
# EEZ BB3 User manual

*Modular T&M chassis*

Ver. 1.09 – 11/2022
www.envox.eu – github.com/eez-open

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# 1. Introduction

## 1.1. Legal notices

The information in this document is subject to change without notice.

Envox d.o.o. makes no warranty of any kind with regard to this manual, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.
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## 1.2. Contact Us

If you have any problem or requirement when using EEZ products or this manual, please contact Envox:

*Discord server:* *https://discord.gg/dhYMnCB*
*E-mail*: support@envox.eu
*Website*: www.envox.eu

## 1.3. Acknowledgments

Icons made by *pixel-perfect* and *freepik* from flaticon.com
Document created in OpenOffice / LibreOffice
Proofreading by *@xlfe*

## 1.4. Revision history

| Date | Version | Changes |
|---|---|---|
| 2020-05-10 | 1.01 | New calibration procedure<br>Firmware upgrade corrections |
| 2020-08-24 | 1.02 | Two modules display view<br>Display test<br>USB OTG, mouse and mass storage<br>Peripheral module firmware upgrade<br>Logged data transfer to a computer<br>Additional notice in calibration section |
| 2020-11-11 | 1.03 | Custom logo<br>Encoder & User SW settings page update<br>System information page update<br>Output INHibit page added<br>MCU module firmware upgrade instructions for Mac OSX<br>Scripting with MicroPython |
| 2021-02-11 | 1.04 | Firmware v1.6 new features<br>Fixed YT scroll and scan view pages<br>Redesigned Power / reset control page<br>MCU module version selection (System information)<br>Labels & Colors (Display settings)<br>Bargraphs scaling (Display view)<br>Redesigned Data logging settings page |
| 2021-04-01 | 1.05 | CE Declaration of conformity, RoHS Compliance Statement<br>Additional notice about MCU selection in firmware update section |
| 2021-06-30 | 1.06 | Firmware v1.7 new features<br>System settings page options without minimized module view<br>Function generator<br>DLOG viewer with bookmarks |

| | | |
|---|---|---|
| 2021-07-07 | 1.07 | Scripting section in General settings |
| 2021-09-23 | 1.08 | Chapter 17. Node-RED integration (*work in progress*)<br>Chapter 18. Troubleshooting (*work in progress*)<br>Chapter 19. MIO168 mixed I/O module |
| 2022-11-29 | 1.09 | Prohibit output enable if external voltage detected (Firmware 1.7.4) |

## 1.5. Who Should Use This Manual

This manual is designed for users who are familiar with basic electrical theory, especially as it applies to the operation of power supplies. This includes understanding of Constant Voltage and Constant Current operating modes and the control of input and output power, as well as the observance of safe techniques while making supply or pin connections and any changes in settings.

## 1.6. Safety Requirements

The EEZ BB3 is only designated for use in laboratory, residential, business, commercial or small business settings.

The EEZ BB3 should only be used for its designated purpose. You must observe all safety and usage instructions documented in this manual and the operating conditions and performance limitations as detailed in the data sheet.

This product documentation helps you to use a EEZ BB3 safely and efficiently.
Keep the product documentation in a safe place and pass it on to the subsequent users.

To avoid any injuries or damage to the EEZ BB3 or any device connected to it you must review the following safety advice carefully before operating the device. Only use the EEZ BB3 as outlined in this manual.

- Use an AC line power cord designed for the EEZ BB3 and authorized by your local regulations. Ensure it is not damaged in any way before connecting it.
- **The EEZ BB3 is grounded through the Protective Earth (PE) lead of the AC line power cord. To avoid electric shock, it is essential to connect the earth terminal of the AC line power cord to the Protective Earth terminal before any inputs or outputs.**
- To avoid fire or shock hazard, observe all ratings and markers on the EEZ BB3 and check your manual for more information about ratings before connecting.
- Do not connect the AC line power cord or operate the EEZ BB3 with its covers or panels removed.
- Make sure that fuses specified for installed modules and AC line voltage are installed.
- If you suspect that the EEZ BB3 is damaged or not operating correctly (e.g. the power up self-test failed or any function does not work as expected) disconnect the device and contact Envox support.
- Ensure adequate clearance to the rear panel cooling fan air intake. Inadequate ventilation may result in high temperature and premature or multiple triggers of the OTP (over-temperature protection).
- In order to avoid short circuit or electric shock, please do not operate the EEZ BB3 in a humid environment.
- In order to avoid damaging the device or personal injury, do not expose the device to flammable gasses.
- Keep EEZ BB3 surfaces clean and dry to avoid the influence of dust and/or moisture in the operating environment.
- Operate in an electrostatic discharge protective area to avoid damage induced by static discharge.

### 1.6.1. Risk of electric shock

The casing and all chassis parts are connected to a Protective Earth (PE) conductor. Disconnection of the earthed protective connection inside or outside the EEZ BB3 is prohibited.

### 1.6.2. Risk of electric shock due to exceeding low voltage protection

Output coupling of two power module in series provides voltage as high as 80 V. In this case, any contact with live components is life threatening. Only qualified and trained personnel should operate the EEZ BB3 and any connected loads.

## 1.7. Care and cleaning

Do not store or leave the EEZ BB3 where it will be exposed to direct sunlight for extended periods as this may result in damage to the TFT display.

It is recommended to clean the EEZ BB3 regularly according to its operating conditions. To clean the exterior surface, perform the following steps:

- Disconnect the EEZ BB3 from AC line power
- Use a lint-free cloth (with a mild detergent or water) to clean the loose dust on the outside of the EEZ BB3. Take extra care when cleaning the TFT display to avoid scratching it.

*WARNING: To avoid injury resulting from short circuit, make sure the EEZ BB3 is completely dry before connecting it to AC line power.*

## 1.8. Environmental Considerations

The following symbol indicates that this product complies with the applicable European Union requirements according to Directives 2012/19/EU on waste electrical and electronic equipment (WEEE) and batteries.

## 1.9. Product End-of-Life Handling

The EEZ BB3 may contain substances that could be harmful to the environment or human health. In order to avoid release of such substances into the environment and harm to human health, we encourage you to recycle this product in an appropriate system that will ensure that most of the materials are reused or recycled appropriately. Please contact your local authorities for disposal or recycling information.

# 2. Key features

The EEZ BB3 is a modular DC power supply with multiple isolated channels, combined power output up to 465 W, maximum voltage output ranging from 24 to 80 V and maximum current output of up to 10 A. The graphical user interface features a large color TFT touch-screen display combined with an incremental encoder providing a clear, responsive and easy to operate interface. Outstanding key features of the EEZ BB3 are:

## 2.1. General

- Modular and open-source design based on EEZ DIB v1.0 specification enabling multiple configurations and future-proof upgrading
- Three module slots for installation of different power modules in any combination
- Minimized wire harness and easily accessible modules simplify assembly, upgrade and maintenance
- High performance 32-bit ARM Cortex M7 master MCU
- Power output coupling *without* external wiring thanks to built in power relays that provide coupling in series, parallel or split rail for two modules and common ground for all three modules
- Down-programmer with high current capability (DCP405 module only)
- Full range auto-switch AC input (115 / 230 Vac)
- Low noise Ø80 mm cooling fan with speed algorithm based on multiple temperature sensors and output current readings
- Compact size: 290 (W) x 123 (H) x 240 (D) mm
- Free and open source software and open source hardware design

## 2.2. User interface and programming

- Large color 4.3” (470 x 272) TFT touch-screen display as human machine interface (HMI) for fast and simple navigation through all available options and each channel's detailed information
- Multiple color themes
- Encoder with switch plus user-defined switch complement the TFT touch-screen for even faster and easier navigation
- Ten user-defined profiles with power-up recall control
- Calibration wizard
- High programming and readback resolution for applications with the highest demands
- Independent real-time voltage, current and power measurement of all installed channels
- Four display modes: numerical, horizontal bar, vertical bar and YT-view
- Two YT-view modes (cursor or data scroll) and with high refresh rate (down to 10 mS)
- Output Enable (OE) synchronization and sequencing with programmable delays
- Arbitrary waveform generation function with user friendly GUI for both voltage and current
- Multi-channel tracking function
- Simple to use data logger and viewer
- File manager
- USB DFU firmware upgrade for master MCU and slave MCUs on peripheral boards
- Trigger system with various inputs (manual, software, digital input, etc.)
- Comprehensive SCPI support (300+ commands)
- MicroPython scripting
- MQTT support for IoT networking
- Cross-platform (Linux, OS X, Windows) EEZ Studio comes with intuitive HMI editor and provides centralized control, programming, data acquisition and analysis of multiple EEZ BB3 and 3rd party SCPI-enabled instruments. Free to download

## 2.3. Connectivity

- Remote control via Ethernet or USB interface
- Removable Micro SD card
- 10/100 Mbit/s Ethernet with Auto-negotiation and Auto-MDIX
- USB FS with OTG (virtual COM port, mass storage, mouse support)
- RTC with battery backup and NTP synchronization (via Ethernet)
- Digital control lines (2 x input + 2 x output, buffered and protected)

## 2.4. Protections and controls

- AC soft-start (inrush current limiter) and standby control
- AC input protection (MOV, VAR, SAR)
- Multiple channel- and system-wide protections against over-voltage, over-current (with

electronic fuse function), over-power and over-temperature with adjustable trip delay
- Remote sense reverse polarity protection (DCP405 module only)
- Fast over-voltage protection with triac crowbar (DCP405 module only)
- User interface lock function with password protections

For a detailed specification, refer to the data sheet.

