Canems Engine Management Solutions
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DRH Performance ECU

Bosch Motronic ML1.x 35-pin replacement

Programmable Fuel Injection & Ignition Controller

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Contents

Features

· ECU plugs directly into Bosch Motronic 35-pin looms
· Uses all existing sensors and wiring; no modifications required
· Uses the same physical mounting points in the vehicle
· PC connection through either serial or USB leads
· Data logging through PC or onboard SD memory card
· Load and save calibration maps to your PC
· All parameters adjustable at runtime
· Choose any load sensor – airflow meter, TPS, MAF, MAP
· Use standard peak & hold or modern saturated injectors
· Use any ignition system – distributor, twin-plug distributor, DIS coil pack or individual coils
· 18 programmable speed sites
· 14 programmable load sites
· Map switching at runtime – switch between sport/economy modes or different fuel grades
· Two 3D fuel maps with injector resolution of 4 microseconds
· Two 3D ignition maps with 0.5 degree increments
· Optional interpolation/mapping modes in all maps
· Optional password entry to protect your maps
· Adjustable fuel priming pulse and temperature
· Adjustable cranking pulse width and flood clear modes
· Fuel decay from cranking to running
· Fuel enrichment after engine start
· Idle valve decay from cranking to running
· Ignition advance when cranking
· Fuel cut rev limiter – alternating between cylinders or full cut, with hot/cold settings
· Injector opening time v Voltage maps for different injectors
· Adjust fuel maps for different injector flow rates or fuel pressures
· Transient fuel enrichment with any load sensor
· Multiple sensitivity and enrichment under transient conditions
· RPM correction and durations for transient enrichment
· Transient enrichment taper back to normal running
· Two stage ignition rev limiter – alternate between cylinders or full cut with hot/cold settings
· Ignition timing adjustment through engine temperature and / or air temperature
· Transient ignition advance – specify maximum advance or retard per revolution
· Dwell v RPM map
· Dwell v Voltage map
· Engine temperature adjustment for cranking and running (cold start and warm up)
· Temperature adjustment under idle conditions
· Air temperature correction
· Temperature sensor failure modes
· Altitude correction
· Wideband or narrowband oxygen sensor input
· Closed or open loop lambda sensor feedback
· Adjustable lambda authority and sampling rates
· Idle control via PWM valve or ignition spark scatter
· Closed or open loop idle control with adjustable authority and sampling rates
· Programmable idle valve decay for sudden deceleration
· Two programmable outputs for shift light / tachometer / cooling fan / warning lamps etc
· Record minimum and maximum outputs to and from ECU
· Crank sensor diagnostic log with export facility

Before you get started…

The DRH Performance ECU has two high current injection outputs and three high current ignition outputs. Each output can hold a constant current of 10 Amps maximum. Ignition coils should have a primary resistance of greater than 0.6 Ohms. Low impedance injectors (with a resistance of less than 6 Ohms) should always be used in peak-and-hold mode (set in software).

Support is available from Canems in sourcing components, installing the engine management system and programming the ECU to suit your requirements. The ECU is designed to operate in conjunction with easily obtainable components. It is our policy to design systems that require no unique hardware, and will always endeavour to have spares available in the future.

PC Tuning software displays all lambda sensor inputs as air fuel ratios (AFRs). It should be noted that only wideband lambda sensors are capable of giving a true reading over a wide range of AFRs. Narrow-band sensors can only indicate an over-lean (or over-rich) mixture, though the ECU, tuning software and data logs will of course reflect this behaviour.

Rolling road time is expensive, so our software is designed to be quick and easy to use; even for people with little experience. All fuel and ignition maps can be accessed with keyboard shortcuts, and you can change values with one touch of the keyboard. There is no need to waste valuable time when typing individual values and you can even tune your 3D maps visually, with the aid of graphical representations.

Our ECUs are designed to give total reliability and total control over engine parameters. However, full responsibility for the engine and vehicle in question remains solely with the owner. Canems can in no way be held responsible for damage or injury caused by incorrect fitting procedures, failure in use or neglect of appropriate safety measures.

Basic terminology

Pulse width

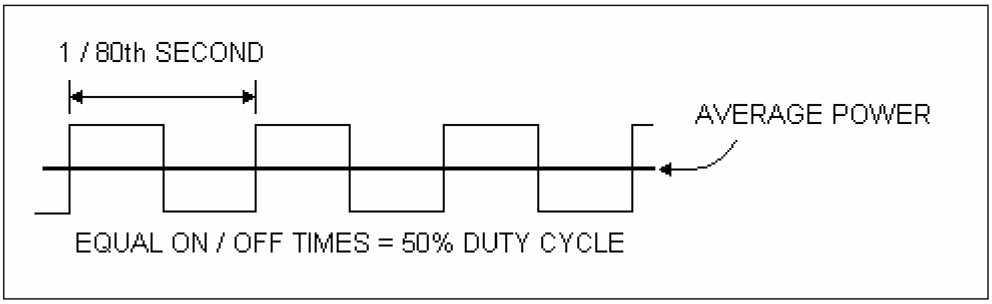
Pulse width is a measurement of time. Typically used to describe the amount of time for which a fuel injector is held open. The longer an injector is held open for, the more fuel is able to flow into the engine. Therefore, there is a direct relationship between fuel mixture and injector pulse width. Due to the fast switching nature of fuel injectors, pulse width will typically be measured in milliseconds (thousandths of a second).

Duty cycle

Duty cycle describes the amount of time for which an output is held ‘on’. It is measured as a percentage. For example, an injector held open for 8 milliseconds, then closed for 2 milliseconds, has a duty cycle of 80%. As RPM increases, fuel injectors have an increasingly short space of time in which to inject the required fuel. It doesn’t help that the engine will probably want more fuel at high speed either. If the duty cycle exceeds 100%, this means the injector is open full-time. It has reached the limit of its flow capabilities and is no longer able to supply more fuel.

PWM

Standing for Pulse Width Modulation, PWM is used by the ECU to vary the amount of power sent to a device (such as an idle control valve). For example, an output switching with a duty cycle of 50% will effectively provide half the power available at 100% duty cycle. Thus, changing the duty cycle will change the average power available to the device. A PWM frequency of 80Hz means that the on / off switching pattern repeats itself 80 times per second.



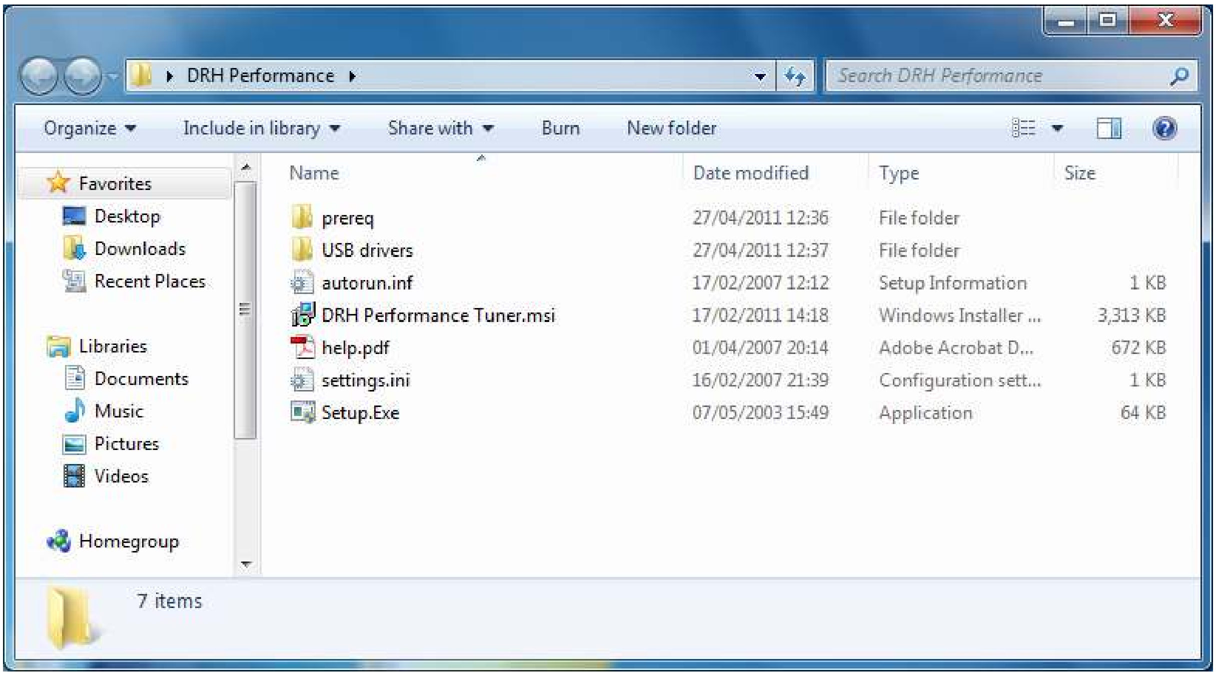
Open loop / closed loop

Open loop control refers to an ECU operation that has no feedback. For example, if a fuel setting in the ECU has been told to inject a certain amount of fuel, it will do this, regardless of whether the engine is already running too rich or too lean.

Closed loop control means that feedback is used. The complement to the example above would be a lambda sensor, which would tell the ECU that the engine is running too rich or too lean. The ECU would then use this feedback to adjust fuel delivery accordingly.

Using the software

To install the software, insert the CD into your CD-ROM drive. The software installation process should begin automatically. If this is not the case, click on the 'My Computer' icon on your desktop and right-click the CD-ROM drive. Now click 'Browse'.



Double-click the icon named 'Setup', and this will start the installation process.

A message will appear once the installation has completed successfully. This means you can start the DRH Performance Tuner software either by double clicking on the DRH icon on your desktop or by accessing the Start > Programs menu.

Connecting the ECU

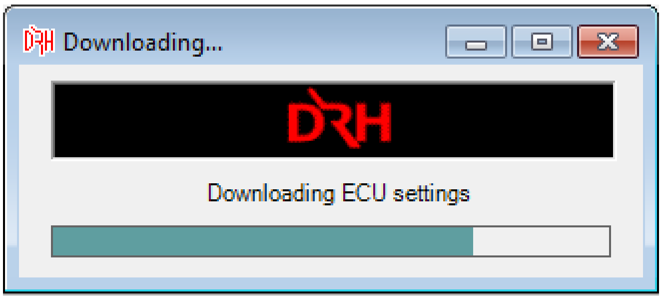
Once the ECU is installed in your vehicle with an ignition-switched power supply, you can test the communication between the tuning software and the ECU module.

The first step in this procedure is to connect the supplied communication lead between the ECU and your computer. The communication lead has a female connection at one end and male at the other. Therefore, it is not possible to connect the two items incorrectly.

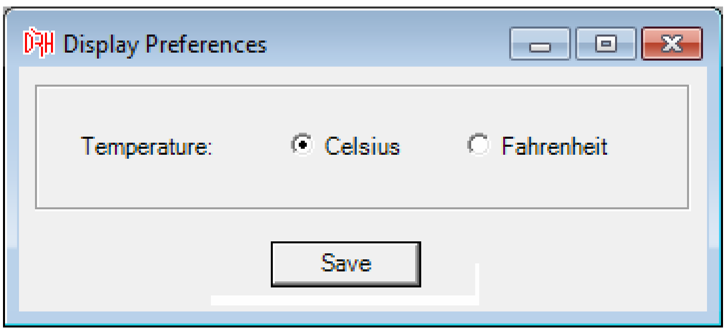
On your computer, the communication lead plugs into a spare serial / COM port. Most computers have such a connection. If your computer does not, connect the USB adaptor supplied with your ECU kit instead.

Once the communication lead has been attached, you can start the DRH Performance Tuner software. This will display the default screen.

The DRH Performance Tuner software will automatically detect the ECU.



Once the software has managed to locate the ECU, all settings will be downloaded to your computer. This process takes only a few seconds, and is the starting point from where you can begin to modify the ECU settings – referred to as '*mapping*'.

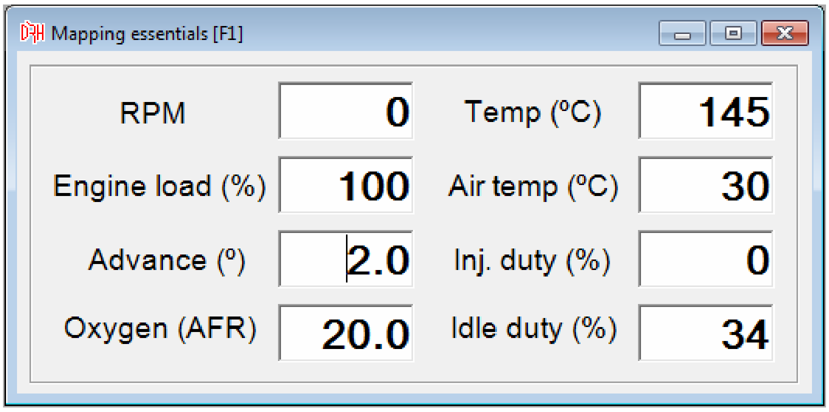


Engine temperatures can be viewed in either degrees Celsius or degrees Fahrenheit. To set your preference, click '**View > Display preferences**'.

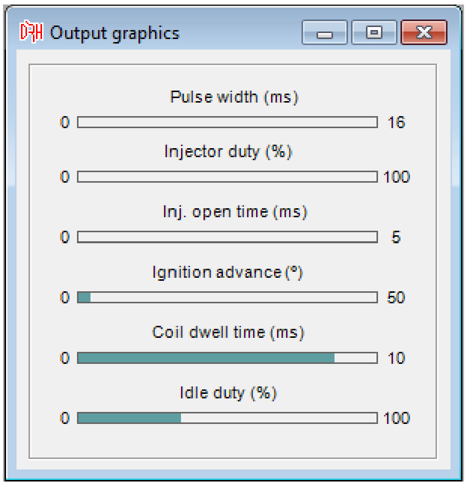
Inputs, outputs and real-time data

Under the '**View**' menu, you will find options to display all inputs and outputs to the ECU. As a default, the software shows the main dashboard and displays the input and output values in a textual format.

The Mapping Essentials screen ('**View > Mapping essentials**') is designed to show the most important data, so it is recommended to load this window when mapping is in progress. For easy access when mapping, you can also press **F1** to view this screen.



Along with textual readouts for inputs, outputs and feedback, there are graphical displays that also represent this data. An example of this is the *Output Graphics* window ('**View > Output graphics**').



A selection of analogue style gauges can also be viewed on-screen, along with an '*ECU status*' window which is used to indicate the status of various outputs and ECU features.

Loading and saving files

It is a wise precaution to save your ECU settings onto your computer. This is particularly true during the mapping process, where it is very easy to upset the engine tuning and therefore you may need to reload your previous settings. To save the ECU settings, click '**File > Save calibration**'.

When loading a calibration file, the engine should not be running. The ECU must of course be connected to the host computer and have a voltage supply. To load a calibration file, click '**File > Load calibration**'.

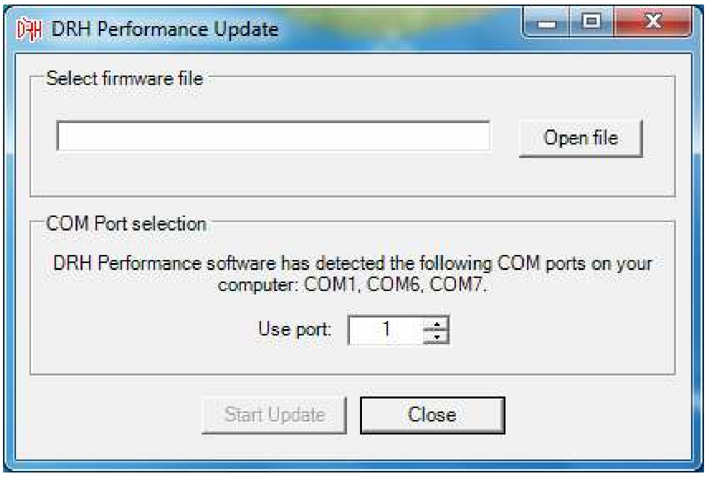
Before closing the Tuner software, a user will automatically be asked if they wish to save their changes. It is recommended that a backup copy is frequently saved during the mapping process.

Firmware Files

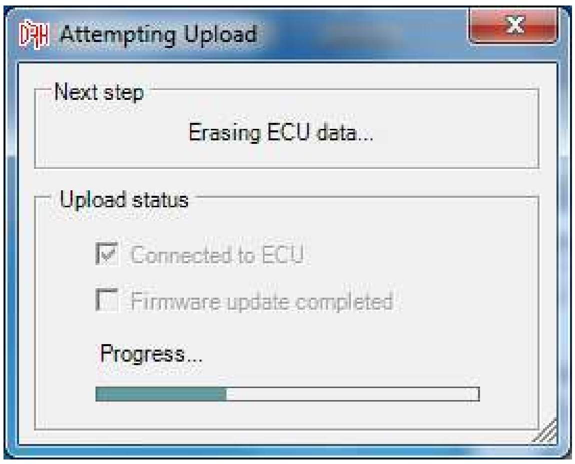
When major changes need to be made to your ECU, you'll need to change the software inside the ECU itself. This is called ECU firmware. To get the latest firmware files, visit the Canems website. From here, upgrades for your ECU can be downloaded free of charge. Firmware files are also distributed with your installation CD though naturally they may not be the most recent.

Uploading firmware files

Changing the firmware in the ECU is a simple process. It is recommended to backup your settings before uploading firmware, although they are not overwritten during the upload process. With the ignition **off**, connect the tuning lead to your computer and open the DRH Firmware upload software. This will be in your '**Start > Programs > DRH Performance**' folder.

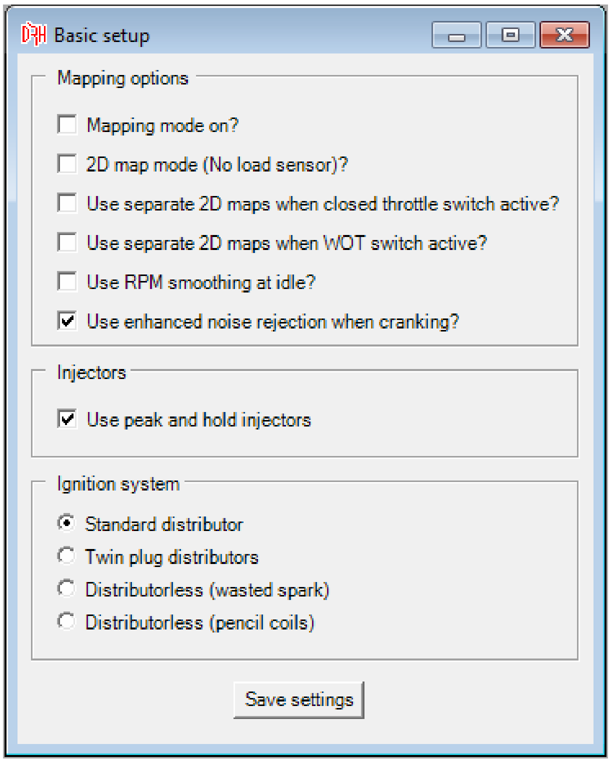


Now, select '**Open file**'. Choose which firmware version you'd like to use by clicking '**Open**'. (This screen shown below left)



To begin the upload process, simply choose the COM port to which the ECU is connected (the software will tell you which ports are currently active) and then click '**Start Update**'. Now turn **on** the ignition. The firmware upload takes approximately fifteen seconds, after which the ECU is ready to use. (Shown above right).

