



# USER MANUAL

## EMU PRO - Software Guide

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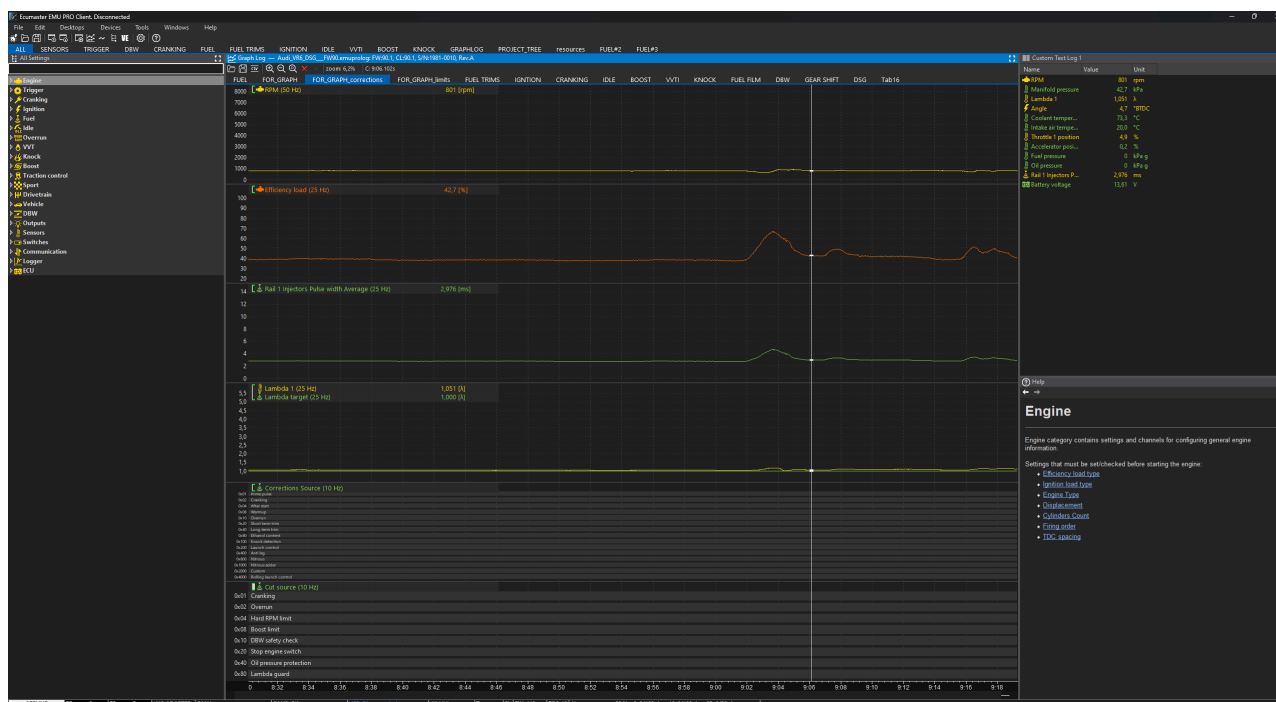
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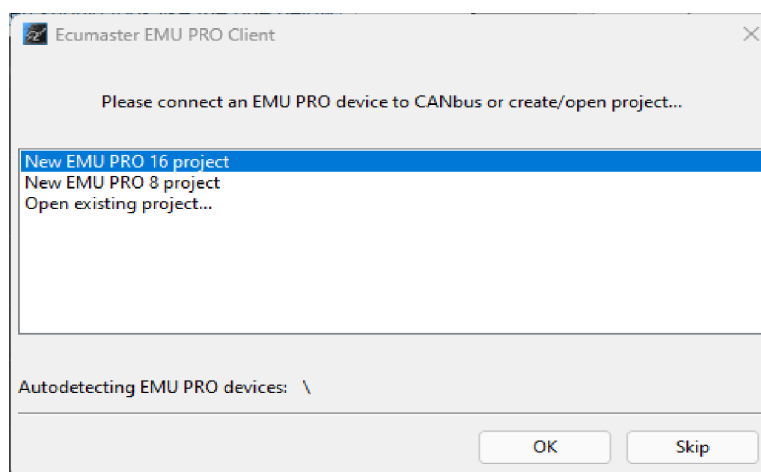
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# 1. Appearance of the application

After installing and launching the application, the application screen should look like the one below:



When starting the application without a connected device, first select for which device (EMU PRO 8 or EMU PRO 16) you want to create a new project or open an existing project. If you connect a device at this point, the appropriate selection will be made automatically.



The project is a tune file that contains all calibrations, settings, maps and user defined objects. The project can be password protected. For more information, see [Appendix A - How-to Use Password Protection \(on page 76\)](#)

At the top of the application, there is a menu bar. Below is a description of all available menu functions

Option	Description
<b>File</b>	
<b>Open project...</b>	Open a project ( <b>Ctrl + O</b> )
<b>Save project</b>	Save a project in the last used location ( <b>Ctrl + S</b> )
<b>Save project as...</b>	Save a project to a new file ( <b>Ctrl + Shift + S</b> )
<b>Load log &gt; Browse PC connected flash drive...</b>	Import a log from a memory stick connected to the PC ( <b>Shift + F4</b> )
<b>Show full screen</b>	Full screen mode. This increases the screen space available to the application ( <b>Ctrl + F</b> ).
<b>Change target device...</b>	When working offline, you can choose the target device: EMU PRO 8 or EMU PRO 16
<b>Update firmware...</b>	Change the internal software of a device
<b>Restore to defaults</b>	Restore a device to the default settings Deletes all settings
<b>Make permanent</b>	Save changes to the Flash memory of a device. Additionally, a file containing the current settings is saved to the <i>MyDocuments / EMU_PRO / DeviceName / QuickSave</i> directory ( <b>F2</b> )
<b>Exit</b>	Exit the application. The desktop arrangement is saved upon exiting ( <b>Alt + X</b> )
<b>Edit</b>	
<b>Undo</b>	Undo the last operation performed ( <b>Ctrl+Z</b> )
<b>Redo</b>	Redo a previously undone operation ( <b>Ctrl+Y</b> )
<b>Show undo list</b>	Display a window with all operations performed.
<b>Desktops</b>	
<b>Revert desktops</b>	Reads desktop configurations from the following file: <i>MyDocuments / EMU_PRO/DEFAULT / desktops.emuprolayout</i>
<b>Store desktops</b>	Save desktop configurations to the following file: <i>MyDocuments / EMU_PRO/DEFAULT / desktops.emuprolayout</i>
<b>Open desktop templates...</b>	Read the desktop configuration from a selected file. This allows to transfer configurations between computers.
<b>Save desktop templates...</b>	Save desktop configurations to a selected file.

Option	Description
	This allows to transfer configurations between computers.
<b>Restore desktops to default</b>	Load default desktop configuration. Restores all default panels in tabs and channels in the graph log.
<b>Add new panel</b>	Add a new panel to the desktop ( <b>F9</b> )
<b>Replace panel</b>	Replace an existing panel with another ( <b>Shift + F9</b> )
<b>Switch desktop to...</b>	Switch to any selected desktop ( <b>Ctrl + 1 – 9</b> )
<b>Next desktop</b>	Move to the next desktop ( <b>Ctrl + Tab</b> )
<b>Previous desktop</b>	Move to the previous desktop ( <b>Ctrl + Shift + Tab</b> )
<b>Toggle full size panel</b>	Switch the currently selected panel to full-size mode ( <b>F6</b> )
<b>Add Graph Log panel</b>	Add a <i>Graph Log</i> panel to the desktop
<b>Add Scope panel</b>	Add a <i>Scope</i> panel to the desktop
<b>Add All Settings - Smart Grid</b>	Add an <i>All Settings - Smart Grid</i> to the desktop
<b>Devices</b>	
<b>Device selector</b>	If one or more EMU PRO devices are connected, a panel enabling toggling between the devices will pop up. After switching to a device, the data between the PC and the device will be automatically synchronized. The names of particular devices can be found on the right-hand side of the application's toolbar. The currently connected device is shown in bold.
<b>Set device #n</b>	Automatic toggling to the connected device no. #n. After switching to a device, the data between the PC and the device will be automatically synchronized. The names of particular devices can be found on the right hand side of the application's toolbar. The currently connected device is shown in bold type ( <b>Ctrl + Shift + 1 – 2</b> ).
<b>Set device name</b>	Assign a name to a connected EMU PRO device
<b>Reboot device</b>	Reset a connected device ( <b>Ctrl + Shift + R</b> )
<b>Reconnect</b>	Re-establish communication with the device ( <b>Ctrl + Shift + B</b> )
<b>Browse PC connected flash drive...</b>	Read logs from a USB storage device connected to the PC ( <b>Shift + F4</b> )

Option	Description
<b>Set Real Time Clock</b>	Set the real-time clock of EMU PRO according to the current PC time. This time is used to date the files of a log saved into an external USB storage device. It can also be displayed on the screen of a device.
<b>Restart project in the EMU PRO</b>	Save the whole project to the EMU PRO device. It's equivalent to saving and restoring the project from the project file. All strategies are reinitialized. <b>(F5)</b>
<b>Tools</b>	
<b>Test outputs</b>	Opens window which allows user to test all EMU PRO outputs from each category: Auxiliary outputs, H-Bridge output, Injector outputs, and ignition outputs. Output can be tested in modes: switch on/off, set PWM frequency, test sequences for each cylinder for ignition and injectors outputs.
<b>Assigned outputs</b>	Opens window which allows user to display all EMU PRO outputs with information if given output is assigned and what is its function.
<b>Assigned inputs</b>	Opens window which allows user to display all EMU PRO inputs (digital, analog and precision analog) with information if given inputs is assigned and what is its function.
<b>APS tuner</b>	Opens window with the wizard performing auto-calibration of accelerator position sensor. For more information about the APS Tuner, see <a href="#">Appendix B - How-to Use APS Tuner (on page 79)</a>
<b>DBW tuner</b>	Opens window with the wizard performing auto-calibration of chosen drive-by-wire throttle. For more information about the DBW Tuner, see <a href="#">Appendix C - How-to Use DBW Tuner (on page 83)</a>
<b>VVT tuner</b>	Opens window with the wizard performing auto-calibration of chosen Variable Valve Timing camshaft. For more information about the VVT Tuner, see <a href="#">Appendix D - How-to Configure VVT (on page 99)</a>
<b>VE tuner</b>	Opens VE Tuner panel and settings window. VE Tuner is a tool, which is helpful to build or improve the Volumetric efficiency table by analysing logged data. For more

Option	Description
	information about the VE Tuner, see <a href="#">Appendix E - How-to Use VE Tuner (on page 111)</a>
<b>Customize keys</b>	Change the shortcut keys assignment
<b>Memory report</b>	Display a window with information on the current usage and the amount of free memory.
<b>Tune Display</b>	Display a floating window showing the selected engine parameters live. Go to the Tune Display Panel description for more details ( <b>F7</b> ).
<b>Logged Channels</b>	Display a dialogue window with a list of all log channels and their frequency. Current size of the log data is visible at the bottom of the window (number of parts and bytes) ( <b>F8</b> ).
<b>Project Tree</b>	Display the project management panel. Go to the <i>Project tree</i> panel description for more details. ( <b>Shift + F7</b> ).
<b>Variables Inspector</b>	Display the user-defined variable monitoring panel. Go to the <i>Variables inspector</i> panel description for more details. ( <b>Shift + F11</b> ).
<b>Smart Grid Panel</b>	Display the panel with all ECU settings and strategies. Go to the Smart Grid panel description for more details.
<b>Options</b>	Display a dialogue window with the application options ( <b>Ctrl + Shift + O</b> ). The description of the <i>General Options</i> window is available below.
<b>Windows</b>	
<b>Next panel</b>	Activate the next panel ( <b>Tab</b> )
<b>Previous panel</b>	Activate the previous panel ( <b>Shift + Tab</b> )
<b>Help</b>	
<b>View help</b>	Display the panel with help for each ECU setting. Go to the Help panel description for more details.
<b>Online Changelog</b>	Open an online <i>Changelog</i> document.
<b>About</b>	Open a window with information about the software version

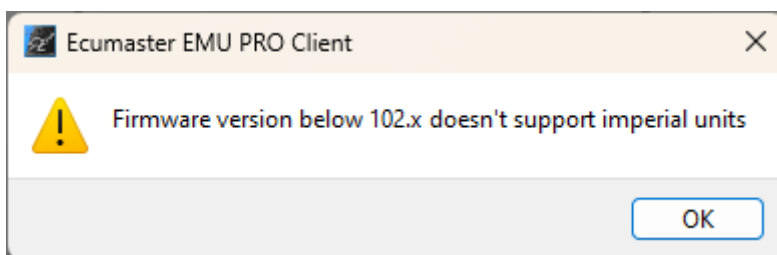
There are icons on the taskbar  indicating:

- **Make permanent** – Saving changes to the non-volatile memory of a device
- **Open project** – opening a project
- **Save project** – saving the current project
- **Restore desktops** – loading the desktop configurations from the file
- **Store desktops** – saving desktop configurations to the file
- **Add panel** – adding a panel
- **Add Graph Log** – adding a *Graph Log* panel
- **Add Scope** – adding a *Scope* panel
- **Add All Settings - Smart Grid** – adding an *All Settings - Smart Grid*
- **Open VE Tuner** – opening a *VE Tuner* window
- **Configuration** – opening the *General Options* configuration window

The *General Options* window contains the following settings:

Option	Description
<b>Save project (Ctrl+S) without dialog</b>	With this option active, the user will not be asked to select save file name and destination
<b>3D tables color scheme</b>	Color scheme for 3D maps
<b>Auto save logs</b>	Automatic saving of logs onto the disc
<b>Use mouse wheel to zoom on Graph Log</b>	Log scaling function using the mouse wheel
<b>Units system</b>	<b>Metric</b> - default units system <b>Imperial</b> - imperial units system (°F, mph, psi ...)

Imperial units are **not supported** in firmware versions **below 102.0**. If connected to an older device with imperial units selected, all units will be displayed in metric. A notification window will appear to inform the user about this limitation.



## 2. Status field

The status field contains important information on the status of a connected device.

<b>Connection status</b>	Specifies, whether a device is connected. One of following is available: DISCONNECTED, CONNECTED, MAKE PERMANENT, OFFLINE
<b>Trigger sync status</b>	Displays value of channel <i>Trigger / Sync state</i> channel: One of following is available: No sync, Skipping time, Skipping impulses, Searching, Primary synced, Fully synced
<b>Engine state</b>	Displays value of channel <i>Engine / State</i> channel. One of following is available: Inactive, Cranking, Running
<b>USB to CAN adapter</b>	Shows the CAN to USB interface type. The following interface types are supported: <ul style="list-style-type: none"> <li>• <b>USBtoCAN</b> - ECUMASTER interface</li> <li>• <b>PCAN-USB</b> - Peak System interface</li> <li>• <b>Kvaser</b> - Kvaser interface</li> </ul>
<b>CAN 1 status (seen from PC)</b>	The status of the CAN 1 bus from the USB to CAN interface
<b>CAN 2 status (seen from device)</b>	The status of the CAN 2 bus read from Can controller of the ADU display
<b>USB logger state</b>	USB drive save status. For more information about the USB logging, see <a href="#">Appendix G - How-to Log Data to a USB Drive (on page 122)</a>
<b>USB buffer usage</b>	Information about the quality of the USB drive (from A to F) and the buffer status
<b>Board temperature</b>	Device temperature
<b>Saving log in progress</b>	Log auto-save status
<b>Device firmware version</b>	Firmware version
<b>Device type</b>	Device type
<b>Used resources</b>	The number of user-defined elements used

If the CAN bus (1 or 2) status differs from OK, it means errors along the bus.

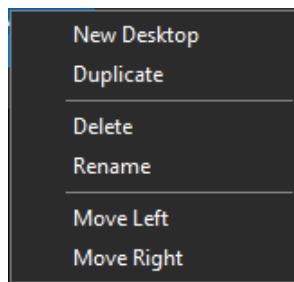
Explanation of CAN statuses of the ECUMASTER USBtoCAN adapter



Status	Typical cause of the problem
OK	CAN bus fully functional, no faults
stuff	Not all devices on the CAN bus send frames at the same speed (wrong speed of device along the CAN bus).
form	Not all devices on the CAN bus send frames at the same speed.
bitrec	No terminator on the CAN bus.
bitdom	CANL and CANH are short-circuited.
bit	Two devices send frames with the same ID but with different DLC / DATA fields.
ack	Interface is the only device on the CAN bus, no other devices. Or: CANL or CANH is disconnected from other equipment. Or: CANL and CANH are interchanged.
Offline	The program operates in Offline mode - there is no access to the CAN bus.

### 3. Desktops

Desktops are an important part of the application. They allow you to arrange your own sets of panels, which makes the software easier and quicker to use. After pressing the right mouse button on the tab the following menu appears:



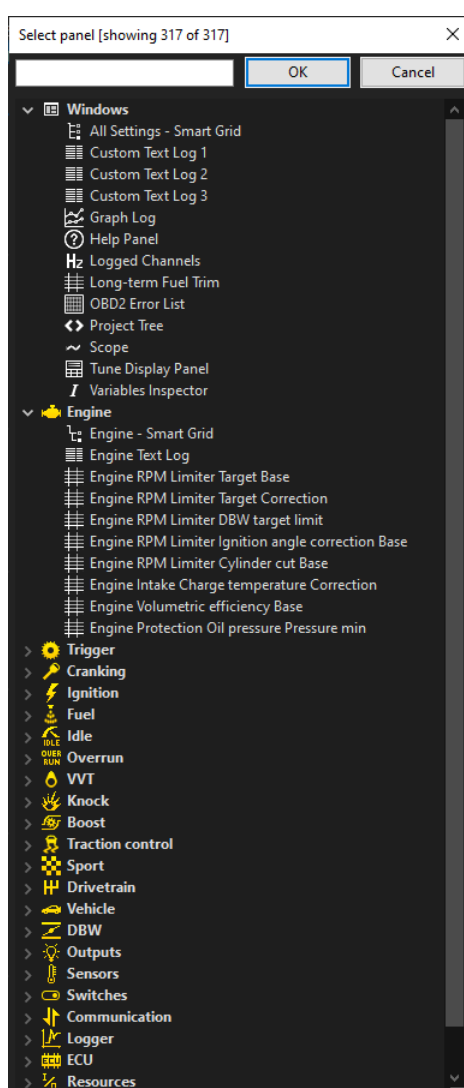
Option	Description
<b>New desktop</b>	Create a new desktop
<b>Duplicate</b>	Duplicate a desktop. This option creates a new desktop and copies into it the contents of a selected one
<b>Delete</b>	Delete desktop
<b>Rename</b>	This function makes it possible to change the name of a desktop
<b>Move Left</b>	Moves a desktop to the left
<b>Move Right</b>	Moves a desktop to the right

You can switch between desktops using keyboard shortcuts:

- **Ctrl+1..0** – Switch to any selected desktop (with the appropriate number)
- **Ctrl+Tab** – Switch to the next desktop
- **Ctrl+Shift+Tab** – Switch to the previous desktop

## 4. Panels

Another element of the interface are panels. Through them you can configure the device. To add a new panel, press **F9** (or click on the **Add panel** icon in the toolbar). A window with all available panels will open. For a quicker search, you can enter the panel you are looking for in the filter field.



Newly opened panel always show up on the right side of the desktop. You can move them by pressing the left mouse button on the *Title bar* and moving the mouse to a new position.

Each panel on the right side Title bar has an icon that temporarily expands it to the entire desktop. When the full size panel functionality is activated, the panel bar is highlighted in green. Clicking

the icon a second time returns the panel to its original size. Switching to another desktop also resets the panel to its normal size. The keyboard shortcuts for full size panel are F6 or Tab+Space.

To remove a panel from the desktop, press the right mouse button on its bar. A menu will appear from which you can delete it (*Close panel*).

Some panels have a taskbar with dedicated icons. Same options are also available in the context menu displayed by right-clicking in the panel field.

Right-clicking on the panel bar opens a menu with the following options:

Option	Key shortcut	Description
<b>Add panel above</b>	<b>Tab+Shift+Up</b>	Adding a panel above
<b>Add panel below</b>	<b>Tab+Shift+Down</b>	Adding a panel below
<b>Add panel on left</b>	<b>Tab+Shift+Left</b>	Adding a panel on the left
<b>Add panel on right</b>	<b>Tab+Shift+Right</b>	Adding a panel on the right
<b>Replace panel</b>	<b>Shift+F9</b>	Replacing a panel
<b>Close panel</b>	<b>Ctrl+F4</b>	Closing a panel

You can switch between panels using keyboard shortcuts:

- **Tab** – Switch to the next panel
- **Shift+Tab** – Switch to the previous panel

There are different panel types.

The most important of them is **Smart grid** containing all settings, tables and channels used in individual strategies. **Tables** can also be displayed as separate panels. Closely related to the Smart grid panel is the **Help** panel, which shows a description of the currently selected parameter.

The **Scope** panel allows measurement of signals present at primary trigger, secondary trigger and all cam inputs. Calculated TDC (top dead center) point, injection time, ignition dwell time and knock window for each cylinder are presented in visual form.

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 inputs assignment is required. Pattern setting can be left unset.

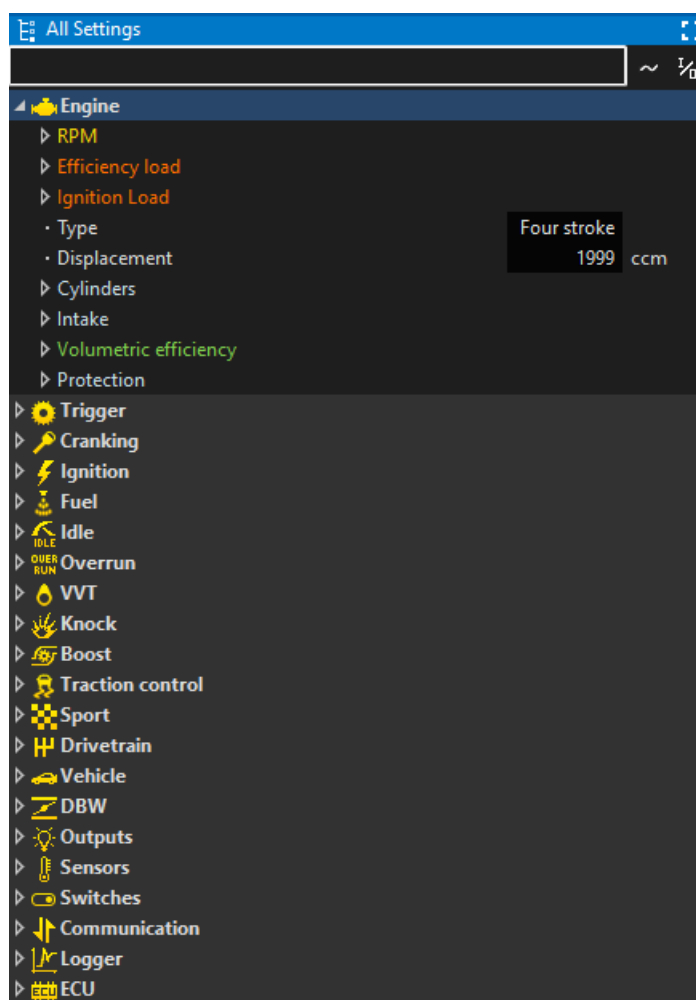
The **Project Tree** panel allows you to create your own elements such as: CAN bus Receive Frame, Table, Number, Logical Function, CAN bus Transmit Frame, Group, Import .CANX /.DBC frame.

Another type are panels for viewing variables, such as **Text log**, **Variables Inspector**, **Tune Display** or **Graph Log** showing the course of logging channels over time.

The **Logged Channels** panel defines the logging frequency (in Hz) for each channel.

## 4.1. Smart grid – All Settings

**Smart grid** is a panel containing all settings for individual strategies arranged in the form of a tree.



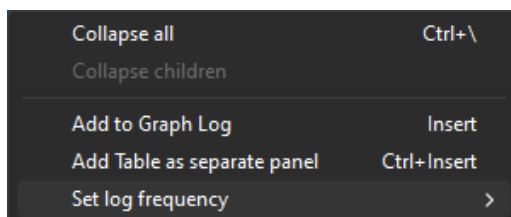
In each category there are dedicated:

- settings of variables (white color)
- tables (light pink color)
- channels (with a color corresponding to the color of the appropriate channel set in the *Graph Log* panel)
- resources (various colors) - for configuration of inputs or outputs of the device

**Resources** are used to configure the device's inputs and outputs. Each resource represents a configurable hardware component (e.g., output, input, sensor controller, etc.). The configuration

of a resource is possible once you assign it to a specific **function**. Settings menu for each resource is displayed when given resource is used.

Right-clicking on a parameter causes a menu to appear with the following options:



- **Collapse all** - closes all expanded items in the tree
- **Collapse children** - closes the sub-items of a given parameter (children of the given object)
- **Add to Graph Log** - adds the selected channel to the *Graph Log* - available only for channels
- **Add Table as separate panel** - available when right-clicking on a table. This option opens the table in a separate panel.
- **Set log frequency** - changes the logging frequency - available only for channels.

In the upper part of the panel there are the following elements:

- **Search bar** - used to quickly find the desired parameter. It is enough to enter a part of the name to get all the parameters with the searched word in their name
- **Show channels icon** - enabled by default. When enabled, all channels and their values are displayed in the tree. When disabled, channels with no children are not visible
- **Show resources icon** - enabled by default. This option controls whether the resource configuration is visible when a resource is assigned

Navigation in the *Smart Grid* panel is done with keyboard arrows (up/down for selecting upper/lower entry, left/right for expanding/collapsing node of the tree) or a mouse (double-click is expanding/collapsing node of the tree).

Changed parameter/table value is instantly sent to the EMU PRO device, but stored in the volatile copy of the project. Make permanent command is necessary to keep the project after disconnecting the PC.

## 4.2. Tables

There are four types of tables: scalar, 2D table, 3D table, and 4D table.

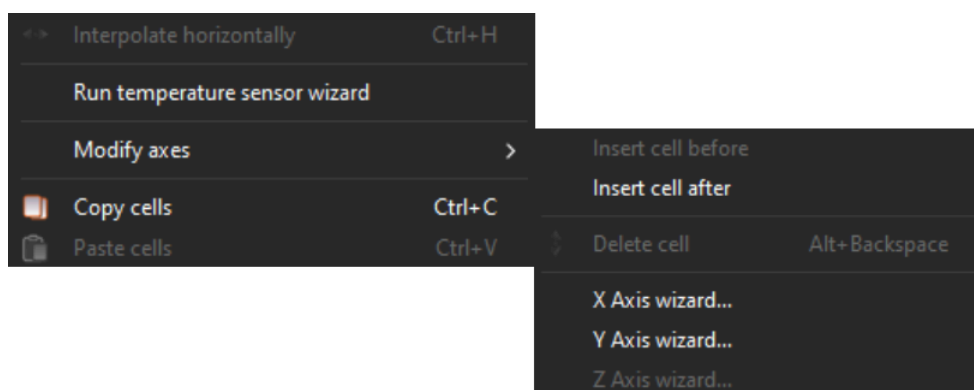
### Scalar

A scalar is a constant value (independent of any channel or condition). However, if more flexibility is needed it can be transformed into a 2,3, or 4 dimensional table).



### 2D tables

The configuration of each type of table is available in the context menu. Click the right mouse button on the top row of the table (specifying the function value).



Description of the commands available in the context menu for a 2D table.

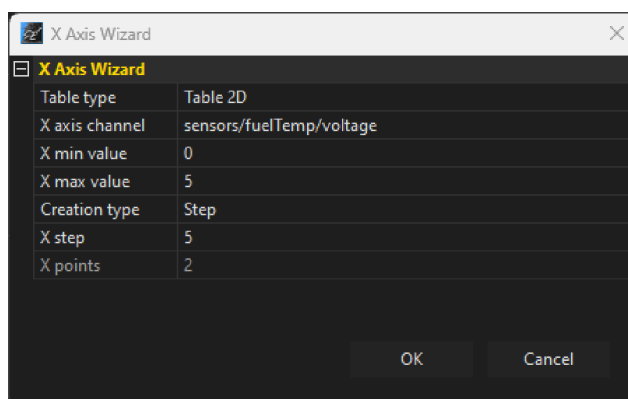
Command	Key shortcut	Description
<b><i>Interpolate horizontally</i></b>	Ctrl+H	Horizontal interpolation: cell values in the selection area are calculated as a linear interpolation of the cells from the left and right edges of the selection.
<b><i>Run temperature sensor wizard</i></b>		Automatic wizard for temperature or pressure sensor
<b><i>Equalize selection</i></b>	E	Smoothing of the selected cells
<b><i>Modify axes / Insert cell before</i></b>		Inserting a point to the left of the selected cell
<b><i>Modify axes / Insert cell after</i></b>		Insert a point to the right of the selected cell
<b><i>Modify axes / Delete cell</i></b>	Alt+Backspace	Delete a selected point (selected cell)

Command	Key shortcut	Description
<b>Modify axes / X Axis wizard</b>		Launching a wizard for the X axis to define a new number of columns and generate X axis cells according to the selected type of interpolation. The X axis define the table type: scalar or 2D
<b>Modify axes / Y Axis wizard</b>		Launching a wizard for the Y axis to define the table type: 2D or 3D
<b>Modify axes / Z Axis wizard</b>		Launching a wizard for the Z axis to define the table type: 3D or 4D
<b>Copy cells</b>	Ctrl+C	Copying the value of the selected cell(s)
<b>Paste cells</b>	Ctrl+V	Pasting of the copied value(s) of the cell(s) in the highlighted area

Each scalar table has no axes defined, the 2D table has only an x-axis defined, the 3D table has an x-axis and y-axis, and the 4D table has an x-axis, y-axis and z-axis defined. It is possible to change the channel that represents a particular axis. To define the X axis (the channel assigned to the X axis and the number of feature points), you can right-click on the bottom row of the table (which defines the points on the X axis) and select **X Axis wizard**.

X Axis wizard...

A window for configuring the X axis will appear.



Parameter	Description
<b>Table Type</b>	Select the table type: Scalar or 2D. The x-axis parameters are only available for the 2D table.
<b>X axis channel</b>	Selecting a channel defining the X axis

Parameter	Description
<b><i>X min value</i></b>	The minimum value on the X axis, (for all arguments smaller than <i>X min value</i> , the function value is the same as for <i>X min value</i> )
<b><i>X max value</i></b>	The maximum value on the X axis, (for all arguments greater than <i>X max value</i> , the function value is the same as for <i>X max value</i> )
<b><i>Creation type</i></b>	Selecting the type of distribution of points on the X axis <b>Step</b> - the distribution of points evenly spaced from each other by a given step: <b><i>X step</i></b> <b>Linear interpolation</b> - distribution of a specified number of points ( <b><i>X points</i></b> ), evenly distributed over a specified interval (between the minimum and maximum values) <b>Exponential interpolation #1/#2</b> - distribution of a specified number of points ( <b><i>X points</i></b> ) over a given range but with a higher density at the beginning of the interval and a lower density at the end. The distribution of points is described by an exponential function with an exponent equal to 1.4 for <b>#1</b> and 1.6 for <b>#2</b> .
<b><i>X step</i></b>	For distribution of points by a given step - a distance between two consecutive points
<b><i>X points</i></b>	The number of points marked on the X axis

To change the distribution of points on the X axis and to assign a specific value to each point, double-click the left button on a specific cell in the table and enter the desired value.

The values of the functions in the table can also be changed using keyboard shortcuts. The currently selected value in the table can be changed using the following keys:

**[** – reduces a value by a ***fine*** step

**]** – increases a value by a ***fine*** step

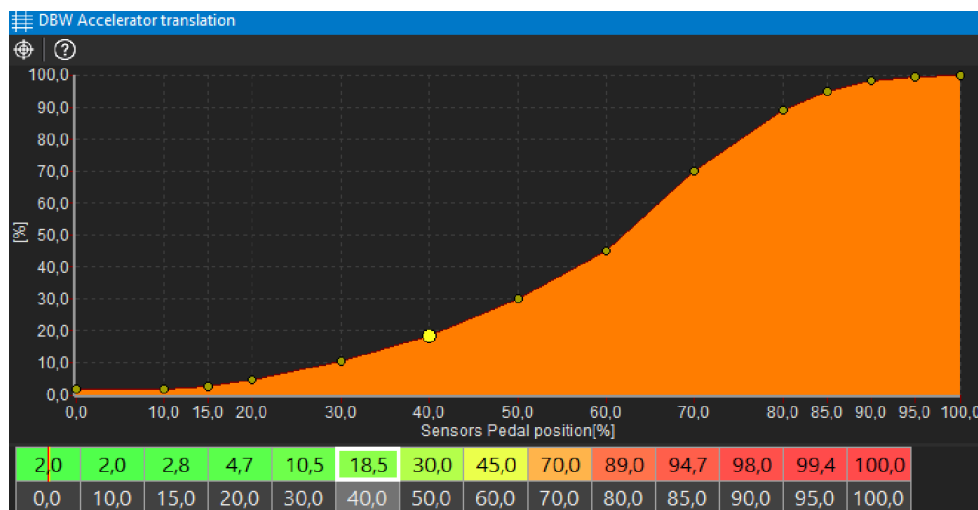
**' - '** – reduces a value by a ***normal*** step

**' + '** – increases a value by a ***normal*** step

**Shift + ' - '** – reduces a value by a ***coarse*** step

**Shift + ' + '** – increases a value by a ***coarse*** step





Automatic wizards are available for pressure sensors (linear characteristic sensors) and temperature sensors (NTC type sensors). After selecting a predefined sensor (from the list of those available) and specifying certain parameters, the characteristics are generated automatically.