# 3. Operation Environment

- Location: Indoor, no direct sunlight, dust free, almost non-conductive pollution (note below)
- Relative Humidity: < 80 %
- Altitude: < 2000 m
- Temperature: 0°C to 40 °C

(Pollution Degree) EN 61010-1:2001 specifies the pollution degrees and their requirements as follows. The EEZ BB3 falls under degree 2. Pollution refers to “addition of foreign matter, solid, liquid, or gaseous (ionized gases), that may produce a reduction of dielectric strength or surface resistivity”.

- Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence.
- Pollution degree 2: Normally only non-conductive pollution occurs. Occasionally, however, a temporary conductivity caused by condensation must be expected.
- Pollution degree 3: Conductive pollution occurs, or dry, non-conductive pollution occurs which becomes conductive due to condensation which is expected. In such conditions, equipment is normally protected against exposure to direct sunlight, precipitation, and full wind pressure, but neither temperature nor humidity is controlled.

## *3.1. Storage environment*

- Location: Indoor
- Relative Humidity: < 70 %
- Temperature: −10 °C to 70 °C

# 4. Unpacking and Checking the EEZ BB3

To remove the EEZ BB3 from its packaging and check the equipment for completeness, proceed as follows:

- Check the package for damage
- Carefully unpack the EEZ BB3 and the accessories
- Check the package contents for completeness using the *Delivery list* and package contents
- Check the equipment for any visible shipping-related damage or other mechanical problems, e.g. loose parts inside

If there is damage or anything missing, contact the supplier and the carrier who delivered the EEZ BB3. Do not operate the EEZ BB3 in this case.

*Retain the original packing material. If the EEZ BB3 needs to be transported or shipped later, you can use the material to protect the exposed and fragile elements on the front panel.*

The EEZ BB3 must be stored in dry, closed, indoor premises. If the EEZ BB3 was transported under extreme temperatures, it is recommended that you allow a minimum of two hours to reach the appropriate temperature before operating the EEZ BB3.

## *4.1. Delivery List*

### 4.1.1. Assembled unit

The EEZ BB3 comes with the following components:

- EEZ BB3 preloaded with selected peripheral modules
- AC mains cable for the selected region
- *Thank you* leaflet with links to online documentation
- Set of DC power cables, clip-on probes and crocodile clips (optional)

### 4.1.2. Kit version (crowdfunding version)

*The EEZ BB3 kit is not an end user product. As such it was not put into any conformance testing and it may not comply with some or any technical or legal requirement that are applicable to finished products including, without limitation, directives regarding electromagnetic compatibility, FCC, CE, or UL.*

Assembling and using the EEZ BB3 requires an understanding of electronic circuits. Additionally, basic computer knowledge is recommended for performing firmware upgrades.
The EEZ BB3 comes in different kit versions. Typical content of the kit version:

- Enclosure kit
- Wire harness, nuts&bolts package
- Set of basic modules (i.e. AUX-PS, MCU and BP3C)
- Set of selected peripheral modules
- *Read me first* leaflet with links to online documentation
- Set of DC power cables, clip-on probes and crocodile clips (optional)

Kit assembly instructions are available on the following link: https://bit.ly/2VtWsZu

## *4.2. Placing the EEZ BB3*

If the EEZ BB3 is operated on a bench top, the surface must be flat. You can place the EEZ BB3 horizontally, or in a slope position by unfolding the front feet.

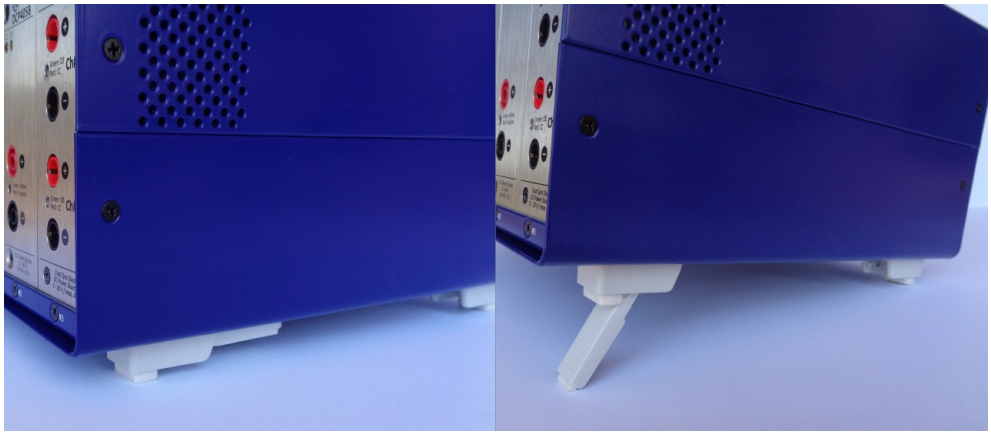


*Fig. 1: Adjustable front feet*

The feet can fold in if they are not folded out completely or if the EEZ BB3 is shifted. Collapsing feet can cause injury or damage the EEZ BB3.

- Fold the feet completely in or out to ensure stability of the EEZ BB3.
- Never shift the EEZ BB3 when the feet are folded out.
- When the feet are folded out, do not work under the EEZ BB3 and avoid placing anything underneath.

The front feet in folded out position can break if they are overloaded. The overall load on the folded out feet must not exceed 50 N. If the front feet are folded in, it is possible to stack the EEZ BB3 with more instruments securely.

## 4.3. Starting the EEZ BB3

The EEZ BB3 is equipped with an AC power supply connector, (IEC C14 type) which can be used with different AC power voltages in wide range without need to adjust manually input voltage or frequency.

*IMPORTANT: The EEZ BB3 must only be connected to an outlet that has a functional ground contact*

- Check the AC line voltage.
- Check the fuse type and if necessary replace the fuse type suitable for the line voltage.
- Connect the EEZ BB3 to the AC mains using the supplied power cable.

## 4.4. Replacing the fuses

The EEZ BB3 has main power fuses, which are located on the rear panel of the unit. Handling the fuses while power is on can lead to electric shock. Therefore, before opening the fuse holder (see Fig. 2), make sure that the EEZ BB3 is disconnected from AC power.


*Fig. 2: Opening the fuse holder*

To replace the fuses the EEZ BB3 has an externally accessible fuse holder combined with the IEC socket.

The nominal current of the fuse depends on the line voltage and number of installed power modules. Select the fuses according to the voltage of the AC line, as specified in Table 1. Fuse size is 20 x 5 mm of *time-lag* type and has to be rated for the selected AC line voltage.

| No. of power modules | 1 | 2 | 3 |
|---|---|---|---|
| *115 V* | *2 x 3.15 A* | *2 x 6 A* | *2 x 8 A* |
| *230 V* | *2 x 2 A* | *2 x 4 A* | *2 x 6 A* |

*Table 1: Fuses selection*

## 4.5. Battery replacement

The CR2032 coin cell battery is used as a power backup for the RTC. It uses a non-rechargeable lithium battery that will need to be replaced when its voltage drops to approximately 90 % of its rated value. The current battery value can be viewed on the *System information* page.

To access the EEZ BB3 interior, First, turn off the EEZ BB3 and unplug the power cord from the back, then remove the top cover, which is secured by four screws (two on each side).

Fig. 3 shows where the battery is located. You can remove the existing battery by pinching it. When inserting a new one, keep in mind the polarity (+ side must face inwards).

Do not use metal pliers instead of your fingers to insert or remove the battery as it may cause a short circuit. If you cannot reach the battery with your fingers, use a plastic tweezers instead.

