EMU

ENGINE MANAGEMENT UNIT

USER MANUAL

ECU MASTER

www.ecumaster.com

ATTENTION !

- **The ECUMASTER EMU is designed for motorsport applications only and cannot be used on public roads!**
- **Electronic throttle modules are only to be used for operating stationary engines (generators, testbenches). For safety reasons, do not use electronic throttle modules in vehicular applications!!!**
- **The installation of this device should be performed only by trained specialists. Installation by untrained individuals may cause damage to both the device and the engine!**
- **Incorrect tuning with the ECUMASTER EMU can cause serious engine damage!**
- **Never modify the device's settings while the vehicle is moving as it may cause an accident!**
- **ECUMaster assumes no responsibility for damage caused by incorrect installation and/or tuning of the device!**
- **To ensure proper use of ECUMASTER EMU and to prevent risk of damage to your vehicle, you must read these instructions and understand them thoroughly before attempting to install this unit.**

IMPORTANT !

- **The manual below refers to the firmware version 1.1 of the ECUMASTER EMU**
- **Modification of the tables and parameters should be performed only by people who understand the operation of the device and operation of modern fuel injection and ignition systems.**
- **Never short-circuit the wires of the engine's wiring loom or the outputs of the ECUMASTER EMU.**
- **All modifications to the engine's wiring loom must be performed with the negative terminal of the battery disconnected.**
- **It is critical that all connections in the wiring loom are properly insulated.**
- **All signals from the variable reluctant sensors and knock sensors should be connected using shielded cables.**
- **The device must be disconnected before performing any welding on the vehicle!**

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ECUMASTER EMU DEVICE

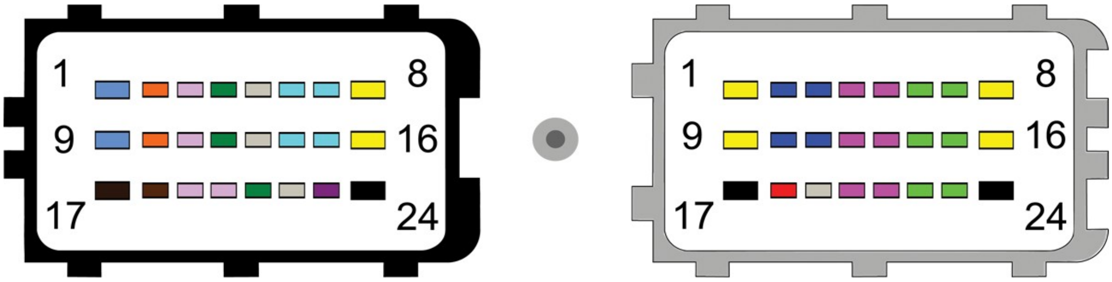
ECUMASTER EMU device is fully programmable, universal engine management unit for controlling spark-ignition engines using Speed Density or Alpha-N algorithms, using wide range of fuels (PB/E85/LPG/CNG). Due to utilizing modern technology and state of the art software, device can fully control fuel mixture using closed loop feedback based on wide band oxygen sensor, is capable of fully sequential injection and ignition, and can sense engine knock allowing optimal ignition advance and safe engine operation.

ECUMASTER EMU supports wide range of OEM sensors (IAT, CLT, MAP, KS, etc.). It has also lots of features used in motor-sports like gear dependent shift-light, flat shift, launch control, NO2 injection control, advanced boost control, and much more.

SPECIFICATION		
1	Power supply	6-20V, immunity to transients according to ISO 7637
2	Current requirement	400mA
3	Operating temperature	-40 do 100˚ C
4	Supported number of cylinders	1-6 – full sequential injection and ignition 1-12 - wasted spark
5	Max supported RPM	12000
6	Injection time	0.1ms – 50ms, resolution 16us
7	Ignition timing	60˚ BTDC – 20˚ ATDC,resolution 0,5˚
8	Injectors outputs	6 protected outputs, max. current 5A
9	Ignition outputs	6 outputs, max. current 7A, software selectable passive / active coils
10	AUX outputs	6 protected outputs, max. current 5A
11	AUX / Stepper	4 outputs,max. current 1A
12	Lambda sensors	- narrow band 4 wires sensor, - wide-band sensor Bosch LSU 4.2
13	Knock sensing	2channels, knock resonant frequency 1-20kHz
14	Crank / Cam signal (primary trigger)	VR sensor (adaptive input), HALL / Optical, software configurable
15	CAM sensors	2 inputs, VR or HALL / Optical software configurable
16	VSS	VR or HALL / Optical software configurable
17	EGT	2 channels, K-Type thermocouples
18	Analog inputs	7 protected analog inputs for sensors TPS, IAT, CLT, etc.
19	Additional outputs	Extension port: CANBus, Bluetooth, etc.
20	Other	Built in 400 kPa MAP and Baro Sensor
21	Communication	USB port
22	Client software	Windows XP, VISTA, Windows 7

FUNCTIONS		
1	Fuel calculation algorithm	Speed Density or Alpha-N
2	Fuel Table	16x16, resolution 0,1% VE
3	Injectors configuration	Phase and injection angle, injectors dead time calibration(16x1), injector flow rate configuration
4	AFR Table	16x16, resolution 0.1 AFR, closed loop feedback
5	Ignition triggers	12 – 60 primary trigger tooth , 0-2 missing tooth, 1 tooth cam sync synchronization
6	Ignition table	16x16, resolution 0,5˚
7	Ignition coils dwell	Dwell time table (16x1), dwell correction table in function of RPM (16x1)
8	Ignition advance corrections	Correction in function of CLT and IAT (16x1), per cylinder correction
9	IAT, CLT sensors	Calibration table (20x1), sensors wizard
10	Cranking fuel table	Table 16x1
11	Enrichments	ASE, Warmup, Acceleration, Deceleration
12	Knock sensing	Resonant frequency, knock window, knock actions like ignition retard, fuel mixture enrichment
13	Idle control	PID based control over stepper motor or idle vale. Ignition angle control. Idle Target table (16x1)
14	Parametric outputs	Fuel pump, radiator fans, tachometer, user defined
15	Boost control	PID base, DC table 16x16, Boost target, Gear and speed dependent
16	Sport functions	Launch control, Nitrous injection, flat shift, gear dependent shiftlight, etc.
17	Variable CAM control	VTEC, iVTECm VVTi, VVL, VANOS, DOUBLE VANOS
18	Drive by wire	3D PID model
19	Others	Check Engine light, fail save values for sensors, password protection
20	Log functions	Logging over 100 parameters, real time view

CONNECTOR PINOUT DETAILS



Device View

BLACK		GRAY	
1	EGT In #1	1	Ignition coil #6
2	Knock Sensor In #1	2	Stepper motor #1 winding A
3	Analog In #2	3	Stepper motor #2 winding A
4	CLT In	4	AUX 6
5	WBO Vs	5	AUX 3
6	Camsync In #2	6	Injector #4
7	Primary trigger In	7	Injector #1
8	Ignition coil #5	8	Ignition coil #1
9	EGT In #2	9	Ignition coil #3
10	Knock Sensor In #2	10	Stepper motor #1 winding B
11	Analog In #3	11	Stepper motor #2 winding B
12	TPS In	12	AUX 5
13	WBO Ip	13	AUX 2
14	VSS In	14	Injector #5
15	Camsync #1	15	Injector #2
16	Ignition coil #4	16	Ignition coil #2
17	ECU Ground	17	Power Ground
18	Sensor Ground	18	Power +12V
19	Analog In #4	19	WBO Heater
20	Analog In #1	20	AUX 4 / Tacho
21	IAT In	21	AUX 1
22	WBO Vs/Ip	22	Injector #6
23	+5V supply	23	Injector #3
24	Power Ground	24	Power Ground

SOFTWARE

Client for Windows

Communication with ECUMASTER EMU device is performed using USB AA cable, and Microsoft Windows based *Client software*. Client allows to modify all settings (parameters, tables) stored in internal device flash memory as well as gathering real time data from engine sensors. Software is available on CD included in the package. For the latest software please visit www.ecumaster.com web page.

Firmware

Firmware is internal EMU software that controls all aspects of device behavior. Due to the fact that device firmware can be upgraded, in future there will be new device functions available. It is required to use latest Client software with new firmware. The Client software is compatible backwards, what means that all previous firmware will work correctly. However the old Client will not work with new firmware (appropriate message will be shown). Firmware is always included with Client software package and can be downloaded from www.ecumaster.com.

Software versions

Main software version is the first digit. The subversion is defined by 2 digits after the dot mark. The third digit means that there are only changes in windows client software and there is no firmware update. For example 1.01 means 1st main version with first software and firmware modification, 1.013 means first firmware update and fourth modification of Windows Client.

Software installation

Windows installation Client version is included on ECUMASTER CD or can be downloaded from *www.ecumaster.com*. To install insert CD into drive and choose appropriate button or run *EmuSetup_xxx.exe*. The software is compatible with the Windows XP, Vista and Windows 7 and Windows 8. It might be also required to install USB drivers that are included on ECUMASTER CD. If you have any problems with software installation, please contact our technical support at tech@ecumaster.com.

Firmware upgrade

To upgrade firmware please choose option *Upgrade firmware* from *File* menu. After selecting proper firmware version press *Open* button. The upgrade should begin immediately. Do not turn of the device during firmware upgrade! When upgrade is finish turn off the device. The process is finished. All parameters and tables are automatically imported.

If the upgrade process fails, turn off device, turn it back on, and repeat the procedure.

ATTENTION !

In case of firmware upgrade failure the project should be saved on a disc before updating!

ATTENTION !

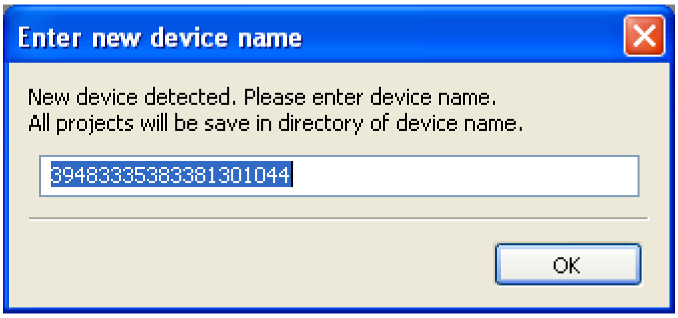
Firmware upgrade should not be performed if there are problems with the communication between the device and PC computer and if car or laptop batteries are not fully charged!

ATTENTION !

Before you perform firmware upgrade, please disconnect injectors and ignition coils !

First connection

During first connection to the EMU device, there will appear a window with the device name.
By default there will be device unique serial number which can be changed for any name. Based on this name there will be sub-directory created in directory *My documents / EMU*. In this sub-directory, the configuration for the given EMU, projects and logs will be saved.



File extensions:

File description	File extension
Project file	*.emu
Data log file	*.emulog
Scope file	*.emuscope
Layout files	*.emulayout
Per device layout	desktops.xml

For each device q*uicksave* subdirectory is created where working copies of calibration is stored when the user press F2 button (*Makes maps permanent*).

User interface

The picture below shows Windows client after first launch.

User interface is divided into 5 areas:

1. Menu
2. Tree view with device parameters (you can hide / show it with key F9)
3. Desktop
4. Event log (you can hide / show this area by keys combination SHIFT + F9)
5. Status bar

Menu

A menu bar consists of the following functions:

FILE MENU	
Open project...	Open previously saved project (*.emu)
Save project as...	Save current project (*.emu)
Show full screen	Toggle full screen mode
Upgrade firmware	Upgrade internal firmware of EMU device
Restore to default	Restore all EMU device parameters to default
Make permanent	Store all parameters inside EMU device data flash
Exit	Terminate EMU client software

EDIT MENU	
Undo	Undo last operation
Redo	Redo the last operation
Show undo list...	Show the window with the last operations list
Toggle panel	Show / hide the left option panel
Toggle log	Show / hide application log panel

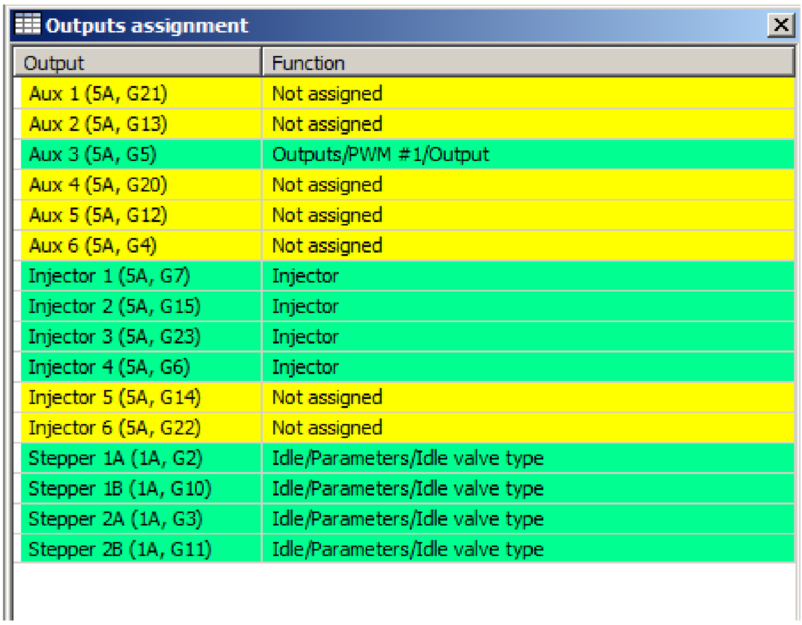
MENU DESKTOPS	
Restore desktops	Restore saved desktops from disk
Store desktops	Store current desktops to disk
Open desktops template	Open and load previously stored desktops layout
Save desktops template	Store to disc desktops layout
Switch to desktop 1-7	Switch between desktops
Next desktop	Switch to the next desktop
Previous desktop	Switch to the previous desktop
Switch option / windows	Switch between option panel and workspace windows

MENU TOOLS	
Show assigned outputs	Show window with all EMU outputs and assigned functions
Customize keys	Show window with keys customization

MENU WINDOWS	
Next	Select next window in the workspace
Previous	Select previous window in the workspace
Close all windows	Close all windows on current desktop

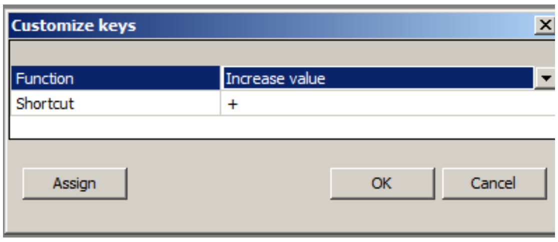
MENU HELP	
Contributors	Show contributors list window
Help	Show help window
About	Information about software version. When the EMU device is connected the information about device serial number and device region is also displayed

In the menu *Tools, you can find the* very useful tool "Output assignment" which shows the assignment of all EMU outputs to the corresponding functions and pins.

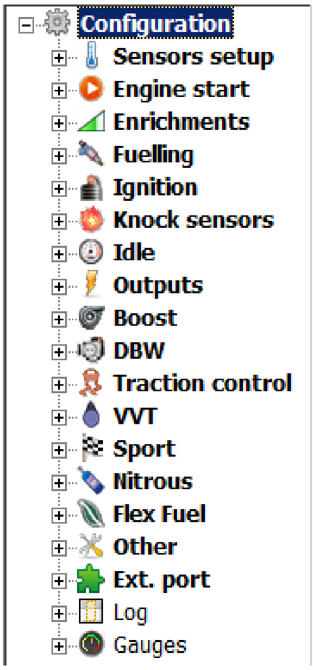


Unused outputs are marked yellow and used are marked green. In the case multiple functions use the one output the color is red.

Other useful tool is the "Customize keys" that allows user to change default keys assignment. To assign new keys combination, select function, press Assign button and then press the keys.



Tree view parameter list



On the left there is a list of all available EMU functions grouped in functional blocks. Depending on firmware version there could be different set of functions. By expanding functional group user can access parameters and tables.

Category *Sensors setup* contains all options required for calibrating engine sensors as well as fail safe values.

Engine start category groups all function and tables used during engine cranking. *Enrichments* group is responsible for all mixture enrichments, and categories *Fueling* and *Ignition* respectively for fuel dose and ignition angle. Category *Knock Sensor* contains functions required for knock sensor configuration, category *Idle* is responsible for controlling engine's idle speed. To configure AUX outputs (eg. Fuel pump, coolant fan, PWM outputs) category *Outputs* needs to be used. Category *Boost* controls boost pressure, *Sport* contains functions used in motorsport, *Nitrous* is responsible for nitrous oxide systems. For logging data and visual representation of EMU parameters categories *Log i Gauges* should be used.

Desktops

There are ten (10) desktops in the Windows Client. On each desktop user can place tables, parameters blocks, gauges, etc. Desktop layouts are assigned to the specific EMU device and are stored on disk when the windows client is closed. To make navigation between *Desktops* easier keyboard shortcuts could be used (CTRL+1 – CTRL+7). There is also possibility to store/load the current layout into file using *Save / Open desktop template*.

To change deskotop name press the right mouse button on the desktop tabs and choose *Rename active desktop* from popup menu.

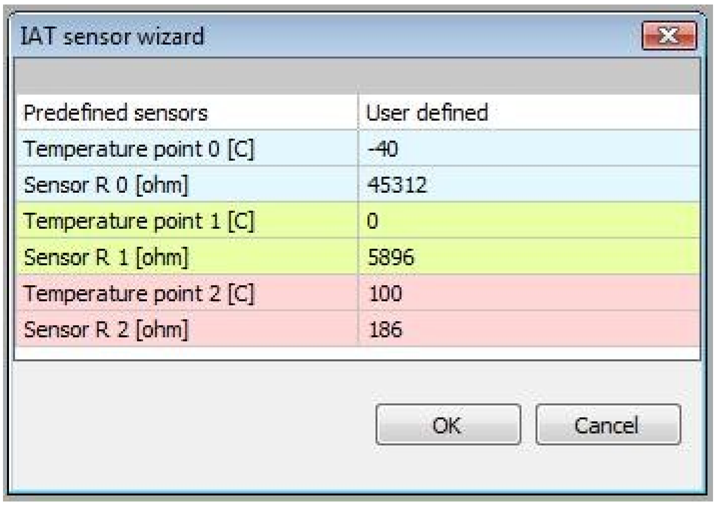
DESCRIPTION OF BASIC CONTROLS

The Client of EMU device consists of several basic controls, that facilitate the proper configuration of the device. We can divide it into particular types:

ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Wizard (creator)
	Paramblock (parameter's block)
	Table 2D
	Table 3D
	Visual log (parameters' log)
	Graph log (graphical log)
	Gauge
	Road dyno
	Scope

Wizard

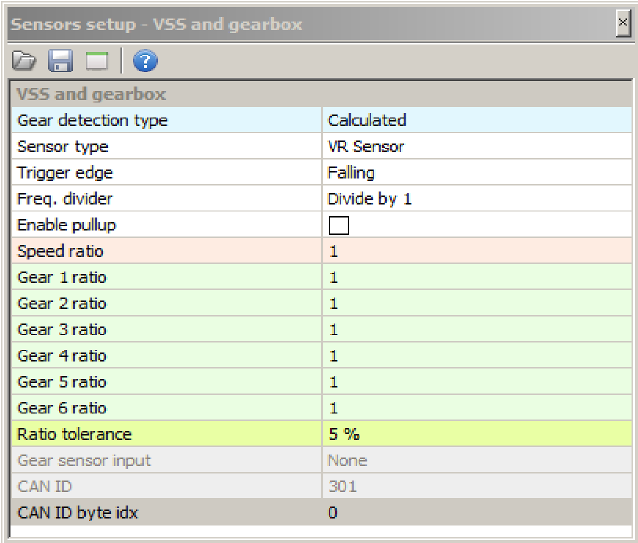
This tool allows you a quick selection of the saved, pre-specified, configuration of the given sensor. An example of a wizard for an intake air temperature sensor is as follows:



The first cell in the right column is always in the form of a drop-down list. It allows to select the right characteristics from the sensors or other devices defined by the manufacturer, such as: thermistors, NTC, injectors, or – by the option "**User defined**" – open a blank column to fill in the values for other sensors not defined in the program. Options for specific wizards will be discussed in appropriate sections of the manual.

Paramblock (parameters' block)

It is a table, in which there are included particular options connected with the configuration of EMU functions. Because of this, it is possible to set all parameters required for the configuration of the given function.



Paramblock always has two columns, while the number of lines may vary from the example indicated above, depending on the configured device function. In cells of the left column there are descriptions of particular options, while in the right column there are its values. After clicking on the cell in the right column we get a chance to modify its content – this can either be a selection from the list, "on-off" option or simply a place to enter the value.

On the toolbar of this window there are 3 icons described below:

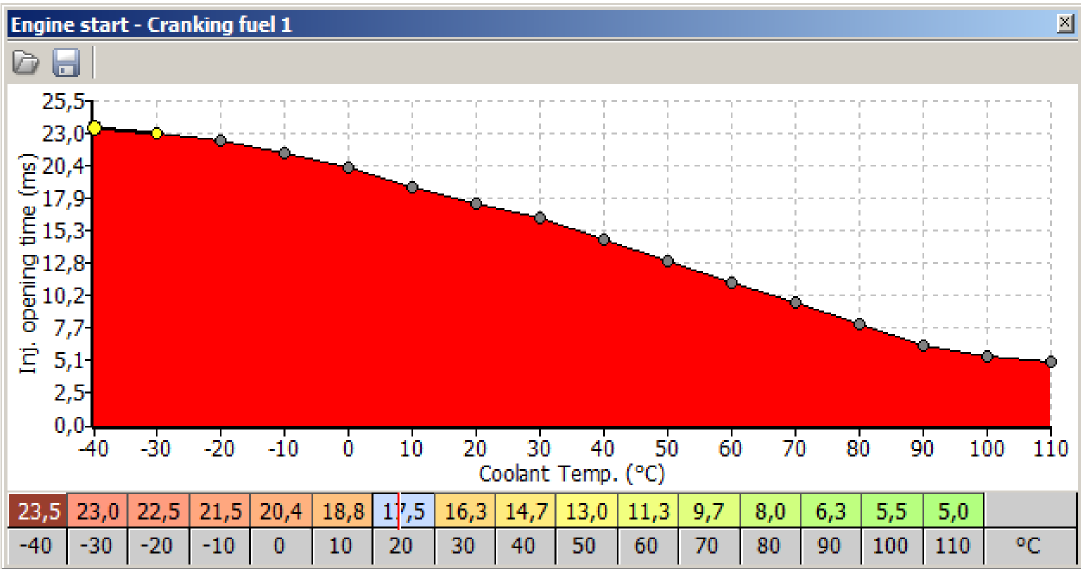
ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Open the file with the configuration of the given parameters' block
	Save the file with the configuration of the given parameters' block
	Restore default values of the given parameters' block
	Help window

Saving particular parameters' blocks is useful during the exchange of configuration with other users or to create the base of settings (e.g., configuration of various ignition systems).

Table 2D

2D tables are used for representing 2 dimensional non-linear functions in an easy to use graphical form. The values corresponding to the graph are located in the table below it. Any of the cell values may be modified. The values from the upper row correspond to the vertical axis on the graph, and values in the lower row correspond to the horizontal axis (bins). In order to change a cell value, highlight the cell to be modified and then enter the desired value. You can also change the value of cells using the + and - keys. To make a smaller alteration press the ALT key, and to make a larger alteration press SHIFT.

To interpolate between table cells, use the context menu (right click on the table area). In the case of 2D tables only Horizontal interpolation is available. Arithmetic operators may be used on the selected cells by entering value followed by an arithmetic operator. For example to add a value of 5 to the selected cells, you should enter **5+**. To scale down all the selected cells by 50%, you should enter **0.5***.



To save or load a 2D table, use the appropriate disk icon on the toolbar. To load a table from an existing project, change the file extension mask to *.emu in the open dialogue window.

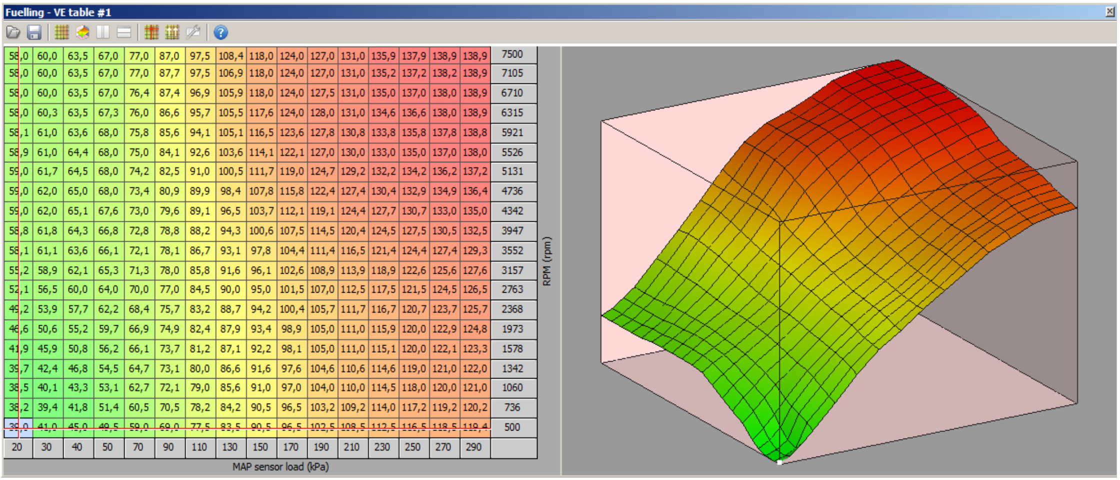
ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Open current 2D table from disc
	Save current 2D table to disc
	Help window

DEFAULT KEYBOARD SHORT-CUTS	
SHORT-CUT	**DESCRIPTION**
=	Increase cell value
SHIFT =	Coarse increase cell value
ALT =	Fine increase cell value
-	Decrease cell value
SHIFT -	Coarse decrease cell value
ALT -	Fine decrease cell value
CTRL + C	Copy selected cells
CTRL + V	Paste copied cells
CTRL + H	Interpolation between selected cells
CTRL + ARROWS	Copy cell value to the cell indicated by arrow key
CTRL + Z	Undo last operation
CTRL + Y	Redo last operation
CTRL + A	Select all table cells

Table 3D

Tables 3D are used for representing three dimensional non-linear functions in an easy to use graphical form. Each 3D table is comprised of numerical values that define a variable (such as ignition timing) as it corresponds to values on two axes (such as load and RPM). There is a wizard available for axis setup (right click on axis description).

WARNING !
Some of the axis definitions are common for several tables (eg. load, RPM). When axis definitions are modified in one table, the axis definition will change for other tables as well.



To interpolate between table cells use the context menu (right click on the table area). There are 3 interpolations available: horizontal, vertical and diagonal. Arithmetic operators may be used on the selected cells by entering value followed by an arithmetic operator. For example to add a value of 5 to the selected cells, you should enter **5+**. To scale down all the selected cells by 50%, you should enter **0.5***.

To save or load a 3D table, use the appropriate disk icon on the toolbar. To load a table from an existing project, change the file extension mask to *.emu in the open dialogue window.

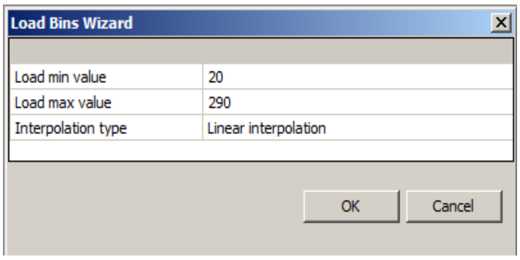
ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Save current 3D table to disc
	Open current 3D table from disc
	Change view to table view
	Change view to 3D graph view
	Change view to both table and 3D graph horizontally divided

	Track with the cursor current table position
	This options automatically increases cell values above the current RPM (cells are marked with white checker) if their value is lower than the value of the modified cell. This option is useful for creating the VE table
	Change view to both table and 3D graph vertically divided
	Tables configuration
	Context help window

DESCRIPTION OF 3D TABLES CONFIGURATION1	
PARAMETER	**DESCRIPTION**
Color scheme	Color scheme of 3D table and graph
Load on Y axis	This option defines the load axis direction in VE, AFR and IGN tables
Display square tables	Make rectangle tables more square by increasing cells height

DESCRIPTION	
SHORT-CUT	**DESCRIPTION**
=	Increase cell value
SHIFT =	Coarse increase cell value
ALT =	Fine increase cell value
-	Decrease cell value
SHIFT -	Coarse decrease cell value
ALT -	Fine decrease cell value
CTRL + C	Copy selected cells
CTRL + V	Paste copied cells
CTRL + H	Interpolation between selected cells
CTRL + ARROWS	Copy cell value to the cell indicated by arrow key
CTRL + Z	Undo last operation
CTRL + Y	Redo last operation
SHIFT + ARROWS	Select area
CTRL + A	Select all table cells
F	Toggle cursor tracking
D	Toggle auto-modification of cells above RPM

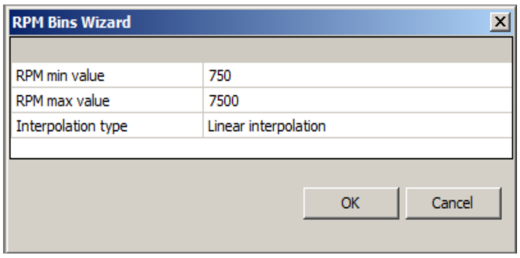
X axis bins wizard



This wizard is used for automatic generation of set points for the load axis (X).