Temperature sensor configuration:

Temperature sensor wizard

**Temperature sensor wizard**

Predefined sensors: Bosch NTC M12-L 0280130039

Rx value (pullup) [Ohm]: 2200

Use table best fit for a sensor: ☒

Number of X axis cells: 20

Temperature point 0 [°C]: -40

Sensor R 0 [Ohm]: 45313

Temperature point 1 [°C]: 0

Sensor R 1 [Ohm]: 5896

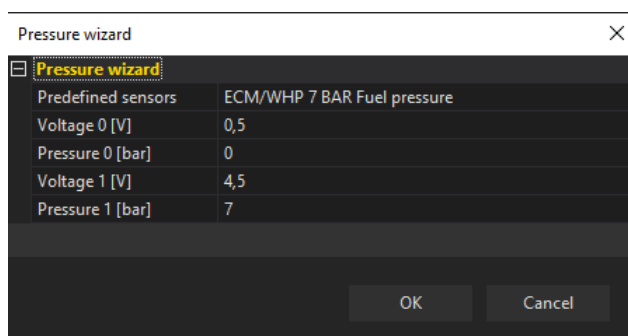
Temperature point 2 [°C]: 100

Sensor R 2 [Ohm]: 187

OK Cancel

Parameter	Description
<b>Predefined sensors</b>	Selection of a predefined sensor for which the resistance measurement points for the wizard are completed automatically.
<b>Rx value (pullup) [Ohms]</b>	The value of the pullup resistor used with the sensor
<b>Use table best fit for a sensor</b>	Automatic adjustment of the density of the axle compartments according to the change in the sensor characteristics
<b>Number of X axis cells</b>	The number of cells for a characteristic
<b>Temperature point # [°C]</b>	The sensor temperature value for the # of the measuring point
<b>Sensor R # [Ohms]</b>	Sensor resistance value for the # of the measuring point

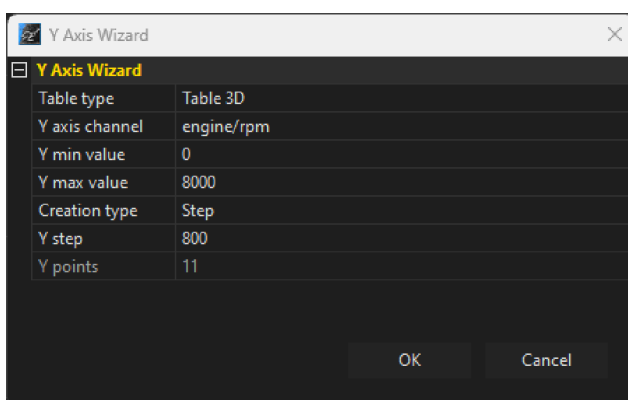
Pressure sensor configuration:



Parameter	Description
<b>Predefined sensors</b>	Selection of a predefined sensor for which the voltage measurement points for the wizard are completed automatically.
<b>Voltage # [V]</b>	Voltage value for the sensor for the # of the measuring point
<b>Pressure # [bar]</b>	Pressure value for the sensor for the # of the measuring point

### 3D tables

To define the table type 3D, select the **Y Axis wizard** from the context menu. The Y axis configuration window will appear.



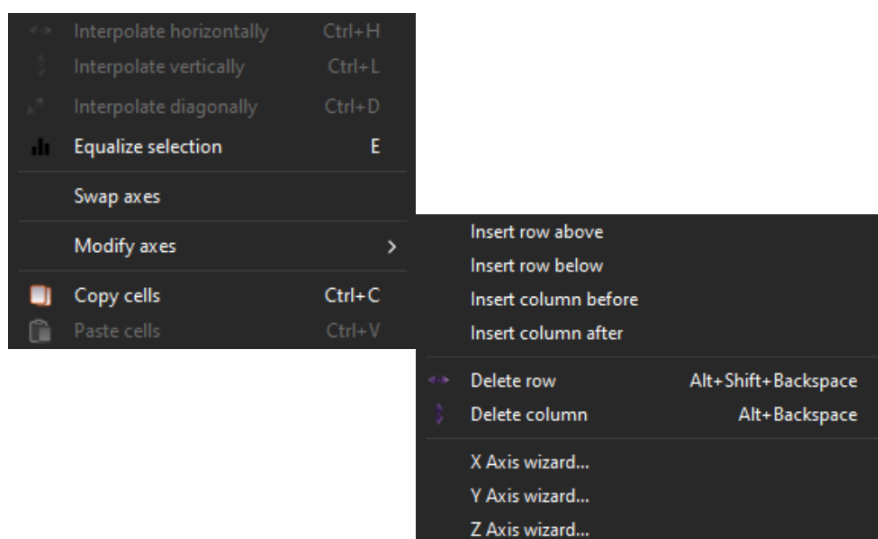
Parameter	Description
<b>Table type</b>	Select the table type: 2D or 3D. The y-axis parameters are only available for the 3D table.
<b>Y axis channel</b>	Selection of the channel defining the Y axis
<b>Y min value</b>	The minimum value on the Y axis
<b>Y max value</b>	The maximum value on the Y axis
<b>Creation type</b>	Selection of the type of distribution of points on the Y axis

Parameter	Description
	<p><b>Step</b> - the distribution of points evenly spaced from each other by a given step: <b>Y step</b></p> <p><b>Linear interpolation</b> - the distribution of a specified number of points (<b>Y points</b>), evenly distributed over a specified interval (between the minimum and the maximum value)</p> <p><b>Exponential interpolation #1/#2</b> - distribution of a specified number of points (<b>Y points</b>) over a given interval, with a higher density at the beginning of the interval and a lower density at the end. The distribution of points is described by an exponential function with an exponent equal to 1.4 for <b>#1</b> and 1.6 for <b>#2</b>.</p>
<b>Y step</b>	For distribution of points by a given step - a distance between two consecutive points
<b>Y points</b>	The number of points marked on the Y axis

Next the cells and axes should be filled with values.

You can select several cells using the **Shift + arrow** key. The **Ctrl + arrow** key copies to adjacent cells. Horizontal and vertical interpolation commands can also be helpful.

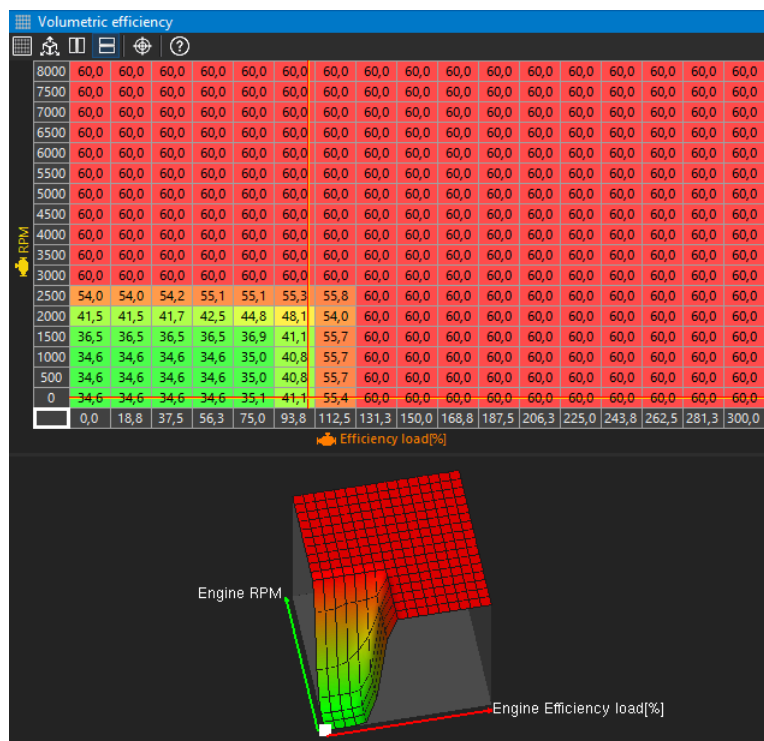
The size of the table (number of columns or rows) can be changed at any time using the context menu available under the right mouse button.



Description of the commands available in the context menu for the 3D table:

Command	Key shortcut	Description
<b>Interpolate horizontally</b>	Ctrl+H	Horizontal interpolation: the cell values in the selection area are calculated as a linear interpolation of the cells from the left and right edges of the selection.
<b>Interpolate vertically</b>	Ctrl+L	Vertical interpolation: the cell values in the selection area are calculated as a linear interpolation of the cells from the top and bottom edges of the selection.
<b>Interpolate diagonally</b>	Ctrl+D	Interpolation between vertices. Define the 4 corner points of the selection and the rest of the cells will be counted as bilinear interpolation. Combines two commands - first the horizontal interpolation followed by the vertical interpolation.
<b>Equalize selection</b>	E	Smoothing of the selected cells
<b>Swap axes</b>		Replacement of axes
<b>Modify axes / Insert row above</b>		Inserting a row above a selected cell
<b>Modify axes / Insert row below</b>		Inserting a row below a selected cell
<b>Modify axes / Insert column before</b>		Insert a column to the left of the selected cell
<b>Modify axes / Insert column after</b>		Insert a column to the right of the selected cell
<b>Modify axes / Delete row</b>	Alt+Shift +Backspace	Delete the row containing the selected cell
<b>Modify axes / Delete column</b>	Alt+Backspace	Delete the column containing the selected cell
<b>Modify axes / X Axis wizard</b>		Launching a wizard for the X axis to define a new number of columns and generate X axis cells according to the selected type of interpolation
<b>Modify axes / Y Axis wizard</b>		Launching the Y-axis wizard to define a new number of rows and to generate Y-axis cells according to the selected type of interpolation

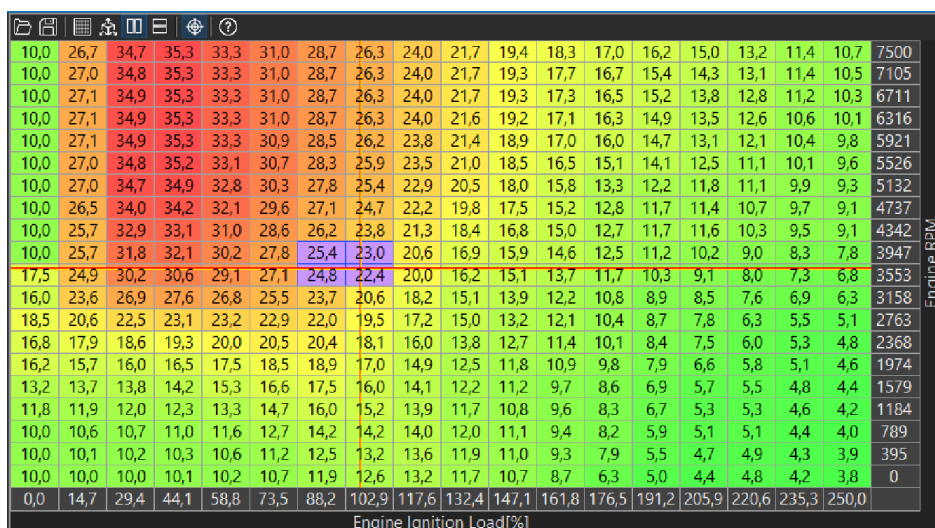
Command	Key shortcut	Description
<b>Modify axes / Z Axis wizard</b>		Launching the Z-axis wizard to define a new number of 3D tables and to generate Z-axis cells according to the selected type of interpolation
<b>Copy cells</b>	Ctrl+C	Copying the value of the selected cell(s)
<b>Paste cells</b>	Ctrl+V	Pasting of the copied value(s) of the cell(s) in the highlighted area



The panel toolbar contains icons allowing:

- displaying only a table: *Only 3D table*
- displaying only a graph: *Only 3D graph*
- displaying a graph next to a table: *Split vertically*
- displaying a graph below a table: *Split horizontally*
- highlighting in violet the cell(s) based on which a value is interpolated: *Follow cursor*

The 3D chart view can be rotated in any way by holding down the left mouse button on the chart and moving the mouse. To return to the default view, double-click the left mouse button on the chart.



10,0	26,7	34,7	35,3	33,3	31,0	28,7	26,3	24,0	21,7	19,4	18,3	17,0	16,2	15,0	13,2	11,4	10,7	7500
10,0	27,0	34,8	35,3	33,3	31,0	28,7	26,3	24,0	21,7	19,3	17,7	16,7	15,4	14,3	13,1	11,4	10,5	7105
10,0	27,1	34,9	35,3	33,3	31,0	28,7	26,3	24,0	21,7	19,3	17,3	16,5	15,2	13,8	12,8	11,2	10,3	6711
10,0	27,1	34,9	35,3	33,3	31,0	28,7	26,3	24,0	21,6	19,2	17,1	16,3	14,9	13,5	12,6	10,6	10,1	6316
10,0	27,1	34,9	35,3	33,3	30,9	28,5	26,2	23,8	21,4	18,9	17,0	16,0	14,7	13,1	12,1	10,4	9,8	5921
10,0	27,0	34,8	35,2	33,1	30,7	28,3	25,9	23,5	21,0	18,5	16,5	15,1	14,1	12,5	11,1	10,1	9,6	5526
10,0	27,0	34,7	34,9	32,8	30,3	27,8	25,4	22,9	20,5	18,0	15,8	13,3	12,2	11,8	11,1	9,9	9,3	5132
10,0	26,5	34,0	34,2	32,1	29,6	27,1	24,7	22,2	19,8	17,5	15,2	12,8	11,7	11,4	10,7	9,7	9,1	4737
10,0	25,7	32,9	33,1	31,0	28,6	26,2	23,8	21,3	18,4	16,8	15,0	12,7	11,7	11,6	10,3	9,5	9,1	4342
10,0	25,7	31,8	32,1	30,2	27,8	25,4	23,0	20,6	16,9	15,9	14,6	12,5	11,2	10,2	9,0	8,3	7,8	3947
17,5	24,9	30,2	30,6	29,1	27,1	24,8	22,4	20,0	16,2	15,1	13,7	11,7	10,3	9,1	8,0	7,3	6,8	3553
16,0	23,6	26,9	27,6	26,8	25,5	23,7	20,6	18,2	15,1	13,9	12,2	10,8	8,9	8,5	7,6	6,9	6,3	3158
18,5	20,6	22,5	23,1	23,2	22,9	22,0	19,5	17,2	15,0	13,2	12,1	10,4	8,7	7,8	6,3	5,5	5,1	2763
16,8	17,9	18,6	19,3	20,0	20,5	20,4	18,1	16,0	13,8	12,7	11,4	10,1	8,4	7,5	6,0	5,3	4,8	2368
16,2	15,7	16,0	16,5	17,5	18,5	18,9	17,0	14,9	12,5	11,8	10,9	9,8	7,9	6,6	5,8	5,1	4,6	1974
13,2	13,7	13,8	14,2	15,3	16,6	17,5	16,0	14,1	12,2	11,2	9,7	8,6	6,9	5,7	5,5	4,8	4,4	1579
11,8	11,9	12,0	12,3	13,3	14,7	16,0	15,2	13,9	11,7	10,8	9,6	8,3	6,7	5,3	5,3	4,6	4,2	1184
10,0	10,6	10,7	11,0	11,6	12,7	14,2	14,2	14,0	12,0	11,1	9,4	8,2	5,9	5,1	5,1	4,4	4,0	789
10,0	10,1	10,2	10,3	10,6	11,2	12,5	13,2	13,6	11,9	11,0	9,3	7,9	5,5	4,7	4,9	4,3	3,9	395
10,0	10,0	10,0	10,1	10,2	10,7	11,9	12,6	13,2	11,7	10,7	8,7	6,3	5,0	4,4	4,8	4,2	3,8	0
0,0	14,7	29,4	44,1	58,8	73,5	88,2	102,9	117,6	132,4	147,1	161,8	176,5	191,2	205,9	220,6	235,3	250,0	

## 4D tables

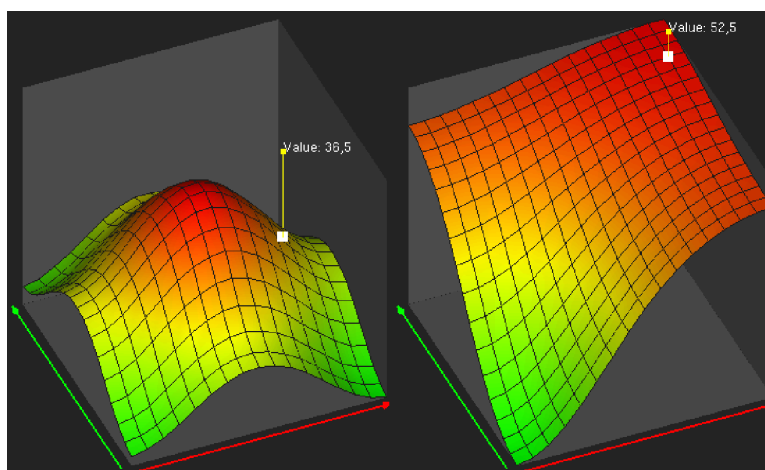
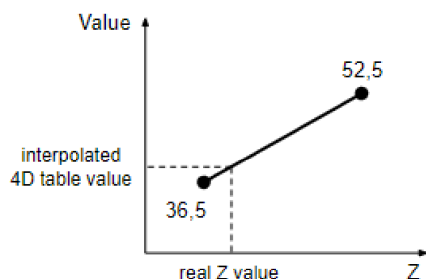
A 4D table is an expansion of a 3D table that introduces an additional dimension - the Z axis. It can be visualized as a series of 3D tables stacked together, with each table representing a distinct slice along the Z axis. The Z axis determines the quantity of these 3D tables that exist in the structure.

To obtain a value from a 4D table, there are two approaches based on the characteristics of the Z-axis.

If the Z-axis channel is discrete (not continuous), such as being determined by rotary switch positions, the value is directly retrieved from the specified 3D table. In this case, there is no need for interpolation as the value is readily available in the predefined table.

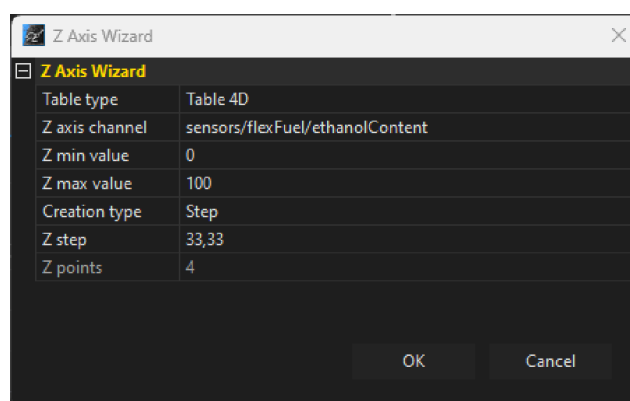
If the Z-axis channel is continuous (e.g., ranging from 0% to 100%), the returned value is obtained through interpolation. This means the value is estimated by considering the slices nearest to the current Z value, and the interpolation process fills in the gap between those slices. You can refer to the accompanying diagram for a visual representation.

Interpolation in a 4D table involves the process of estimating values along the Z-axis by interpolating between the 3D tables. When performing interpolation in a 4D table, we consider the known values in adjacent 3D tables along the Z-axis. By analyzing the data in these neighboring tables, we can approximate the values for the intermediate slices.



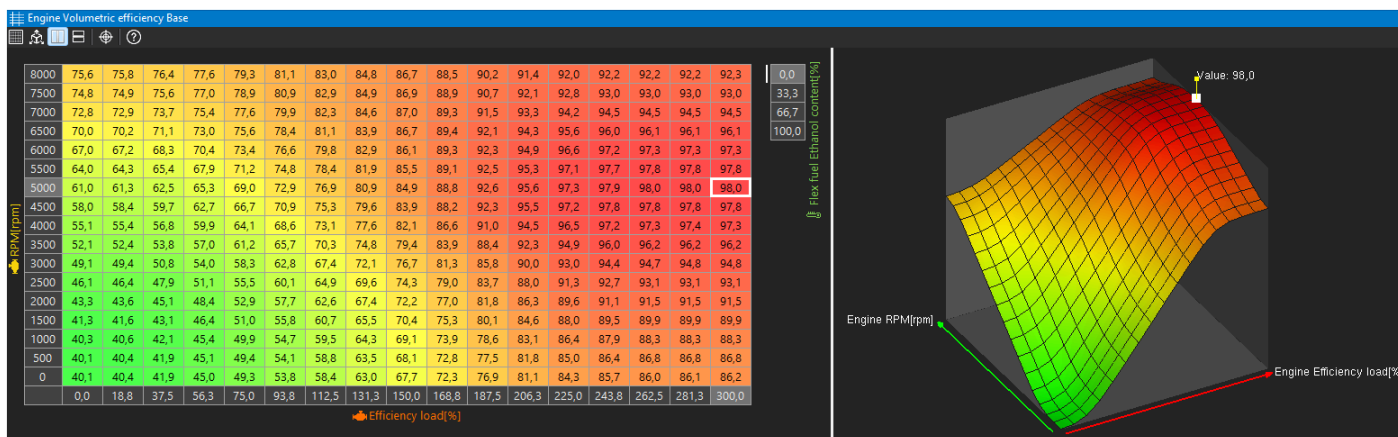
The keyboard shortcut **Z** allows switching between the active Z-axis and the currently selected 3D table. Additionally, the keyboard shortcuts **Page Up** and **Page Down** enable users to move through the cells in the Z-direction.

Select the **Z Axis wizard** from the context menu to define the 4D table and configure the Z axis.

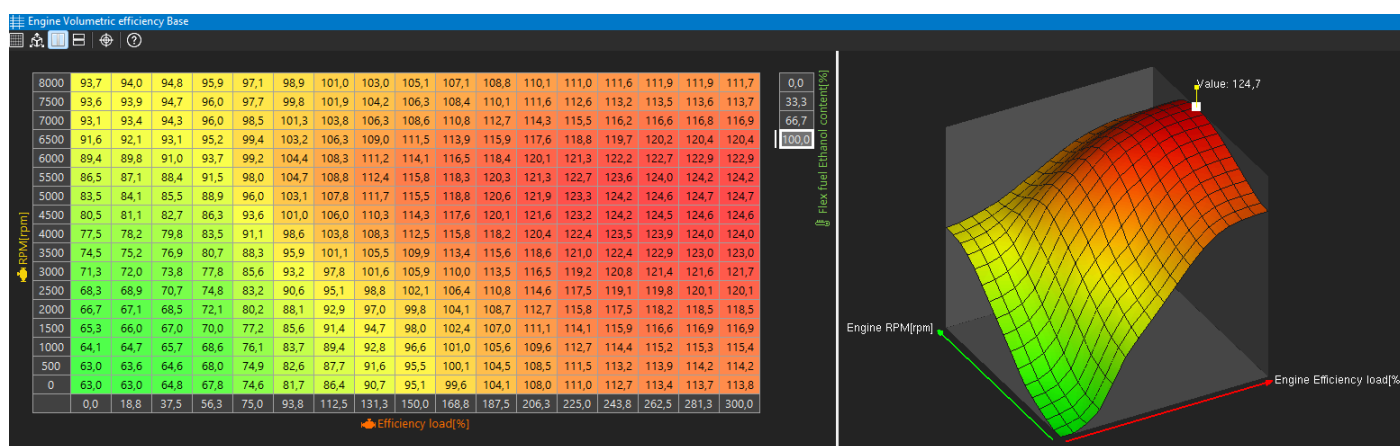


Parameter	Description
<b>Table type</b>	Select the table type: 3D or 4D. The z-axis parameters are only available for the 4D table.
<b>Z axis channel</b>	Selection of the channel defining the Z axis
<b>Z min value</b>	The minimum value on the Z axis
<b>Z max value</b>	The maximum value on the Z axis
<b>Creation type</b>	Selection of the type of distribution of points on the Z axis

Parameter	Description
	<p><b>Step</b> - the distribution of points evenly spaced from each other by a given step: <b>Z step</b></p> <p><b>Linear interpolation</b> - the distribution of a specified number of points (<b>Z points</b>), evenly distributed over a specified interval (between the minimum and the maximum value)</p> <p><b>Exponential interpolation #1/#2</b> - distribution of a specified number of points (<b>Z points</b>) over a given interval, with a higher density at the beginning of the interval and a lower density at the end. The distribution of points is described by an exponential function with an exponent equal to 1.4 for <b>#1</b> and 1.6 for <b>#2</b>.</p>
<b>Z step</b>	For distribution of points by a given step - a distance between two consecutive points
<b>Z points</b>	The number of points marked on the Z axis







## 4.3. Graph Log

**Graph log** is the panel plotting channels data as a function of time

The panel toolbar allows to:



- **Open log** - reading the log file from the disk - adding a new log (**Append data**) or replace the currently open logs with other (**Replace data**)
- **Save log** - saving the log file to disk along with user-created bookmarks
- **Export to CSV** - exporting to CSV file
- **Zoom In, Zoom Out, Zoom extents** - change of scale
- **Clear log** – remove logged data
- **Pause / Resume log** – when connected to the device, the log has to be paused to view past data. Otherwise the cursor will be always showing the current data point.
- **zoom:** - the current zoom rate is displayed on the taskbar
- **C:** - information about the current position of the cursor is displayed on the taskbar.

The **Graph Log** panel, just like the main application dashboard, has tabs that can be used to organise the displayed channels (e.g. Fuel, Ignition, etc.). The handling of the tabs is no different to that of the main application desktop.



Elements of the *Graph Log* panel:

1. **Channel panel** – displays the channels presented on a given chart along with the values of these channels indicated by the cursor. In case of a selection, it displays the channel value for the start cursor. The active channel is indicated by a vertical white line next to the name. The active channel can be changed with the Page Up/Down keys or by right clicking on the channel name. It is also possible to select a channel by right-clicking on the chart.
2. **Cursor**
3. **Value axis** – if two or more channels are displayed on one chart, the channels with the same unit have a common axis, the next added channel with a different unit has a separate axis (displayed on the right hand side), and each next added channel with a different unit has the displayed axis on the left when this channel is selected (the axis for the underlined channel is visible on the left hand side).

In the autoscale mode, the maximum and minimum values of all channels within the graph are searched. Green dashes next to the channel name mean that autoscaling is enabled.

When autoscaling is off, the lines are white. Autoscaling is enabled/disabled by using the 'A' hotkey or calling the **Axis properties** window.

#### 4. Time axis - time elapsed from the beginning of the log

##### Navigation in the *Graph Log* panel

Clicking the left mouse button on the chart causes the cursor to move. Double-clicking with the left mouse button starts edition of the selection. The selection can be confirmed by clicking the left mouse button again, in which case the selected fragment will be zoomed in. If you hold down the Shift key when confirming a selection, the selected area remains selected without zooming in.

By pressing the right mouse button in the log area, the context menu is called up:

Change channel	E
Create new graph	C
Insert channels	Insert
Remove graph	Shift+Delete
Remove channel	Delete
Move up	Alt+Page Up
Move down	Alt+Page Down
Set log frequency	>
Toggle autoscale	A
Channel properties	Return
Axis properties	Shift+Return

Option	Key shortcut	Description
<b>Change channel</b>	<b>E</b>	Replace the selected channel
<b>Create new graph</b>	<b>C</b>	Add a channel on a new graph
<b>Insert channels</b>	<b>Insert</b>	Add a channel on the currently active graph
<b>Remove graph</b>	<b>Shift+Delete</b>	Delete a graph
<b>Remove channel</b>	<b>Delete</b>	Remove a selected channel from the graph
<b>Move up</b>	<b>Alt + PageUp</b>	Move a graph up
<b>Move down</b>	<b>Alt + PageDown</b>	Move a graph down
<b>Set log frequency</b>	<b>Alt + 1..8, Alt + `</b>	Change the logging frequency
<b>Toggle autoscale</b>	<b>A</b>	Enable/disable auto-scaling of the selected axis
<b>Channel properties</b>	<b>Return</b>	Display the properties window for the channel
<b>Axis properties</b>	<b>Shift + Return</b>	Display the axis properties window

### Channel properties

Option	Description
<b>Log channel</b>	Name of the edited channel
<b>Graph color</b>	Select the display color of the channel
<b>Filter samples [0=off]</b>	Filter of the waveform, i.e. how many samples the value at a given point is to be determined from. A value of 0 means no filtering.
<b>Enable alarm</b>	Checking the box will activate the alarm (displayed on the application toolbar) if the condition defined in the <b>Condition</b> and <b>Alarm value</b> fields is met at the cursor position
<b>Condition</b>	Condition specifying alarm activation for values: <b>Greater</b> - greater than <b>Alarm value</b> <b>Lower</b> - smaller than <b>Alarm value</b>
<b>Alarm value</b>	Alarm value

The axis settings are available by selecting the following option from the menu **Axis properties**.

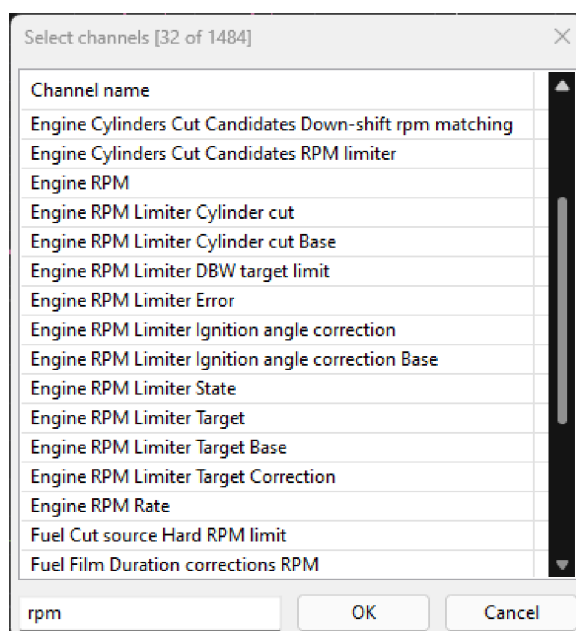
Option	Description
<b>Unit</b>	Displays information in which unit the axis is expressed
<b>Range mode</b>	<b>Autoscale</b> – This option causes the range of values to be calculated automatically based on the logged data <b>Manual</b> – the range of values is fixed
<b>Min value</b>	Minimum value of the axis (in manual mode)
<b>Max value</b>	Maximum value of the axis (in manual mode)

Additional operations on the *Graph Log* panel are possible using the following keyboard shortcuts:

Option	Key shortcut	Description
Cursor movement	←/→	Moves the cursor forward/backward by one unit
Move the cursor by a bigger distance	<b>Ctrl</b> + ←/→	Moves the cursor forward/backward by ten units
Screen offset	<b>Shift</b> + ←/→	Moves the screen without changing the cursor position

Option	Key shortcut	Description
Marking the area	<b>Ctrl + Shift + ←/→</b>	Marks the area between the start and end positions of the cursor
Zoom in/out	<b>↑/↓</b>	Zoom in/out view
Positioning the cursor at the beginning	<b>Home</b>	Moves to the start of the log/ lap in lap comparison mode
Positioning the cursor at the end	<b>End</b>	Moves to the end of the log/ lap in lap comparison mode
Changing the active channel	<b>PageUp</b> <b>/ PageDown</b>	Changes the active channel to the channel above/below
Add bookmark	<b>Ctrl+T</b>	Adding a new bookmark
Toggle line style	<b>Shift + S</b>	Changing the display mode: line / dots / connected dots

If you change or add a new channel to the chart, the channel selection window appears. For easier searching, the channel name can be entered in the lower field of the window, which will filter the available channels. For example, if you enter the word **rpm**, only channels containing the word **rpm** will be displayed. Using the Shift or Ctrl keys, it is possible to select multiple channels to be added to one chart.



## 4.4. Scope

The **Scope** panel allows measurement of signals present at primary trigger, secondary trigger and all cam inputs. Calculated TDC (top dead center) point, injection time, ignition dwell time and knock window for each cylinder are presented in visual form.

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 inputs assignment is required. Pattern setting can be left unset.



The panel toolbar allows to:



- **Open scope** – opening a previously saved chart Scope
- **Save scope** – saving the chart Scope
- **More commands** → **Configure VVT angles** – automatically fills in Position/Initial teeth angles table for all used camshafts for position based on the downloaded scope.
- **Zoom In / Out** – zooming the chart in/ out
- **Zoom extents** – zooming in on the selected area of the chart
- **Get scope data** – sampling the signal from sensors (samples), recording the signal (rising and falling edges) from crankshaft and shaft position sensors.

- **Draw vertical lines** – displaying a bar graph where the height of the bar is the time between the occurrence of the successive *Primary Trigger* teeth
- **Show factors** – a factor determining the distance between the current and the previous edges relative to the distance between the two preceding edges (used for a *Longer than factor* toothed wheel)
- **Lock to engine cycle** – locks displayed cycle on following downloaded scopes data on the previously set cycle.
- **Show ignition output timing** – when enabled, the scope shows the actual timing of the ignition output activation. When disabled, it shows the theoretical spark timing (including latency). The latency value is saved in the scope file and requires regenerating the scope to update.

