	14.6	14.6	14.5	14.5	14.4	14.3
12	3	14.5	14.5	14.5	14.5	14.5	14.4	14.4	14.3	14.2
19	4	14.4	14.4	14.4	14.4	14.4	14.3	14.2	14.2	14.1
25	5	14.3	14.3	14.3	14.3	14.3	14.2	14.2	14.1	14.0
31	6	14.2	14.2	14.2	14.2	14.2	14.1	14.1	14.0	13.9
38	7	14.1	14.1	14.1	14.1	14.1	14.0	13.9	13.9	13.8
44	8	14.0	14.0	14.0	14.0	14.0	13.9	13.8	13.8	13.7
50	9	13.8	13.8	13.8	13.8	13.8	13.8	13.8	13.7	13.7
57	10	13.7	13.7	13.7	13.7	13.7	13.7	13.6	13.6	13.6

\Injection map \AFR target \AFR corrections \Feedback mode \Closed loop settings /

AFR target

Rich (11.0:1)
Lean, (16.0:1)

The *AFR target* table has the same speed / load configuration as the main injection table. Each cell in this table is the target AFR for the corresponding cell for the main injection table.

The cells are colour coded to help visualise the target AFR settings. A white cell represents lambda 1 (14.7:1). Cells are shaded from white to red for AFR settings of 14.7:1 to 11:1 in the rich area. Cells are shaded from white to blue for AFR settings of 14.7:1 to 16:1.

The ECU determines the target AFR by reading this table. This target is used by the ECU in closed loop and adaptive feedback modes. The target AFR information is displayed on the *Live adjustments* screen regardless of the feedback mode and can be a helpful mapping aid even if the closed loop or adaptive modes are not used.

Control mode

Additional controls

- Plus (+) key   -   cycle cell contents, *open loop→closed loop→adaptive*
- Minus (-) key   -   cycle cell contents, *open loop←closed loop←adaptive*

The *Control mode* table has the same speed/load configuration as the main injection table. The feedback mode of each individual cell can be set to open loop, closed loop or adaptive.

When set to closed loop or adaptive modes the ECU evaluates the closed loop settings before the feedback mode is changed. **If the feedback mode does not change as expected you will find that one or more of the conditions on the *closed loop settings* has not been met.**

AFR corrections

Additional controls

- Right-mouse-click   -   Apply corrections option

The *AFR corrections* table has the same speed/load configuration as the main injection table. Each cell in this table is a percentage correction that the ECU will apply to the corresponding cell in the main injection table.

When determining the injection pulse width the ECU first looks to the main injection table. The ECU then looks to the *AFR corrections* table. The AFR correction value is then used to correct the main injection value, this result of this correction is then used to calculate the actual injection pulse width.

This AFR corrections table is always active. The value the ECU reads from the main injection table will always be corrected by the value read from the AFR corrections table regardless of the feedback mode.

The *AFR corrections* table is special in that the ECU is also allowed to make adjustments to these values. When the adaptive feedback mode is active the ECU will adjust the fuelling in an attempt to attain the target AFR. This adjustment trim is saved in the ECU's own AFR corrections table.

Note: The ECU only adjusts the AFR corrections table stored in the ECU. To view any adjustments the ECU may have made, you must read the map from the ECU. A PC connection is not required for the *adaptive* feedback mode to work.

Assuming the adaptive feedback mode is enabled, the ECU will adjust the AFR corrections table over time. After reading the map from the ECU you can view any changes made. You are able to adjust this table in any way. For example, you can set all the values in the table to zero then reprogram the map to the ECU in order to reset the adaptive process completely.

Apply corrections to injection map

At some stage you may wish to end your mapping process with a finalised injection table that is not being corrected by the AFR corrections table. Highlight the AFR correction cells (individual cell, area or complete table) that are to be applied. Right click gives you the option to *Apply selected corrections to injection map*. You are given the option to zero these selected corrections once the injection map has been adjusted. The ECU must be programmed with this new map before any changes take effect.

Closed loop settings

Settings

- *Sensor type*
  Used to inform the ECU of the sensor type connected.

  - *Simple O2 sensor*
    A narrow band lambda sensor. The ECU will only look to input pin 7 for the 0-1v narrow band lambda sensor signal.

  - *Wideband+controller, AFR*
    A wideband lambda sensor connected via a dedicated controller. The input the ECU looks to for this 0-5v signal is determined by the ECU configuration settings.

Conditions that enable closed loop mode

- *After engine start delay*
  How many seconds from engine start up the ECU waits before closed-loop control is allowed.

- *Sensor warm up delay*
  How many seconds from key-on the ECU waits before closed-loop control is allowed.

- *Coolant temp above*
  Coolant temperature above which the ECU will allow closed-loop.

- *TPS decel sensitivity*
  If the throttle close rate is higher than this value closed-loop operation is suspended. You can view the live accel/decel rate values from the *Accel fuelling* screen.

- *TPS accel sensitivity*
  If the throttle open rate is higher than this value closed-loop operation is suspended. You can view the live accel/decel rate values from the *Accel fuelling* screen.

- *Overrun recovery delay*
  Closed-loop operation is automatically suspended if the *over-run fuel cut-off function* is active. This engine turn count delay determines how long the ECU will wait after normal fuelling has been restored, before allowing closed-loop operation to resume.

Settings that determine closed loop fuelling

- *Max positive correction*
  The maximum injection correction the closed-loop function is allowed to increase the fuelling by.

- *Max negative correction*
  The maximum injection correction the closed-loop function is allowed to reduce the fuelling by.

- *Correction gain*
  This determines how much of the calculated fuelling change (according to target & actual AFR readings) is used to update the closed-loop fuelling trim. This is the error tracking speed. If it is set too high, the fuelling may continuously overshoot the target AFR.

- *Update every...*
  This sets how often the closed-loop function is refreshed by the ECU. Set this according to the lambda response time. If the ECU updates the fuelling faster than the lambda sensor signal response time, the closed-loop function may become unstable and can result in the fuelling continuously overshooting the AFR target.

- *Minimum engine turns*
  Ensures that a minimum number of engine turns occur before the closed-loop function is refreshed, regardless of the *Update every* setting. This setting allows the closed-loop function to operate quickly at higher engine speeds whilst allowing time for the lambda signal to stabilise at low engine speeds.

Conditions that enable update of corrections table

- *Speed_int*
  The level of interpolation between speed sites must be within this boundary before the ECU will record anything in the *AFR corrections* table. The ECU interpolates/calculates 255 positions between each speed site. A visual representation of the current interpolation position is the target board shown in the *Live Adjustments* screen.

- *Load_int*
  The level of interpolation between load sites must be within this boundary before the ECU will record anything in the *AFR corrections* table. The ECU interpolates/calculates 255 positions between each load site. A visual representation of the current interpolation position is the target board shown in the *Live Adjustments* screen.

- *Lock-on timer*
  Once within the *Speed_int and Load_int* boundaries the ECU will wait for this amount of time before recording a correction value in the *AFR corrections* table.

- *AFR target within...*
  Determines how close the actual lambda AFR signal is to the target AFR before changes are recorded in the *AFR corrections* table.
  Note that if you set the AFR target as in the above example (AFR target within 0.2 AFR) there will be no recording of the mapping changes until the mixture gets within the target area. For example if the mixture target AFR is 13.7 to 1 and your base map is way out at 15.7 to 1, there will be no recorded change until the mixture ramps up to at least 13.9. This may take some time so if you move off the target area before the mixture is close enough to record the trim then nothing will appear in the AFR corrections table for that speed and load site. The answer is to either spend more time on the speed and load site and give the mixture time to adjust or widen the target AFR for a much coarser adjustment.
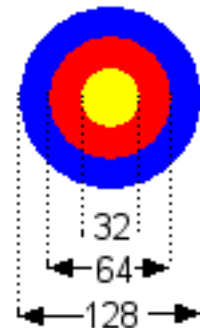
Map switching

- The ECU can store up to three completely separate maps.

- If set to do so the ECU will allow you to freely switch between maps on-the-fly.

- The mapping software also holds three maps in memory and will switch maps in sync with the ECU.

- The mapping software uses a new file format that allows three maps be to stored within the one file.