ECU Setup



Before attempting to start the engine, it is vital to complete the 'basic setup' options ('**ECU setup > Basic setup**').

Mapping mode on?

The DRH Performance ECU has inbuilt interpolation on all maps. This means that values from adjacent sites will always be taken into consideration when the ECU is locating a value. For example, consider the case where the ignition timing is specified as 20° at 2000 RPM and 26° at 3000 RPM. Using interpolation between the two values, the ECU will calculate that an advance figure of 23° is required at 2500 RPM.

The effect of interpolation is to smooth the transition from site to site, blending values so that there are no sudden jumps in either fuel mixture or ignition timing.

When you are setting up the ECU (known as 'mapping') it can be advantageous to turn off the interpolation mechanism. Without interpolation, changes to a single site in a map will produce a much more obvious change in engine performance. Mapping with interpolation turned on would require all adjacent sites to be altered before a significant change can be recognised.

2D Map mode?

If the ECU is being used as an ignition-only controller (typical with carburettor conversions, such as a Porsche 911 with PMO's), then it can be used in a 2D only mode. This is similar to running a distributor without a vacuum advance unit. In nearly all cases it is advantageous to use a load sensor, but this option allows operation without.

Use separate 2D maps when closed/open throttle switch active?

The original Motronic ECU has two throttle switches rather than an infinitely variable potentiometer. These switches tell the ECU whether the throttle is either fully open or fully closed. Using these two settings, you can force the ECU to use a separate 2D map for fuel quantity and ignition timing whenever the throttle is fully open or fully closed.

Use RPM smoothing at idle?

Selecting this option can improve idle quality with high lift / large overlap camshafts. The ECU will take an average reading of engine RPM, rather than a real-time reading. Fuel quantity and ignition timing requirements are then calculated from this average measurement which can prevent a 'hunting' idle condition.

Use enhanced noise rejection at idle?

This setting is designed to improve engine starting by rejecting any unexpected noise from the crank sensor signals. It is recommended to leave this setting turned on.

Use peak and hold injectors?

The DRH Performance ECU is designed to use either the original peak-and-hold injectors (found on all Motronic ML1.x installations) or more modern saturated injectors. You must select this option if your engine is fitted with peak-and-hold injectors, otherwise there is a risk of overheating the ECU and/or fuel injectors.

Ignition system

• Standard distributor. The vehicle is fitted with a single ignition coil and distributor (all standard Motronic installations).

• Twin-plug distributors. The vehicle has a twin plug conversion (a relatively common modification for tuned 911s). There are two coils and two distributors.

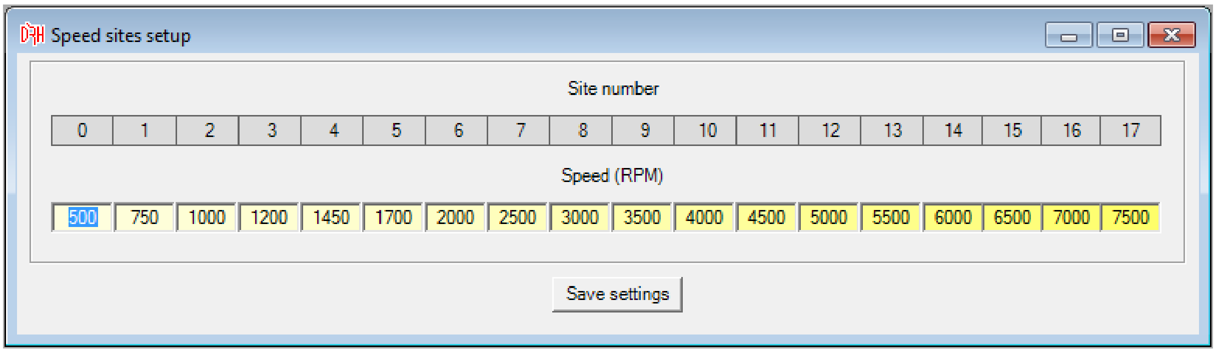
• Distributorless (wasted spark). The vehicle is using a DIS coil pack conversion.

• Distributorless (pencil coils). The ignition system is using an external amplifier system. In this case, the ECU provides a low current 5V logic signal, rather than acting as a high current switched earth.

For more details see “*Modifying your ignition system*”

Setting speed and load sites

You must choose suitable values for the ECU *Speed Sites*. These values are used in all of the 3D ECU maps, and as such they help to determine fueling and ignition parameters for all engine speeds. To view the speed sites, click ‘**ECU setup > Speed sites**’.

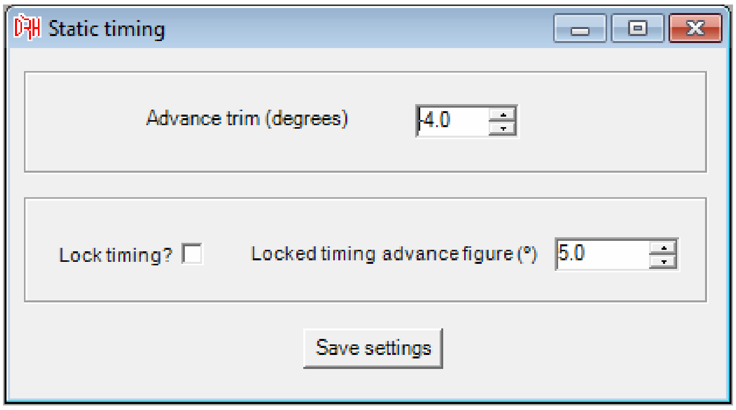


The speed sites should be spread across a suitable range from approximately 500 RPM up to the maximum expected engine speed. It is common to group speed (and load) sites together more closely in some places, corresponding to the most frequently used engine speeds (or loads). This will allow a greater degree of fine-tuning in the most commonly used areas in a 3D map, ultimately leading to improvements in economy or performance – whichever is desirable.

Speed sensing & TDC location

The DRH Performance ECU measures engine speed and crank sensor location via two crank sensor signals. By analysing the signal from multiple flywheel teeth, the ECU is able to calculate engine speed. A separate TDC reference pulse enables the ECU to recognise crankshaft position within the engine.

All Motronic ML1.X systems have these two crank sensors already installed. Despite this, it is advisable to check the static timing to ensure that your ignition timing is as accurate as possible.



To check the static timing in your system, the engine must be running with a strobe light attached to HT lead, number one cylinder. In the DRH Performance Tuner software, click '**ECU setup > Static timing**'. Select the option to lock ignition timing, and choose a suitable figure for '**Locked timing advance figure**'. Click '**Save settings**'.

The ECU will now fix the ignition timing at this figure exactly. It doesn't matter whether the engine speed increases or decreases, or whether there is any change in engine load.

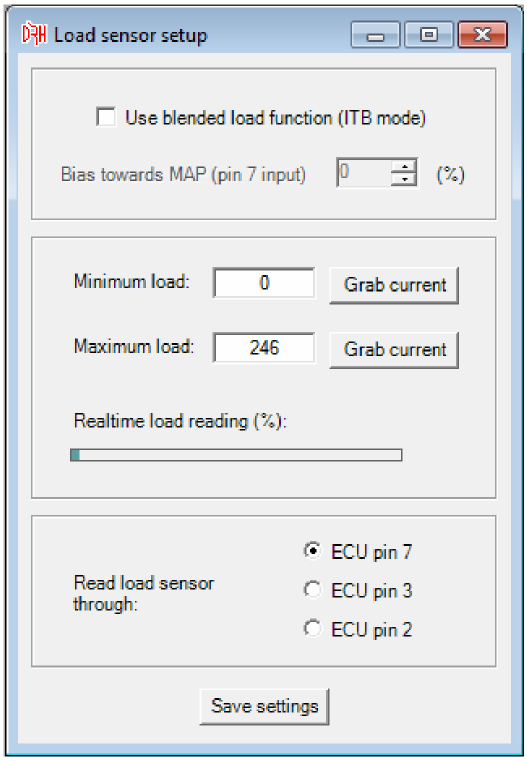
Verify with the strobe light that the spark is occurring at the correct time. If not, use the '**Advance trim**' setting to move the static timing position. You can move the ignition point in 0.5 degree increments. When the strobe light figure matches the 'Locked timing' figure, unselect the '**Lock timing?**' check box, and remember to click '**Save settings**'.

Take care! If you've upgraded to distributorless ignition, remember that your strobe light will see two sparks per 720 degrees of crankshaft rotation. If your strobe light has an advance/retard knob, then this can confuse matters. If in any doubt, lock the timing at 0.0 degrees and set the static timing to TDC.

Load sensing

Most of the main maps in the DRH Performance ECU are 3D. This means each map has a speed-referenced axis and a load-referenced axis. The speed axis is based on how quickly the engine is turning, while the load axis is based on how hard the engine is working. For example, an engine pulling top gear up a hill is working much harder than an engine coasting downhill in second gear. This is where the load sensor comes in – it can differentiate between the two conditions.

On standard Motronic installations, vehicles are fitted with a 'barn door' air flow meter. These are underrated devices in terms of accuracy, but they do wear badly due to moving parts and electrical contacts. Modern equivalents include MAP sensors, MAF sensor and throttle position sensors. All four load measuring devices are compatible with the DRH Performance ECU.

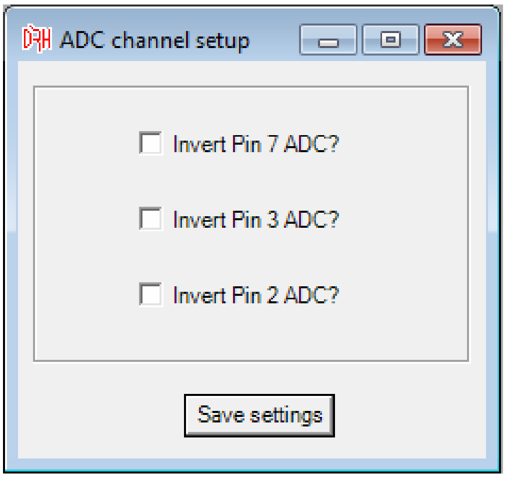


After installing a load sensor, you must specify the minimum and maximum ADC readings. The DRH Performance ECU has three ADC (analogue to digital converter) channels. ECU pin seven is typically used as the main load sensor input.

The ADC channels count from 0 to 255, with 0 equating to 0V and 255 equating to 5V. In the illustrated example, maximum load is indicated by an ADC value of 246, or 4.82 Volts.

If you are using a throttle position sensor to measure load (common with individual throttle body [ITB] setups), you must reset these figures after setting the engine idle speed.

We have found the best way to measure load with ITB arrangements is a blend of TPS *and* MAP readings. You therefore have the option to 'blend' the analogue inputs from Pin 7 (usually connected to a MAP sensor) and Pin 3 (usually the TPS input).

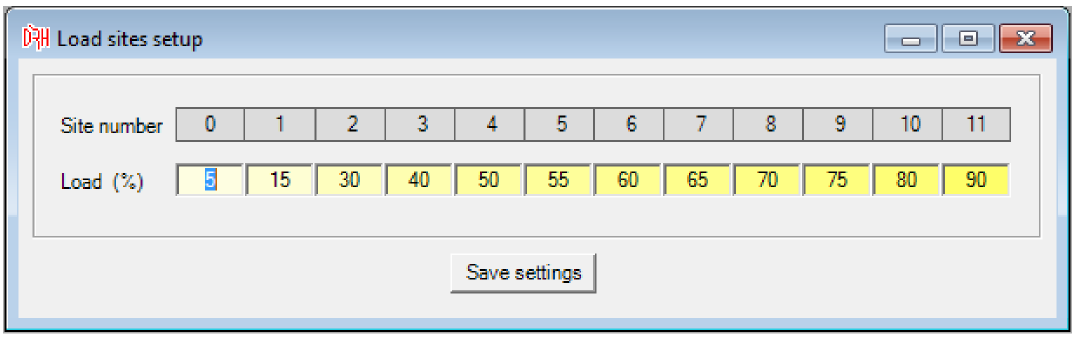


If you set a bias of 35%, this means the ECU will take 35% of the load measurement from the MAP and 65% from the TPS.

It is also possible to invert the readings on the ADC input channels. To do this, click '**ECU setup > ECU channel setup**'.

This will display the screen to the left, where each of the three ADC channels have a corresponding option.

The DRH Performance ECU has twelve programmable load sites, which are used in all 3D maps, most typically to calculate fuel quantity and ignition timing requirements. To access the load sites setup, click '**ECU setup > Load sites**'. This will display the screen below:



Load sites should be programmed to fall within the range of possible load values (0 to 100%). Load values should increase in size from left to right. After changing load site values, click '**Save settings**'.

Throttle Switches

The original Motronic ECU has two throttle switches rather than a variable potentiometer. These switches tell the ECU whether the throttle is either fully open or fully closed. Using these two settings, you can force the ECU to use a separate 2D map for fuel quantity and ignition timing whenever the throttle is fully open or fully closed.

To access the settings for the throttle switch setup, click '**ECU setup > Throttle switches**'. These settings are shown to the right.

Typically, Motronic systems will connect the closed throttle switch to ECU pin 2, and the open throttle switch to ECU pin number 3.

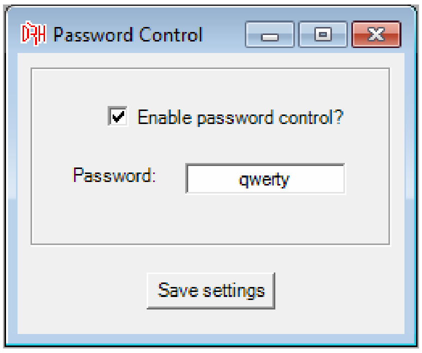
Even if you have removed the original throttle switches, you can still mimic their behaviour in software. For example, setting the throttle switch inputs to pin number seven would take a reading from the main load sensor such as a TPS with individual throttle bodies.

ECU Password Control

To secure your ECU settings, it is possible to place a password lock on the ECU. This will prevent viewing or alteration without authorisation. To set a password, click '**ECU setup > Password control**'.

Select the option to '**Enable password control**', and enter your six digit alphanumeric password. Remember to click '**Save settings**'.

The next time you restart the ECU *AND* reload the DRH Performance Tuner software, you will be prompted for the password before any communication is granted with the ECU.



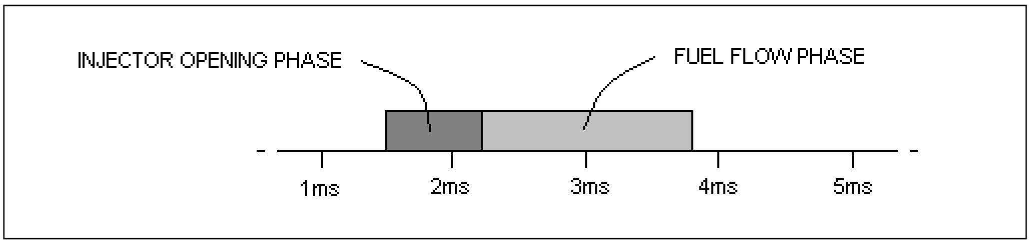
If you have forgotten the password or would like to force entry into a previously locked ECU, this is also possible, although all settings in the ECU will be completely removed.

If you do need to force entry to the ECU, press the '**F8**' key when the 'Password Entry' screen appears. This will display the warning message shown to the right.

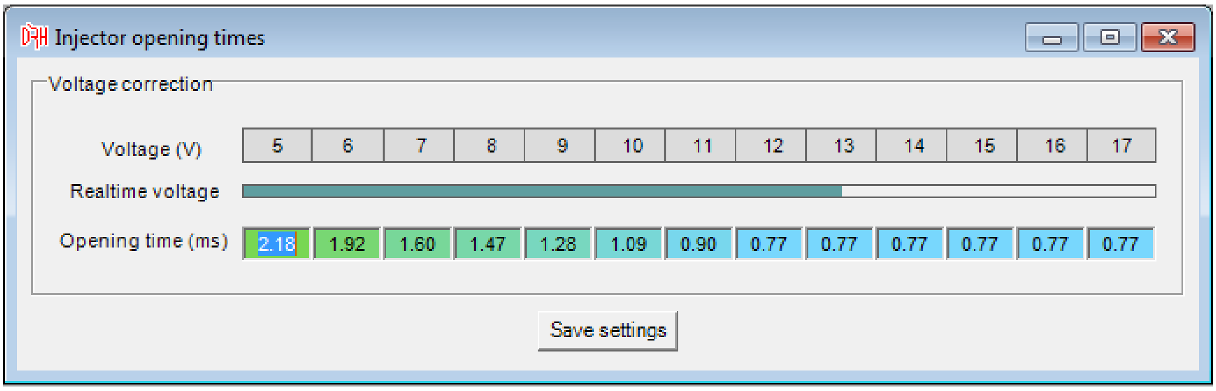
If you click 'Accept', all data in the ECU will be wiped. **DO NOT attempt to start the engine until suitable settings have been restored.**

Injector opening times

A fuel injector is activated when the ECU allows current to flow through the internal solenoid. Before fuel actually begins to flow, the solenoid must open an internal valve. This process takes a finite amount of time and is dependant on the voltage available. Lower voltages will take longer to activate the solenoid an open the valve.



The diagram above shows that the total injector pulse width actually consists of two separate phases; that in which the injector is opening and there is negligible fuel flow, and that in which fuel is actually released. This being the case, the ECU features a programmable map of injector opening time against vehicle voltage. To view the map, click '**Fueling > Injector opening times**'.

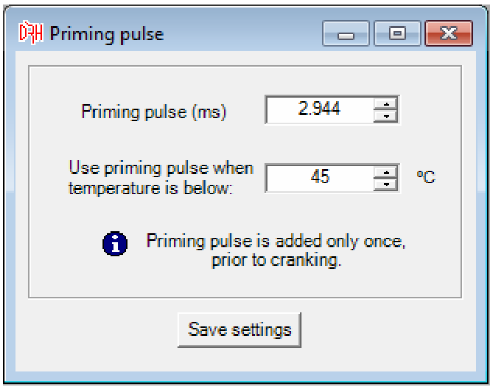


For each possible voltage, there is a programmable opening time (in ms). Most injectors have an opening time of between 0.8 to 1.0 milliseconds at 12V. Injector opening times can be specified to the nearest 64 microseconds.

After making changes, click '**Save settings**' to store the values in the ECU.

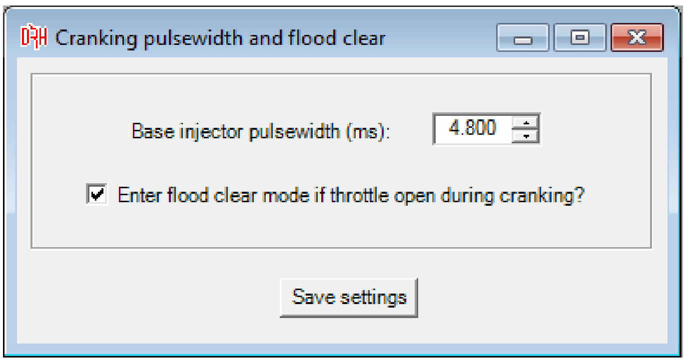
Priming, cranking and flood clear modes

When the ECU receives power (ignition is turned on), all fuel injectors in the system will deliver a short 'priming pulse' to start the engine. The priming pulse is programmable in length, and can be temperature dependant. Typically the priming pulse is not required when engine temperature is above 30ºC. To modify the priming pulse settings, click '**Cranking/startup > Priming pulsewidth**'.