PARAMETER	DESCRIPTION
Load min value	Minimal value for axis X
Load max value	Maximal value for axis X
Interpolation type	The way of dividing set points on axis X between the minimal and maximal value. We have 3 options to choose from: *Linear interpolation* **–** linear interpolation between values *Exponential interpolation 1* – exponential interpolation, version 1 *Exponential interpolation 2* – exponential interpolation, version 2

RPM bins wizard



Wizard of RPM values for scale Y acts identically as wizard for axis X.

Visual log

Using the parameters' log we can real-time track the selected parameters of the engine's work. Parameters are grouped according to the function, what facilitates tracking of the device's functions (e.g. *Idle control*)

Log group Basic

Name	Value	Unit
RPM	0	RPM
MAP	0	kPa
BARO	0	kPa
TPS	0	%
IAT	0	°C
CLT	0	°C
Battery voltage	0	V
EGT #1	0	°C
EGT #2	0	°C
Oil pressure	0	Bar
Oil temperature	0	°C
Fuel pressure	0	Bar
EMU State	0	
EMU Reset	0	
Tables set	0	

Gauges

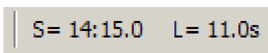
It is an informative tool, used to control particular parameters' values in the real time. Apart from the analogue display with a needle on the scale at the 270 degree angle, the indicator also shows the precise value in the digital form. Examples are presented in the picture below:

Pressing right mouse button on the gauge area display a menu to allow fast resize the gauge to one of the three predefined sizes.

Graph log

Graph log is a tool to analyse any aspects of engine work and ECUMASTER EMU device state. Data is shown as a graph in function of time. The detailed information about channel log value can be obtained by indicating interesting point on the graph. This tool is a key to create engine calibration as well as for troubleshooting. It allows to display 8 channels at once, however all available channels are gathered in the background. The list of the all channels could be found at the end of this manual.

On the toolbar of this window there are seven icons described below.

TOOLBAR ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Open log file from disk... (*.emulog)
	Save log data to file... (*.emulog)
	Export of visible log channels to csv file (*Excel, Open Office Calc*) to make custom data analyzys
	Zoom in the graph log area
	Zoom out the graph log area
	Clear the log
	Pause / resume graph log refresh
	The list of visible log channels
	The list of predefined log channels groups
	Display help window
	Information about current log time indicated by cursor (C) or information about selection start (S) and selection length (L) in seconds

DESCRIPTION OF DEFAULT KEYBOARD SHORT CUTS	
SHORT CUT	**DESCRIPTION**
SPACE	Pause / resume graph log refresh
ARROWS LEFT/RIGHT	Fine movement (left / right) of the graph log
SHIFT + ARROWS LEFT/RIGHT	Fast movement (left / right) of the graph log
PAGE UP / PAGE DOWN	Very fast movement (left / right) of the graph log
HOME	Go to the beginning of the log
END	Go to the end of the log
Q	Zoom in the graph log area
A	Zoom out the graph log area

Scope

ECUMASTER EMU has built in scope tool that allows measurement of signals present at *primary trigger, CAM#1 and CAM#2* inputs. By using this tool it is possible to determine the trigger pattern for crankshaft and camshafts trigger wheels, to check if the polarity of the signal is correct and to save the trace for further analysis or for our technical support for troubleshooting.

For correct reading the signal, *primary trigger* input is required. To activate scope functionality, the option 'enable scope' need to be checked in Primary trigger configuration window. The scope tool is available in log/Scope options.

To take scope trace, during engine operation (cranking or running) the blue arrow should be pressed (or *CTRL+SPACE* short-cut). Additional data is shown for selected region for analysis purpose.

SELECETD AREA DATA DESCRIPTION	
t	Current scope trace time
ts	The time of selection start
te	The time of selection end
dt	Selection length (*te - ts*)
RPM	Theoretical engine RPM for selected area
NE	Number of trigger edges for selected area

ICONS DESCRIPTION	
ICON	**DESCRIPTION**
	Open scope trace file from disk... (*.emuscp)
	Save scope trace to disk... (*.emuscp)
	Zoom in the scope trace
	Zoom out the the scope trace
	Download scope trace from device
	Context help window

DEFAULT KEYBOARD SHORT-CUTS	
SHORT-CUT	**DESCRIPTION**
Q	Zoom in the scope trace
A	Zoom out the the scope trace
CTRL + SPACE	Download scope trace from device

Status bar

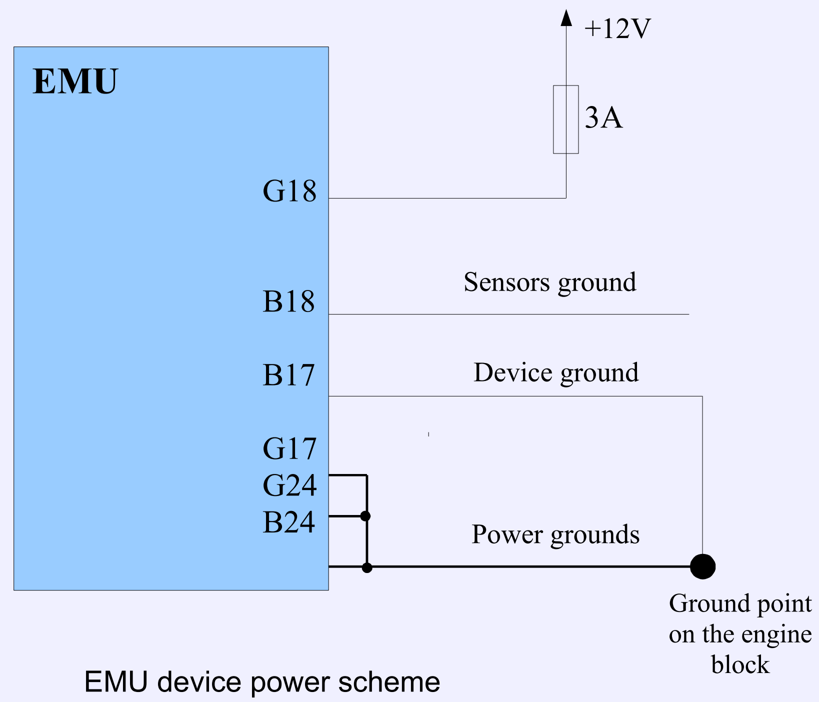
Status bar shows the most important parameters of EMU device to allow easy trace of them.

DESCRIPTION OF STATUS BAR	
Connection status	**DISCONNECTED** - there is no communication with EMU device **CONNECTED** - communication with EMU device established
Ignition status	Information about synchronization of ignition system **NO SYNC** – no synchronization **SYNCHRONISING** – trying to synchronize **SYNCHRONISED** – ignition system synchronized
STATE	Current state of the EMU device **INACTIVE** - there are no calculations connected to fuelling and ignition system **CRANKING** - in this state fuel dose is taken directly from *Cranking fuel* table, and ignition angle is defined by *Cranking ignition angle* parameter **AFTERSTART** - the engine is running, *Afterstart enrichment* is present **RUNNING** - the engine is running normally
TBL SET	Information about current tables set
CAN BUS	Current state of CAN BUS module ***BUS OK*** - CAN BUS module works correctly ***MODULE DISCONNECTED*** - CAN BUS module is not connected to extension port **BUS ERROR** - CAN BUS error (inappropriate speed, wrong connection, termination problems)
CEL	Information about "check engine light"
FW VER	Firmware version of connected EMU device
LC	*Launch control* strategy active
FC	Fuel cut
SC	Spark cut
ALS	*ALS* strategy active
KS	Knocking occurs
RAL	*Rolling antilag* strategy active
IDL	*Idle control* strategy active
PO1-PO4	Parametric outputs state

CONNECTING THE EMU DEVICE

When connecting the EMU device, special ATTENTION should be paid to the connection of device's grounds and their wiring in the car's installation. Wrong connections can create loops, so called *Ground loops.* Bad ground connections can cause many problems, such as noisy readings from analogue sensors or problems with trigger errors. EMU device has several kinds of grounds. Device's grounds (pin B17) is a ground used to power the device, *analogue ground* (pin B18) is the ground point for analogue sensors, and *power grounds* (B24, G17 i G24) are used to supply power outputs and ignition outputs. The perfect situation is when the device's ground and *power ground* are connected to one ground point on the block / engine's head and are lead through separate wires. Power grounds in case of using active coils should be connected using wires with the 1,5 – 2mm diameter. +12V power supply should be connected through the 3A fuse.

Below there is example of grounds' connections to the device.



EMU device power scheme

IMPORTANT !

⚠ **Always use the fuses on the power lines!**

INPUTS AND OUTPUTS

Ignition outputs

Ignition outputs can be used to control passive coils as well as active coils (with ignition module). The coil type is defined by the parameter Ignition outputs / *Coil type.* In the case of using passive coils the EMU enclosure acts like a heat sink. The passive coils also require high current and proper wire size must be used (>1mm^2).

Injectors / AUX outputs

Injectors and AUX outputs are *Low side* type (switch to ground). Fuel injectors can be controlled only by injector outputs. Other functions can use both *Injectors* and *AUX* outputs. All of the outputs are rated for 5A and have over temperature protection. It is allowable to connect up to 4 high impedance (Z) injectors to one output. In the case of controlling solenoids with PWM signal (like VVTi or Idle solenoid) it is required to use a flyback diode.

WARNING !
Disconnecting the grounds during device operation may lead to device damage!

Stepper motor outputs

Stepper motor outputs are used to control unipolar and bipolar stepper motors (for idle control). It could be also used as generic output to control relays / solenoids with a current draw less than 1A. Stepper motor outputs are 2 state output (ground / +12v) and have built-in flyback diodes. Due to this fact it is very important to assure that devices (relays, solenoids, etc.) connected via stepper motor outputs will not be powered if the ignition is off. Otherwise the EMU device will be powered via the embedded flyback circuit.

Frequency inputs

Trigger inputs and VSS input are considered as a frequency inputs. All of them can work with VR as well as Hall sensors. *Primary trigger input* in the case of VR sensors acts like an adaptive one which significantly increases the immunity to noise. For all frequency inputs, it is possible to activate a built in 2Kohm pull-up resistors to +5V.

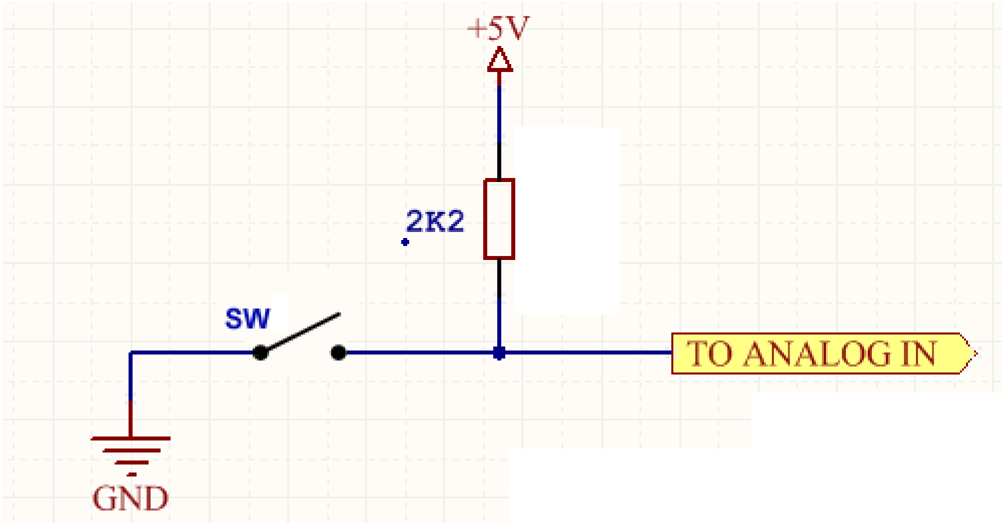
Analog inputs

EMU device has two kinds of analog inputs. The first type is fixed for given sensors like IAT, CLT and TPS. The second type is universal one. It could be used to connect any sensor in the voltage range from 0-5v or as switch inputs for activating different strategies like ALS, Launch control, etc. The CLT and IAT inputs have built in 2.2Kohm pull-ups to +5V.

User switches

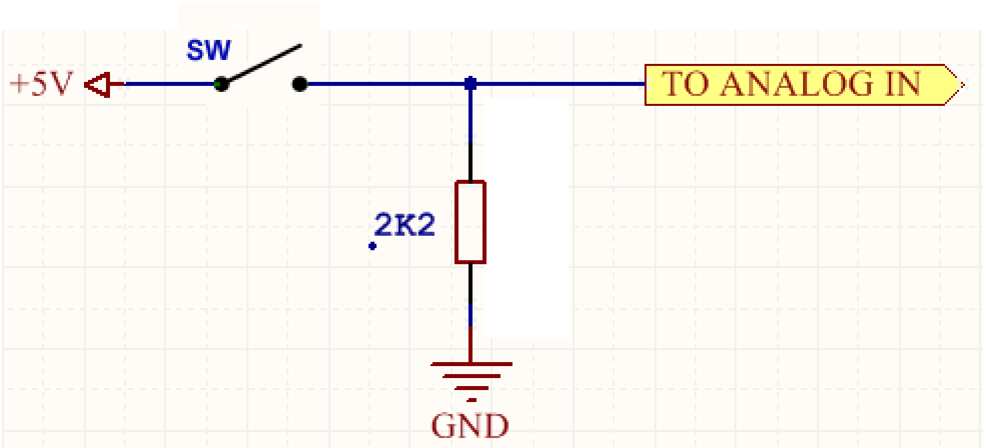
To activate some functions like *Launch control, table switch, Flat Shift* or other, it is required to connect a switch. There are several options to do it.

ANALOG #1 - ANALOG #4 INVERTED



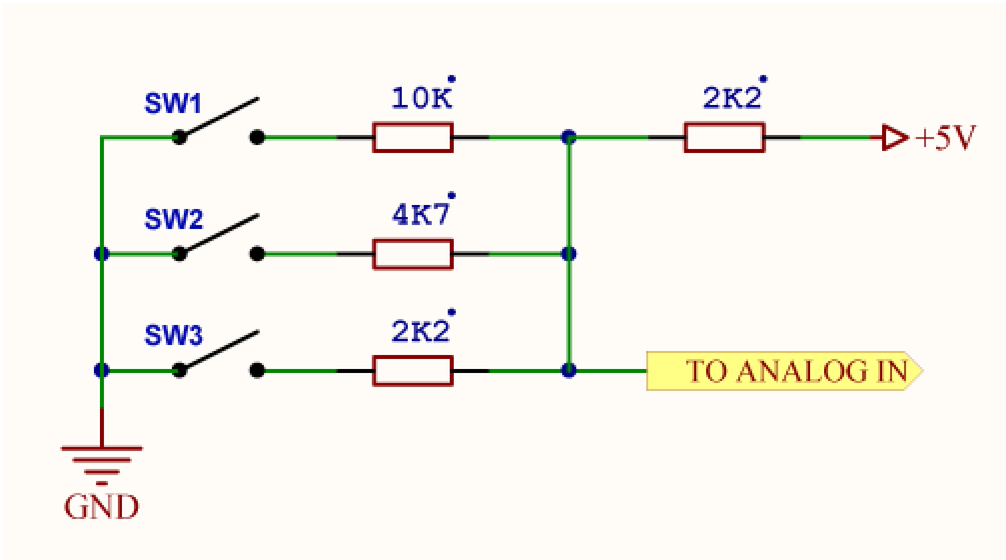
In the case of Analog input #x inverted option, the activation is performed if the voltage on analog input is lower than 1V

ANALOG #1 - ANALOG #4



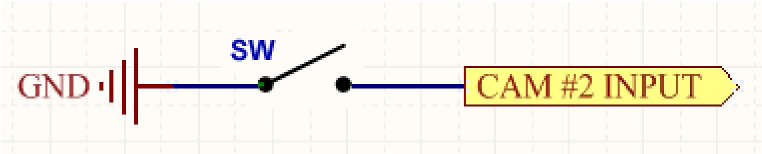
In the case of Analog input #x option, the activation is performed if the voltage on analog input is greater than 4V

MUX SWITCH 1-3



The MUX Switch function allows to connect up to 3 switches to one analog input. More information can be found in *Sensors setup / MUX Switch* section

SWITCH ON CAM#2 INPUT



There is an option to connect switch to *CAM#2 input*. To use this option internal pullup of CAM#2 input must be activated in *Ignition / CAM #2 options*

SENSORS

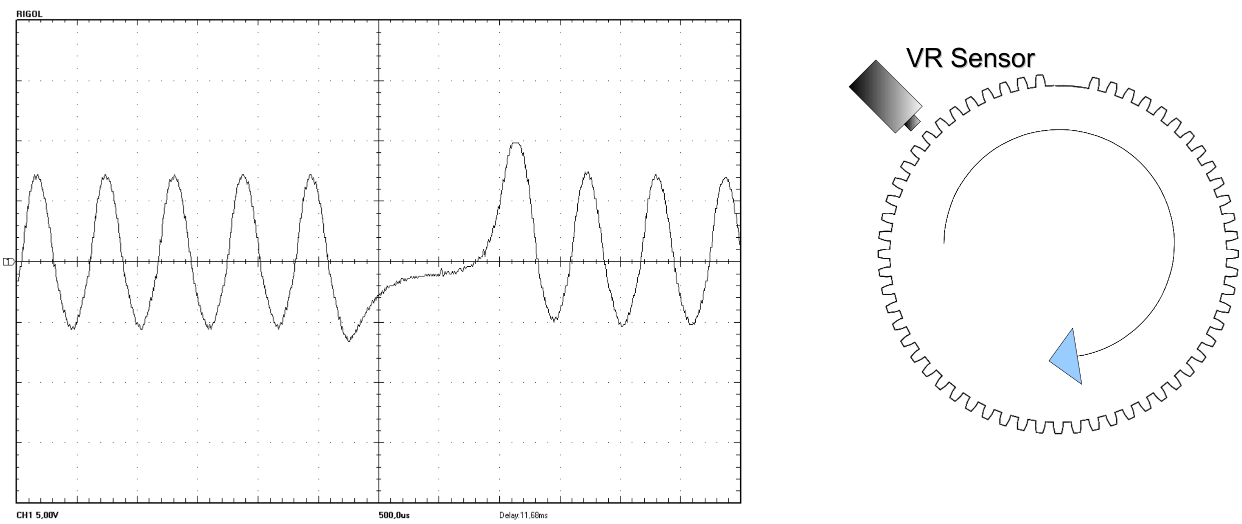
In case of sensors used in cars' electric installations, we are dealing with several types:

- resistance sensors,
- voltage sensors,
- magneto-inductive sensors,
- optical sensors / Hall's,

Resistance sensors are used to measure temperatures (e.g. temperature of cooling liquid) or the position of a throttle (TPS sensors). Voltage sensors are characterised by the fact that the value they measure is expressed in voltage. Such sensors include the sensor of absolute pressure in the intake manifold or the knock sensor.

The key sensors, from the point of view of engine's management work, are sensors of crankshaft's positions and/or of camshaft, thanks to which it is possible to read the speed of the engine and to control the ignition angle and injection.

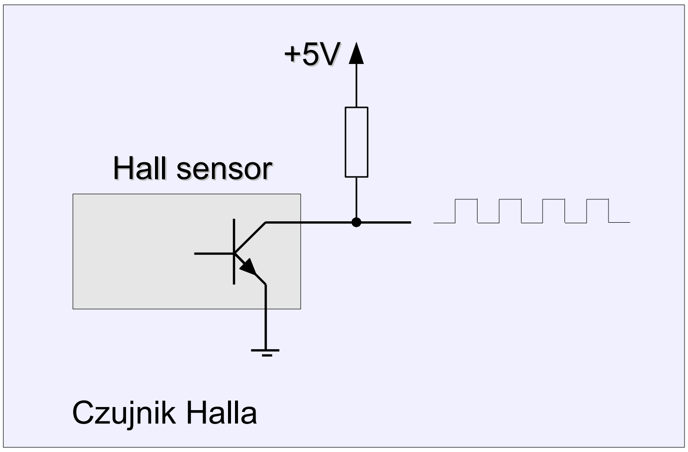
The most popular sensor of this type is the variable reluctant (VR) sensor. It works on the principle of inducing the electromotive force in the winding of sensor's coil wound on a permanent magnet, under the influence of ferromagnetic movement of the impulse wheel. The induced voltage is proportional to the sensor's distance from the impulse wheel and its rotational speed.

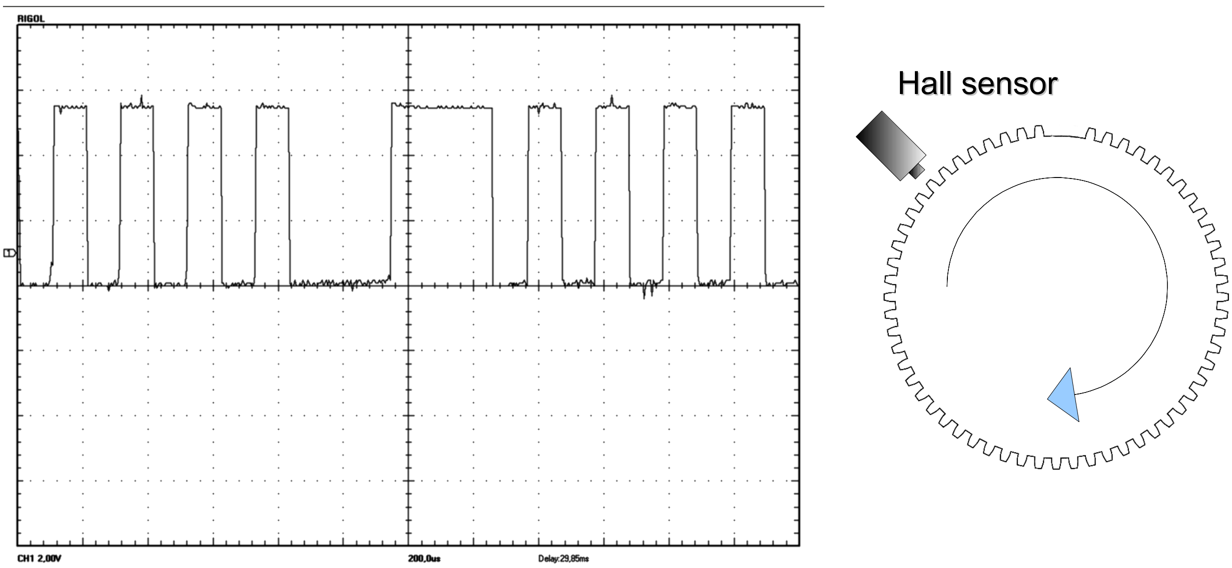


Scope trace of VR sensor output using trigger wheel 60-2

What is characteristic for this sensor is the fact that it has polarity, which is crucial when connecting it to EMU. Inversely connecting it will prevent the synchronization of ignition. Signal from such sensor, especially with low speeds, where its amplitude reaches several hundred millivolts, is very sensitive to interference. For this reason it must always be connected with a shielded cable. It should also be emphasized that the screen connected to the mass can be only on one side of the cable.

A different kind of sensor of engine speed is a sensor using the so-called Hall's phenomenon. In contrast to the variable reluctant sensor, it requires powering. In most such cases, sensors have "open collector" outputs and require using the *pullup* resistor (in case of EMU computer, *pullup* 2K2 resistor is activated with the proper output configuration).

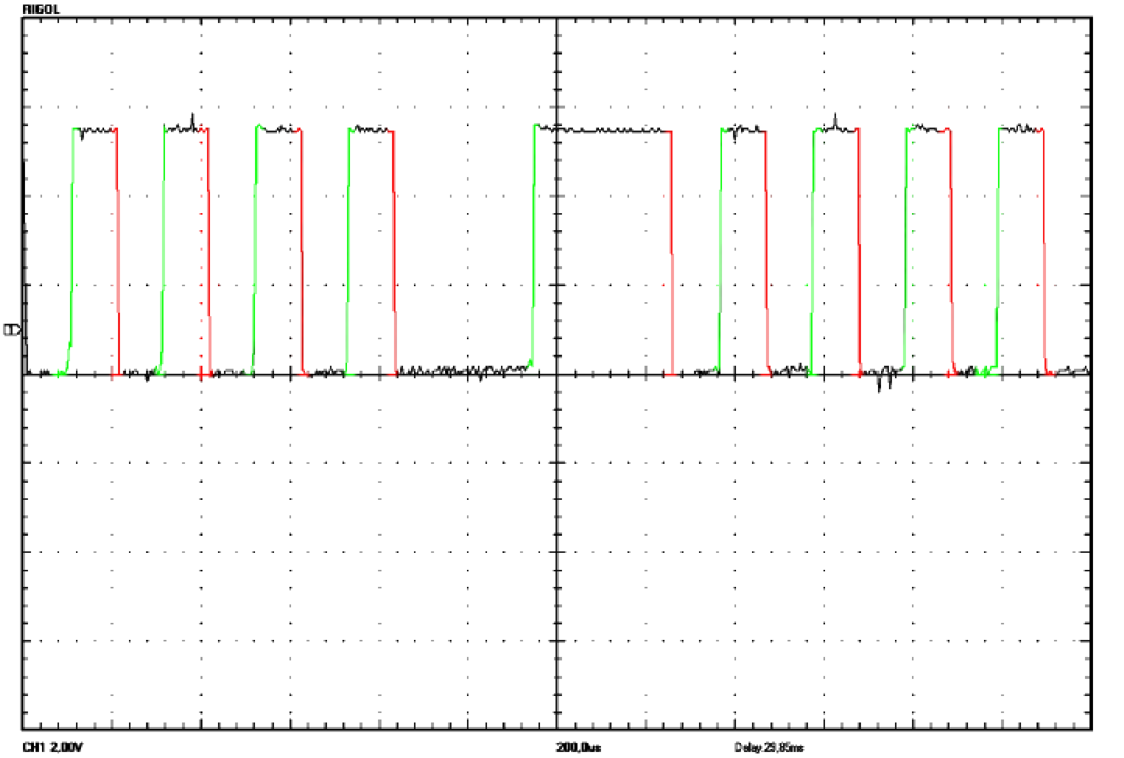




Scope trace of Hall sensor output using trigger wheel 60-2

Hall's sensors require powering (5-12V), but they are much more resistant to interference than magneto-inductive sensors. In practice, we also use shielded cables to minimise chances of interference of the signal from the sensor.

In case of signals waveform from Hall sensors, we are also dealing with the term of so-called signal edge (*signal edge*). We can distinguish two edges: rising (*rising,* when the voltage's value grows) and falling (*falling*, when the voltage's value falls).



In the picture above the falling edges *are marked* with red colour, and the rising edges with green colour.

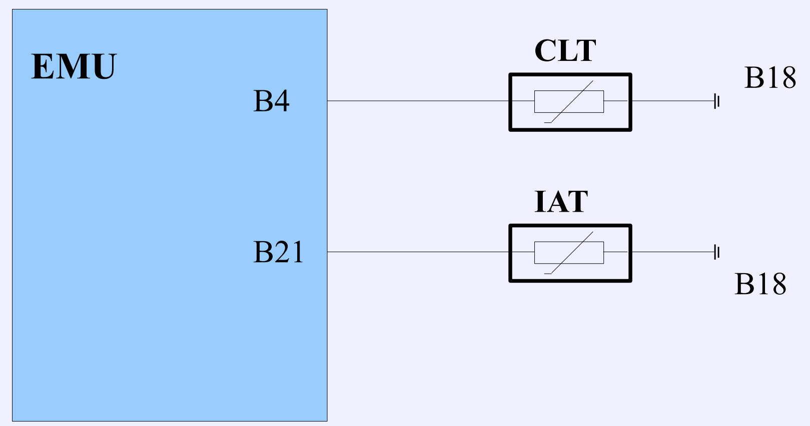
SENSORS CALIBRATION

Calibration of analogue sensors is done from the *Sensors Setup* level.

Coolant temperature sensor (CLT) and intake air temperature (IAT) sensors

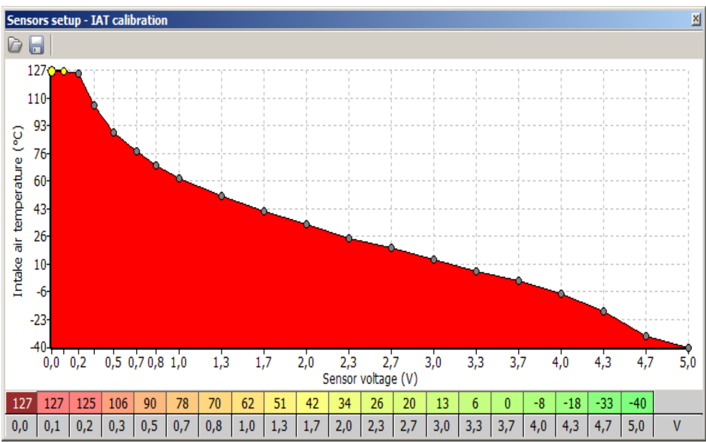
IAT and CLT sensors are in most cases the NTC thermistors. NTC thermistor is a nonlinear resistor, whose resistance depends strongly on temperature of the resistance material. As its names indicates (*Negative Temperature Coefficient)* thermistor has a negative temperature coefficient, so its resistance decreases when temperature grows.