- A 0-5 volt signal via an analogue input can be used to instruct the ECU which map to use. A simple two position on-off switch can be used to provide a high-low signal that will enable you to switch between two maps. To switch between three maps a rotary multi-position switch or potentiometer can be used.
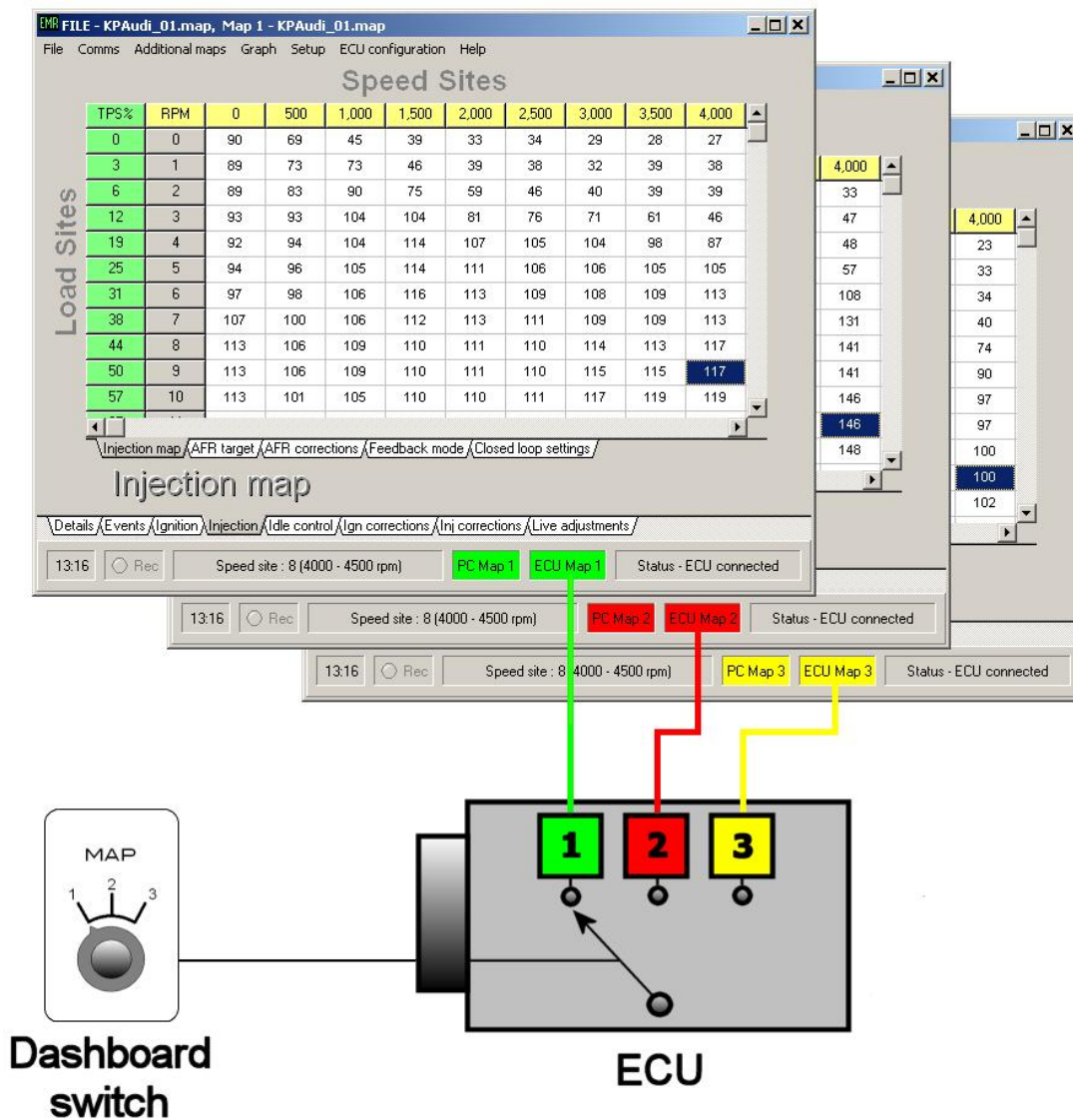
Map switching – software

The K3 ECU has the ability to retain three totally separate maps within the ECU. The laptop or PC also has three map screens available. For as long as the PC is communicating with the ECU it will automatically switch the maps displayed to stay in sync. If you want to work on a map that is not currently selected without using the ECU to switch maps you can power down the ECU (or unplug the communications lead) and select 'Switch to map' from the 'File' menu.
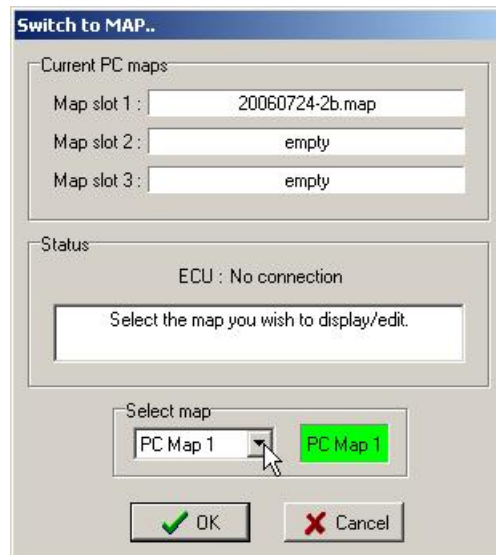
There is a short-cut to this map selection screen by clicking the PC map box at the bottom of the main screen.

Note: To prevent confusion the PC will not allow you to switch maps when linked to the ECU.

For example: if mapping on a rolling road you can alter the fuel and ignition settings on map 1 (green map) via the live mapping page (F8) and then, via a switch on the dash, switch to map 2 (red map). The PC will bring the red map to the front of the screen and you can alter fuel and ignition timing again via the live mapping screen exactly as before. Switch the ECU to map 3 (yellow map) and repeat the mapping process.

Map switching - configuration

There are various ways of setting up the ECU to read the switching signal. Below are two examples.

Example 1

The ECU is to switch between two maps according to a user activated switch. In this particular case AuxIn35 is unused so it is available as an input source for the map switching function. By enabling the internal pull-up resistor on the AuxIn35 input we can change maps using a simple switch to earth.
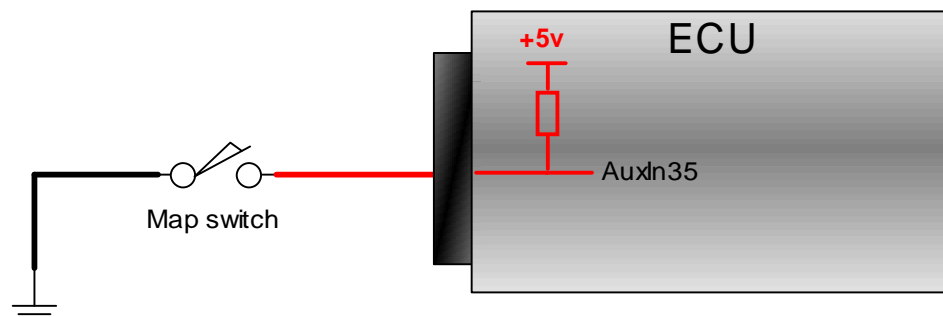
With the switch in the open position the internal pull-up resistor results in the ECU reading 5v at the AuxIn35 input. With the switch in the closed position the ECU will read 0v at the AuxIn35 input. The internal pull-up to +5v for AuxIn35 must be enabled in the 'Input channels' section of the 'ECU configuration' as shown below.
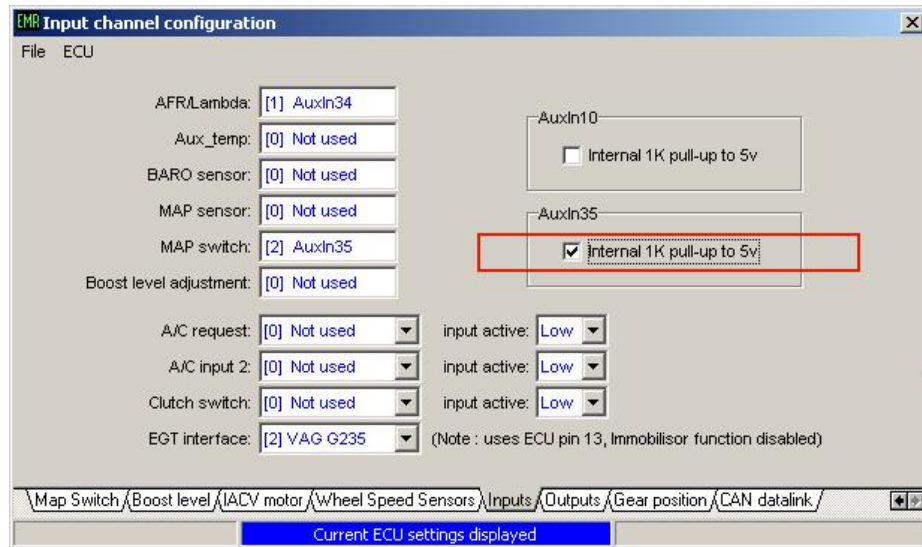
To configure the map switching function select 'Map switching' from the 'ECU configuration' menu. In this example we have two voltage levels, 0v and 5v, at AuxIn35 depending on the position of a switch.
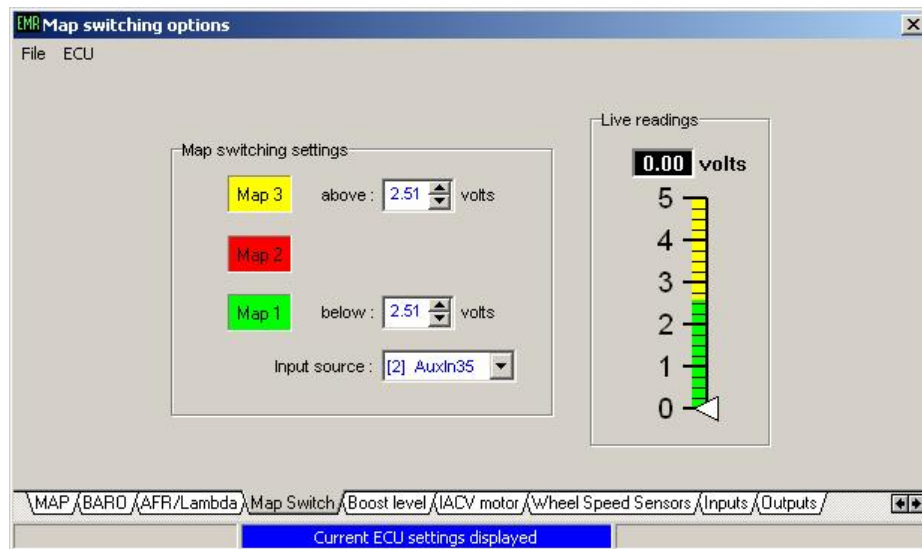
The input source has been set to AuxIn35. Two voltage levels are used to determine which map the ECU should be using. Map 1 is selected if the voltage is *below* a certain threshold and Map 3 is selected if the voltage is *above* a certain threshold. Map 2 is selected if the input voltage lies between the *above* and the *below* thresholds.

For this example the mid-point voltage of 2.51 volts is used as the above and below thresholds. Map 1 is selected if the voltage at AuxIn35 is below 2.51 volts (switch is in the closed position) and Map 3 is selected if the voltage at AuxIn35 is above 2.51 volts (switch is in the open position). Map 2 is not used and cannot be activated.