To start downloading the data click *Get scope data*, turn on the starter and turn it off after the graph appears.

**PRIMARY TRIGGER** graph (green) is a record of the crankshaft signal.

**SECONDARY TRIGGER** graph - from the camshaft (used as the *Secondary Trigger*).

**INTAKE# CAMSHAFT** and **EXHAUST# CAMSHAFT** shown the signal from individual camshafts (intake and exhaust).

Once all settings have been properly corrected and a new signal recording has been downloaded, a visualization of the following events in relation to time will appear on the graph under **EVENTS**:

**tdc#** - upper dead center position of individual pistons

**inj#** - injection time for individual cylinders

**ign#** - ignition coil charging time (*Dwell time*) and ignition time for individual cylinders

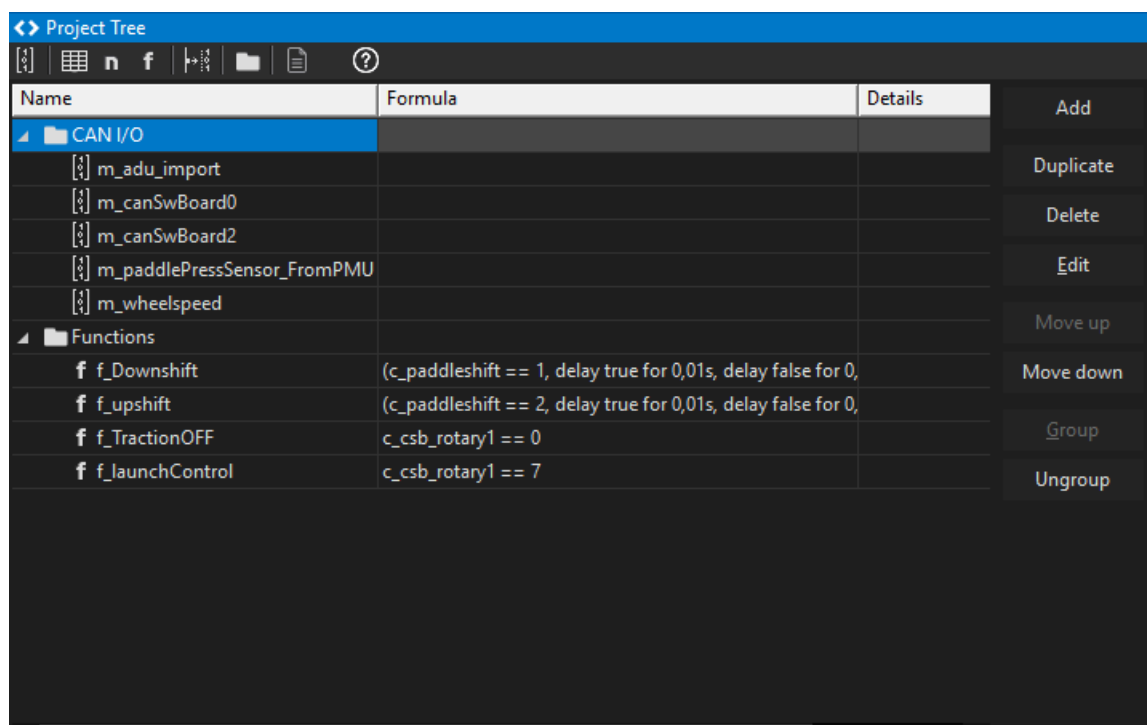
**knk#** - knocking monitoring window for individual cylinders for *the Knock* strategy (knock window)

**pump#** - indicates the activation of the pump output for the high-pressure fuel pump. A thick line shows the time when the pump valve is fully engaged. The pump TDC is marked with a short vertical red line. A thin diagonal line represents the *Dead time*.

Additionally, for *Delivery when unpowered*, the *Margin angle* is shown as a thin horizontal line, and the *Delay time* at the end as a thin diagonal line. For more details on Direct Injection, see: [Appendix I - How-to Tune the GDI Engine \(on page 135\)](#).

## 4.5. Project Tree

The **Project Tree** panel is used to define all user custom elements in the project.



To add a new element, select the icon from the toolbar or click the **Add** button on the right side of the panel. The following selection options will appear:

- **CANbus Receive Frame (rx)** – a CAN message frame, where an incoming CAN frame can be defined. Within each frame, data channels are defined.
- **CANbus Keyboard** – an element defining the keyboard
- **Table** – an element defining the table that can be used to transform data (e.g. transform an analog input voltage into temperature)
- **Number** – an element defining complex mathematical operations combining other channels values
- **Logical Function** – an element for creating complex logical functions combining other channels values
- **CANbus Transmit Frame (tx)** – an element for sending CAN frames with chosen channel values or constant values.
- **Group** – a function for grouping elements; it allows a hierarchy to be introduced into a project in an easy way.
- **Import .CANX/ .DBC** file – this function is intended for downloading predefined CAN streams for different devices (e.g. CAN Switchboard, PMU-16, etc.)

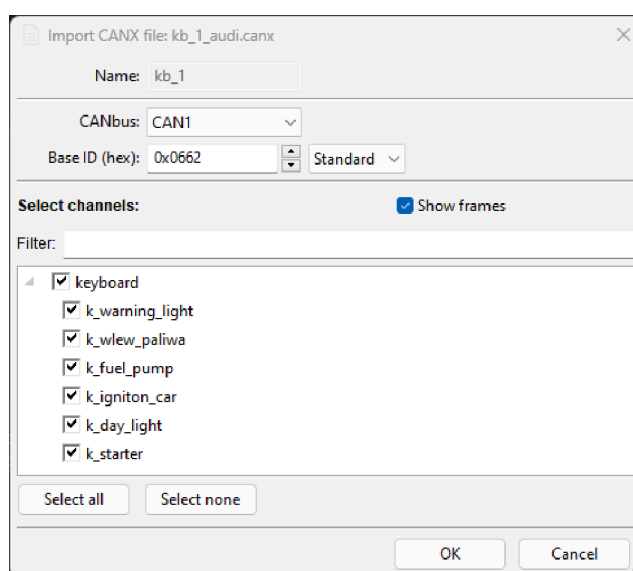


When adding different elements to the project, it is recommended to use the **Group** element, which allows elements to be grouped into logical sets. You should also make sure to assign correct names to elements and variables. This will facilitate project management in the future.

You can also duplicate project elements using the **Duplicate** button.

#### 4.5.1. Using predefined streams from .CANX and .DBC files

The simplest way to work with the CAN bus is to use predefined streams from **.CANX** and **.DBC** files. Having selected an icon from the taskbar or choosing the **Project tree > Add > Import .CANX / .DBC file** option and pointing to the **.CANX** or **.DBC** file, a window with the import settings will open.



First, choose the CAN bus from which data will be received. The EMU PRO device has two CAN buses: CAN1 and CAN2. Next, select the channels to be imported. You can use the filter to select individual channels or select all using the '**Select all**' button.

The following warnings may appear when importing a **.DBC** file:

- about units not defined in the EMU PRO;
- about channels already existing under a particular name.

After confirming with the OK button, the selected channels will be added to the **Project Tree**. In addition, one or more **CANbus Receive Frame** responsible for receiving frame groups will be created.

## 4.5.2. CANbus Receive Frame (rx)

**Edit CANbus Receive Frame (rx)**

Name:

CANbus:

Frame ID (hex):

Type:

Timeout [s]:

Channels:

Name	Type	Endian	Bytes (bits)	Start bit	Bit count	Format	Factor	Offset	Unit
T1	unsigned	BIG	0	56	8	X8	1,000000	0,000000	°C
T2	unsigned	BIG	1	48	8	X8	1,000000	0,000000	°C
T3	unsigned	BIG	2	40	8	X8	1,000000	0,000000	°C
T4	unsigned	BIG	3	32	8	X8	1,000000	0,000000	°C
T5	unsigned	BIG	4	24	8	X8	1,000000	0,000000	°C
T6	unsigned	BIG	5	16	8	X8	1,000000	0,000000	°C
T7	unsigned	BIG	6	8	8	X8	1,000000	0,000000	°C
T8	unsigned	BIG	7	0	8	X8	1,000000	0,000000	°C

Test data:

Length: Data: (hex)

☒ Live Capture  Freq. [Hz]:

OK Cancel

In the EMU PRO device, you can create your own CAN streams. The configuration begins with the creation of a **CANbus Receive Frame (rx)** element in the **Project tree**. After choosing a CAN bus you should select a **Frame ID** and the **Type** (*Normal* or *Compound*) of received frames. If the device is connected, a preview of the stream in real-time (**Live Capture**) will be displayed. It facilitates diagnostics and speeds up work.



### Important:

For **Live Capture** preview to work properly, active logging is required - logging cannot remain in pause mode!



### Important:

Frame CAN IDs in the EMU PRO Client are always presented in hexadecimal notation (they usually begin with the 0x prefix, which is a symbol of the hexadecimal notation).

In the next step, you can start adding and defining channels.

To create a new channel, choose a unique name (1) so that it can be identified.

The next step is setting the **Byte offset** parameter (5). It marks the location of the values in the CAN frame (0– 7).

You should select:

the **Type** of the number (2):

- **Signed** – a number with a sign (it can receive positive and negative values, as well as zero).  
An example of such a value is the value from the coolant temperature sensor.
- **Unsigned** – positive numbers or zero. For example engine speed (RPM).
- **Float** – a number using IEE 754 notation (32-bit floating point number)

the **Data format** (3):

- **8 bit / 16 bit / 32 bits**– number width in bits; 1 byte, 2 bytes, or 4 bytes, respectively
  - signed 8 bit – range of numbers -128–127
  - unsigned 8 bit- – range of numbers 0–255
  - signed 16 bit – range of numbers -32768–32767
  - unsigned 16 bit – range of numbers 0– 65535
  - signed 32 bit - range of numbers  $(-2^{31}) - (2^{31}-1)$
  - unsigned 32 bit - range of numbers  $0 - (2^{32}-1)$

- The **Custom** data format allows the exact width and position (expressed in bits count) of the information stored in the CAN frame to be determined. The information can occupy a maximum of 32 bits, but these can be taken from up to 5 bytes. The bit numbering is compatible with Kvaser Database Editor 2.

the **Endian** (4):

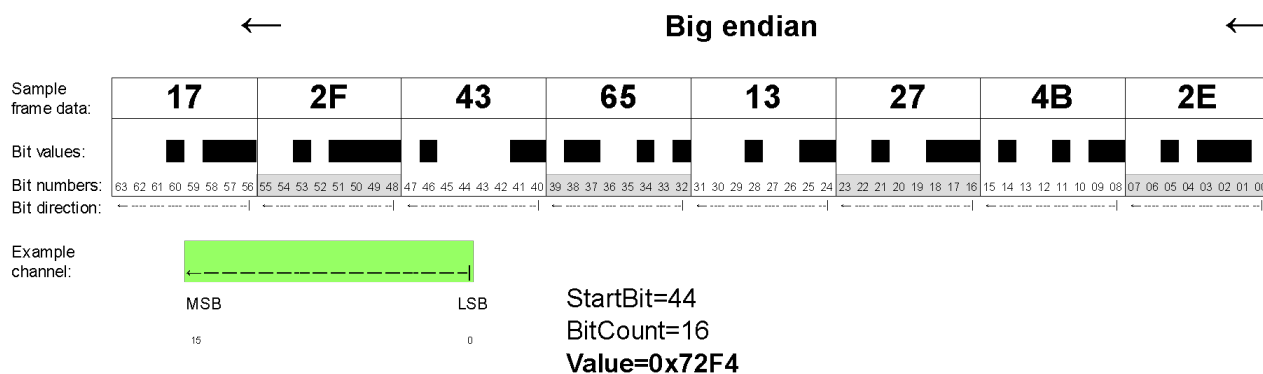
- **BIG / little** – the “sequence” of bytes for 16bit, 32bit, and custom “Data format”. It shows how a number stored in consecutive bytes shall be interpreted. E.g. numbers 0x12, 0x34 can be interpreted as 0x1234 for the **big endian** or 0x3412 for the **little endian**.

You can also define “**Extract bitfield**” (6) (for Data format 8bit, 16bit, and 32bit) to take only a part of an 8- or 16- or 32-bit number.

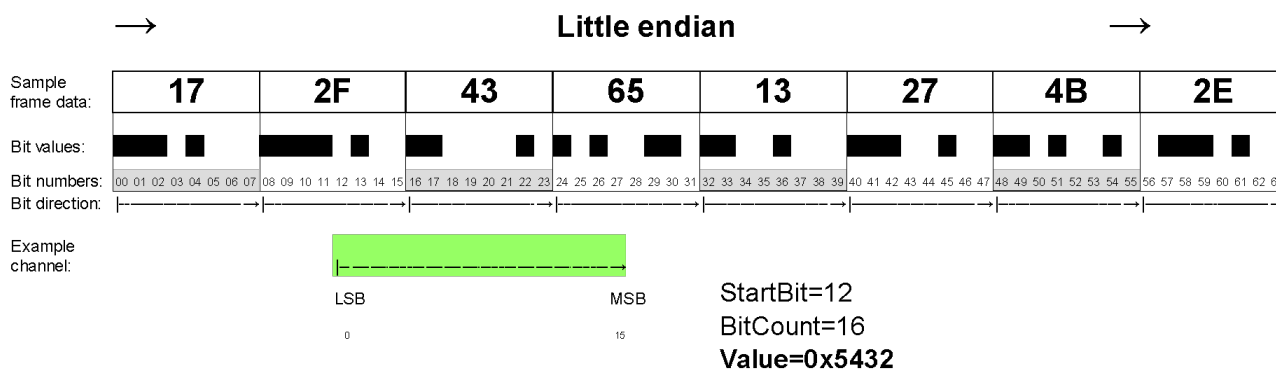
The **Bit count** parameter determines how many consecutive bits (1-32 bits) of information are present.

The **Start bit** parameter specifies the bit number at which the information in the CAN frame starts. For example, to check the setting of a bit of a 0x80 mask the following settings should be used:  
Bit count: 1, Bit position: 7.

Example for Endian **BIG**, for Data format *custom*:



Example for Endian **little**, for Data format *custom*:



The next step is to scale / offset the raw value to the physical value (7).

The “raw” value interpreted using the Format (3) fields can be scaled.

For example, Lambda in the Lambda To CAN stream is saved as the 16-bit value in range 0..65535, where:

- raw value 0 means Lambda = 0.0,
- raw value 1000 means Lambda = 1.0,
- raw value 2000 means Lambda = 2.0,

This value should be scaled. The following settings can be used: **Factor**=0,001, **Offset**=0. This way, you will add the end value of 0.850 for the raw value of 850.

Selection of a physical value and the unit (8). Typical SI units as well as units commonly used in the automotive industry are available. If a requested unit is not on the list, you can also use the **User** unit.

Once a unit has been selected, set the selection to the default value (9).

A default value is used from starting the device until receiving the first frame containing the channel. The default value is expressed as a physical (no raw) value.

Defining the behaviour in case of a loss of CAN bus frames is done in the **If message time out** (10) field. If a particular frame cannot be received for longer than the timeout defined in the **CANbus Receive Frame** configuration (**Timeout** parameter in seconds), there are two options available:

- (a) the last value (possibly the default value if a frame was never received) may remain (**Use previous value**);
- (b) a specific value can be set (**Set value**).

The last element of the **Add channel** defining window is the **Test data** field. They are used only during editing. You can observe a received frame in real time (**Live capture** on) (11) or enter test data (**Live capture** off). In both cases, the calculated final value is displayed, which accelerates configuration.

### 4.5.3. CANbus Transmit Frame (tx)

Access to the CAN bus in the EMU PRO device is open, which allows sending any available channel of the device. Frames with any CAN ID can be transmitted on one of two CAN buses.

The **CANbus Transmit Frame** configuration window consists of the following sections:

#### CAN bus selection (1)

Select on which CAN bus the frame should be transmitted (CAN1 or CAN2)

#### Selecting the CAN frame ID (2)

When selecting the CAN ID frame identifier, it is important to ensure that it does not come into conflict with other communications on the network. Recommended range of identifiers for the user: 0x500–0x50F, and 0x520–57F. In this respect, ECUMASTER devices will never have their default CAN ID in the future.



#### Important:

In a CAN network, it is not permitted for two devices to transmit frames with the same CAN ID.

#### Determination of frame length *DLC* (3)

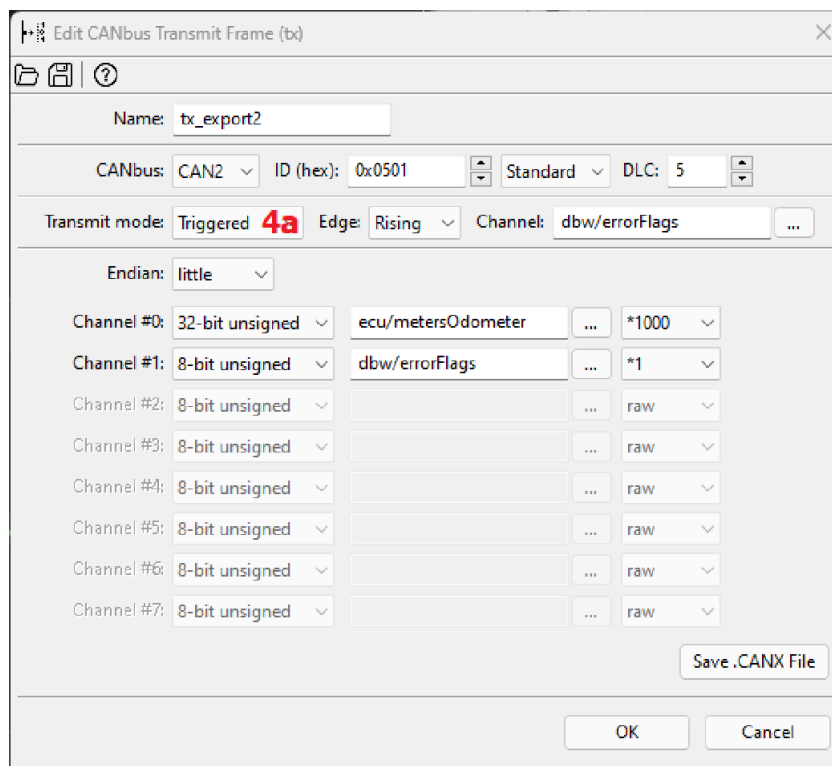
The *DLC* determines the length of a frame: from 0 to 8 bytes.

## Selecting transmission type

### Continuous transmission **Cycle (4)**

For continuous transmission, select a sending frequency (**Frequency**) in the range from 1 to 100 Hz (from 1 to 100 frames sent per second).

The constraint for the whole system limits the maximum of 500 frames per second possible to be sent on the CAN1 bus and 500 frames per second on the CAN2 bus.



### Triggered transmission **Triggered (4a)**

With **Triggered** transmission, a frame is sent when the appropriate **Edge** appears on the selected **Channel**: (**Rising** or **Falling**).

### Endian selection (5)

**Big / little** – the “sequence” of bytes for 16– or 32– bit or custom numbers. It shows how a number stored in consecutive bytes shall be interpreted. E.g. numbers 0x12, 0x34 can be interpreted as 0x234 for the **big endian** or 0x3412 for the **little endian**.

### Selection of the type of data sent (6)

There are 7 options available:

- **8bit unsigned** – the value of the channel is limited to the range of 0..255 and sent as a single byte in a frame.
- **8bit signed** – the value of the channel is limited to the range of -128..127 and sent as a single byte in a frame.

- **16bit unsigned** – the value of the channel is limited to the range of  $0..(2^{16}-1)$  and sent as two bytes in a frame with endianness set in Endian(5) field.
- **16bit signed** – the value of the channel is limited to the range of  $(-2^{15})..(2^{15}-1)$  and sent as two bytes in a frame with endianness set in Endian(5) field.
- **32bit big endian** - the value of the channel is limited to the range of  $0..(2^{32}-1)$  and sent as four bytes in a frame with endianness set in Endian(5) field.
- **32bit little endian** - the value of the channel is limited to the range of  $(-2^{31})..(2^{31}-1)$  and sent as four bytes in a frame with endianness set in Endian(5) field.
- **Custom** – the value of the channel is limited to the range defined by bits number and signness. Signness and bit count (from 1 to 32) is defined by the user.

4-byte values (**32bit**) are used, for example, to transmit the *ECU/Meters/Odometer* channel value. In order to maintain adequate accuracy of the transmitted data, the **raw** value may be used, which, for this example is expressed in 0.001 km (km multiplied by  $10^{-3}$ ).

For signals being transmitted on part of the byte or spread for 2 or more bytes

- LSB bits are occupied first (in the order that channels appear) for *little* Endian selection
- MSB bits are occupied first (in the order that channels appear) for BIG Endian selection

### Selected channels or constants (7)

You should select a channel from the list or enter a constant. In addition to the decimal notation, a constant can also be saved in a hexadecimal notation - 0x prefix must be used (e.g. 0xE3 or 0xE3).

### Selection of a multiplier or a raw value (8)

It is possible to multiply the actual value by a constant in the 1-1000 range (the fractional part is discarded) or alternatively to send the **raw** value.

#### Example:

From the drawing of the window tx\_ export1:

- **Channel #0** – voltage value at input *Analog 2* will be sent as a number from the range: 0, 1, 2, 3, 4, 5 (in volts, but without the fractional part).
- **Channel #1** – voltage value at input *Analog 2* will be sent as a number from the range 0 – 5000 (in millivolts).
- **Channel #2** – voltage value at input *Analog 2* will be sent as a raw value from the ADC converter as a number from the range – 4095.
- **Channel #3** – voltage value at input *Analog 2* will be sent as a number from the range 0 – 255.
- **Channel #4** – a constant value will be sent– 15 in the decimal system.



Below is a frame preview as seen in the ECUMASTER Light Client. At the input *Analog 2*, the voltage is exactly 5 V. Accordingly, the channels **Channel #0** - **Channel #5** present themselves as in the example below:

ID	DLC	Bytes	Freq	Count
501h	8	00 05 13 88 0F FF FF 0F	10,0 Hz	1181
		#0 #1 #2 #3 #4		

- **Channel #0** – 0x0005, i.e. 5 [V]
- **Channel #1** – 0x1388, i.e. 5000 [mV]
- **Channel #2** – 0x0FFF, i.e. 4095 [adc]
- **Channel #3** – value 0xFF, i.e. 255
- **Channel #4** – value 0x0F, i.e. 15

### Saving to a .CANX file (9)

A configured **Transmit Frame** can be saved into a .CANX file using a toolbar button.

### 4.5.4. Reserved CAN IDs

ID range	Default CAN bus	CAN bus configuration possible	Configurable ID	Description
0x012-0x017	CAN1	No, only CAN1	No, ID is fixed	Communication with EMU PRO Client
0x032-0x035	CAN1	No, only CAN1	No, ID is determined	Communication with Light Client

### 4.5.5. CAN bus keypad support

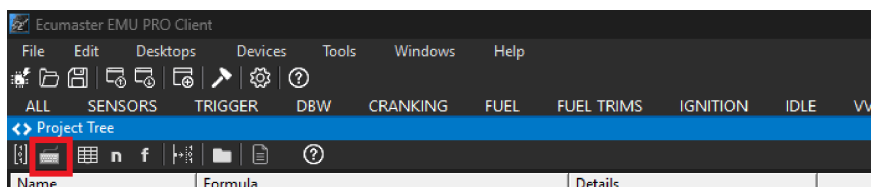


From software version 98.0, the option of connecting and operating a CAN bus keypad is available.

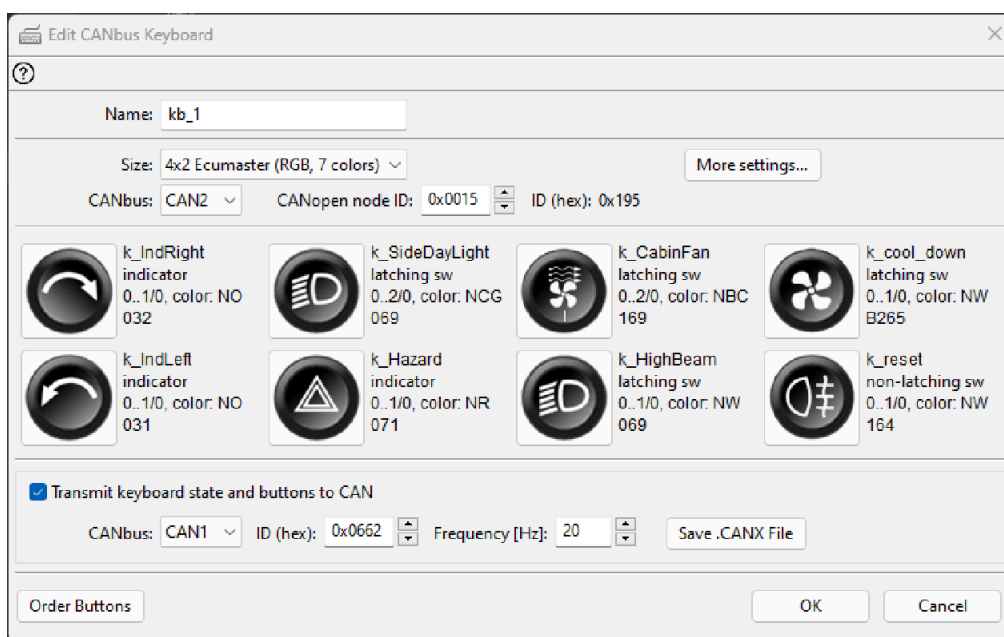
Keyboards from Ecumaster and Grayhill (using CAN open protocol) are supported. EMU PRO also supports a 5x3MT keyboard with two encoders; for more details, see [Appendix H - How To Configure 5x3MT Keyboard \(on page 128\)](#).

Up to two keypads can be connected to the EMU PRO device.

To configure a keyboard, click **Add** in the **Project Tree** and then select **CANbus Keyboard** from the list or click the keyboard icon in the toolbar.

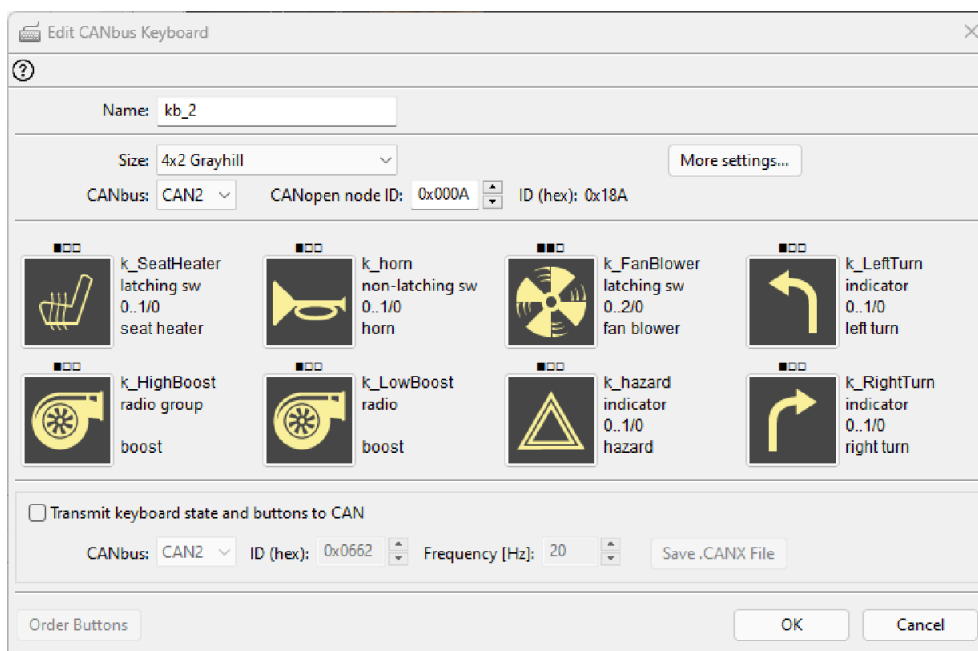


After opening the **CANbus Keyboard** window, individual parameters must be set:



- **Name** - name of the keyboard
- **Size** - size and type of keyboard to be configured.
- **CANbus** - CAN communication bus to which the keypad is connected

The default speed of Ecumaster keyboards is 500 kbps, so it is recommended to select the CAN2 communication bus, which is set to the same speed by default. The CAN1 bus can only be selected for keyboards communicating at 1 Mbps.



• **More settings**

Settings	Description
<b>Show open ceremony</b>	Opening ceremony, i.e. key highlight animation when switching on the device (only for Ecumaster keyboards)
<b>Key LED brightness</b>	Backlighting intensity of the keys (Ecumaster keyboards) or LEDs above the keys (Grayhill keyboards)
<b>Back light brightness</b>	Backlighting intensity of the entire keyboard (night backlighting)
<b>Back light color</b>	Full keyboard backlighting color (only for Ecumaster keyboards)
<b>Alternative brightness channel</b>	Channel defining alternative backlighting
<b>Alternative key LED brightness</b>	Intensity of alternative key backlighting (Ecumaster keyboards) or LED above the keys (Grayhill keyboards)
<b>Alternative back light brightness</b>	Alternative backlighting intensity of the entire keyboard (night backlighting)
<b>Alternative back light color</b>	Alternative backlighting color of the entire keyboard (only for Ecumaster keyboards)

- **CANopen node ID** - the factory setting for Ecumaster keyboards is 0x0015 (this item needs to be changed if there is a **CANopen node ID** conflict with another keyboard connected to the CAN bus).

A detailed description of **CANopen node ID** changes can be found at:

[www.ecumaster.com/files/LightClient/LightClientManual\\_1\\_0.pdf](http://www.ecumaster.com/files/LightClient/LightClientManual_1_0.pdf) in section 11.3.

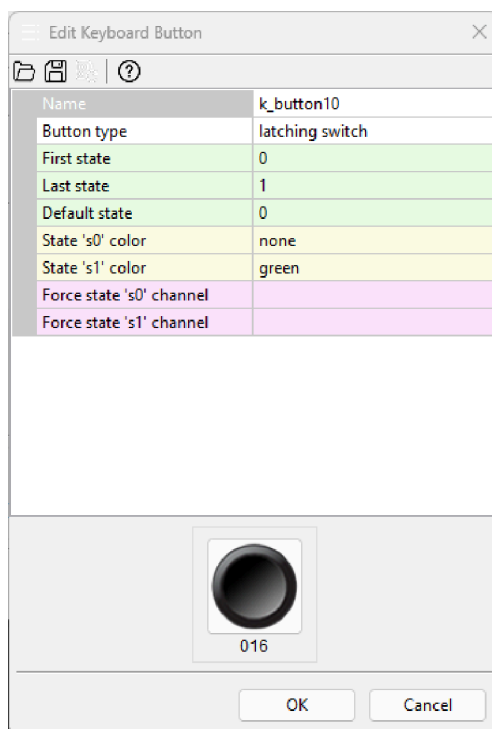
- **Export keyboard state and buttons to CAN** - allows the export of keyboard status from the keyboard to the same or another CAN bus without the need to create and configure the **CANbus export**. With this feature, the keyboard configured in the **EMU PRO** will also work on other devices, e.g. **ADU** or **PMU** modules.

For the **EMU PRO**, simply save the keyboard configuration settings to a **.CANX** file and then load the saved file (Import **.CANX / .DBC** file), which automatically configures the **CANbus Receive Frames** in the software.

- **Edit Keyboard Button** - edit individual keys:

Parameter	Description
<b>Name</b>	Button name
<b>Button type:</b>	Button mode of operation: <ul style="list-style-type: none"> <li>◦ <b>non-latching switch</b> - a non-latching button in which the user-defined backlight color of the button depends on one of the two possible states of the button.</li> <li>◦ <b>latching switch</b> - a latching button in which two to four stable states can be defined. The color of the key's backlighting depends on the status of the button.</li> <li>◦ <b>radiobutton group</b> - button to open a group of radio buttons</li> <li>◦ <b>radiobutton</b> - further buttons in the radio button group</li> <li>◦ <b>indicator</b> - a momentary pushbutton, with illumination to the specified color done by channel-assigned conditions (as opposed to a non-latching switch). Up to three different conditions can be set to change the state of illumination.</li> <li>◦ <b>indicator 3</b> - in Grayhill keyboards, indicator mode 3 is available in addition to indicator mode. The difference between the two is that in indicator 3 mode, the independent illumination of each diode (in each possible configuration) is triggered by the fulfilment of three individual conditions</li> </ul>

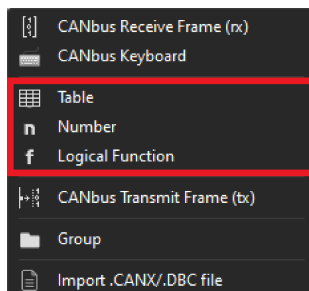
Parameter	Description
	assigned by separate channels. For the <b>indicator</b> mode on <b>Grayhill</b> keyboards however, there is only one channel to assign conditions, the fulfilment of which allows the LEDs to be illuminated in up to three different states - one, two or three LEDs lit.
<b>Default state</b>	Default setting for the status of the button when the keyboard is activated
<b>State 's#' color</b>	Setting the color for a button state (only for Ecumaster keyboards)
<b>Force state 's#' channel</b>	Option available in <b>latching switch</b> mode. A channel for assigning a condition the fulfilment of which forces a change in the state of the button.
<b>Source channel</b>	Option available for <b>indicator</b> mode. Source channel for assigning a condition, the fulfilment of which triggers the illumination assigned to the button state.
<b>Choose Button Image</b>	Choice of button icons



- **Order buttons** - prepares copy-ready information on the numbers of plastic key inserts, with selected laser-engraved icons, for order preparation.