If your engine fails to start, it is recommended to keep the ignition *on* rather than restarting the ECU before every attempt – this will prevent the addition of more than one priming pulse which could lead to a flooded engine.

Once the engine is running, the ECU will revert to a main 3D fuel map, where it will work out how much fuel is required. At cranking speeds however, the ECU will use a preset injector pulse width. This is set under '**Cranking/startup > Pulsewidth and flood clear'**.



In case the engine happens to flood during cranking, there is an optional 'Flood Clear' setting available.

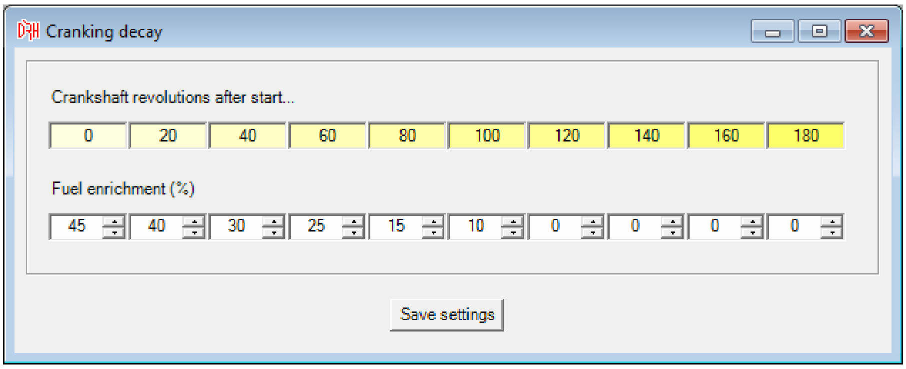
If selected, no fuel will be injected during cranking provided that the throttle is fully open. This helps to clear any fuel residue from the cylinders before further attempts are made at starting the engine.

The injector pulse width should be set at a suitable value for hot cranking conditions. This can easily be determined by trying to start the engine with different values once the engine is thoroughly warmed through. It's advisable to start with a low value to prevent flooding the engine.

The injector pulse width can be specified to the nearest 64 microseconds. After changes have been made, click '**Save settings**' to store the value in the ECU.

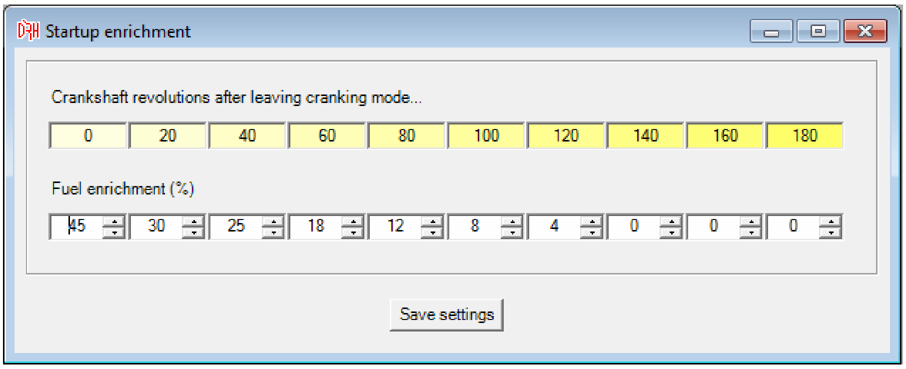
To ensure correct fueling at all temperatures, the cranking pulse width is corrected by the coolant temperature sensor. For more information, see the section entitled '*Cranking correction*'.

Cranking Decay



If an engine fails to start immediately, the existing fuel is not burnt. This can soon lead to a build-up of fuel in the cylinders which will soak the spark plugs and make starting even more difficult. Under '**Cranking/startup > Cranking decay**'. There is therefore a 2D map available which will acts to decay the fuel quantity after a certain time period. More accurately, the cranking pulse width is increased by a certain percentage to begin with, and this percentage tapers to zero after perhaps one hundred crankshaft revolutions.

Startup enrichment



Once the engine has fired, the ECU will enter a condition known as '*after start enrichment*'. The aim of this is to richen the mixture so that the transition from cranking to running can be performed smoothly. To view the after start enrichment settings, click '**Cranking/startup > Startup enrichment**'. This will display the screen to the above.

The after start enrichment amount is a programmable percentage enrichment. 0% implies no enrichment, whereas 100% would double the normal amount of fuel.

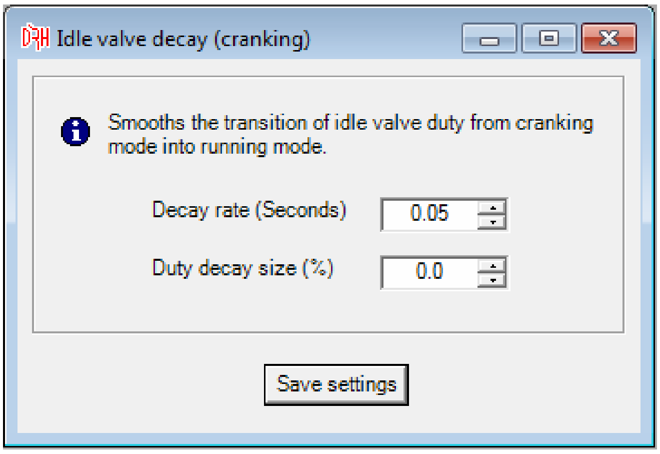
The number of crankshaft rotations for which this enrichment is applied can also be specified. During this period, the fuel enrichment will gradually decay so that by the end of the after start enrichment period the ECU will be operating solely from the main fuel maps.

With correct settings, there should be a smooth transition between cranking and running conditions. As with other values, click '**Save settings**' to store new settings in the ECU memory.

Idle valve duty (cranking)

When starting the engine, we also need to specify the quantity of air that is required. This is governed by the idle control valve. In cold temperatures, more air is required to provide a higher engine speed. To access the settings for the idle control valve when cranking, click '**Cranking/startup > Idle valve setting**'.

Typical settings would range from ~55% when cold down to ~30% when hot. With the idle valve duty set correctly, the engine should fire without needing to press the throttle pedal at all.



It is important that the idle valve duty doesn't change too suddenly. This can cause the engine speed to over correct, either stalling the engine or overshooting the target idle speed.

Therefore, a further setting (idle valve decay) can be accessed under '**Cranking/startup > Idle valve decay**'.

The aim of this setting is to smooth the transition from cranking to running, so if there is any difference in the idle valve duties in the two modes, the change will be performed gradually.

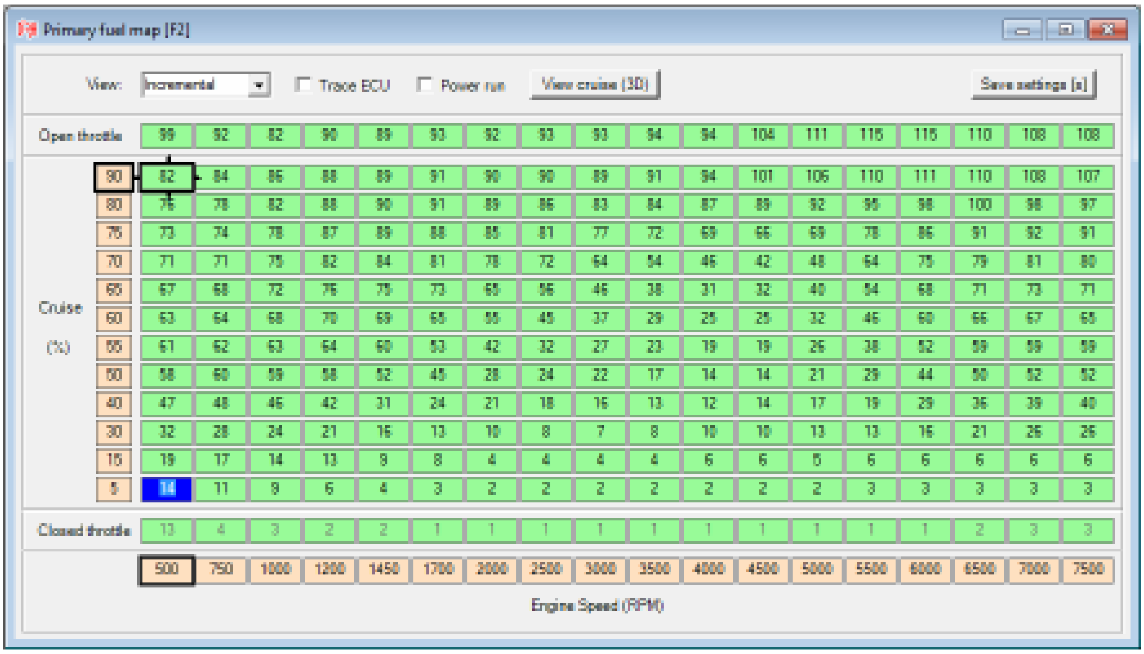
Cranking Advance & RPM

It is possible to specify the RPM range that is considered as 'cranking'. This is useful because a large V8 engine will have a much lower engine speed during cranking than a small four cylinder. To access this setting, click '**Cranking/startup > Cranking RPM**'. A typical setting would be 450 RPM. In this case, whenever the engine speed drops below 450 RPM, the cranking maps would be used.

Finally, ignition advance can also be specified under cranking conditions. To access this setting, click '**Cranking/startup > Ignition advance**'. Typical ignition advance will be in the range of two to five degrees at cranking speeds.

Fuel maps

The ECU has two fuel maps which are switchable whilst the engine is running. This gives the option of choosing either performance or economy settings. For more information see the '*Map switching*' section. To access the fuel maps, click either '**Fueling > Primary fuel map**' or '**Fueling > Secondary fuel map**'. For easy access, you can also press **F2** or **F4** to view the fuel maps.



Open throttle	99	92	82	90	89	93	92	93	93	94	94	104	111	115	115	110	108	108
90	82	84	86	88	89	91	90	90	89	91	94	101	106	110	111	110	108	107
80	76	78	82	88	90	91	89	86	83	84	87	89	92	95	98	100	98	97
75	73	74	78	87	89	88	85	81	77	72	69	66	69	78	86	91	92	91
70	71	71	75	82	84	81	78	72	64	54	46	42	48	64	75	79	81	80
65	67	68	72	76	75	73	65	56	46	38	31	32	40	54	68	71	73	71
60	63	64	68	70	69	65	55	45	37	29	25	25	32	46	60	66	67	65
55	61	62	63	64	60	53	42	32	27	23	19	19	26	38	52	59	59	59
50	58	60	59	58	52	45	28	24	22	17	14	14	21	29	44	50	52	52
40	47	48	46	42	31	24	21	18	16	13	12	14	17	19	29	36	39	40
30	32	28	24	21	16	13	10	8	7	8	10	10	13	13	16	21	26	26
15	19	17	14	13	9	8	4	4	4	4	6	6	5	6	6	6	6	6
5	14	11	9	6	4	3	2	2	2	2	2	2	2	3	3	3	3	3
Closed throttle	13	4	3	2	2	1	1	1	1	1	1	1	1	1	1	2	3	3
	500	750	1000	1200	1450	1700	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500

The ECU has an adjustable injector resolution of between 4 microseconds and 80 microseconds (µS). By default, fuel maps display an 'incremental' view. This is where each fuel site is a multiplier of the injector resolution.

To set the resolution, click '**Fueling > Injector resolution / MSPB**'. Here you can specify the multiplier (actually measured in microseconds per bit, or MSPB). For large fuel injectors you will typically use a small MSPB figure. This increases the accuracy with which you are able to control fueling.

Note that fuel maps can only accept a value of between 0 and 255, so if you use small injectors and a small MPSB value you may actually run short of fuel under full power. To correct this, increase the MPSB value and tick '**Rescale fuel maps to suit new resolution**'; this will automatically correct your fuel maps without you needing to start from scratch on your mapping work.

As an example of fuel injector operation, if your MSPB figure is set to 64 microseconds, a fuel site with the incremental value '54' would actually hold the injector open for

$$54 \times 64 = 3456\ \mu S \quad \text{(or 3.456 milliseconds)}$$

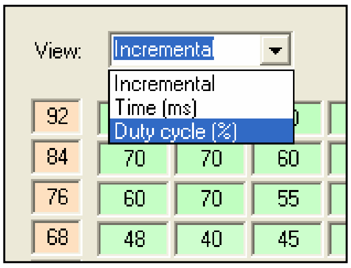
This figure excludes the injector opening time and any acceleration enrichments which are also added on to calculate the total injector pulse width.

To program the fuel map, move to the site you want to alter using the arrow keys on your keyboard. Alternatively, you can use the cursor to select a site. You can then either type in a numerical value and press 'Enter' or use the 'Page Up' and 'Page Down' keys to increase or decrease the fuel quantity. Remember that every increment will add to the total injector flow time, and therefore enrichen the air fuel mixture.

To adjust more than one site at a time, you can click and drag over the sites you need to change. This will highlight them in yellow. You can then enter a new value, subtract a certain amount or add a certain amount.

Like all other maps, when you have finished making changes, click '**Save settings**' to permanently store the changes in the ECU memory.

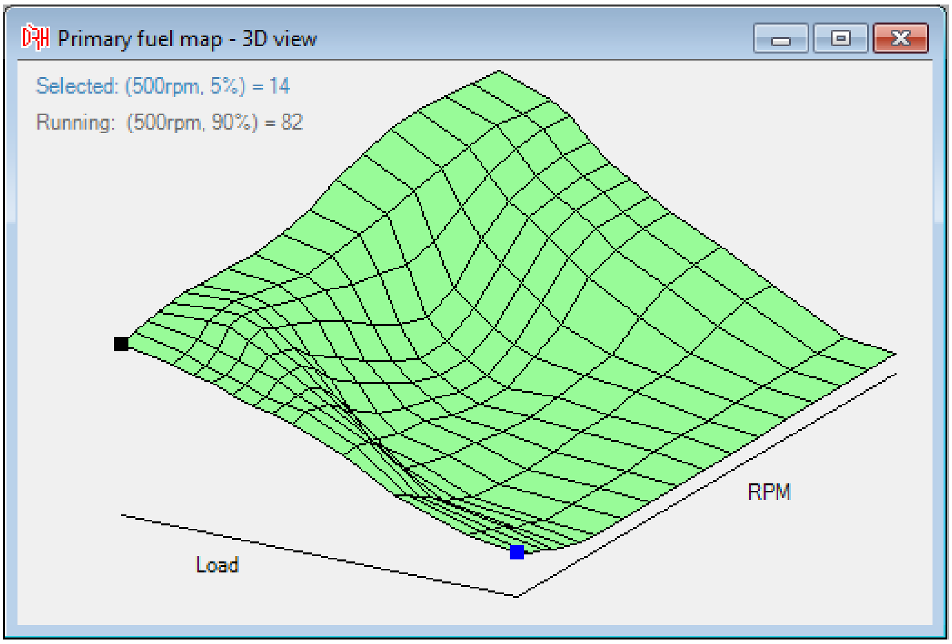
Along with the incremental view, the fuel map can also be viewed in actual time units (milliseconds), or in terms of injector duty cycle percentage. The duty cycle view is particularly useful, as it will indicate whether the fuel injectors are likely to have reached their maximum possible flow rate.



To change fuel map view, click on '**View**', and then select either '**Incremental**', '**Time (ms)**' or '**Duty cycle (%)**'. The duty cycle view will naturally display higher percentages at high RPM readings and under heavy load.

When programming the fuel map, it can be useful to enable the ECU trace facility. To do this, click '**Trace ECU**'. The site you are editing will automatically follow the ECU, so you can adjust fuel mixture whilst watching dyno power outputs or AFR readings instead of looking at the computer screen.

You are also able to program the fuel map via a 3D visual representation. To view the representation click '**View cruise (3D)**'.

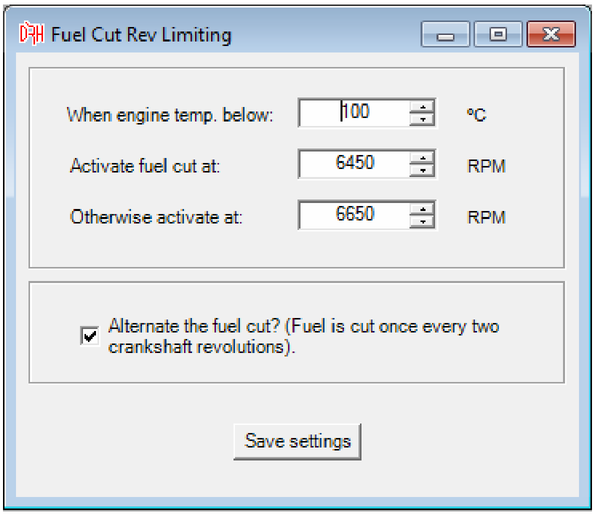


The 3D representation draws the fuel map as a three dimensional shape, making it easy to spot spikes or troughs in the fuel map. Typically, a smooth transition between fuel sites will be reflected in an equally smooth drive quality once the mapping process has been finished.

As with traditional table-based mapping, you can use the arrow keys to move to the site that you'd like to change. Then simply use 'Page up' and 'Page down' to adjust the fuel mixture as necessary. You can also press the 'S' key on the keyboard to permanently save any changes to the ECU.

Fuel Cut Rev-limiting

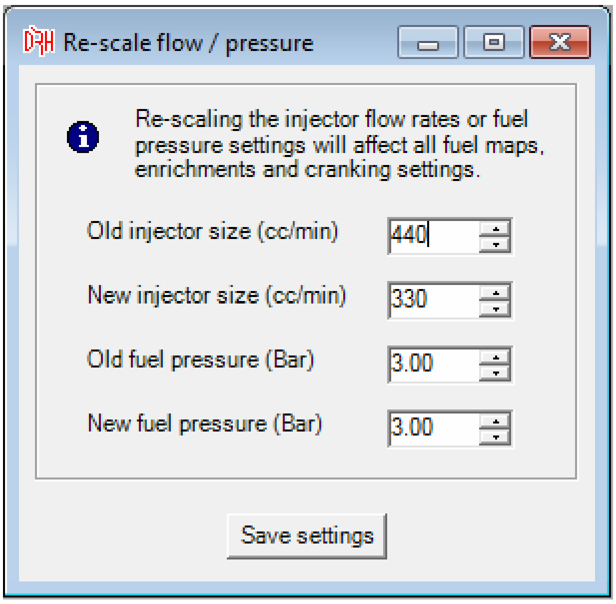
The ECU has the ability to cut fuel injection at a user defined engine speed. In factory Motronic installations, the fuel cut acts as a rev-limiter.



To access the fuel cut settings, click '**Fueling > Fuel cut rev-limiter**'. Both hot and cold settings are available, so it is recommended to use a lower rev limit when the engine is cold to prevent damage.

There is also an option to alternate the fuel cut between cylinder banks, cutting fuel once every two crankshaft revolutions. This has a less profound effect, so use with caution.

Re-scaling injectors



If it is necessary to replace the fuel injectors with those of a different size, all fuel parameters in the ECU can be modified accordingly. Click '**Fueling > Re-scale flow / pressure**'.