These sensors are connected to the EMU device in the following way:

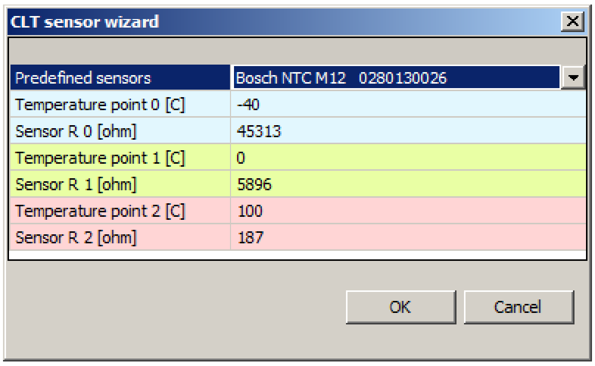


CLT and IAT sensors wiring diagram

IAT and CLT sensor calibration takes place by using 2D tables, respectively, *IAT Calibration* and *CLT Calibration.* This table defines the divider's voltage created by the sensor and built in the EMU pull-up resistor corresponding to the given temperature. In order to facilitate the sensor calibration, you should use the wizard.



Using the wizard we can use the predefined sensor, or create its characteristic, providing the sensor resistance for 3 known temperatures. The highest difference of temperatures is recommended in the wizard (these data can be found in the car's service book or can be collected with ohmmeter in 3 different temperatures)



Predefined sensors – names of predefined sensors. In case of choosing the „User defined" sensor it is possible to add temperature values and resistance of own sensor.

After selecting the sensor, you should press the OK button, what will create the calibration table.

WARNING !

To permanently save a change in the device's FLASH memory, you should select *Make Maps Permanent* option (shortcut key F2).

CLT, IAT input

CLT, IAT input configuration window is used to define which inputs are used to read *Intake Air Temperature* (IAT) and *Coolant Temperature* (CLT) sensors values. By default IAT and CLT sensors should be connected to dedicated inputs (B21 and B4) which are equipped with internal 2.2K pull-up resistors connected to +5V.

When temperature sensors are shared with stock ECU, it is possible to connect them to general purpose analog inputs to eliminate pull-up resistors influence on temperature reading.

IAT sensor is essential for fuel calculation strategy. It's reading is used to calculate air density and therefore air mass entering the cylinder.

CLT sensor is used to determine engine temperature and all fuel and ignition corrections related to it. Also idle control is dependent on this sensor.

IAT and CLT calibration are defined in IAT sensor calibration and CLT sensor calibration 2D tables. To create sensor calibrations, *CLT Wizard* and *IAT Wizard* can be used.

PARAMETER	DESCRIPTION
CLT Input sensor	**Use default input** -CLT sensor connected to dedicated input (B4) **Analog input** -CLT sensor connected to analog input
IAT Input sensor	**Use default input** - IAT sensor connected to dedicated input (B21) **Analog input** - IAT sensor connected to analog input

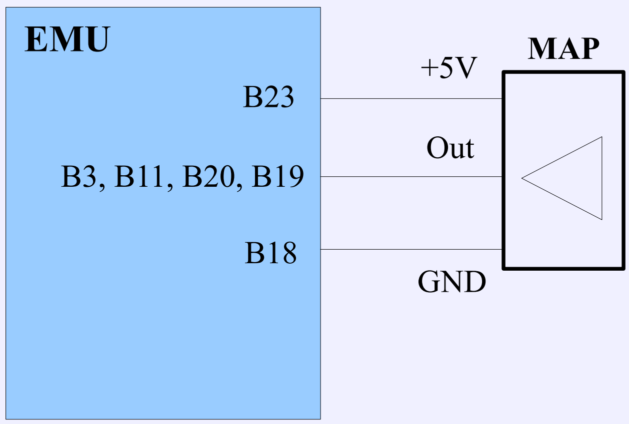
MAP sensor (*manifold absolute pressure sensor*)

Pressure sensors are used to measure pressure in the engine's intake manifold (MAP sensor) and atmospheric pressure (baro sensor). MAP sensor fulfils the following functions:

1. In algorithm *Speed Density* determines the engine's load and is the basic parameter while calculating the fuel's dose and the angle of ignition's timing.
2. In case of boost control in the feedback loop, the pressure's value in the intake collector is the basic information for the algorithm.
3. Fuel cut, when the pressure value is very low or exceeds the maximum value (overboost fuel cut).
4. BARO sensor is used to calibrate the fuel dose in case of algorithm Alpha-N

MAP sensor pressure should be taken from the intake manifold from the place closest to the throttle, so that its value most closely matches the average pressure value in the intake manifold. Pressure hoses should be as short as possible, with hard walls. In case of individual throttle bodies, pressure from each runner should be connected to the collecting can and only then to the MAP sensor. EMU device has an in-built pressure sensor with a measuring range of 400kPa, and a built-in barometric pressure sensor. It is possible to use the external MAP sensor connected to one of the analogue inputs.

Using the configuration of the MAP sensor we can decide whether to use the built-in sensor (*Use built in map*) or the external one. In case of using the external sensor we should choose the analogue input, to which we connect (*Analogue input*) and we enter its measuring scope 0 (*MAP range and MAP offset*).



Wiring diagram of external MAP sensor

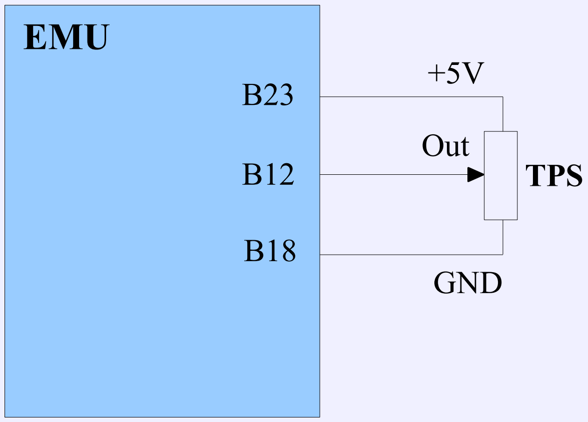
PARAMETER	DESCRIPTION
Use built in MAP	When checked, internal MAP sensor is used
Built in MAP offset	Offset used to precisely calibrate internal MAP sensor readings
MAP Range	Measurement range of external map sensor in kPa of absolute pressure
MAP Offset	Offset used to precisely calibrate external MAP sensor readings
Analog input	Analog input used to read voltage from external MAP sensor
Built in BARO offset	Offset used to precisely calibrate BARO sensor readings
Enable digital filter	When checked, activates MAP sensor signal digital filter
Digital filter power	Power of MAP sensor digital filter. Higher filter power gives more "smoothing" to the signal, but with higher filter power comes longer signal delay from MAP sensor. Value set here is used only when **Digital filter mode** is set to **Mode 0**.
Digital filter mode	**Mode 0** is used to keep compatibility with software 1.066 and lower. **Modes 1 - 3** are used to select low-pass filter cutoff frequency. Cutoff frequency decreases with mode number. When mode 1-3 is selected, filter power can be set in *MAP Filter power* table

TPS (Throttle position sensor)

Throttle position sensor is, next to the MAP sensor, the key sensor allowing to define the engine's load in algorithm Alpha-N, to calculate the coefficient of enriching the mixture with the acceleration and controlling engine idle. Calibration of this sensor is limited to the determination of 2 limit positions of the boundary locations of acceleration pedal. Voltage from TPS can be checked in *Log / Analog Inputs / TPS Voltage*.

PARAMETER	DESCRIPTION
TPS min voltage	TPS voltage for fully closed throttle
TPS max voltage	TPS voltage for fully opened throttle
TPS value under min voltage	TPS value assumed when TPS voltage is below ***TPS Min. Voltage***
TPS value over max voltage	TPS value assumed when TPS voltage is above***TPS Max. Voltage.***Can be used as a failsafe.
dTPS update interval	Time constant used to calculate TPS Rate (dTPS) value. It is used to regulate TPS Rate sensitivity.

TPS sensor should be connected as follows:



TPS sensor wiring diagram

Oxygen sensor (lambda sensor)

Lambda sensor allows the determination of the composition of fuel-air mixture. EMU device supports both narrowband and wideband sensors (Bosch LSU 4.2) The selection of the sensor is done in the set of parameters *Oxygen Sensor (Sensor Type).* In case of narrowband sensor, no further configuration is required. In case of LSU 4.2 probe, you should choose the fuel type (AFR value depends on it), and set the *Rcal* value (this is the value of sensor's calibration resistor and it can be measured with ohmmeter (ranges from 30-300 ohms) between pins of 2 and 6 of LSU 4.2 sensor connector).

WARNING !

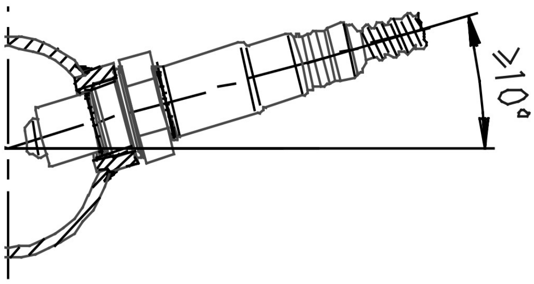
Incorrect Rcal value will cause false readings of the lambda sensor!

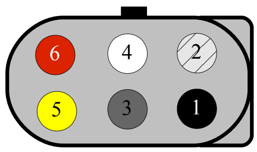
PARAMETR	OPIS
Sensor type	**Narrow band -** Both 1 and 4 wire sensor can be used. This type of sensor operates only near stoichiometric mixture (Lambda = 1) **Wide band -** For this type of sensor, Bosch LSU 4.2 must be used. Accurate *Rcal* value should be entered for correct measuring results. *Rcal* resistance can be measured on terminals 2 and 6 of wide band sensor. Correct Rcal value should be in 30-300 ohm range. **External controller** - Should be selected when external sensor

	controller is used and linear signal is connected to EMU.
Fuel type	Oxygen sensor measures Lambda value of mixture. To obtain adequate AFR measurement, correct fuel type must be selected here.
Heater kP	Sensor heater PID controller kP coefficient. Preset value should not be changed
Heater kI	Sensor heater PID controller kI coefficient. Preset value should not be changed
Heater kD	Sensor heater PID controller kD coefficient. Preset value should not be changed
Heater integral limit	Sensor heater PID controller integral windup limit. Preset value should not be changed.
Pump kP	Sensor pump cell PID controller kP coefficient. Preset value should not be changed.
Pump kI	Sensor pump cell PID controller kI coefficient. Preset value should not be changed.
Pump kD	Sensor pump cell PID controller kD coefficient. Preset value should not be changed.
Pump integral limit	Sensor pump cell PID controller integral windup limit. Preset value should not be changed.
RCal	Calibrating resistor value. *Rcal* resistance can be measured on terminals 2 and 6 of wide band sensor. Correct *Rcal* value should be in 30-300 ohm range and is essential for accurate measuring results.
Enable when no RPM	When selected, sensor heater is enabled when EMU is powered, unlike in normal operation mode, when heater is enabled after engine is started. This mode can be used to measure mixture ratio during engine startup. If heater is enabled when condensation is still present in exhaust system, sensor could be damaged, so for normal use, it is advised to disable this option.
AFR at 0V	In case of external sensor controller, defines AFR value at 0Vvoltage.
AFR at 5V	In case of external sensor controller, defines AFR value at 5Vvoltage.
Ext. controller input	Analog input used to connect external sensor controller.
Use WBO heater for NBO sensor	In case of narrow band sensor, option enables heater output to drive the sensor heater.

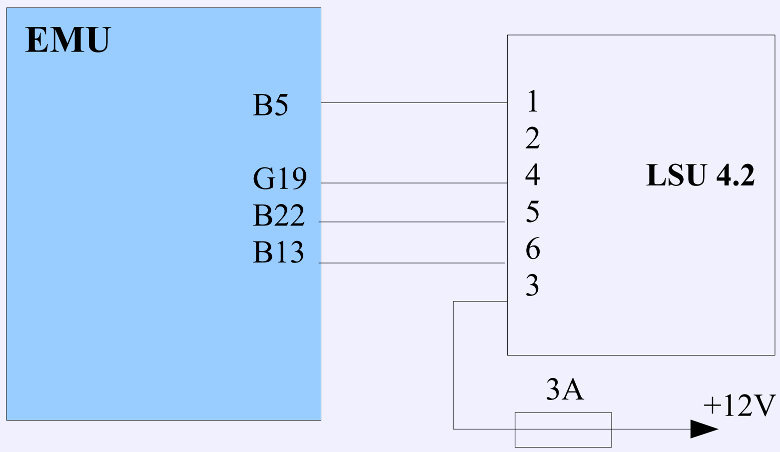
In the case of LSU 4.2 probe, you should apply the following guidelines:

- the probe must be installed in a place, where exhaust gas temperature (EGT) does not exceed 750 degrees Celsius.
- in turbo cars we install oxygen sensor in down-pipe,
- the sensor should be installed in a position close to vertical,
- you should always use original connectors,
- the connectors must be clean and dry. You must not use means like contact spray or other anti-corrosion means,
- you must not drive without a connected sensor into the EMU device, as it will cause a significant shortening of probe's life,
- EMU requires calibration (*Rcal* parameter) when being connected to the new probe.



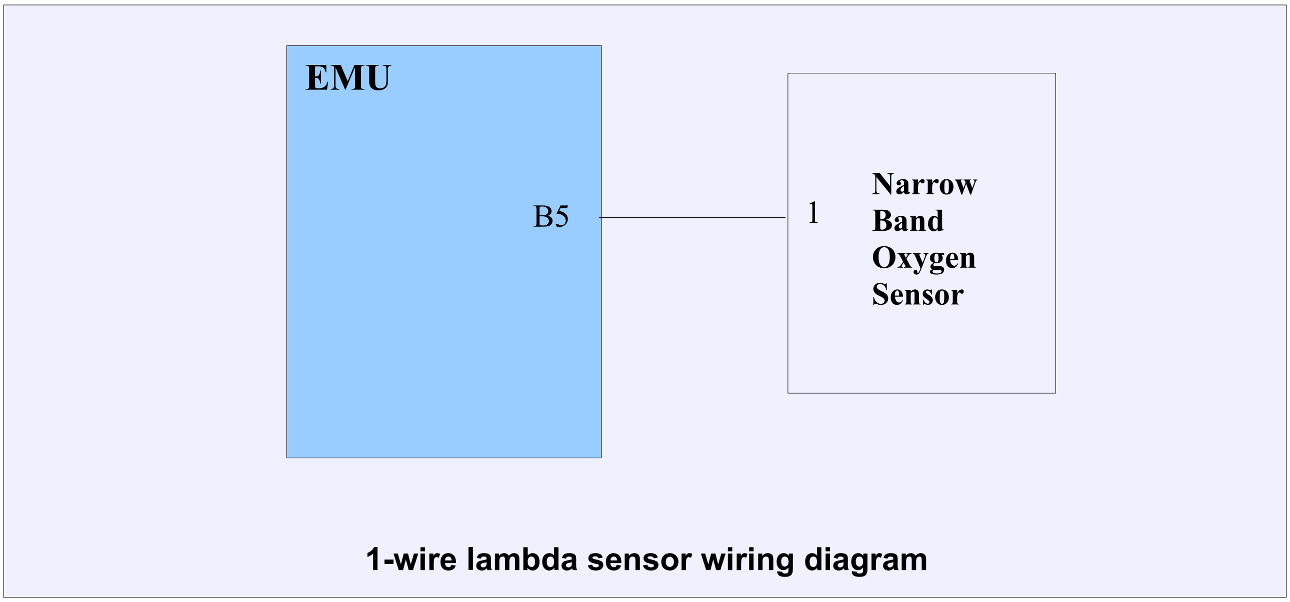


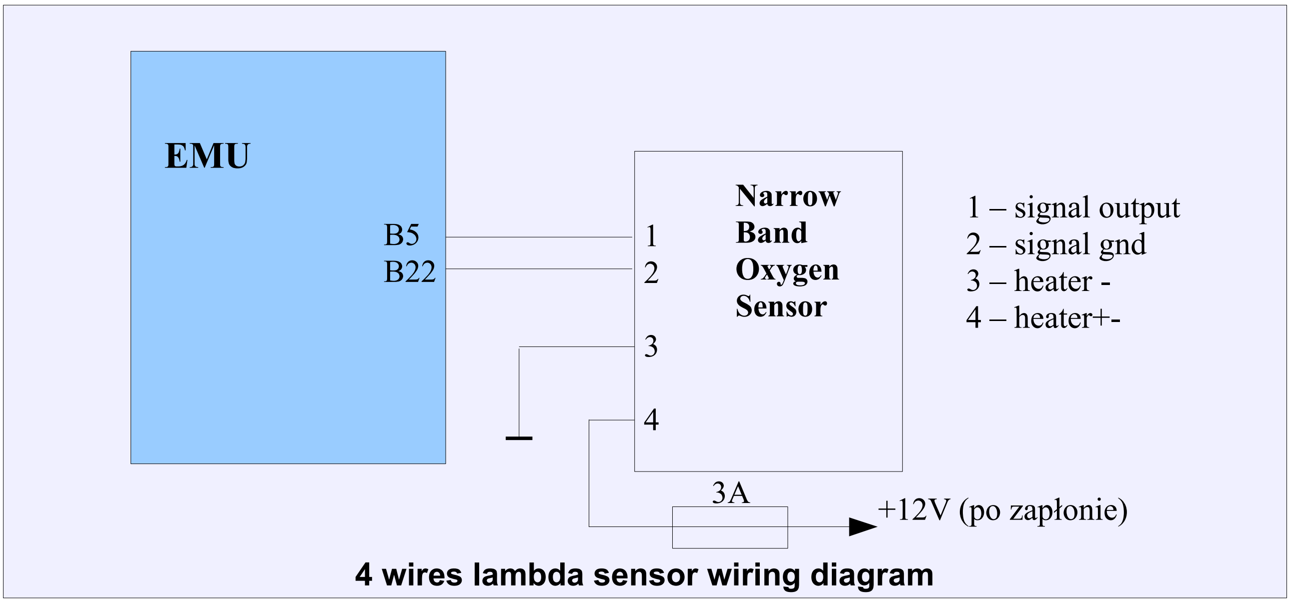
Installation of the lambda probe in the exhaust system. **Pionout of the LSU 4.2 connector**



Bosch LSU 4.2 wiring diagram

It is also possible to connect narrow band oxygen sensor:





In the case of using 1 wire oxygen sensor the voltage read by EMU for stoichiometric mixture is 2.95V, for the 4 wire sensor it is 0.45V.

VSS and gearbox

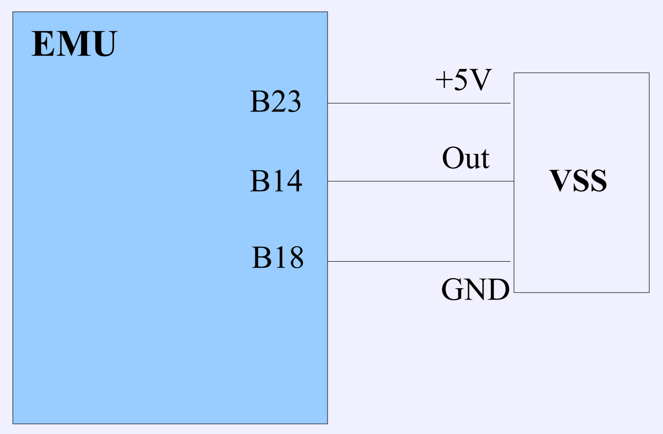
Vehicle's speed sensor is usually placed in the gearbox. It is used by factory systems, e.g., speedometer or the system supporting the steering wheel (e.g., electrical support system). Vehicle's speed can be also read from ABS sensors.

Ecumaster EMU device uses the VSS reading to regulate the boost pressure towards the vehicle's speed, controlling idle or the recognition of the currently selected gear.

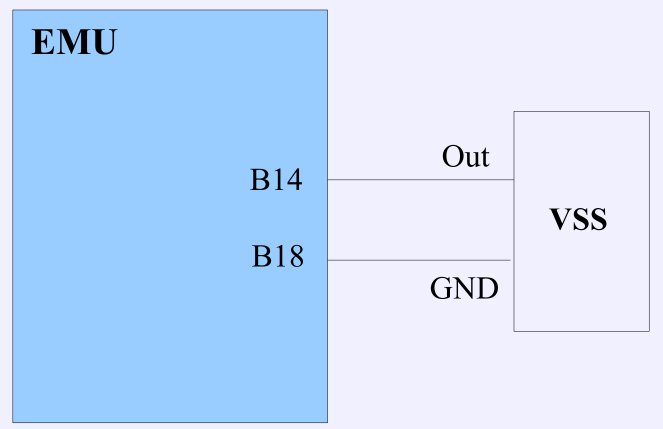
To configure the VSS sensor, you should open the set of parameters VSS and gearbox.

PARAMETER	DESCRIPTION
Gear detection type	**Calculated -** current gear is determined on the basis of Vehicle Speed / Engine RPM ratio. Calculated ratios can be read from(*VSS and gears/ Gear ratio*). For detection to work properly, ratios must be entered in fields *Gear x ratio* **Gearbox sensor -** current gear is determined by measuring voltage from sensor located in gearbox. Sensor calibration can be found in *Gear sensor calibration* table **CAN BUS** - gear information is read from Can Bus signal
Sensor type	Type of sensor used to detect vehicle speed. VR or Hall sensor can be selected
Trigger edge	Edge of sensor signal used to calculate vehicle speed
Freq. divider	Speed sensor signal frequency divider is used in case of high frequency signal
Enable pullup	Activates 2k ohm pull-up resistor from signal input and +5V
Speed ratio	Frequency multiplier used to calculate km/h speed from VSS signal frequency
Gear X ratio	Vehicle Speed / Engine RPM ratio for gear X. For calibration, value can be checked in *VSS and gears/ Gear ratio* log.
Ratio tolerance	Maximum allowed gear ratio deviation for gear to be determined
Gear sensor input	Analog input used to connect gearbox gear sensor
CAN ID	Can Bus frame ID containing information about current gear
CAN ID byte idx	Number of byte in frame that contains information about current gear

VSS sensor’s connection



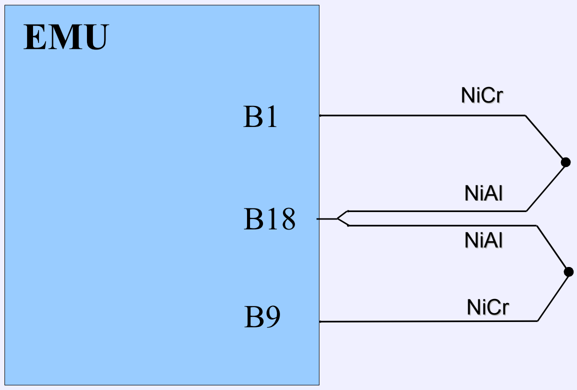
VSS wiring diagram. Hall type sensor



VSS wiring diagram. VR type sensor

EGT sensors

EMU device can use the K type thermocouple to measure the exhaust temperature. Sensor should be installed as close to head's exhaust channels as possible.



K type thermocouples connection diagram

ATTENTION!	
⚠	**To maintain the accuracy of a thermocouple measurement system, K type thermocouple compensation cable is required to extend from the thermocouple sensor to the EMU device.**

Failsafe

In case of failure of essential engine's sensors, EMU device is equipped with a protection, enabling fail-safe operation of the engine under certain conditions. Smooth operation of the engine and its power will be significantly decreased, however this allows to keep the vehicle’s mobility, which allows you to reach the service point. In case of failure of any sensors IAT, CLT or MAP, EMU device will automatically take on values determined by the user for the damaged sensor. These values can be adjusted in the parameter set *Failsafe*.

PARAMETER	DESCRIPTION
MAP fail safe	Fail safe value for Manifold Air Pressure (MAP) sensor
CLT fail safe	Fail safe value for Coolant Temperature (CLT) sensor
IAT fail safe	Fail safe value for Intake Air Temperature (IAT) sensor

FPRD failsafe

Fuel Pressure Rail Delta Failsafe function allows to limit engine RPM and indicate failure with *Check Engine light* when *Fuel Pressure Delta* (difference of *Fuel Pressure* and *Manifold Air Pressure*) exceeds defined values. *Fuel pressure sensor* needs to be connected and calibrated for this function to work properly (*Sensors setup/Extra sensors*).
To enable *Check Engine Light* indication, *Report fuel pressure failure* option must be checked in *Other/Check engine* parameters.

PARAMETER	DESCRIPTION
Enable failsafe	Activates FPRD failsafe function
Minimum FPR Delta	Minimum FPR delta interpreted as correct
Maximum FPR Delta	Maximum FPR delta interpreted as correct
Delay	Minimum time period with abnormal fuel pressure required to activate failsafe
Enable rev. limit	Enables RPM restriction in case of abnormal fuel pressure
Rev. limit	RPM limit for fuel cut, enabled when abnormal fuel pressure is detected

Extra sensors

Extra sensors configuration window allows you to select which inputs additional sensors are connected to. Example sensors that have special functions in EMU software are *Oil pressure*, *Oil temperature, Fuel pressure* and *Fuel level sensors.*

PARAMETER	DESCRIPTION
Oil pressure input	Analog input used to read oil pressure sensor value. Sensor calibration can be found in *Sensors setup / Oil press. cal.* table
Oil temperature sensor input	Analog input used to read oil temperature sensor value. Sensor calibration can be found in *Sensors setup / Oil temp. cal.* table
Fuel pressure sensor input	Analog input used to read fuel pressure sensor value. Sensor calibration can be found in *Sensors setup / Fuel press. cal.* table
Fuel level sensor input	Analog input used to read fuel level sensor value. Sensor calibration can be found in *Sensors setup / Fuel level cal.* table

Analog Inputs

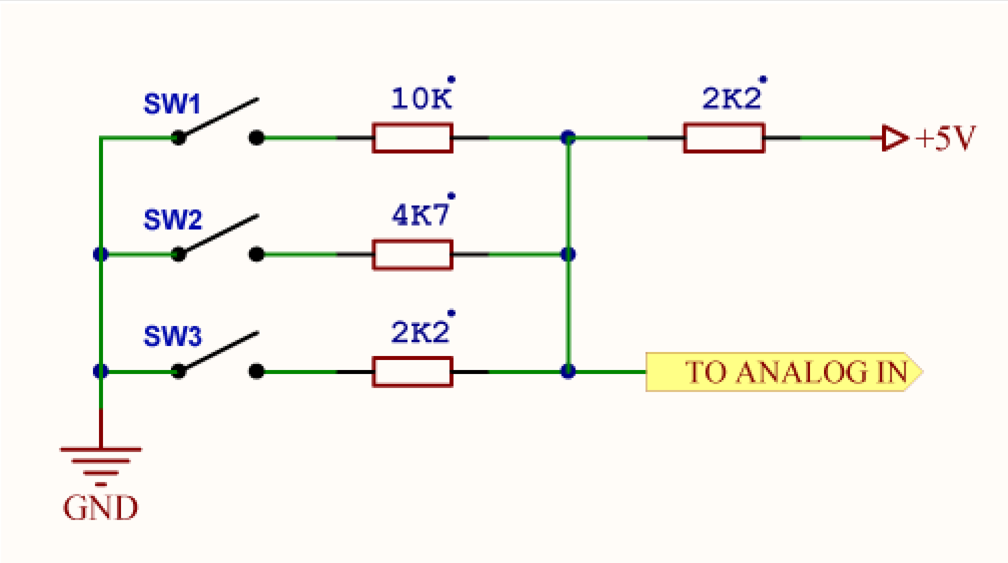
EMU device has 4 analog inputs, which can be used as inputs activating functions of the device, such as, e.g., launch control, or to log in signals from additional sensors. There is a possibility to configure sensors, so that voltage from the sensor is presented as physical value, e.g., pressure expressed in bars. To configure sensors connected to analogue inputs you have to use parameters *Analog Inputs*.

PARAMETER	DESCRIPTION
AIN#X unit	Unit displayed after calculated value from analog input X
AIN#X ratio	Ratio of displayed value to input voltage (slope of linear function)
AIN#X offset	Offset added to value multiplied by ratio (intercept of linear function)
AIN#X min.	Minimum allowed value
AIN#X max.	Maximum allowed value

Displayed value [UNIT] = Input voltage * RATIO + OFFSET

MUX switch

MUX switch function allows the connection of up to 3 switches to one analog input. Switches can activate various functions such as Launch Control, ALS, Pit Limiter and others. Switches connected with mux switch function are visible in software with names Mux switch 1-3. Mux switch state can be checked in Log/Other/Mux switch state. To use this function, switches must be connected according to the following diagram. It's advised to use resistors with 1% tolerance and Sensor ground for grounding.



MUX switch wiring diagram

PARAMETR	DESCRIPTION
MUX Switch enabled	Activates MUX switch function
MUX Switch input	Analog input connected with MUX Switch

FUELING PARAMETERS

Configuration of *Fuelling* parameters is responsible for fuel dosing, both for the dose's size and the fuel injection angle. The performing element in case of fuel dosage is the injector. It is the electro valve that allows the precise dosage of the sprayed fuel. Fuel dosage is regulated by the width of electric pulse on the winding of injector coil.