### 4.5.6. Processing information in the project tree in the EMU PRO

The EMU PRO has 3 information processing elements:



1. **Tables** – lookup tables
2. **Numbers**– complex mathematical operations with result channel
3. **Functions** – complex logical operations with result channel

The above elements are processed at 500 Hz (every 2 ms).

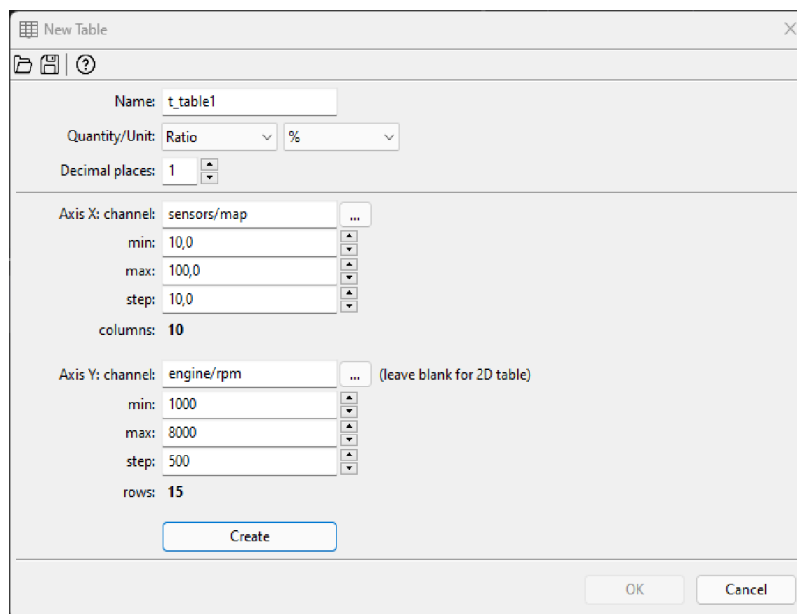
Processing elements can be put in arbitrary order. The order in which the elements are listed in the project tree is in the order in which they are processed. The type of the element does not affect the order of evaluation.

### 4.5.7. Tables

Configuration of a table starts with defining channels representing axe or axes. If a table is to be two-dimensional, leave the **Axis Y: channel** field empty.

You should also define the axis bins scope: **min** and **max**. To change the number of elements in a table, change the **step** parameter which defines a step between bins on each axis.

Table size can range from 2x1 to 32x1 for 2D, or 2x2 to 32x32 for 3D.



Next, fill the cells and axes with values. The bins values defined on axes are independent for each table.

Table Name: t\_table1  
Quantity/Unit: Ratio %  
Decimal places: 1

8000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
7500	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
7000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
6500	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
6000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
5500	89,4	89,9	90,3	93,0	96,2	99,2	99,9	100,0	100,0	100,0	100,0
5000	65,4	65,5	66,3	71,9	87,0	95,4	99,2	99,9	100,0	100,0	100,0
4500	34,6	34,5	35,4	43,5	63,7	86,1	95,4	99,2	99,9	100,0	100,0
4000	10,6	10,1	10,9	17,0	37,5	62,9	86,1	95,4	99,2	99,8	100,0
3500	1,3	1,2	1,6	4,9	14,0	37,1	62,9	86,0	95,0	98,1	100,0
3000	0,0	0,0	0,1	0,8	4,6	13,9	37,1	62,5	82,9	88,1	100,0
2500	0,0	0,0	0,0	0,1	0,8	4,6	13,9	36,3	56,5	63,9	100,0
2000	0,0	0,0	0,0	0,0	0,1	0,8	4,6	13,0	28,1	33,4	100,0
1500	0,0	0,0	0,0	0,0	0,0	0,1	0,8	3,8	7,1	10,0	100,0
1000	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0
	10,0	20,0	30,0	40,0	50,0	60,0	70,0	80,0	90,0	100,0	

Manifold pressure [kPa]

You can select several cells using the Shift key. The Ctrl + arrow key copies to adjacent cells. You can also find the horizontal (Ctrl+H), vertical (Ctrl+L), and diagonal (Ctrl+D) interpolation commands helpful.

Table Name: t\_table1  
Quantity/Unit: Ratio %  
Decimal places: 1

8000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
7500	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
7000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
6500	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
6000	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
5500	89,4	89,9	90,3	93,0	96,2	99,2	99,9	100,0	100,0	100,0	100,0
5000	65,4	65,5	66,3	71,9	87,0	95,4	99,2	99,9	100,0	100,0	100,0
4500	34,6	34,5	35,4	43,5	63,7	86,1	95,4	99,2	99,9	100,0	100,0
4000	10,6	10,1	10,9	17,0	37,5	62,9	86,1	95,4	99,2	99,8	100,0
3500	1,3	1,2	1,6	4,9	14,0	37,1	62,9	86,0	95,0	98,1	100,0
3000	0,0	0,0	0,1	0,8	4,6	13,9	37,1	62,5	82,9	88,1	100,0
2500	0,0	0,0	0,0	0,1	0,8	4,6	13,9	36,3	56,5	63,9	100,0
2000	0,0	0,0	0,0	0,0	0,1	0,8	4,6	13,0	28,1	33,4	100,0
1500	0,0	0,0	0,0	0,0	0,0	0,1	0,8	3,8	7,1	10,0	100,0
1000	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	100,0
	10,0	20,0	30,0	40,0	50,0	60,0	70,0	80,0	90,0	100,0	

Manifold pressure [kPa]

The size of the table (number of columns or rows) can be changed at any time using the context menu available under the right mouse button.

Description of the commands in the context menu:

Command	Key shortcut	Description
<b><i>Interpolate horizontally</i></b>	Ctrl+H	Horizontal interpolation: the cell values in the selection area are calculated as a linear interpolation of the cells from the left and right edges of the selection.
<b><i>Interpolate vertically</i></b>	Ctrl+L	Vertical interpolation: the cell values in the selection area are calculated as a linear interpolation of the cells from the top and bottom edges of the selection.
<b><i>Interpolate diagonally</i></b>	Ctrl+D	Interpolation between apexes. Define the 4 corner points of the selection and the rest of the cells will be counted as bilinear interpolation. The command combines two commands: first the horizontal and then vertical interpolation.
<b><i>Equalize selection</i></b>	E	Smooths out selected cells values
<b><i>Swap axes</i></b>		Swaps channels on axis x and axis y and makes transpose of the table values.
<b><i>Insert row above</i></b>		Inserts a row above the selected cell
<b><i>Insert row below</i></b>		Inserts a row below the selected cell
<b><i>Insert column before</i></b>		Inserting a column to the left of the selected cell
<b><i>Insert column after</i></b>		Inserts a column to the right of the selected cell
<b><i>Delete row</i></b>	Alt+Shift +Backspace	Deletes a row containing the selected cell
<b><i>Delete column</i></b>	Alt+Backspace	Deletes a column containing the selected cell
<b><i>X Axis bins wizard</i></b>		Starts the creator for the X axis bins values allowing to define of a new number of columns and generating the X axis bins according to the selected creation type
<b><i>Y Axis bins wizard</i></b>		Starts the creator for the Y axis bins values allowing to define of a new number of rows and generating the Y axis bins according to the selected creation type



### 4.5.8. Numbers

The *Number* allows you to create complex mathematical operations on selected values or channels with a new channel resulting from these operations. When you create a new channel, give it a relevant name (*Name*) and define the physical quantity and unit (*Quantity/Unit*) defining the created channel.

In the simplest form, the *Number* calculates the sum of the products of the selected values or channels.

**value =**

```

    C1
    * C2
    * C3
    * ...
+
    C4
    * C5
    * ...
+
    ...

```

**where C1, C2, C3... - is the selected channel or constant value (*Channel or Constant*)**

To use the selected channel or constant value for calculations, click on the formula editor and select the field with the ellipsis '...'. Then click the **Add** button (located on the right).

The Add operation window will appear, in which you select the relevant operation. When selecting the operation (**Operation:**) *Channel or constant*, enter a constant value in the **Result:** field or by clicking the button marked '...' select the relevant channel from the list.

For a faster search, you can enter the name of the channel you are looking for in the filtering field at the bottom of the **Select Channel** window.

After confirming with the **OK** button, the selected value or channel will appear in the formula field. Remember to select the relevant field (...) when assigning another channel, depending on whether it is multiplied (\* ...) or added to the previously selected channel.

After marking channels in the formula editor, you can delete (*Delete*), edit (*Edit*), or move one place up (*Move up*) or down (*Move down*) in the formula.

You can also use other mathematical operations, including integer division - the *Divide* operation ("*/*") or the remainder of the division - *Modulo* operation (***mod***).

e.g. value =

C1  
\* C2  
/ C3

or value =

C1  
mod C2  
+  
C3  
\* C4  
\* C5

#### List of operations available for mathematical channels.

**FACTOR** is a single multiplier (a constant or a channel) in the C1\*C2\*C3 notation.

**RESULT** is the calculated result of previous multiplications or divisions / residues.

Operation	Parameter	Pseudocode
<b>Int constant</b>	Result <sup>1</sup>	<i>FACTOR = Result</i>
<b>Float constant</b>	Result <sup>2</sup>	<i>FACTOR = Result</i>
<b>Channel constant</b> or	Result <sup>3</sup>	<i>FACTOR = Result</i>
<b>Choose</b>	Condition channel Result if true Result if false	if <i>Condition_channel</i> ≠ 0 then <i>FACTOR = Result_if_true</i> else <i>FACTOR = Result_if_false</i>
<b>Divide</b>	Value	<i>RESULT := RESULT DIV Value</i> (DIV - integer division; eg.: 9 DIV 2 = 4)
<b>Modulo</b>	Value	<i>RESULT := RESULT MOD Value</i> (MOD - division reminder; eg.: 9 MOD 5 = 4)
<b>Addition</b>	Value 1 Value 2	<i>FACTOR = Value_1 + Value_2</i>
<b>Subtraction</b>	Value 1	<i>FACTOR = Value_1 - Value_2</i>

Operation	Parameter	Pseudocode
	Value 2	
<b>Min</b>	Value 1 Value 2	if $Value\_1 < Value\_2$ then FACTOR = $Value\_1$ else FACTOR = $Value\_2$
<b>Max</b>	Value 1 Value 2	if $Value\_1 > Value\_2$ then FACTOR = $Value\_1$ else FACTOR = $Value\_2$
<b>Clamp</b>	Input Min Max	if $Input < Min$ then FACTOR = $Min$ else if $Input > Max$ then FACTOR = $Max$ else FACTOR = $Input$

- <sup>1</sup> – The constant value may be in the range  $[-2^{31}, +2^{31}-1]$  range
- <sup>2</sup> – The constant value may be in the range  $[-2147483.000, +2147483.000]$  range.
- <sup>3</sup> – The constant value for **Chanel or constant** operation may be in the  $[-16383, +16383]$  range

### Channel value modifiers.

The value of each channel available for mathematical operations can be modified. You may multiply by 1, 10, 100 or 1000.

For the *Integer (raw) Calculation method* the fractional part is discarded after multiplication, so for this calculation method, this value modifier is necessary to not lose the fractional part of the channel value.

You may also choose to use the **raw** value with no modification – raw memory representation is used. For example, when it is a voltage value from an ADC converter – the value is in the range of 0-4095.

### Calculation method

The result of each mathematical operation within one number is calculated as a floating point (real number representation) or integer number (decimal places of the operation are ignored).

#### Calculation method: Floating (real)

Calculations are done using real values. Each indirect operation within one number is done using floating point (IEEE 754) but the result is stored as the integer with decimal places (raw value is equal to real value multiplied by  $10^{[Decimal\ places]}$ )

Examples:

- 3.140 with 3 decimal places is stored as 3140
- 3.140 with 2 decimal places is stored as 314

**Calculation method: Integer (raw)**

Calculations are done using integers. The fractional part of each indirect operation is discarded. In order to obtain the needed accuracy of the created Channel Number, each constant value or channel used in mathematical operations of the created channel should be multiplied by the appropriate value modifier (multiplier) and then take into account the decimal places by "moving" the decimal point by the accuracy by which the individual channels / values were multiplied.

**Decimal places**

Each mathematical channel can store raw values within the range defined in.

You can additionally define decimal places. For example, when **Decimal places** are set to 1, a such 16-bit channel can store real values in the [-3276.8; +3276.7] range.

For Calculation method: Floating (real):

Values of each indirect operation are calculated using the real value saved as a floating point (IEEE 754), so after obtaining any channel/previous operation value fractional part is kept.

For Calculation method: Integer (raw):

Values are calculated based on integers and then the point is "moved" by a defined number of decimal places which divides the operation's final result by  $10^{[\text{Decimal places}]}$ .

Indirect calculations are performed using a 32-bit range of numbers (ca.  $\pm 2 \cdot 10^9$ ). For example, calculations can be performed for the following values  $1000 \cdot 1000 / 123$ . In the end, the result is restricted (*clamp*) to the specified format range.

**Example:****Calculating the average speed of left wheels**

Two channels are given: *Sensors / Wheel Speed / Front left* and *Sensors / Wheel Speed/Rear left* with speed in km/h with accuracy 0.01km/h.

Let's assume that we want to obtain a result accuracy of 0.1 km/h.

For Calculation method: Floating (real):

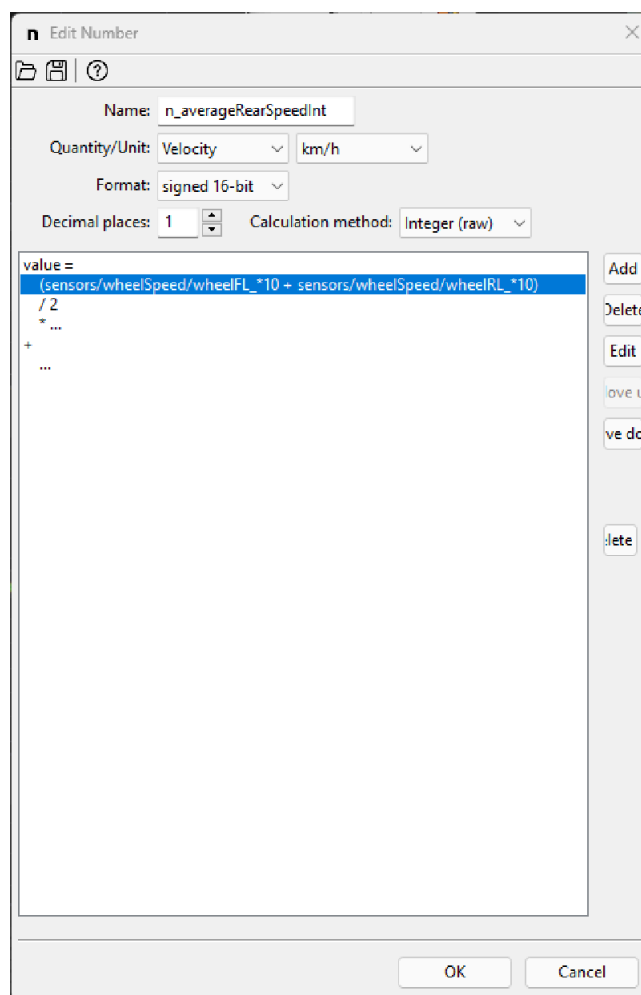
The screenshot shows the 'Edit Number' dialog box. The 'Name' field is 'n\_averageRearSpeedReal'. The 'Quantity/Unit' is 'Velocity' and 'km/h'. The 'Format' is 'signed 16-bit'. The 'Decimal places' is '1'. The 'Calculation method' is 'Floating (real)'. The formula field contains the following text: 'value =', '(sensors/wheelSpeed/wheelFL + sensors/wheelSpeed/wheelRL)', '/ 2', and a '+' sign. The formula is partially entered, with the first part highlighted. The dialog has buttons for 'Add', 'Delete', 'Edit', 'Move up', 'Move down', and 'Delete all' on the right, and 'OK' and 'Cancel' at the bottom.

The following formula should be input:

**n\_averageRearSpeedReal = (sensors/wheelSpeed/wheelFL + c\_sensors/wheelSpeed/wheelRL) / 2**

The Decimal places should be set to 1.

## For Calculation method: Integer (raw)



The following formula should be input:

**n\_averageRearSpeedInt = (c\_sensors/wheelSpeed/wheelFL\*10 + c\_sensors/wheelSpeed/wheelRL\*10) / 2**

The decimal point should be moved by 1 place to the left. The “/” operation means integer division.

If you need to apply more complex mathematical operations (and it is difficult or impossible to keep the order of operations in one *Number* channel), you should break the operation into several stages by using multiple *Number* channels.

e.g. **n\_1 = C1+C2+C3**

**n\_2 = C4+C5+C6**

**n\_3 = n\_1\*n\_2**

If the final result of such operations should have the appropriate accuracy, remember that this accuracy must be taken into account at each stage of the calculation (in each intermediate channel created).

### 4.5.9. Logical Functions

Logical functions are used to create a set of rules and conditions depending on the channel input values. As a result of these operations, a value of 1 - true or 0 - false can be obtained.

#### List of operations available for logical functions.

Operations for logical functions can be divided into two groups: simple and special.

Simple operations are those whose result depends on the input state (alternatively a delay can be used for this result). Simple operations include: testing (*Is False*, *Is True*), ( $=$ ,  $\neq$ ,  $<$ ,  $\leq$ ,  $>$ ,  $\geq$ ) comparisons, and logic operations (*And*, *Or*, *Xor*).

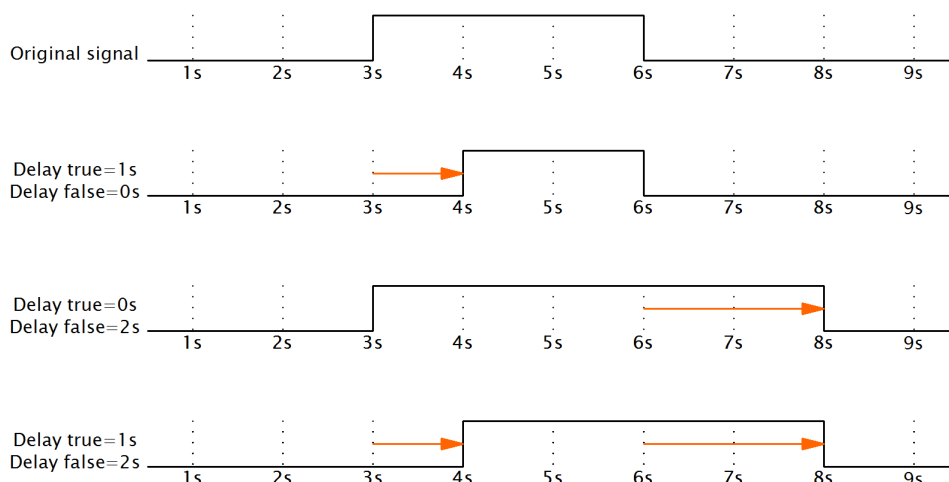


#### Important:

The following description contains **false** and **true** notions. **False** means a value of '0' (zero), and **true** means any value **other** than zero (e.g. '1').

Testing operations	
<b>Is True</b>	Returns <b>1</b> when the Channel value is <b>true</b> (non-zero); <b>0</b> otherwise.
<b>Is False</b>	Returns <b>1</b> when the Channel value is <b>false</b> (zero); <b>0</b> otherwise. (In electronics a NOT gate is analogous to this operation.)
Comparing operations	
<b>Equal</b>	Returns <b>1</b> when the Channel value = Constant; returns <b>0</b> otherwise.
<b>Not Equal</b>	Returns <b>1</b> when the Channel value $\neq$ Constant; returns <b>0</b> otherwise.
<b>Less</b>	Returns <b>1</b> when the Channel value $<$ Constant; returns <b>0</b> otherwise.
<b>Less or Equal</b>	Returns <b>1</b> when the Channel value $\leq$ Constant; returns <b>0</b> otherwise.
<b>Greater</b>	Returns <b>1</b> when the Channel value $>$ Constant; returns <b>0</b> otherwise.
<b>Greater or Equal</b>	Returns <b>1</b> when the Channel value $\geq$ Constant; returns <b>0</b> otherwise.
Logic operations	
<b>And</b>	Returns <b>1</b> when the values of both Channel #1 and Channel #2 are <b>true</b> (non-zero); returns <b>0</b> otherwise.
<b>Or</b>	Returns <b>1</b> when at least one of the channels, i.e. Channel #1 or Channel #2 is <b>true</b> (non-zero), returns <b>0</b> otherwise.
<b>Xor</b>	(Exclusive Or) Returns <b>1</b> only when exactly one of the channels Channel #1 or Channel #2, has a value of <b>true</b> (non-zero), returns <b>0</b> otherwise.

All simple operations allow to delay of the switching on (**Delay true**) and the switching off (**Delay false**). The figure below shows the original signal and the following figures show how the **Delay true** and **Delay false** parameters modify with this signal.



The bulb goes on following pressing the button and remains on for another 120 s after releasing it.

This functionality can be achieved using the *Is True* operation with the parameter Delay false = 120 s.

### Special operations

Signal generating	
<b>Flash</b>	<p>This operation generates impulses so long as the <b>Channel</b> is <b>true</b> (non-zero). When the <b>Channel</b> value assumes <b>false</b> (zero), the operation returns the value <b>0</b>.</p> <p>When a high state appears on the <b>Channel</b> channel (non-zero value), the <b>Flash</b> operation starts cycling between the value of <b>1</b> (duration defined by <b>Time on</b>) and the value <b>0</b> (duration defined by <b>Time off</b>). When the <b>Channel</b> value is <b>false</b> (zero), the operation will immediately start returning <b>0</b>, thus interrupting the cycle.</p>
<b>Pulse</b>	<p>This operation generates N impulses following the appearance of a trigger edge.</p>



When the selected edge appears ( **Rising** or **Falling** ) on the **Channel** impulse generation will start. Each impulse has an active phase (then the operation returns **1**) and a non-active phase (the operation returns **0**).

The number of impulses is determined by the **Count** parameter.

The length of each pulse high state is determined by the **Time on** parameter.

The length of the low state between the following pulses is determined by the **Time off** parameter.

The **Retrigger** parameter determines if the appearance of a trigger edge during impulse generation will cause the process to restart or if it will be ignored.

### State-storing operations

#### Set-Reset Latch

The operation sets a new or returns the previous one according to the settings of the two input channels: **Set Channel** and **Reset Channel**.

<b>Set channel</b> value	<b>Reset channel</b> value	Operation value
true (non-zero)	false (0)	1
false (0)	true (non-zero)	0
true (non-zero)	true (non-zero)	0
false (0)	false (0)	previous value

An analogous operation is performed in the electronic SR latch. SR latch):

[https://en.wikipedia.org/wiki/Flip-flop\\_\(electronics\)](https://en.wikipedia.org/wiki/Flip-flop_(electronics))

The initial value of this operation following starting of the device can be defined using the **Default State** parameter.

#### Toggle

**Toggle** changes the state between **0** and **1** each time the selected **Edge** (**Rising** or **Falling**) appears on the **Channel**.

The **Set channel** allows setting the value to **1**, and **Reset channel** resets the value to **0**. The initial value of this operation following starting of the device can be defined using the **Default State**.

<b>Toggle channel</b>	<b>Set channel</b> value	<b>Reset channel</b> value	Operation value
Rising	false (0)	false (0)	state change
Falling	false (0)	false (0)	previous state

	x	true (non-zero)	false (0)	1
	x	x	true (non-zero)	0
	x - regardless of the condition The table uses the <b>Toggle</b> channel with an <b>Edge: Rising</b> .			
Detecting changes				
Changed	When the value of the <b>Channel</b> changes by a predefined <b>Threshold</b> , the operation will initiate an active state (it will return the value 1) for the number of seconds defined using the parameter <b>Time on</b> . If, during this time, the channel value changes by the set threshold once again, the active state will be extended again by the number of seconds specified by the parameter <b>Time on</b> . After the end of the active state, the operation will begin returning the value 0.			
Hysteresis				
Hysteresis	a) For the <b>Polarity=Above</b> parameter If the value of the <b>Source channel</b> is greater than the predefined <b>Upper value threshold</b> , the value of the operation will be 1. If it is lower than the <b>Lower value threshold</b> , the value of the operation will be 0. If it is within [ <b>Lower value, Upper value</b> ] range, the value of the operation will be the previous value.  b) For the <b>Polarity=Below</b> parameter If the value of the <b>Source</b> channel is lower than the predefined <b>Lower value threshold</b> , the value of the operation will be 1. If it is greater than the <b>Upper value threshold</b> , the value of the operation will be 0. If it is within the [ <b>Lower value, Upper value</b> ] range, the previous value will be the value of the operation.			

**Important:**

For **Pulse**, **Flash**, and **Changed** operations setting the **Time on** parameter to 0 s will result in the generation of a 2 ms impulse.

### 4.5.10. Custom Elements Limitations

The limits are shown at the bottom right of the status bar:

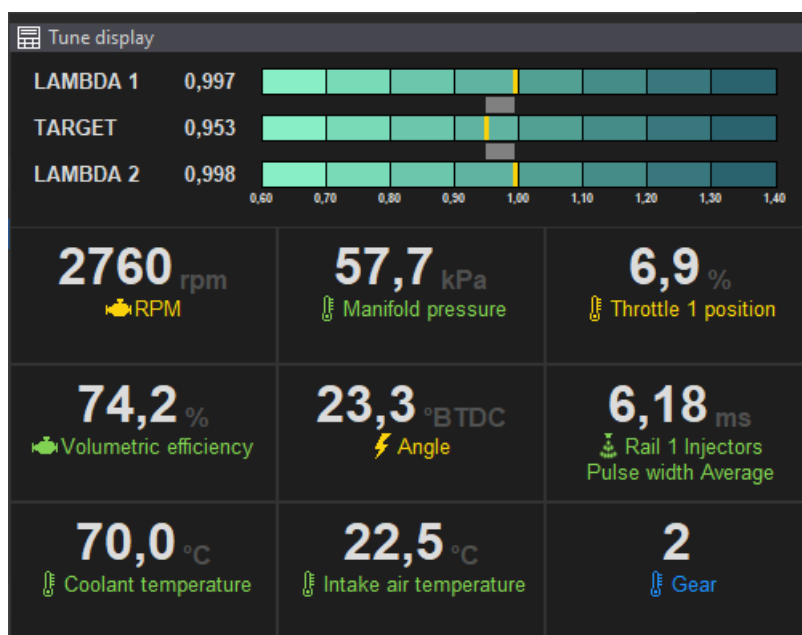
Usage: 47 % (9808/20480 B) x8: 2/100 ch x16: 0/100 ch x32: 1/20 ch

- 100% of memory - memory is shared for: standard tables, user tables, logical functions, Numbers, CAN channels, and names of every custom project element (project tree elements)
- 100 of 8-bit channels
- 100 of 16-bit channels
- 20 of 32-bit channels
- 20 of CAN ID for reception

Logical functions are always 8-bit. The data type for Numbers and CANbus Receive Channels depends on selected settings. For example "Unsigned 12-bit CANbus Receive Channel" will use one 16-bit channel.

## 4.6. Tune Display

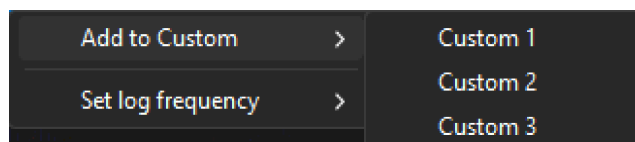
Floating window or docked panel displaying live data values received from the EMU PRO device. Data grid size and displayed channels may be configured by the user. Lambda target with companion of 1- or 2- lambda sensor readouts in graphical form is displayed on the of the window.



## 4.7. Text Log

The Text Log panel presents the values from the channels for a given category in the form of a table for time marked by the cursor on the graph log (when log is paused) or live data if the EMU PRO device is connected. Displays the channel name, value and unit.

Pressing the right mouse button in the panel area displays the context menu:



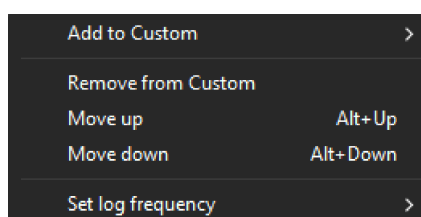
Option	Description
<b>Add to Custom</b>	Adding a channel to <i>Custom</i> panel
<b>Set log frequency</b>	Change the logging frequency

### 4.7.1. Custom Text Log

EMU PRO Client allows the user to create three separate custom logging groups. Any channel can be added to each of them (**Custom 1**, **Custom 2**, **Custom 3**).

To add a selected channel (from any text log panel) to the Custom group, right-click on it, then select **Add to Custom** and select the appropriate group (**Custom 1**, **Custom 2** or **Custom 3**).

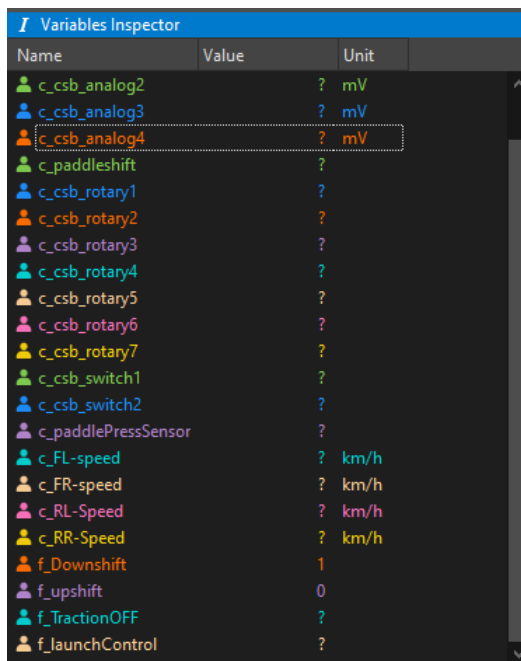
Pressing the right mouse button in the **Custom** panel area displays the context menu:



Option	Key shortcut	Description
<b>Add to Custom</b>		Adding a channel to another <i>Custom</i> panel
<b>Remove from Custom</b>		Removing a channel from the Custom panel
<b>Move up</b>	<b>Alt + Up</b>	Moving the selected row up
<b>Move down</b>	<b>Alt + Down</b>	Moving the selected row down
<b>Set log frequency</b>		Change the logging frequency

## 4.8. Variables Inspector

The **Variable inspector** panel is used to view values of elements channels values defined in the project tree including **CANbus Receive Frame channels** (variables from CAN bus), **Tables** (values from the tables), **Numbers** (mathematical function values) or **Logical Functions** (logical function values).



Name	Value	Unit
c_csb_analog2	?	mV
c_csb_analog3	?	mV
c_csb_analog4	?	mV
c_paddleshift	?	
c_csb_rotary1	?	
c_csb_rotary2	?	
c_csb_rotary3	?	
c_csb_rotary4	?	
c_csb_rotary5	?	
c_csb_rotary6	?	
c_csb_rotary7	?	
c_csb_switch1	?	
c_csb_switch2	?	
c_paddlePressSensor	?	
c_FL-speed	?	km/h
c_FR-speed	?	km/h
c_RL-Speed	?	km/h
c_RR-Speed	?	km/h
f_Downshift	1	
f_upshift	0	
f_TractionOFF	?	
f_launchControl	?	

If a value is not a number but the ? symbol, then the logging function for this channel is deactivated. To activate logging (or change the log frequency for a given channel) click the right mouse button on a given variable and select **Set log frequency** and then the desired frequency from the pop up menu. If logging is suspended on the Graph Log (*Pause*), logging should be resumed (*Resume log*).

## 4.9. Logged Channels

The **Logged Channels** panel defines the logging frequencies for particular channels. These values are expressed in Hz.

Logged Channels			
Name	4	Base profile	Custom profile
Engine			
Trigger			
Cranking 1			
State		5	5
Idle air flow 2		5	5
Fuel Volume correct		5	5
Fuel Lambda target 3		5	5
Volumetric efficienc		5	5
Ignition angle		5	5
Fuel Prime pulse cor		5	5
Fuel Injection angle		5	5
Ignition			
Fuel			
Idle			
Overrun			
VVT			
Knock			
Boost			
Traction control			
Sport			
Drivetrain			
Vehicle			
DBW			
Outputs			
Sensors			
Switches			
Communication			
Logger			
ECU			
Resources			
Custom			
Usage 5		83%	83%
212 logged part(s), 838 B. 6			

It is worth noting that the same frequencies are used for both logging to the USB storage device and for logging directly to the EMU PRO Client program (via USBtoCAN) on the PC.

In the configuration panel, we can distinguish the following elements:

- Groups (1) containing channels associated with a particular scope
- Channels (2) containing data corresponding to their names
- Channel logging frequencies (3) for Base or Custom profile (4). Custom profile is used when channel associated in Logger/Custom profile enable channel has non-zero value. This channel value change is evaluated 25 times per second.
- The bandwidth usage (5), expressed in [%] for particular Log profiles
- The bandwidth usage expressed in bytes (6).