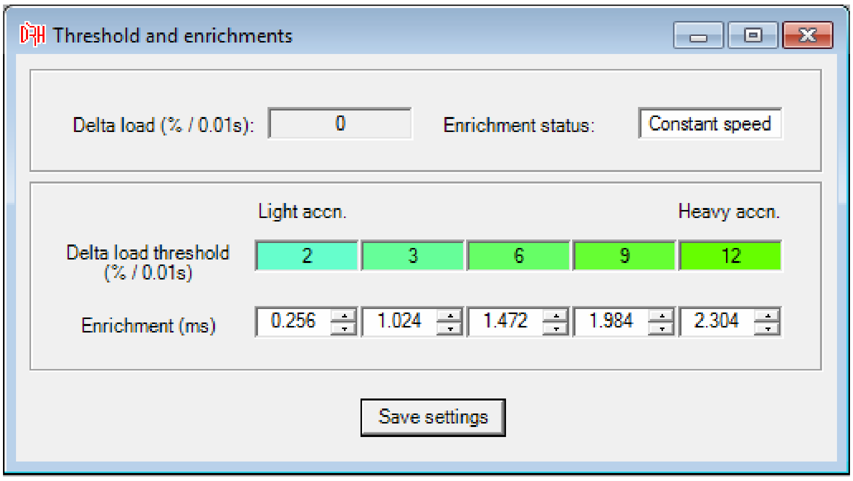
It is a simple case of entering the old injector flow rate and the new flow rate (both in cc/min). If the fuel pressure is remaining unchanged, enter the same values for new and old fuel pressure. Now click '**Save settings**' once only. The cranking settings, main maps and acceleration enrichments are all adjusted to compensate for the change in flow rate.

If a change in fuel pressure is necessary, enter the same flow rates for '*Old injector size*' and '*New injector size*'. Now enter old & new fuel pressures (both measured in Bar), and click '**Save settings**'.

Transient Fueling

The main fuel maps should be programmed to provide adequate fueling for a smooth driving style under all speed and load conditions. However, under rapid acceleration or aggressive driving, extra fuel enrichment may be required. This is the equivalent of a pump jet on a carburettor.

To view the acceleration enrichment settings, click '**Transient fueling > Thresholds and enrichments**'.



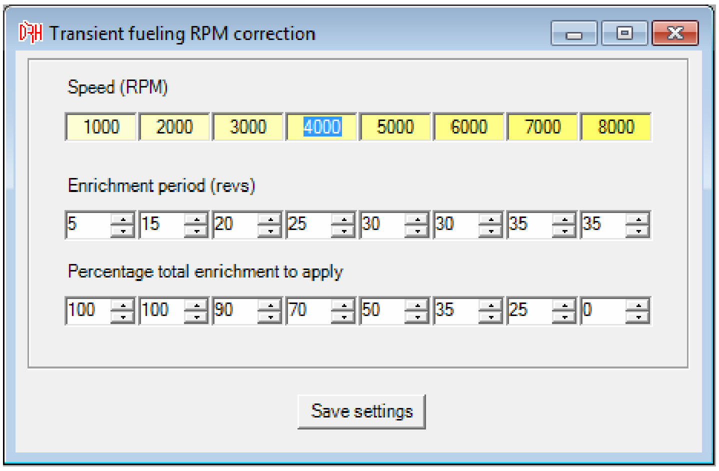
Enrichment is triggered by rapid depression of the throttle pedal (which in turn operates the throttle position sensor). The sensitivity of this trigger depends on the '*Delta load threshold*' setting. A low percentage value will easily be triggered, whereas a high value will need the throttle pedal to be depressed very quickly before triggering takes place.

To test the threshold value, press the accelerator and keep an eye on the box that reads '*Constant speed*'. If this box turns orange and instead reads '*Accelerating*', the threshold has been reached and acceleration enrichment enabled. The threshold should be set so that it is triggered by heavy acceleration.

You have five separate threshold values, which should increase from left to right, as in the screenshot above. A typical minimum value for activation is 3 – any less than this and you risk activating the transient enrichments through normal driving which will simply waste fuel.

The '*Enrichment*' values correspond to the amount of extra fuel that will be injected into the engine once acceleration enrichment has been triggered. Start with a low value to avoid flooding the engine. Increase the value until the engine accelerates smoothly. Remember to test this setting under realistic driving conditions; it's unlikely that any engine will respond well if the throttle pedal is rapidly pushed to the floor whilst idling.

Naturally, heavy acceleration will require a larger enrichment value than light acceleration to counteract the sudden change in air available to the engine.



To program the number of crankshaft revolutions for which acceleration enrichment is applied, click '**Transient fueling > RPM correction**'.

You are able to specify the number of crankshaft revolutions for which the enrichment is applied. Typically you will need to apply enrichments for a greater number of revolutions at high speed.

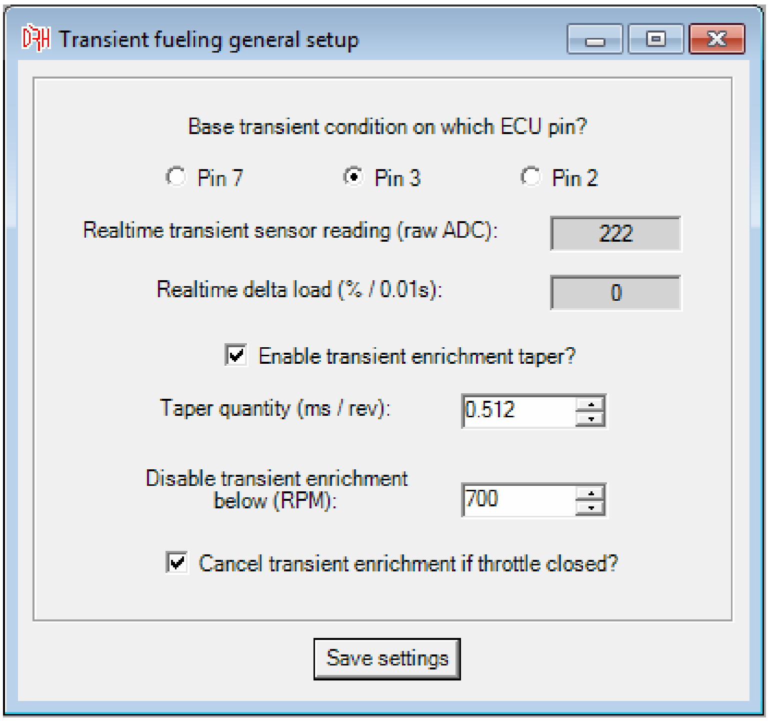
The engine will not require as much fuel at high speed. It is therefore possible to specify a percentage of the total enrichment to apply between 1000 and 8000 rpm.

To smooth out the transition from acceleration back to normal running, it is possible to taper the enrichment back to zero after enrichment has finished rather than abruptly jumping from full enrichment to no enrichment. To do this, click '**Transient fueling > General setup**'. From here you can enable or disable the transient enrichment taper.

It is also possible to specify a taper quantity (measured in milliseconds per rev). A smaller value here will result in a more gradual taper, but also have the effect of prolonging acceleration enrichment. Typical values will be in the region of 0.25 milliseconds.

Finally, it is possible to disable transient enrichments below a certain RPM. Typically this will be set to coincide with the idle speed of your engine.

You must specify the pin number on the ECU that is being used to detect transient conditions. Typically, this will be a throttle position sensor (in this example connected to pin number three).



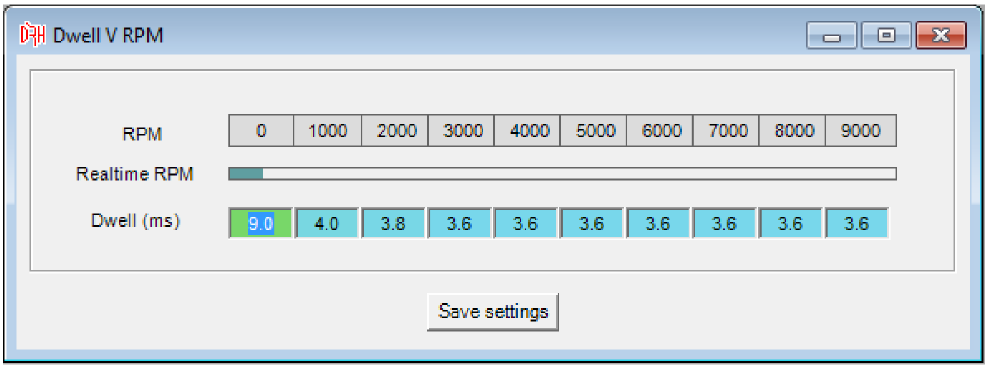
Ignition

The ECU supports distributor-based ignition for up to eight cylinders or DIS ignition for engines of up to six cylinders. The ECU can operate ignition independently from fuel injection, so programmable ignition can be achieved whilst still running carburettors.

Dwell

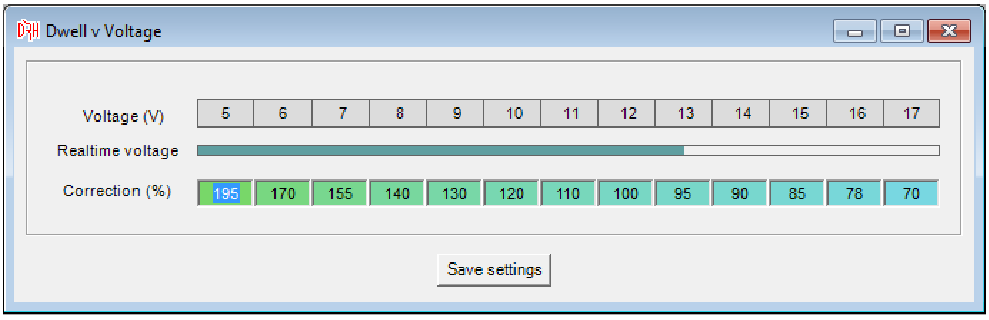
It is important to set the dwell characteristics in the ECU to suit the type of coils you are using. A dwell time that is too high can over charge the ignition coil and result in excessive heat / possible ECU damage. Conversely, a dwell time that is too short will not charge the ignition coil sufficiently, resulting in a weak spark / misfires under heavy load conditions.

To set the coil dwell time, click **Ignition > Dwell v RPM**. This will display the following screen:



You are able to specify dwell times such that they alter dynamically throughout the RPM range. The example above shows settings for a DIS coil pack (constant energy ignition – coil charge time does not diminish as RPM increases). With distributor based systems it's vital to decrease dwell time as RPM increases, or excessive heat will be generated within the ECU. Contact Canems if unsure.

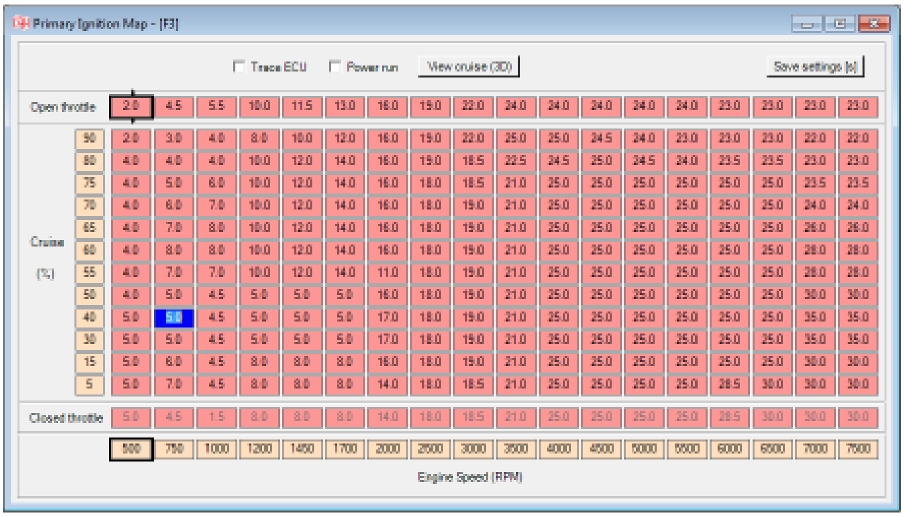
The dwell time is also corrected with regard to input voltage. To view these settings, click **Ignition > Dwell v Voltage**.



When the supply voltage drops below 12v, a coil will take longer to charge and therefore the percentage correction should be greater than 100%. The opposite is true when the voltage is higher than 12v. The correction should always be set to 100% at 12v.

Ignition maps

The ignition advance curve is fully programmable. There are two spark maps, each with 252 programmable sites between -20º and 49º. The spark maps are switchable at run-time via the map switching input (see *Map switching*). All values are interpolated (averaged) to give a smooth advance curve rather than jumping from site to site. However, interpolation can be turned off by setting the ECU into '*Map mode*', which makes mapping much easier. You can access the ignition maps by clicking '**Ignition > Primary ignition map**' or '**Ignition > Secondary ignition map**'. For easy access, you can also press **F3** or **F5**.

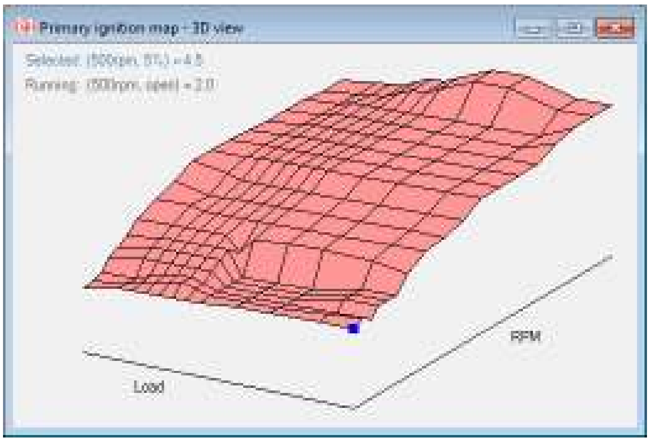


	500	750	1000	1200	1450	1700	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
Open throttle	2.0	4.5	5.5	10.0	11.5	13.0	16.0	19.0	22.0	24.0	24.0	24.0	24.0	24.0	23.0	23.0	23.0	23.0
Cruise (%) 90	2.0	3.0	4.0	8.0	10.0	12.0	16.0	19.0	22.0	25.0	25.0	24.5	24.0	23.0	23.0	23.0	22.0	22.0
80	4.0	4.0	4.0	10.0	12.0	14.0	16.0	19.0	18.5	22.5	24.5	25.0	24.5	24.0	23.5	23.5	23.0	23.0
75	4.0	5.0	6.0	10.0	12.0	14.0	16.0	18.0	18.5	21.0	25.0	25.0	25.0	25.0	25.0	25.0	23.5	23.5
70	4.0	6.0	7.0	10.0	12.0	14.0	16.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	24.0	24.0
65	4.0	7.0	8.0	10.0	12.0	14.0	16.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	26.0	26.0
60	4.0	8.0	8.0	10.0	12.0	14.0	16.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	28.0	28.0
55	4.0	7.0	7.0	10.0	12.0	14.0	11.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	28.0	28.0
50	4.0	5.0	4.5	5.0	5.0	5.0	16.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	30.0	30.0
40	5.0	5.0	4.5	5.0	5.0	5.0	17.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	35.0	35.0
30	5.0	5.0	4.5	5.0	5.0	5.0	17.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	35.0	35.0
15	5.0	6.0	4.5	8.0	8.0	8.0	16.0	18.0	19.0	21.0	25.0	25.0	25.0	25.0	25.0	25.0	30.0	30.0
5	5.0	7.0	4.5	8.0	8.0	8.0	14.0	18.0	18.5	21.0	25.0	25.0	25.0	25.0	28.5	30.0	30.0	30.0
Closed throttle	5.0	4.5	1.5	8.0	8.0	8.0	14.0	18.0	18.5	21.0	25.0	25.0	25.0	25.0	28.5	30.0	30.0	30.0

To program an ignition advance site, click the value you wish to modify. Then replace with the new advance value and press enter. Alternatively, use the arrow keys to navigate to a site and then use 'Page Up' or 'Page Down' to change the ignition advance. This will send the value to the ECU, which will start to use the new settings immediately. The status bar in the tuning software will show '*Calibration changed*'. This denotes the ECU settings have been modified, not saved. To store the settings permanently you must click '**Save settings**'.

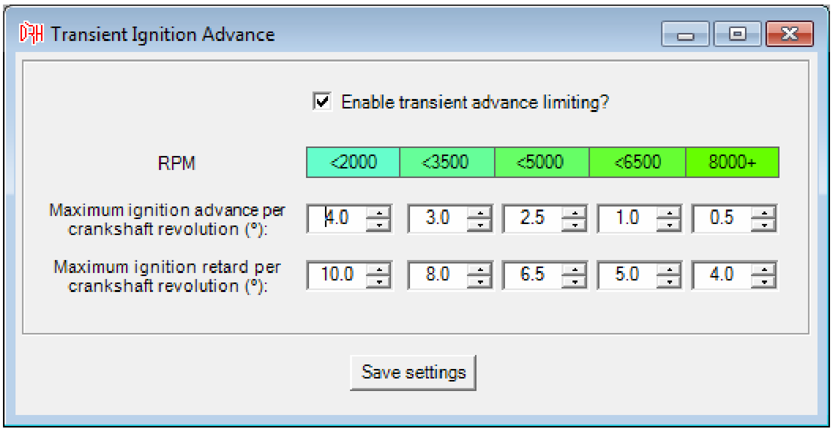
To view a 3D representation of the ignition map, click '**View cruise (3D)**'. This will launch a new window. The 3D view can be useful for smoothing peaks and troughs in the advance curve and ensuring that the map follows a general pattern.

When programming the maps, it can be useful to have a visual indicator as to where the ECU is currently operating. Click on '**Trace ECU**' either on the map itself or the 3D representation. This will display a black marker which points to the current position / value in the map. This is very helpful when mapping the system.



Resistor-type spark plugs should always be used. If in doubt, check, because using non resistor plugs can produce sufficient electrical noise to interfere with the ECU operation. Spark plugs should be gapped to approximately 0.035 inch for normally aspirated applications.

Transient Ignition Advance



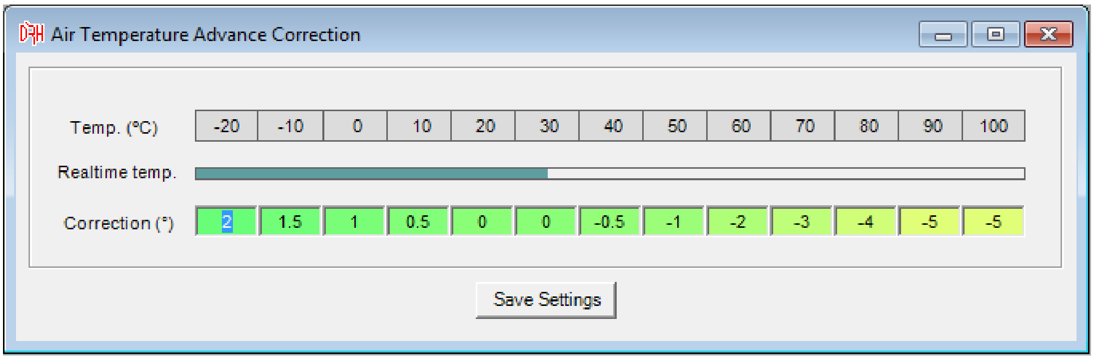
To prevent excessive strain from being placed on the engine, limitations can be placed on the rate-of-change of ignition advance. This is true for both advancing and retarding ignition, and can be programmed to act dynamically throughout the RPM range. To view these settings, click '**Ignition > Transient Advance**'.