When the ECU is connected the live readings panel shows the real-time input voltage used for the map switching function. The bar graph has a vertical scale that presents 0 to 5 volts and is also colour coded to show the voltage to map selection relationship. The vertical colour coding of the bar graph is colour coded according to the map switching settings.

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Example 2

The ECU is to switch between the three maps according to a 3-way rotary position switch mounted on the dash board.

As with the previous example, using an analogue input that has an internal pull-up resistor simplifies the map switch wiring. Using such an input gives us two voltage levels with a switch to earth (open = 5 volts, closed = 0 volts). By switching this input to earth via a resistor we create a potential divider circuit which will result in a third voltage level of between 0 volts and 5 volts (depending on the value of the resistor used). As the ECU uses 1KΩ internal pull-up resistors we can switch the input to earth via another 1KΩ resistor to give a mid-point voltage level of 2.5 volts.
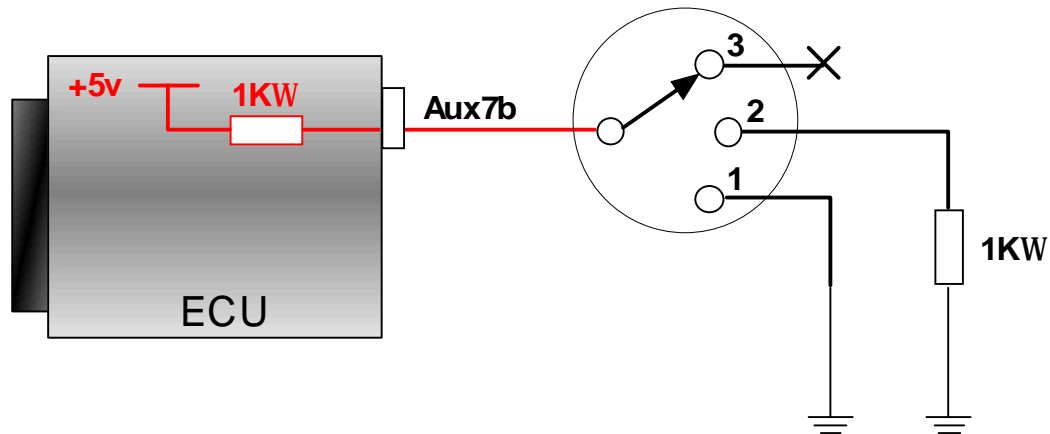
In this example Aux7b is free so will be assigned to the map switching function. Aux7b, Aux8b and Aux9b have fixed internal 1KΩ pull-up resistors.

With the rotary position switch at position 1 Aux7b is connected to earth which results in an input voltage of 0 volts. At position 2 Aux7b is connected to earth via a 1KΩ resistor resulting in 2.5 volts at Aux7b. At position 3 Aux7b is unconnected so will be at 5 volts due to the internal pull-up resistor.

The ECU configuration for this example is shown below.
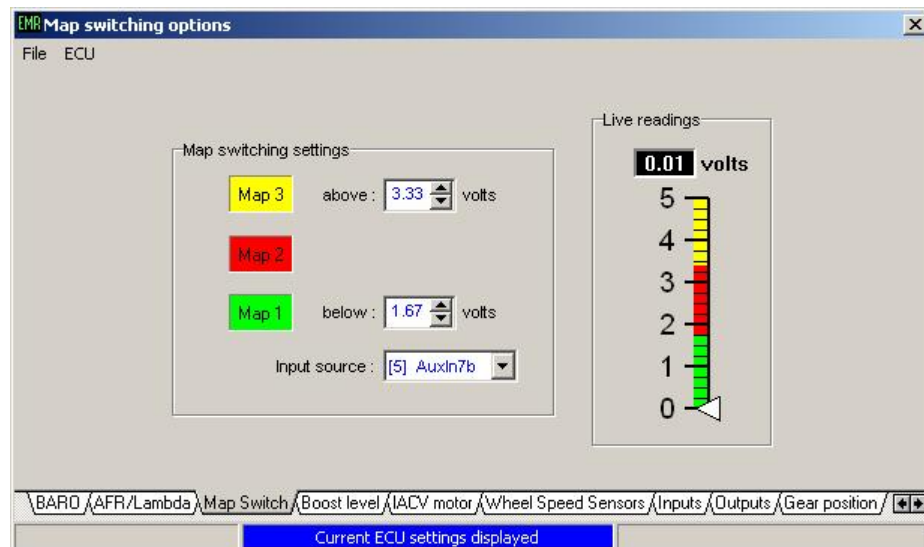
Here the map switch thresholds have been set so that the boundaries are spaced evenly to give more than enough room for error.

The map switching function monitors the input voltage approximately 5 times per second. Before changing maps the ECU will re-evaluate the new map according to the current running conditions to ensure the change is seamless. This process takes approximately 1- 2mS.

The ECU will switch maps on-the-fly regardless of engine rpm or load.

Full throttle gear shift (Flat shift)

This function is used to interrupt/reduce engine power so that a fast gear change can be made without lifting the throttle. Engine power is reduced by retarding the ignition to a set position. This ignition timing can be negative (After TDC). If turbo-charged, this retarded ignition timing during a gear change can provide a form of anti-lag.

The flat shift function will be activated if certain user adjustable conditions are met and a user assigned input is activated.

This flat shift function can be configured according to the gear box type used.

- Sequential gearbox.
  The user assigned input can be wired to a gear lever movement switch or clutch switch. The flat shift function can be configured to interrupt power for a specific amount of time according to the gear selected.

- H-pattern gearbox.
  The user assigned input can be wired to a clutch position or pressure switch. The flat shift function can be configured to interrupt power for as long as the input is activated, i.e. until the clutch pedal is released.

Select 'full throttle gear shift' from the 'Additional maps' menu to access the settings page for this function. The settings are grouped into 3 areas on the screen: *Activation conditions*, *Engine control settings* and *Power cut table*.

Activation conditions

The activation conditions determine how and when the gear shift function can be activated.

- Flat shift enabled: Sets whether this function is enabled or not.

- Clutch input: Shows the current clutch switch status .

- Throtte position at or above: Throttle position must be above this before the
                                         flat shift function will activate.

- Engine speed at or above: The flat shift function will only activate above
                                         this rpm.

- Re-activate delay: How long the ECU will wait before allowing
                                         this function to activate again.

Engine control settings

This engine control settings determine how the engine power is cut and how low the engine rpm is allowed to drop.

- Retard ignition to: Sets the fixed ignition timing during the gear
                                         change. You can retard as far as -30 °BTDC (30 °ATDC).
- Power cut type: *Continuous* for a power cut for as long as the
                                         input switch is activate or *Timed* for a timed cut according to the
                                         gear table.
- Minimum engine speed: When activated this function will not allow the
                                         engine rpm to fall below this setting.

Power cut table

This table is only used when the power cut type is set to 'timed'. A timed power cut is usually only used if you have a sequential gear box.

Selected Gear	Cut time (Secs)
1	0.13
2	0.12
3	0.10
4	0.09
5	0.08
6	0.07
7	0.00
8	0.00

Set the cut-time according to the selected gear. If the cut-time is set to zero, the function will not activate. Use the +/- keys to adjust the table values. You can highlight more than one cell and adjust them together.

Clutch switch wiring example
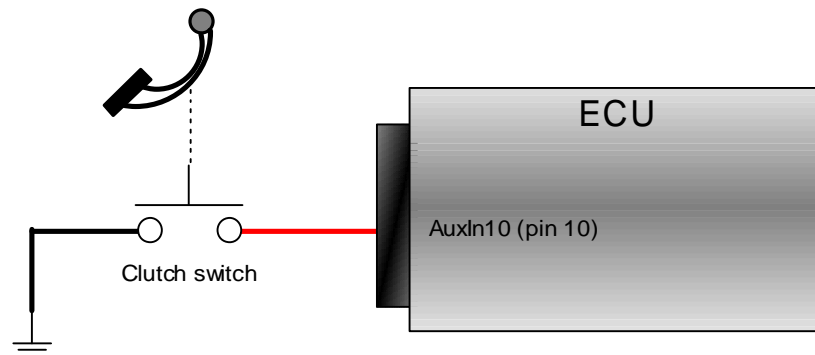
Any spare analogue input can be used to activate the full throttle gear shift function. This example uses ECU pin 10 (AuxIn10), with the internal pull-up enabled, wired to a switch on the clutch pedal.

When the clutch pedal is up (not pressed) the clutch switch contacts are open. The internal pull-up resistor sets the input level 'high'. When the clutch pedal is down the switch contacts are closed, the AuxIn10 input is connected to earth which sets the input 'low'.

In this example the clutch input is active low, i.e. the signal at AuxIn10 is low when the clutch is pressed. The ECU should be configured to read AuxIn10 as the clutch signal and also set to recognise that the clutch is down/pressed when the signal level is low.