Directly to EMU we can connect high impedance (*Z*) injectors (>= 8 Ohm). Up to 2x Hi-*Z* injectors can be connected to one *Injector* output. In case of Lo-*Z* injectors (<4 Ohm) we should apply a current limiting resistor (4,7 Ohm 50W) for each injector or additional external *Peak and Hold* controller.

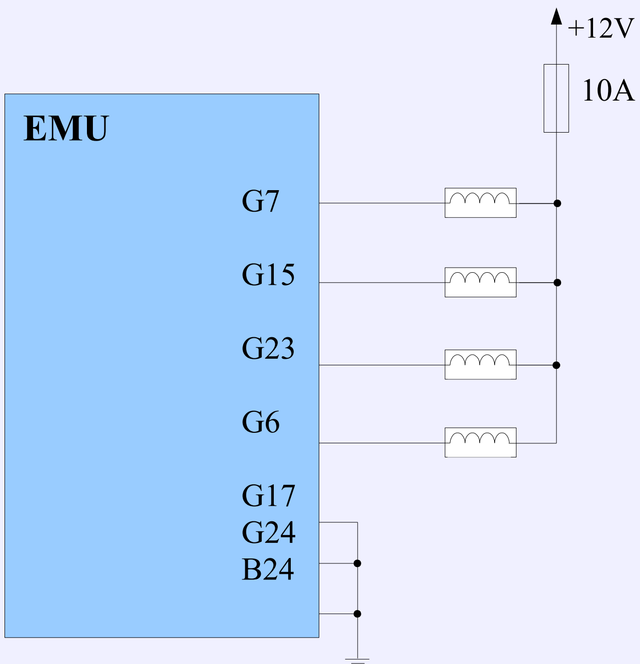
ATTENTION !

Connecting Lo-Z injectors directly to EMU device can lead to the damage of the device or injectors.

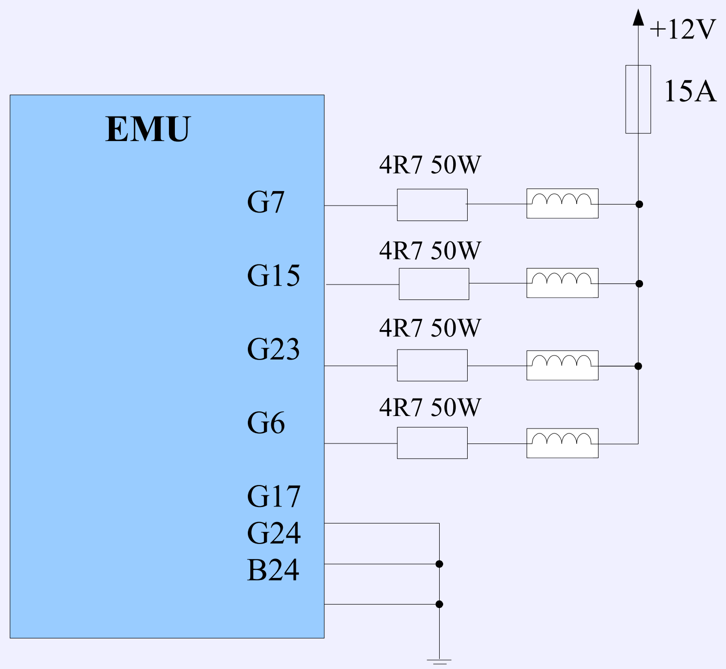
ATTENTION !

Injectors should be powered by the properly selected fuse. The fuse's value results from the maximal current taken by the given injectors.

Injectors are controlled by switching to the ground and require the connected power grounds (G17, G24, B24)



4 Hi-Z injectors wiring example



4 Lo-Z injectors wiring example

Selecting of injectors

To determine required injector's flow rate, you should know the engine's BSFC. BSFC (*brake specific fuel consumption*) is the amount of fuel needed to generate 1 horsepower per hour. For naturally aspirated engines this value is about 5,25cm^3/min, while for turbo engines about 6cm^3/min. We select injectors' flow rate to achieve the expected power with 80% duty cycle (DC). Fuel injector duty cycle is a term used to describe the length of time each individual fuel injector remains open relative to the amount of time that it is closed and is expressed in %.

Injectors flow rate = (Horsepower * BSFC) / (number of injectors * max. DC)

For example, for 4 cylinder naturally aspirated engine with 150KM power

Injectors flow Rate = (150 * 5,25) / (4 * 0,8) = 246 cm^3/min

General

Fuelling general configuration window is used to set up general fueling strategy and parameters. Values entered here directly influence fuel dose, so it's important to enter values that reflect real engine parameters.

PARAMETER	DESCRIPTION
Engine displacement	Engine displacement in cubic centimeters
Fueling type	Fueling strategy selection. Fueling strategies are described below.
Enable baro correction	Enables fuel dose correction as a function of barometric pressure. Value of correction is defined with *Barometric corr.* 2D map. Barometric correction should be used with *Alpha-N* fueling strategy.
Injectors size	Injector flow in cubic centimeters per minute. If number of injectors is not equal to the number of cylinders, average injector flow per cylinder should be entered here.

Speed density

The basic algorithm of calculating the fuel dose can be used for turbo engines as well as for naturally aspirated ones. It can be characterized by the fact that engine's load is defined by the value of absolute pressure in the intake manifold.

In this algorithm the fuel dose is calculated as follows:

PW = INJ_CONST * VE(map,rpm) * MAP * AirDensity * Corrections + AccEnrich + InjOpeningTime

PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(map, rpm)	value of volumetric effectiveness read from the VE table
MAP	Intake manifold pressure
AirDensity	percentage difference of air density towards air density in temperature 21°C

Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

ALPHA-N

Algorithm used in naturally aspirated engines, where there is no stable vacuum (sport cams, ITB, etc.). It is characterized by the fact that the load is defined by the TPS. It is not suitable nor recommended for turbocharged engines.

PW = INJ_CONST * VE(tps,rpm) * AirDensity * Corrections + AccEnrich + InjOpeningTime

PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(tps, rpm)	value of volumetric effectiveness read from the VE table
AirDensity	percentage difference of air density towards air density in temperature 21°C
Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

ALPHA-N with MAP multiplication

Algorithm combining features of Speed Density and Alpha-N. The load is defined by TPS, while VE value is multiplied by the value of absolute pressure in the intake manifold. It can be used for both naturally aspirated and turbocharged engines.

PW = INJ_CONST * VE(tps,rpm) * MAP * AirDensity * Corrections + AccEnrich + InjOpeningTime

PW (*pulse width*)	final time of injector's opening
INJ_CONST	a constant for the given size of injectors, engine's displacement, pressure 100kPa, temperatures of the intake air 21°C, VE 100%, time of injectors' opening required to obtain the stoichiometric mixture (Lambda = 1)
VE(tps, rpm)	value of volumetric effectiveness read from the VE table
MAP	Intake manifold pressure
AirDensity	percentage difference of air density towards air density in temperature 21°C
Corrections	fuel dose corrections (discussed in the following pages)
AccEnrich	acceleration enrichment
InjOpeningTime	the time it takes for an injector to open from the time it has been energized until it is fully open (value from the calibration map *Injectors cal.*)

Corrections

Corrections = Baro * Warmup * ASE * EGO * KS * NITROUS

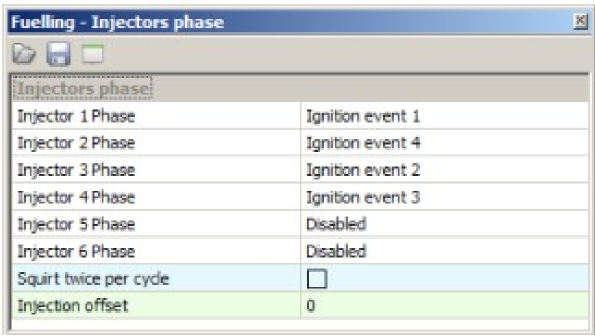
Corrections	Final percentage value of fuel dose correction
Baro(*barometric correction***)**	Barometric correction used in Alpha-N algorithm
Warmup*(warmup enrichment)*	value of mixture enrichment in the function of cooling liquid temperature expressed in percentage
ASE(*Afterstart enrichment)*	Enrichment applied after engine start for given number of engine cycles
EGO(*Exhaust gas oxgen sensor correction***)**	correction according to indications of the Lambda probe
KS(*Knock Sensor Correction)*	enrichment in the moment of knock occurrence
NITROUS	enrichment of the mixture with the activation of nitrous oxide system

Injectors phase

Injectors phase configuration window connects fuel injection start with *Ignition Events*. Injections starts *N* degrees before Top Dead Centre of cylinder connected with *Ignition Event*, to which the injector is assigned. *N* is a base angle that is equal to *Trigger angle value* from *Primary trigger configuration.*

Number of *Ignition Events* equals number of cylinders in the engine. Every injector opens only one time in engine cycle (720 degrees) except when *Squirt twice per cycle* option is activated, then every injector opens twice per cycle. This option is used for bank fire injection.

PARAMETER	DESCRIPTION
Injector X Phase	*Ignition Event* to which injector X opening is associated.
Squirt twice per cycle	Activates two fuel injections during full engine cycle
Injection offset	Offset of injection angle from base angle described above

<table>
<tr><th colspan="2">Example configurations</th></tr>
<tr><td>Full sequential injection for 1-3-4-2 ignition sequence</td><td>
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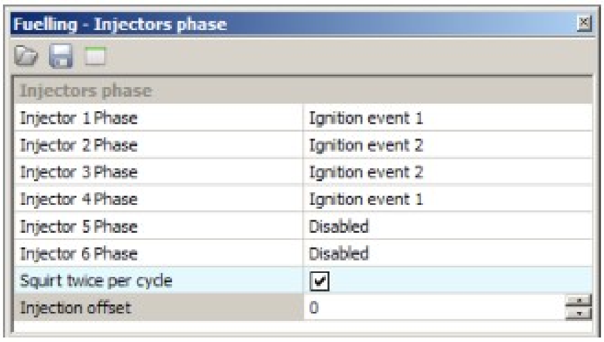
<tr><td>Bank fire injection for wasted spark ignition</td><td>
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Injectors trim

Injectors trim configuration is used to correct fuel dose for individual injectors. It's useful for precise fuel dose control for each individual cylinder.

Fuel cut

Fuel cut parameters are responsible for setting up circumstances to occur for *Fuel Cut* to be executed. These can be excessive engine RPM or MAP. Deceleration fuel cut can also be set here.

PARAMETER	DESCRIPTION
RPM Limit	RPM value for fuel cut rev limiter. Used to protect engine from over revving
Fuel cut above pressure	Minimum intake manifold air pressure to execute fuel cut. Acts as a protection from over boost
Fuel cut under pressure	Cuts fuel when throttle is closed and MAP drops below set value. Used to improve fuel economy when braking with engine
Fuel cut TPS limit	Maximum TPS value for*Fuel cut under pressure*to occur
Fuel cut above RPM	Minimum RPM value for*Fuel cut under pressure*to engage
Fuel resume below RPM	RPM value under which fuel injection is unconditionally resumed
Overrun fuel cut decay rate	In case of overrun fuel cut, defines rate at which fuel dose is reduced with every engine revolution. 100% is full fuel cut in one engine revolution
Disable spark during overrun fuel cut	Allows to disable spark executing during overrun fuel cut

EGO feedback

EGO feedback configuration window is used to set up *EGO closed loop correction* operation parameters. Both wideband and narrowband sensors can be used for correction. In case of narrowband sensor, it's only possible control mixture content around stoichiometric *(NBO Ref Target*). Use of wideband sensor allows controlling mixture to achieve values set in AFR table.

PARAMETER	DESCRIPTION
Enable EGO feedback	Enables EGO closed loop correction
Rich limit	Fuel mixture enrichment limit
Lean limit	Fuel mixture leaning limit
NBO change step	Used only with narrowband sensor. Defines fuel dose correction step size in percent
NBO change rate	Used only with narrowband sensor. Defines correction calculation interval in engine revolutions
NBO ref target	Reference voltage to be held for narrowband sensor correction
Warmup time	Defines how long the system is inactive after engine start
TPS limit	Minimal TPS value for EGO feedback to be active
Min CLT	Minimal engine coolant temperature for EGO feedback to be active
Min RPM	Minimal engine RPM for EGO feedback to be active
Max RPM	Maximum engine RPM for EGO feedback to be active
Min MAP	Minimal Manifold Air Pressure for EGO feedback to be active
Max MAP	Maximum Manifold Air Pressure for EGO feedback to be active
Fuel Cut delay	Time in ms for EGO feedback to be reactivated after fuel cut
EGO kP	Proportional gain of EGO correction PID controller
EGO kI	Integral gain of EGO correction PID controller
EGO Integral Limit	Limit to prevent PID controller integral windup

EGT Correction

EGT correction is fuel dose correction function used to protect engine from excessively high EGT by enriching air fuel mixture. Per injector correction can be set by selecting EGT sensors associated with particular injector. Value of correction can be set up in EGT Correction 2D table.

PARAMETER	DESCRIPTION
Enable correction	Activates EGT fuel dose correction function
Injector N probe	EGT sensor signal responsible for fuel dose correction on injector N.

Injectors cal.

Injectors cal. table is used to calibrate injectors dead time as a function of supply voltage. Injectors take some time, to start delivering fuel, from the beginning of electrical signal. This time is longer for lower supply voltages and it depends on used injector. Also higher fuel pressure can cause longer dead time.

In case of using popular injector types*Injectors Wizard*could be used to set up dead time.

Barometric correction

Barometric correction table defines fuel dose correction as a function of barometric pressure. It's used with ALPHA-N fueling strategy. To activate barometric correction it is necessary to check Enable Baro Correction in General options.

IAT correction

Fuel dose correction table is used to additional correction of fuel dose in a function of Intake Air Temperature. It can be used as extra correction independent of fueling strategy calculated air density correction.

ATTENTION !

Fuel calculating strategy takes in account changes of air density related to its temperature. IAT correction is additional function used to implement engine cooling strategies.

DFPR correction

DFPR correction table is used to set up fuel dose correction related to fuel rail pressure delta. Delta pressure is pressure difference between fuel rail pressure and manifold air pressure. With properly working fuel system this delta pressure should always be constant. DFPR corr. function is useful to correct fuel pressure regulator non-linearities or to protect the engine in case of fuel pump or regulator failure. To use this function it is necessary to have fuel pressure sensor installed and calibrated. Sensors setup / Extra sensors.

Engine protecting fail-safe functions, that will activate with abnormal delta fuel pressure, can be enabled in Sensors setup / Fail safe FPR.

EGT correction table

EGT correction table is used to correct fuel dose in function of exhaust gases temperature. In case of using multiple thermocouples it is possible to trim fuel dose per individual cylinder. The thermocouples assignment table could be found in *Fuelling/EGT correction.*

VE table 1 and 2

VE table is 3D table of engine volumetric efficiency as a function of engine RPM and load. Volumetric efficiency is ratio of air that is trapped by the cylinder during induction over the swept volume of the cylinder. VE table is the most important table used to tune fuel dose. Different available fueling strategies are described in *Fuelling - General* section. It's important to take in account that fuel dose depends also on many different corrections and enrichments, not only on VE table.

AFR table 1 and 2

AFR Table defines target AFR for EGO closed loop operation. Two separate AFR tables exist, that could be switched by user or interpolated using signal from *FlexFuel* sensor.

TPS vs MAP correction

TPS vs MAP corr. is fuel dose correction table as a function of MAP pressure and TPS position.

CONFIGURATION OF IGNITION PARAMETERS

Configuration of ignition parameters is crucial from the point of view of the correct engine work and should be performed with the utmost care.

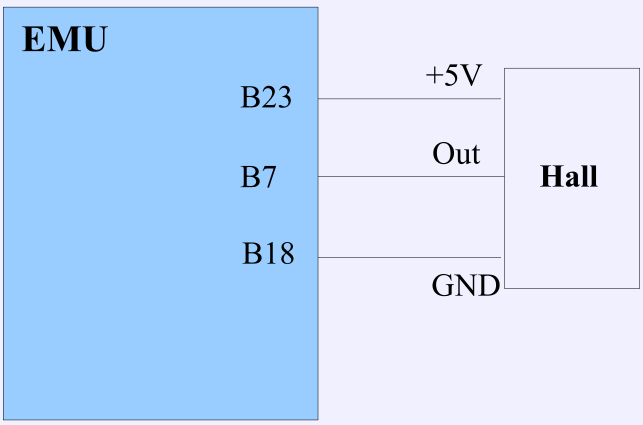
Primary trigger

Primary trigger options are responsible for configuring the main sensor directing ignition system and base ignition advance. The signal source (sensor) can be located on the crankshaft as well as on the camshaft. After each change of parameters, the ignition angle should be checked with a timing light.

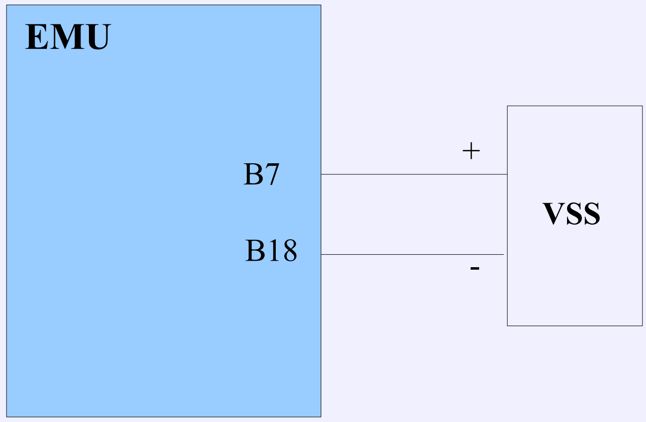
ATTENTION !
Proper configuration of the ignition system is essential for safe operation of the engine!

ATTENTION !
After each modification to the ignition system parameters it is necessary to check ignition angle advance using a timing light

Depending on the type of the sensor, the scheme of connections looks as follows:



Hall's / Optical sensor connection



VR sensor connection

ATTENTION !
In case of VR sensors connecting the sensor with the device must be done with the shielded cable, while the shield must be connected to the ground only at one end!

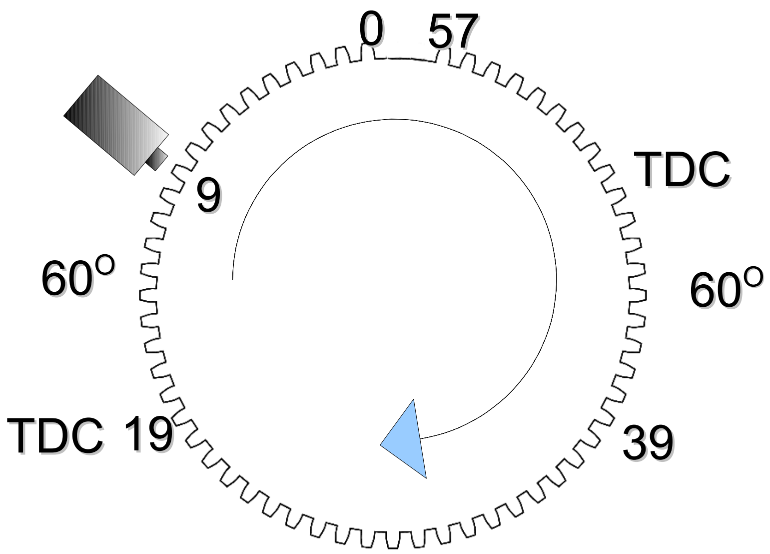
ATTENTION !
In case of VR sensor the sensor's polarity is important!

PARAMETER	DESCRIPTION
Sensor type	Indicates the type of sensor connected to the *Primary trigger* input. For Hall/Optical sensors option *Enable pullup* is required
Enable pullup	Enable 2K pullup to +5V on *Primary trigger* input. This function is used in the case of Hall and Optical sensors that have open collector outputs
Trigger type	Supported *Primary trigger* decoders. More information about supported decoders could be found further
Trigger edge	Trigger edge of input signal used for decoding trigger pattern. More information about proper trigger selection can be found further
Number of cylinders	Number of engine cylinders. This determines the number of *ignition events* which are always equal to number of cylinders
Num teeth (incl. missing)	Number of teeth on primary trigger toothed wheel including missing ones. In the case of toothed wheel with additional tooth the additional tooth is excluded. For example for 12+1 wheel, *num teeth* should be 12. In the case of some *trigger types* this value has no effects

First trigger tooth	The tooth index that defines first *ignition event.* Detailed information about the *first trigger tooth* and *trigger angle* configuration can be found further
Trigger angle	The angle defines the location of the *First trigger tooth* in relation to Top Dead Center. This number will be a positive value that indicates the number of degrees before Top Dead Center. This value also defines the maximum allowable ignition advance. The suggested value is between 50-60 degrees. Detailed information about the *first trigger tooth* and *trigger angle* configuration can be found further
Cranking gap detection scale	When using trigger decoders with missing tooth (teeth) or an additional tooth, during engine starting (*Cranking*) this parameter influences the way the missing (or additional) tooth is detected. This option is useful for engines with high compression ratios when the crankshaft angular speed is uneven.
Next edge rejection angle	The distance in crank degrees from the last trigger edge, below which any incoming trigger edge will be ignored as noise. This parameter is used for noise reduction
Enable scope	This function activates the EMU scope function which allows logging of signals on the *Primary trigger*, *Secondary trigger* and *CAM#2* inputs
Ignition angle lock	This option locks the ignition timing to a fixed value. This is useful for checking the base ignition angle and trigger settings using a timing light. Be sure to disable ignition lock after verifying timing.
Lock angle	Ignition angle value for *ignition angle lock* function

Trigger wheel configuration

In the following example, ***Trigger Tooth*** is defined as 9th tooth, which is located 60 degrees before engines first cylinder Top Dead Center (which is located at 19th tooth). Next ignition event is located on 39th tooth (in 4 stroke engine ignitions are spaced by 180 degrees). The trigger teeth for any ignition event must not overlap with missing teeth on trigger wheel!



60-2 trigger wheel

ATTENTION !	
⚠	**After each modification to the ignition system parameters it is necessary to check ignition angle advance using a timing light**

Supported trigger wheels

PARAMETER	DESCRIPTION
Toothed wheel with 2 missing teeth	The toothed wheel with missing two teeth. The typical sample of such pattern is 60-2 toothed wheel. The tooth number 0 is the first tooth after the gap and does not depend on the camshaft synchronization what in this case determines engine cycle
Toothed wheel with 1 missing tooth	The toothed wheel with missing tooth. A typical example of this pattern is the Ford 36-1 toothed wheel. The tooth number 0 is the first tooth after the gap and does not depend on the camshaft synchronization what in this case determines engine cycle
Multitooth	Toothed wheel with evenly spaced teeth. In the case of *multitooth* pattern it is necessary to use camshaft synchronization to determine tooth number 0. Cam sync is only optional when a distributor is used and the number of teeth on the camshaft are equal to the number of cylinders
Nissan trigger	Ignition system that utilizes a CAS trigger wheel with 360 outer slits and 4 or 6 inner slits. This signal is converted to *multitooth* 60
Toothed wheel with additional tooth	Toothed wheel with evenly spaced teeth and one additional tooth used for synchronization. The tooth number 0 is the first tooth after the additional one and does not depend on the camshaft synchronization what in this case determines engine cycle
Honda J35A8	Ignition system specific to J35A8 engine. The signal is converted to *multitooth* 24, but the tooth number 0 is determined and does not depend on the camshaft synchronization what in this case determines engine cycle
Rover 18-1-18-1	Ignition system specific to Rover engines. The signal is converted to *multitooth* 36 but the tooth number 0 is determined and does not depend on the camshaft synchronization what in this case determines engine cycle
Porsche 132 teeth	Ignition system specific to Porsche engines. The signal is converted to *multitooth* 2 and it is required to synchronize with camshaft sensor
Rover 13-1-2-1-14-1-3-1 (Lotus Elise)	Ignition system specific to Rover engines. The signal is converted to *multitooth* 12 but the tooth number 0 is determined and does not depend on the camshaft synchronisation what in this case determines engine cycle
Subaru 36-2-2-2	Ignition system specific to Subaru engines. The signal is converted to *multitooth* 12 but the tooth number 0 is determined and does not depend on the camshaft synchronisation what in this case determines engine cycle
Subaru 6 teeth	Ignition system specific to Subaru engines. The signal is converted to *multitooth* 2 but the tooth number 0 is determined and does not depend on

	the camshaft synchronisation what in this case determines engine cycle
Dodge 18-2-18-2	Ignition system specific to Dodgde engines. The signal is converted to *multitooth* 36 but the tooth number 0 is determined and does not depend on the camshaft synchronization what in this case determines engine cycle
Audi trigger 135 tooth	Ignition system specific to Audi engines. It is converted to *multitooth* 45. It is required to synchronize with 2nd crank sensor and camshaft sensor
CAM toothed wheel with additional tooth	Toothed wheel with evenly spaced teeth and one additional tooth used for synchronization located at camshaft. The tooth number 0 is the first tooth after the additional one and does not require synchronization
TFI	FORD TFI ignition system
Renault Clio Williams44-2-2	Ignition system specific to Renault Clio Williams. It requires using distributor
BMW E30 M3 116 teeth	Ignition system specific to Porsche engines. The signal is converted to *multitooth* 2 and it is required to synchronize with camshaft sensor
Mitsubishi Colt 1.5CZ	Ignition system specific to Mitsubishi Colt 1.5CZ engines. The signal is converted to *multitooth* 12 but the tooth number 0 is determined and does not depend on the camshaft synchronization what in this case determines engine cycle
Toothed wheel with 3 missing teeth	The toothed wheel with missing two teeth. The tooth number 0 is the first tooth after the gap and does not depend on the camshaft synchronization what in this case determines engine cycle

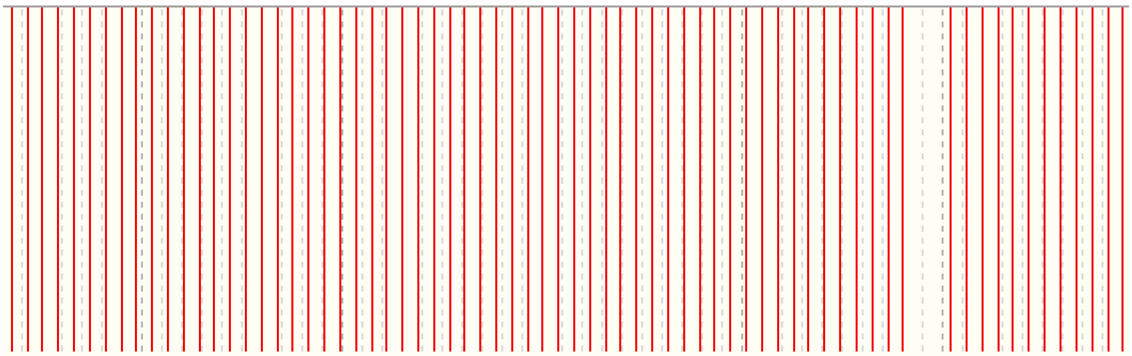
Trigger edge selection

For proper signal processing, it's important that you select the correct trigger edge for the crankshaft and camshaft position sensors. The EMU is equipped with a Scope tool which is useful to verify that the signal is being decoded correctly.

ATTENTION !
⚠ **Changing a trigger edge also changes the base ignition angle. You must verify ignition timing with a timing light after making any trigger setting changes.**

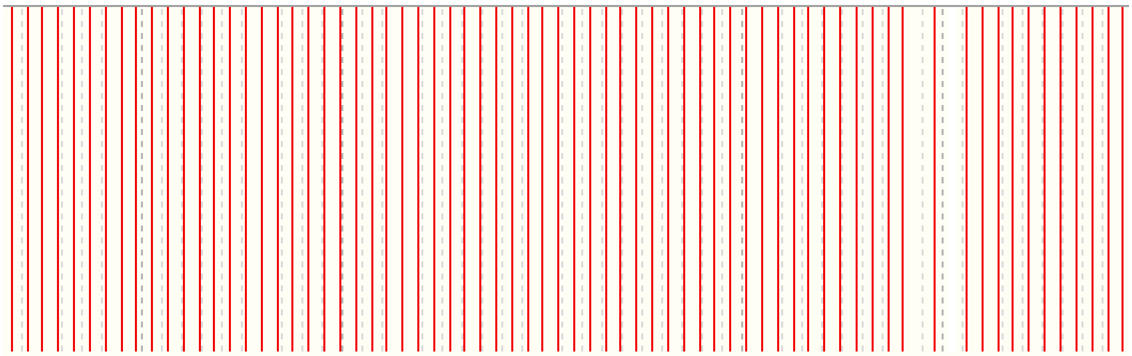
Trigger edge selection for trigger wheels with missing teeth

When trigger wheel with missing teeth is used, edge choice can be verified by inspecting the scope results in the region of the missing teeth.