Transient advance can be either enabled or disabled using the checkbox. If enabled, the advance settings come into play. In the example screenshot above, assuming that the engine is running at 6000rpm, the ECU will not allow the ignition to advance more than 2.5 degrees per crankshaft revolution. It'll not allow the advance to retard by more than 6.5 degrees per revolution.

Naturally, higher engine speeds will require a smaller ignition advance or retard limitation. In this example, the advance can only increase by 0.5 degrees per crankshaft revolution at engine speeds of over 8000rpm.

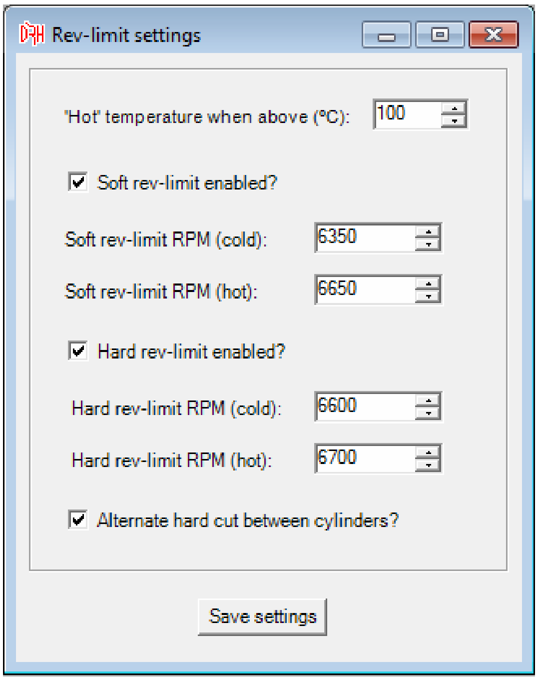
Engine Temperature & Air Temperature Adjustment

Along with engine speed and load, ambient conditions can also affect the amount of ignition advance that is required. Corrections are therefore available for air temperature and engine temperature. To access these, click '**Ignition > Air temp. adjust**' or '**Ignition > Engine temp. adjust**'.



It is possible to specify ignition advance correction in 0.5 degree increments, which will act on top of the advance figure calculated from the main ignition maps. In the example above, an ambient air temperature of fifty degrees Celsius would reduce the total amount of ignition advance by one degree.

Rev Limiters



Along with the fuel cut rev limiter (already covered in this manual), the ECU can use ignition advance and spark cut limiters to form a two-stage ignition limit.

To access the settings for these rev-limiters, click '**Ignition > Rev-limiters**'.

The first setting allows different RPM limits, dependant on engine temperature. It is recommended to reduce the limits significantly when the engine is cold, with an aim to preventing engine damage.

The hard rev limit will cut ignition completely once the activation RPM is reached. This will produce a very harsh cut which should be used in conjunction with a fuel cut limit, to prevent unburnt fuel from igniting when the engine speed has dropped.

An option is available to alternate the hard cut limit between cylinders. The aim of this is to give a softer impact and also prevent the possibility of spark plug fouling after prolonged periods at the rev limit activation point. A fuel cut limiter MUST be used in conjunction with this setting, as the alternating hard cut limiter may not be enough to stop the engine.

The soft cut rev limiter reduces ignition to ten degrees BTDC once the activation RPM is reached. Typically the activation RPM will be set just slightly lower than the hard limit point, acting to slow down acceleration in anticipation of the hard cut.

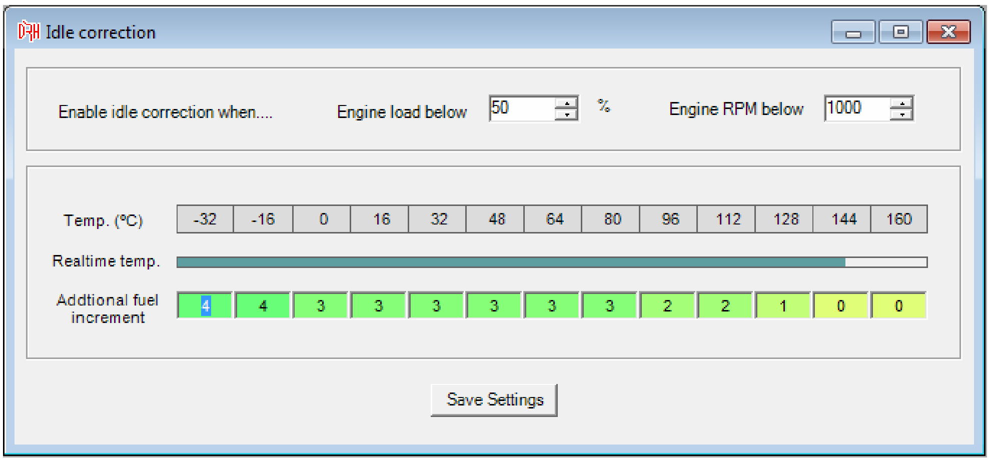
Atmospheric Correction – Cranking / Running

Dependant upon engine temperature, it is necessary to change the fuel mixture required when the engine is cranking. This is similar to operating the choke with a carburettor equipped engine. To alter these settings, click '**Atmospheric correction > Cranking correction**'. Under normal running conditions (ie. once the engine has fully warmed up), the correction percentage should be 100%. This indicates that no extra fuel enrichment is required. Under freezing point, enrichment may need to exceed 150%.

Once the engine has moved from cranking to running mode (the engine has started), the fuel correction is based on the 'running correction' values instead. To access these, click '**Atmospheric correction > Running**'. The layout for these settings is as above; a 2D map consisting of engine temperature against fuel percentage correction.

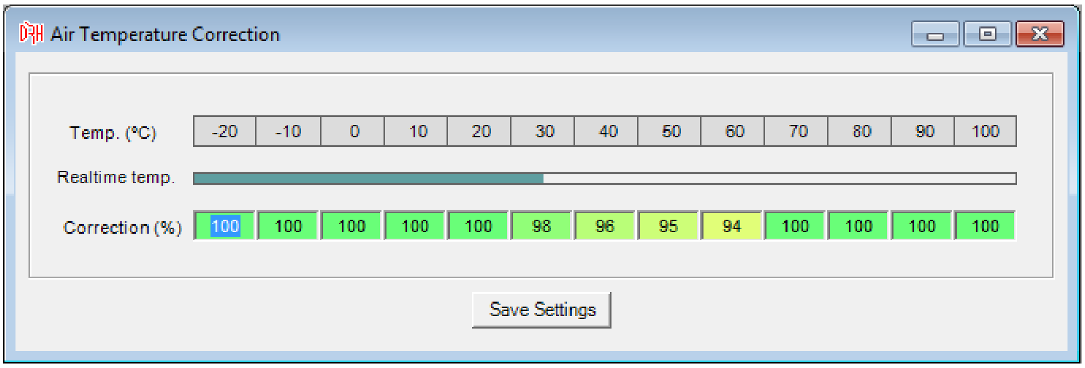
Idle correction

Air cooled engines are extremely sensitive to changes in cylinder head temperature at idle. The standard cranking/running corrections (described above) may not be enough to produce a smooth idle under all conditions. Thus, a further map is available under '**Atmospheric correction > Idle temperature correction**'.



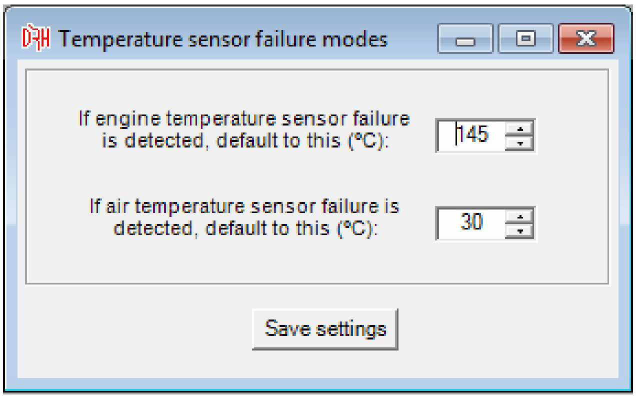
In the example above, engine load must be under 50%, and speed must be under 1000 RPM before the map will come into effect. If these conditions are met, the incremental fuel value from the main fuel maps will be added to the temperature-dependant additional value specified here. For example, if the engine temperature is sixteen degrees Celsius, the fuel value will be increment by three. Assuming the MSPB value is 64, the fuel pulse will be lengthened by (64 x 3) = 192 microseconds.

Air Temperature Correction



Ambient air temperature has a significant bearing on the fuel quantity required by an engine. Hot air is less dense, so less fuel is required to achieve a given AFR target. A 2D map of air temperature against fuel correction is therefore available under '**Atmospheric correction > Air temperature correction**'.

Sensor Failure Modes



As the ECU depends heavily on readings from the engine temperature and air temperature sensors, it's important that it should know what to do in the event of a failure.

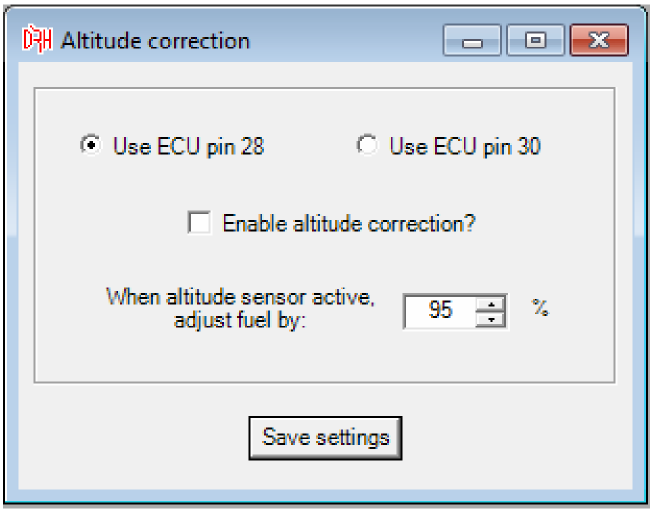
Settings under '**Atmospheric correction > Sensor failure modes**' achieve this. Should a reading go out of range (due to a wiring fault for example), the ECU will default to a certain temperature reading instead.

Altitude Correction

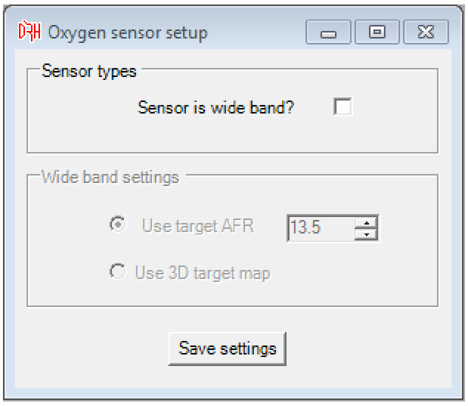
Most standard Motronic installations have an altitude pressure sensor built into the system. This is a simple on/off device, indicating whether the vehicle is operating in a low pressure area or not.

This can be connected to ECU pin 28 or 30, depending on the vehicle. Click '**Atmospheric correction > Altitude correction**' to view the settings for this sensor.

Fuel can be reduced by a user defined percentage if the altitude correction is activated.



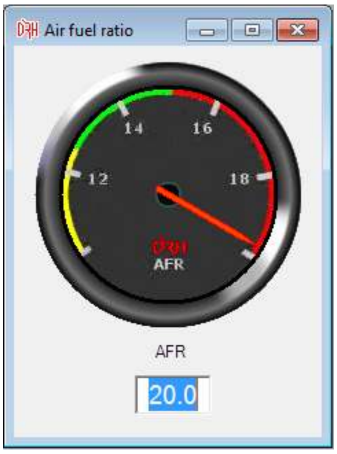
Oxygen sensing / feedback



The ECU can accept an input signal from either wide band or narrow band sensors. The ECU must be programmed to tell it which sensor is connected. To program the ECU, click **Oxygen sensing > Setup**. This will display the screen on the right.

To connect a wideband sensor to the ECU, you must program an analog output on the wideband sensor such that it gives an output of 0V for 10:1 AFR and 5V for 20:1 AFR. This analog output from the lambda sensor is then connected to the oxygen sensor input (pin 24) on the ECU.

Once connected, a lambda sensor allows real-time monitoring of the air fuel ratio being produced by the engine. To view lambda sensor readouts in the software, click **View > AFR gauge**.



Data logging can also be set up so that AFR inputs are recorded, along with the input conditions that produced these results. This can be very useful for diagnosing flat-spots or mixture problems in the rev-range. For more information see the *Data logging* section

Note that narrow-band sensors can only give accurate AFR readings in the region of 14.7. This AFR is known as the stoichiometric point. Deviations from this mixture (either richer or leaner) will not be reflected accurately by the software gauges or datalogger, though they will certainly show the general pattern.

Once the oxygen sensor has been installed, closed loop feedback control can also be implemented. This allows the readings from the oxygen sensor to have some authority over the amount of fuel that is being injected into the engine. For example, if the oxygen sensor detects a lean mixture, the ECU will add more fuel to compensate – until the oxygen sensor is satisfied.

Due to their limited range of AFR detection, narrow band sensors can only aim for an air fuel ratio of 14.7:1. Remember that this is too lean for older designs of engine, and too lean to produce maximum power from performance engines. If using a wideband sensor, you can specify a ‘target’ AFR or use a 3D target map.

When using a target AFR, you can tell the ECU to aim for any AFR between 10.0 and 20.0. Alternatively, using a 3D target map allows you to provide a target AFR for any possible speed or load combination (as per the main fuel and spark maps). To view the 3D AFR target map, click **Oxygen sensing > Target AFR map**.

AFR Targets

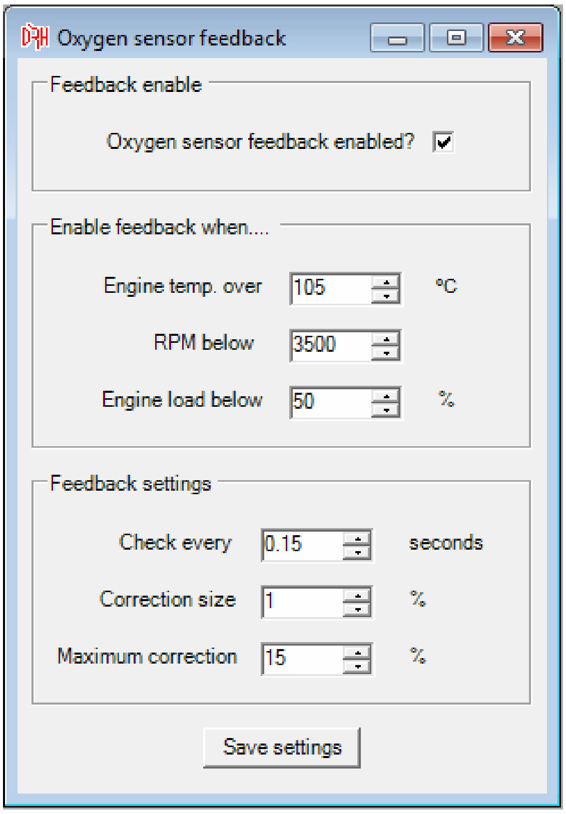
Trace ECU | Power run | View cruise (3D) | Save settings [s]

	500	750	1000	1200	1450	1700	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500
Open throttle	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Cruise (%) 90	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
80	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
75	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0	13.0
70	13.4	13.4	13.4	13.0	13.0	13.0	13.0	13.0	13.1	13.2	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3
65	13.5	13.5	13.5	13.4	13.4	13.4	13.0	13.0	13.0	13.0	13.0	13.1	13.2	13.3	13.4	13.4	13.4	13.4
60	13.6	13.6	13.7	13.8	13.8	13.8	13.4	13.5	13.5	13.4	13.4	13.4	13.4	13.4	13.5	13.5	13.5	13.5
55	14.0	14.0	14.3	14.3	14.3	14.4	14.3	14.1	14.0	13.9	13.7	13.7	13.8	13.8	13.8	13.8	13.8	13.6
50	14.3	14.3	14.3	14.3	14.3	14.5	14.6	14.7	14.8	14.6	14.6	14.2	14.0	13.8	13.8	14.0	14.0	14.0
40	14.2	14.2	14.2	14.5	14.5	14.5	14.5	14.5	14.5	14.7	14.8	14.9	14.9	14.8	14.6	14.2	14.0	14.0
30	15.0	14.9	14.8	14.4	14.4	14.4	14.5	14.5	14.5	14.5	14.5	14.6	14.7	14.8	14.9	14.9	14.8	14.7
15	14.9	15.0	15.0	15.0	14.9	14.9	14.7	14.6	14.6	14.7	14.7	14.7	14.7	14.7	14.7	14.8	14.9	15.0
5	13	14.9	14.9	15.0	15.0	15.0	15.0	15.0	15.0	14.9	14.8	14.8	14.8	14.8	14.8	14.8	14.8	14.8
Closed throttle	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.9	14.9	14.9

Engine Speed (RPM)

It is important to remember that the oxygen sensor is relatively slow to react to changes in AFR. Therefore, an oxygen sensor should never be relied upon to provide accurate fueling when an engine is under full load. Instead, set the closed-loop feedback to activate when certain conditions are met.

To view the oxygen sensor feedback settings, click **Oxygen sensing > Feedback settings**. From here, you can enable or disable closed loop feedback control.



There are three enabling requirements, all of which are programmable. These requirements must be met before closed-loop control activates.

Feedback should be disabled when the engine is cold, because we don't want the oxygen sensor to try leaning out a purposefully rich mixture.

Feedback should be disabled above a certain RPM, so that there will be no mixture adjustment whilst the engine is under load.

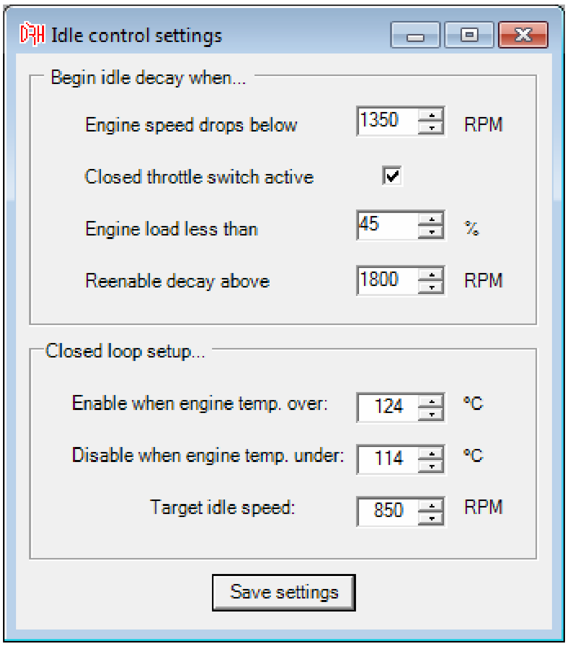
Finally, closed-loop feedback should be disabled if the throttle is opened more than a certain percentage. This will prevent any enrichments from being leaned out during heavy acceleration.

The feedback rate is entered in the 'Check every…' box. A fast feedback rate is not necessarily best, because the engine will not respond quickly enough to changes in fueling. This can lead to a 'hunting' condition, where the mixture alternates between too rich and too lean.