Select 'Input channels' from the 'ECU configuration' menu. As shown below, the clutch switch channel has been set to **AuxIn10**, the input active has been set to **Low** and the **internal 1K pull-up to 5v** has been enabled. ECU inputs AuxIn10 and AuxIn35 have switchable internal pull-up resistors. If another input connection were to be used instead, e.g. AuxIn34 or AuxIn36, an external pull-up resistor would need to be fitted. The AuxIn7b, AuxIn8b and AuxIn9b inputs have internal pull-ups.
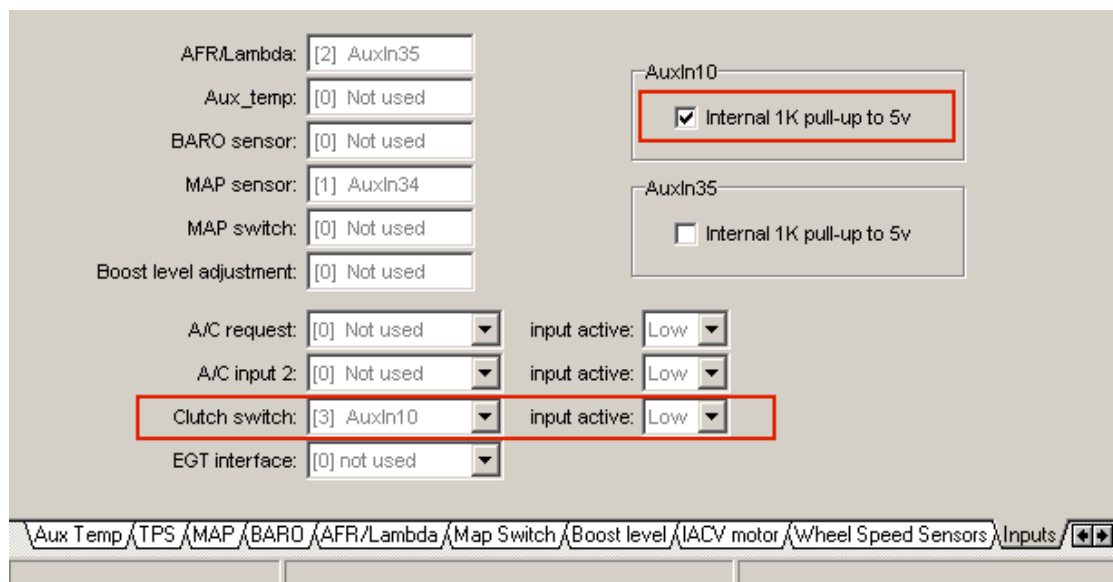
example clutch switch configuration settings

Gear position

The ECU is able to calculate the selected gear by using engine rpm, road speed and a gear position look-up table. Select 'Gear position' from the 'ECU configuration' menu to access the gear position calculation settings…
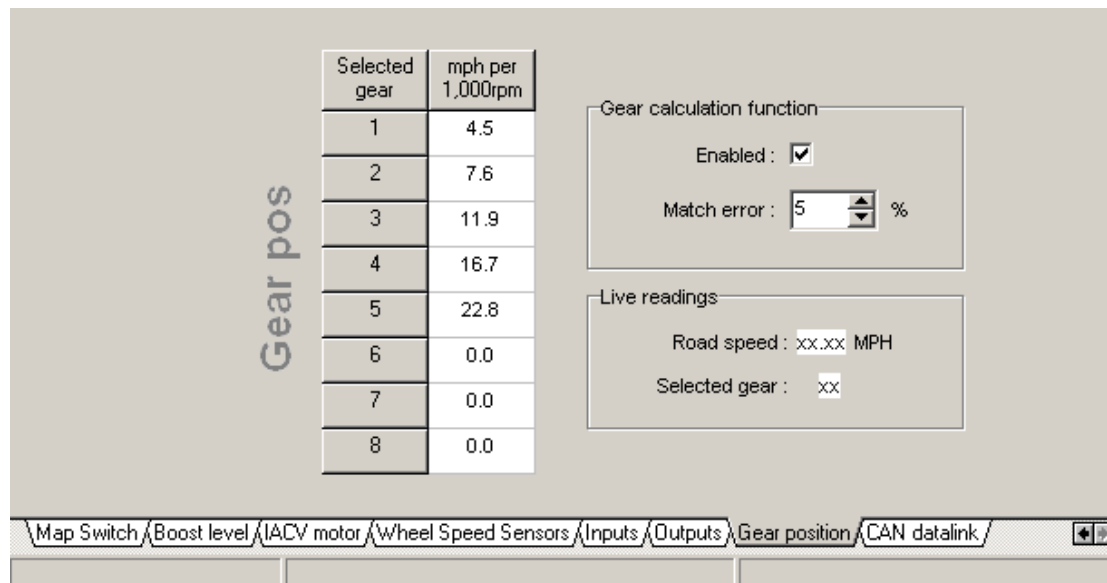
Gear calculation function

- Enabled: Sets whether this function is enabled or not.
- Match error: Sets how close the ECU's calculations must be to the figures set in the gear pos table.

Gear pos table

For each of the forward gears set the speed (mph/kmh) per 1,000rpm in the table.

The easiest method to determine these values is to set the PC data logger to record engine rpm and road speed. Drive for a short amount of time in each gear and then use the data logger trace to determine the table settings.

For example in 3rd gear, at a road speed of 38.0mph, with an engine speed of 3,193rpm :-

Mph per 1,000rpm = $\dfrac{38.0}{3193}$ x 1000 = **11.9**

Use the +/- keys to adjust the table values. You can highlight more than one cell and adjust them together.

Note: Gear position calculations are suspended while the clutch switch input is active (clutch = down). If a clutch switch is not fitted ensure that this input is disabled.

Road speed measurement

The ECU has 4 wheel speed (frequency measurement) input channels via Aux port B. These input channels can be wired directly to inductive wheel speed sensors or a digital speed signal. For speed measurement only one wheel speed signal is needed. If this measurement is used to calculate the selected gear the signal must be from a driven wheel. Select 'Wheel Speed Sensors' from the 'ECU configuration' menu to access the wheel speed sensor settings.
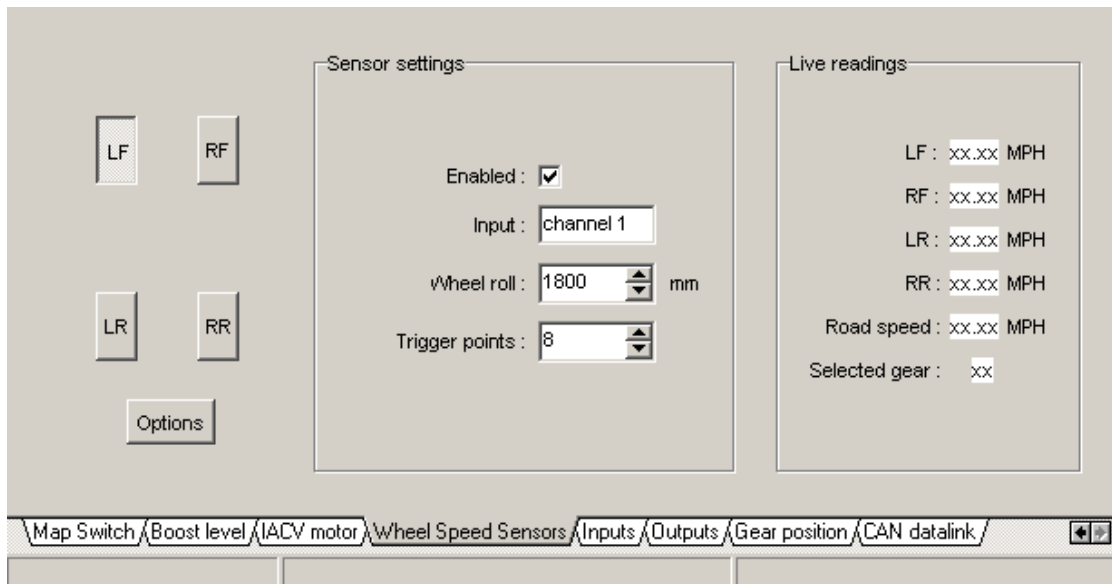
The four wheel speed input channels are identified as follows

Input	Label	Aux Port B pin number
Channel 1	LF (**L**eft **F**ront)	2
Channel 2	RF (**R**ight **F**ront)	3
Channel 3	LR (**L**eft **R**ear)	4
Channel 4	RR (**R**ight **R**ear)	5

LF, RF, LR, RR sensor settings

Each channel is enabled and configured independently from the other channels. This flexibility allows differing wheel sizes and/or sensor set ups on each of the four wheels. Click the label button (LF, RF, LR, RR) to access the settings for that input channel.
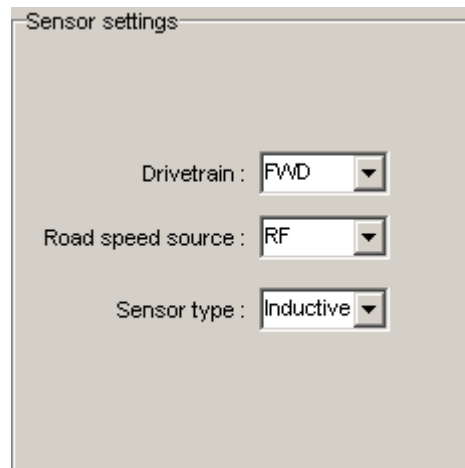
Each channel has the following settings:

- Enabled: Tick the enable box if this channel is used.

- Wheel roll: Distance travelled for one rotation of the wheel.

- Trigger points: Number of pulses per wheel rotation

The trigger points setting can be determined by counting the number of teeth/points that will pass the wheel speed sensor in one revolution of the wheel.

A quick/simple method to determine the wheel roll setting is to put a chalk mark at the bottom of the tyre (at the 6 o'clock position) and mark the ground at the same point. Roll the car forwards so the wheel rotates once and mark the ground in line with the tyre mark. The distance between the two ground chalk marks, in mm, is the 'wheel roll'. A rolling road can be used to compare actual and measured road speeds - adjust the wheel roll value if necessary.

Options

- Drivetrain: This setting is not currently used.
- Road speed source: Set to the channel you wish to measure road speed from
- Sensor type: Global setting for wheel speed sensors, inductive or digital. Open collector digital sensors will require a pull-up resistor.

Exhaust Gas Temperature

The Emerald K3 is able to read EGT via an external signal conditioning unit. To ensure the best accuracy the exhaust gas temperature reading is transmitted digitally between the signal conditioning unit and the ECU.