*Do not expose the battery to high temperature or fire. Keep it out of the reach of children. Improper change of a battery may cause damage, fire or explosion.*

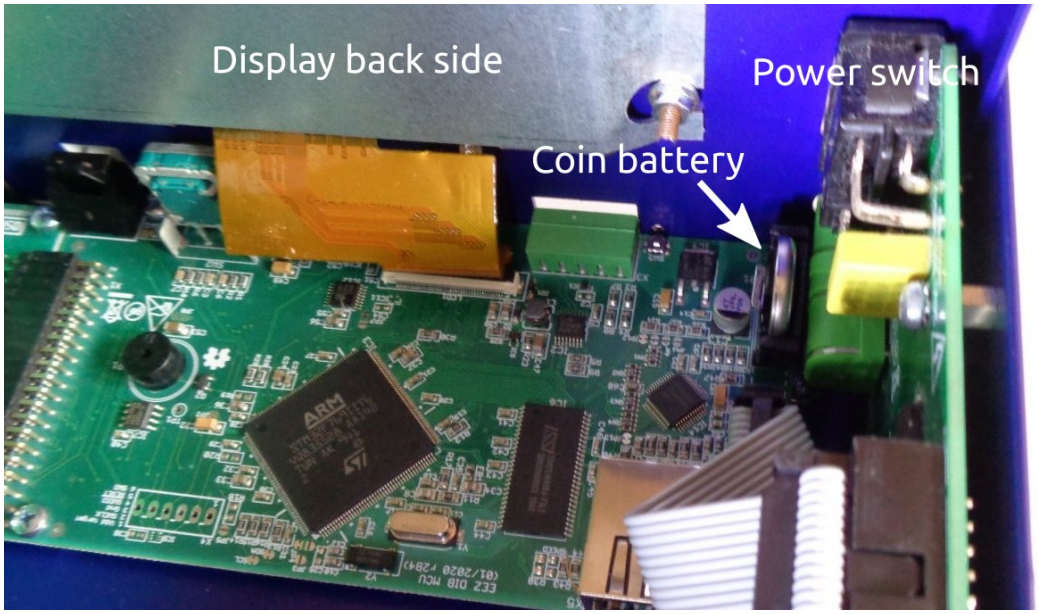




*Fig. 4: Coin battery location (MCU r3B3)*

## 4.6. Micro SD card (non-volatile memory)

The EEZ BB3 uses a micro SD card as a non-volatile memory. Due to its small size, extra care will be required when inserting and pulling out to prevent damage to the card or socket.

Attention should also be paid that the card is inserted correctly into the socket otherwise it could fall inside the enclosure. Therefore, it is recommended that the EEZ BB3 be completely switched off (not in standby mode!) when the card is inserted.

Fig. 5 shows how the card should be positioned when inserted: its connectors should be facing up (i.e. must be visible).


*Fig. 5: Micro SD card insertion*

# 5. The EEZ BB3 overview

## 5.1. Front panel overview


*Fig. 6: Left side of the EEZ BB3 chassis front panel*

**1** 4.3” (480 x 272) color TFT touch-screen display, 16-bit (65536) colors with brightness and luminosity control: used for local system and module specific parameter display and settings.

**2** AC mains power switch: turns the EEZ BB3 on and off.

**3** Standby indicator: on when EEZ BB3 is in standby mode (power modules AC mains power is switched off).

**4** Protective Earth (PE) 4 mm socket.

**5** Master MCU *BOOT0* miniature tactile switch access hole (*MCU r2B4 only*): when pressed on start up the EEZ BB3 enters a special bootloader mode for system firmware uploading.

**6** Digital I/O terminals (two input and two output, protected)

**7** Micro SD card with card detection switch.

**8** 5-pin USB Mini AB socket (with OTG support)

**9** Incremental encoder with switch

**10** User-defined tactile switch can be assigned to perform selected action e.g. entering inhibit mode, taking screenshot, manual triggering, etc. (see *User SW*). In the version with MCU module r3B3 it is also used to enter a special bootloader mode.

## 5.2. Module front panels overview

The EEZ BB3 can accommodate up to three modules. An example with three power modules are shown on Fig. 7.


*Fig. 7: Right side of the EEZ BB3 chassis front panel*

**1** Operation mode indicators: *CC* – Constant Current mode, *CV* – Constant Voltage mode, *Rprog* – Remote programming is active (DCP405 only), *Sense* – Remote sensing is selected (DCP405 only)

**2** Advanced options input terminals (DCP405 only): Remote programming, Remote sensing and PE. If PE is used for shielding remote sensing cable, connect it on one side only to avoid creation of ground loop.

**3** Positive output (Vout+) power connector, 4 mm, "floating" (i.e. galvanically isolated from the MCU module ground, therefore not connected to the PE potential).

*Warning: The potential on this point could be up to 80 V on slot #1 when two power modules are coupled in series.*

**4** OE (Output Enable) indicator, bi-color: Green – output is active and uncoupled, Red – output is active and coupled.

**5** Negative output (Vout-) power connector, 4 mm, "floating"

**6** Positive output (Vout+) power connector, 4 mm (DCM220 only)

**7** Channel indicator, bi-color (DCM220 only): Green – output is active in CV mode, Red – output is active in CC mode.

**8** Negative output (Vout-) power connector, 4 mm (DCM220 only). Please note that Vout- of Ch1 and Ch2 are on the same potential but still "floating" (i.e. not connected to PE potential).

## 5.3. Rear panel overview

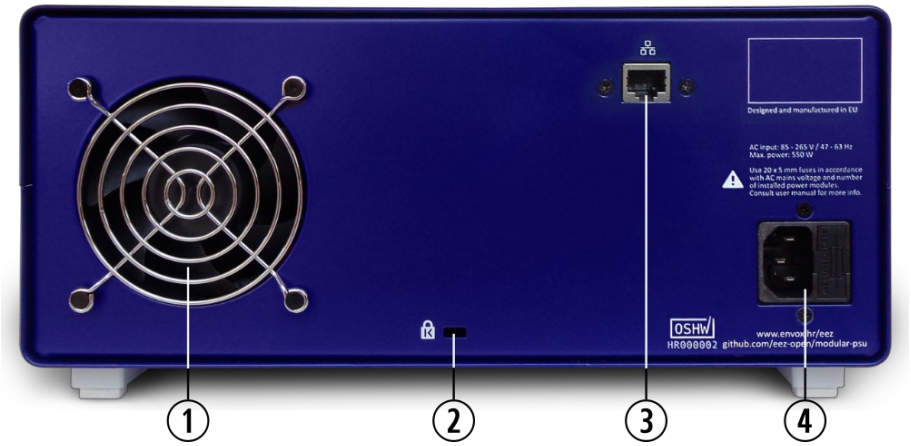



*Fig. 8: The EEZ BB3 rear panel*

**1** Low noise Ø80 mm cooling fan with speed algorithm based on multiple temperature sensors and output current readings.

**2** Kensington Security Slot™ (K-slot) for anti-theft cable.

**3** RJ-45 Ethernet socket (10/100 Mbit/s)

**4** AC power inlet with two 20 x 5 mm fuses

## 5.4. Display pages overview

The color display is used as a primary means of user interaction. Its content is dynamically rendered in order to enable quick and structured access to a multitude of system and module specific parameters. The touch-screen completely eliminates the need for specialized function keys, dedicated numeric keypad, etc. It takes no more than a couple of clicks to access any function, prioritizing access to those functions that are more important or used more frequently.

Fig. 9 shows home page of the EEZ BB3 loaded with three different power module (see Fig. 7) using the default view (*numeric*) for presenting output states, and measured and set values. This module configuration (i.e. DCP405 and DCM220) will be used as an example throughout this manual.

Items 1 to 3 are module specific while the rest (displayed on the status bar) are used for accessing various system options.

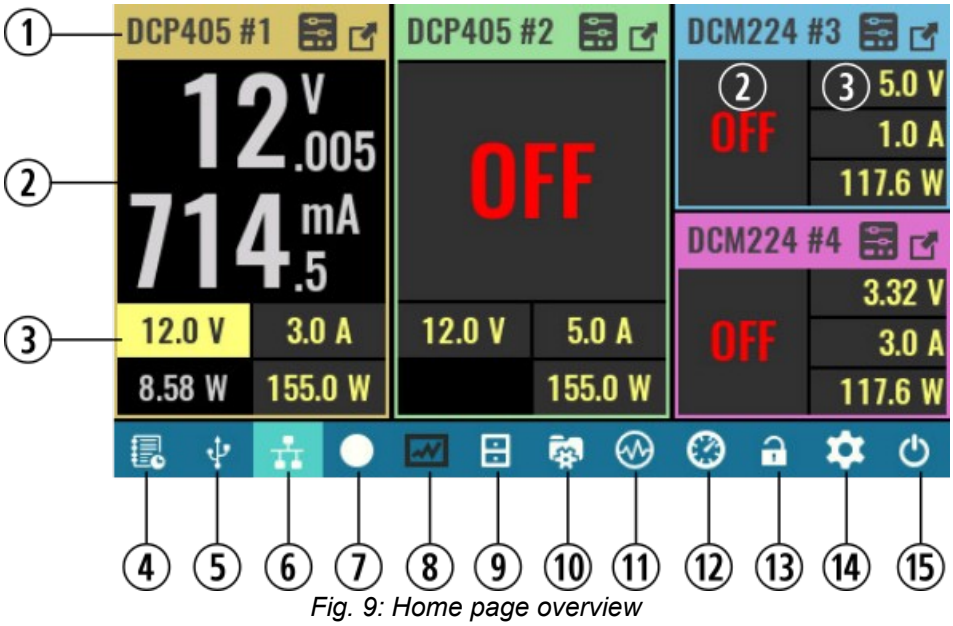



*Fig. 9: Home page overview*

1 **Channel header**: for better distinction between modules different colors are used for each header. Module name and assigned channel number are displayed together with shortcuts to channel settings (a shortcut to set or clear protection modes – If any have been tripped – and a channel "maximize" button).