Idle control – Basic settings

Within the ECU firmware there are essentially three modes of idle control. When cold, the idle valve operates in an open loop mode (no feedback from the engine speed sensor is used to adjust the idle speed). When hot, the idle valve enters a closed loop mode. The idle speed is automatically adjusted to an idle speed of your preference. The third mode of operation is called 'Idle Decay'. This aims to prevent the engine from stalling if the RPM suddenly drops, such as unexpected braking at a junction. The valve will gradually taper the idle speed rather than attempting to drop the engine to idle speed immediately.

All two and three wire PWM valves are compatible with the ECU. To access the basic idle control settings, click '**Idle control > Idle control settings**'.



The first settings you can modify are the enabling conditions, used to enter idle decay mode. Normally idle decay will trigger when the engine speed drops under around 1300 RPM, with light engine load and the throttle closed.

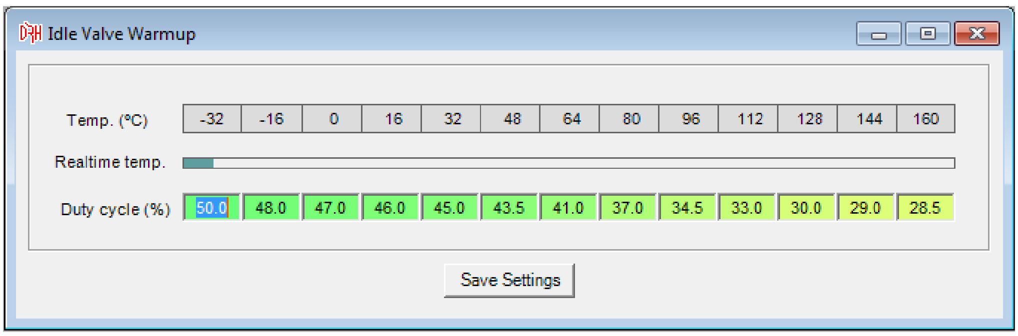
To ensure idle decay is not triggered erroneously, there is also a setting to re-enable idle decay, once crankshaft speed has exceeded a certain limit. In this example, 1800 RPM.

Closed loop operation should only begin once the engine has reached operating temperature. When the engine is warming up, it'll naturally require a higher idle speed.

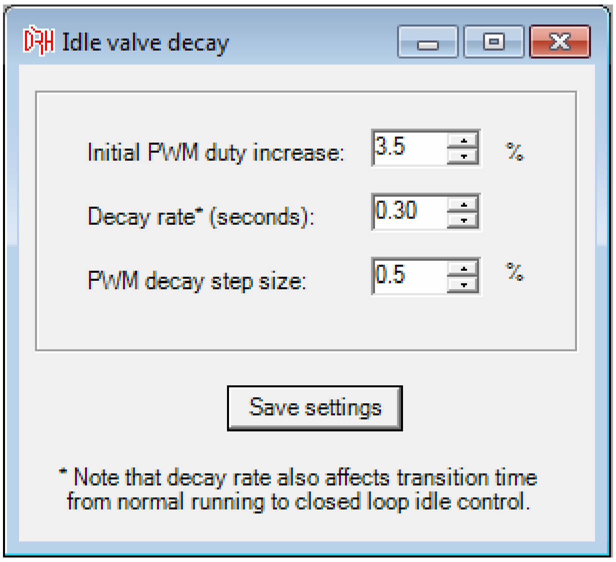
Therefore, enabling and disabling conditions for closed loop control are available. To prevent instability on the temperature switchover point, the enabling temperature is normally set around ten degrees higher than the disabling temperature. The target idle speed is also specified amongst these basic settings.

Idle Valve Warmup

To access the idle valve warmup map, click '**Idle control > Idle valve warmup**'. This reveals a 2D map, specifying engine temperature against idle valve duty cycle. These settings form the open loop part of the idle control strategy. Duty cycle can be specified to 0.5%, decreasing as engine temperature rises.



Idle Valve Decay

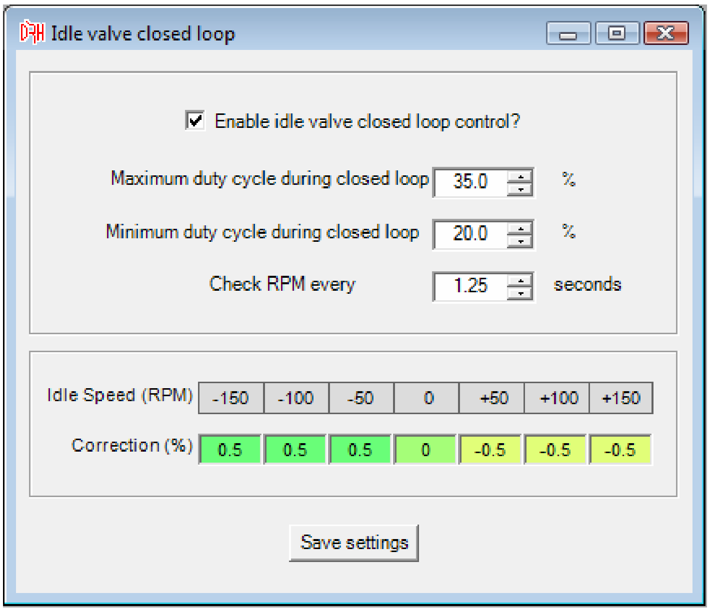


Once the ECU enters Idle Decay mode, it aims to gradually reduce engine speed until normal idle speed is reached. This prevents the risk of stalling or misbehaving at junctions.

Three adjustable settings are available, under '**Idle control > Idle valve decay**'.

Firstly, the 'Initial PWM duty increase'. This specifies the amount of extra air that is provided when the engine drops to idle speed. In this example, the idle valve duty cycle increases by 3.5%.

The idle valve duty cycle then decrease by '*PWM decay step size*' every '*Decay rate*' seconds. The duty cycle continues to decay until it reaches the value that you've specified in the Idle Valve Warmup map. Naturally this is temperature dependant, so the idle decay feature works successfully throughout the warmup cycle.



Idle Valve Closed Loop

To enable closed loop idle control, click '**Idle control > Idle valve closed loop**'. From this menu, you can enable closed loop control.

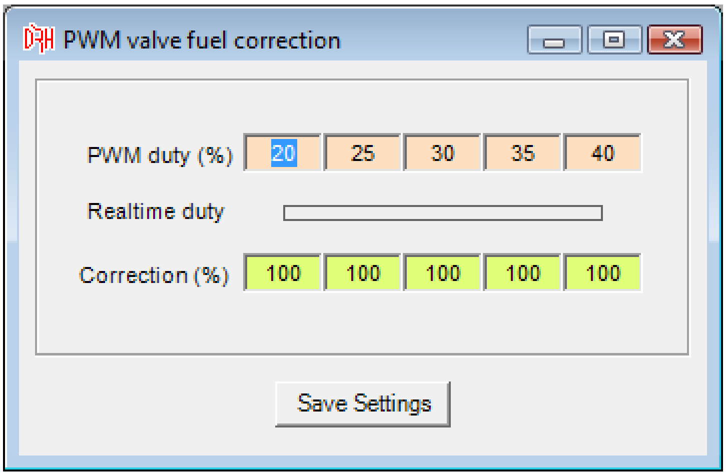
To calculate duty cycle, the 2D Idle Valve Warmup map is used as a starting point. The engine speed is then analysed by the closed-loop software. If it's too fast, the duty cycle will be reduced. Conversely, if the engine speed is too slow, duty cycle increases.

Incorrect settings can therefore easily create a 'hunting' idle with an unsteady RPM.

You are able to specify minimum and maximum duty cycles. These settings prevent over-correction from the closed loop software. The 'Check RPM every X seconds' figure is important for a stable idle too. It's important that the engine has long enough to respond to a change in duty cycle, but also that the RPM is analysed frequently, so that the RPM can be adjusted quickly enough.

At the bottom of the menu, there is a 2D correction map. This gives you control over the idle valve response during closed loop operation. When the idle speed is too low, the correction percentage is a positive number. This indicates that the idle valve duty should increase. When the idle speed is too high, the correction percentage is a negative figure. This will reduce the idle valve duty cycle and reduce the amount of air available to the engine. If the idle speed is perfect, the correction should be zero, indicating that no change is required from the current idle valve duty cycle.

PWM Valve Fuel Correction



If you are using a throttle position sensor to measure engine load, you can still use a PWM idle valve.

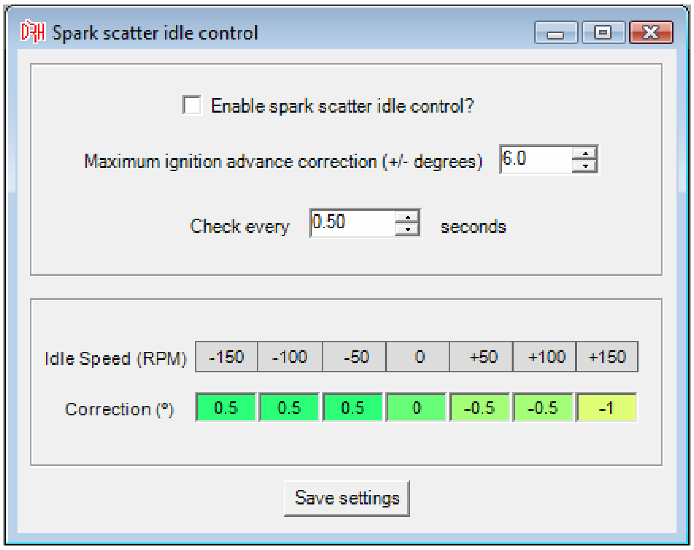
However, because there is no automatic mixture enrichment due to higher manifold pressures (as there is with a MAP/MAF sensor), we must use PWM valve fuel correction. This option is available under '**Idle control > Idle valve fuel correction**'.

The PWM duty should range from the lowest percentage to the highest percentage in your Idle Valve Warmup map. When the PWM duty is lowest, fuel correction should be set at 100%. The correction percentage should then increase from left to right, such that the quantity of fuel increases as the idle valve opens. This balances any extra air with extra fuel, keeping the fuel mixture consistent throughout the warmup cycle.

Note that the correction figures should always be set at 100% if you are not using a TPS to measure engine load and you are not using a PWM idle valve.

Spark Scatter Idle Control

The DRH Performance ECU is also capable of spark scatter idle control. This is where the ignition timing is adjusted to maintain a target idle speed. To view the settings click '**Idle control > Spark scatter idle control**'.

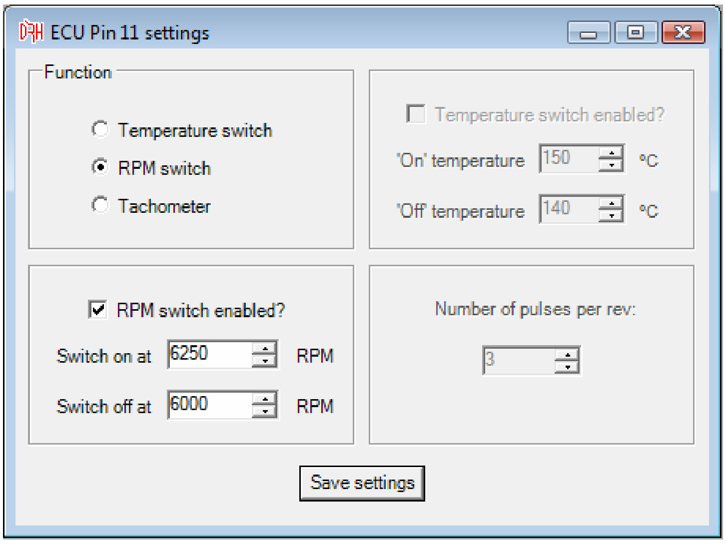


To activate spark scatter idle control, click '*Enable spark scatter idle control*'. The '*Maximum ignition advance correction*' figure denotes the maximum advance adjustment that can be made. In the screenshot above for example, if the engine is running with a timing figure of 16°, the spark scatter control has the authority to move the ignition timing anywhere between 8° and 24°.

'*Check every*' is the rate at which the engine speed is analysed and, if necessary, corrected. If the rate is too slow, the ignition advance will not respond quickly to changes in engine speed. On the other hand, if the rate is too quick, the closed loop control may over compensate and cause the engine to enter a hunting condition. Like the PWM valve idle control, the correction map is based on the difference between engine speed and target idle speed. If these two speeds are equal, there should be no correction. If the engine RPM is too high, the ignition should be retarded so the correction value should be negative. The opposite is true when the engine is running too slowly; in this case, the ignition timing should be advanced. After changing any settings, remember to click '**Save settings**'.

ECU Outputs

The DRH Performance ECU has two general purpose outputs; pin 11 and pin 21. To view the settings for an output pin, click '**Inputs / Outputs > ECU pin X**'.



The output pins can be used as temperature switches, to operate electric cooling fans (via a relay) or to operate a temperature warning lamp on the dashboard.

They can also be used as RPM switches, typically as a gearshift warning indicator.

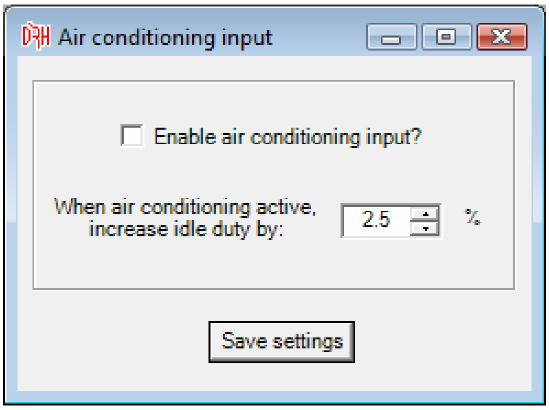
Finally, the output pins can also be used to drive a tachometer with a 12V digital output. You can specify the number of pulses per crankshaft revolution (eg. three pulses per rev. for a Porsche flat-six).

Air Conditioning Input

Some vehicles fitted with the Motronic ML1.X management system were also supplied with air conditioning.

The air conditioning pump can place a heavy load on the engine, so it's important to provide more air. This prevents the idle speed from dropping too low.

Pin 29 on the ECU accepts a 12V signal from the air conditioning system. When the air con is active, idle valve duty cycle can be increased by a specific amount.



To access this setting, click '**Inputs / Outputs > Air conditioning**'. From here, you can enable or disable this input pin, and specify the percentage increase in duty cycle. The increase in duty cycle is applied during open loop, decay mode, and closed loop idle valve operation.

Switchable Maps

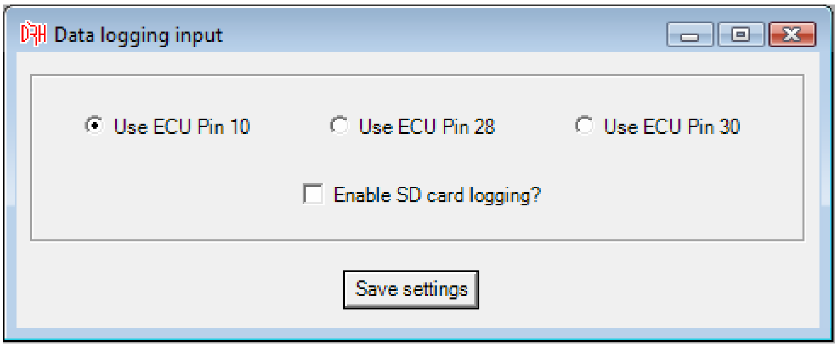
The DRH Performance ECU gives you the option of running two entirely different fuel and ignition maps. This is useful if you're looking for sport/economy modes, or perhaps use two different petrol octane ratings.

To view the settings, click '**Inputs/Outputs > Switchable Maps**'. You can then enable the switchable maps function, and specify which input pin you'd like to use on the ECU; either pin 10, 28 or 30.

SD Card Datalogging

The DRH Performance ECU can record data logs in real-time to an onboard SD memory card. This can be useful either in competition or for diagnosing long-term faults that occur infrequently. Typically the onboard data logger operates with a frequency of over 20Hz.

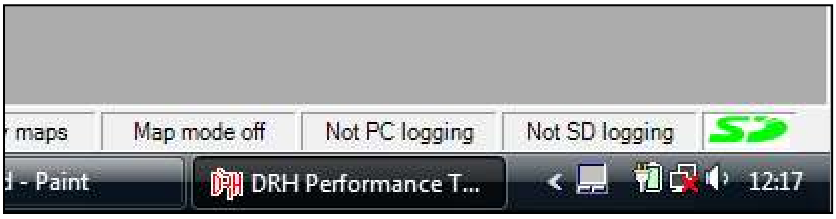
The onboard data logger is turned on and off by a switch (typically dashboard mounted). You must therefore specify which input pin is connected to the switch; either pin 10, 28 or 30. To access this setting, click '**Inputs/Outputs > Data logging input**'. You must also click 'Enable SD card logging' before use.



Before using the SD card data logger, you must erase your memory card. **This procedure will remove all existing data from the card** – make sure you have copied any photographs or documents onto your PC beforehand.

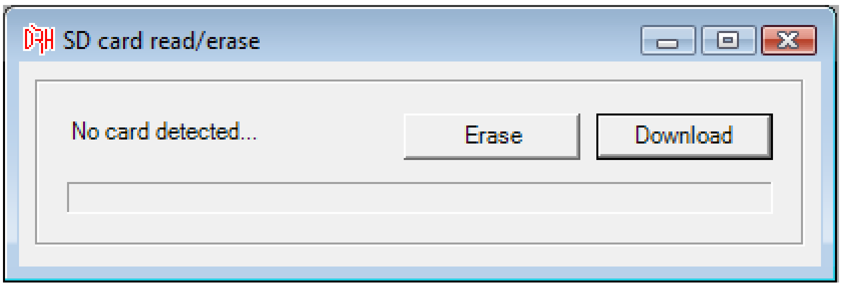
The SD card must be fully inserted into the ECU before turning on the vehicle ignition. The card is a gentle push-fit into the rear of the unit, with the metal contacts facing upwards (towards the top of the ECU).

Once the SD card is inserted, and the vehicle ignition is turned on, you'll notice that the 'SD' icon in the bottom-right hand corner of your screen has changed from red to green.



This green 'SD' icon indicates that the ECU is successfully communicating with your SD memory card and is ready for use. However, before you actually start to data log, you MUST erase the memory card.

To erase the memory card, click '**Logging > SD Card Read/Erase**'. This will display the menu below.



To erase the card, simply click 'Erase'. This is a quick procedure that only takes a moment to complete.

Once you have erased the memory card, you are ready to start logging. Simply flip the switch on your dashboard, and the data from your engine will be saved automatically.

You can save up to 255 separate data logs on a single card, with the length of each log only limited by the capacity of your memory card. Realistically, even a 1GB card will store sufficient data for around one week of continuous logging.

To finish an onboard data log, you must turn off the data logging switch on your dashboard. Do not simply turn off the vehicle ignition, because the ECU needs to finalise the data and write it to the SD card before power is removed from the system.