The VAG G235 exhaust gas temperature interface combines a thermocouple probe suitable for pre-turbo gas temperature measurements, along with a combined amplifier and serial data output. The serial data output line from the G235 should be wired to ECU pin 13.
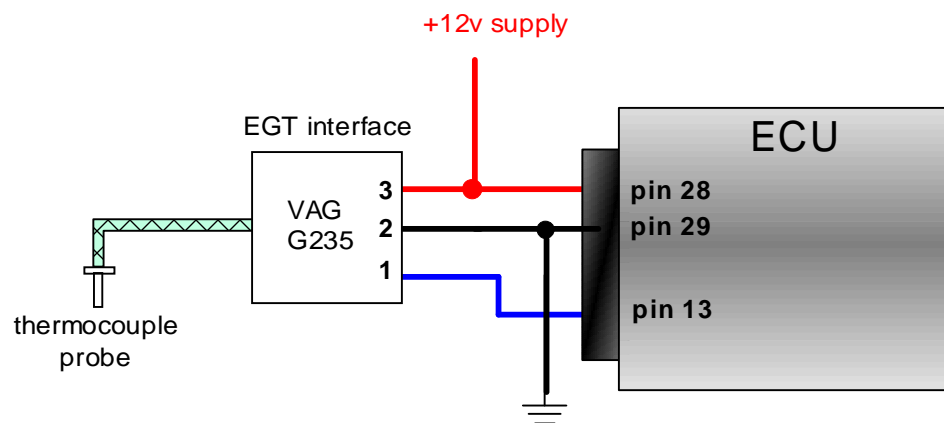
VAG G235 to Emerald K3 connection diagram

Wire side of G235 loom connector
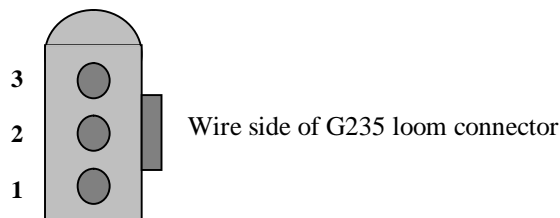
To set the ECU to read the G235 exhaust gas temperature serial data the 'EGT interface' setting in the 'Input channels' section of the ECU configuration should be to '[2] VAG G235' as shown below…
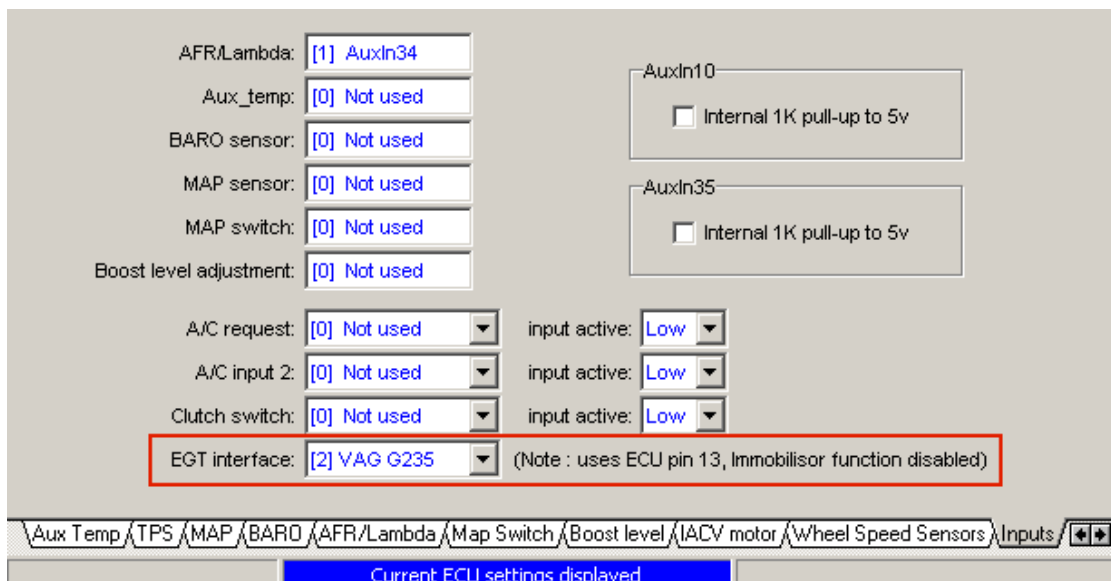
Once configured to read EGT from the G235 this EGT measurement can be displayed on the 'live adjustments' screen. This EGT reading can also be recorded, along with other readings, into the data-logger.

EGT:	843 °C
Ign Corr:	-0.5 °Adv
Lambda O2:	0.73 volts
Inj PW:	4.85 mS

The EGT can be used, in conjunction with the feedback table, to adjust the fuelling and/or boost pressure.

EMR Exhaust Gas Temperature feedback

EGT (°C)	Injection enrichment (%)	Boost level allowed (%)
750	0	100.0
800	0	100.0
850	0	100.0
900	10	91.0
950	20	82.0
1000	30	50.2
1050	30	0.0
1100	30	0.0

An external signal conditioning unit is required for the ECU to measure EGT.
The ECU must be configured correctly to read the digital EGT information.

Option
Enable feedback input ☑

Live Adjustments screen
Warning temperature : 900 °C

\Accel Fuelling /AirCon /BatteryV Comp /Boost Control /Coil on-time /Cyl trims /Double injector /EGT feedback /

Use the +/- keys to adjust the table values. You can highlight more than one cell and adjust them together.

CAN data-link

The K3 ECU can be configured to set transmit data to external devices, such as dashboards, using its **C**ontroller **A**rea **N**etwork interface.

The CAN was originally developed by Bosch Gmbh as a robust serial communications protocol to pass information between controllers on an automotive network. Communication speeds can be up to 1 Mbit/s between multiple devices sharing the same 2-wire CAN bus.

The CAN bus wiring should be a twisted-pair cable and, if required, shielded. The CAN bus must be terminated at each end by a 120Ω resistor. The K3 ECU, with its internal 120Ω termination resistor, provides one end of the CAN bus. When connecting another device/s you must ensure that the CAN bus is correctly terminated with another 120Ω resistor. This termination resistor must be at the other end of the CAN bus. Some devices (e.g. the AIM MXL dash logger) also have an internal termination resistor so an external resistor is not required.

AIM dash logger connection
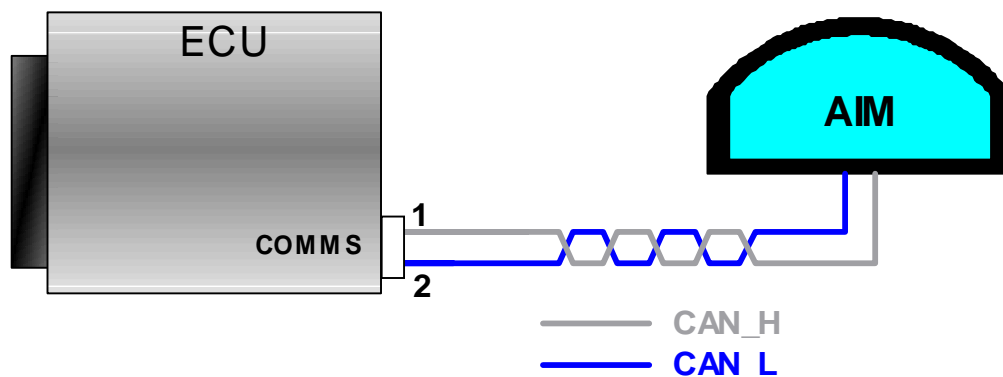
Refer to the 'Communications port' section of the manual for further details of the communications port.

K3 CAN configuration

Select 'CAN data-link' from the 'ECU configuration' menu.
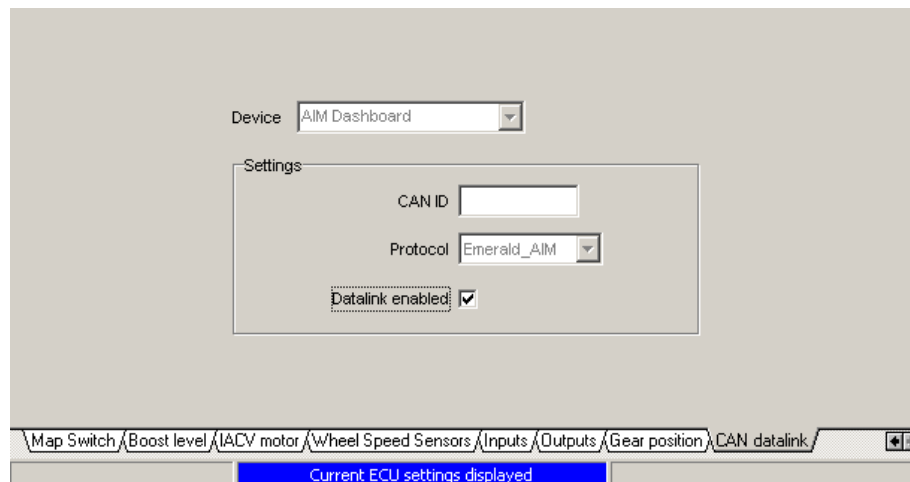
From the 'Device' drop down menu select 'AIM dashboard'. To enable this K3 to AIM data-link ensure the 'data-link' check box is ticked.

Before configuration changes can take effect the ECU must be updated. Select 'Update ECU configuration' from the 'ECU' menu.

AIM MXL configuration

Using the AIM Race Studio 2 software select 'System manager'.

Retrieve the current configuration from the AIM dash by clicking the 'Receive' button. Click the 'ECU manufacturer' entry for the current configuration and set to 'AIM'. Click the 'ECU model' entry for the current configuration and set to 'PROT_CAN'.

If you wish to change how/what data from the ECU is displayed on the AIM dash click the 'System configuration' tab and set accordingly. Once you are happy with your channel/display settings update the AIM dash by clicking the 'Transmit' button.

Refer to your AIM manual for detailed information.

Air conditioning

The Emerald K3 has a general purpose air conditioning control function that can be adapted to suit different systems.

The ECU is often part of an air conditioning system in order to simplify the wiring and to also provide intelligent activation of the compressor. ECU control can prevent over-speeding of the compressor by disengaging the drive above a set rpm. There are other settings to ensure the air conditioning compressor clutch is not engaged until the engine has been started, or to disengage the compressor if engine power demand exceeds a set level.