2 **Channel main display section** contains information about measured output voltage and current. Units of measurement are also displayed depending on the measured value (i.e. mV or V for voltage or µA, mA or A for current.

*Note – this section looks different for 2-channel modules such as DCM220 due to more limited display area.*

3 **Channel supplemental display section** is used for set output voltage, current and power. Additionally is used for displaying measured output power together with related units of measurement (mW or W).

*Note – this section looks different for 2-channel modules such as DCM220 due to more limited display area.*

4 **Event view**: View the event log. The icon color will change color if unread warning or error messages have been added to the log.

5 **USB activity** indicator and shortcut to serial communication settings. The icon is not visible if USB/serial communication is disabled and its background becomes highlighted if USB/serial communication is established.

6 **LAN activity** indicator and shortcut to the Ethernet communication settings. The icon is not visible if Ethernet communication is disabled and its background becomes highlighted if LAN communication is established.

7 **Recording / Stop**: Data logger control. Use to start data logging or to stop logging before a defined end.

8 **Data log view**: if logging is in progress it displays real time data. When logging is completed or stopped, it will display data from the last log.

9 **File manager**: Allows access to data on a SD card such as user profiles, program lists, logged data or screenshots. Logged data and screenshots can be uploaded to EEZ Studio with one click.

10 **User profiles**: 10 different profiles (with auto-recall function) are available for saving and recalling module parameters.

11 **Function generator**: a simple signal generator of several predefined waveforms.

12 **Display view selection**: toggle between five different presentations of output module parameters (default is numeric view – as shown on Fig. 9).

13 **Display lock/unlock**: when locked all local user interaction via touch-screen display will be disabled until the same option is selected again. Unlocking is not possible without entering valid system password (the system password is *not* defined by default).

14 **System settings**: use it to access system-wide protection settings, display, sound, trigger, digital I/O, date & time, Encoder and user switch, AUX temperature & fan control, Ethernet, Serial/USB and channels calibration

15 **Power / Reset control**: allows access to standby, "soft" reset (see also *RST), "hard" reset (equivalent to power up reset) and option to turn off display

## 5.5. Module display views

Five different views are available to satisfy various use cases as well as user preference for numeric or graphic representation of measured output values.

Regardless of the selected display view and color theme each channel will be represented in consistent order with its assigned color. The same convention is also used when a channel is displayed over the whole screen (e.g. in the case of *Protection mode settings or the channel settings* page). In those cases where a channel is maximized the channel color is visible on the status bar instead of the header area.

*Fig. 10: Display view icon*

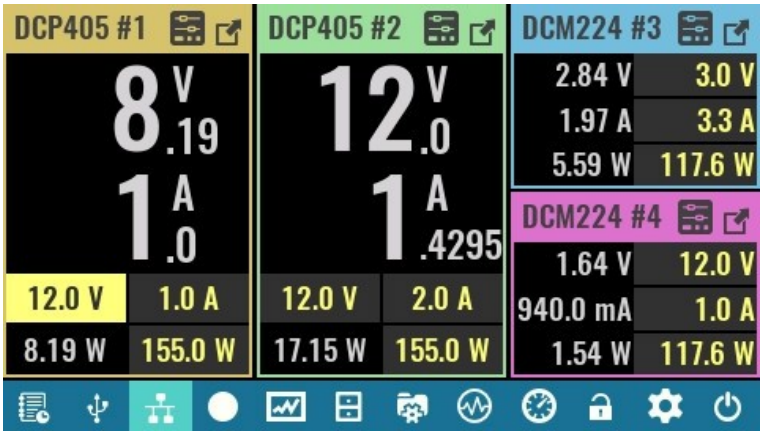
Use icon shown on Fig. 10 to toggle between all available display views.

**Numeric**

Default display view with the largest font used to show measured voltage and current.

Output values of 2-channel modules like DCM220 are displayed with a regular font size due to lack of space.

SCPI
```
DISPlay:VIEW 1
```




**Vertical bar**

This view is useful when the output values are changing rapidly.

Currently measured values are displayed with regular font size, hence user has to be closer to the EEZ BB3 to read the displayed values.

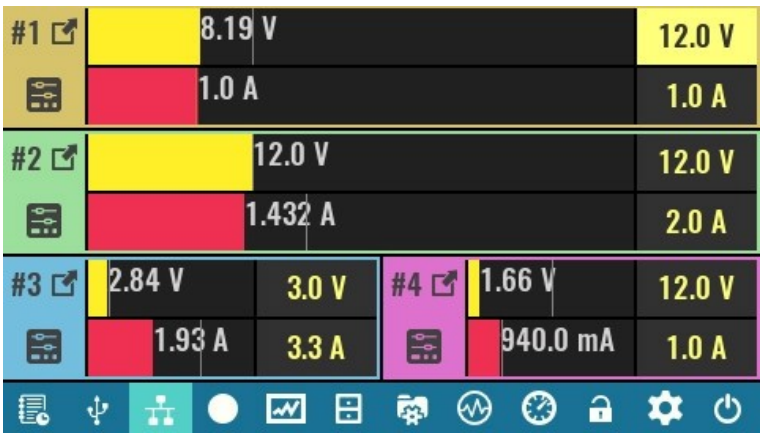
SCPI
```
DISPlay:VIEW 2
```


**Horizontal bar**

Similarly to previous view but output values are displayed as horizontal bars.

This view allows graphical presentation of the 2-channels modules, too.

SCPI
```
DISPlay:VIEW 3
```

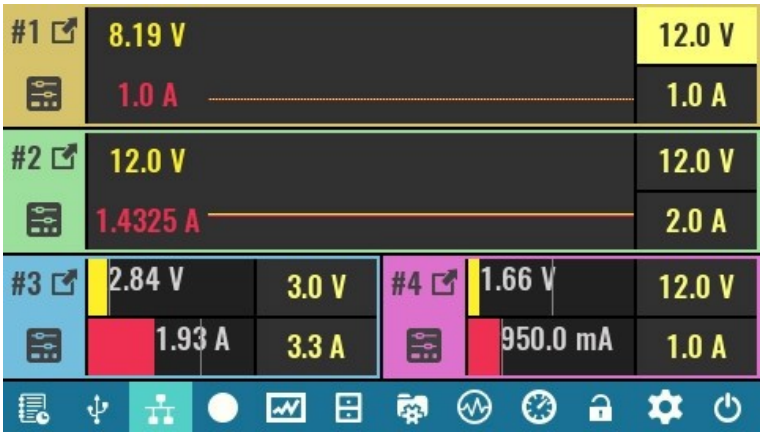


**YT view (scan)**

Similar to the previous view but a moving cursor is not used, and all data displayed moves from right to left with the speed defined by *YT view sampling rate* (default is 100 ms).

This type of presentation is also known as *roll* mode.

SCPI
```
DISPlay:VIEW 4
```

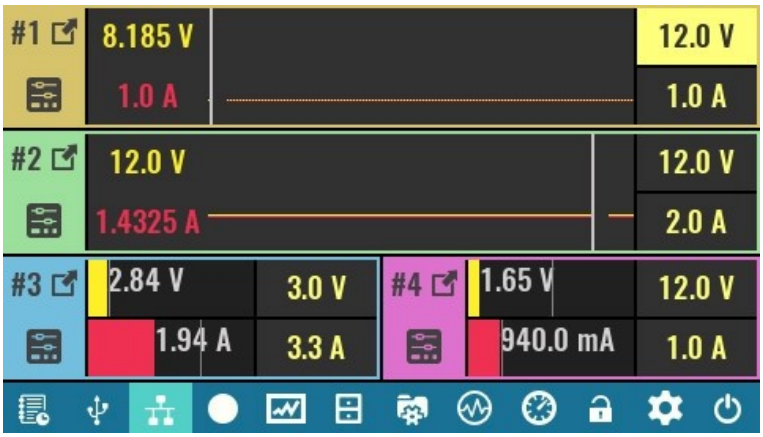



**YT view (scroll)**

Measured values are displayed on the Y-axis of a 2D graph. The cursor position moves with the speed defined by *YT view sampling rate* (default is 100 ms).