Correct scope for 60-2 trigger wheel

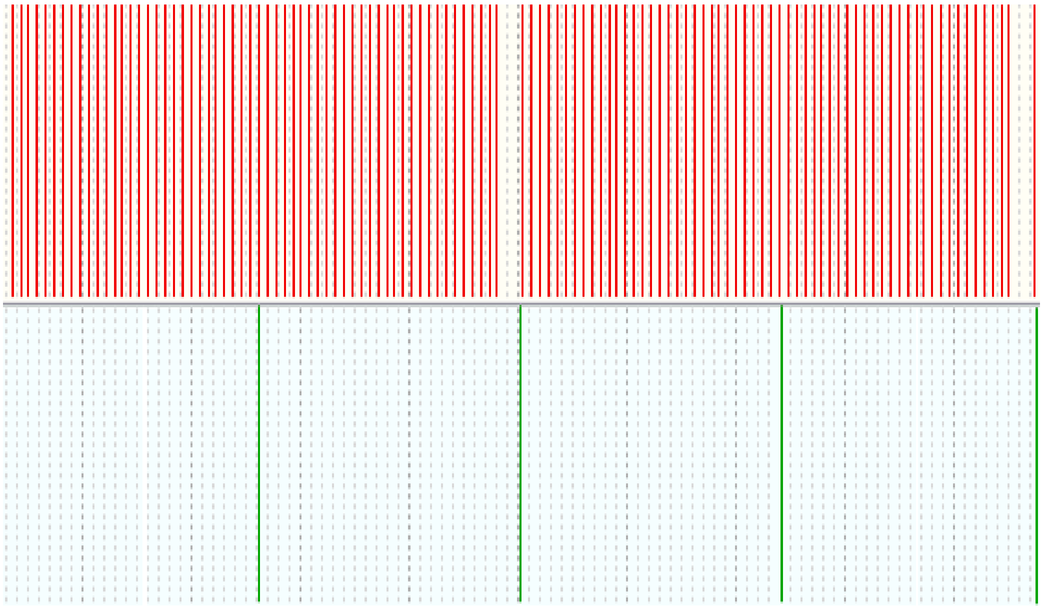
When the edge is selected incorrectly, the gap associated with the missing teeth is smaller than expected by the decoding algorithm.



Incorrect scope for 60-2 trigger wheel

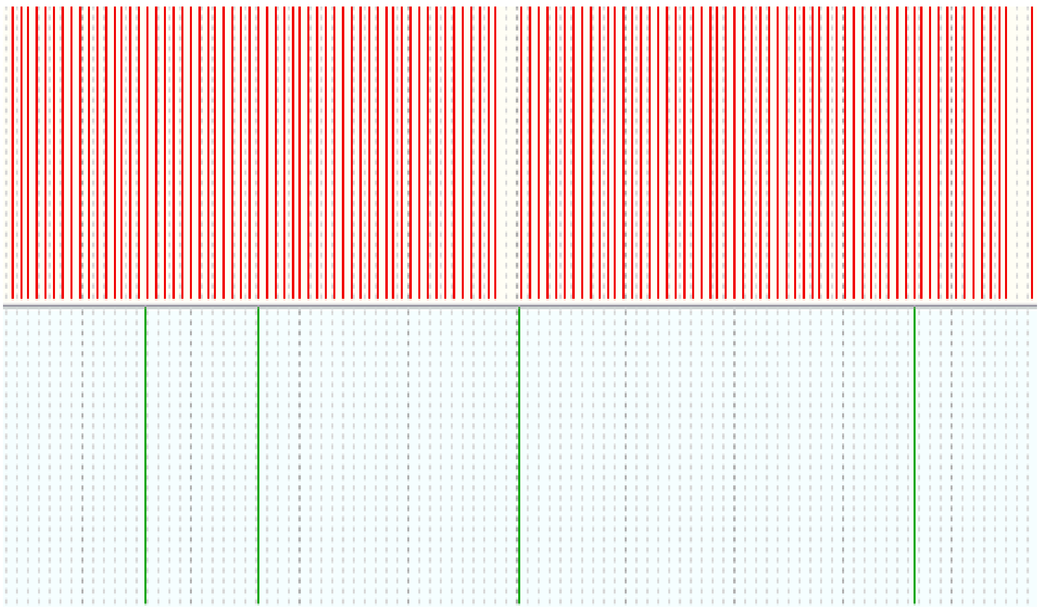
Edge selection for camshaft trigger wheel signal

Frequently, when a variable valve timing system is present in an engine, incorrect signal edge selection makes proper signal decoding impossible.



Incorrect scope for camshaft trigger wheel signal

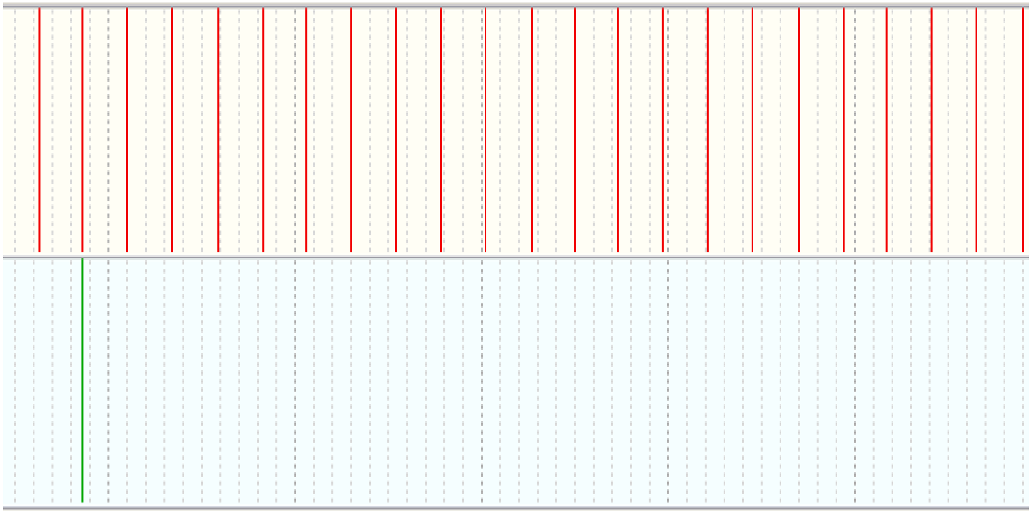
The scope above shows a camshaft trigger wheel signal decoded with equal distances between signal edges (teeth). This configuration prevents clear engine stroke detection. After edge change, the decoded signal is clearly different between engine strokes. This makes possible to use camshaft trigger wheel signal decoder (N+1 in this case)



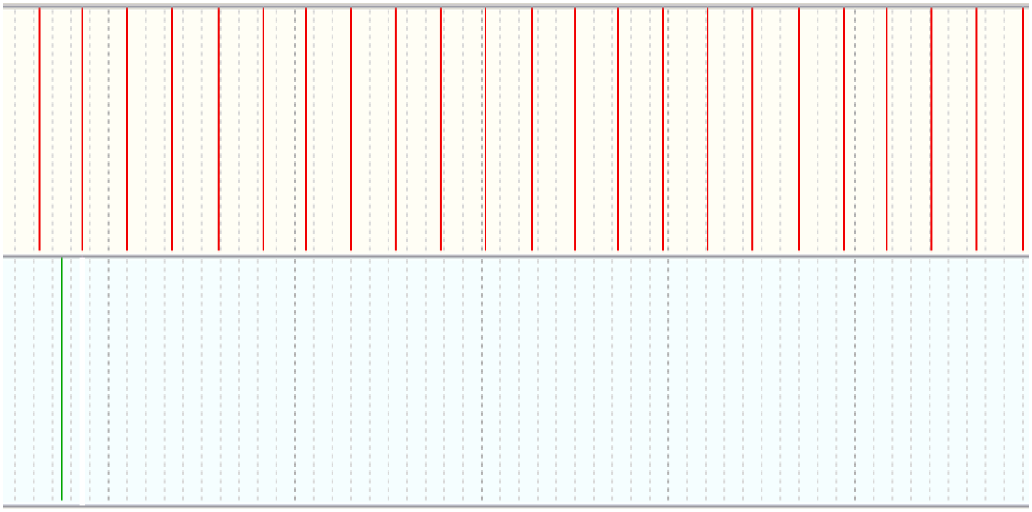
Correct scope for camshaft trigger wheel signal

Edge selection for multitooth trigger wheel signal

When a trigger wheel with equal tooth spacing (multitooth) is connected to the Primary Trigger input, and synchronization is based on a camshaft trigger wheel signal, edges should be selected in a manner that gives the maximum distance between Primary Trigger and Secondary Trigger edges. If the distance is too small, the synchronizing trigger tooth can change at higher RPM.



Incorrect trigger edge setup for multitooth



Correct edge setup for multitooth

Proper edge selection can be checked by monitoring Cam sync trigger tooth parameter in log. With a multitooth trigger, this parameter must be constant. Any Cam sync trigger tooth change during engine operation indicates incorrect edge selection or poor trigger wheel signal quality.

Secondary trigger

Secondary trigger parameters are used to synchronize the crank position to the engine cycle phase. This allows you to use full sequential ignition and injection. Camshaft position sensors are also required for using VVTi/VANOS systems. The EMU device supports several different secondary trigger wheels, and supports VR as well as HALL/Optical sensors.

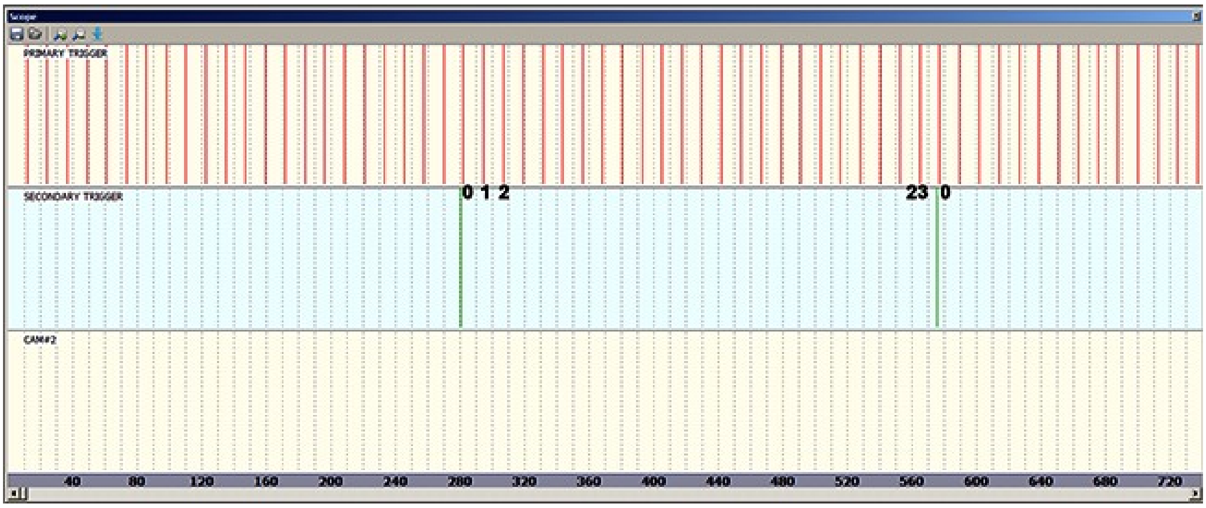
PARAMETER	DESCRIPTION
Sensor type	Type of the sensor connected to *Secondary trigger* input. For Hall/Optical sensors option *Enable pullup* is required
Enable pullup	Enable 2K pullup to +5V on *Secondary trigger* input. This function is used in the case of use Hall and Optical sensors that have open collector output
Trigger type	Supported *Secondary trigger* decoders. More information about supported decoders can be found in next section
Trigger edge	Trigger edge of input signal used for decoding trigger pattern
Disable camsync above RPM	This option disables cam shaft synchronization above a defined RPM. This function can be used for noisy sensor signals
Nissan sync window width	Option available for Nissan trigger decoder. More information can be found in next section
Sensitivity switch RPM	This options allows to change input sensitivity from 250mV to 2.5V when the engine s RPM are higher than defined. It is used for VE sensors and can increase noise immunity
Next edge rejection angle	The angular distance in crank degrees from the last trigger edge, below which distance any incoming trigger edge will be ignored as a noise. This is used for noise reduction
User cam min tooth	In the case of *User defined* trigger decoder, the range of *Primary trigger* tooth where the cam sync trigger edge appears should be defined. CAM min tooth defines the beginning of this range
User cam max tooth	In the case of *User defined* trigger decoder, the range of *Primary trigger* tooth where the cam sync trigger edge appears should be defined. CAM min tooth defines the end of this range
Enable advanced filter	Activation of advanced filter for secondary trigger input
Trigger tooth	This parameter defines the *Primary trigger tooth* where cam sync should occur, otherwise cam sync is ignored
Tooth deviation	This parameter defines allowable deviation from the trigger tooth. In the case of *multitooth* primary trigger this value must be 0

Supported trigger wheels

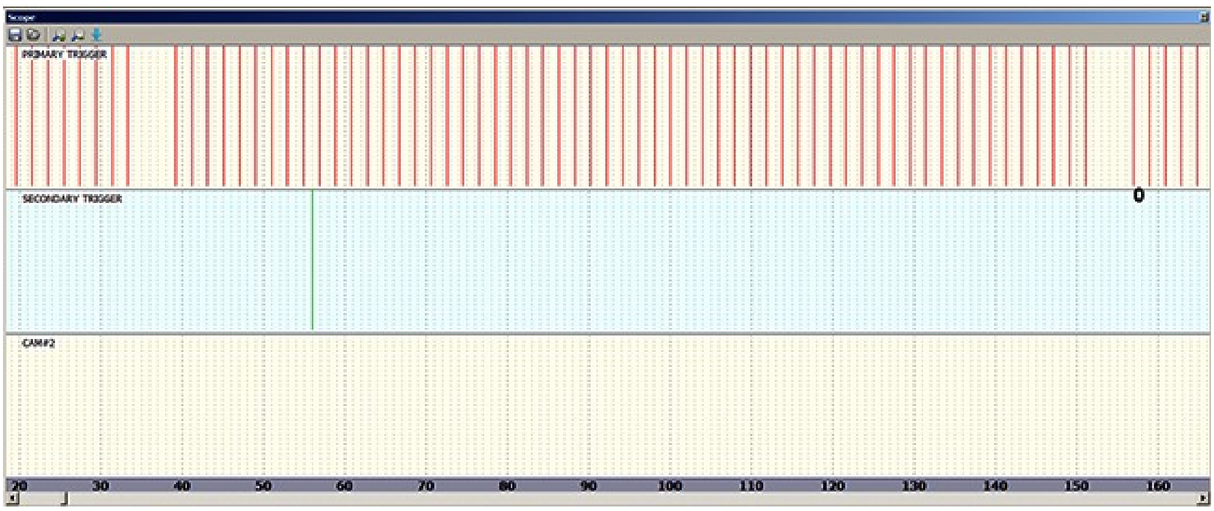
PARAMETER	DESCRIPTION
Do not use camsync	Do not synchronize with camshaft position
1 tooth	A toothed wheel with the only 1 tooth that synchronize the engine cycle (cam sync). When using a multitooth primary trigger, the next tooth after camshaft tooth will have index 0. In the case of toothed wheel with missing / additional tooth the tooth 0 will be always after the gap (or additional tooth) and camshaft tooth will determine the engine cycle
Nissan trigger	Decoder specific for Nissan trigger (360 slits CAS disc). Depending on the number of cylinders, synchronization is performed by detecting one of 4 or 6 gap with the width defined by number of primary trigger slits. This value is defined by *Nissan sync window width* and can be 4, 8, 12, 16
N+1	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is greater that the time between previous and current tooth (DT) multiplied by 2. **prevDT > DT * 2**
2JZ VVTI 3 teeth	Decoder specific to Toyota 2JZ VVTi engine (3 symmetrical teeth)
VW R32 4 teeth	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is greater that the time between previous and current tooth (DT) multiplied by 2. **prevDT > DT * 2**
Honda J35A8	Decoder specific to J35A8 engine
Missing tooth	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is less that the time between previous and current tooth (DT) multiplied by 0,66. **prevDT < DT * 0,66**
Subaru 7 teeth	Decoder specific to Subaru engine
EVO / MX-5 2 teeth	Decoder specific to Mitsubishi Lancer EVO and Mazda MX5 1.8BP
Dodge SRT	Decoder specific to Dodge SRT engine
VW 1.8T	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is less that the time between previous and current tooth (DT) multiplied by 0,66. **prevDT < DT * 0,6**
N+1 60%	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is greater that the time between previous and current tooth (DT) multiplied by 1,6. **prevDT > DT * 1,66**
Audi trigger	Decoder specific to *Audi trigger*
3UZ-fe vvt-i	Decoder specific to *3UZ-fe vvt-i* engine

2 symetrical tooth	Decoder for camshaft trigger wheel with two evenly spaced tooth. It allows to synchronize ignition system for *wasted spark* mode
2 missing teeth	The synchronization (cam sync) occurs in the case the time between 2 previous teeth (prevDT) is less that the time between previous and current tooth (DT) multiplied by 0,4. **prevDT < DT * 0,4**
Mitsubishi Colt1.5CZ	Decoder specific to*Mitsubishi Colt 1.5CZ*
User defined	The tooth inside user defined range causes camshaft synchronization

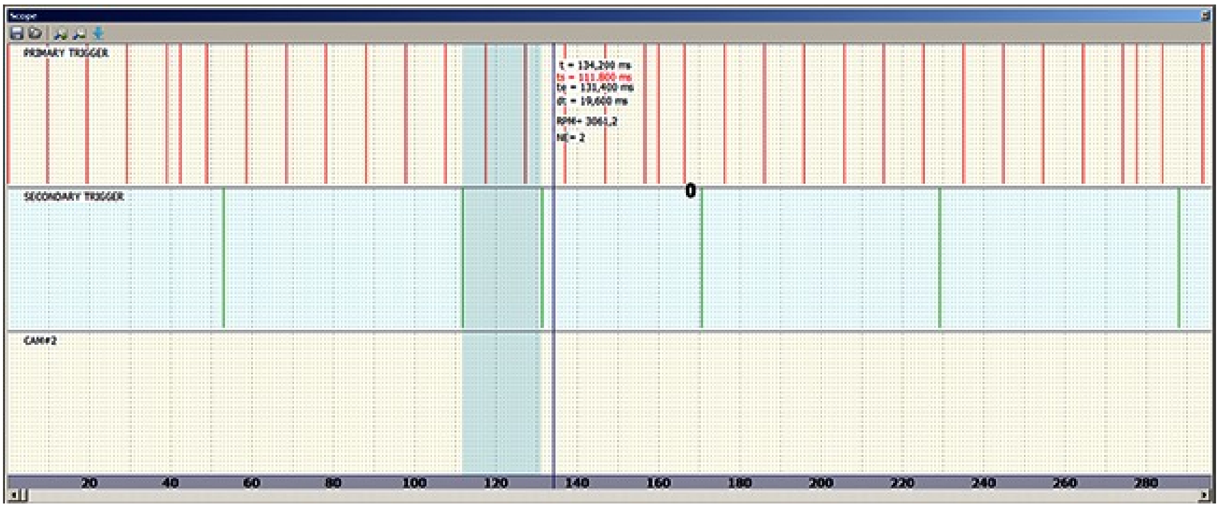
Examples



Toothed wheel with 12 evenly spaced teeth located on crankshaft, 1 tooth cam sync



Toothed wheel 60-2 located on crankshaft, 1 tooth cam sync



Toothed wheel 12+1located on crankshaft, camsync N+1. N+1 cam docoder.

Condition: prevDT > DT * 2. In this case prevDT=58ms, DT=19,6ms

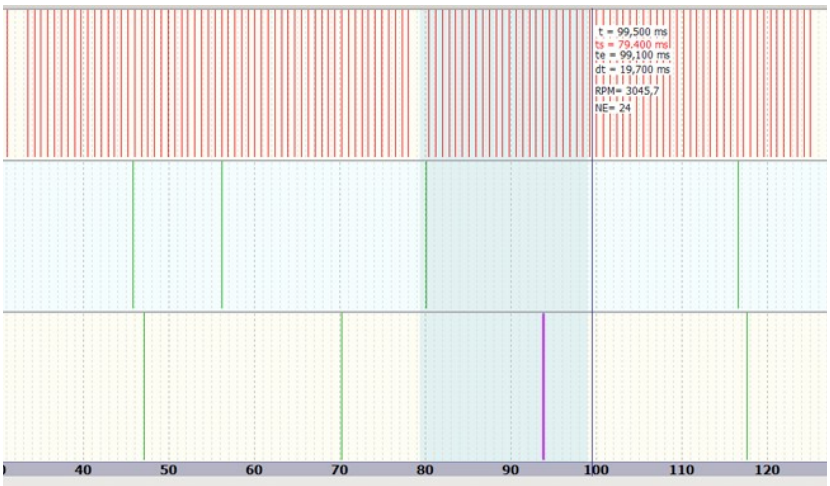
CAM #2

CAM#2 trigger is required to control variable valve timing on the second camshaft. It is used for calculating cam angle in relation to crank shaft position (it is not used for synchronising engine phase). EMU supports HALL/ Optical and VR sensors.

ATTENTION !
We suggest that you use Prim Trig Tooth Range CAM#2 decoder. Other decoders are present for backward compatibility.

PARAMETER	DESCRIPTION
Sensor type	Type of the sensor connected to *CAM#2* input. For Hall/Optical sensors option *Enable pullup* is required
Enable pullup	Enable 2K pullup to +5V on CAM#2 input. This function is used for Hall and Optical sensors that have open collector outputs
Trigger type	Supported CAM#2 decoders. We suggest using the *Prim Trig Tooth Range* decoder
Trigger edge	Trigger edge of input signal used for decoding trigger pattern.
Min tooth	The minimal value of tooth range of primary trigger toothed wheel. The incoming CAM#2 signal edge in this range will be used for calculating camshaft angle
Max tooth	The maximum value of tooth range of primary trigger toothed wheel. The incoming CAM#2 signal edge in this range will be used for calculating camshaft angle

On the example below, the correct tooth range for CAM#2 trigger edge marked in purple is from 12 to 24. A wide range allows for the change in camshaft position without the risk of losing correct synchronization. Too wide a range can cause the other CAM#2 edge to be used. On the log it will appear as an abrupt change in camshaft position (*CAM#2 Angle* channel).

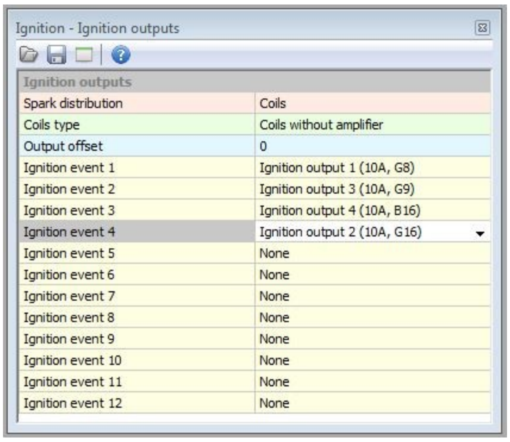


Ignition outputs

Ignition output table is responsible for assigning ignition events to ignition outputs.

ATTENTION !
Selecting active coils in the software when using passive coils will lead to damage to the coils or EMU device!

PARAMETER	DESCRIPTION
Spark distribution	This parameter defines spark distribution type. The difference between *Distributor* and *Coils* is the method of calculating dwell time
Coils type	When using passive coils (without ignition amplifier) the option *Coils without amplifier* should be used. For active coils (with ignition module) the option *Coils with built in amplifier* should be used
Output offset	The parameter *Output offset* changes the ignition event to ignition output assignment. This feature is useful in the case when the primary trigger configuration indicates a cylinder other than number 1
Ignition event X	Assignment of *ignition events* to *ignition outputs*. The number of *ignition events* is always equal to the number of cylinders



Ignition outputs configuration for 4 cylinders engine, full sequential ignition, coils without amplifier (passive). The ignition order is **1-3-4-2**.

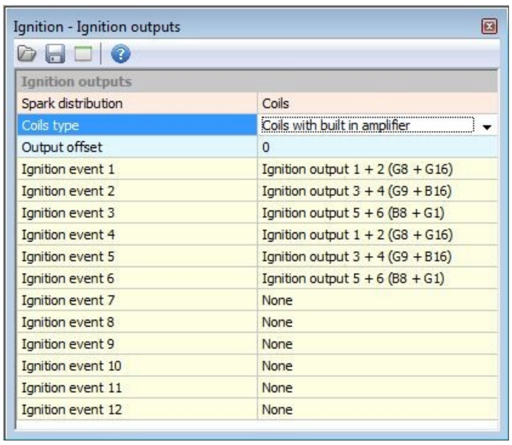
Coils are connected in the following way:

Coil 1 - Ignition output 1

Coil 2 - Ignition output 2

Coil 3 - Ignition output 3

Coil 4 - Ignition output 4



Ignition outputs configuration for 6 cylinders engine, wasted spark ignition, active coils. The ignition order is 1-5-3-6-2-4.

Coils are connected in the following way:

Coil 1 - Ignition output 1

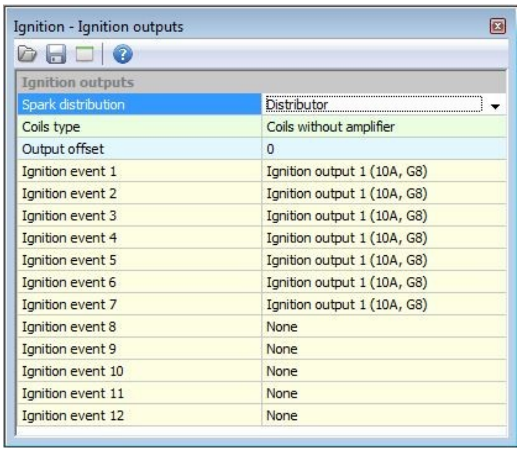
Coil 6 - Ignition output 2

Coil 5 - Ignition output 3

Coil 2 - Ignition output 4

Coil 3 - Ignition output 5

Coil 4 - Ignition output 6

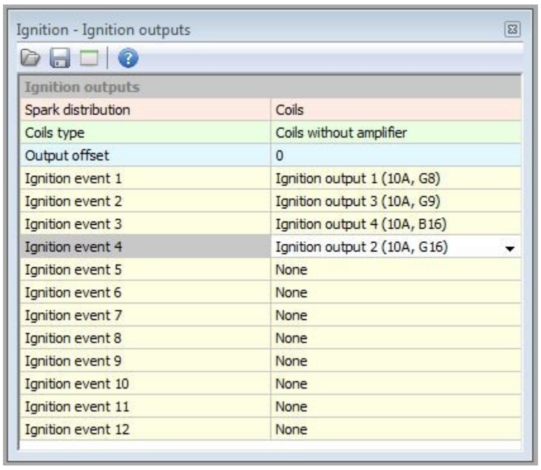


Ignition - Ignition outputs

Ignition outputs	
Spark distribution	Distributor
Coils type	Coils without amplifier
Output offset	0
Ignition event 1	Ignition output 1 (10A, G8)
Ignition event 2	Ignition output 1 (10A, G8)
Ignition event 3	Ignition output 1 (10A, G8)
Ignition event 4	Ignition output 1 (10A, G8)
Ignition event 5	Ignition output 1 (10A, G8)
Ignition event 6	Ignition output 1 (10A, G8)
Ignition event 7	Ignition output 1 (10A, G8)
Ignition event 8	None
Ignition event 9	None
Ignition event 10	None
Ignition event 11	None
Ignition event 12	None

Ignition outputs configuration for 8 cylinders engine, one ignition coil with distributor

It is common that settings for primary and secondary triggers define the correct base ignition angle, but the spark at cylinder 1 is not executed during *ignition event #1*. In this case it is possible to use *output offset parameter* to "move" the first ignition event in the *ignition outputs table*.