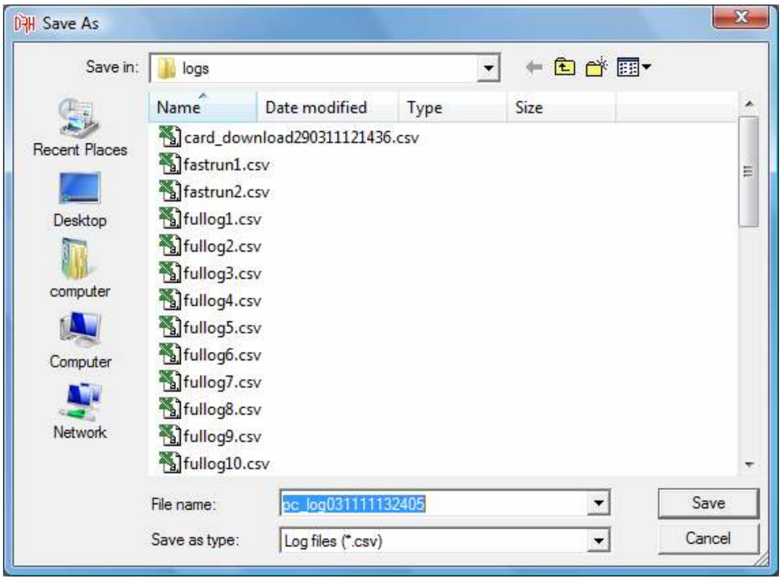
To download an SD card file, click ‘**Logging > SD card read/erase**’. The SD card must be inserted in the ECU, with the ignition power on. Then click ‘Read’. You will be prompted for a suitable file name (although the current date and time is used as a default). Click ‘Save’ to start the download. Download time depends on the size of your data log. You are kept up-to-date with progress via the on-screen progress bar.

PC-based Data Logging

If you just need to perform a quick data log, and you don’t mind having the PC in your vehicle, you can also log directly to the PC hard disk.

To do this, click ‘**Logging > Start PC logging**’. You are then prompted for a suitable file name (the current date and time is used as a default).

Click ‘Save’ to start the download. Once you have finished data logging, click ‘**Logging > Stop PC logging**’.

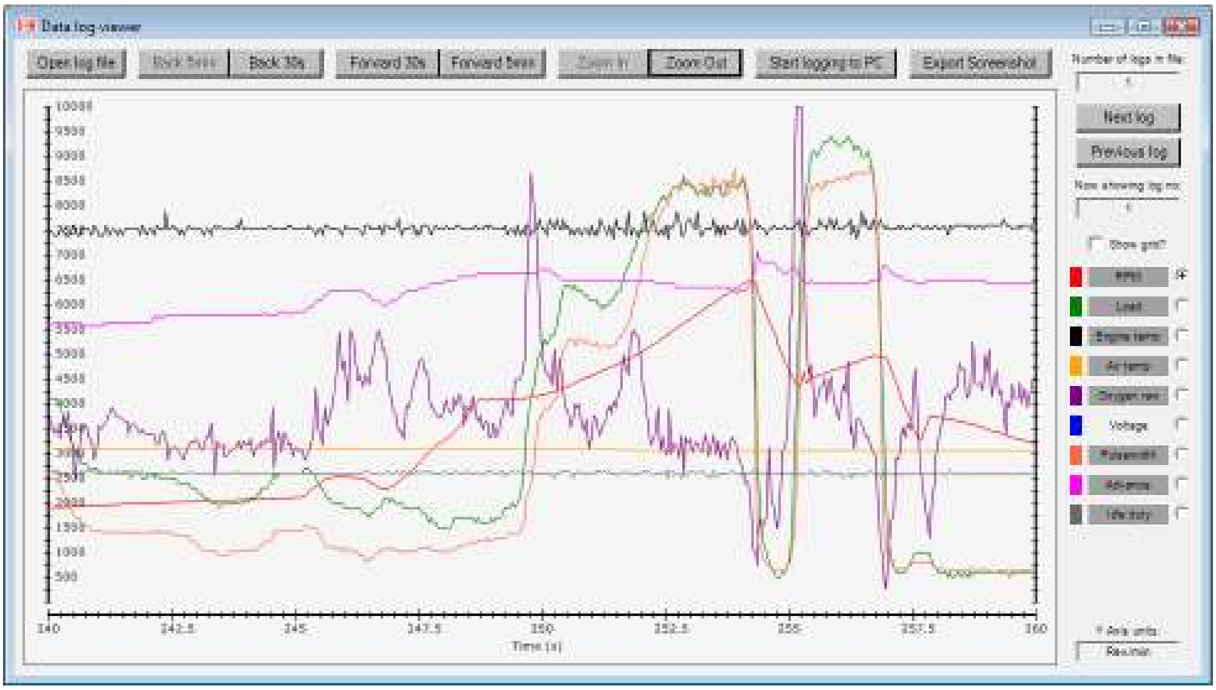


When you are data logging (either with the on board memory or via a connected PC), the status bar panels in the bottom-right hand corner of your screen will highlight in orange. An example screenshot is pictured below, indicating that the PC Data logging is currently active.

Log Viewer

Once you have saved a data log (either PC-based or via your SD card), you can use the Log Viewer tool to graphically illustrate the engine behaviour. Click ‘**Logging > Log Viewer**’.

You must then select the data log that you wish to view, by clicking ‘Open log file’. Select the correct file name and click ‘Open’. This will display the data in a graphical format as shown below.



You can zoom in and fast forward in time, using the buttons at the top the screen. You can also export a bitmap image file to your PC (ideal for showing to a customer if you have traced a fault on their car).

If you have downloaded the log file from an SD card, it is possible that you might have multiple different logs on the same card. The text boxes on the right hand side of the screen will tell you how many separate logs are in this file, and you can then use the ‘Next log’ or ‘Previous log’ buttons to swap between them.

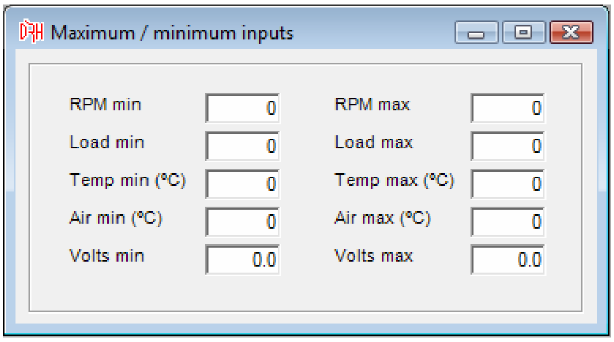
Finally, you can choose which items you want to display on the Log Viewer. For example, if you’re not interested in engine temperature, simply click ‘Engine temp.’ This will remove the individual trace from view, simplifying the readout for you.

Viewing raw data

Data logs from the DRH Performance ECU are saved in a comma delimited file (.csv) which makes it easy to import the data into third-party analysis software such as Microsoft Excel®. In most cases, simply double-clicking on the log file will open your chosen spreadsheet software. You can then build your own charts or even write macros to analyse the performance of your engine.

Diagnostics - Maximum / minimum readings

When your PC is connected to the ECU, the maximum and minimum values for all engine parameters are stored automatically. This can be of great help if you are trying to diagnose a fault with the engine management system. For example, if the maximum engine temperature recorded on a long run is 20°C, it's a fair bet that the sensor or wiring is faulty.



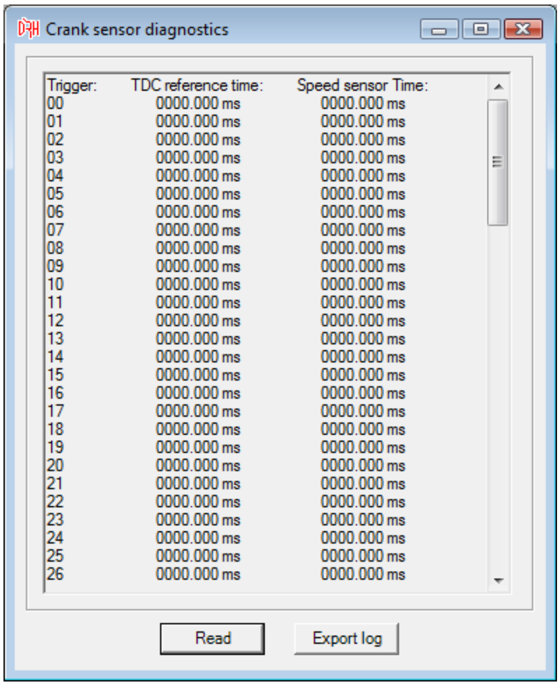
To view the maximum/minimum inputs, click '**Diagnostics > Min/max inputs**'. Similarly, to view the maximum/minimum output values, click '**Diagnostics > Min/max outputs**'.

Crank sensor diagnostics

Crank sensors can cause problems on the Motronic ML1.X installations, and it doesn't help that there are two sensors that can deteriorate.

Using the DRH Performance ECU, it's possible to data log the first one hundred crank sensor pulses, for both the TDC reference sensor and the flywheel speed sensor.

Naturally, the TDC reference time should equate to one crankshaft revolutions, whereas the speed sensor time should equate to one crankshaft revolution divided by the number of flywheel teeth (129 in the case of Porsche 911, 116 for most BMWs etc.)



To take a crank sensor reading, turn on the vehicle ignition and crank the engine. It doesn't matter whether the engine actually starts or not (making this a valuable diagnostic tool in the event of a non-start situation). Leave the vehicle ignition turned on, even if the engine fails to start. Now click '**Diagnostics > Crank sensors**'. This will display the screen shown above.

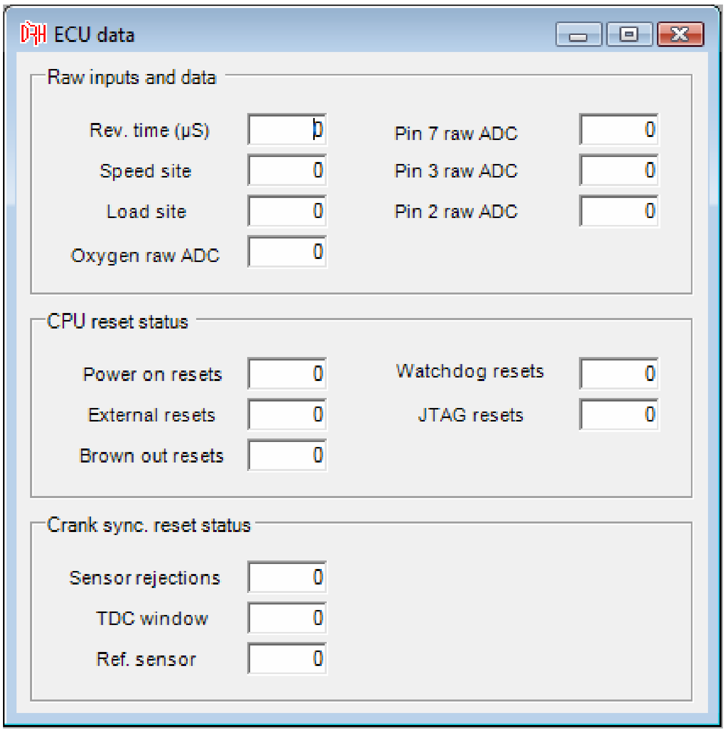
Click 'Read' to download the crank sensor pulse times. It will immediately be apparent if there is no activity from either sensor, which is the most common failure mode in the case of a non-starting vehicle.

Finally, it is also possible to export the crank sensor diagnostic log into a text (.txt) file. This is ideal if you are a mechanic and you have located a problem with a customers' vehicle.

Diagnostics – ECU Data

At any time, you can view raw data as seen by the ECU itself. This can help to diagnose any problems with your engine management system. Amongst other readings, you can view the raw analogue-to-digital converter (ADC) readings for the oxygen sensor input, pin 2, pin3 and pin7 on the ECU.

To view these ADC inputs in real-time, click ‘**Diagnostics > ECU data**’.



In use, your ECU should never reset. However, if you have a fault with the engine management system (such as badly corroded earth connections), it is possible that this could occur. In a moving vehicle, this will be felt as a short misfire.

The DRH Performance ECU records any such faults, andthese are displayed in the ‘ECU data’ box.

Firstly, the ‘CPU reset status’ records any faults with the power supply to the ECU. It is normal for the ‘Power on resets’ figure and the ‘Brown out resets’ figure to increase by one count, every time you start the engine.

If these figures are increasing when the engine is running, or they correspond with a misfire, there is a power supply issue.

If a fault is detected with the crank sensor inputs, the ECU will also reset and record a fault code. This is because it has lost the location of TDC and needs to relocate the crankshaft position. Thus, if the ‘Sensor rejections’ figure is increasing, corresponding with a misfire, then you have a fault with the crank sensor and/or associated wiring.

Diagnosing Faults

It is not possible for the DRH Performance ECU to function correctly if you already have a fault with your engine management system. Ensure that any problems with the factory-fitted Bosch Motronic system are resolved before the ECU is replaced.

Naturally you can use the DRH Performance ECU as a ‘known-good’ unit if you are having problems with a vehicle. You can also use the data logging features and real-time readouts to pin point any existing problems.

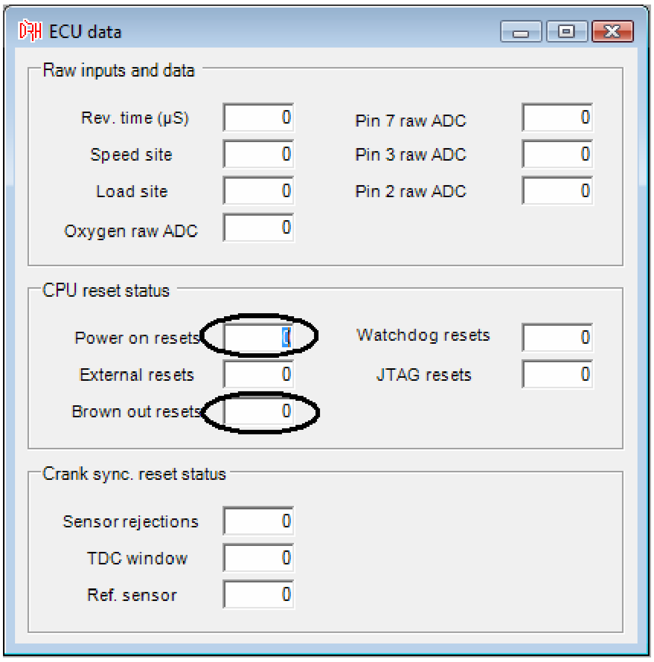
Symptom	Check list
No start	· Check that the ECU has a 12V power supply at ECU pin 18 and 35. If not, suspect main relay or poor earth connections. · Does the fuel pump run for two seconds when the vehicle ignition is turned on? If not, suspect main relay or poor earth connections. Check for 12V at fuel pump connections. Possible faulty fuel pump. · Check for spark at sparking plugs. If no spark, suspect coil(s), power supply. · Check for 12V at fuel injectors. · Check for adequate fuel pressure at injector fuel rail. · Faulty crank sensor(s). Check using crank sensor diagnostic tool in ECU.
Hesitating / misfiring under load	· Defective air flow meter (if fitted). Use data logger to check for uneven output signal. · Poor fuel supply. Replace filter, check fuel pressure, clean fuel injectors. · Poor spark quality. Check condition of ignition components.
Rich mixture	· Check engine temperature / air temperature sensor operation
Hunting at idle	· Idle speed requires manual adjustment · Vacuum leaks (manifold to cylinder head) or vacuum piping to fuel pressure regulator and/or accumulator.
Stalling	· Idle speed requires manual adjustment on throttle body. · Dirty or sticking idle valve unit – remove and clean or replace.
Misfiring at high RPM	· Make sure all earth points are very clean. Particularly battery to chassis, and main engine management loom to engine block. · Crank sensor gaps to flywheel are too small. · Insufficient fuel. Check fuel pump and or regulator.
Backfiring	· Non-resistor type spark plugs fitted. · Poor earth connections. · Inadequate fuel supply.

Power supply

If you are unable to communicate with your ECU unit, via the connected PC, it is possible that no power is reaching the ECU. You should also hear the fuel pump run for two seconds when the vehicle ignition is turned on. Failure of both of these tests would indicate a problem with the main relay; a common fault with the Motronic 1.X systems.

If you have an intermittent power supply issue (normally caused by a faulty main relay with poor contacts), it is likely that you’ll experience stumbles or misfires on a running vehicle.

To diagnose an intermittent power supply problem, click '**Diagnostics > ECU data**'.



The 'Power on resets' figure and 'Brown out resets' figure should not increase when the engine is running.

A perfect reading here would be one; indicating that 12V power was applied to the ECU and the engine started in one attempt.

It is common for poor earth connections to cause these symptoms too. Ensure that the connections from battery to body, body to engine and wiring harness to engine are scrupulously clean.

Closed throttle / open throttle switches

It is common for the throttle switches to cause problems with Motronic 1.X systems. The delicate micro-switch contacts suffer from exposure to heat and dirt.

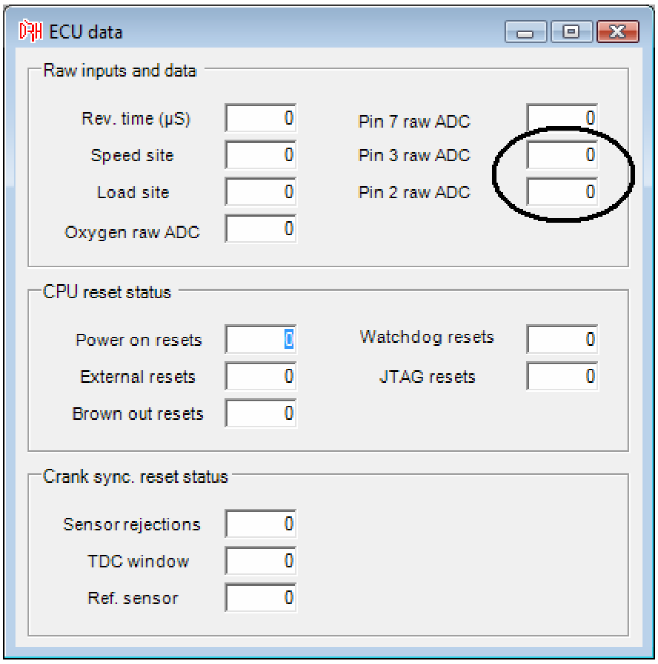
Click '**Diagnostics > ECU data**' to view the raw ADC data visible to the ECU.

'Pin 3 raw ADC' should change markedly in response to full throttle (press the accelerator pedal to the floor).

Failure usually results in a lean fuel mixture at full throttle.

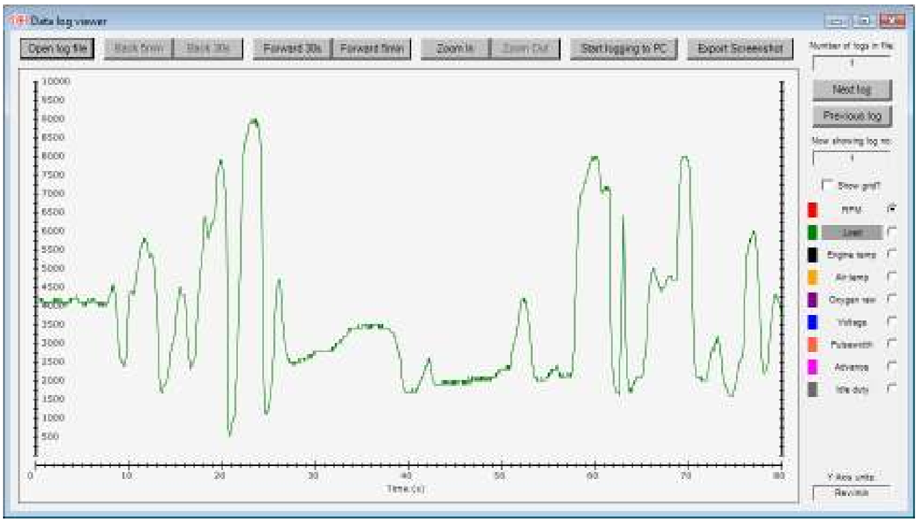
'Pin 2 raw ADC' should change markedly as soon as you apply light pressure to the throttle pedal.