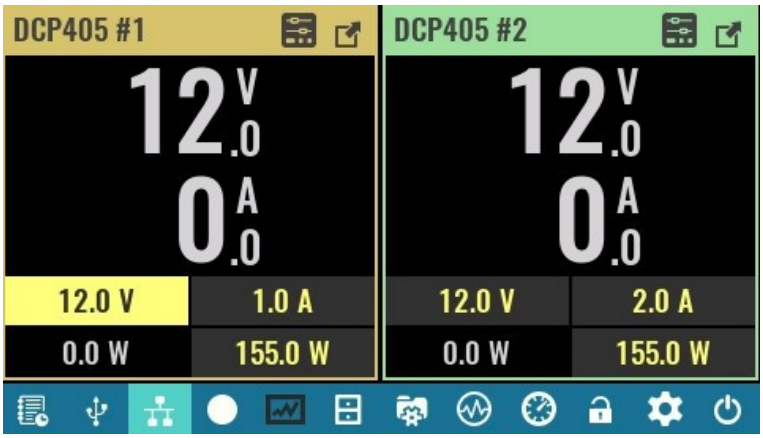
The cursor moves cyclically – rewriting older data with new data.

SCPI
```
DISPlay:VIEW 5
```

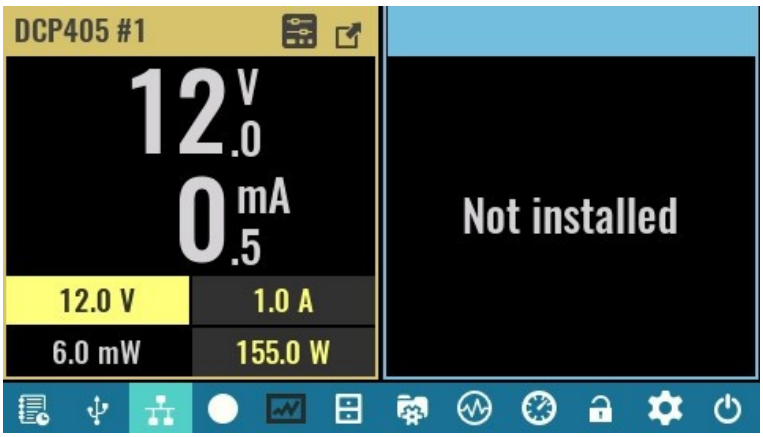



### 5.5.1. Two modules display view

When all three slots are not filled with modules, two modules display view is used otherwise one third of the screen would be unused (in that part the message *Not installed* would be displayed continuously).

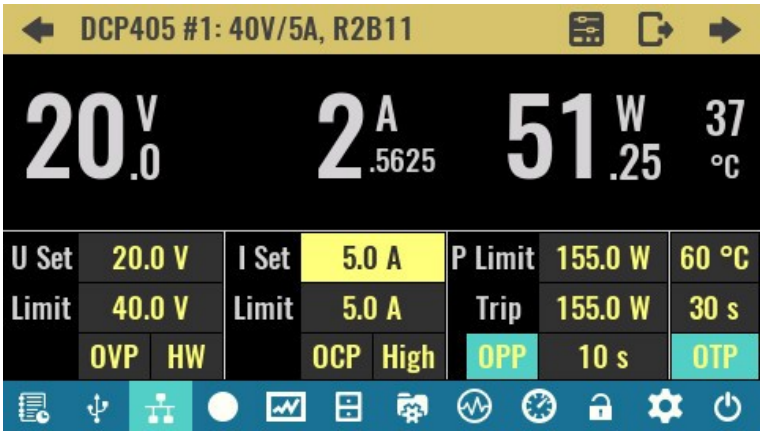



However, if only one module is installed and no maximized view is used, a *Not installed* message will be displayed on one half of the screen.

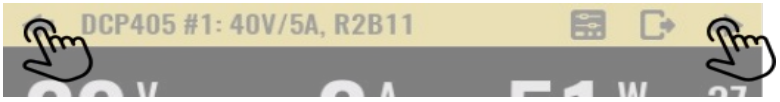


### 5.5.2. Maximized module view

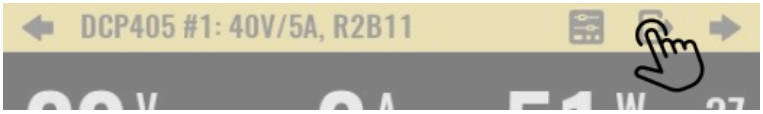
Module resources can also be displayed across the entire page by selecting the *Maximized* view option from the module header.




Once the maximized view is selected it is possible to navigate between the modules using the left and right arrows. The modules shown will also be in maximized view.

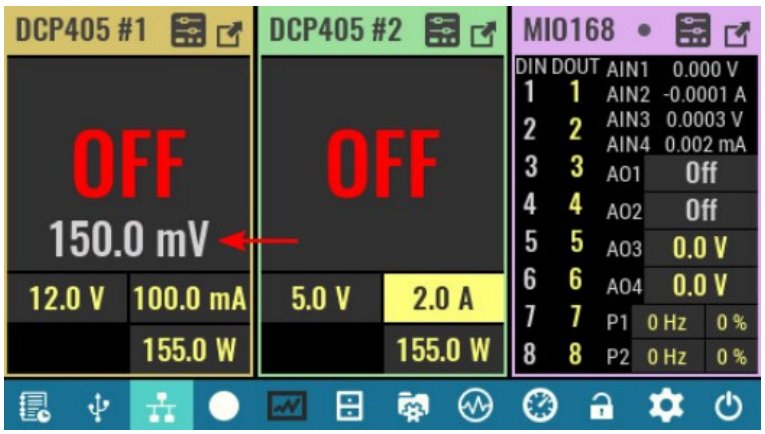



The *Minimized* option is used to exit the maximized view.




### 5.5.3. Display voltage when output is disabled (DCP405 only)

The measurement and display of the voltage at the output terminals will continue even when the output is disabled. If no load is connected through which the output capacitor would be discharged, the residual voltage will be displayed (below OFF text), flashing red while this voltage is greater than 500 mV. Display of the measured voltage will stop when it drops below 100 mV.




This feature can be useful to check whether the battery you were charging may have been left connected or the measured voltage comes from some other source, which is the reason why you should check the wiring before the next activation of the output.

# 6. Getting started

## 6.1. Powering on

Before switching on check that *Safety Requirements* are observed. Connect the AC line power cable to the IEC power socket on the rear panel and switch on the main power switch on the front panel. The welcome page will appear (Fig. 11) and a self-test procedure will be performed to detect the installed modules and diagnose any error conditions which may inhibit normal operation.

*The EEZ logo on the welcome page can be replaced with a custom logo in .jpg or .bmp format which can be max. 480 x 136 pixels in size. The image file should be stored in the root (/) folder on the SD card (*logo.jpg *or* logo.bmp*).*

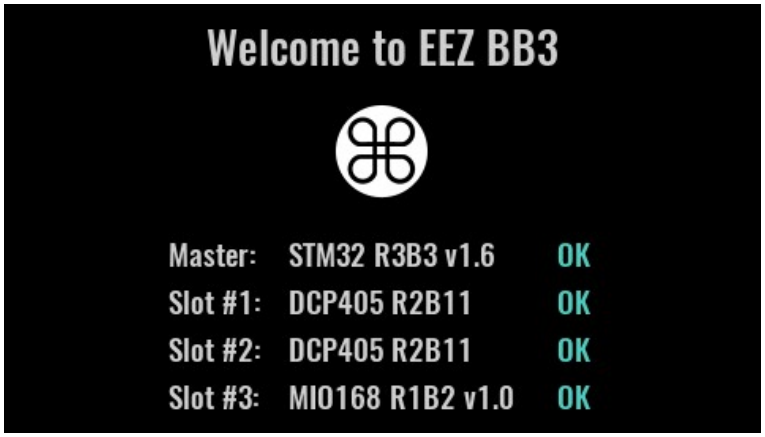



*Fig. 11: Welcome page*

The channel output state is defined in the selected user profile. A special option in *System settings* can also be set which overrides the state set by the particular selected user profile.