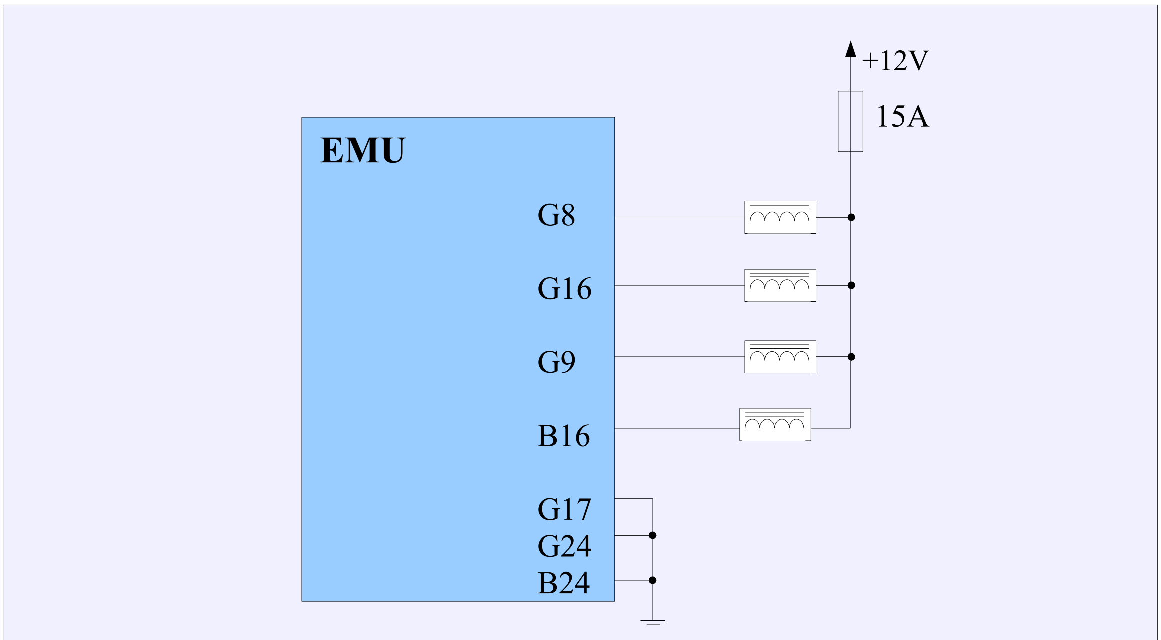


Ignition - Ignition outputs

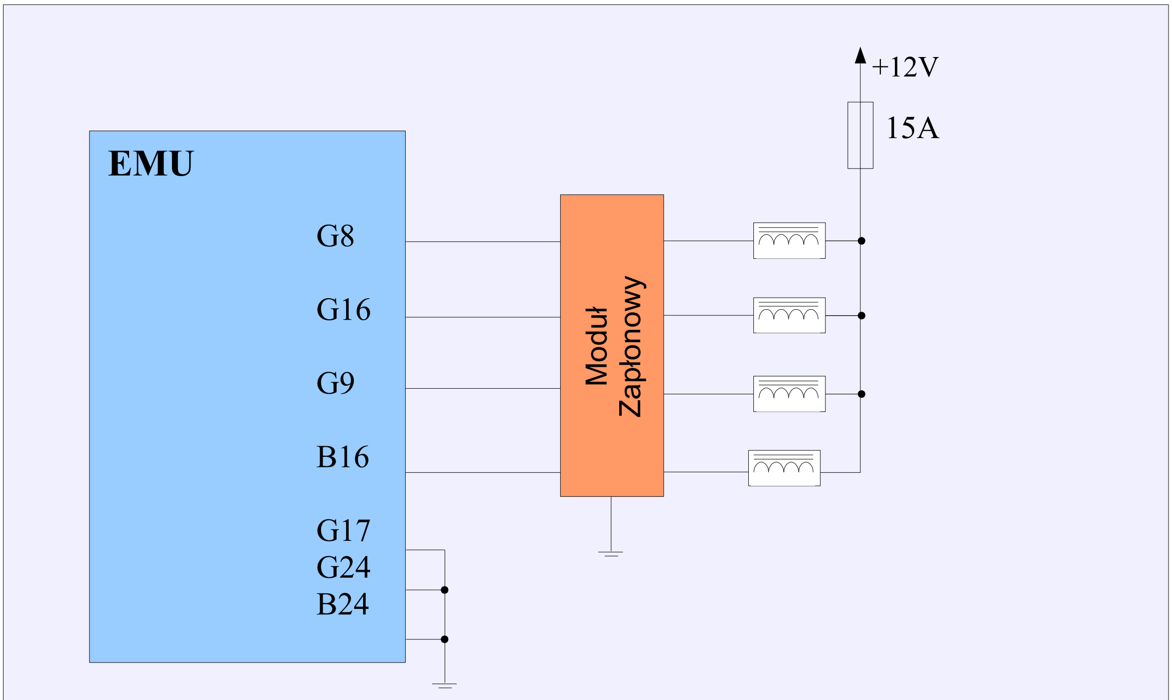
Ignition outputs	
Spark distribution	Coils
Coils type	Coils without amplifier
Output offset	0
Ignition event 1	Ignition output 1 (10A, G8)
Ignition event 2	Ignition output 3 (10A, G9)
Ignition event 3	Ignition output 4 (10A, B16)
Ignition event 4	Ignition output 2 (10A, G16)
Ignition event 5	None
Ignition event 6	None
Ignition event 7	None
Ignition event 8	None
Ignition event 9	None
Ignition event 10	None
Ignition event 11	None
Ignition event 12	None

In the configuration on the left the ignition order is **1-3-4-2**, for *output offset* equal to 1 the ignition order will be **3-4-2-1**, for *output offset* equal to 2 the firing order will be **4-2-1-3**, and so on.

Example of connecting the ignition coils to the EMU device



Connection of 4 passive ignition coils



Sample of connection of 4 passive coils using ignition module

In case of active coils or using ignition modules, there is a chance to connect two coils or module inputs to one ignition output in order to do wasted spark ignition.

Ignition event trims

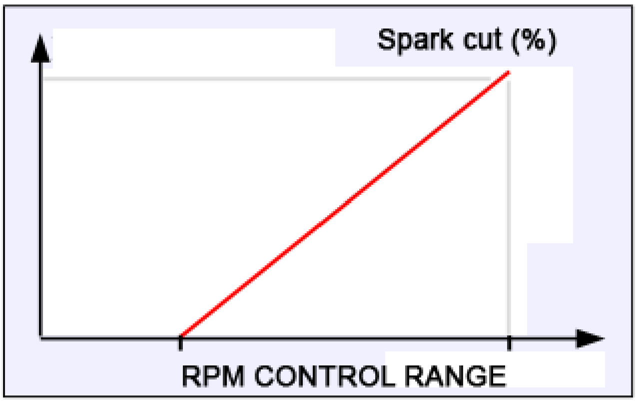
Ignition event trims table defines ignition angle correction for each ignition event. Using this table you can adjust ignition timing for each cylinder on an individual basis.

Soft rev limiter

The ignition soft rev limiter offers a smoother method for limiting engine RPM when compared to the fuel cut RPM limiter. In order to function properly, the soft cut ignition limiter RPM must be set below the fuel cut based limiter (Fuelling / Fuel cut).

PARAMETER	DESCRIPTION
Enable soft rev limiter	Activates soft rev limiter
Rev limit	Rev limier RPM
Control range	The range below rev limit RPM where the spark cut occurs. In this range the value of *Spark cut percent* and *Ignition retard* are interpolated (see the picture below the table)

Spark cut percent	Maximum percentage of cut spark at rev limit RPM. If this value is too small the soft rev limiter will not be able to limit the RPM
Ignition retard	The ignition angle retard in the *Control range* area. This parameter can be used to soften the rev limiter and protect the engine against knock during RPM limit



Interpolation of spark cut value in the control range region

Coil dwell time

Coil dwell table defines how long the ignition coil will be energized as a function of battery voltage. The lower the battery voltage, the longer time is required to energize the coil. Dwell times that are too short will lead to weak spark and misfires. Dwell times that are too long will lead to overheating the coils.

To create the *Coil dwell table* you are advised to use the Coils dwell wizard or use the coil manufacturer datasheet.

Coil dwell correction

Coil dwell correction table is used to correct coil dwell time as a function of RPM. It is common to increase dwell time at low RPM to improve combustion efficiency. Due to the low RPM, coil thermal stress doesn't increase substantially.

Ignition vs CLT correction

Igntion vs CLT table defines ignition angle correction as a function of engine coolant temperature. When active idle control via ignition timing is used, it references the *Idle ign. vs CLT table*.

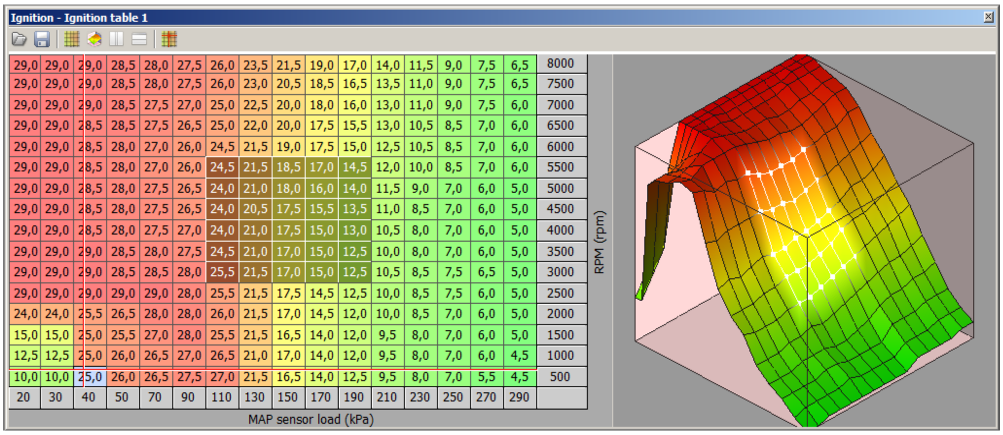
Ignition vs IAT correction

Ignition va IAT table defines the correction of ignition angle as a function of intake air temperature.

TPS vs MAP correction

TPS vs MAP correction table defines the ignition angle correction as a function of throttle position and manifold absolute pressure.

Ignition angle table 1 i 2



RPM \ kPa	20	30	40	50	70	90	110	130	150	170	190	210	230	250	270	290
8000	29,0	29,0	29,0	28,5	28,0	27,5	26,0	23,5	21,5	19,0	17,0	14,0	11,5	9,0	7,5	6,5
7500	29,0	29,0	29,0	28,5	28,0	27,5	26,0	23,0	20,5	18,5	16,5	13,5	11,0	9,0	7,5	6,5
7000	29,0	29,0	29,0	28,5	27,5	27,0	25,0	22,5	20,0	18,0	16,0	13,0	11,0	9,0	7,5	6,0
6500	29,0	29,0	28,5	28,5	27,5	26,5	25,0	22,0	20,0	17,5	15,5	13,0	10,5	8,5	7,0	6,0
6000	29,0	29,0	28,5	28,0	27,0	26,0	24,5	21,5	19,0	17,5	15,0	12,5	10,5	8,5	7,0	6,0
5500	29,0	29,0	28,5	28,0	27,0	26,0	24,5	21,5	18,5	17,0	14,5	12,0	10,0	8,5	7,0	6,0
5000	29,0	29,0	28,5	28,0	27,5	26,5	24,0	21,0	18,0	16,0	14,0	11,5	9,0	7,0	6,0	5,0
4500	29,0	29,0	28,5	28,0	27,5	26,5	24,0	20,5	17,5	15,5	13,5	11,0	8,5	7,0	6,0	5,0
4000	29,0	29,0	28,5	28,0	27,5	27,0	24,0	21,0	17,5	15,0	13,0	10,5	8,0	7,0	6,0	5,0
3500	29,0	29,0	29,0	28,5	28,0	27,5	24,5	21,0	17,0	15,0	12,5	10,0	8,0	7,0	6,0	5,0
3000	29,0	29,0	29,0	28,5	28,5	28,0	25,5	21,5	17,0	15,0	12,5	10,5	8,5	7,5	6,5	5,0
2500	29,0	29,0	29,0	29,0	29,0	28,0	25,5	21,5	17,5	14,5	12,5	10,0	8,5	7,5	6,0	5,0
2000	24,0	24,0	25,5	26,5	28,0	28,0	26,0	21,5	17,0	14,5	12,0	10,0	8,5	7,0	6,0	5,0
1500	15,0	15,0	25,0	25,5	27,0	28,0	25,5	21,5	16,5	14,0	12,0	9,5	8,0	7,0	6,0	5,0
1000	12,5	12,5	25,0	26,0	26,5	27,0	26,5	21,0	17,0	14,0	12,0	9,5	8,0	7,0	6,0	4,5
500	10,0	10,0	25,0	26,0	26,5	27,5	27,0	21,5	16,5	14,0	12,5	9,5	8,0	7,0	5,5	4,5

Ignition angle table is the main table used for ignition angle advance. The resolution of this table is 0.5 degrees. Positive values indicate a spark angle before TDC, negative values mean the spark angle after TDC.

Important !
The values of ignition angle table are correct only when the configuration of the base ignition angles (primary and secondary triggers) are correct!

The final ignition angle is calculated in the following way:

Angle = IGN(load,rpm) + CYLCorr(cyl) + IATCorr + CLTCorr + KSCorr + IDLECorr + LCCorr + Nitro(load, rpm) + TPSvsMAP(tps, MAP)

PARAMETERS	DESCRIPTION
IGN(load,rpm)	Ignition angle from the *Ignition* table
CYLCorr(cyl)	Per cylinder ignition angle trim from *Ignition event trims* table

IATCorr	Ignition correction based on intake air temperature defined in I*gnition vs IAT* table
CLTCorr	Ignition correction based on intake air temperature defined in *Ignition vs CLT* table
KSCorr	Ignition angle correction connected to knock action
IDLECorr	Ignition angle correction connected to idle control strategy
LCCorr	Ignition angle correction of *Launch control* strategy
Nitro(load,rpm)	Ignition angle correction based on *Nitrous ignition mod.* table
TPSvsMAP(tps,MAP)	Ignition angle correction based on *Ignition TPS vs MAP corr.* table

CONFIGURATION OF ENGINE START PARAMETERS

Settings in the parameter group *Engine Start* are used in the start-up phase of the engine.

Parameters

The *Engine start parameters* menu defines parameters like ignition angle, injectors configuration and other important parameters related to the engine cranking phase.
The *Cranking fuel table* defines the injector opening time as a function of engine coolant temperature. In addition, the *Fuel TPS scale* table defines the injector opening time correction as a function of throttle position. Using this table, an anti flood strategy can be enabled.

PARAMETER	DESCRIPTION
Enable prime pulse	This parameter enables a single fuel dose when the engine is cranked, but before synchronization has been achieved. This function can improve engine starting. The injector opening time during prime pulse is defined in *Prime pulse* table
Batch all injectors	When this parameter is checked all injectors squirt together at every ignition event
Cranking threshold	If the engine RPM is higher than *Cranking threshold* value, the EMU will change state from *Cranking* to *Afterstart* and the fuel dose will be calculated based on the VE table
Engine stall rev. limit	The engine RPM below which the EMU stops executing ignition and fuel injection
Cranking ign. angle	Ignition angle during cranking
Use injectors cal.	This option enables battery correction of injectors opening time from tables *Prime pulse* and *Cranking fuel.* The battery calibration table is defined in *Fueling injectors cal. table*

Cranking fuel 1 & 2

Cranking fuel table is used to define the injectors opening time during engine start up (cranking). This time depends on engine coolant temperature and should be higher for lower engine temperatures. There are two cranking fuel tables that can be switched using Other / Tables Switch functionality or these tables can be interpolated as a function of ethanol content. More information about 2D tables and keyboard shortcuts can be found in 2D Tables section.

ATTENTION !
Excessive amounts of cranking fuel may lead to engine flooding. Due to this fact it is advised to start with lower values and increase them until the engine starts easily.

Fuel TPS scale

Fuel TPS scale table is used to scale the injector pulsewidth during engine cranking as a function of throttle position.

Prime pulse

Prime pulse table is used to define a single fuel injection event when the Primary trigger sensor signal is first recognized. To enable this feature, Enable prime pulse option should be checked in Engine start / parameters.

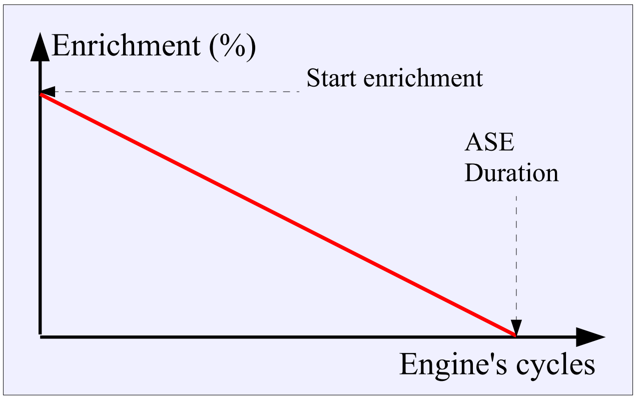
Time corrections

Time corrections table is used to scale injectors pulse width during engine cranking as a function of cranking time. This feature can be useful to avoid engine flooding if the engine doesn't start immediately after engaging the starter.

ENRICHMENTS

Afterstart enrichment

Afterstart enrichment function enables a fuel dose enrichment for a set number of engine cycles after engine start. Values in the table define the initial enrichment rate. With every engine cycle after start this value decreases linearly to zero. Initial enrichment value as a function of engine temperature can be set in *ASE table*.



Warmup table

Warmup enrichment compensates for poor fuel vaporization in low temperatures. Enrichment should be set to 100% (no enrichment) at normal operating temperature. To protect engine from overheating, fuel dose can be enriched in excessively high temperature range. Additional fuel vaporization will help to cool the engine.

Acceleration enrichment

During sudden acceleration (fast throttle opening), engine air flow increases rapidly and causes a temporary "lean" condition. To compensate for this, *Acceleration Enrichment* is used. Its calculation is based on throttle opening speed (dTPS), actual throttle angle (TPS), current engine RPM and temperature.

Acc enrich. = dTPS rate(dTps) * RPM Factor(rpm) * TPS Factor(tps) * CLT Factor(clt)

PARAMETER	DESCRIPTION
dTPS Threshold	Minimal dTPS value to apply Acceleration Enrichment. This feature used to filter out minor changes in TPS value caused by electrical noise.
Sustain rate	Percentage of enrichment sustained to next engine cycle. A higher value here results in longer lasting enrichment.
Enrichment limit	Maximum enrichment value allowable. This value is used to trim enrichment independently of enrichment calculation.

The following 2D tables are connected with the function of *Acceleration enrichment*.

Acc. DTPS Rate

Defines percentage of enrichment as a function of throttle opening speed (dTPS). The faster the opening speed, the larger the enrichment should be.

Acc. TPS Factor

Defines how enrichment value will be scaled as a function of throttle opening angle. Enrichment should be scaled down during changes at larger throttle angles (near wide open throttle).

Acc. RPM Factor

Defines how acceleration fuel enrichment will be scaled as a function of engine RPM. Enrichment should be higher at low engine RPM.

Acc. CLT Factor

Defines how acceleration fuel enrichment will be scaled as a function of engine RPM. Enrichment should be higher at low engine RPM.

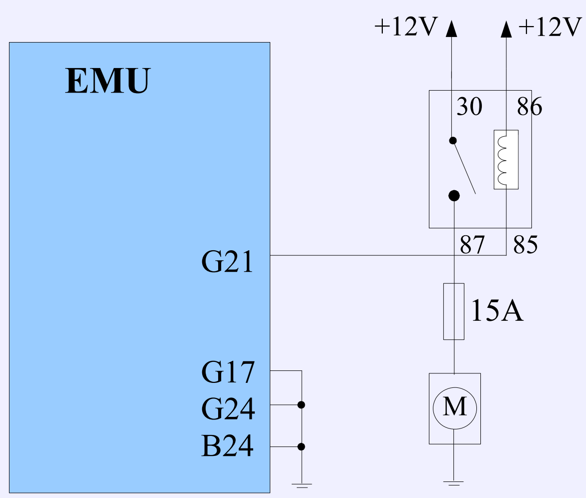
CONFIGURATION OF OUTPUTS PARAMETERS

Fuel pump

Fuel pump options determine which output is used to control the fuel pump relay and its control parameters.

PARAMETER	DESCRIPTION
After start activity	Specifies how long the fuel pump will run after the device is powered on (time in seconds). This time must be long enough to allow the pump to build nominal pressure in the fuel line
Output	Device output to which the fuel pump relay is connected
Invert output	Invert the output state. Can be used to test the operation of the fuel pump relay

Relay and 10-20A fuse must be used for proper fuel pump wiring.



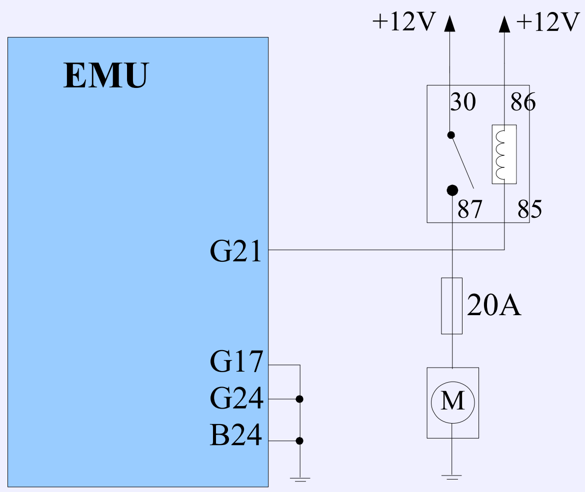
Example of the fuel pump relay wiring diagram

Coolant fan

Coolant fan options determine which output is used to control the radiator fan relay and its control parameters.

PARAMETER	DESCRIPTION
Activation temperature	Cooling fan turn-on temperature
Hysteresis	Hysteresis which defines how many degrees the coolant temperature must fall below the *Activation temperature* to turn off the cooling fan
Output	Device output to which the coolant fan relay is connected
Invert output	Reversal of output state. Can be used to test the operation of the coolant fan
Turn off during cranking	This option allows to turn off coolant fan during cranking

Relay and appropriate fuse must be used for proper radiator fan wiring.

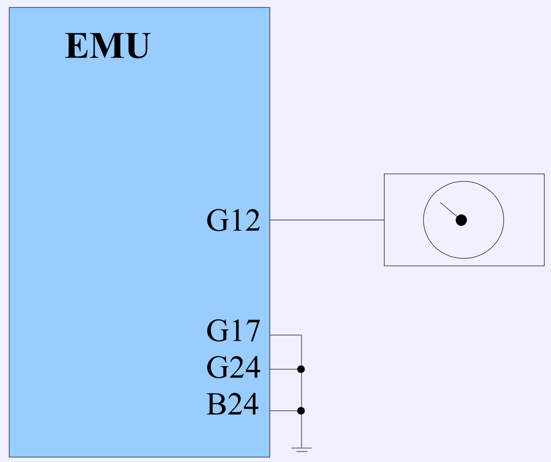


Example of the radiator fan relay wiring diagram

Tacho output

Tacho output function is used to control electronic tachometers. Based on engine speed, the EMU generates a square wave signal with a frequency proportional to the crankshaft speed. The tachometer should be connected to AUX 4 which is equipped with a 10K pullup resistor connected to + 12V. If any other output than AUX 4 is used, an external pullup resistor must be used.

PARAMETER	DESCRIPTION
Output	Device output to which the tachometer is connected
RPM Multiplier	The value of the output frequency scaling that matches tachometer indication to the engine speed

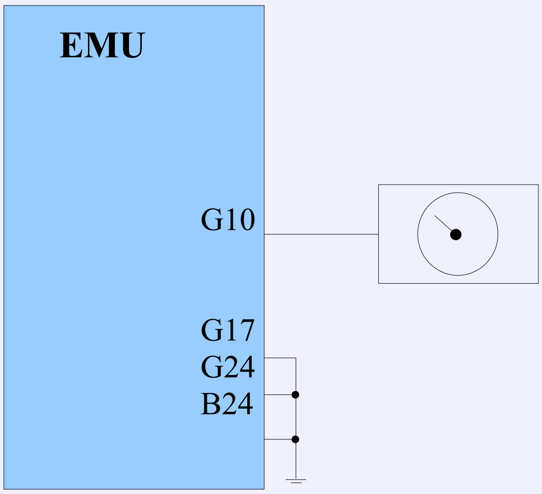


Example of the tachometer wiring diagram

Speedometer output

Speedometer Output function is used to operate an electronic speedometer. On the basis of vehicle speed, it generates a square wave signal with a frequency proportional to the vehicle speed. The speedometer can be connected to one of the outputs for Stepper motor or free INJECTOR / AUX.

PARAMETER	DESCRIPTION
Output	Device output to which the speedometer is connected
VSS Multiplier	The value of the output frequency scaling, which allows to match speedometer indication to the vehicle speed



Example of the speedometer wiring diagram

Main Relay

Main relay configuration defines which output is used to connect the main relay. This relay is responsible for switching voltage of +12V to a relay that powers devices such as injectors, ignition coils, solenoids etc.

PARAMETER	DESCRIPTION
Main relay output	Device output to which the main relay is connected
Invert output	Reversal of output state. Can be used to test the operation of the main relay

Param. output

Parametric output strategy can be used to perform specific functions like alternator control, electric pumps, electric blow off valve, variable intake manifold length etc.

Parametric Output 1 has 3 conditions that control the state of the output, the other parametric outputs have only 2 conditions. These conditions can be combined with logical operators OR / AND.

PARAMETER	DESCRIPTION
Output	Device output to control with the parametric output strategy
Invert output	Reversal of output state
Variable #X type	The first condition variable: RPM, MAP, TPS, IAT, CTL, VSS, analog input voltage Analog In#, Oil pressure, Oil temperature, Fuel pressure, battery voltage
Variable #X operator	Mathematical operator of the condition to change the state of the output: GREATER THAN , LOWER THAN , EQUAL OR GREATER THAN, LOWER THAN OR EQUAL
Variable #X value	The value on which the output depends (unit depends on the *variable type*)
Variable #X hysteresis	Hysteresis limit value at which it will return to its original state
Logical operator 1	Option adds next condition with logical operator "OR" "AND"
Enable cycling	Turns cyclic operation
Cycling on time	The time for which the output will be active
Cycling off time	The time for which the output is not active
Cycle once	Option turn of cycling after one cycle

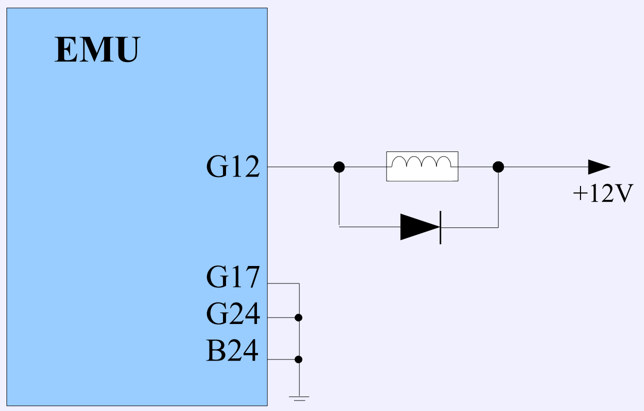
PWM #1

The *PWM #1* output is used to control an external solenoid with a predefined frequency and duty cycle (DC) defined in *3D PWM table*.

PARAMETER	DESCRIPTION
Output	Device output used for solenoid
Frequency	The frequency of the PWM signal
Disable output if no RPM	This option allows to disable PWM output during cranking

ATTENTION !

In the case of solenoid valves with high current consumption and high frequency operation, use an external flyback diode.



Example of the solenoid wiring diagram

Honda CLT dash output

Honda CLT dash function is used to generate coolant temperature signal from EMU to the electronic indicator on the dashboard of the Honda S2000.

PARAMETER	DESCRIPTION
Enable	Enable signal generation
Output	Output to which indicator is connected

CLT Freq. output

The *Clt freq. output* function is used to generate a signal with a frequency dependent on the coolant temperature. Frequency for a given temperature is defined on the *Clt freq. Output* table. This function is used to provide a signal that can be read by some models of instrument clusters.

PARAMETER	DESCRIPTION
Output	Output to which indicator is connected

PWM#1 CLT scale

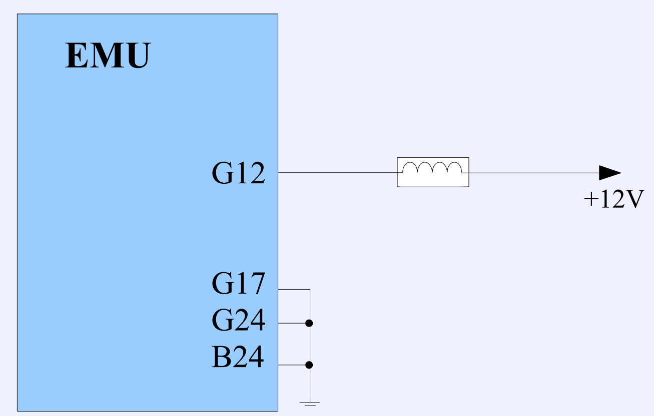
PWM#1 CLT scale table scales the value of duty for *PWM #1* from a table dependent on coolant temperature. This feature allows you to generate a signal for coolant temperature indicator or a water pump controlled by a PWM signal. This table is used by *PWM Output #1* function.

CONFIGURATION OF IDLE PARAMETERS

Idle parameters

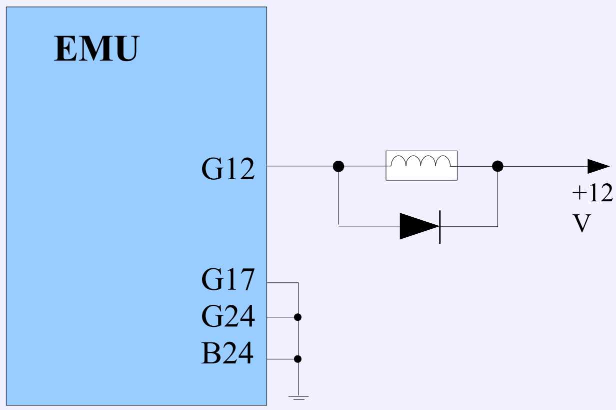
Idle parameters are used to configure engine idle control options. A valve that regulates engine air flow during idle is the base device of idle control system. Base map for idle tuning is *Idle Ref table* which defines base opening of idle control device with relation to *engine coolant temperature* (CLT). With lower *Coolant Temperature*, higher air flow is needed to keep engine RPM at required level. Ignition angle modification is an effective method of idle RPM stabilization. It can be implemented with PID controller or with simple table defining angle modification as a function of *RPM Error* (Idle ign. corr). *RPM Error* is a difference between current engine RPM and target RPM defined in I*dle Target RPM*. Information about current idle control state (active or not) and controller parameters can be found in *Log group idle*.

ON/OFF – such valve has only two conditions: on and off. It is always a by-pass. Valves of such type occur in old cars and it is a rarely used solution.