Failure usual results in an unstable idle with an excessive idle speed.



Air flow meter

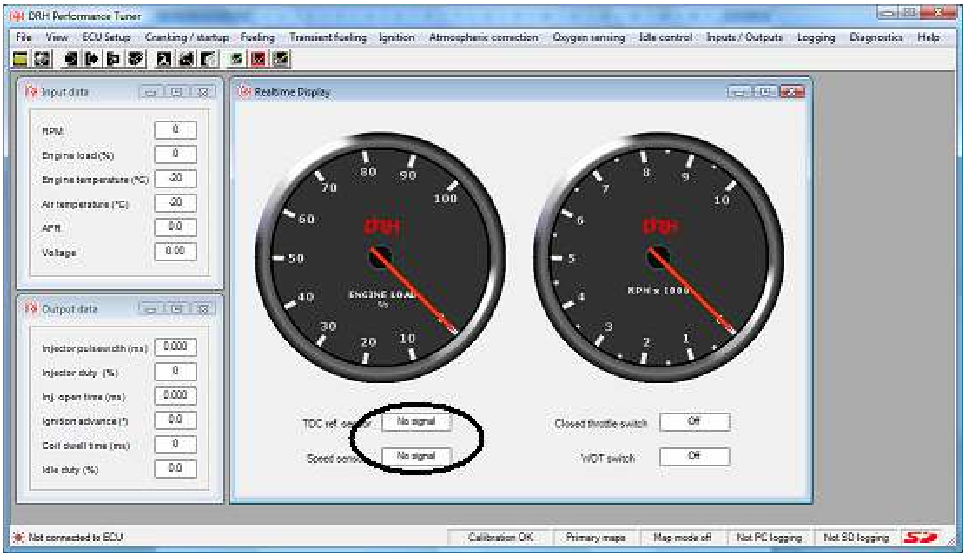
The air flow meter acts in the same manner as a potentiometer, so it is expected that the output signal will be smooth with no sudden peaks and troughs. The best way to analyse this output is to perform a data log (see *PC-based data logging*).



This example data log represents the output from an air flow meter in perfect working order. With a faulty sensor, you will typically recognise a sudden drop in output voltage – corresponding to a worn or dirty carbon track inside the air flow meter itself.

Speed sensor / TDC reference sensor

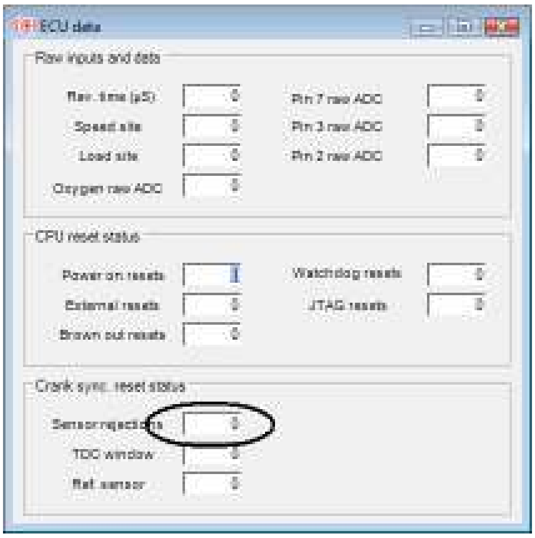
If you suspect that the speed sensor or TDC reference sensor may be faulty, there are three possible diagnostic checks. Firstly, if the engine will not start at all, look at the main dashboard when you start the DRH Performance Tuner software.



Initially, the two boxes (circled) will read '*No signal*'. Once the ECU successfully receives a signal, during cranking, these two boxes will change in colour, and then read '*OK*'. If this is not the case, replace the defective sensor and/or check the wiring loom for faults.

If the engine has difficulty starting in certain conditions (ie. damp / very hot / very cold), you can record the input signals from each crank sensor for the first one hundred input pulses. This has already been covered in the section entitled '*Crank sensor diagnostics*'. After the first twenty or so pulses, the times between crank sensor events should remain constant. That is, until the engine fires (when the times will drop significantly due to increasing crank speed).

Finally, the ECU will also record any faults when the engine is actually running. Normally a crank sensor fault will result in a harsh misfire or stumble, only lasting a fraction of a second. This is because the ECU needs to relocate TDC before it can safely continue.



Click '**Diagnostics > ECU data**' to analyse the crank sensor behaviour.

Any faults caused by the crank sensors will be recorded in the 'Sensor rejections' box. This number increases every time the ECU has attempted to find TDC.

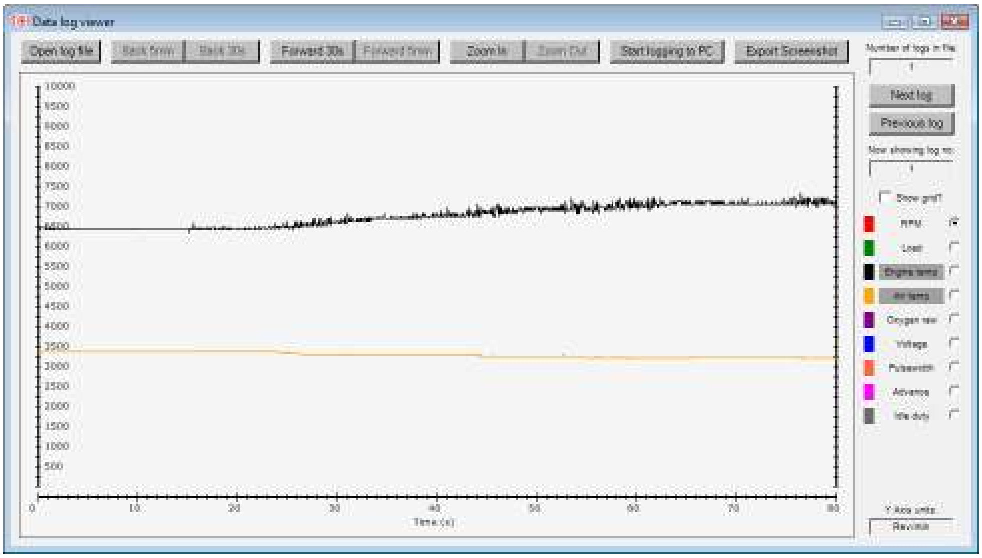
Normally this should only occur during cranking of course.

If faults do occur here, it's most probable that the speed sensor is at fault, rather than the TDC reference sensor.

Engine / air temperature sensors

It is best to analyse the behaviour of the temperature sensors using the data logger (see '*PC-based data logging*'). As with the air flow meter, no sudden peaks or troughs should be visible in the data log – the plots should represent a steady increase in temperature as the engine warms through fully.

In certain applications, the temperature sensors do not have a dedicated earth pin – instead, they earth through the engine block. This can result in small ripples in the temperature reading (shown in the plot below). This is perfectly normal background noise, but highlights the importance of cleaning all earth points.



ECU Pin Functions

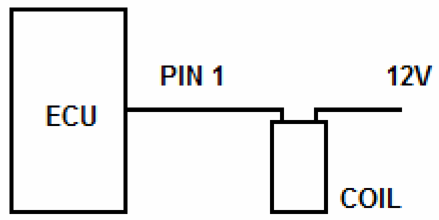
Pin no.	Function
1	Ignition output 1
2	Pin 2 ADC (Closed throttle)
3	Pin3 ADC (Open throttle)
4	
5	Earth
6	Earth (Air flow)
7	Pin 7 ADC (Air flow signal)
8	Speed sensor earth
9	Air flow meter 5V supply
10	Pin 10 input
11	Pin 11 output
12	
13	Engine temperature
14	Injectors bank 2
15	Injectors bank 1
16	Earth
17	Earth
18	12V supply

Pin no.	Function
19	Earth
20	Main relay switched earth
21	Pin 21 output
22	Air temperature
23	Earth (shielded cabling)
24	Oxygen sensor ADC
25	TDC reference signal
26	TDC reference earth
27	Speed sensor signal
28	Pin 28 input
29	Air conditioning input
30	Pin 30 input
31	Ignition output 2*
32	Ignition output 3*
33	Idle valve output A
34	Idle valve output B
35	12V supply

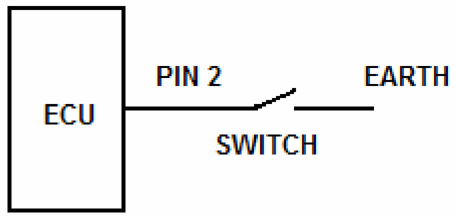
* With Porsche 944 Turbo firmware, these pins can also communicate with the knock unit:

Pin 31 – Trigger signal to KLR (knock sensing) unit
Pin 32 – Input from KLR (knock sensing) unit

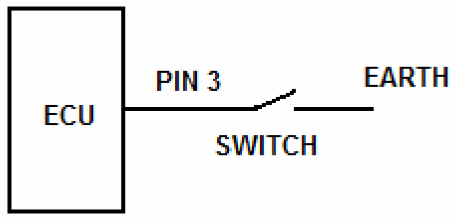
Ignition system (standard distributor based)



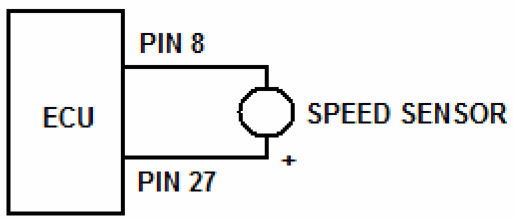
Closed throttle switch



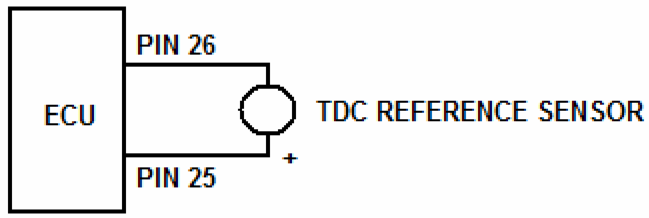
Open throttle switch



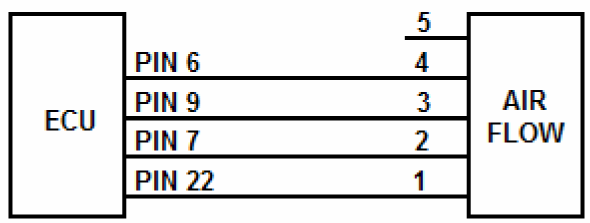
Speed sensor



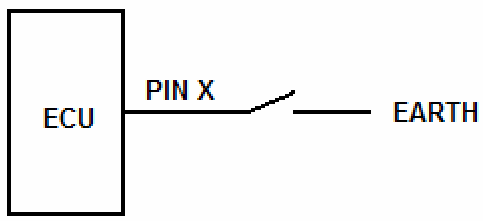
TDC Reference sensor



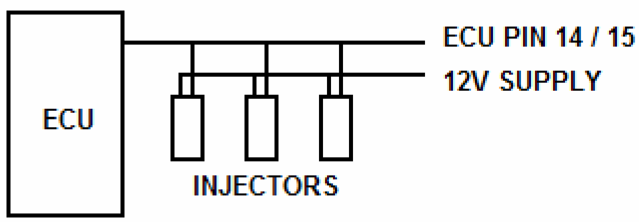
Air flow meter (incorporating air temperature sensor)



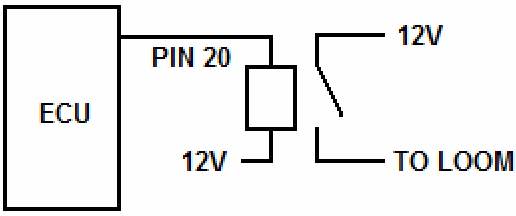
Input pin 10 / Input pin 28 / Input pin 30



Injector bank 1 / Injector bank 2

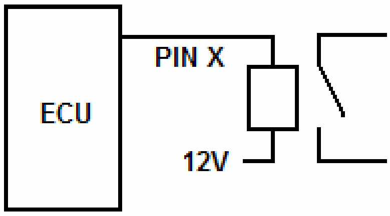


Main relay output (switched earth)

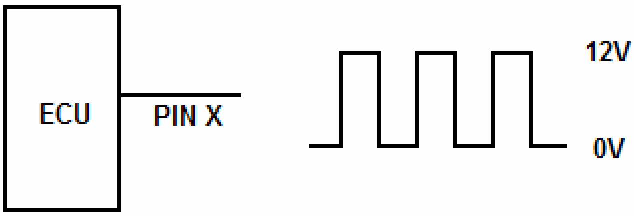


Output pin 11 / Output pin 21

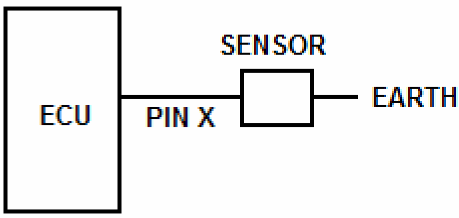
When used as an on/off switch (eg. cooling fan or shift light control).



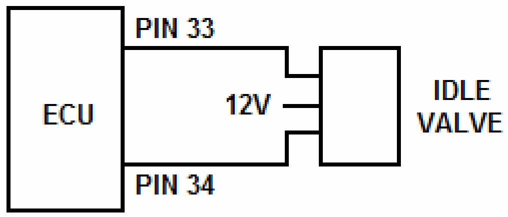
When used as a 12V square-wave tachometer output (connect pin directly to tach)



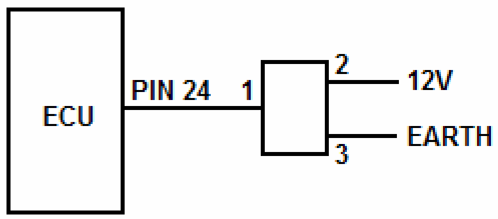
Engine temperature (Pin 13) / Air temperature (Pin 22)



Idle Speed Control Valve



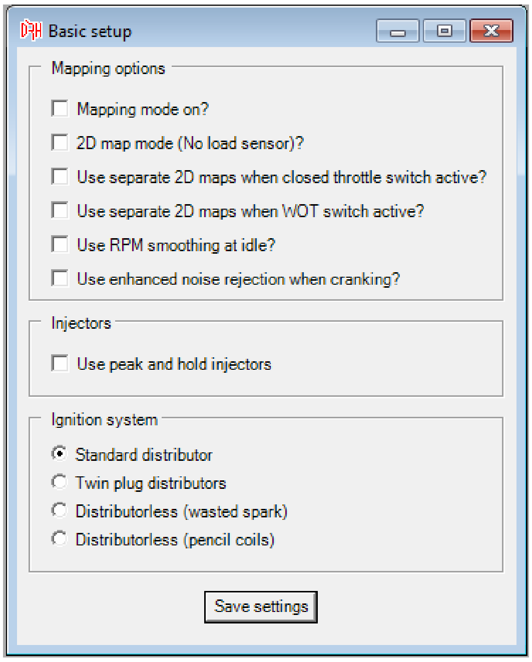
Lambda Sensor



If using wideband lambda sensor, connect ECU pin 24 to wideband analogue output (0 – 5V).

Upgrading your ignition system

With the DRH Performance ECU, it's possible to upgrade your ignition system in a variety of ways. The ECU contains three high current ignitors, so it is suitable for running up to six cylinders with distributorless ignition (DIS). Alternatively, the ECU can also interface with logic-level external ignitors or pencil coils via the same pins on the connector. It's therefore important to correctly configure your software to match your hardware on the engine itself.



Single coil, single distributor (stock Motronic)

Click '**ECU setup > Basic setup**'. Then select '*Standard distributor*' and save settings.

Pin number 1 (Ignition output 1) on the ECU is connected directly to the negative terminal on the ignition coil. The coil is fired by the onboard ignitor, which also acts as a current limiter.

It's important to ensure that dwell times are not excessive; this can result in excessive heat within the ECU. If in doubt, contact Canems.

Two coils, two distributors (twin-plug conversion)

It's particularly common with air cooled Porsche engines to add a second spark plug to each combustion chamber.
Normally this is referred to as 'twin-plugging'. This modification was introduced as a factory standard starting with the 964 models.

To fire a second coil, select '**ECU setup > Basic setup**'. Then select '*twin plug distributors*' and save settings.

Pin number 1 (Ignition output 1) is connected directly to the negative terminal of the first ignition coil. Pin number 31 (Ignition output 2) is connected directly to the negative terminal of the second ignition coil. Both coils are fired by onboard ignitors, also acting as current limiters.

Distributorless (wasted spark)

From the TDC reference sensor, the ECU knows the location of top-dead-centre. It's therefore possible to run an engine via distributorless coil pack (each spark plug fires on both compression and exhaust strokes). This eliminates the king lead, rotor arm and distributor cap and also provides constant-energy ignition throughout the RPM range – there's no decrease in dwell time at high speed, as there is with a single coil system.

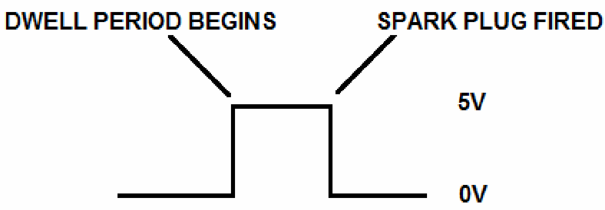
Select '**ECU setup > Basic setup**'. Then select '*Distributorless (wasted spark)*' and save settings.

The ECU is connected directly to the DIS coil pack, with the coils (two for four cylinder engines or three for six cylinder engines) being fired by onboard ignitors.

Distributorless (pencil coils)

In this mode, the ECU outputs a logic level pulse, which is designed to interface to external ignitor units. None of the high-current switching is actually performed internally in the ECU. In the case of modern pencil coils, the ignitor units are actually built into the top of the unit.

To activate the logic-level drivers, click '**ECU setup > Basic setup**'. Then select '*Distributorless (pencil coils)*' and save settings. The ouput from the ECU is as follows:



ECU connections with distributorless modes

Whether you're using the internal ignitors ('*Wasted spark'*) or driving external ignitors via the logic level outputs ('*Pencil coils'*), it's very important to ensure the correct firing order.

The three ignition outputs from the ECU fire in sequential order, starting with number one.

For a four cylinder engine (firing order 1-3-4-2), the coil(s) for cylinder numbers one and four would be connected to ECU pin 1 (Ignition output 1). The coil(s) for cylinder numbers three and two would be connected to ECU pin 31 (ignition output 2).

For a six cylinder engine (firing order (1-6-2-4-3-5), the coil(s) for cylinder numbers one and four would be connected to ECU pin 1 (Ignition output 1). The coil(s) for cylinder numbers six and three would be connected to ECU pin 31 (ignition output 2). The coil(s) for cylinder numbers two and five would be connected to ECU pin 32 (ignition output 3).

Upgrading your injection system

Standard Bosch Motronic ML1.X systems use low resistance ('peak and hold') injectors. The DRH Performance ECU will control these injectors effectively and will also control modern high resistance ('saturated') injectors. In a custom-built injection system, it is normally preferable to use the modern saturated injectors. These produce very little electrical noise compared to their earlier counterparts.

To choose the fuel injector style, click '**ECU setup > Basic setup**'. Simply choose which style of injector you are using and then click '**Save settings**'.