The default display view is *numeric* and the default color theme is *dark*. Both can be changed. The home page of the 4-channel configuration example is shown in Fig. 12:

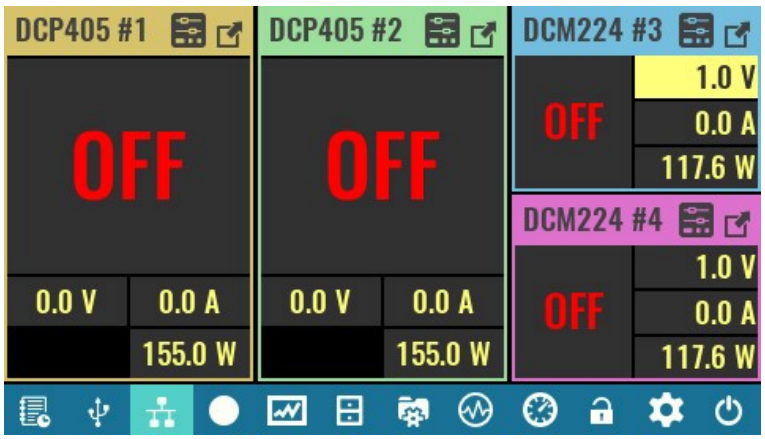



*Fig. 12: Home page on first start (with three modules installed)*

## 6.2. Standby mode and switching off

The EEZ BB3 offers two options to switch off / power down: entering standby mode or using AC power switch on the front panel. In both cases all installed modules are disconnected from AC power. In standby mode the MCU module remains powered (as indicated by the *Standby* indicator on the front panel). Fig. 13 shows the user interface prior to entering Standby mode and the info message that is fading out. To resume normal operation from standby mode, tap any part of the display and wait a moment for the power-up procedure to complete.


*Fig. 13: Entering standby mode*

SCPI

```
SYSTem:POWer OFF
```

The main power switch on the front panel can be used in any situation to immediately cut off AC power. However, if it is not an emergency situation, it is recommended to initiate a graceful shutdown that ensures that the latest information are stored in non-volatile memory. Use the option as shown in Fig. 14 and wait until the message appears that your EEZ BB3 can be switched off using the front panel switch.


*Fig. 14: Initiate safe shutdown*

# 7. Basic operations

## 7.1. Turn channel output on and off

**Turn channel on (OE on)**

Turning the channel output on is performed by taping anywhere inside the main channel display area.
The changed output state is indicated by display of the measured output values instead of “OFF”.

SCPI

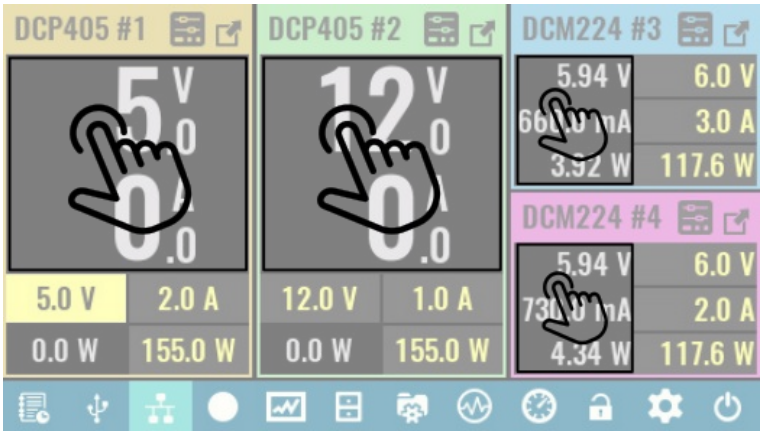
```
OUTPut ON
OUTPut ON, <channel>
```


**Turn channel off (OE off)**

Turning the channel output off is performed by taping anywhere inside the main channel display area. The content of that area will be replaced with “OFF”.

SCPI

```
OUTPut OFF
OUTPut OFF, <channel>
```




## 7.2. Set channel output values

Channel output values can be set regardless of the currently selected display view and channel output state as long as a trigger mode is not active (i.e. channel’s trigger is set to *Fixed*).

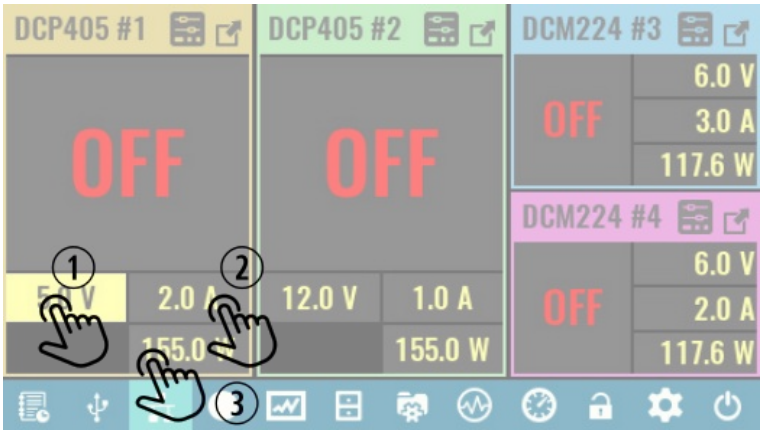
By default clicking the encoder switch navigates between editable parameters; when a parameter is highlighted (as shown in the figure below) its value can then be set with the encoder knob.

1 **Set output voltage**

Tap inside the *voltage* area of the channel secondary display area. If it is already selected (as shown), a keypad will appear as described in *Data input methods*. The voltage set here is the max. output voltage when channel is in CV mode.

SCPI

```
VOLTage <voltage>
```



**2** **Set output current**

First tap the *current* area of the secondary channel display. A second tap is required if this option was not selected previously (as in the above example).
The current set here is the max. output current when channel is in constant current (CC) mode.

SCPI
```
CURRent <current>
```

**3** **Set output power limit**

Follow the above described procedure.

*Note that when a power output limit is specified, it is the product of the voltage and current parameters used to calculate the output power limit rather than the actual measured output values. For example, if power limit is set to 100 W (DCP405) then set current cannot exceed 2.5 A for a max. voltage of 40 V. Similarly the output voltage cannot be set above 20 V if max. current is selected as 5 A even if the actual measured output current with a connected load is well below the set limit.*

SCPI
```
POWer:LIMit <power>
```

## 7.3. Data input methods

In addition to the physical rotary encoder on the front panel there are three touch-screen options to enter data. Two of those (*Step* and *Slider*) can be used in *non-confirmation* (default) or *confirmation* mode, or, in combination with the encoder knob. All data input methods are accessed from the same popup menu with the three options shown as tabs on the right side. Tapping the icon will display that particular data input tab.

**Keypad**

**1** This is the default data entry option.
The keypad is used to enter a new value for the parameter that is displayed in the header (Ch1 voltage in this example).

You can also select unit of measurement if more then one is available (e.g. mV and V for voltage).

This data entry method always requires confirmation.

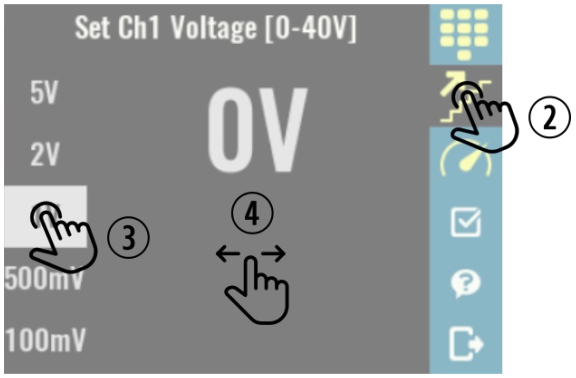

**Step**

**2** Tap on *step* method icon.

**3** Select step value or increment.

**4** Sliding across the main part of the window will increase (right) or decrease (left) the value of the selected parameter using the increments selected.

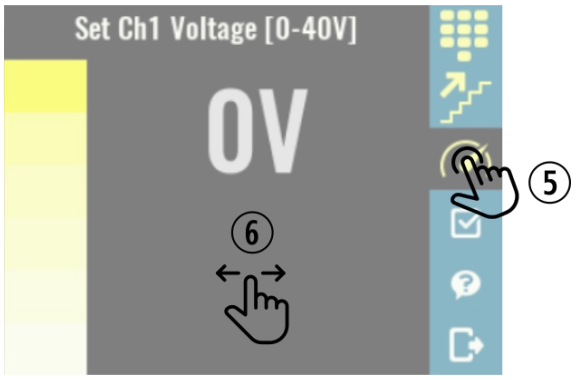
The encoder knob can also be used to change the value. (1 V is the selected increment in this example).




**Slider**

**5** Tap on *slider* method icon.

**6** Sliding across the main part of the window will increase (right) or decrease (left) the value of the selected parameter.



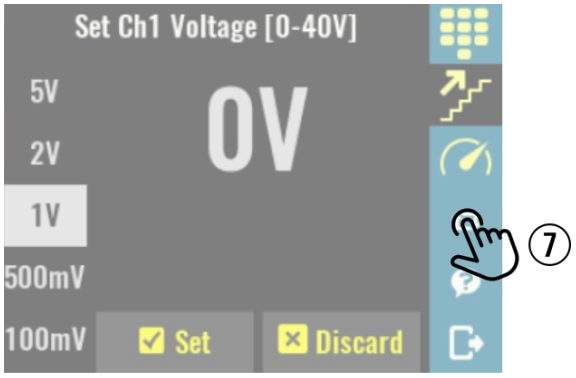

**Confirmation mode**

**7** Confirmation mode blinks the new value of the setting until it is confirmed by pressing the *Set* button, at which point the new value is applied. The parameter value can be reset to the previous value using the *Discard* button.