Configuration can be carried out in the context menu or by using the shortcut keys listed below. If a given command or key is used on an entire group, the frequency will change for all channels within it. However, if they are used in a single channel, they will change the frequency of that channel only. **Log condition values** may be changed individually or all at once depending on the column selected.

Key:	Logging frequency:
Alt+`	Deactivation of channel / group logging

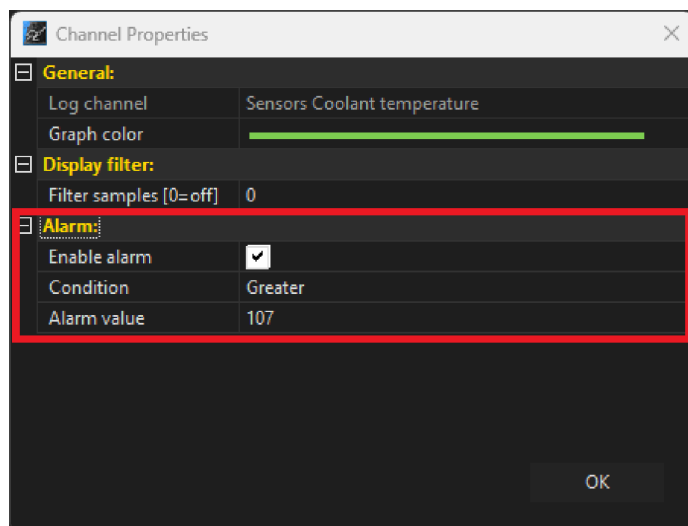
Key:	Logging frequency:
Alt+1	1 Hz
Alt+2	5 Hz
Alt+3	10 Hz
Alt+4	25 Hz
Alt+5	50 Hz
Alt+6	100 Hz
Alt+7	250 Hz
Alt+8	500 Hz

## 5. Alarms

The role of alarms is to display information about emergency states detected by the device.

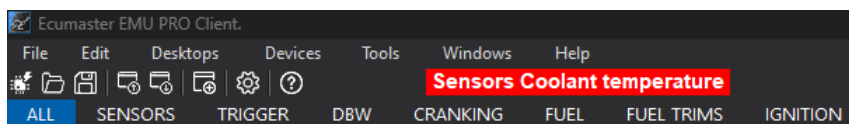
### Alarm configuration

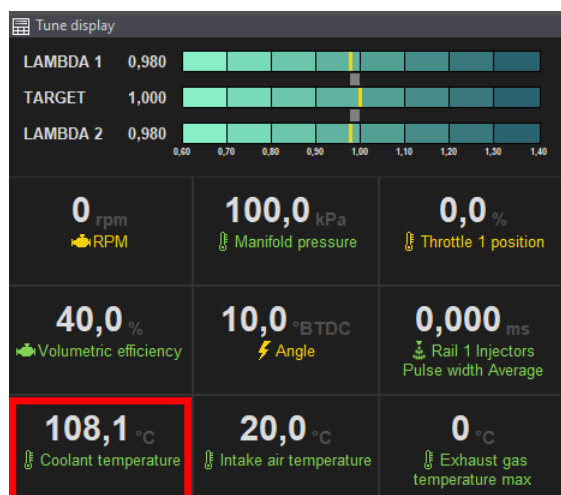
To set an alarm for a channel, right-click on the channel in the Graph Log or Tune Display panel and open the Channel Properties window.



In the Alarm tab, check the Enable alarm box, and specify the condition and value that will activate the alarm.

The alert will be displayed in the main toolbar of the Client software and in the Tune Display panel.





### Important:

The alarm will not be activated if a log file is uploaded while the ECU is powered.

There may be a situation where critical parameters, set in the channel options, are exceeded during engine operation while the user is reviewing the data uploaded from a file. In this case, the actual engine data will not be updated.

## 6. Keyboard shortcuts

### Smart grid

Ctrl + Space - change parameter value to next, enable/disable passive function

Ctrl + Shift + Space - change parameter value to previous one

Enter - shows the list of possible values / edit parameter value

### Custom 1, Custom 2, Custom 3

Alt + Up - move up

Alt + Down - move down

Alt + 1...8 - set logging frequency of selected channel to 1Hz...500Hz

### Panels

Tab - activate next panel

Tab + Up - activate panel above

Tab + Down - add panel below

Tab + Left - activate panel on the left

Tab + Right - activate panel on the right

Tab + Shift + Up - add panel above



Tab + Shift + Down - add panel below

Tab + Shift + Left - add panel to the left

Tab + Shift + Right - add panel to the right

Shift + Tab - activate previous panel

## Menu

Name	Shortcut
<b>Desktops</b>	
Add new panel	F9
Close panel	Ctrl+F4
Next desktop	Ctrl+Tab
Next desktop #2	Ctrl+Page Down
Open desktops template	
Previous desktop	Ctrl+Shift+Tab
Previous desktop #2	Ctrl+Page Up
Replace panel	Shift+F9
Restore desktops to default	
Revert desktops	
Save desktops template	
Select desktop 1	Ctrl+1
Select desktop 2	Ctrl+2
Select desktop 3	Ctrl+3
Select desktop 4	Ctrl+4
Select desktop 5	Ctrl+5
Select desktop 6	Ctrl+6
Select desktop 7	Ctrl+7
Select desktop 8	Ctrl+8
Select desktop 9	Ctrl+9
Store desktops	
<b>Devices</b>	
Device selector	

Name	Shortcut
Reboot device	Ctrl+Shift+R
Browse PC connected flash drive...	
Reconnect	Ctrl+Shift+B
Restart project	F5
Set Real Time Clock	
Set device #1	Ctrl+Shift+1
Set device #2	Ctrl+Shift+2
Set device name	
<b>Edit</b>	
Redo	Ctrl+Y
Show undo list	
Undo	Ctrl+Z
<b>File</b>	
Exit	Alt+X
Make permanent	F2
Open project	Ctrl+O
Restore to defaults	
Save project	Ctrl+S
Save project as	Ctrl+Shift+S
Show full screen	Ctrl+F
Update firmware	
<b>Help</b>	
About	
View help	
<b>Tools</b>	
APS tuner	
Assigned inputs	
Assigned outputs	
Customize keys	

Name	Shortcut
DBW tuner	
Logged Channels	F8
Memory report	
Options	Ctrl+Shift+O
Project Tree	Shift+F7
Set meters	
Smart Grid Window	
Test outputs	
Tune Display	F7
VVT tuner	
Variables Inspector	Shift+F11
<b>Windows</b>	
Next window (panel)	Tab
Previous window (panel)	Shift+Tab

## Table

Name	Shortcut
3D Rotate view anticlockwise	D
3D Rotate view clockwise	A
3D Rotate view downwards	S
3D Rotate view upwards	W
Copy cells	Ctrl+C
Decrease value	-0
Decrease value coarse	Shift+-
Decrease value fine	[
Delete column	Alt+Backspace
Delete row	Alt+Shift+Backspace
Equalize selection	E
Increase value	=
Increase value coarse	Shift+=

Name	Shortcut
Increase value fine	]
Interpolate diagonally	Ctrl+D
Interpolate horizontally	Ctrl+H
Interpolate vertically	Ctrl+L
Move down	Down
Move left	Left
Move right	Right
Move up	Up
Paint cell down	Ctrl+Down
Paint cell left	Ctrl+Left
Paint cell right	Ctrl+Right
Paint cell up	Ctrl+Up
Paste cells	Ctrl+V
Select all cells	Ctrl+A
Select bottom-right cell	End
Select top-left cell	Home
Set default value	Delete
Toggle axis mode	X
Toggle follow cursor	F

### Graph log

Name	Shortcut
Add bookmark	Ctrl+T
Axis properties	Shift+Return
Change channel	E
Change selection down	Page Down
Change selection up	Page Up
Channel properties	Return
Clear log	Ctrl+X
Create graph	C

Name	Shortcut
Delete channel	Delete
Delete graph	Shift+Delete
Group selection	Ctrl+G
Insert channels	Insert
Move left	Left
Move left large step	Ctrl+Left
Move left large step with selection	Ctrl+Shift+Left
Move right	Right
Move right large step	Ctrl+Right
Move right large step with selection	Ctrl+Shift+Right
Move screen left	Shift+Left
Move screen right	Shift+Right
Move selected graph down	Alt+Page Down
Move selected graph up	Alt+Page Up
Open log append	Alt+O
Open log replace	O
Save log	S
Set cursor at end	End
Set cursor at start	Home
Set log frequency 1 Hz	Alt+1
Set log frequency 5 Hz	Alt+2
Set log frequency 10 Hz	Alt+3
Set log frequency 25 Hz	Alt+4
Set log frequency 50 Hz	Alt+5
Set log frequency 100 Hz	Alt+6
Set log frequency 250 Hz	Alt+7
Set log frequency 500 Hz	Alt+8
Set zoom 100%	Ctrl+0
Toggle autoscale	A

Name	Shortcut
Toggle dots	Shift+S
Toggle log	Space
Turn logging off	Alt+`
Ungroup selection	Ctrl+U
Zoom extents	Z
Zoom in	Up
Zoom out	Down

## Scope

Name	Shortcut
Fit all	X
Get data	Space
Move left	Left
Move left large step	Ctrl+Left
Move right	Right
Move right large step	Ctrl+Right
Set cursor at end	End
Set cursor at start	Home
Zoom extents	Z
Zoom in	Up
Zoom out	Down

## 7. Document history

Version	Date	Changes
90.3	2023.02.24	First version
91.2	2023.03.28	Description of the EMU PRO 8/16 device selection window added Project Tree description added
96.0	2023.05.15	Description of the scalar and 4D table added
98.0	2023.05.25	Description of the CAN bus Keyboard added
99.3	2023.09.05	Updated version for official release. No changes in content.
102.0	2024.03.06	Updated for version 102.0. Added all How-to documents as appendices.
102.0.1	2024.03.07	Appendix F - How-to Configure Fuel Film added
110.6	2024.07.24	Changes from software version 110.6 added
116.2.1	2024.12.16	Added a description of the "Add Table as separate panel", "Show channels" and "Show resources" functionalities of the Smart Grid Appendix G - How-to Log Data added Appendix H - How-to Configure 5x3MT Keyboard added
216.0	2025.01.16	Changed from "Upgrade Firmware" to "Update Firmware" Description of "Show ignition output timing" (toolbar option) and "pump#" (Event marker) added to the Scope chapter Appendix I - How-to Tune the GDI Engine added

## 8. Appendix A - How-to Use Password Protection

### 8.1. Introduction

EMU PRO's password protection feature is engineered to address two essential needs:

#### 1. Protecting your work

This feature ensures that only individuals who know the password can make alterations to your calibration settings. This prevents your work from being shared or modified without your consent.

#### 2. Easy and safe updates even without knowing the password

The software allows for effortless and secure updating of firmware and calibration settings of devices using the same password. This protects your password from being compromised by keyloggers. Additionally, this allows users to carry out the update process on their own, even if they were not provided with the password by the tuner.



#### Note:

Once you assign a password, all your project files saved to the disk will also be encrypted, including all QuickSave files and firmware update backups.

### 8.2. Software required

EMU PRO firmware **100.0 or later** is required to use password protection. (Use top menu **File / Update firmware...** to upgrade the firmware).

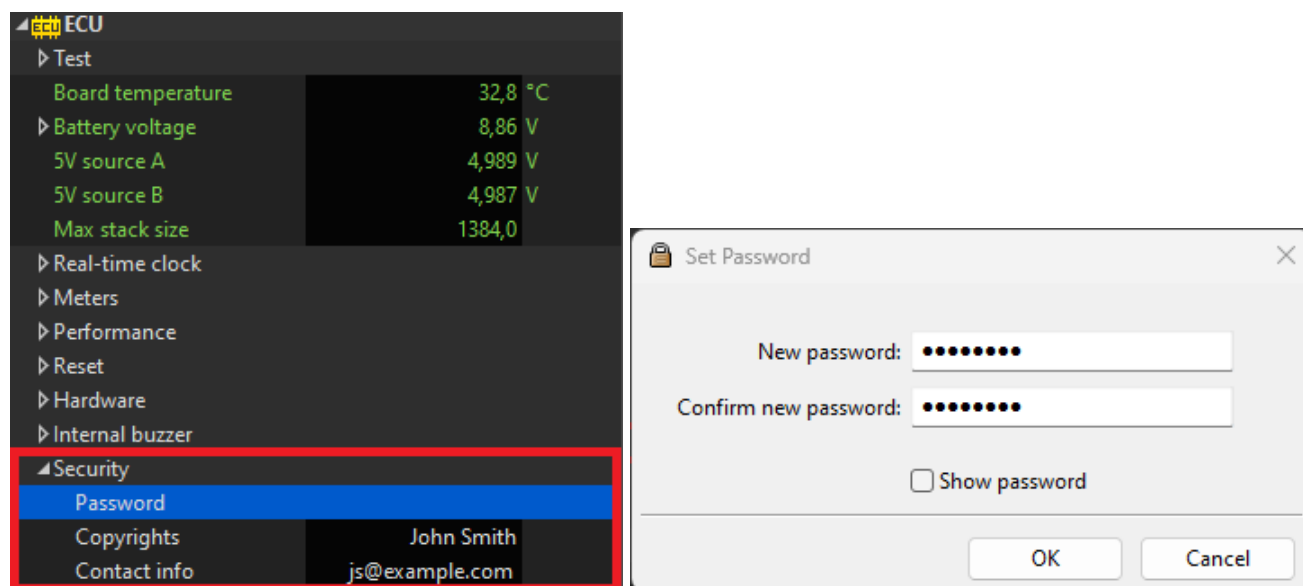
### 8.3. Workflow

1. The engineer installs the ECU and tunes the car.
2. The engineer locks the ECU by entering a password.
3. The engineer saves a copy of the project file to a disk.
4. The calibrated device, now password-protected, is handed over to the customer.
5. If needed, the customer requests the engineer to modify the tune file.
6. The engineer modifies the project file for the customer.
7. The engineer provides the customer with the updated, encrypted project.
8. The customer uploads the revised project to the device, with no password entry required.



## 8.4. Setting up a password

The password can be set in the **All Settings** panel by navigating to **ECU / Security / Password**.



## 8.5. Working with password-protected EMU PRO

After connecting to a password-protected device, a window will pop up, offering a range of options to choose from:



- Choose **Upload encrypted project to device...** to upload an encrypted project file even without knowing the password.

**Note:**

To update the encrypted project on a device, the passwords for both the updated project and the one on the device must match.

- Choose **Get full access by entering password...** to have full access to view and edit the tune file on the device.
- Choose **Set real time clock...** to automatically set time and date in the device.
- Choose **Erase password and overwrite data...** option to remove the password from the device and overwrite the data on the device with the data currently loaded in the Client software.

## 8.6. FAQ

**1. Are the backup files stored during firmware upgrades and projects in the QuickSave folder also encrypted?**

Yes, all the project files saved on the disk are encrypted, and a password is required to open them.

**2. Can I erase the ECU to factory settings when I forget the password?**

Yes, you can erase to factory settings without providing the password, but all the calibration data will be lost.

**3. Is Ecumaster able to download a project from my password-protected device?**

No, the system was designed without any backdoor implementations. The security of your data is as strong as the strength of your password.

## 8.7. Document history

Version	Date	Changes
1.0	2023.09.11	Initial release
1.1	2024.06.05	Minor changes to text formatting

## 9. Appendix B - How-to Use APS Tuner

### 9.1. Introduction

The main aim of the APS Tuner in EMU PRO is to calibrate the accelerator position sensor when used in the Drive-By-Wire (DBW) System. This tuner ensures voltage calibration for 0% and 100% accelerator positions, assuming a linear voltage progression in between.

### 9.2. Requirements

Before starting the APS tuner, the following parameters should be configured:

1. Set *Throttles type* to **DBW Throttles**

In *Sensors / Accelerator position / Throttle type*

2. Choose the analog input and voltage reference to which the *Main signal* from the accelerator sensor is connected:

In *Sensors / Accelerator position / Main signal / Input*

*Sensors / Accelerator position / Main signal / Voltage reference*

3. Choose the analog input and voltage reference to which the *Check signal* from the accelerator sensor is connected:

In *Sensors / Accelerator position / Check signal / Input*

*Sensors / Accelerator position / Check signal / Voltage reference*

If *Check signal* is not required, select the same input as for *Main signal*.



#### **Warning:**

It is highly recommended to use two independent position sensors for the accelerator pedal. Using only one sensor increases the risk of not detecting possible failure.

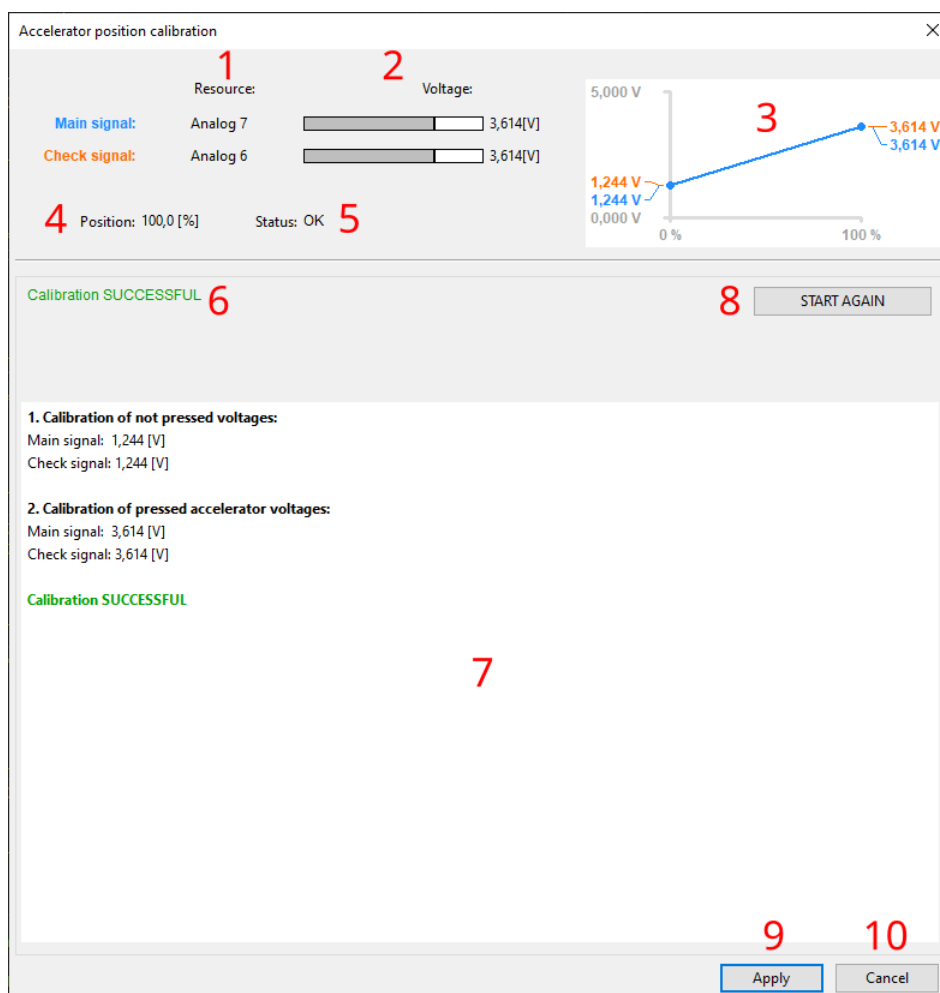


#### **Note:**

Note that for firmware version 103, Digital Input PWM, Custom Voltage Channel, and Custom Value Channel as Source are currently not supported by APS Tuner.

## 9.3. Using the APS Tuner

To access APS Tuner, navigate to the main menu, and select *Tools / APS Tuner*.



The APS Tuner window description:

1. Assigned resources - Analog Input for *Main* and *Check signal*
2. Voltage of each used resource
3. Plot with voltage progression for each APS position for *Main signal* (blue) and *Check signal* (orange).
4. APS position channel value. Not visible during calibration or if calibration fails.
5. APS Diagnostics. Not visible during calibration or if calibration fails.
6. Calibration result.
7. Calibration report window.
8. Button to start or abort the auto-calibration.
9. *Apply* button: Saves parameters calculated by auto-calibration and closes the window.
10. *Cancel* button: Discards parameters calculated by auto-calibration and closes the window.

### Calibration Procedure for APS Tuner:

- Ensure the ignition is switched on while the engine is turned off.
- If there are no 'Missing configurations' messages, start the calibration process.
- Click the *Start* button when the pedal is in the limp position (not pressed, 0% position).
- Quickly press the pedal to reach the 100% position.
- Calibration will only proceed if both the *Main signal* and *Check signal* change by a minimum of 0.1V.
- If the *Main signal* and *Check signal* do not change, calibration will wait indefinitely.
- After pushing the pedal, the voltage read after 3 seconds is stored as the voltage for the 100% position.
- To save the calibration in the project, click *Apply*.
- To discard the calibration, click *Cancel*.

Parameters not set by the APS Tuner:

*Sensors / Accelerator position / Rate calculation interval,*

*Sensors / Accelerator position / Check signal / Error tolerance.*

## 9.4. Possible errors

*"Calibration FAILED. STOP the engine during the calibration!"*

Calibration will be aborted if the engine is running or started during the calibration.

*"Lost connection with the device. Tuner will be closed."*

If the connection with EMU PRO is lost during calibration, it will be aborted, and changes will not be saved.

*"Calibration FAILED. Max voltage of main sensor is greater than 4.900V - signal range too close to 5.000V."*

The working range of the main sensor signal must be between 0.1V and 4.9V.

*"Calibration FAILED. Min voltage of main sensor is less than 0.100V - signal range too close to GND."*

The working range of the check signal must be between 0.1V and 4.9V.

*"Currently only Analog Input APS Source supported"*

For firmware version 103, Digital Input PWM, Custom Voltage Channel, and Custom Value Channel as Source are currently not supported by APS Tuner.

*"Select 'DBW throttles' in 'Sensors / Accelerator position / Throttles type' to use APS tuner."*

APS Tuner calibrates the accelerator position sensor only within a Drive-By-Wire (DBW) system.

*"Please setup: 'Sensors / Accelerator position / Check signal / Input'. If check signal is not required, select same input as for main signal."*

Both the *Main signal Input* and *Check signal Input* must be configured before starting the calibration process. If only one analog input for the accelerator pedal is used, assigning the same analog input for *Main signal* and *Check signal* is possible. WARNING: It is highly recommended to use two independent position sensors for the accelerator pedal. Using only one sensor increases the risk of not detecting possible failure.

*"Please setup: 'Sensors / Accelerator position / Main signal / Input'."*

*Main signal Input* must be configured before starting the calibration process.

*"Upgrade firmware to version 81.0 or higher to use APS tuner with Client in this version."*

Calibration is possible from version 81 onwards. Note: Version 81 was before the official product release.

## 9.5. Document history

Version	Date	Changes
1.0	2024.02.29	Initial release

## 10. Appendix C - How-to Use DBW Tuner

### 10.1. Introduction

The DBW Tuner in EMU PRO is designed to calibrate the throttle position sensor (TPS) and H-Bridge control parameters, including PID coefficients, in Drive-By-Wire (DBW) Systems.

### 10.2. Requirements

Before starting the DBW tuner, the following parameters should be configured:

1. Set *Throttles type* to **DBW Throttles**

In *Sensors / Accelerator position / Throttle type*

If the vehicle is equipped with dual throttles, the following parameters should be configured for both throttles indicated by the # symbol in the settings path. In this path, the # symbol is replaced with:

- 1 for vehicles with a single throttle body
- 1 and 2 for vehicles with dual throttle bodies

2. Choose the analog input and voltage reference for the *Main signal* from the **Throttle # position** sensor.

In *Sensors / Throttle # position / Main signal / Input*

*Sensors / Throttle # position / Main signal / Voltage reference*

3. Choose the analog input and voltage reference for the *Check signal* from the **Throttle # position** sensor.

In *Sensors / Throttle # position / Check signal / Input*

*Sensors / Throttle # position / Check signal / Voltage reference*

If there is no second signal for the sensor (no physical *Check signal*), select the same input as for *Main signal*.



#### **Warning:**

It is highly recommended to use two independent position sensors for the accelerator pedal. Using only one sensor increases the risk of not detecting possible failure.

4. Choose the output for **Throttle #**

In *DBW / Throttle # / Setup / Output*

5. Set the output frequency for **Throttle #**

In *DBW / Throttle # / Setup / Output frequency*

according to the throttle manufacturer's recommendations.

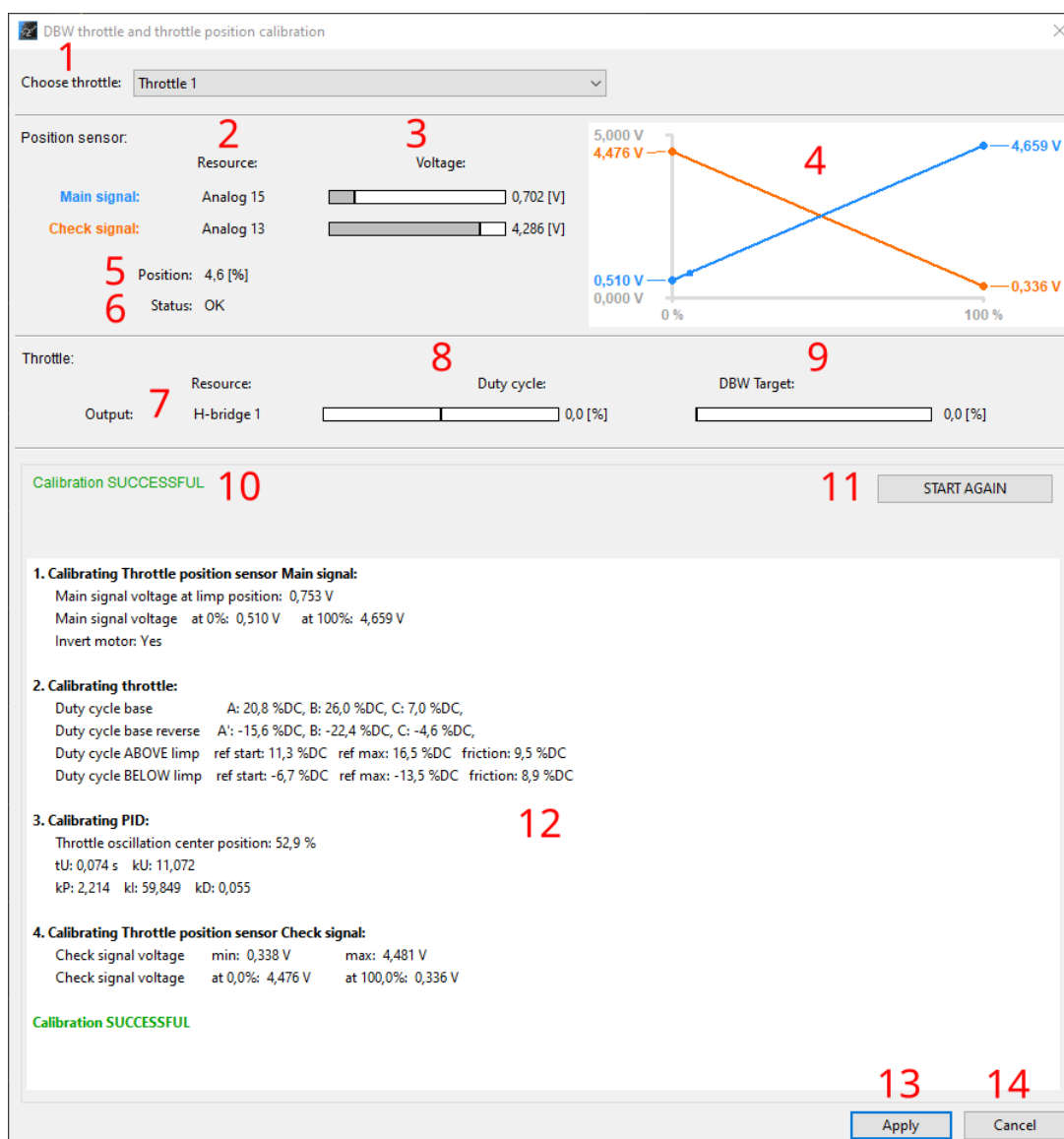
6. Set the current limit for **Throttle #**

In *DBW / Throttle # / Setup / Output / Current limit*

according to the throttle manufacturer's recommendations.

## 10.3. Using the DBW Tuner

To access DBW Tuner, navigate to the main menu, and select *Tools / DBW Tuner*.



The DBW Tuner window description:



1. Choosing a throttle for calibration
2. Assigned resources for TPS - Analog Input for *Main* and *Check signal*
3. Voltage of each used resource
4. Plot with voltage progression for each TPS position of the *Main signal* (blue) and the *Check signal* (orange).
5. TPS position channel value. Not visible during calibration or if calibration fails.
6. TPS Diagnostics. Not visible during calibration or if calibration fails.
7. Control resource in use (H-Bridge or BMW S65)
8. Current duty cycle of the H-Bridge
9. Current DBW target of the throttle
10. Calibration result
11. Button to start or abort the auto-calibration
12. Calibration report window
13. Apply button: Saves parameters calculated by auto-calibration and closes the window
14. Cancel button: Discards parameters calculated by auto-calibration and closes the window

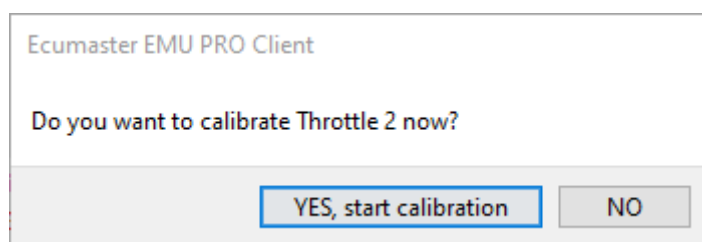
#### **Calibration Procedure for DBW Tuner:**

- Ensure the ignition is switched on while the engine is turned off.
- Choose desired Throttle (1 or 2).
- If there are no 'Missing configurations' messages, start the calibration process.
- Process of autocalibration should take about 1-2 minutes.

##### Calibration process:

1. Disabling the H-Bridge to check the limp position
2. Verifying the throttle's extreme positions by setting 100% duty cycle (max throttle opening) and -100% duty cycle (max throttle closure)
3. If necessary, reversing the H-Bridge direction (to ensure 100% duty cycle opens the throttle)
4. Determining the minimum duty cycle for which the throttle can reach 100% position
5. Establishing the duty cycle hysteresis while maintaining the throttle position at 100% (calibration of the static throttle friction above the limp position)
6. Determining the minimum duty cycle for which the throttle can reach 0% position
7. Establishing the duty cycle hysteresis while maintaining the throttle position at 0% (calibration of the static throttle friction below the limp position)

8. Determining the frequency and amplitude of oscillations at half of the throttle's operating range to determine coefficients for PID control
  9. Determining the voltage progression for individual throttle positions.
- The DBW Tuner assumes that the TPS Main Signal voltage is linear between 0% and 100%, but the TPS Check Signal voltage progression may not be linear. The voltage for the 100% position must be equal to either the minimum or maximum voltage.
  - Calibration will only proceed if both the Main signal and Check signal change by a minimum of 1V.
  - If both throttles have been configured, after completing the calibration of the first one, a window will appear, asking whether to proceed with the calibration of the second one.



- To save the calibration in the project, click Apply.
- To discard the calibration, click Cancel.
- After completing the calibration, configure the following parameters:  
*Sensors / Throttle # position / Rate calculation interval*  
*DBW / Throttle # / Setup / Output / Disable when no RPM*

Parameters not set by the DBW Tuner:

*Sensors / Throttle # position / Rate calculation interval*

*DBW / Throttle # / Setup / Output / Disable when no RPM*

For the ITB (Individual Throttle bodies) from the BMW S65 (V8), only TPS1 and TPS2 are calibrated. H-Bridge control parameters are not calibrated, as the throttle controller is responsible for them.

The detailed description of the configuration and calibration for the BMW S65 is in chapter: [Configuration of ITB for BMW S65 \(on page 91\)](#).

## 10.4. Possible errors

*"Stop the engine during the calibration!"*

The engine must be turned off throughout the entire calibration process.

*"Select 'DBW throttles' in 'Sensors / Accelerator position / Throttles type' to use DBW tuner."*

The throttle type must be chosen as DBW throttles. Change the setting of accelerator position sensor. The DBW is not present in cable operated throttles.

*"Sensors / Throttle position # sensor / Main signal / Input - not defined."*

Main signal Input must be configured before starting the calibration process.

*"Sensors / Throttle position # sensor / Check signal / Input" - not defined. If 'Check signal' is not required, select same Input as for 'Main signal'."*

Both the Main signal Input and Check signal Input must be configured before starting the calibration process. If only one analog input is used, assigning the same analog input for Main signal and Check signal is possible. WARNING: It is highly recommended to use two independent position sensors for the accelerator pedal. Using only one sensor increases the risk of not detecting possible failure.

*"DBW / Throttle # / Output" - resource is duplicated."*

The selected H-Bridge is assigned to two functions in the project. Navigate to *Tools / Assigned outputs* to check the H-Bridge's assignments.