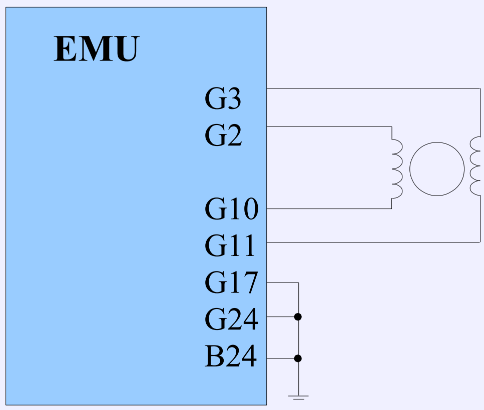
Sample wiring diagram of On/Off solenoid

PWM – valve with the possibility of the smooth change of opening through the modulation of impulses' width. It is always a by-pass. Usually the increase of the duty cycle causes the increase of the amount of air flowing through the valve. In case of valves controlled by high frequency (e.g., Bosch 0280 140 512) you should use the external flyback diode.



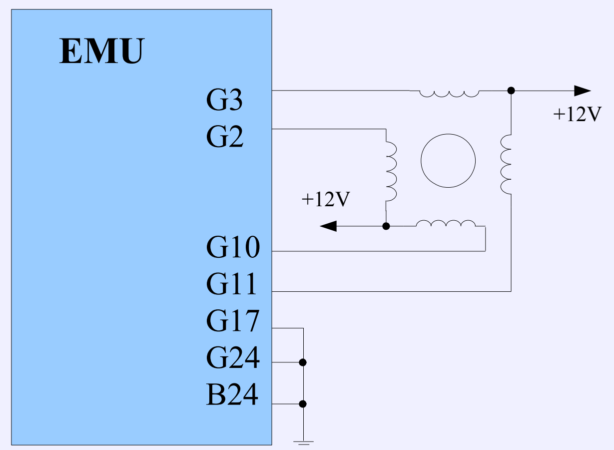
Sample connection of PWM valve with flyback diode

Stepper motor – valve, which performing element is the stepper motor. It only requires the power supply during the change of the stepper motor position.



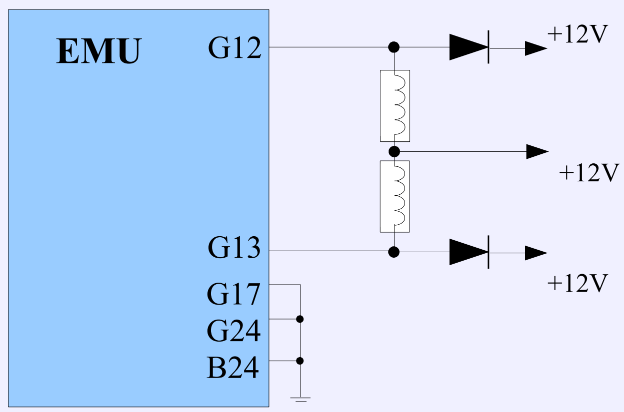
Sample connection of bipolar stepper motor

Unipolar stepper motor - valve, which performing element is the unipolar stepper motor. It only requires the power supply during the change of the stepper motor position



Sample connection of unipolar stepper motor

3 Wire PWM – valve using two windings (e.g., Bosch 0280 140 505). When it is not powered, it is in the middle position. Depending on which winding is powered, the valve will get more closed or opened.



Sample connection of 3 wire PWM valve with flyback diode

DBW – idle control is performed by electronic throttle. In this case the *Idle ref table* sets the throttle position by scaling of DBW *Idle Range* parameter.

Ignition cut - idle is controlled by regulating executed spark percent with *Idle ign. cut table*.

PARAMETER	DESCRIPTION
Idle valve type	**On/Off** - the simplest valve which is opened when engine is cold and closed after warm-up. **PWM -** valve which increases air flow with Duty Cycle of PWM controlling signal. **Stepper** - bipolar stepper motor (4 wire), **3 Wire PWM** - PWM valve with two coils, **Unipolar stepper** - unipolar stepper motor (6 wire), **DBW** - idle control implemented with Drive By Wire electronic throttle. **Ignition cut** - idle is controlled by regulating executed spark percent with *Idle ign. cut* table
Frequency	PWM frequency for idle valve or stepping signal frequency for stepper motor
Stepper steps range	Stepper motor range defined in number of steps. Stepper motor is calibrated with each EMU startup
Reverse	In case of PWM valve, checking this function inverts Duty Cycle of signal. When stepper motor is used, stepper rotation direction is reversed
Idle PWM output	Output used to drive the PWM valve
Idle PWM output #2	Output used to drive second wiring of two-coil valve (**3 Wire PWM**)
Idle control max RPM	RPM limit reached to disable idle control
Afterstart RPM increase	Defines target idle RPM increase during after-start period
Afterstart duration	Duration of after-start period with increased idle RPM
Idle On if TPS below	Idle control is activated when Throttle Position Sensor signal drops below this value
Idle Off is TPS over	Idle control is deactivated when Throttle Position Sensor signal rises above this value
Increase idle above VSS	Defines minimum Vehicle Speed to activate increased idle RPM function
VSS idle increase value	Amount of idle RPM increase implemented when Vehicle Speed exceeds *Increase idle above VSS* parameter.
DC during cranking	Defines idle device Duty Cycle for engine cranking. In case of stepper motor, stepper position is calculated as *DC * Stepper steps range.* In case of Drive By Wire, idle throttle opening angle is calculated as*DC **

	DBW Idle range
Idle valve min DC	Minimum allowed signal Duty Cycle for PWM valve
Idle valve max DC	Maximum allowed signal Duty Cycle for PWM valve
Idle corr. analog input	Defines which analog input is used to read and calculate correction value for idle device Duty Cycle. Correction value is defined in *Analog in corr.* table

PID control

Idle PID control parameters are used to configure idle RPM PID regulator. Regulator is designed to keep engine RPM at level defined in *Idle Target RPM* table. Regulation is based on values from *Idle Ref table*. Is is possible to use simplified regulator based on *DC error correction* map.

Information about idle control state (active or not) and controller parameters can be found in *Log group idle.*

ATTENTION !

Fine tuned VE table in idle range is a groundwork for idle tuning.

PARAMETER	DESCRIPTION
Enable PID control	Activates PID regulator for idle control
kP	PID regulator proportional term coefficient
kI	PID regulator integral term coefficient
kD	PID regulator derivative term coefficient
Integral limit +	PID regulator positive integral windup limit
Integral limit -	PID regulator negative integral windup limit
Max feedback +	Maximum positive regulator influence on Duty Cycle value
Max feedback -	Maximum negative regulator influence on Duty Cycle value
Deadband RPM	Minimum RPM error to start idle correction. When RPM is lower than entered value, PID regulator is inactive.

Ignition control

Idle ignition control function is used to control idle RPM by ignition angle modification. Advance of ignition angle leads to increase of RPM, retardation lowers RPM. Ignition control regulates ignition angle to achieve engine RPM defined in *Idle target rpm table.* Idle control state (active or not) and current controller parameters can be checked in *Log group idle.*

PARAMETER	DESCRIPTION
Enable ignition control	Activates idle control by ignition angle strategy
Use correction table	When checked, ignition angle is controlled by *Idle ign. corr.* table as a function of *RPM Error* instead of being controlled with PID controller.
Max ignition advance	Defines maximum allowed ignition advance for PID controller. Not used when *Idle ign. corr.* table is active.
Max ignition retard	Defines maximum allowed ignition retardation for PID controller. Not used when *Idle ign. corr.* table is active.
Ignition angle change rate	Defines how often ignition angle is changed. Value entered here is number of engine cycles for one degree ignition angle change. Not used when *Idle ign. corr.* table is active.

Idle target RPM

Idle target RPM table is used to define target engine idle RPM as a function of engine *Coolant Temperature* (CLT). Table is active only when one of following idle strategies is active: *PID control*, *DC error correction* or *Ignition control*.

Idle ref. table

Idle ref table is used to define base idle valve Duty Cycle as a function of engine *Coolant Temperature* (CLT) when *Idle Control* is active. Values from table have different meaning in case of different idle control devices. When PWM valve is used, DC of valve is defined. In case of stepper motor, stepper position is calculated as DC * Stepper steps range. In case of *Drive By Wire*, idle throttle opening angle is calculated as DC * DBW Idle range. When *On/Off* valve is used or idle control is implemented with *Ignition cut*, *Idle ref table* is not used.

Idle ign. correction

Idle ign. correction is used to define ignition angle correction as a function of RPM error (difference between current RPM and target RPM). Target RPM can be set in Idle Target RPM table. Idle control by ignition angle change is activated in Idle ignition control options.

Idle RPM ref

Idle RPM ref table is used to define idle valve Duty Cycle as a function of engine RPM. Values from the table are executed only when Idle control is not active.

Idle IGN cut

Idle ign. cut table is used to define ignition event cut percent as a function RPM error (difference between current RPM and target RPM). Target RPM can be set in *Idle Target RPM* table. Idle control by ignition cut is activated in *Idle parameters* by setting Idle valve type as Ignition cut.

Idle IGN vs CLT

Idle ign. vs CLT is used to correct ignition angle as a function of engine *Coolant Temperature* (CLT). Function is only active when idle RPM's are being controlled (*Idle control active*).

Analog in corr.

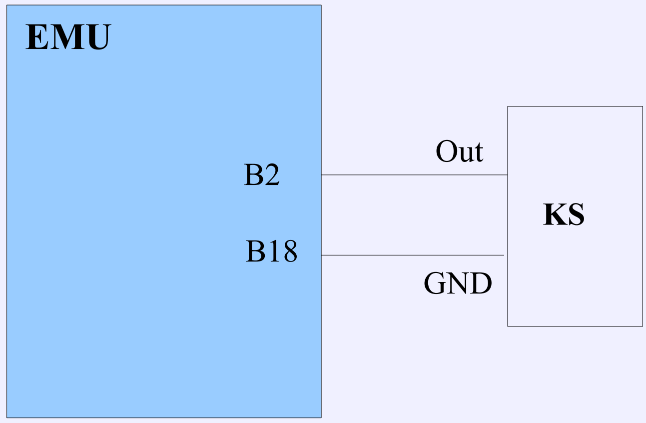
Analog in correction table is used to regulate Duty Cycle of idle valve in relation to analog input voltage. Function can be useful to manually change idle with potentiometer. Analog input to be used is set up in *Idle parameters* (*Idle corr. analog input*).

DC error correction

DC error correction table is used to set idle valve Duty Cycle correction as a function of RPM error (difference between current RPM and target RPM). Target RPM can be set in *Idle Target RPM* table.

CONFIGURATION OF KNOCK SENSORS PARAMETERS

EMU has the ability to work with common knock sensors and to take appropriate corrective actions when knock is detected. Common correction strategies are to enrich the fuel dose and to retard ignition timing. The EMU employs advanced knock processors designed for use with flat response (wideband) knock sensors. Flat response knock sensors are able to capture much more information than older style sensors, and advanced filtering and processing is performed by the EMU in order to better detect knock. Connection for two-wire sensors is shown below. One-wire sensors do not need a ground wire as the body of the sensor is grounded by mounting to the engine block.



Knock sensor sample connection

ATTENTION !
Knock sensors must be connected with shielded cables. Shielding must be connected to ground on only one end.

Sensor parameters

PARAMETER	DESCRIPTION
Knock frequency	The engine knock characteristic frequency used to configure the band-pass filter. This characteristic is different for every engine. It can be approximated with the following equation: *Knock frequency (kHz) = 1800/(Pi * D)* Where **D** is cylinder diameter in millimeters
Gain	Knock sensor signal gain should be adjusted so that the *Knock sensor value* parameter doesn't exceed 3V across the full RPM range during normal combustion

Integrator	Time constant of signal integrator. -Higher value gives better immunity to noise and lowers *Knock sensor value* parameter. Too high a value can cause light engine knock to be filtered out. -Lower values increases engine knocking sensitivity but it also increases susceptibility to noise. This yields a higher *Knock sensor value* parameter It's advised to set values between 100μs and 200μs

Sampling

Sampling parameters allows you to configure when the knock sensor signal is processed by the EMU. To reduce interference from noise, the knock sensor signal is only processed during the defined *Knock window*. The knock window represents the area where engine knock is most likely to occur. Because it is possible to install more than one knock sensor, it is necessary to configure which knock sensor channel should be processed for each ignition event.

PARAMETER	DESCRIPTION
Knock window start	Crankshaft rotation angle after TDC when *Knock window* starts
Knock window duration	Knock window length in crankshaft rotation degrees
Ignition event X knock input	Assign a knock sensor channel to ignition event X

Engine noise

Engine noise 2D table is used to define noise level of normal engine operation across the whole RPM range. If Knock sensor value exceeds *Engine noise* from table, it is interpreted as engine knocking. This difference is named *Knock Level*. Higher Knock Level means more severe engine knock.

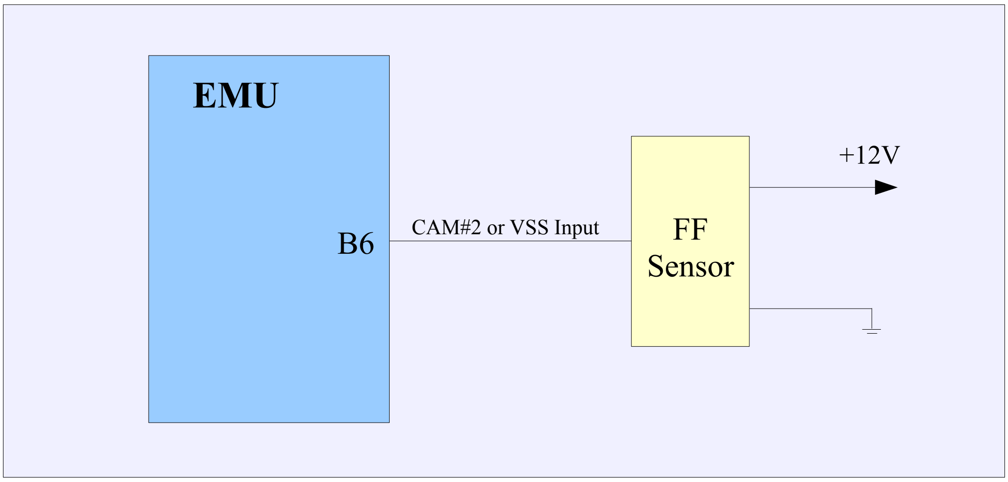
Knock action

Action menu allows you to define which actions should be taken when knock is detected. The knock level is equal to *Knock sensor value* - *Knock Engine Noise*.

PARAMETER	DESCRIPTION
Active	Activates engine knock protection
Min RPM	Minimal engine RPM for the system to be active
Max RPM	Maximum engine RPM for the system to be active
Fuel enrich rate	Percent of air fuel mixture enrichment for every 1V of *Knock level* parameter
Max fuel enrich	Maximum allowed mixture enrichment
Ignition retard rate	Ignition angle retardation for every 1V of *Knock level* parameter
Max ignition retard	Maximum allowed ignition retardation
Restore rate	Number of engine revolutions counted from last engine knock detected to restore 1% of fuel enrichment and 1 degree of ignition retard

FLEX FUEL SENSOR

A *FlexFuel* sensor measures the ethanol content of the fuel as it passes through the fuel system. Information about ethanol content can be utilized by the ECUMASTER EMU to adjust the fuel dose, ignition advance, or boost pressure. The EMU supports GM/Continental frequency sensors.



The *FlexFuel* sensor should be connected to the CAM#2 input or to VSS input if the CAM#2 input is used for a camshaft position sensor. To activate the *FlexFuel* sensor, the *Enable FlexFuel* parameter should be checked and *Table switch mode* should be set to *FlexFuel* blend in options menu *Other/Tables switch*.

Parameters

PARAMETER	FUNCTION
Enable FlexFuel	Activates *FlexFuel* sensor support
Sensor input	Defines EMU input used for *FlexFuel* sensor (*CAM#2* or *VSS*)
Maximum TPS to read sensor	Maximum throttle position under which the ethanol content will be read from the sensor (clamps the ethanol content signal at high throttle inputs)
Blend VE tables	Activate blending between *VE #1* and *VE #2* tables
Blend IGN tables	Activate blending between *IGN #1* and *IGN #2* tables
Blend AFR tables	Activate blending between *AFR #1* and *AFR #2* tables
Blend Boost tables	Activate blending between *Boost DC Ref #1* and *Boost DC Ref #2*, and *Boost target #1* and *Boost target #2 tables*
Blend fuel when cranking tables	Activate blending between *Cranking fuel #1* and *Cranking fuel #2* tables
Blend ASE tables	Activate blending between *ASE #1* i *ASE #2* tables (*afterstart enrichment*)
Blend warmup tables	Activate blending between *Warmup tbl. #1* and *Warmup tbl. #2*

Enable temp. correction	Activate fuel dose correction in function of fuel temperature
Error frequency	If the frequency of the *FlexFuel* sensor is greater or equal *Error frequency*, the sensor is not working correctly. In such cases the check engine light can be enabled ***(Check engine)*** and the value from the *Fail safe Ethanol content* parameter is used
Fail safe Ethanol content	The fail safe value of ethanol content in the case of *FlexFuel* sensor failure
Fail safe temperature	The fail safe value of fuel temperature in the case of *FlexFuel* sensor failure

Sensor calibration

Sensor calibration table is used to define fuel ethanol content as a function of *FlexFuel* sensor signal frequency. For GM/Continental sensors, ethanol content at 50Hz is 0% and 100% at 150Hz.

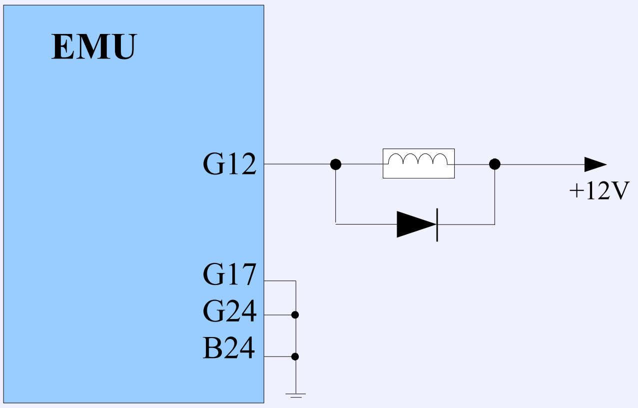
Tables blend

Interpolation between tables based on ethanol content is available for the flowing maps: *VE, IGN, AFR, Boost, Crank fuel, ASE*. The blending factor between the tables is defined with corresponding blending table (eg. VE Blend for VE table). The final value is calculated as follow::

Value = Tbl1[] * Blending% + Tbl2[] * (100% - Blending%)

VVT – Variable Valve Timing

Typical variable valve timing system is based on PWM controlled solenoid that regulates the oil pressure applied to an actuator to adjust the camshaft position.



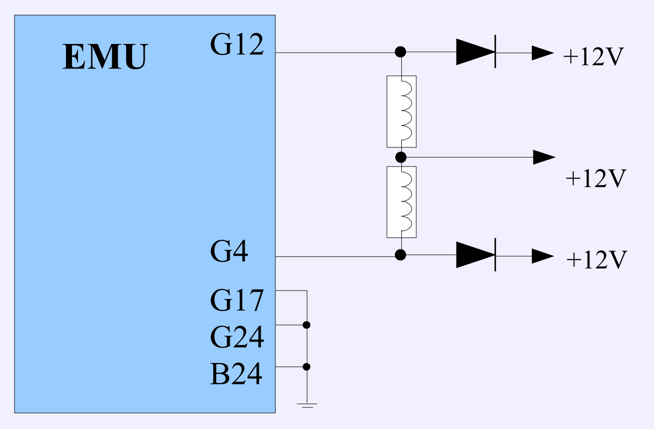
Sample connection of single PWM VVT control solenoid

PARAMETER	DESCRIPTION
CAM Offset	This parameter is used for camshaft starting position calibration. The correct value should be chosen to make *Cam #1 angle* log channel equal to 0 deg, when the solenoid is not powered
Max. retard / advance	Maxim allowable value to retard / advance the camshaft position
Control type	**VVTi -** control of camshaft position is based on one solenoid. Dependant of control signal DC (duty cycle) camshaft position can be advance or retard. **Double Vanos** - the control of camshaft position is based on two solenoids. Each solenoid is responsible for moving the camshaft position in one direction
Solenoid output #1	Output used for camshaft control solenoid (*VVT)* or one of the *Double Vanos* solenoids
Solenoid output #2	Output used for second camshaft control solenoid of the *Double Vanos* system
Output frequency	The frequency of signal controlling solenoid
Steady pos DC	In the case of VVT system based on one camshaft control

	solenoid this value define the DC when the camshaft position is stable. In practice this value defines when the camshaft changes its movement direction. In *Double Vanos* system this value should be 50%
Max DC	Maximum allowable DC value of camshaft control solenoid
Min DC	Minimum allowable DC value of camshaft control solenoid
Higher DC	**Increase cam angle** - increasing signal DC increases the value of cam shaft position **Decrease cam angle** - decreasing signal DC increases the value of cam shaft position
Min coolant temp	The minimum coolant temperature value that allows camshaft position control
Min RPM	The minimum RPM value that allows camshaft position control
kP	Proportional gain of PID controller
kI	Integral gain of PID controller
kD	Derivative gain of PID controller
Integral limit	Prevents the integral term from accumulating above this limit
Deadband	The neutral zone where no DC change is performed

Double Vanos

By default Double VVT solenoids (Vanos) are controlled by +12V (High side). The EMU controls solenoids by switching them to the ground (Low side). In this case it is required to change direction of diodes that are built in into solenoid connectors or solenoids module.



Sample connection of double solenoid VVT

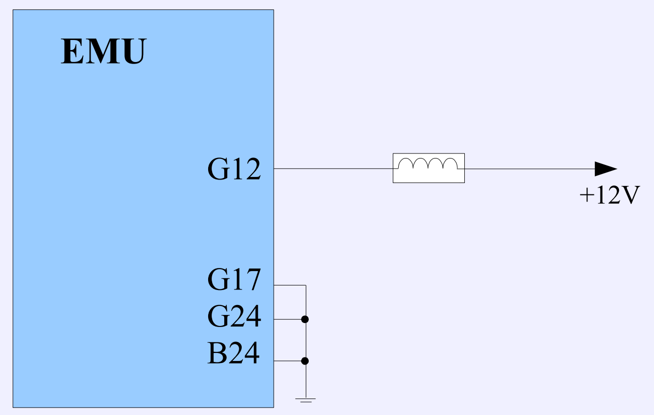
VTEC

VTEC control parameters are used for controlling variable timing and lift of the valves using on/off type solenoid. There is an option to automatic switch tables when the solenoid state changes. To do this in parameters *Tables Switch/Table switch mode* option *VTEC Switch* must be enabled. Activation of VTEC control solenoid can be defined by two non-continuous areas, in ranges of RPM, TPS and intake manifold pressure (MAP).

PARAMETER	DESCRIPTION
VTEC Output	The EMU output used for VTEC control solenoid
Invert output	Inverting the output state
RPM Min/Max	The range of RPM that is used for activation of VTEC control solenoid
RPM Hist.	RPM range hysteresis
MAP Min/Max	The range of MAP sensor values that is used for activation of VTEC control solenoid
MAP Hist	MAP range hysteresis
TPS Min / Max	The range of throttle position that is used for activation of VTEC control solenoid
TPS Hist	TPS range hysteresis
VSS Min	The minimum vehicle speed for activation of VTEC control solenoid
VSS Hist	Speed hysteresis

Boost control

Boost control strategy allows for electronic boost pressure control. Boost pressure can be adjusted as a function of exhaust gas temperature, air temperature or vehicle speed. Boost control has two sets of 3D tables to permit switchable boost sets. These tables can be changed by a switch connected to one of the analog inputs of the EMU.



Sample connection of boost control solenoid

Parameters

PARAMETER	DESCRIPTION
Enable boost control	Activation of boost control
Boost control Type	Activation of the PID controller for boost correction for closed loop feedback. You may also correct boost pressure using the *DC error correction* table (open loop control)
Solenoid output	Output to which boost control solenoid is connected
Invert output	Reversal of output state
Solenoid frequency	Operating frequency of the boost control solenoid
Solenoid min DC	Minimum duty cycle of the boost control solenoid
Solenoid max DC	Maximum duty cycle of the boost control solenoid
Disable output under	The pressure under which the solenoid is not powered
Boost switch input	Analog input used to switch the boost map

Open loop control strategy

Open loop control allows you to control the boost pressure without PID. This strategy uses *Boost DC re map* and does not use the *Boost target* table.

Closed loop control strategy

Closed loop control bases on PID control. The EMU will aim to obtain boost pressure defined in *Boost target table* by reducing or increasing the duty cycle from the *Boost DC ref* map. Another strategy to use in the closed loop operation is to use the *Boost DC error correction* table which allows you to correct the value from the *Boost DC ref table* as a function of current boost error.

PID Parameters

Boost PID parameters are used to configure PID terms of the boost control strategy. The PID controller works only when *Closed Loop* option is turned on.

PARAMETER	DESCRIPTION
kP, kI, kD	Proportional gain (kP), integral gain (kI), and derivative gain (kD) of PID controller
Integral limit +	The maximum saturation of the integral term (positive and negative)
Feedback + / -	The maximum value ("+" and "-"), by which the controller can change DC of solenoid defined in the *Boost DC ref* table

Gear scale

Gear scale table is used to define the scaling of boost pressure as a function of current gear. When open loop boost control is used, the duty cycle value of the DC Ref table is scaled. When closed loop control is used, both the DC Ref and Boost target tables are scaled.

EGT, VSS, IAT scale

Scale tables are used for scaling the boost pressure as a function of EGT, VSS or IAT. When boost control is used with *open loop control*, the duty cycle value of *DC Ref table* is scaled. For *closed loop control* both *DC Ref table* and *Boost target table* are scaled.

DC Ref table

Boost DC reference table defines the duty cycle of the boost control solenoid as a function of throttle position and engine RPM. If closed loop control is enabled, boost pressure will maintain a defined boost target.

Boost target table

Boost target table defines boost pressure as a function of throttle position and engine RPM. Depending on settings, the feedback loop can be defined by PID controller or Boost DC error corr table. For proper boost control, the Boost DC ref table must be created first.

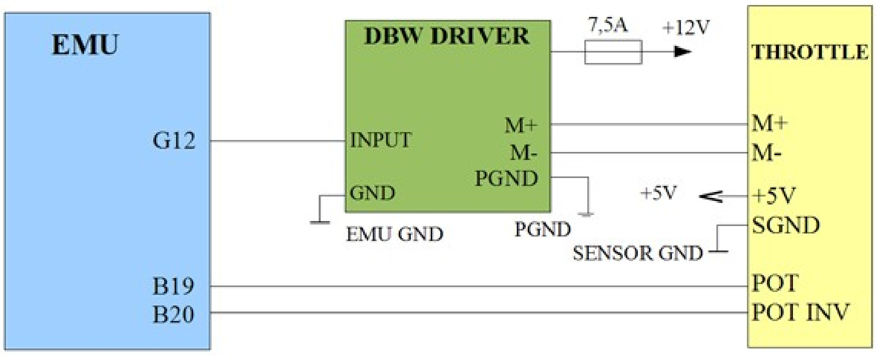
Boost error correction

Boost DC error correction table corrects the boost control solenoid duty cycle as a function of boost pressure error (the difference between actual and target pressure). This table works with open and closed loop control strategy.

DBW

ATTENTION !
The functions associated with operating the electronic throttle are only for testing stationary engines (generators, test benches, engine dynometers). For safety reasons, do not use the electronic throttle service on the road !!!!

In order to use the electronic throttle (DBW) you need an additional control unit. DBW Module (driver) which controls the engine throttle based on the control signal from the EMU. The module input is connected to one of the EMU outputs (injector, AUX, stepper). The electronic throttle is equipped with two potentiometers that determine the current percentage of its opening. The second potentiometer (POT INV) produces an inverse signal from the primary potentiometer (POT) The sum of the two voltage signals will always remain 5V. If irregularities are detected the throttle is automatically closed in transition to safe mode. This DBW safety function will be disabled if only one potentiometer is connected.



The diagram shows how to connect the module DBW, EMU and the electronic throttle

DBW MODULE CONNECTORS DESCRIPTION	
Terminal	**Description**
A	+12V after ignition fuse 7.5A!
B	Power ground
C	EMU ground
D	Input Signal (Connect to Injector, AUX or Stepper Motor)
E	Motor -
F	Motor +

Table

P table defines proportional gain of PID controller in function of current throttle position and position error (the difference between target and current position).

I Table

I table defines integral gain of PID controller in function of current throttle position error (the difference between target and current position).

D Table

D table defines derivative gain of PID controller in function of current throttle position delta error (the difference between current and previous throttle position error).

Stiction

The friction table define the force against the throttle spring in function of the current throttle position.

Characteristic

Characteristic table defines how the accelerator pedal position (TPS) is mapped into electronic throttle position.

TRACTION CONTROL

Traction control strategy allows engine torque to be reduced in the case of wheel slip. Wheel slip is detected based on engine RPM increase. For the traction control strategy to work correctly a VSS sensor or gear sensor is required. In addition to gear detection, a rotary switch (or potentiometer) should be installed. The rotary switch is used for traction control sensitivity control.

The main variable used in traction control strategy is the value of *TC dRPM RAW*. This value equals the current change in engine *RPM*. When the *TC dRPM RAW* is too high for a given gear, wheel slip is occurring and torque reduction should be performed. The torque reduction is performed by cutting spark events. The Traction control/Gear Scale table is used to define the different torque transfer for each gear. In addition the sensitivity of traction control can be adjusted by rotary switch or potentiometer and is defined with *Adj. scale* table.