Air conditioning input / output configuration

There are a number of inputs and outputs that can be associated with the air conditioning function. The ECU configuration determines how the A/C system is connected to the ECU.

- **A/C request input**

   The switched signal that arrives at the ECU when the driver switches on the air conditioning

- **A/C trip switch input**

   A secondary input that can be used to increase the cooling level or shut off the compressor should a set pressure or temperature be exceeded.

- **A/C clutch output**

   This output will switch to ground in order to activate the compressor clutch via a relay.

- **Cooling fan 1 output**

   The engines main cooling fan control output (high speed). This is ordinarily only switched with engine temperature but the air conditioning function can override this control if necessary.

- **Cooling fan 2 output**

   The low speed and/or condenser fan control output. This output can be used to switch the condenser fan or, in conjunction with the *Cooling fan 1 output*, control a 2-stage cooling fan.

The A/C inputs channels are defined in the 'Inputs' section of the ECU configuration settings. The A/C output channels are defined in the 'Outputs' section of the ECU configuration settings.

Air conditioning control settings

Click 'Air conditioning control' from the 'Additional settings' menu. These settings determine how the ECU responds to inputs from the a/c system and also how/when it switches related outputs. These A/C control settings are part of the ECU's main map.
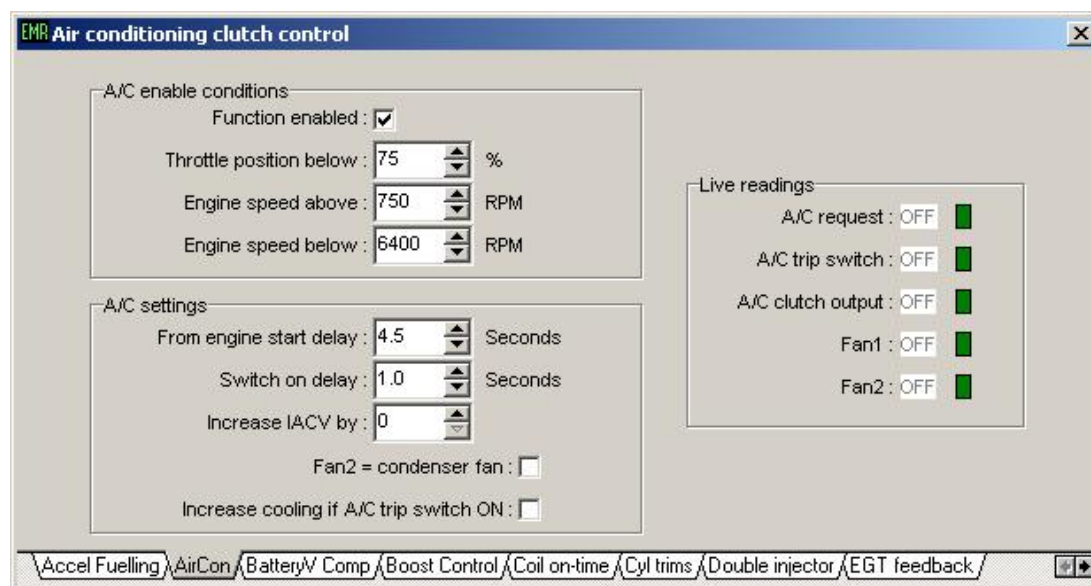
Note: The ECU has three maps - remember to adjust/update all used maps if A/C control is to remain the same regardless of map selection.

A/C enable conditions

- **Function enabled**
  A/C function on/off

- **Throttle position below**
  A/C only enabled below this throttle position

- **Engine speed above**
  Disable A/C if rpm drops below this threshold

- **Engine speed below**
  Disable A/C if rpm is above this threshold

A/C settings

- **From engine start delay**
  The amount of time, after the engine is started that the ECU delays before the A/C can be enabled. This can be used to allow the engine to start and settle at idle before the A/C system is switched on.

- **Switch on delay**
  Determines how long the ECU waits before responding to an A/C request signal.

- **Increase IACV by**
  The IACV position will be increased by this amount when the A/C clutch is switched.

- **Fan2 = condenser fan**
  Tick this setting if the ECU is controlling 2-stage fan/s where the first stage doubles as the condenser fan. Fan2 will switch with A/C as well as coolant temperature.

- **Increase cooling if A/C trip switch ON**

Air conditioning control example

This example is of a typical simple air-conditioning system with ECU control of the compressor clutch. The air conditioning system provides the ECU with an a/c request signal when the user switches on the air conditioning.
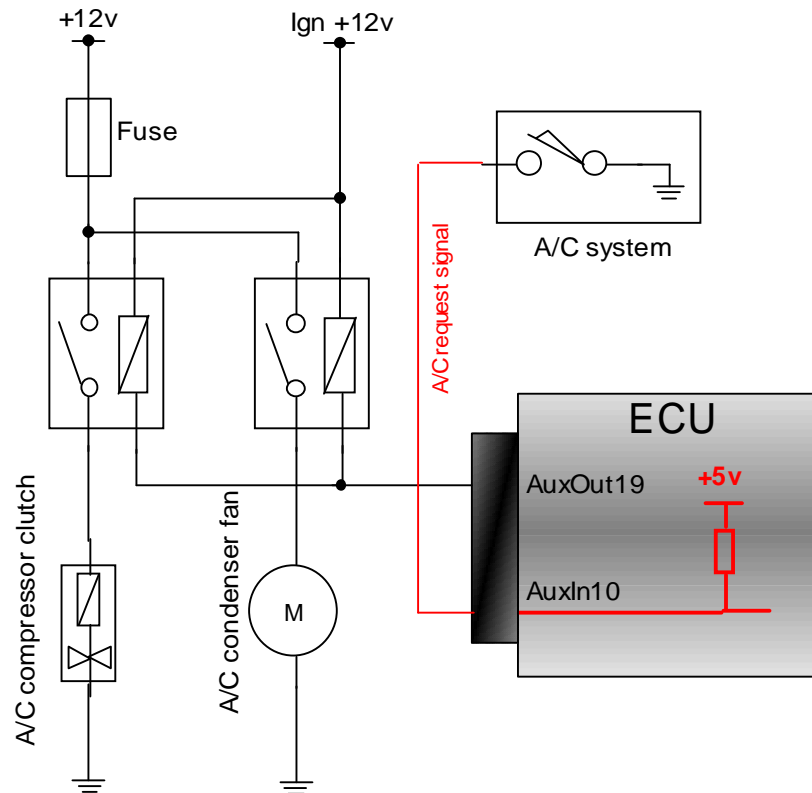
This example uses AuxIn10 to read the a/c request signal. This a/c system just provides a switch-to-earth request signal. The internal pull-up to 5v is used to allow the ECU to sense the switch to earth. The input is set to 'active low', i.e. a 0v reading means the a/c system is requesting activation and a +5v reading means the a/c system should be off.
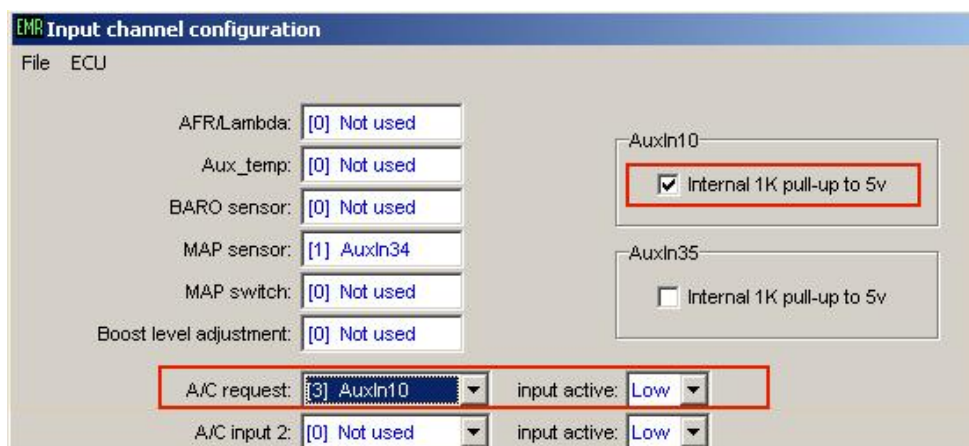
This example uses AuxOut19 to switch the A/C clutch so the output channel configuration should be set accordingly. **Note** that AuxOut19 has been made available by disabling the shift light output that is usually set to AuxOut19 by default.
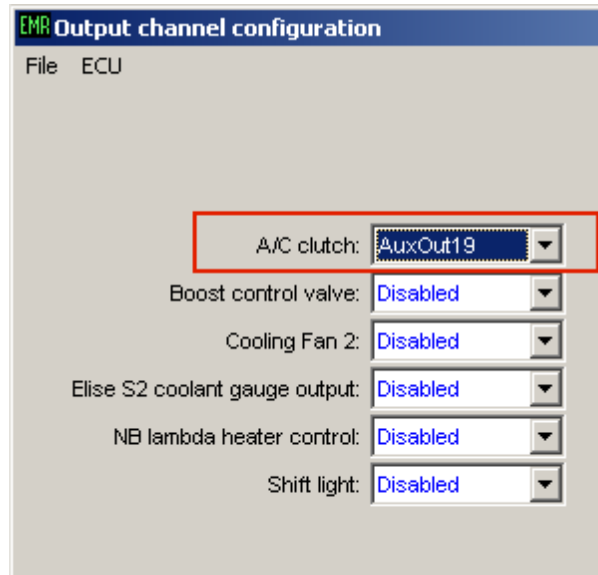
Once the input and output channels have been set the ECU must be updated with this new configuration. Select 'update ECU configuration' from the 'ECU' menu. The ECU should be fully reset (power off/on) to ensure the new configuration settings are fully implemented.