*"DBW / Throttle # / Output" - not defined."*

The H-Bridge's must be assigned before starting the calibration process.

*"Both 'Main signal' and 'Check signal' voltages do not change enough (only ... V and ... V of change, should be more than 1.000 V). Motor control problem or voltage measurement problem on both signals."*

The minimum voltage change for both Main Signal and Check Signal is 1V. Any change less than 1V during calibration is considered improper sensor behavior.

*"Main signal voltage does not change enough (only ... V of change, should be more than 1.000 V). Main signal voltage measurement problem."*

The minimum voltage change for both Main Signal and Check Signal is 1V. Any change less than 1V during calibration is considered improper sensor behavior.

*"Check signal voltage does not change enough (only ... V of change, should be more than 1.000 V). Check signal voltage measurement problem."*

The minimum voltage change for both Main Signal and Check Signal is 1V. Any change less than 1V during calibration is considered improper sensor behavior.

*"Main signal inverted. Swap the sensor SGND with +5V or swap 'Main signal / Input' with 'Check signal / Input'."*

The main signal must be increasing. Voltage for 0% position (throttle closed) should be lower than the voltage for 100% position (throttle open).

*"Voltage for 0% position of the main sensor is less than 0,125V - signal range too close to GND."*

The minimum accepted voltage for 0% position is 0.125V to allow error detection.

*"Voltage for 100% position of the main sensor is greater than 4.9V - signal range too close to 5.000V."*

The maximum accepted voltage for 100% position is 4.9V to allow error detection.

*"Min voltage of main sensor is less than 0.125V - signal range too close to GND."*

The minimum accepted voltage for the main signal is 0.125V to allow error detection.

*"Max voltage of main sensor is greater than 4.75V - signal range too close to 5.000V."*

The maximum accepted voltage for the main signal is 4.75V to allow error detection.

*"Not enough free table memory for Check signal Expected voltage."*

There is insufficient free memory to correctly fill the table *Sensors / Throttle X Position / Check Signal / Expected voltage*. Free up memory by reducing the size of any other table or removing objects from the project tree.

*"Throttle did NOT reach back the limp position. There may be the problem with the return spring."*

Mechanical inspection of the throttle body is necessary.

*"Throttle does NOT open from limp position."*

Mechanical inspection of the throttle body is necessary.

*"Throttle starts to open but does NOT reach max open position."*

Mechanical inspection of the throttle body is necessary.

*"Throttle did NOT close automatically. There may be the problem with the return spring."*

Mechanical inspection of the throttle body is necessary.

*"Throttle did NOT reach back the limp position. There may be the problem with the return spring."*

Mechanical inspection of the throttle body is necessary.

*"Could not reach DBW Target (Throttle at ... position)."*

During calibration check, the throttle must reach the specified target (+/- 0.5%) within 1 second. Failure to reach the target may be due to incorrect PID calibration or throttle malfunction (e.g., high resistance). In the case of ITB throttles, improper adjustment of individual blades (small single throttle bodies) between them.

*"Check signal voltage for 100% position is not equal to minimum neither maximum sensor reachable voltage. Swap the 'Main signal / Input' with 'Check signal / Input'."*

The Check signal voltage for 100% position must be equal to either the minimum or maximum reachable sensor voltage.

*"Check signal voltage for 0% position is not equal to minimum neither maximum sensor reachable voltage. Swap the 'Main signal / Input' with 'Check signal / Input'."*

The voltage for the Check position at 0% must be equal to the minimum or maximum reachable voltage.

*"Throttle in limp position is too wide open. In BMW S65 DBW limp position must be close to 0.0%."*  
Applicable only to BMW S65.

*"Lost connection with the device. Tuner will be closed."*

If the connection with EMU is lost, the tuner will close. Restore the connection with the EMU and try again.

*"Sensors / Throttle position # sensor / Main signal / Input' - must be 'BMW S65 CAN'."*

Only for BMW S65, configuration error.

*"DBW / BMW S65 / Clutch output' - must not be 'None'."*

Only for BMW S65, configuration error.

*"DBW / BMW S65 / Clutch output 2' - must not be 'None', or 'DBW / BMW S65 / Use two clutch outputs' - must be disabled."*

Only for BMW S65, configuration error.

*"Timeout while waiting for the power cycle of the EMU PRO. Tuner will be closed. EMU PRO - DBW Tuner"*

Only for BMW S65, the user did not perform the power cycle or EMU could not reconnect with the client.

*"No CAN communication with the S65 DBW module. Check 'DBW / BMW S65 / Diagnostic' channel."*

Only for BMW S65, communication error.

*"General error" received from the S65 DBW module. Check 'DBW / BMW S65 / Diagnostic' channel."*

Only for BMW S65, error reported by the throttle controller.

*"No movement at startup error" received from the S65 DBW module. Check 'DBW / BMW S65 / Diagnostic' channel."*

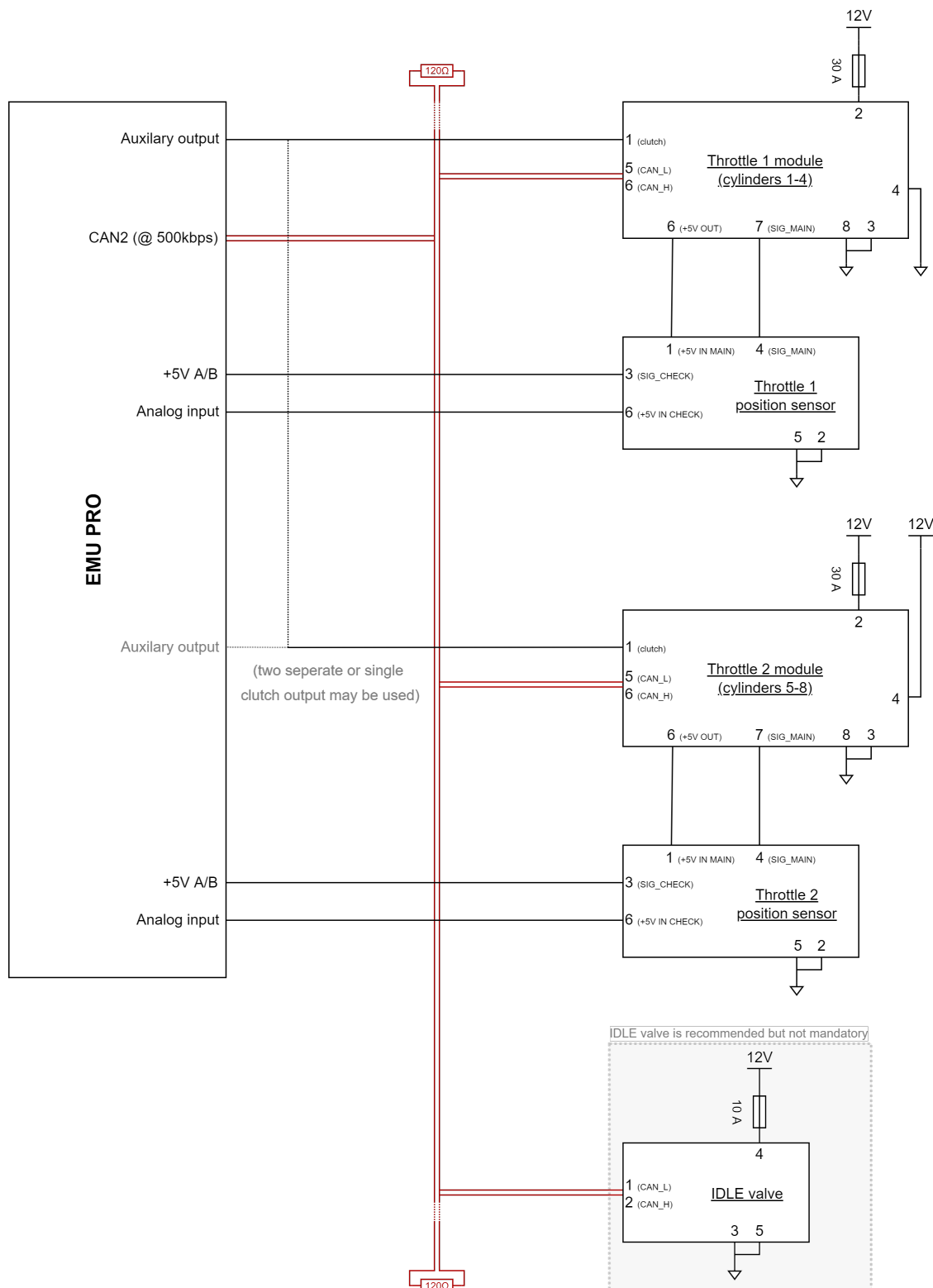
Only for BMW S65, the throttle should perform an auto-check during startup. If it doesn't, it is interpreted as an error.

*"Upgrade firmware to version 83.0 or higher to use DBW tuner with Client in this version."*

Calibration is possible from version 83 onwards.

## 10.5. Configuration of ITB for BMW S65

### 10.5.1. Wiring harness



Schematic description:

- Throttle 1 (for cylinders 1-4) has pin 4 connected to GND
- Throttle 2 (for cylinders 5-8) has pin 4 connected to power supply +12V
- All modules (*Throttle 1 module*, *Throttle 2 module* and *IDLE valve*) have to be connected to the same CAN bus – in the EMU PRO it is CAN2 set to 500kbps.  
For modules *Throttle 1* and *Throttle 2* pin 5 is connected to CAN\_L and pin 6 is connected to CAN\_H. IDLE valve on pin 1 to CAN\_L and on pin 2 to CAN\_H.
- Aim of pin 1 (clutch) in modules *Throttle 1* and *Throttle 2* is to connect clutch between electric engine and the throttle body itself. In the EMU PRO should be connected to any Auxiliary, Injector or H-Bridge output.
  - clutch inputs for modules *Throttle 1* and *Throttle 2* can be connected separately for each of the modules (parameter *use two clutch output* should be enabled) or can be connected to one output in EMU PRO and activated simultaneously (parameter *use two clutch output* should NOT be enabled). Connection method does not affect how the strategy works. Only wiring harness may be more simple to manufacture.
- On output 6 of the Throttle position sensor it is *Check signal* of the sensor. It is analog signal in range 0-5V. Should be connected to any analog input in EMU PRO.
  - Reference (+5V) should be connected to 5V A or 5V B output in EMU PRO and to output 6 in each Throttle position sensor.
- IDLE valve is recommended to be used, but is not mandatory for the system to work.
- In modules *Throttle 1* and *Throttle 2* inputs 3 and 8 (by OEM) are connected to the GND, and output 2 is connected to the power supply (12V) with fuse 30A.
- On output 4 of the Throttle position sensor there is a main signal of the Throttle position sensor. It is analog signal in range 0-5V. It is connected to input 7 in each of the *Throttle 1* and *Throttle 2* modules.
  - *Main signal* reference (+5V) is connected to output 6 in the *Throttle 1* or *Throttle 2* and input 1 in each of the throttle position sensor.



## 10.5.2. DBW settings

DBW	
Target	0,0 %
Target unlimited	0,0 %
Target source	Accelerator translati...
Target source components	
Accelerator translation	
Accelerator translation	0,0 %
Speed limit	#
Throttle 1	
Setup	
Output	BMW S65 CAN
Target spring position	0,0 %
Error	0,0 %
Absolute error	0,0 %
Delta error	0,0 %/s
Throttle 2	
Setup	
Output	BMW S65 CAN
Target spring position	0,0 %
Error	0,0 %
Absolute error	0,0 %
Delta error	0,0 %/s
Safety	
Disable brake check	[ ]
State	
BMW S65	
Use two clutch outputs	[X]
Clutch output	Auxiliary 7
Current	0,00 A
Testing	[ ]
Clutch output 2	Auxiliary 8
Current	0,00 A
Testing	[ ]
Diagnostic	
Throttle A no CAN communication	1
Throttle A no movement at startup	0
Throttle A general error	0
Throttle B no CAN communication	1
Throttle B no movement at startup	0
Throttle B general error	0
Throttle A,B enable line state	1
Idle throttle no CAN communication	1
Idle throttle general error	0

In **DBW** category must be configured:

**Throttle 1** / Setup / Output on BMW S65 CAN

**Throttle 2** / Setup / Output on BMW S65 CAN

**BMW S65:**

- enabled **use two clutch outputs** if two separate clutch outputs are used for Throttle 1 and Throttle 2
- **Clutch output**

- when **use two clutch outputs** is NOT enabled – clutch output (common for two throttles) must be chosen
- when **use two clutch outputs** is enabled – clutch output for Throttle 1 must be chosen
- **Clutch output 2** (visible only when **use two clutch outputs** is enabled)
  - when **use two clutch outputs** is enabled (true) - clutch output for Throttle 2 must be chosen

### 10.5.3. Sensors / Throttle # position configuration

Throttle 1 position	
Value	25,6 %
Main signal	
Input	BMW S65 CAN
Value	25,6 %
Check signal	
Input	Analog input #4
Pullup / pulldown	1M Pulldown
Voltage	3,453 V
Voltage	3,453 V
Expected voltage	
4,212 1,204	
0,0 100,0	
Throttle 1 position Main signal Value[%]	
Voltage reference	5V output A
Error tolerance	10,0 %
Error	0,3 %
Min valid voltage	1,004 V
Max valid voltage	4,414 V
Rate calculation interval	50 ms
Rate	0,0 %/s
Status	OK (1)
Throttle 2 position	
Value	25,6 %
Main signal	
Input	BMW S65 CAN
Value	25,6 %
Check signal	
Input	Analog input #2
Pullup / pulldown	1M Pulldown
Voltage	3,441 V
Voltage	3,453 V
Expected voltage	
4,223 1,219	
0,0 100,0	
Throttle 2 position Main signal Value[%]	
Voltage reference	5V output B
Error tolerance	10,0 %
Error	0,0 %
Min valid voltage	1,018 V
Max valid voltage	4,424 V
Rate calculation interval	50 ms
Rate	0,0 %/s
Status	OK (1)

In **Sensors** category must be configured:

**Throttle 1 position:**

- **Main signal / Input** to **BMW S65 CAN**
- **Check signal / Input** as Throttle 1 position sensor analog input
  - **Pullup / pulldown** to **1M Pulldown**
  - **Voltage reference** to used reference +5V output (**5V output A** or **5V output B**)

**Throttle 2 position:**

- **Main signal / Input** to **BMW S65 CAN**
- **Check signal / Input** as Throttle 2 position sensor analog input
  - **Pullup / pulldown** to **1M Pulldown**
  - **Voltage reference** to used reference +5V output (**5V output A** or **5V output B**)

Next autocalibration should be performed. To do so choose Tools / DBW tuner, next push Start button and follow instruction on the screen

DBW throttle and throttle position calibration

Choose Throttle 1

Position sensor:

	Resource:	Position / Voltage:
Main signal:	BMW S65 CAN	0,0 [%]
Check signal:	Analog input #4	4,195

Position: 0,0 [%]  
Status: Error: BMW S65 Error

Throttle:

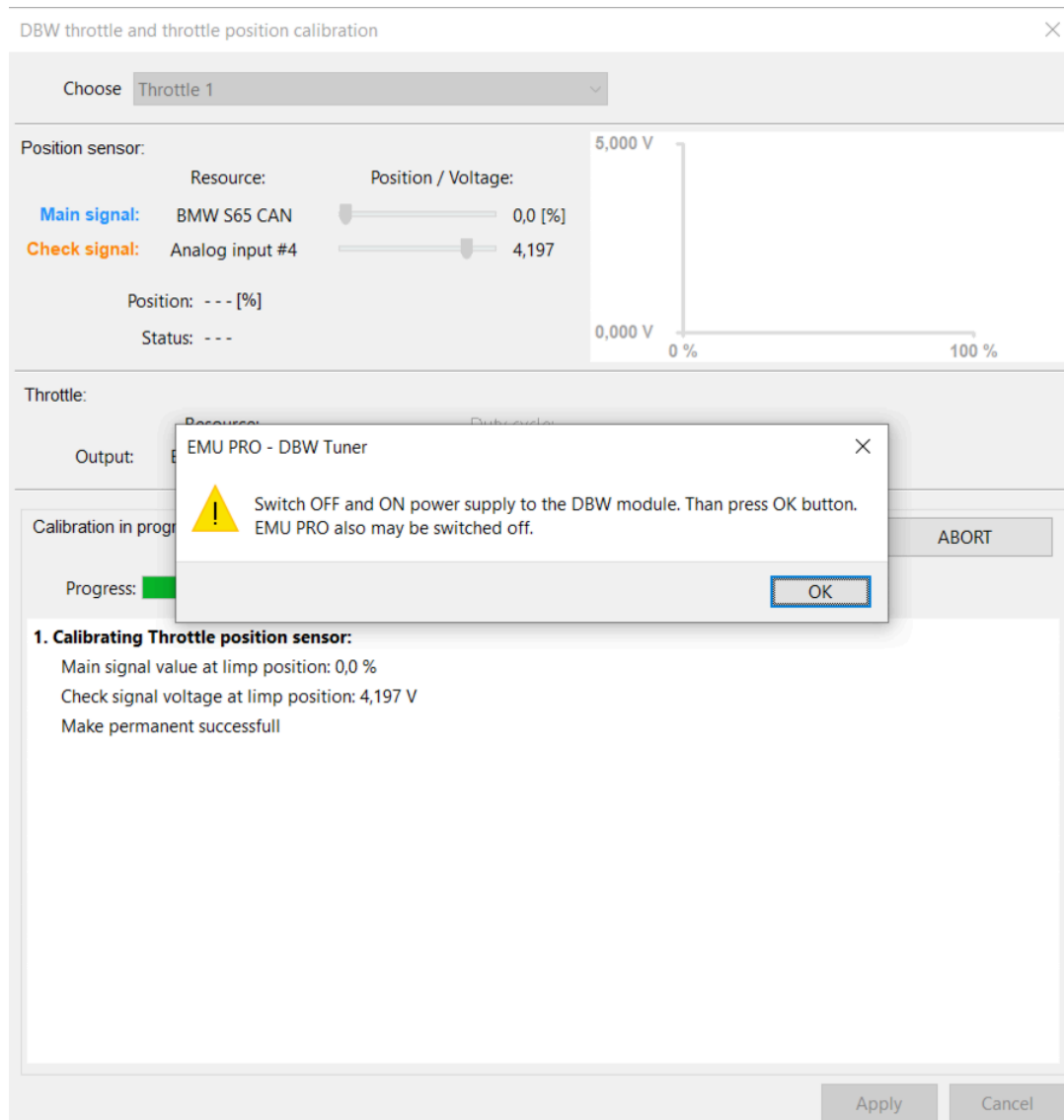
	Resource:	Duty cycle:
Output:	BMW S65 CAN	0,0 [%]

Press the START button to begin the calibration process...

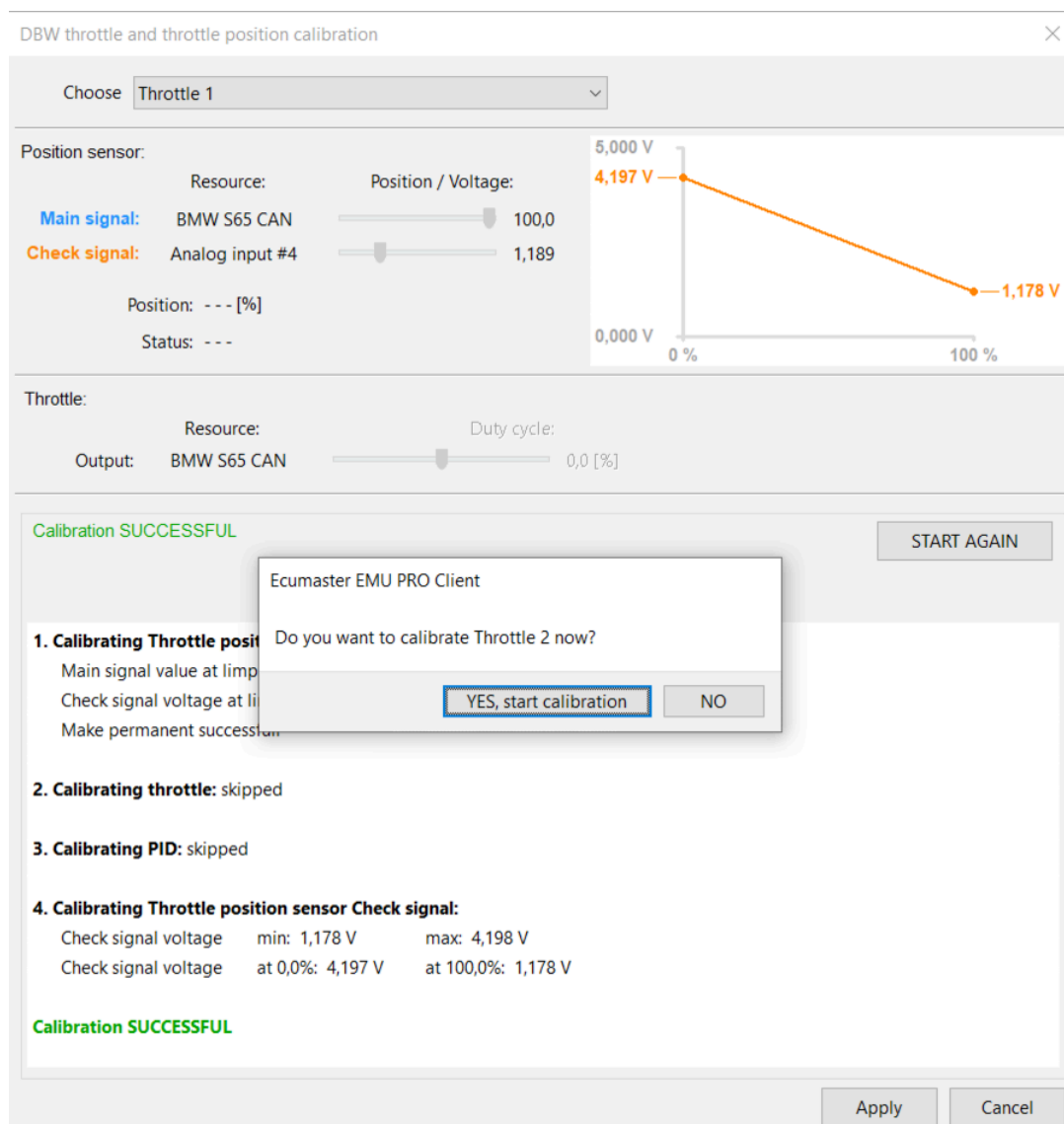
START

Apply Cancel

When pop-up asking for restarting the DBW module will be shown – switch off and on the power supply for the throttle bodies. It can be done by switching off and on for the main power supply (EMU PRO is allowed to restart).



After finishifg calibration of the Throttle 1 pop-up asking for calibration Throttle 2 will show up. Push **Yes, start calibration**.



After finishing the calibration push the **Apply** Button. Pushing Cancel will reject whole calibration process.

DBW throttle and throttle position calibration

Choose **Throttle 2**

Position sensor:

Resource: Position / Voltage:

Main signal: BMW S65 CAN 0,0 [%]

Check signal: Analog input #12 4,205

Position: 0,0 [%]

Status: Error: BMW S65 Error

5,000 V  
4,207 V  
0,000 V  
0 % 100 %

Throttle:

Resource: Duty cycle:

Output: BMW S65 CAN 0,0 [%]

Calibration **SUCCESSFUL** **START AGAIN**

**1. Calibrating Throttle position sensor:**  
Main signal value at limp position: 0,0 %  
Check signal voltage at limp position: 4,197 V  
Make permanent successfull

**2. Calibrating throttle:** skipped

**3. Calibrating PID:** skipped

**4. Calibrating Throttle position sensor Check signal:**  
Check signal voltage min: 1,211 V max: 4,205 V  
Check signal voltage at 0,0%: 4,207 V at 100,0%: 1,211 V

Calibration **SUCCESSFUL**

Apply Cancel

After calibration switch off and on the Throttle controller. It can be done by switching off and on for the main power supply (EMU PRO may restart).

## 10.6. Document history

Version	Date	Changes
1.0	2024.03.06	Initial release

# 11. Appendix D - How-to Configure VVT

## 11.1. Introduction

VVT systems are used to modify valve timing and lift in order to improve engine performance, fuel economy and emissions. In most cases intake camshafts can be advanced and exhaust camshafts can be retarded according to their base position. However every engine producer designs different VVT systems and the operation may vary.

In simple terms, VVT timing systems can be divided into groups:

- Discrete adjustment – camshafts can be phased only to fixed positions, typically depending on engine RPM (e.g. VTEC with third camshaft profile). See: *VVT / **Switched*** in Smart Grid
- Continuous adjustment – camshafts can be phased to every position within working range. See: *VVT / **Timing*** in Smart Grid

Camshafts are phased by hydraulic systems controlled by actuators. To reach specified camshaft position, PID controllers are used to run the solenoids.

**Note:**

This document covers continuous camshaft phasing only.

## 11.2. Getting started

This chapter explains key concepts of VVT handling in EMU PRO. In this document, the following convention is used for Smart Grid navigation: *[In\Ex]* means it can be either an intake or exhaust camshaft, and *#* indicates it can be either 1 or 2.

**Position read-out**

*VVT / Timing / [In\Ex] / [In\Ex] camshaft # / **Position***

Position of each camshaft is calculated from camshaft trigger wheel position in relation to primary trigger. Position is determined at each camshaft tooth.

## Position unit [°ADV]

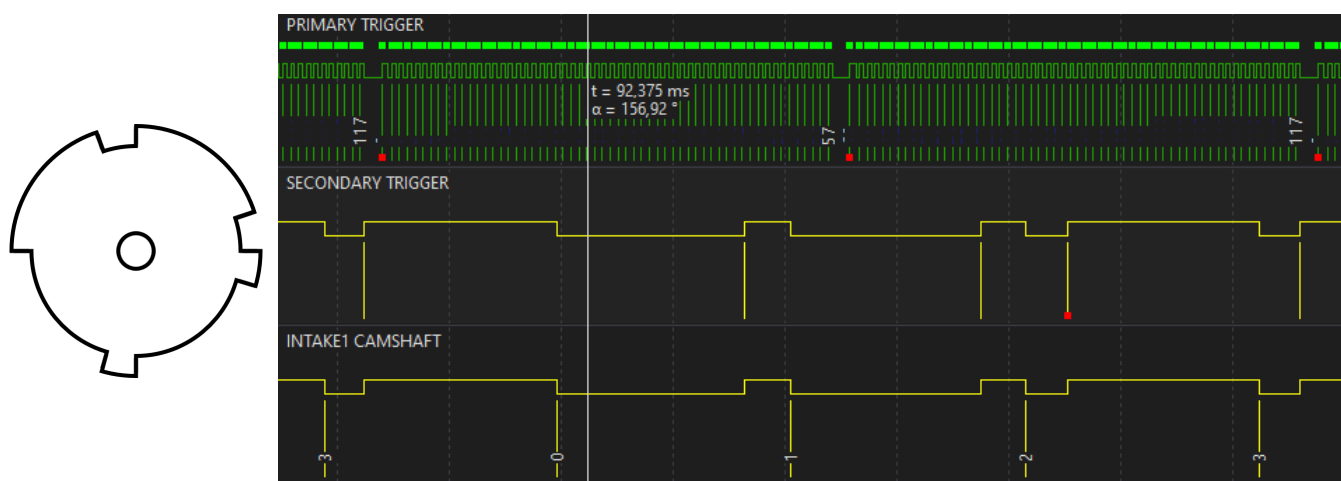
VVT / Timing / [In\Ex] / [In\Ex] camshaft # / **Position**

The unit of camshaft position in EMU PRO is advance degrees for both intake and exhaust. Negative values mean retard. VVT Tuner assumes that intake camshaft moves in advance direction and exhaust one in retard.

## Signal edge

VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Signal edge**

Unlike secondary trigger edge, for VVT purpose choose the one, which provides evenly spaced edges (if possible). For example for the following trigger rising edge is for synchronization and falling edge is for VVT position read-out.



## Primary trigger start tooth

VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Primary trigger start tooth**

This parameter defines the primary trigger tooth number from which camshaft teeth are numbered and counted for one cycle. If a camshaft tooth crosses the sync primary trigger tooth, it is crucial to set offset in reference to the sync primary trigger tooth, which would assure that camshaft teeth numbering would not change.

This value can be automatically calculated by VVT Tuner.

## Duty cycle range

VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Duty cycle [min\max]**

Range of duty cycle must be large enough to assure quick camshaft move in both directions. In some cases (e.g. Ford Coyote engine) there is a minimal duty cycle which enables VVT.



## Moving average

VVT / *Timing* / [In\Ex] / [In\Ex] camshaft # / *Position* / **Moving average**

Do not use *Moving average* feature when configuring VVT. It averages position from all teeth and thus it could conceal problems with position read-out when ... / *Position* / **Initial teeth angles** or ... / *Position* / **Primary trigger start tooth** are not configured correctly. If needed, turn it on after proper configuration.

## VANOS with dual solenoid

VVT configuration in this case assumes using VVT / *Timing* / [In\Ex] / [In\Ex] camshaft # / *Actuator* / *Solenoid* / **Output** to move camshaft away from base position and ... / *Actuator* / *Solenoid* / **Output 2** to move towards base position – it should be configured in that way.

Similarly in case of using H-bridge output ... / *Actuator* / **Active state** set to High side (12V)) positive PWM duty cycle should move camshaft away from base position and negative towards base position.

VVT Tuner can detect reverse direction of control and work properly, however tuning procedure would take more time.

# 11.3. Configuration

## 1. Specify VVT activation rules

In VVT / *Timing* / **Activation**

- *Engine RPM min*
- *Engine RPM hysteresis*
- *Engine coolant temperature min*
- *Engine coolant temperature hysteresis*
- *Engine oil temperature min*
- *Engine oil temperature hysteresis*
- *Engine runtime min*

## 2. Set camshafts count for each intake and exhaust

In VVT / *Timing* / [In\Ex] / [In\Ex] **camshafts count**

- None – VVT control disabled
- Single – one camshaft with VVT
- Dual – two camshafts with VVT (for two cylinder banks)

**Steps 3-7 needs to be performed for each camshaft separately.**

### 3. Configure Position settings

In *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / **Position***

- *Sensor input* – digital input pin to which camshaft trigger wheel sensor is connected
- *Sensor type* – VR or Hall
- *Pullup / pulldown* – None or 1K
- *Signal edge* – rising or falling.

### 4. Configure Actuator settings

In *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / **Actuator***

- *Type* – single solenoid (most cases) or dual solenoid (one of VANOS variants)
- *Active state* – the state of active solenoid output, low side (GND) or high side (12V) – applies to dual solenoid type setting only
- *Solenoid / Output* – output pin connected to VVT solenoid. For high side dual solenoid only H-bridge can be used
- *Solenoid / Output 2* – output pin connected to the second solenoid – used for low side dual solenoid only
- *Solenoid / Frequency* – output PWM frequency
- *Solenoid / Duty cycle [min\max]* – range of PWM duty cycle used to control the solenoid

### 5. Run the VVT Tuner

To simplify the configuration of other necessary settings, you can use the VVT Tuner. For more details about its operation, see chapter 4.



#### **Warning:**

VVT Tuner uses full range of VVT position.

If your engine does not have VVT position limiters thus some positions could damage the engine, DO NOT USE this tuner!

VVT should be tuned at operating conditions. It is recommended to warm up the engine and keep at least 2000 RPM during VVT Tuner procedure running to build oil pressure.

Select the camshaft to configure and press the START button.

After successful calibration output log will show:

- number of teeth in camshaft trigger wheel (*VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Teeth count***)
- calculated *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Primary trigger start tooth*** (if non-zero)
- minimum duty cycle (if detected) *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Duty cycle min***
- camshaft position at LOW duty cycle
- camshaft position at HIGH duty cycle
- steady state duty cycle
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Control direction***
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **PID** settings*

## 6. Verify the results

The chart in VVT Tuner window shows whether the configured camshaft moves as intended. Additional look at output log would give more information about the calibration.

Usually in VVT systems:

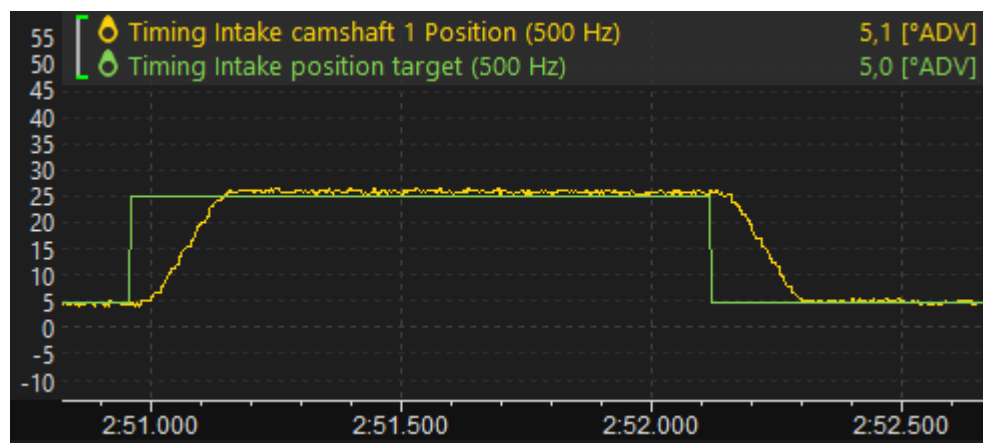
- working range is up to 70°
- P and I gains are between 1 and 6
- D gain is lower than 0.5
- P gain is greater than I gain

## 7. Check the operation

In *Graph Log* add camshaft position *VVT Timing [In\Ex] camshaft # Position* and target *VVT Timing [In\Ex] position target* channels on the same graph and set for them at least 100 Hz of logging frequency.