The set and discard buttons are shown on the bottom of the screen.

To enable or disable confirmation mode tap the checkbox icon on the right.

Note: confirmation mode can be used in *Step* and *Slider* input modes only.




## 7.4. Accessing channel protections and settings

The EEZ BB3 firmware includes comprehensive control of each power module and the feature list goes well beyond the basic operation of setting and displaying output parameters. Other channel specific functions are shown in the *Protections and settings* page.

The channel *Protections and settings* page can be reached whenever the channel is in regular or maximized view.

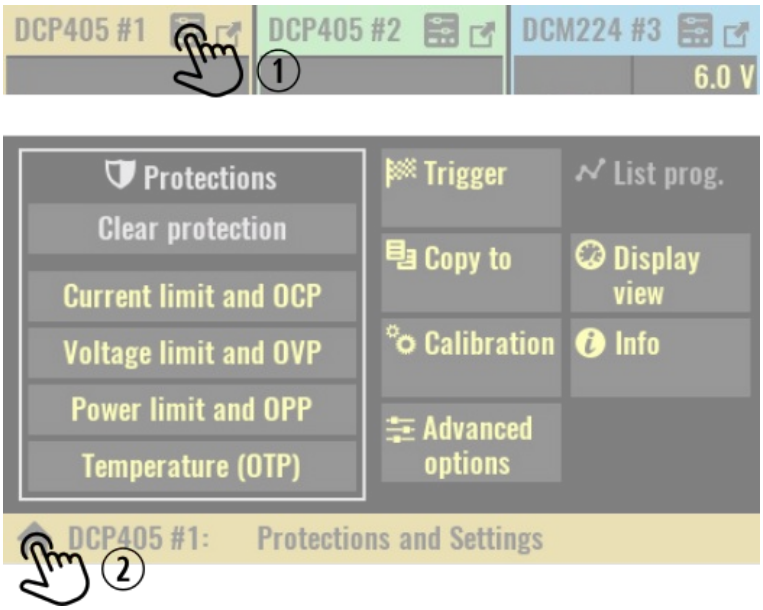
Note that if any of channel's protection modes have tripped, tapping the *Protection* icon will take you to the *Clear / Disable protection* page – regardless of whether the channel is in regular of maximized view.

**1 Access protections and settings in regular view**

Select the channel whose settings you want to change and tap on its *Protection* icon.

A new page with channel's protection section and channel settings will be displayed.

Availability of certain options depends on the channel mode (e.g. when channel is in tracking or coupling mode *Calibration* is disabled) and capability (e.g. DCM220 module does not have any *Advanced options*).

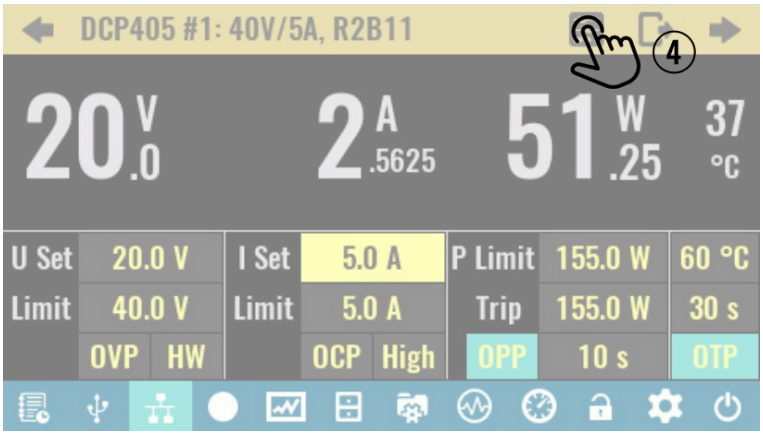


2 Exit *Protections and settings* page.

3 **Access protections and settings from maximized view**

If channel is in regular view, tap on the channel's *Maximize* icon.


4 Tap on its *Protection* icon.



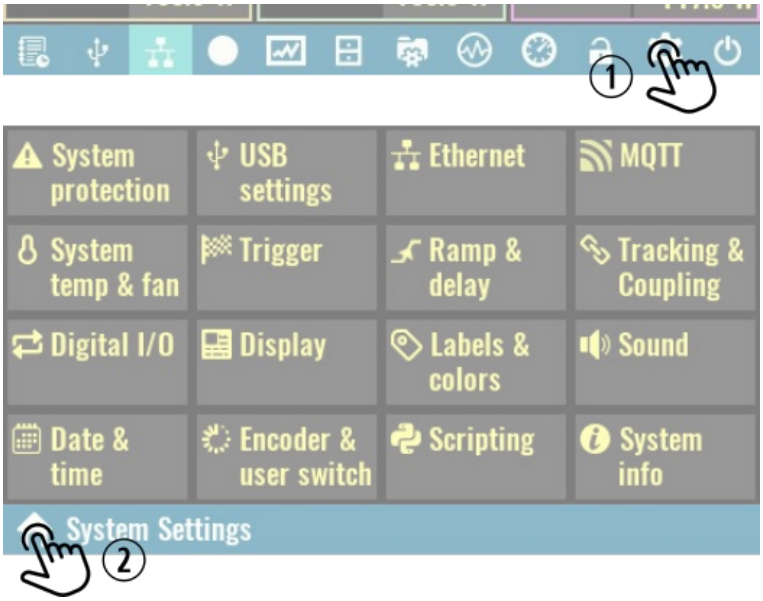

## 7.5. Accessing system settings

1 Tap on *System settings* icon on the status bar.

The number of available options depends of firmware version.

When System settings page is displayed it is still possible to check channel's output state and values (e.g. in this example all outputs are turned off).

2 Exit *System settings* page.



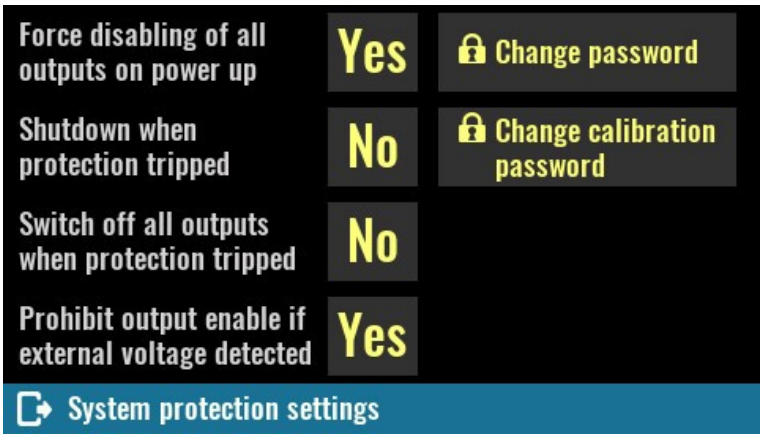

# 8. System settings

- System protection
- USB settings
- Ethernet interface
- MQTT
- System temp & fan
- General Trigger
- Ramp and delay
- Tracking and power outputs coupling
- Digital I/O (incl. UART settings)
- Display
- Labels & colors
- Sound
- Date & time
- Encoder & user switch
- Scripting
- System Info

## 8.1. System protection

Parameters in this section define channel output states on power up and options when a protection mode is tripped to prevent or reduce the possibility of damaging the connected loads.

Additionally, the system password that is used to unlock the display and calibration password can be defined or changed here.




**Force disabling of all outputs on power up**
Active by default this option ensures that all channel outputs will be switched off on power up to prevent connected loads from being damaged unintentionally.

SCPI
```
SYSTem:PON:OUTPut:DISable ON
```

**Shutdown when protection tripped**
When selected, any protection mode that is tripped on any channel will automatically put the EEZ BB3 in standby mode.

SCPI
```
SYSTem:POWer:PROTection:TRIP ON
```

**Switch off all outputs when protection tripped**
Similar to the previous option except instead of entering standby mode all channel outputs will be turned off.