K3 36-way loom connector

25 → ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ← **36**

24 → ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ← **13**

1 ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ ◯ **12**
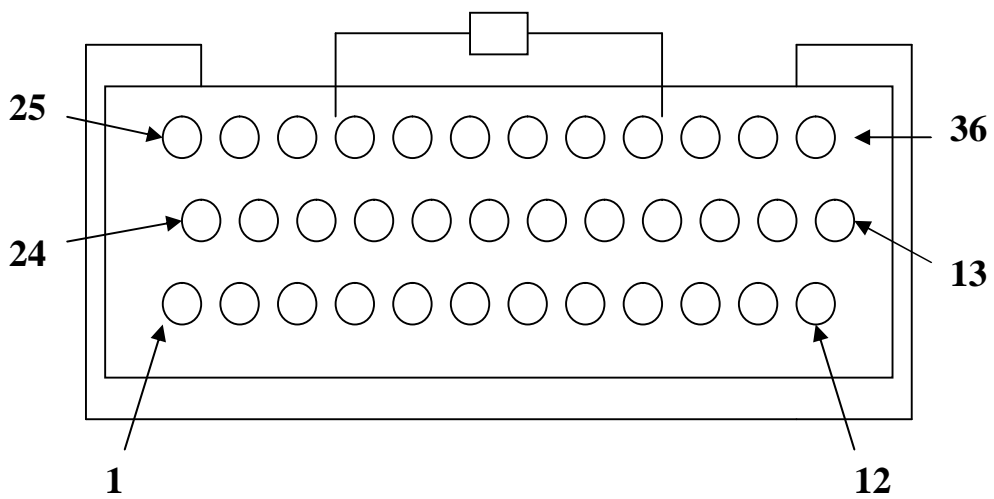
Rear view of connector
(wire side)

ECU pin out table

Pin no.	Connection	Comments
1	Injector driver 4/AuxOut1	Injector driver 4 or user assigned output
2	IACV2/AuxOut2	IACV stepper motor channel 2 or user assigned outputt
3	IACV1/IACV-PWM/AuxOut3	IACV stepper motor channel 1, IACV pwm control or user assigned output
4	Ignition driver 3/Main Relay Control	Ignition driver 3 or main relay control output according to ECU configuration
5	Ignition driver 2/AuxOut5	Ignition driver 2 or user assigned output
6	Cooling fan relay control	Output switches to earth to activate relay & fan
7	Oxygen sensor signal input	0-1v input from narrow band sensor
8	Throttle pot signal input	0-5v input from throttle position sensor
9	+5v sensor supply	5v output, 100mA max supply for sensors such as TPS, MAP, etc
10	AuxIn10	User assigned 0-5v input. An internally switched pull-up resistor can be enabled on this input.
11	Ignition sense input	+12v supply via ignition switch
12	Tacho output signal	0-12v pulsed output
13	Immobilisor/EGT digital input	Digital input from a Lucas 5AS immobilisor or VAG EGT sensor interface
14	+8v sensor supply	+8v supply for external sensors
15	Cam phase or custom input	Cam sensor input (if required)
16	Air temperature signal input	NTC temperature sensor input
17	Injector driver 5/Ignition driver 4/AuxOut17	Injector driver 5, Ignition driver 4 or user assigned output according to ECU configuration
18	Oxygen sensor signal earth	
19	Shift-light driver/AuxOut19	Shift-light output (switched earth) or user assigned output according to ECU configuration
20	Fuel pump relay driver	Switched earth
21	Injector driver 6/AuxOut3	Injector driver 6 or user assigned output
22	IACV3/AuxOut22	IACV stepper motor control or user assigned output
23	Injector driver 2	
24	Injector driver 1	
25	Ignition driver 1	
26	Injector driver 3/AuxOut26	Injector driver 3 or user assigned output
27	IACV 4/AuxOut27	IACV stepper motor control or user assigned output
28	+12v Ignition supply	Supply from main relay **or** common with pin 11
29	ECU earth	Good earth (direct to battery)
30	Sensor earth	Common earth for air, coolant & throttle sensors
31	Main trigger signal input	Crank sensor or digital distributor input signal
32	Main trigger sensor earth	Earth return for main/cam trigger sensors
33	Coolant temp signal input	NTC temperature sensor input
34	AuxIn34	User assigned 0–5v input
35	AuxIn35	User assigned 0-5v input. An internally switched pull-up resistor can be enabled on this input for temperature sensors.
36	AuxIn36/AuxOut36	User configurable input or output pin

Note : Apart from the Tacho output, all ECU driver outputs are switched earths.

Important: Although the ECU's injector drivers are fully overload protected they are designed to control *high* impedance injectors. Low impedance injector should only be used if fitted with suitably sized ballast resistors.

Wiring example - typical distributor based system

+12v (Ignition controlled)

Fuse
(size to suit lamp)

Rev Counter

Computer

Throttle-Potentiometer
Red + to pin 9
Green 0 to pin 8
Black – to pin 30

⊗ **Shiftlight**

To shiftlight driver
(pin 19)

To tacho signal output (pin 12)

Comms cable

ECU

**Distributor
(input trigger)**

Loom connector

Digital
+ Sensor supply (Lumenition, Red) to pin 14
0 Signal (Lumenition, Blue) to pin 31
- Sensor earth (Lumenition, Black) to pin 32

Inductive pickup
Sensor + to pin 31
Sensor – to pin 32

Air temp
Signal to pin 16
Earth to pin 30

Coolant temp
Signal to pin 33
Earth to pin 30

Injectors (bank 1)

To injector driver 1 (pin 24)

Fuse 2A
(optional)

To ECU supply
(pins 11 & 28)

Ignition Coil

Injectors (bank 2) – 6&8 cyl only

To injector driver 2 (pin 23)

ECU earth (pin 29)
to battery or good
chassis-earth

To fuel pump relay
control (pin 20)

Fuel Pump

Fuse

Fuel pump relay

Ignition Control

EMERALD
M3D Wiring diagram 1
rev 3   3/01

Wiring example - typical distributorless system

+12v (Ignition controlled)

Fuse
(size to suit lamp)

Rev Counter

Computer

Throttle-Potentiometer
Red + to pin 9
Green 0 to pin 8
Black – to pin 30

Shiftlight

To shiftlight driver
(pin 19)

To tacho signal output (pin 12)

Comms cable

Crank sensor

Inductive pickup
Sensor + to pin 31
Sensor – to pin 32

Digital
+ Sensor supply to pin 14
0 Signal to pin 31
- Sensor earth to pin 32

Sensor

ECU

Loom connector

Air temp Signal to pin 16
Earth to pin 30

To ignition driver 1 (pin 25)

Map Sensor
Pin 1 (c) = Signal to pin 34
Pin 2 (b) = Earth to pin 30
Pin 3 (a) = Supply to pin 9

Coolant temp Signal to pin 33
Earth to pin 30

To ignition driver 2 (pin 5)

Injectors (bank 1) cylinders 1&4

To injector driver 1 (pin 24)

Ign. Coil
Cyl 1&4
Cyl 2&3

Fuse 2A
(optional)

Injectors (bank 2) cylinders 2&3

To injector driver 2 (pin 23)

To ECU supply
(pins 11 & 28)

ECU earth (pin 29)
to battery or good
chassis-earth

To fuel pump relay
control (pin 20)

Fuel Pump

Fuse

Ignition Control

Fuel pump relay

– +

EMERALD
M3D Wiring diagram 2
rev 3   3/01

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Wiring information

Example wire types

| Connection	Wire type	Note
ECU supply (pin 11, 28) Main ECU earth	Stranded $0.5mm^2$ Stranded $1.0mm^2$	Use quality cable, routed direct to battery if possible
Actuators (coils, injectors, etc)	Stranded $0.5mm^2$ - $1.0mm^2$	Route away from sensitive sensor wiring
Sensors (temperature, TPS, MAP, etc)	Stranded $0.5mm^2$	Group each sensors wires and twist together, e.g. air temp sensor signal wire twisted with it's sensor earth wire.
Inductive distributor/Crank sensor	Twin-core shielded cable	Earth shielding at one end only, preferably at the ECU, pin 29

Important issues to be aware of when constructing your own loom

- Use a high current rating cable for the ECU's main earth connection, route this cable directly to the battery earth if at all possible.
- Route any sensor wiring as far away from sources of electrical noise as possible. These sources can be the alternator & cabling, starter motor, coils/leads/distributor, injectors, etc.
- Very sensitive sensors such as inductive pickups should be wired using shielded cable. The shielding MUST be earthed and at one end only (preferably at the ECU) to be effective.
- Wire sensors in a twisted pair fashion. Group together the wires for each sensor and twist these together. A pair of wire wrapping pliers are useful for this purpose, the wires can be clamped at one end and the whole length twisted tightly together using the rotating pliers. Although this is not essential it helps to keep the wiring neatly grouped when installing and also helps reduce interference to the signal wires.
- Provide a good +12v supply to the ECU, coils, injectors, etc. Poor quality, high resistance connection or wiring to these components can reduce spark performance and cause noise from some components to affect the ECU.
- Support cable that has to run to the engine. The engine will move/vibrate, ensure that this movement will not stress the cable. If possible use an outer sheathing or plastic binding to remove the direct stress from the cable.
- Protect cables with sheathing/insulating material that have to run close by the exhaust manifolds.
- Limit the amount of soldered joints – a crimped connection can actually be more reliable. Solder can extend a little way, underneath the insulation, from a joint, this stiffens the cable at this point making it more prone to failure from fatigue. This is worth being aware of when making joints to cables that may be subjected to high vibration levels!
- Remember the ECU has two power supply input pins, ECU pin 11 & ECU pin 28.

When installing an ignition/injection system to a car not originally designed for it you are introducing more electrical load. An ignition controlled +12v supply to a single high resistance points style coil may not be sufficient when powering an ECU, multiple low impedance coils and a number of injectors!

If in doubt use the example below to provide power to the coils and injectors.