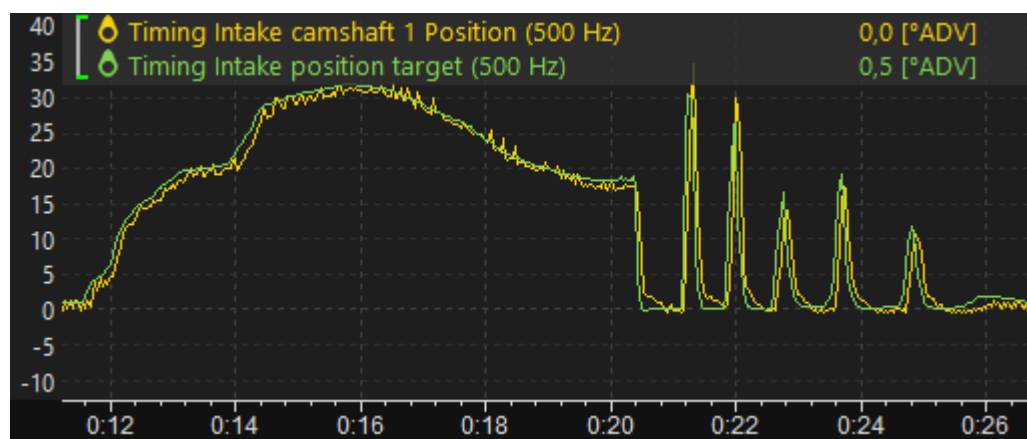
To check whether VVT is working properly, change target values in base map *VVT / Timing / [In\Ex] / [In\Ex] position target / **Base*** and observe the position changes. Since values from maps are interpolated, select the whole map and set the value for all the cells. For example change between 5 and 25 for advancing camshaft (or -5 and -25 for retarding case).

Position should reach the target quickly (approx. 200-300 ms) and without significant overshoot.

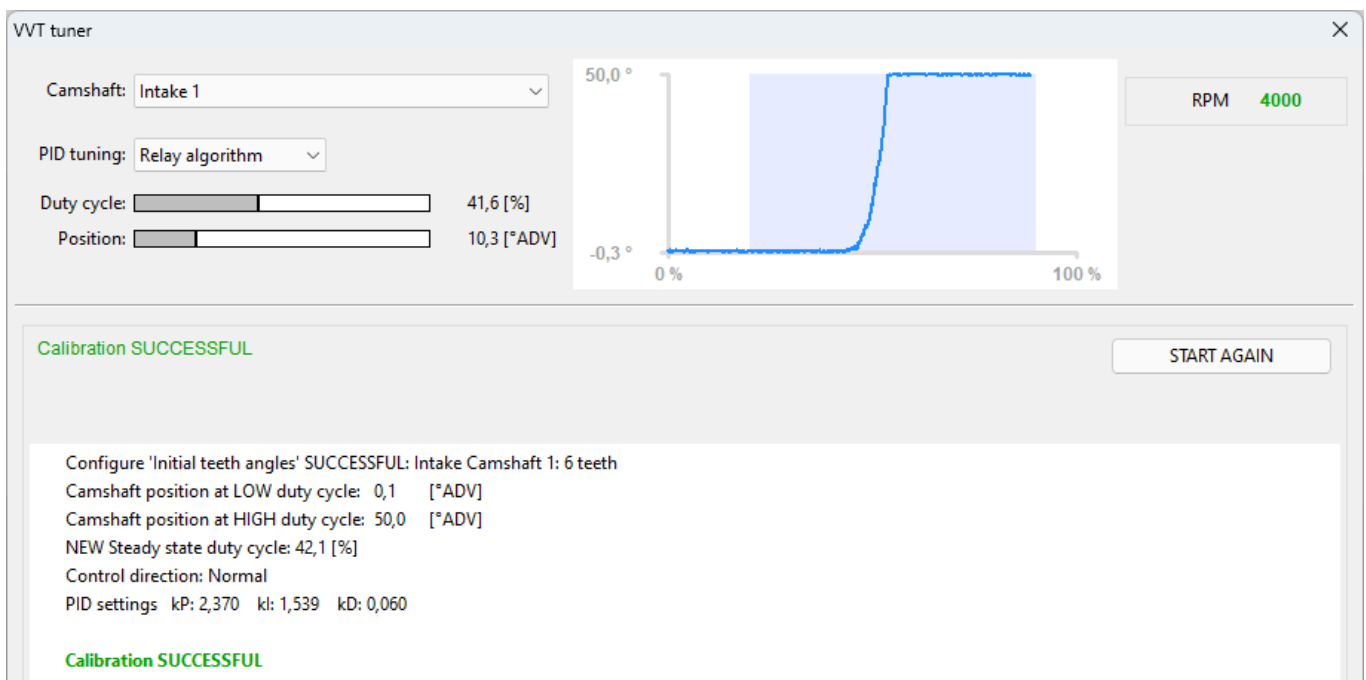


## 8. Configure target position maps

Set the map *VVT / Timing / [In\Ex] / [In\Ex] position target / **Base*** values to reach the best performance. It is a good idea to check VVT work during normal usage too. Position value should follow the target.



## 11.4. VVT Tuner



VVT Tuner configures:

*VVT / Timing / [In\Ex] / [In\Ex] camshaft # / **Position**:*

- *Primary trigger start tooth*
- *Teeth count*
- *Initial teeth angles*

*VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / **Solenoid**:*

- *Control direction*
- *Steady state duty cycle*
- *PID gains*
- *Duty cycle min (only when necessary)*

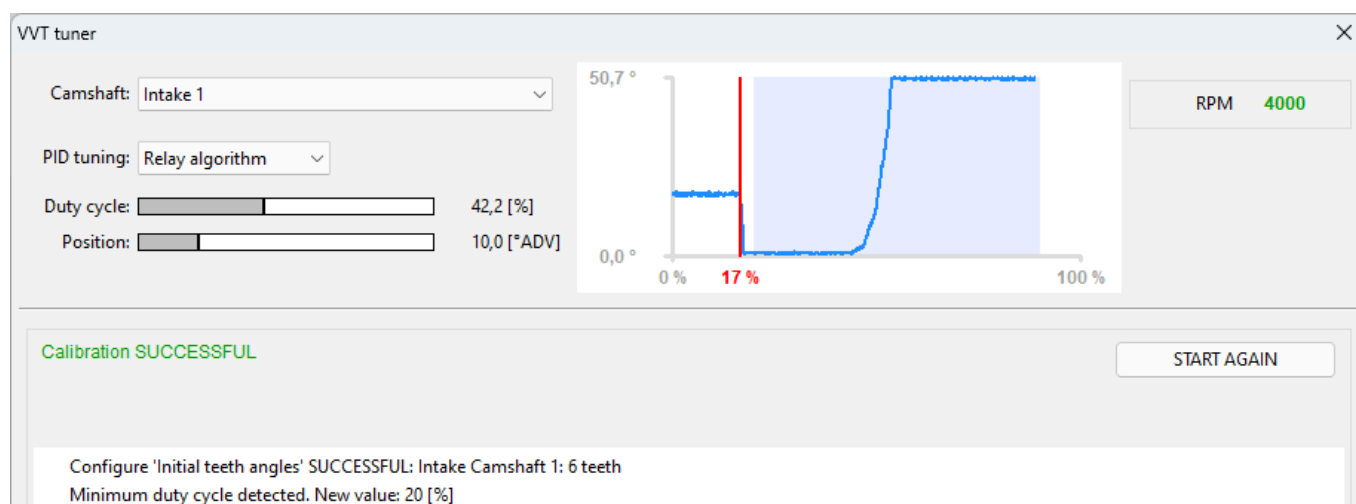
There are two algorithms for *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / PID* gains calculations. The first one, Relay algorithm, should work for most cases. If not, AMIGO algorithm may be used instead.

If the position signal is very noisy, enabling *Moving average* option sometimes may improve the VVT Tuner work.

While the VVT Tuner is active, you can view the current position and duty cycle values on sliders. The chart will also display how the position changes when the duty cycle varies from 0 to the

specified duty cycle. Light blue background shows the duty cycle range specified by ... / *Actuator / Solenoid* / **Duty cycle min** and **Duty cycle max** parameters.

Some of the VVT systems (e.g. in Ford Coyote engine) needs to be controlled by duty cycle above some threshold to enable VVT work and move to the border position. If the minimal duty cycle was detected, it would appear on the chart as a red line. ... / *Actuator / Solenoid* / **Duty cycle min** parameter would be set 3% above the detected threshold.



## 11.5. VVT Tuner errors

'VVT / Timing / [In\Ex] / [In\Ex] **camshafts count**' - wrong setting for this camshaft.

➤ Set *Single* for one cylinder head or *Dual* for two cylinder heads.

'VVT / Timing / [In\Ex] / [In\Ex] camshaft / Position / **Sensor input**' - not defined.

➤ Set proper input pin with connected camshaft trigger wheel sensor.

'VVT / Timing / [In\Ex] / [In\Ex] camshaft / Actuator / Solenoid / **Output**' - not defined.

➤ Set proper output pin with connected actuator (solenoid).

'VVT / Timing / [In\Ex] / [In\Ex] camshaft / Actuator / Solenoid / **Output 2**' - not defined.

➤ Set proper output pin with connected actuator (solenoid) - only for low side dual solenoid system.

➤ Set *Single* camshafts count if the engine has one cylinder head.

'Duty cycle max' must be greater than 'Duty cycle min'. Correct the values and try again.

➤ Please look at VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Duty cycle min** and ... / **Duty cycle max** parameters, and correct the values.

'*Duty cycle min*' seems to be too high. Consider decreasing the value.

'*Duty cycle max*' seems to be too low. Consider increasing the value.

➤ Specified range should allow to control the camshaft. If there is no reason to narrow down the operating duty cycle range, keep *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Duty cycle min*** close to 0 and ... / **Duty cycle max** close to 100. PWM output duty cycle value is in the range of:

- 0% to 100% for single solenoid VVT
- -100% to 100% for dual solenoid VVT

Can't get scope from device!

➤ There could be a problem with primary trigger wheel signal or camshaft trigger wheel signal. Check the trigger wheel sensors and specified input pins in configuration.

Too low position range. Check the setup and restart calibration.

➤ Position range of camshaft movement usually is greater than 20°. When camshaft does not move or it moves too close, the problem could be caused by:

- too low duty cycle range
- steady state duty cycle is too close to *Duty cycle min* or *Duty cycle max*
- output testing is enabled
- camshaft position sensor not connected or problem with wiring
- actuator not connected or problem with wiring
- wrong setting of *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / Sensor input **Pullup / pulldown*** for specified **Sensor type**

Too high position range. Check the setup and restart calibration.

➤ Since camshaft movement is usually mechanically limited, the problem is caused by wrong position read-out because of wrong calculations of *VVT / Timing / Intake / Intake camshaft / Position / **Initial teeth angles*** or **Primary trigger start tooth**. If restarting VVT Tuner calibration does not succeed, changing the *Signal edge* could solve the problem.

PID calibration failed. Check the setup and restart calibration.

➤ This could happen when VVT Tuner wrongly determine the *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Control direction***. Too low duty cycle range could be one of the possible reasons. If this problem occurs repeatedly, contact us on [tech@ecumaster.com](mailto:tech@ecumaster.com)

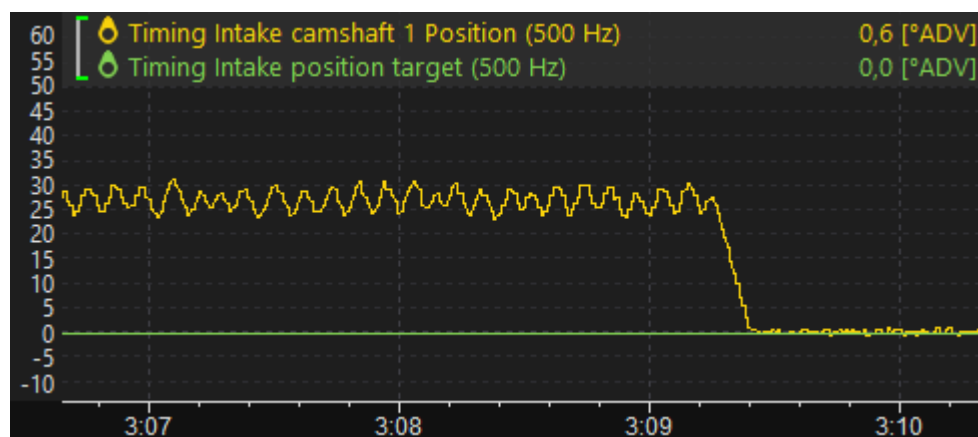
PID parameters were clamped to maximal values. Please check the numbers and consider recalibration.

➤ That indicates some problem with calculating the PID gains. Too low duty cycle range could be one of the possible reasons. If this problem occur repeatedly, contact us on [tech@ecumaster.com](mailto:tech@ecumaster.com)

## 11.6. Troubleshooting

The position channel is very noisy:

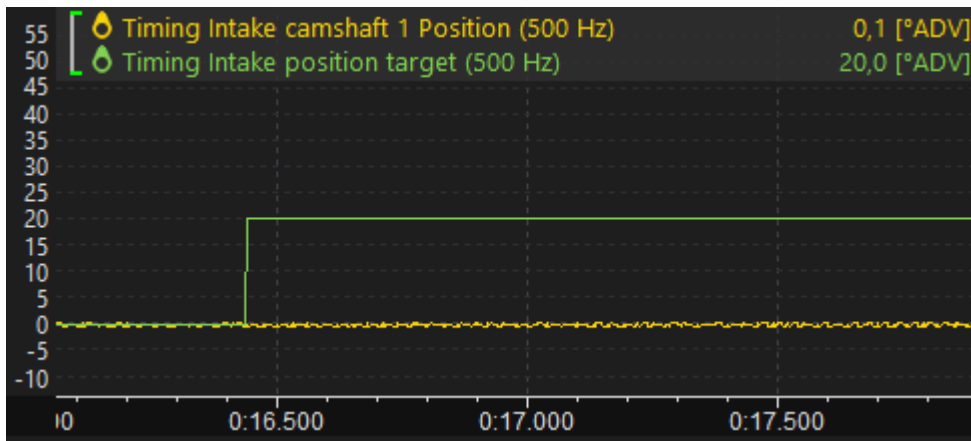
- Some of the *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **PID*** gains are too large
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Frequency*** of PWM output is too low or too high
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Initial teeth angles*** are not properly configured – check the angles values in a scope



Camshaft position does not follow the target at all:

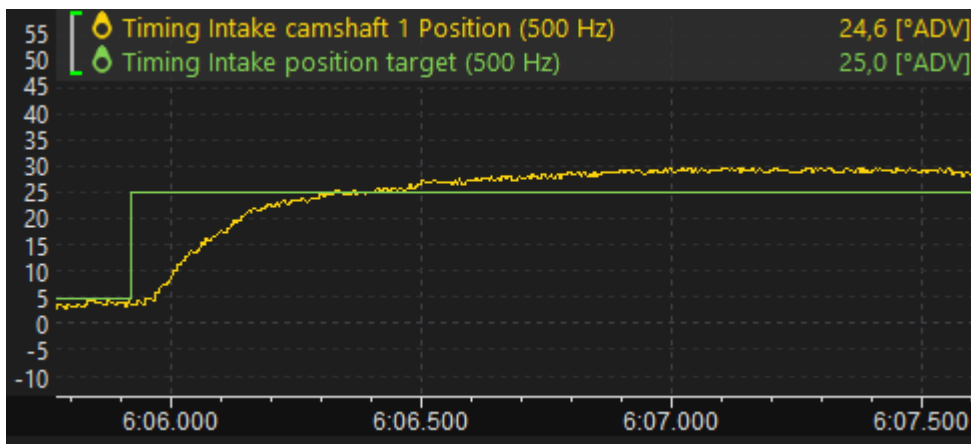
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Output*** testing mode is enabled
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **PID*** gains are set to zero
- *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **Control direction*** is set incorrectly
- Target values in the map *VVT / Timing / [In\Ex] / [In\Ex] position target / **Base*** are outside the camshaft working range
- Camshaft position sensor not connected or problem with wiring
- Actuator not connected or problem with wiring
- Wrong setting of *VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / Sensor input **Pullup / pulldown*** for specified **Sensor type**





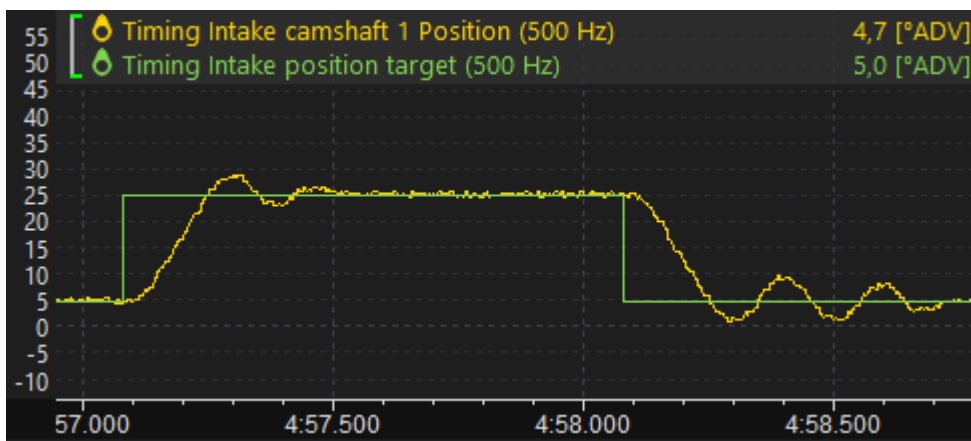
Camshaft position follows the target too slow:

- VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **PID** proportional and/or integral gain are too small



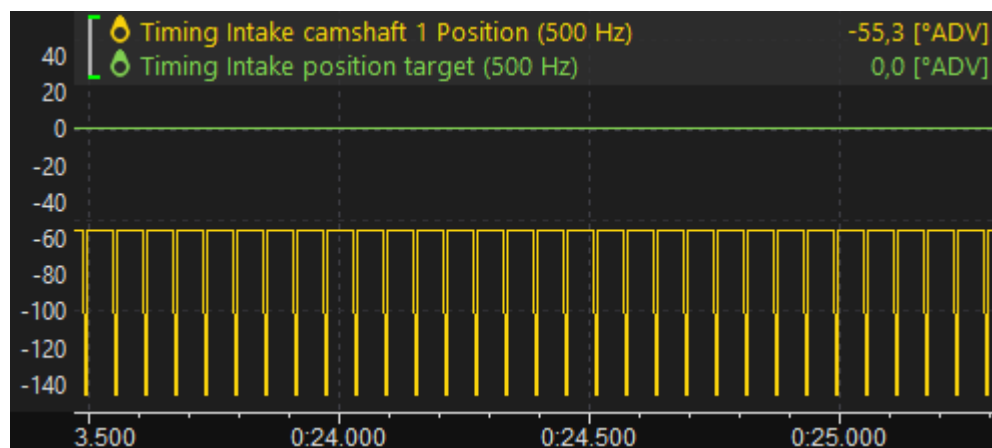
Camshaft position follows the target with high overshoot:

- VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Actuator / Solenoid / **PID** proportional and/or integral gain are too large



Camshaft position has spikes:

- VVT / Timing / [In\Ex] / [In\Ex] camshaft # / Position / **Initial teeth angles** or **Primary trigger start tooth** are not configured properly



## 11.7. Document history

Version	Date	Changes
1.0	2024.02.01	Initial release

## 12. Appendix E - How-to Use VE Tuner

### 12.1. Introduction

VE Tuner is a tool, which is helpful to build or improve the *Volumetric efficiency* table by analysing logged data.

The process consists of the three main steps:

1. Gathering data (log)
2. Processing data
3. Analysing data and applying changes

#### 12.1.1. Gathering data

Gathering data is a crucial step in the process. It is important to keep the engine in a steady state in many load / RPM setpoints. The algorithm will ignore any data gathered during transient condition (e.g. acceleration). It is essential to build Lambda target table before running the VE Tuner.

To collect data, ensure the engine coolant reaches its normal operating temperature. Gather data using various gears and throttle positions. The goal is to cover as large *Volumetric efficiency* table area as possible.

#### 12.1.2. Processing data

To process data in VE Tuner, project and log must be loaded.

It uses log to calculate corrections for the *Volumetric efficiency* table. VE Tuner performs data validation to reject samples during transients and specified time afterwards (recovery delay).

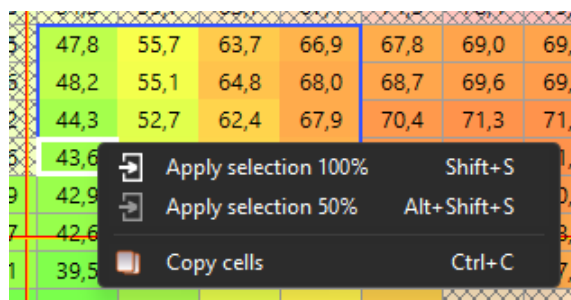
Corrections are calculated after opening settings window or changing any condition. A VE Tuner table will be filled with calculated values.

#### 12.1.3. Analysing data

The base view is Proposed VE table. All the highlighted cells contain values calculated from a log which meets the requirements, the rest are masked (cross-hatched).

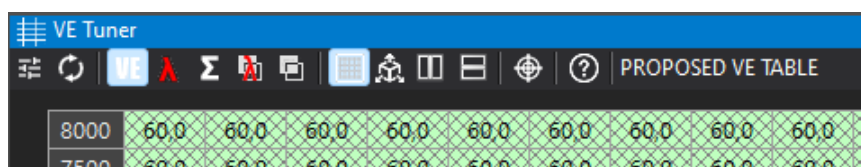
To apply the changes to the *Volumetric efficiency* table, select cells of interest and choose *Apply selection 100%* or *Apply selection 50%* from a context menu (right mouse button). Apply 100%

means that Proposed VE values will be copied to VE table, apply 50% means that the average value of *Volumetric efficiency* table and Proposed VE table will be set.





## 12.2. How to use






By default VE Tuner panel is located on FUEL desktop. It can also be found in menu *Tools / VE Tuner* or can be manually added to any desktop. The panel contains a toolbar and a table of the same size and axes as *Volumetric efficiency* table.



VE Tuner table shares common functionalities with other standard tables, however it has enhanced toolbar with dedicated buttons:

-  VE Tuner settings – shows settings of log data conditions
-  Recalculate – updates graph selection and recalculates corrections

There are five views of results:

-  Proposed VE table – proposed corrected *Volumetric efficiency* table
-  Lambda – measured lambda values
-  Number of samples – number of collected valid samples
-  Lambda difference – difference between lambda target and measured lambda values
-  VE difference – difference between current and proposed *Volumetric efficiency* table

The label on the toolbar shows the currently selected view.

## 12.3. Settings

Settings window contains all the conditions which are used to validate log data. Corrections would only be calculated from data which meets specified requirements. After each value change followed by Enter key or by using up/down arrow buttons next to values, the corrections will be recalculated.

VE Tuner - settings

**Lambda source:**  
Sensor: Lambda 1

**VE table target:**  
Table: Bank 1

**Conditions:**  
Engine RPM range: 500 - 15000 [rpm]  
Efficiency load range: 0 - 300 [%]  
Throttle position range: 0 - 100 [%]  
Coolant temperature min: 50 [°C]  
Min number of samples: 100

**Short term trim parameters:**  
☐ From project  
☒ Manual:  
Engine RPM rate max: 2000 [rpm/s]  
Engine load rate max: 200 [%/s]  
Constant lambda delay: 150 [ms]  
Recovery delay: 1,0 [s]

**Log range:**  
☒ Entire  
☐ Selected

Update selection from Graph Log

Close

The drop-down list at the top defines the **Lambda source** whose data would be used to calculate the corrections.

If separate Volumetric Efficiency tables for two cylinder banks are required, the **VE table target** drop-down list defines the target table, indicating which one, Bank 1 or Bank 2, the corrections will be applied to.

## Conditions description

Parameter	Description
<b>Engine RPM range</b>	range of analysed RPM from log
<b>Efficiency load range</b>	range of analysed <i>Efficiency load</i> from log
<b>Throttle position range</b>	range of analysed TPS values from log
<b>Coolant temperature min</b>	minimal coolant temperature to calculate corrections
<b>Min number of samples</b>	minimal number of samples in each cell to use corrections
<b>Sensor</b>	choice of lambda sensor 1 or 2, or average of both sensors

**Manual parameters** – use the following parameters when *Short term trim* is not configured

Parameter	Description
<b>Engine RPM rate max</b>	maximal rate of change of RPM
<b>Engine load rate max</b>	maximal rate of change of <i>Efficiency load</i>
<b>Constant lambda delay</b>	time delay of exhaust fumes reaching lambda sensor. It is dependent on the distance from exhaust manifold to lambda sensor and exhaust gas speed. It is advised to configure the delay in <i>Short term trim</i> section
<b>Recovery delay</b>	delay of recovery from transient state

**Short term trim parameters** – use of rate and delay parameters configured in *Short term trim* section in the *Smart Grid* panel

## Log range

**Entire** – entire log is used to calculate corrections

**Selected** – only selected range of log is used to calculate corrections. Log can be selected by left mouse button with Shift key pressed or by left / right arrows with Ctrl+Shift keys pressed.

**Update selection from Graph Log** button applies current *Graph Log* selection.

## 12.4. Fuel trims

### Short term trim

If *Fuel Short term trim* is enabled, it is important to set logging of appropriate correction channel to at least 25 Hz. Its values would be taken into consideration. Depending on chosen sensor, different channel would be used:

- Lambda 1 – Short term trim Correction 1
- Lambda 2 – Short term trim Correction 2
- Average 1&2 – Short term trim Correction average

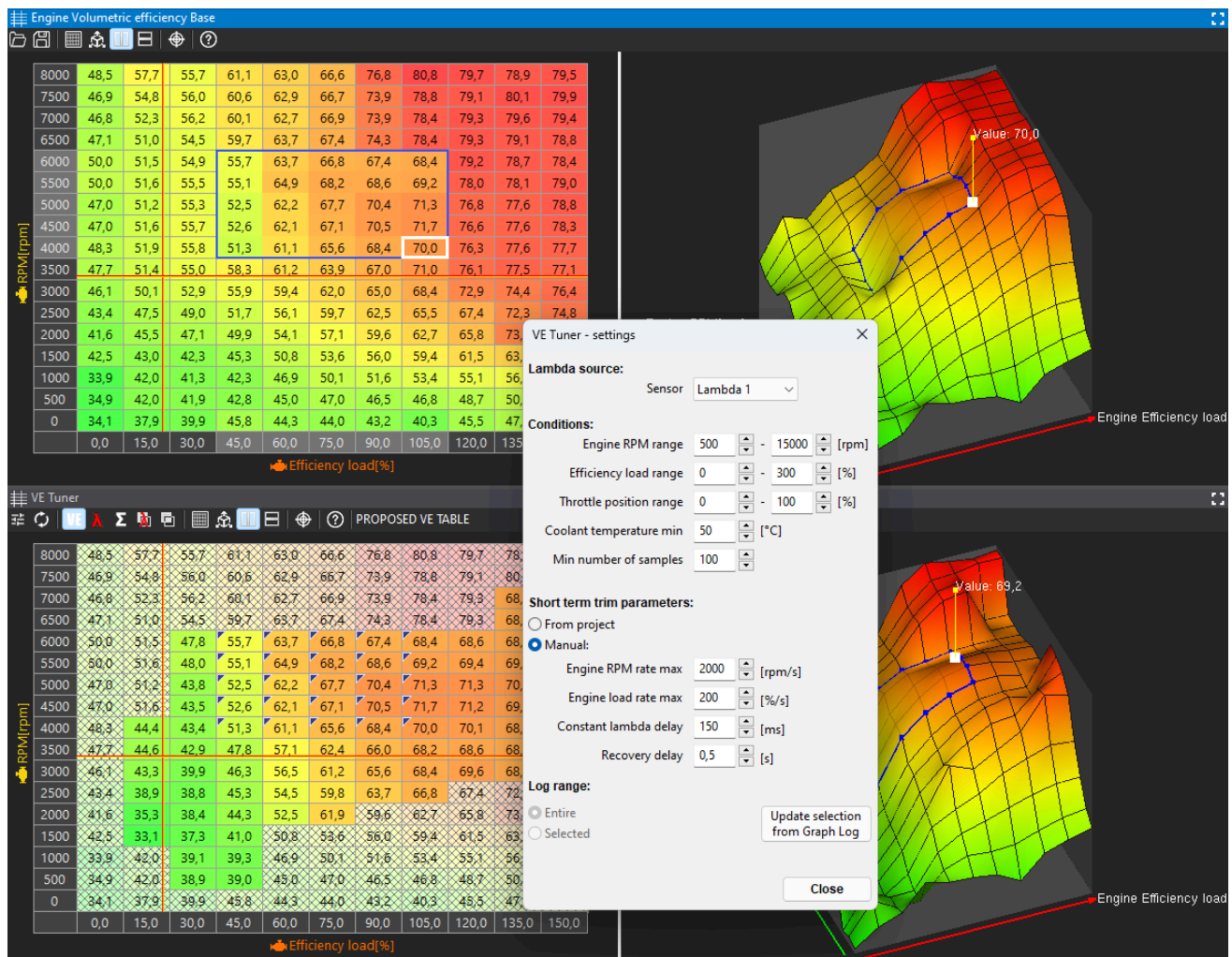
### Long term trim

For best results it is recommended to apply or clear Long term trim corrections before gathering data for VE Tuner calculations.

If separate Volumetric efficiency tables for two cylinder banks are required, they can be enabled by selecting the appropriate option in *Engine / Volumetric Efficiency / Bank 2 table mode*. These tables can then be tuned individually using the VE Tuner. For optimal results, it is advised to set the same size and axes for both tables and enable 25 Hz logging for the following channels:

- Engine Volumetric efficiency Bank 1
- Engine Volumetric efficiency Bank 2

## 12.5. Step by step Volumetric efficiency table tuning procedure:



1. Prepare *Volumetric efficiency* table that allows the engine to run and assure that in high engine load the mixture is rich
2. Prepare *Fuel Lambda target* table
3. For precise lambda delay value configure *Fuel Short term trim Lambda Delay*
4. Drive the car under different load / RPM conditions
5. Run the VE Tuner tool
6. Select the *Lambda* sensor whose data you would like to use and target the ***Volumetric efficiency* table for corrections**
7. Apply changes in desired *Volumetric efficiency* table cells
8. Correct unmodified (not visited during test drive) VE table cells manually to fit them to corrected ones. You can use Equalize function (E button on selected cells)
9. If ***Volumetric efficiency Bank 2 table mode*** is enabled, repeat from point 6 to apply corrections for Bank 2



10. Clear the log
11. Test the engine with a new *Volumetric efficiency* table. If needed, repeat the procedure from point 4 until satisfactory results are achieved

## 12.6. Channels used for data validation and calculations

- Engine Cylinders Cut
- Engine Efficiency load
- Engine Efficiency load Rate
- Engine RPM
- Engine RPM Rate
- Engine Volumetric efficiency
- Fuel Film State
- Fuel Lambda target
- Fuel Rail 1 Injectors Pulse width Average
- Fuel Rail 2 Injectors Pulse width Average
- Fuel Rail 3 Injectors Pulse width Average
- Fuel Short term trim Correction average
- Fuel Short term trim Correction 1
- Fuel Short term trim Correction 2
- Resources Lambda controller 1 Heater state
- Resources Lambda controller 2 Heater state
- Sensors Coolant temperature
- Sensors Lambda 1
- Sensors Lambda 2
- Sensors Throttle 1 position
- Engine Volumetric efficiency Bank 1
- Engine Volumetric efficiency Bank 2

## 12.7. Document history

Version	Date	Changes
1.0	2023.09.14	Initial release
1.1	2024.02.01	Adjusted to changes from software version 102.0
1.2	2024.04.03	Adjusted to changes from software version 103.0
1.3	2024.07.24	Changes from software version 103.0 made official

## 13. Appendix F - How-to Configure Fuel Film

### 13.1. Introduction

This document describes the Fuel Film strategy in EMU PRO and presents practical steps for the tuning process.

The Fuel Film strategy provides a way to make fuel corrections for sudden changes in the throttle position. Often called acceleration enrichment or wall wetting.

The concept of this strategy is to model the realistic behavior of the fuel sticking to the intake path and evaporating. Five main variables change the amount of fuel film formed on the walls:

- intake manifold pressure – higher pressure = larger film,
- air flow speed (represented by RPM) – lower RPM = larger film,
- engine temperature – lower temperature = larger film,
- intake charge temperature – lower temperature = larger film,
- relative fuel amount (represented by lambda target) – richer mixture = larger film.