The torque reduction is defined in *Traction control/Torque reduction* 3D table. The Y axis value (*TC Delta RPM*) is calculated as follow:

TC DELTA RPM = TC dRPM RAW * Gear Scale[Current gear] * Adj. Scale[Switch pos]

PARAMETER	DESCRIPTION
Enable TC	Activation of *Traction Control* strategy
Disable if second table set	This option allows to disable traction control when the second tables set is active
After gear cut disable time	The time after *Gear Cut* strategy is activated, when the *Traction Control* is not active
Sensitivity	The time base for *dRPM Raw* integrator. The lower value the lower *dRPM Raw* value
Adjustment switch input	Analog input that potentiometer or rotary switch is connected to control TC sensitivity
TC active output	The output used for *traction control* activity indication
Minim speed to activate	The minimal vehicle speed to activate *traction control* strategy

Gear scale

Gear scale table defines how to scale TC Delta RPM RAW depending on current gear. The lower the gear, the value in the table should also be lower. The value of 100% means no scale of TC Delta RPM RAW.

Adjust scale

Adjust scale table is used to define how the *TC Delta RPM RAW* value should be scaled depending on rotary switch / potentiometer position. The value of 0% means no traction control. The discrete positions of rotary switch / potentiometer are defined in *Traction control / Adjust scale* calibration table.

Adj. cal.

Adjust scale calibration table is used to define the voltage for each discreet position (1-10) of rotary switch or potentiometer. More information about TC can be found in *Traction control* section.

Torque reduction

Torque reduction table is used to define torque reduction in function of load and TC Delta RPM value. The value of 0% means no torque reduction (no spark event to be skipped), 100% means no torque (all spark events skipped).

WARNING !

Torque reduction is performed by spark cutting and may lead to catalytic converter damage or destruction.

OTHER

Tables switch

Tables switch options are used to define how the tables will be change. The tables that can be switched have suffix #1 and #2. Tables can be change via switch or automatically when the VTEC option is activated. There is also an option to interpolate between tables based on external signal such as fuel ethanol content from *FlexFuel* sensor readings. In the case of boost tables switching it is defined in *Boost/Parameters* options.

Information about current table set can be found on the application status bar (**TBL SET)**.

PARAMETER	DESCRIPTION
Tables switch mode	**Do not switch tables -** table switch function is disabled **Switch with user input -** switching tables using switch connected to one of the EMU inputs **VTEC Switch -** automatic switch when the VTEC solenoid is activated **FlexFuel blend -** dual tables are used for interpolation based on *FlexFuel* configuration
Tables switch input	The EMU input used for tables switch. More information about switches can be found in *User switches* section
Switch VE table	Activation of switching *VE* tables
Switch IGN table	Activation of switching *IGN* tables
Switch AFR table	Activation of switching *AFR* tables
Switch CAM #1 table	Activation of switching *VVTi* tables for *CAM* #1
Switch CAM #2 table	Activation of switching *VVTi* tables for *CAM* #2
Switch cranking fuel	Activation of switching *Cranking fuel* tables
Switch warmup enrichment	Activation of switching *Warmup enrichment* tables

Protection

Password protection is used to protect access to the EMU device. The password is required to access any data and log. In the case of missing password it is possible to restore device to factory defaults, however all information will be lost.

PARAMETER	DESCRIPTION
Enable password protection	Activate password protection
Copyrights	The string with author information
Contact info	The string with email address or phone number to allow contact with password owner
Password	The password

Oil pressure cut

Oil pressure cut strategy is used for engine protection in case of low oil pressure during engine work. If the oil pressure for given RPM is lower than defined the engine will shut off. The minimal oil pressure for given RPM is defined in the *Oil Pressure Cut table.*

PARAMETER	DESCRIPTION
Oil pressure cut enable	Activation of oil pressure protection strategy
Oil pressure start delay	The time after engine start up when the function is not active (time required to build up oil pressure by the oil pump)
Oil pressure cut delay	The allowable time during the oil pressure is lower than the pressure defined in *Oil Pressure Cut table*. After this time the engine will shut off
Oil pressure restart time	The time required to start the engine again

Check engine

Check engine function is used to indicate possible sensor failures detected by EMU device.

PARAMETER	DESCRIPTION
Check engine light output	Output used for indication device (LED, bulb, buzzer, etc.)
Invert output	Invert output state (can be used to test indicator)
Report failure of WBO sensor	Oxygen sensor circuit malfunction
Report failure of IAT sensor	Intake air temperature sensor (IAT) circuit malfunction
Report failure of CLT sensor	Coolant temperature sensor (CLT) circuit malfunction
Report failure of MAP sensor	Manifold absolute pressure sensor (MAP) circuit malfunction
Report failure of EGT1 sensor	Exhaust gas temperature sensor #1 circuit malfunction
Report failure of EGT2 sensor	Exhaust gas temperature sensor #2 circuit malfunction
Report EGT alarm	Excessive exhaust gas temperature
Report knocking	Knock sensor alert
Report failure of FlexFuel senosr	FlexFuel sensor circuit malfunction
Report failure of DBW	Electronic throttle circuit malfunction
Report fuel pressure failure	Fuel pressure alert

EGT Alarm

EGT function is used to indicate overrun of defined exhaust gas temperature. In the case of two sensors it is possible to define which sensor should be used for alarm function. There is also an option to indicate temperature overrun using check engine light. To activate this feature in options *Check Engine/Report EGT* alarm should be checked.

PARAMETR	DESCRIPTION
Alarm type	Selection of EGT sensor(s) that should be used for alarm
Alarm output	The output for indicator device (LED, buzzer, etc.). In the case of using *Check Engine / Report EGT alarm* option, this output could be unassigned
Invert output	Inverting of output state (could be used for testing output)
EGT temperature	The alarm temperature limit

Engine protection

Engine protection strategy is used to protect the engine by limiting the maximum RPM when the specific conditions are met.

PARAMETER	DESCRIPTION
Enable over temp. rev limit	Over-temperature engine protection. When CLT temperature is higher than defined the new rev limit is used
High temperature limit	Temperature limit to activate protection function
Rev. limiter	Fuel cut based rev limiter when the temperature is above the limit
Soft rev. limiter	Soft rev limiter (spark cut based) when the temperature is above the limit
Enable low temp. rev limit	Cold engine protection. When CLT temperature is lower than defined the new rev limit is used
Low temperature limit	Temperature limit to activate protection function
Rev. limiter	Fuel cut based rev limiter when the temperature is below the limit
Soft rev. limiter	Soft rev limiter (spark cut based) when the temperature is below the limit

Debug functions

Debug functions parameters are used to analyze PID controllers. To analyst a particular PID controller *PID debug option* must be selected in options. The controller data is then available for analysis in the following log channels: *Debug PID P Term, Debug PID I Term, Debug PID D Term*.

PARAMETER	DESCRIPTION
PID Debug option	PID controller to be analyzed

Dyno

Dyno parameters are used to set up road dyno parameters (Dyno). The accuracy of the generated power curve will largely depend on the preciseness of the values entered.

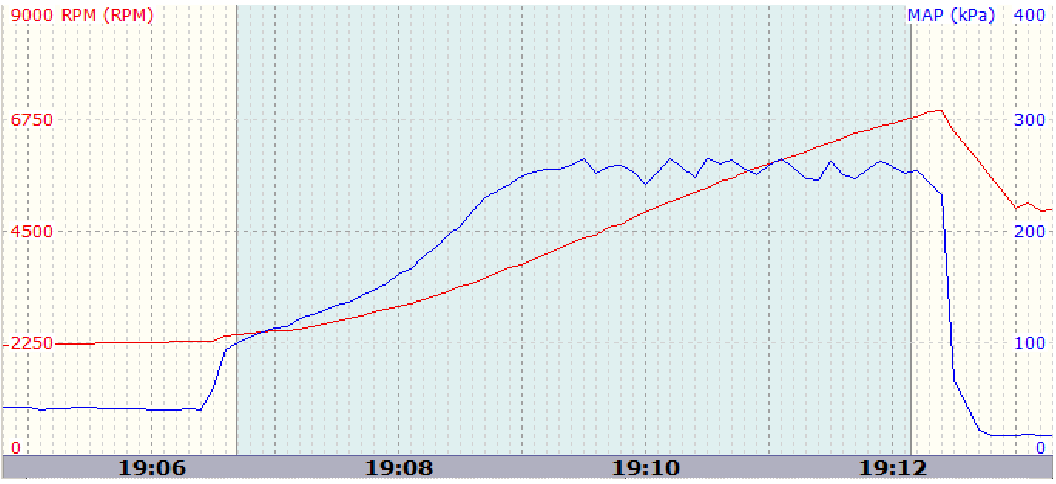
PARAMETER	DESCRIPTION
Coefficient of drag	Coefficient of drag can be found in technical documentation of the car as a Cx value
Frontal area	The frontal area of the car
Car mass	The weight of the car (with driver, fuel, etc.)
RPM Ratio	Ratio between RPM and vehicle speed in km/h multiplied by 100 **RPMratio = (Speed / RPM) * 100**
Filter power	The coefficient of digital filter used to smooth power and torque curve. The higher value the more filtering will be applied
Aero correction	If this parameter is checked the aerodynamics of the car (parameters *Coefficient of drag and Frontal area*) are used for power and torque calculations
Show AFR	Shows AFR curve on the dyno graph
Show MAP	Shows MAP curve on the dyno graph
Show IAT	Shows IAT curve on the dyno graph
Min RPM	Minimal RPM on the dyno graph
Max RPM	Maximal RPM on the dyno graph

DYNO TOOL

ATTENTION !

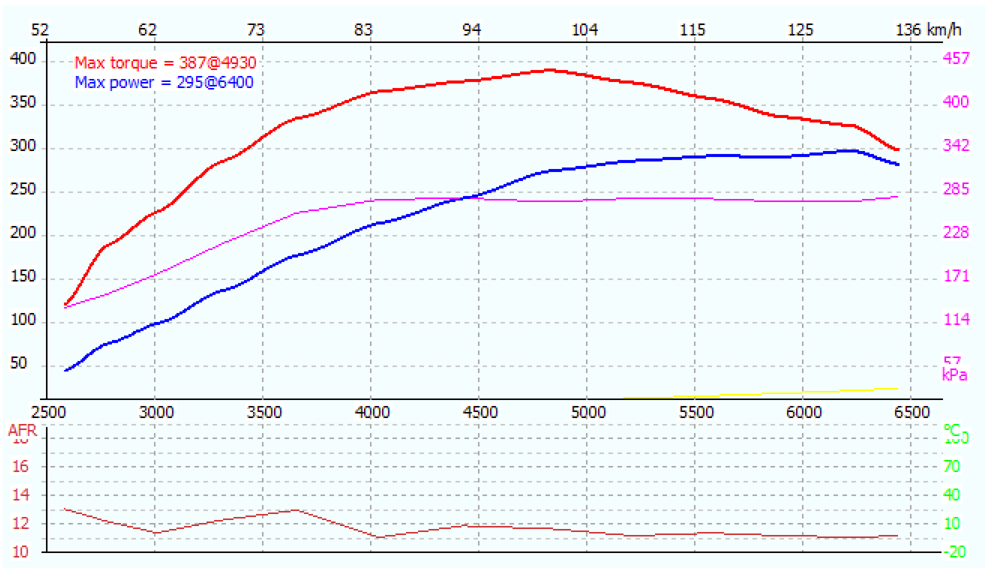
The dyno tool is used for estimation of engine power (at the wheels) and to analyze boost pressure, AFR, and IAT as functions of engine RPM

To generate estimated power and torque graphs, test runs must be made on a flat road. During the test run only one gear should be used. The higher gear the better (more data). During the test run, no wheel slip is allowed. To create a dyno plot, highlight the section of the graph log to be analyzed as shown below.



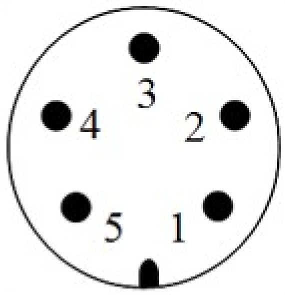
Selected area will be used for dyno graph generation

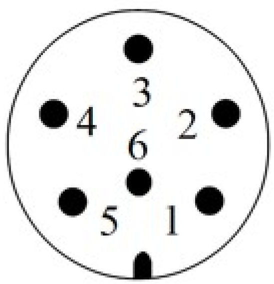
To generate the dyno graph, right click on the highlighted area (context menu will appear), and choose option *Create Dyno Graph.* To get accurate data on the dyno graph, vehicle information should be entered in *Other/Dyno* parameters window. On the graph below you will see power, torque, MAP, AFR and IAT curves



EXT. PORT

Extension port is used for EMU communication with additional modules like the *BlueTooth*, CAN-BUS module and racing Dashboards. The extension port is compatible with RS232 serial communication. With the *BlueTooth* module connected to the extension port it is possible to use an Android application to display gauges on a tablet or phone. Sport dashboards such as *RaceTechnology* or *AIM* with serial input can be connected directly to the extension port. For Dashboards utilizing CAN-BUS protocol, you may connect the CAN-BUS module to the extension port.

EXTENSION PORT PINOUT DESCRIPTION	
	**1 - RXD**
	2 - TXD
	3 - +3,3V
	4 - GROUND
	5 - +5V

CAN-BUS MODULE PORT DESCRIPTION	
	**1 - CAN L**
	2 - EXT ANALOG #1
	3 - EXT ANALOG #2
	4 - EXT ANALOG #3
	5 - CAN H
	6 - EXT ANALOG #4

PARAMETER	DESCRIPTION
Device	**AIM Dashboard** - AIM protocol support. Use this protocol for AIM dashboards or Android dashboard applications compatible with AIM protocol **Race Technology Dashboard** - Race Technology protocol support. It allows direct communication to the Race Technology dashboards and dataloggers.

	ECUMASTER Serial Protocol - ECUMASTER serial protocol allows to connect Android based dashboard application. **CAN-Bus** - this device type should be selected for CAN-BUS module support **Always reset EMU device after selecting new device protocol!**
CAN-Bus speed	Speed of the CAN-BUS
Send EMU data over CAN-Bus	This option allows to send ECUMASTER EMU data over CAN-BUS
CAN-Bus Dashboard	Select supported Dashboard to send compatible data over CAN-BUS

DASHBOARD	SUPPORTED FUNCTIONS
BMW E46	RPM, CLT, check engine light, Drive by wire error, overheat light, oil temperature, alternator light
BMW E46 M3	RPM, CLT, check engine light, Drive by wire error, overheat light, shift light (limit must be set in Shift Light EMU options), oil Temperature, alternator light
CITROEN C2	RPM, vehicle speed, enable power steering, enable heater blower
VOLKSWAGEN	RPM
FORD FIESTA MK7	RPM, vehicle speed, check engine light, low oil pressure light, alternator light, overheat light, enable power steering, enable heater blower
LOTUS	RPM, water temperature, vehicle speed, check engine light, low oil pressure light, shift light (limit must be set in Shift Light EMU options), fuel level
MOTEC M800 set 1	RPM, TPS, MAP, IAT, CLT, lambda 1, fuel temp., fuel pressure, oil temp., oil pressure, EGT 1, EGT 2, VBAT, ECU temp., vehicle speed
HALTECH E8 E11v2	RPM, VSS, oil temp., oil pressure, fuel pressure, VBAT, TPS, MAP, IAT, EGT1, lambda, ign. angle, gear, injectors DC
PECTEL SQ 6	RPM, VSS, oil temp., oil pressure, fuel pressure, VBAT, TPS, MAP, IAT, EGT1, EGT2, lambda, ign. angle, gear, injectors DC, ECU Temp
BMW Z4	RPM, Oil pressure light, Oil temperature or CLT if the oil temp. sensor is not connected, alternator light, Check engine light
MAZDA RX8	RPM, vehicle speed, check engine light, CLT, Oil pressure light, alternator light

APPENDIX 1 – the list of available log channels

LOG CHANNEL	DESCRIPTION
Acc. Enrichment	Current value (%) of *acceleration enrichment*
Acc. Enrichment PW	Current value (in ms) of additional injector pulse width due to *acceleration enrichment*
Acc. Ignition Correction	Current Ignition angle correction due to *acceleration enrichment*
AFR	Current AFR value
AFR Target	Current *AFR* target (only available when *EGO feedback* function is active)
Afterstart Enrichment	Current value of *Afterstart enrichment*
ALS Active	Information about activation of *Anti lag (ALS)*
ALS fuel correction	When *Anti lag (ALS)* is active, this value represents the fuel dose enrichment in % from *ALS fuel correction table*
ALS ignition angle	When *Anti lag (ALS)* is active, this value represents current ignition angle from *ALS ignition table*
ALS spark cut	When *Anti lag (ALS)* is active, this value represents current spark cut percent from *ALS spark cut table*
Analog #1	The voltage of signal connected to *Analog In #1*
Analog #2	The voltage of signal connected to *Analog In #2*
Analog #3	The voltage of signal connected to *Analog In #3*
Analog #4	The voltage of signal connected to *Analog In #4*
BARO	Barometric pressure value
BARO Correction	The correction of fuel dose (in %) resulting from barometric pressure based on *Barometric correction table*
Battery voltage	Vehicle battery voltage
Boost Correction	Boost correction (of *Boost target* when using Closed loop control or *DC* when using Open loop control) resulting from correction tables *VSS, IAT, EGT*
Boost DC	Current value of DC (duty cycle) of boost control solenoid
Boost DC error corr.	The value of boost DC correction resulting from *DC error correction*
Boost DC From Table	The value of DC (duty cycle) of boost control solenoid from *Boost DC table*

Boost DC PID Correction	The value of correction of DC of boost control solenoid resulting from PID control (*Closed loop control*)
Boost Table set	Current boost tables set
Boost Target	The final value of boost target for closed loop control (PID) or DC error correction table
Boost Target From Table	The value of boost target from *Boost target table* (before corrections)
Cam #2 signal present	Information about presence of signal pulses on CAM#2 input
Cam signal present	Information about presence of signal pulses on *Secondary trigger* input
Cam sync trigger tooth	This value indicates the primary trigger tooth where synchronization of the cam trigger occurs
CAM1 angle	The *CAM1* angle (in degrees) in terms of crankshaft position. This value is connected to the variable valve timing control (VVT)
CAM1 angle target	The *CAM1* angle target (in degrees) in terms of crankshaft position. This value is defined in *CAM#1 Angle target*
CAM1 valve DC	The DC of the solenoid controlling variable valve timing for camshaft #1 (*CAM1*)
CAM2 angle	The *CAM2* angle (in degrees) in terms of crankshaft position. This value is connected to the variable valve timing control (VVT)
CAM2 angle target	The *CAM2* angle target (in degrees) in terms of crankshaft position. This value is defined in *CAM#2 Angle target*
CAM2 valve DC	The DC of the solenoid controlling variable valve timing for camshaft #2 (*CAM2*)
CAN Analog #1	The voltage from CAN module analog #1 input
CAN Analog #2	The voltage from CAN module analog #2 input
CAN Analog #3	The voltage from CAN module analog #3 input
CAN Analog #4	The voltage from CAN module analog #4 input
CAN EGT #1	The temperature of EGT #1 sensor connected to external EGT2CAN controller
CAN EGT #2	The temperature of EGT #2 sensor connected to external EGT2CAN controller
CAN EGT #3	The temperature of EGT #3 sensor connected to external EGT2CAN controller
CAN EGT #4	The temperature of EGT #4 sensor connected to external EGT2CAN

	controller
CAN EGT #5	The temperature of EGT #5 sensor connected to external EGT2CAN controller
CAN EGT #6	The temperature of EGT #6 sensor connected to external EGT2CAN controller
CAN EGT #7	The temperature of EGT #7 sensor connected to external EGT2CAN controller
CAN EGT #8	The temperature of EGT #8 sensor connected to external EGT2CAN controller
CAN-Bus State	Current state of CAN BUS module ***BUS OK*** - the CAN module and CAN BUS are working correctly ***MODULE DISCONNECTED*** - CAN module is not connected to the external port **BUS ERROR -** CAN bus error (wrong speed or connection)
Check engine code	Current engine error code: **NONE** - no errors **CLT** - CLT sensor error, the CLT value is taken from *Fail safe* settings **IAT** - IAT sensor error, the IAT value is taken from *Fail safe* settings **MAP** - MAP sensor error, the MAP value is taken from *Fail safe* settings **WBO** - wideband oxygen sensor error **EGT1** - EGT #1 sensor disconnected or broken **EGT2** - EGT #2 sensor disconnected or broken **EGT ALARM** - EGT too high (defined in *EGT Alarm*) **KNOCK** - knock is detected **FF SENSOR** - Flex Fuel disconnected or broken **DBW** - drive by wire connection / control error **FPR -** fuel pressure error
CLT	The temperature of coolant temperature
CLT Ignition Trim	The ignition advance correction in function of coolant temperature resulting from *Ignition vs CLT table*
DBW delta error	The difference between current and previous error resulting from commanded and current throttle position (*DBW error - Prev DBW error*)
DBW error	The difference between current and commanded electronic throttle

	position
DBW Out. DC	The DC value of signal controlling the electronic throttle module
DBW pos	Current electronic throttle position
DBW pot error	The error resulting from the sum of the voltage from both potentiometers of electronic throttle
DBW target	Required position of the electronic throttle
Debug PID D Term	The value of D term of PID controller. To debug specified PID controller you should select the appropriate channel in *Debug functions*
Debug PID I Term	The value of I term of PID controller. To debug specified PID controller you should select the appropriate channel in *Debug functions*
Debug PID P Term	The value of P term of PID controller. To debug specified PID controller you should select the appropriate channel in *Debug functions*
Dwell Error	The difference between required and executed dwell time
Dwell Time	Required dwell time
ECU Reset	Information about EMU device reset
ECU State	Current state of EMU device: **INACTIVE** - there are no calculations connected to fuel dose and ignition advance **CRANKING** - in this state the fuel dose is based on *Cranking fuel table*, and ignition advance is defined as *Cranking ignition angle* **AFTERSTART** - the engine is working, *Warmup enrichment* is active **RUNNING** - the engine is working normally
ECU Temperature	The temperature of EMU device
EGO Correction	Correction of fuel dose resulting from *EGO Feedback* strategy
EGT #1	The temperature of EGT sensor #1
EGT #2	The temperature of EGT sensor #2
Executed sparks count	The number of executed ignition events
FF Blend AFR	The blending percent between *AFR* tables resulting from fuel ethanol content according to *Flex Fuel AFR Blend* table
FF Blend ASE	The blending percent between *ASE* tables resulting from fuel ethanol content according to *Flex Fuel ASE Blend* table
FF Blend Boost	The blending percent between *Boost* tables resulting from fuel ethanol content according to *Flex Fuel Boost Blend* table
FF Blend Cranking	The blending percent between *Cranking Fuel* tables resulting from fuel

Fuel	ethanol content according to *Flex Fuel Crank Fuel Blend* table
FF Blend IGN	The blending percent between *Ignition angle* tables resulting from fuel ethanol content according to *Flex Fuel IGN Blend* table
FF Blend VE	The blending percent between *VE* tables resulting from fuel ethanol content according to *Flex Fuel VE Blend* table
FF Blend Warmup	The blending percent between *Warmup* tables resulting from fuel ethanol content according to *Flex Fuel Warmup Blend* table
FF Ethanol content	Fuel ethanol content according to *Flex Fuel* sensor readings
FF Fuel Temp	Fuel temperature according to *Flex Fuel* sensor readings
FF Fuel Temp Correction	Fuel dose correction resulting from fuel temperature according to *Flex Fuel temp. corr table*
FF Sensor frequency	The frequency of signal from *Flex Fuel* sensor
Flat Shift Active	Information about activation of *Flat Shift* strategy
Flat Shift Fuel Cut	Information about fuel cut performed by *Flat Shift* strategy
Flat Shift Ign. Cut	Information about ignition cut preformed by *Flat Shift* strategy
Fuel Cut	Information about fuel cut
Fuel level	The fuel level according to *Fuel level cal.* table
Fuel pressure	The fuel pressure according to *Fuel press. cal.* table
Fuel pressure delta	The difference between fuel pressure and current manifold absolute pressure (MAP)
Fuel pressure delta correction	Fuel dose correction resulting from *DFPR Corr*. table
Gear	Current gear
Gear Ratio	Quotient of vehicle speed (*VSS*) and engine *RPM*
IAT	Intake air temperature (*IAT*)
IAT Correction	The fuel dose correction according to *Fuelling IAT correction* table
IAT Ignition Trim	The value of ignition angle correction as a function of intake air temperature, according to *Ignition VS IAT* table
Idle Control Active	Information about activation of idle control
Idle Ign. Correction	The value of ignition angle correction according to *Idle ignition control* strategy
Idle ign. cut percent	Current cut spark percent according to *Idle ign. cut* strategy
Idle Motor Step	Current position of stepper motor

Idle PID DC Correction	DC correction according to idle control PID controller
Idle Target	The RPM target value according to *Idle RPM target* table
Idle Valve DC	Duty cycle of signal controlling idle control solenoid. In the case of stepper motor or electronic throttle this value defines percent of defined *step range* or the range of electronic throttle opening (*idle range)*
Ignition From Table	The value of ignition angle advance according from *Ignition angle* table
Igntion Angle	Current ignition angle advance
Injector 1 trim	Fuel dose correction of injector connected to *injector output #1*
Injector 2 trim	Fuel dose correction of injector connected to *injector output #2*
Injector 3 trim	Fuel dose correction of injector connected to *injector output #3*
Injector 4 trim	Fuel dose correction of injector connected to *injector output #4*
Injector 5 trim	Fuel dose correction of injector connected to *injector output #5*
Injector 6 trim	Fuel dose correction of injector connected to *injector output #6*
Injectors cal. time	The time required to open the injector according to the *Injectors cal.* table
Injectors DC	The percentage of time the injectors are switched on
Injectors PW	The final injectors opening time in ms
Knock Action Fuel Enrich	Fuel dose correction resulting from *Knock action* strategy
Knock Action Ign. Retard	Ignition angle correction resulting form *Knock action* strategy
Knock Engine Noise	The value of "engine noise" according to *Knock engine noise* table
Knock ignition event	Indication of ignition event(s) causing knocking
Knock Level	The current level of knocking (*Knock sensor value* - *Knock engine noise*)
Knock Sensor value	The voltage from the knock sensor
Lambda	Lambda value from wide band oxygen sensor
LC Active	Information about activation of *Launch control* strategy
LC Fuel Enrichment	Fuel dose enrichment resulting from *Launch control* strategy
LC Ign. Retard	Ignition angle correction resulting from *Launch control* strategy
MAP	Manifold absolute pressure value (MAP)
MUX switch state	Information about state of *MUX Switch*

Nitrous Active	Information about activation of *Nitrous* control
Nitrous fuel scale	Fuel dose correction resulting from *Nitrous* strategy according *to Nitrous Fuel Scale* table
Nitrous ign. mod.	Ignition angle correction resulting from *Nitrous* strategy according *to Nitrous ignition mod.* table
None	Disable displaying log channel on the graph log
Oil pressure	Oil pressure value according to *Oil pressure cal.* table
Oil temperature	Oil temperature value according *Oil temperature cal.* table
Overdwell	Information about ignition coil overdwell (DC >= 100%)
Param. Output #1	The state of *Parametric output #1*
Param. Output #2	The state of *Parametric output #2*
Param. Output #3	The state of *Parametric output #3*
Param. Output #4	The state of *Parametric output #4*
Pit limiter active	Information about activation of *Pit limiter* strategy
Pit Limiter torque reduction	Torque reduction (in %) resulting from *Pit limiter* strategy
PWM #1 DC	Duty cycle of PWM#1 output
Rolling anti lag active	Information about activation of *Rolling anti lag* strategy
Rolling anti lag ign. retard	The ignition angle resulting from *Rolling anti lag* strategy
Rolling anti lag target	The target RPM acquired for *Rolling anti lag*
RPM	Engine speed
RPM 2nd engine	The RPM of the second engine transmitted by ECUMASTER serial protocol
Shift Light On	Information about output state of *Shift light*
Spark cut percent	Information about current spark cut percent
Tables set	Information about current selected table set
TC adjust pos	Position of sensitivity switch used by *Traction control* strategy
TC dRPM	Corrected value of delta RPM used by *Traction control* strategy
TC dRPM Raw	The value of delta RPM (how fast the RPM increases) used by *Traction control* strategy
TC Torq. Reduction	Torque reduction (in %) resulting from *Traction control* strategy
TPS	Current throttle position

TPS Rate	Throttle position change rate
TPS Voltage	Voltage value from TPS sensor
Trigger error	Information about trigger errors connected to primary or/and secondary trigger
Trigger sync status	Information about state of ignition system **NO SYNC** – no synchronization **SYNCHRONISING** – trying to synchronize **SYNCHRONISED** – ignition system synchronized
VE	The value of VE according to *VE table*
Vehicle Speed	The vehicle speed based on signal from *VSS sensor*
VSS Frequency	The frequency of signal from *VSS sensor*
VTEC Active	Information about activation of *VTEC* strategy
Warmup enrichment	Fuel dose enrichment according to *Warmup enrichment* table
WBO Heater DC	Duty cycle of WBO heater control signal
WBO IP Meas.	Measure IP value of wide band oxygen sensor
WBO IP Norm.	Normalized IP value of wide band oxygen sensor
WBO RI	The RI value of wide band oxygen sensor
WBO VS	The VS value of wide band oxygen sensor