Ignition controlled
+12v supply

Fuse
(e.g. 20A)

Main relay

− +

Power to coils &
injectors

ECU main relay control
(pin 4)
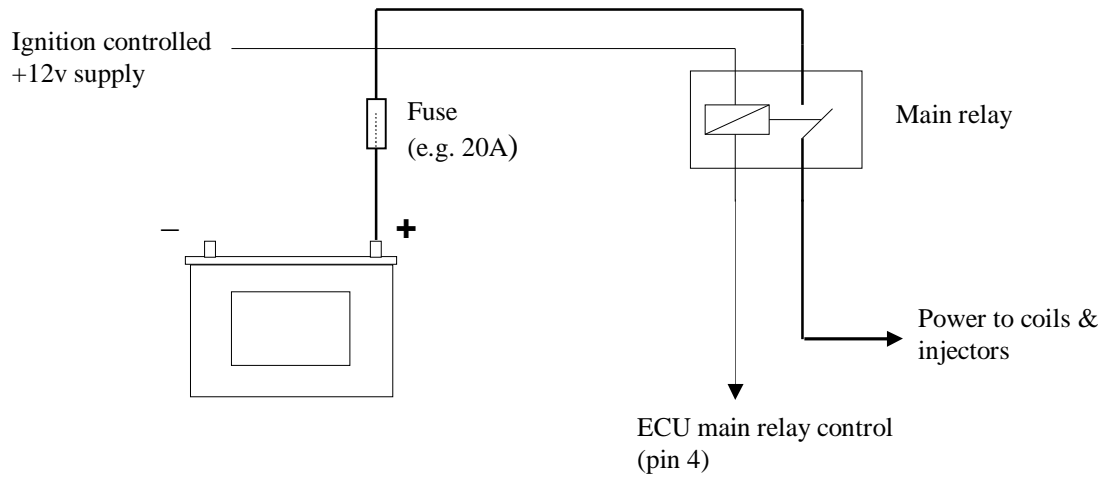
Example. ECU controlled supply to coils & injectors.

Communications port

Notes:

1.   The CAN bus must be terminated with two 120 Ohm resistors. The ECU's CAN interface includes a 120 Ohm internal termination resistor.
When connecting devices to the CAN bus confirm that the external CAN bus is terminated with a 120 Ohm resistor (either an external 120 Ohm resistor or by a device that has an internal terminating resistor). See example below…

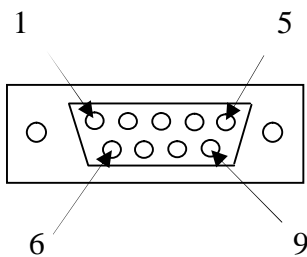| Pin number	Connection	Comments
1	CAN_H	CAN bus interface[1]
2	CAN_L	CAN bus interface[1]
3	-	Not used
4	-	Not used
5	earth	Signal earth
6	-	Not used
7	Rx	RS232 serial interface, data receive
8	Tx	RS232 serial interface, data transmit
9	CTS	RS232 serial interface, clear to send
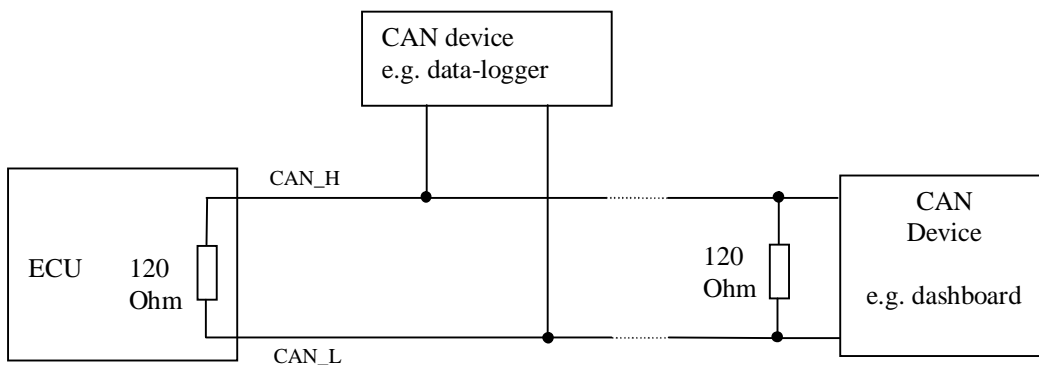
Emerald serial communications lead

The serial communications lead for connection to the PC is *NOT* a standard a standard RS-232 serial lead.

Warning: Use of a standard RS-232 lead could lead to damage of either the PC or ECU.

A serial communications lead is supplied with each ECU at no extra charge. The lead information is included below if you wish to repair / extend or construct a new lead.

PC 9-way D-type socket	Wire colour	ECU 9-way D-type plug
2	Yellow	8
3	White	7
5	Black	5
8	Red	9
Cable shield not connected	-	Cable shield soldered to outer casing

cable side of PC comms lead socket
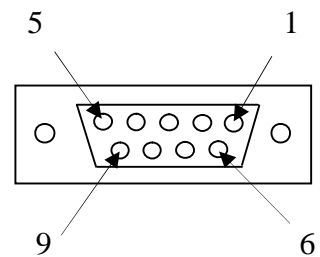
cable side of ECU comms lead plug

Aux input, port B

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← Aux input
Port B
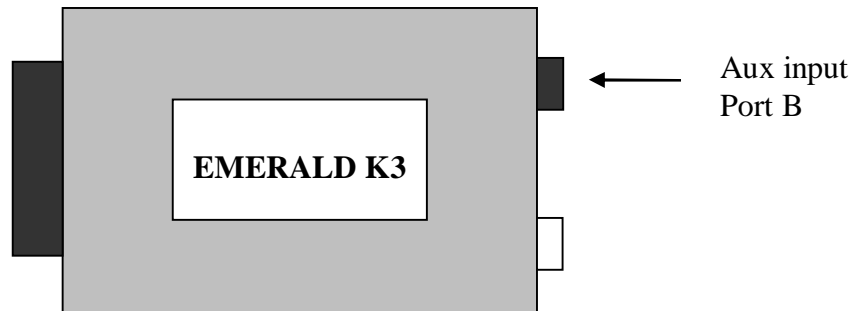
Pin number	Connection	Comments
1	Earth	Common earth point for wheel speed sensors / switch inputs
2	WSS_LF	Signal input from **L**eft **F**ront wheel speed sensor [1]
3	WSS_RF	Signal input from **R**ight **F**ront wheel speed sensor [1]
4	WSS_LR	Signal input from **L**eft **R**ear wheel speed sensor [1]
5	WSS_RR	Signal input from **R**ight **R**ear wheel speed sensor [1]
6	Status_LED	LED control output. [2] Direct anode connection (no current limit resistor needed)
7	AuxIn7b	Level switch input [3]
8	AuxIn8b	Level switch input [3]
9	AuxIn9b	Level switch input [3]

Notes:

1. Wheel speed sensor input signals can be analogue or digital (inductive or hall sensor). Global inductive/digital setting in software applies to all WSS inputs.
If the hall/digital sensor has an open-collector output a suitable pull-up resistor should be connected to the input line (e.g. 4.7K Ohm to +12v).

2. ECU provides direct control of the status LED. The output is a switched +5v signal via an internal 470 ohm current limiting resistor. Connect this output to anode of LED, cathode to earth.

3. Analogue input with internal 1K Ohm pull-up to +5v. Use a switch to earth for simple on/off control.

Appendix 1

Keyboard shortcuts

The Emerald software uses the normal Windows short cuts for navigation. The Windows navigation keys can be used in place of the mouse in most cases.

Screens

- o **F1**   Switch directly to the *Details* page of the main screen
- o **F2**   Switch directly to the *Events* page of the main screen
- o **F3**   Switch directly to the *Ignition* page of the main screen
- o **F4**   Switch directly to the *Injection* page of the main screen
            Repeat presses of the **F4** key will cycle between the sub pages of the
            Injection screen (*Injection map→AFR target→AFR corrections→Feedback mode→Closed loop settings*).
- o **F5**   Switch directly to the *Idle control* page of the main screen
- o **F6**   Switch directly to the *Ignition corrections* page of the main screen
- o **F7**   Switch directly to the *Injection corrections* page of the main screen
- o **F8**   Switch directly to the *Live adjustments* page of the main screen
- o **F12**   Switch directly to the *data-logger* screen. From the data-logger screen use the **F1** to **F8** short cut keys to return to main window.

Map tables

- o **+ / -**   Adjust selected cell/s values by 1 unit.
- o **C**   Calculate function (not all tables have this function enabled)
- o **Enter**   Some map tables will allow direct value entry. Press Enter to set a cells value.
            If more than one cell is selected then the Enter key will call up a multi-option map editing function. This function is not available with all tables.

Live adjustments screen

- o Zero (0)   Zero trim 1 (trim 1 is assigned to the ignition map by default)
- o Minus (-)   Reduce trim 1 by 1 unit (retard trim by 1°)
- o Plus (+)   Increase trim 1 by 1 unit (advance trim by 1°)
- o 1   Zero trim 2 (injection trim by default)
- o 2   Reduce trim 2 by 1 unit (reduce injection trim by 1)
- o 3   Increase trim 2 by 1 unit (increase injection trim by 1)
- o Enter   Store trim 1 and/or trim 2 in their associated maps (both in ECU and the PC).
- o ALT + 1   Change the map assigned to trim 1 (*Ignition→Injection→Boost PWM→INJ position→PWM→VVT position*)
- o ALT + 2   Change the map assigned to trim 2 (*Ignition→Injection→Boost PWM→INJ position→PWM→VVT position*)
- o Space   Start/Stop the data-logger. This can only work if the data-logger is enabled and the start/stop conditions are set to User.
- o Page Up   Increase the IACV open position by 1% (manual mode only)
- o Page Down   Decrease the IACV open position by 1% (manual mode only)
- o Home   Reset the IACV position to fully shut (manual mode only)