Fuel film in the engine is controlled by adding or removing a specific fuel volume and tracking all those corrections. The strategy is making corrections to achieve the fuel film volume target set by the user. This film target is set in microliters for a single cylinder, and all corrections are controlled and tracked independently for each cylinder.

Corrections are applied after a sudden change in the film target and decay over time. The duration of that decay must also be set by the user. There are separate duration settings for increasing and decreasing the fuel film.

### 13.2. Channels

**Fuel Film State** – state of the strategy

**Fuel Film Volume** – the volume of the fuel film tracked by the strategy

**Fuel Film Correction** – currently applied fuel correction

**Fuel Film Target** – the current target for the film calculated from the base table and corrections

### 13.3. Parameters

**Fuel / Film / Activation / Instant correction max** – the amount of fuel film target change to activate the corrections

**Fuel / Film / Target / Base** – base table for setting the film volume target in microliters

**Fuel / Film / Target / Corrections** – tables with film target corrections in percent

**Fuel / Film / Increase duration / Base** – base table for setting decay time in milliseconds when increasing the film

**Fuel / Film / Decrease duration / Base** – base table for setting the decay time in milliseconds when decreasing the film

**Fuel / Film / Duration corrections** – tables with decay duration corrections in percent

## 13.4. Tuning requirements

- Good base fuel map
- Engine at operating temperature
- Disabled short term trim

## 13.5. Tuning process

Ideally, we want to isolate as many variables as possible. That's why the best way to tune fuel film is on a load dyno, keeping constant RPM, but it can also be done on the road or even without any load on the engine.

The first situation to tune is the worst-case scenario (for a warm engine). This means low RPM and the biggest change in manifold pressure. For most engines, we recommend starting with 2000 RPM. Engine speed should be relatively low but out of the idle range, so the idle control doesn't affect the tuning process.

To check the effects of fuel film, keep the engine at the RPM you chose. Next, push the throttle to 100% and hold it there for 1-2 seconds, then release it. Don't make a fast push of the throttle and immediate release because that creates a situation where you first need to add fuel and then remove it shortly after that, which makes tuning harder.

After the throttle stab, there will be a lean spike if there is insufficient fuel correction. Adjusting the correction is done by changing the fuel film target. Open the Fuel Film Target Base table and double all the values. Do the throttle stab again and check the effects. Repeat that process until you start seeing the positive effects of the fuel correction. Then you can begin dialing values more precisely. The maximum value in the table can be in the range from a few tenths to a few thousand microlitres, depending on the engine setup. Engines with ITB and injectors very close to intake

ports create low amounts of fuel film, while engines with long intake injectors far from the head and running on ethanol will have much larger film.

The decay duration should be adjusted to replicate the needed correction over time. If the duration is too short, the lambda after pushing the throttle will be correct initially but then will have a lean spot. If the duration is too long, there will be a rich spot after the correct lambda. Changing the duration might require additional fine-tuning of the film target.

The rest of the process is fine-tuning for different conditions. Use the correction tables for target and duration to adjust the film at different engine speeds, amount of throttle actuation, and temperatures.

## 13.6. Document history

Revision	Date	Changes
1.0	2024.03.07	Initial release

# 14. Appendix G - How-to Log Data to a USB Drive

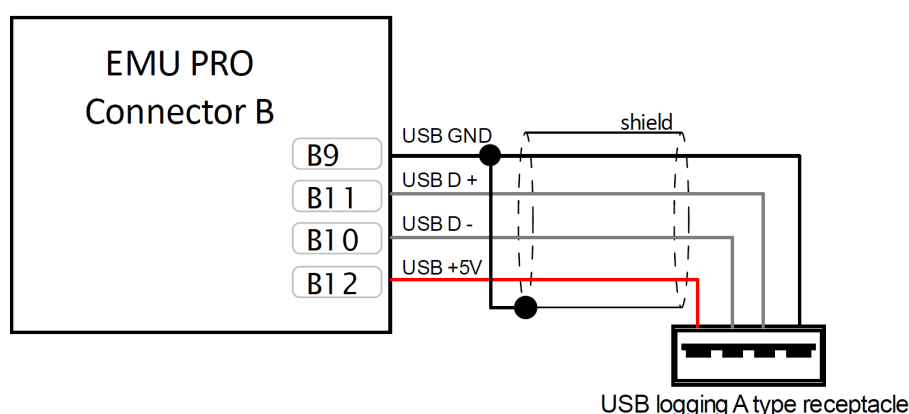
## 14.1. Description

The EMU PRO device allows users to log data directly to a connected PC or to an external USB drive, with a frequency of up to 500Hz. For logging without a PC, the USB setup must be properly configured. The logged data can be then analyzed to solve issues or further improve performance. This guide provides step-by-step instructions on how to enable and configure data logging, manage channels, adjust sampling rates, and monitor buffer usage to ensure efficient data recording. By following these steps, users will be able to tailor the system to their specific needs.

### 1. Connection Setup

Logging on EMU PRO requires proper wiring of the USB cable. Follow the connection diagram and ensure all connections are properly shielded to prevent interference. Logging is possible by connecting a USB female cable to the designated connector. Logged data will be saved directly to this drive. Use a drive formatted with the FAT32 file system, with a recommended size of 32 GB (logging capacity is approximately 11 hours per 1 GB).

Connection diagram



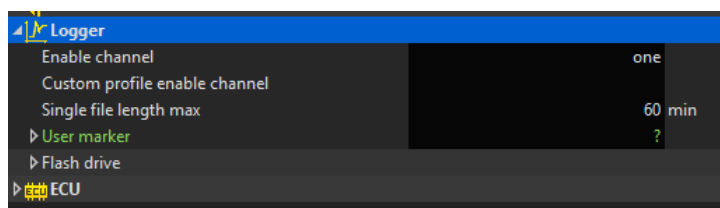
### 2. Enabling Logging in EMU PRO Client Software

In the EMU PRO Client software, navigate to the *Smart Grid* panel and go to the **Logger** category. To activate constant data logging, set **Enable channel** to 'one' (this is the default setting).

For advanced configurations, you can set *Enable channel* to a different channel. However, use this feature carefully, as logging will only be active when the specified channel's value is not zero. For most users, we recommend leaving this set to 'one' to ensure consistent data logging.

For more control, use the **Custom profile enable channel** to define a logging profile – specifying which channels are logged and at what sampling frequency.

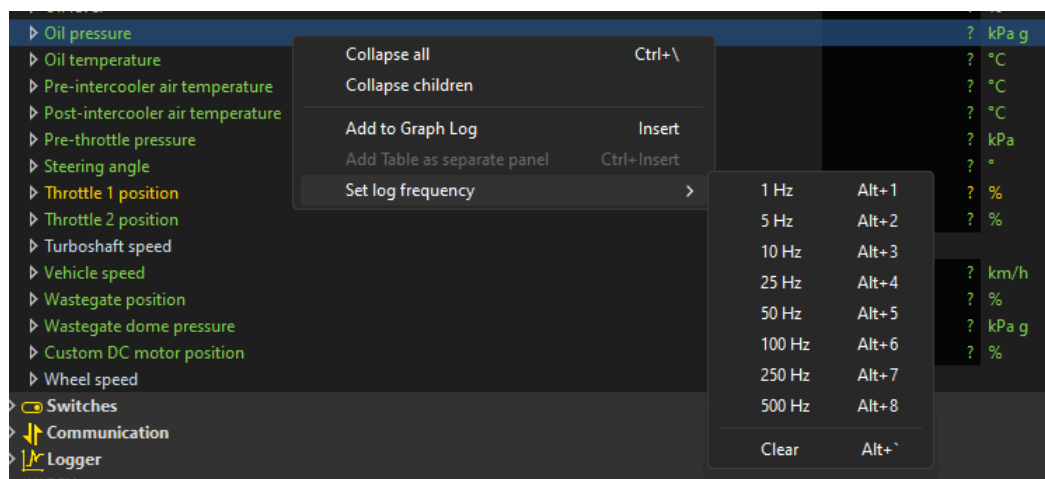
Note that the maximum duration for each log file is set by *Single file length max*; after this time, a new file will be automatically created.



### 3. Configuring Logged Channels

The maximum buffer size is 1024 B. Each data channel can be logged at a different sampling rate, which affects how quickly the shared buffer fills. It is essential to carefully select which channels to log and adjust their sampling rates to manage the available buffer capacity effectively. Higher sampling rates (e.g., 500 Hz) generate more data and fill the buffer faster, while lower rates (e.g., 1 Hz or 5 Hz) allow more data to be logged within the same buffer size. Additionally, certain critical channels, such as *Engine RPM*, have a minimum required logging frequency to ensure accurate data capture. Monitor and balance sampling rates to ensure the buffer can handle the total data load.

To change a channel's sampling rate, right-click on the channel and select **Set log frequency** from the context menu in any panel displaying channels (such as *Logged Channels*, *Graph Log*, or *Smart Grid*).



Regardless of the panel in which the change is made, the selected channel's sampling rate will be updated, and this change will be reflected in the **Logged Channels** panel, where the logging frequencies for each channel are displayed.

Alternatively, use the following keyboard shortcuts:

Alt+1 for 1 Hz,

Alt+2 for 5 Hz,

Alt+3 for 10 Hz,

Alt+4 for 25 Hz,

Alt+5 for 50 Hz,

Alt+6 for 100 Hz,

Alt+7 for 250 Hz,

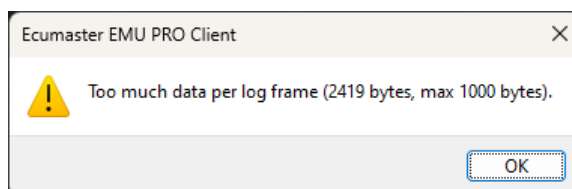
Alt+8 for 500 Hz,

Alt+` to turn logging off.

At the bottom of the *Logged Channels* panel, you can monitor the buffer usage, which shows the percentage of total buffer capacity used for both the Base Profile and Custom Profile. It also displays the number of logged parts and their size in bytes.

For Custom Profile configurations, users can define specific parameters that determine when logging should occur, allowing for more advanced control of the logging process. These profiles are particularly useful for conditional logging based on dynamic parameters.

If the buffer usage approaches the maximum limit, the software will prevent the configuration from exceeding it and display a warning message.





For more detailed information on the *Logged Channels* panel, refer to [https://www.ecumaster.com/files/EMU\\_PRO/EMU\\_PRO\\_Software\\_Guide.pdf](https://www.ecumaster.com/files/EMU_PRO/EMU_PRO_Software_Guide.pdf) in the *Logged Channels* chapter.

The EMU PRO Client software includes a status bar at the bottom of the main window, which provides quick access to real-time information about various system components, including the **USB logger state** and **USB buffer usage**. This allows users to monitor the condition of the connected USB drive and ensure logging operations are functioning properly without having to navigate to specific panels or sections.



#### 4. Setting the Real-Time Clock (RTC)

To ensure logs saved to the USB drive have correct and meaningful names, the device must have the correct date and time configured. This setting does not update automatically, it requires manual configuration in specific situations:

- **Initial Setup:** When configuring the device for the first time.
- **Time Zone Changes:** After moving the device to a different time zone.
- **Daylight Saving Adjustments:** When transitioning between standard time and daylight saving time.
- **Long-Term Power Disconnection:** If the device has been without power or battery backup for an extended period (e.g., over six months), the clock settings may need to be reconfigured.

Once set, EMU PRO maintains the date and time using its internal power supply, ensuring the settings persist under normal operating conditions.

Connect to the ECU using the EMU PRO Client software. From the top menu, navigate to **Devices / Set Real Time Clock**.

Without setting the RTC, log files saved to the USB drive may display incorrect dates and times, making it harder to organize and locate specific logs.

This setup allows efficient and controlled logging of data on EMU PRO, stored in organized, manageable log files.

## 14.2. Troubleshooting

If logs are not being created, or if the logs are incomplete, it's important to first check the *Logger Flash Drive State* channel in the **EMU PRO Client** software. This channel provides valuable information about potential logging issues. To check the status:

1. **Connect the device** to your PC.
2. **Insert the USB drive** to the USB receptacle wired to the EMU PRO.
3. **Monitor the value** of the *Logger Flash Drive State* channel.

This channel will provide a code that can help identify the specific issue with the logging process. Based on the status, you can then proceed with the appropriate troubleshooting steps

### 0: Disconnected

- **USB Wiring:** Ensure the USB drive is properly connected to the designated port on the device. Pay special attention to the D+ and D- wires, as it is easy to accidentally swap them; make sure they are correctly connected. Additionally, verify that proper shielding is in place to prevent interference.

### -1: Unrecognized file system

- **File System:** Verify that the USB drive is formatted to the FAT32 file system. Other formats are not supported.

### -2: Memory is full

- **Drive Health:** Confirm that the USB drive has sufficient free space. If the drive is full, delete unnecessary files to free up space.
- Use high-quality USB drives from reputable manufacturers (e.g., SanDisk, Kingston) to ensure reliable performance.

### -3: Memory too slow

- **Drive Health:** Ensure the USB drive has adequate read/write speeds. Slower drives may cause logging interruptions. Use high-quality drives from reputable brands to avoid this issue.

If the *Logger Flash Drive State* channel does not indicate a specific problem but logs are still not being created:

- **Enable Logging:** In the EMU PRO Client software, make sure logging is enabled. Navigate to the *Smart Grid* panel, go to the *Logger* category, and confirm that *Enable Channel* is set to 'one' (or to the appropriate channel for conditional logging).

- **Power Supply:** Verify that the device has a stable power supply. Power fluctuations or interruptions can disrupt the logging process. Use a reliable power source to avoid these issues.
- **Ensure Proper Shielding:** Proper shielding of all connections is crucial to prevent electromagnetic interference, which can disrupt the data logging process. Use shielded cables, particularly for the USB connection, and verify that the shielding is properly grounded. Poor shielding can lead to gaps or incomplete logs by allowing noise to interfere with data transmission.
- **Use a Short USB Drive:** Physically small USB drives are less prone to connection interruptions caused by vibrations. Larger USB drives may experience occasional disconnections due to their size and weight under vibration or movement conditions.

By addressing these issues, you can ensure reliable and consistent data logging on your EMU PRO device.

## 14.3. Document history

Version	Date	Changes
1.0	2024.12.17	Initial release

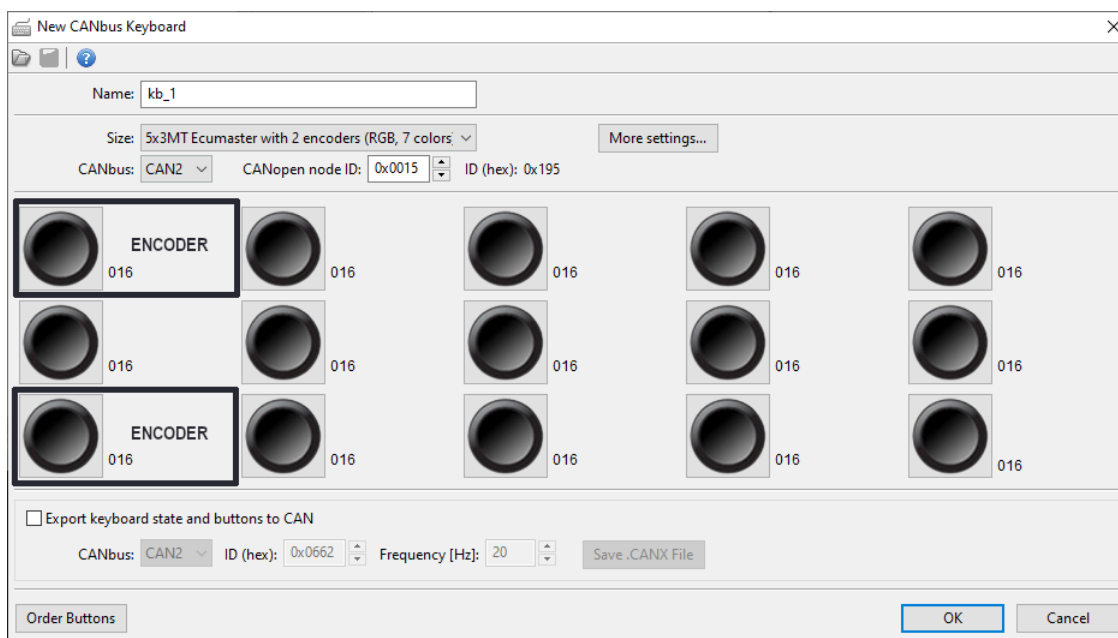
# 15. Appendix H - How To Configure 5x3MT Keyboard

## 15.1. Description

This guide explains how to set up the 5x3MT Ecumaster keyboard, which is equipped with 13 ordinary buttons and 2 rotary encoders. This guide focuses mainly on the configuration options for the encoders. For more general information on CAN bus keyboard support, see the EMU PRO Software Guide: [https://www.ecumaster.com/files/EMU\\_PRO/EMU\\_PRO\\_Software\\_Guide.pdf](https://www.ecumaster.com/files/EMU_PRO/EMU_PRO_Software_Guide.pdf).



To configure a keyboard, click Add in the Project Tree and then select CANbus Keyboard from the list or click the keyboard icon in the toolbar. Select the 5x3MT from the Size menu. The window will look as follows, with encoder positions marked with a frame:



Knowing the three types of encoder operations is essential for getting the best configuration:

### 1. **encoder**

Rotating the encoder adjusts the associated channel's value. Unlike a rotary switch, you have the flexibility to configure the encoder's range of values.

- *First state* - the lowest encoder state
- *Last state* - the highest encoder state
- *Default state* - after startup, the encoder will adopt its default state

### 2. **changer**

Operation in *changer* mode is similar to *encoder* mode but its main use is to change pages in the ADU. Turning the encoder clockwise moves to the next page, while turning counter-clockwise goes back to the previous page.

In changer mode, the LEDs illuminate in a fan-like pattern, offering a visual indication of the operating mode.

- *First state* - the number of the first page
- *Last state* - the number of pages in the ADU
- *Default state* - after startup, the page you want to start on
- *Wrap pages* - decide if the encoder should jump from the last page to the first and vice versa

For more information about the operation of the *changer* mode, see [Example \(on page 130\)](#).

### 3. **parameter controller** and **parameter selector**

You can use the keyboard encoder to control multiple settings. This is possible by setting it to *parameter controller* mode. For each setting you want to manage, select a button and set its mode to *parameter selector* mode. These selector buttons function like radio buttons, allowing you to choose one active parameter at a time that is modified by the knob.

Each *parameter selector* comes with its own range and state, updating the *parameter controller* when pressed.

- a. If there are no button presses defined as a *parameter selector*, *parameter controller* remains neutral and rotation has no effect.
- b. Pressing the button defined as a *parameter selector*, conveys the parameter information to the encoder. Encoder can change the state of the *parameter selector*.
- c. After pressing the currently selected *parameter selector* button again or pressing the *parameter controller*, the encoder returns to the neutral behaviour. (Pressing any other button (not defined as a *parameter selector*) will not cause the encoder to lose control of the *parameter selector*.)

Surrounding the encoder are 16 LEDs that visually represent the current state of the encoder. Default starting LED is at 9 o'clock, numbered clockwise. To change, go to *More settings*, adjust *Start offset for encoder LEDs'* from 0 to 15, with 0 as the 9 o'clock position.

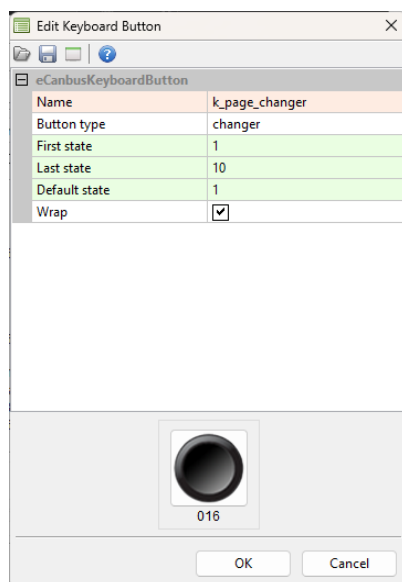
## 15.2. Example

We're configuring the 5x3MT to quickly navigate pages in ADU and finely adjust four parameters with the two rotary encoders. In this example, we'll use the top encoder for pages and the bottom one to control parameters.

### Changing pages in the ADU via the EMU PRO

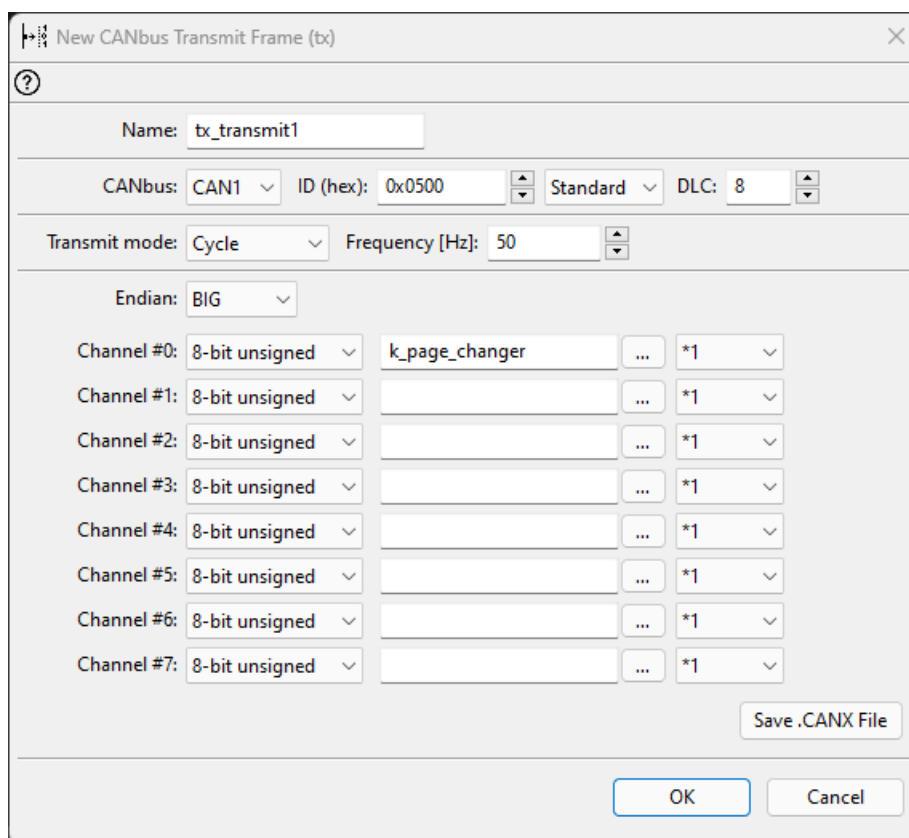
In the keyboard settings, select the top-left box for the rotary encoder. Set it as a *changer*. Determine the following parameters:

- *First state* - set to 1, to avoid confusion in page counting
- *Last state* - the number of pages in the ADU (remembering that it is not updated automatically - when you add or remove a page in ADU, it must be changed)
- *Default state* - after startup, the page you want to start on
- *Wrap pages* - decide if the encoder should jump from the last page to the first and vice versa

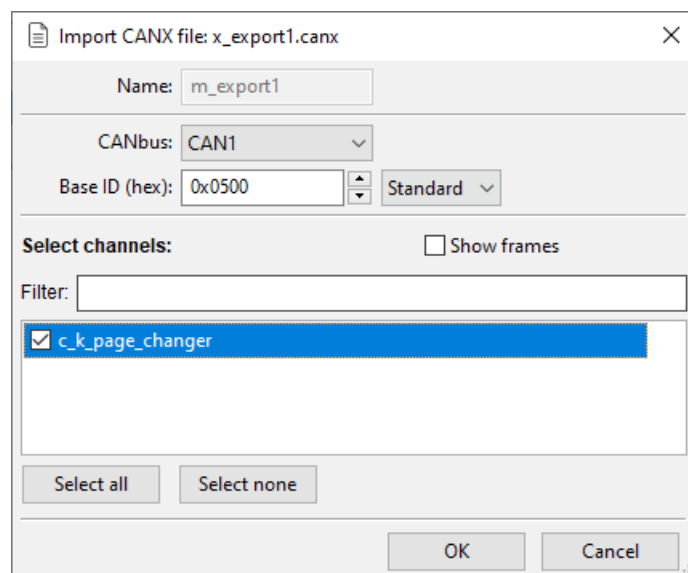


To enable page changes in the ADU, both the ADU and the EMU PRO must be connected to the same CAN bus. Start in EMU PRO, by adding CAN export in the Project tree. Remember to set correct CAN bus and an unoccupied ID. Select the channel that corresponds to the keyboard encoder set up in the previous step (*k\_page\_changer* in our example).

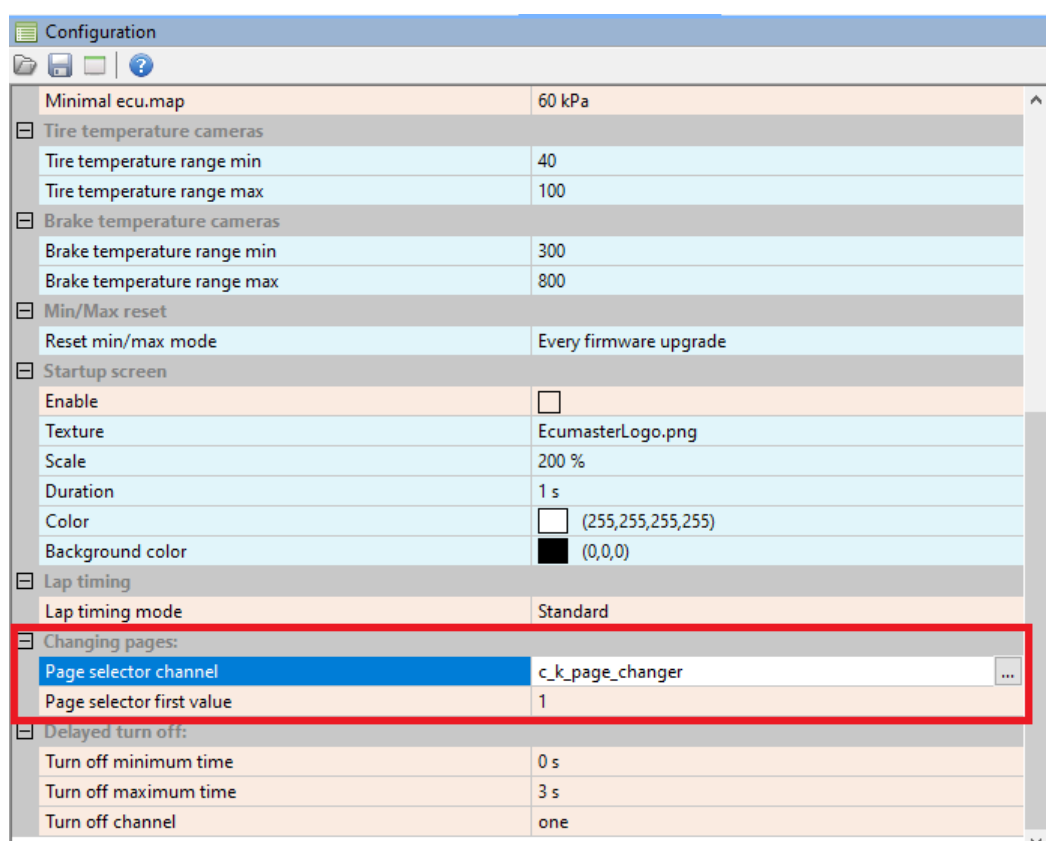
To streamline the import in the ADU, use *Save .CANX File* button.



In the next step, import the .CANX file created in the previous step into the ADU project.



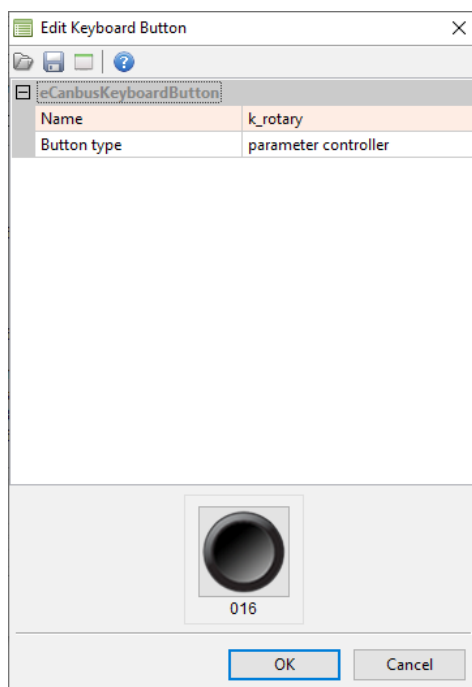
Then assign this imported channel in the *Configuration* panel to the *Page selector channel* and set *Page selector first value* as in the EMU PRO configuration, equal to 1:



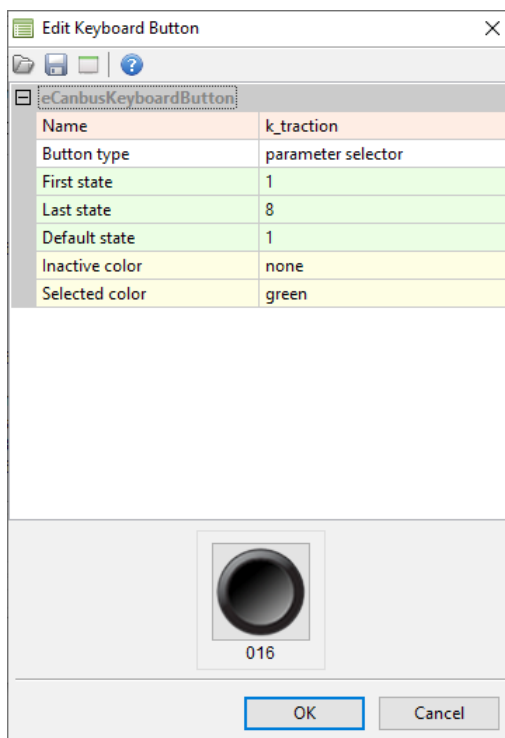
## Controlling multiple parameters

Back to the EMU PRO software, we aim to use the other encoder for controlling four parameters. Begin by selecting the bottom-left box and designate it as a *parameter controller*.

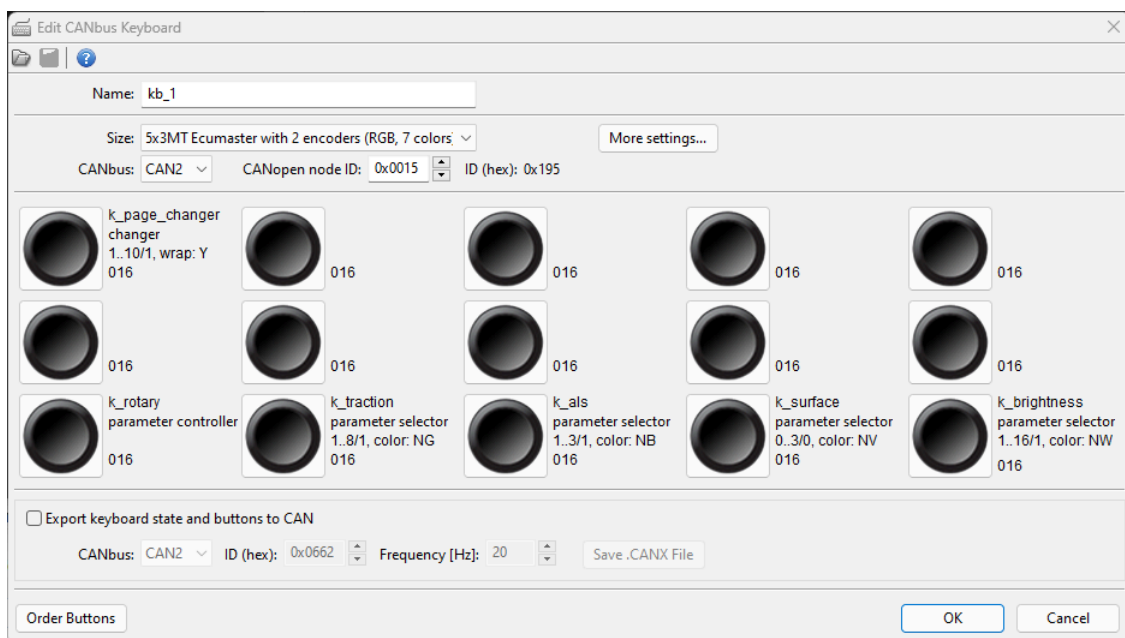




Now proceed to configure each parameter. For each of the four, choose one button, change its type to *parameter selector* and set the first, last, and default states to adjust their value range.



The final setup of our example keyboard looks as follows:



When the driver wishes to adjust a setting, they can press the corresponding button. The rotary encoder will activate, enabling them to change the parameter by turning it.

## 15.3. Document history

Version	Date	Changes
1.0	2024.07.26	Initial release

## 16. Appendix I - How-to Tune the GDI Engine

Due to its large size, this document is available as a separate file: [https://www.ecumaster.com/files/EMU\\_PRO/How-to/How-to\\_Tune\\_the\\_GDI\\_Engine\\_in\\_EMU\\_PRO.pdf](https://www.ecumaster.com/files/EMU_PRO/How-to/How-to_Tune_the_GDI_Engine_in_EMU_PRO.pdf)