SCPI
```
OUTPut:PROTection:COUPle ON
```

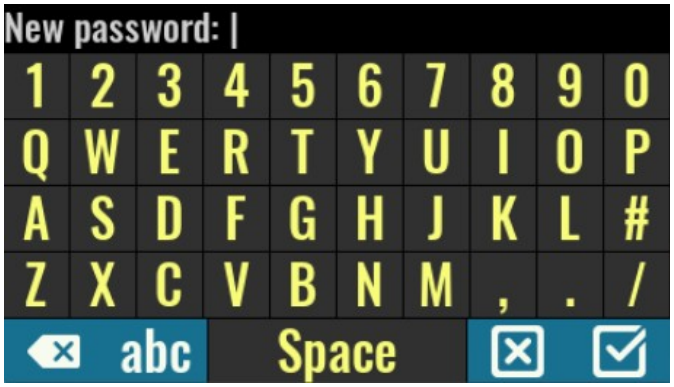
**Prohibit output enable if external voltage detected**
DCP405 power module only: active by default this option enables the voltage on the output terminals to be monitored even when the output is disabled. When it is active, the output cannot be turned on as long as the measured voltage is greater than 500 mV.

*It is strongly recommended that this option be active when the DCP405 module is used to charge batteries. In this case, it will not be possible to enable power output with the battery connected, because that will lead to an OVP trip, and if HW OVP is selected, it may damage the crowbar circuit. This option will force you to first enable the output and only then connect the battery you want to charge.*

SCPI
```
OUTPut:PROTection:MEASure ON
```

**Change password**
The system password is used to unlock the display. By default system password is not defined ("") and it may contain up to 16 characters. Minimum length is 4 characters. The new password is automatically stored in non-volatile memory.

When selected an on-screen keyboard will appear. Characters entered will be replaced with * shortly after entry. The new password has to be entered twice.

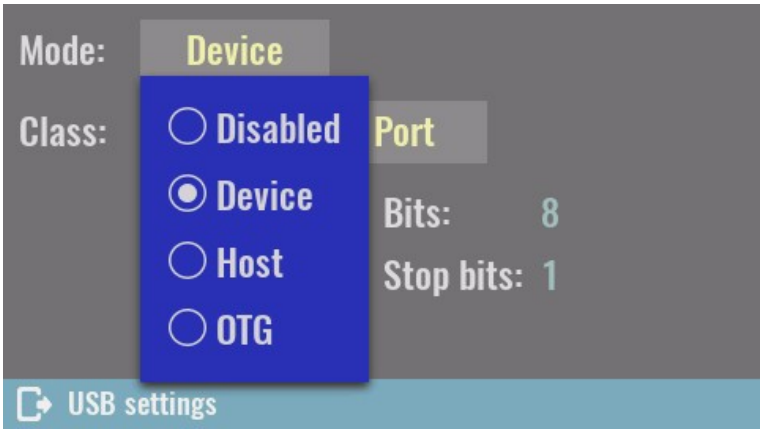


SCPI
```
SYSTem:PASSword:NEW {<old>}, {<new>}
```

**Change calibration password**
The calibration password is used to secure access to calibration data. Unlike a system password this password is defined by default (*eezbb3*) and has to be entered first before new password can be entered.
The calibration password may contain up to 16 characters. Minimum length is 4 characters.
The new password is automatically stored in non-volatile memory.

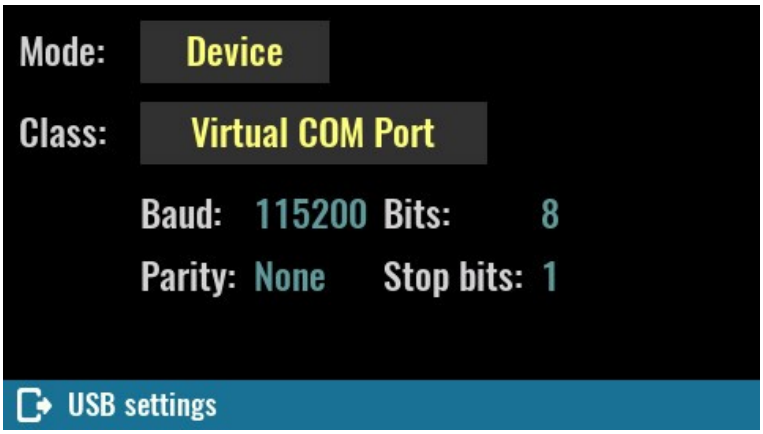
SCPI
```
CALibration:PASSword:NEW {<old>}, {<new>}
```

## 8.2. USB settings



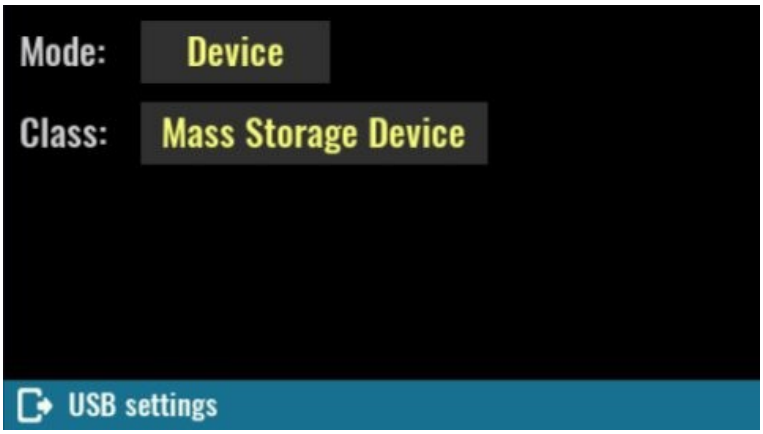

**Mode**
Defines the operating mode or turns off the USB interface.

SCPI
```
SYSTem:COMMunicate:ENABle {<bool>}, USB
SYSTem:COMMunicate:USB:MODE
```




**Virtual COM Port**
Defines activity of the serial interface over USB connection (i.e. Virtual COM port).
When selected serial communication parameters will be displayed (*Baud*, *Bits*, *Parity* and *Stop bits*).

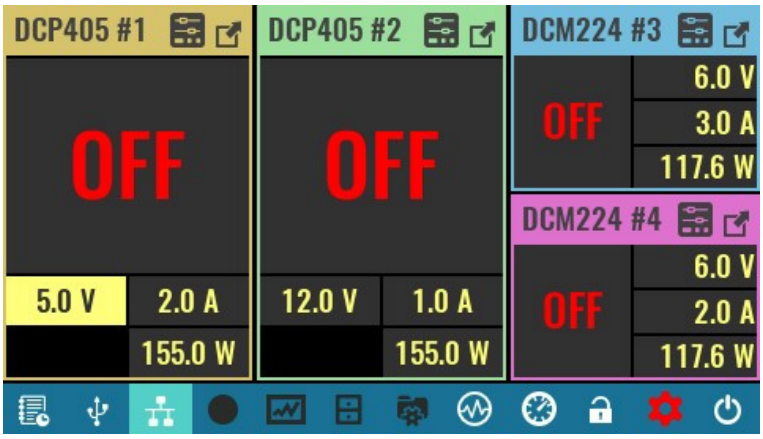
SCPI
```
SYSTem:COMMunicate:USB:CLAss VCOM
```




**Mass storage device**
When this class is selected the operating system of the connected computer will see the installed SD card as a mass storage device. It will be possible to work with the SD card as well as other disks (browse, read, write, delete, create new folders, rename, etc.)

The selection of this class will be valid until the next restart when it will return to *Virtual COM port* again.

*IMPORTANT: when the SD card is in this mode, EEZ BB3 cannot save events to log, access file manager, user profiles, etc.*
*For this reason, there will also be disabled icons in the status bar, and the system settings icon will turn red because the status of the SD card will change to* Not present.

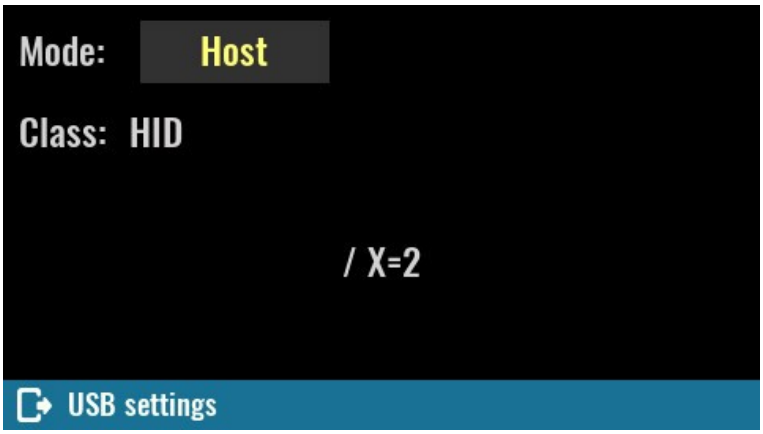



**SCPI**

```
SYSTem:COMMunicate:USB:CLAss MSTO
```

**Host**

When this mode is selected the EEZ BB3 provides VBUS power for connected USB device (e.g. mouse, keypad, foot pedal, etc.).
The USB *Class* will be automatically set to HID.




USB mouse (wired or wireless) is supported and if connected, the cursor will appear and information on the cursor coordinates will be displayed.

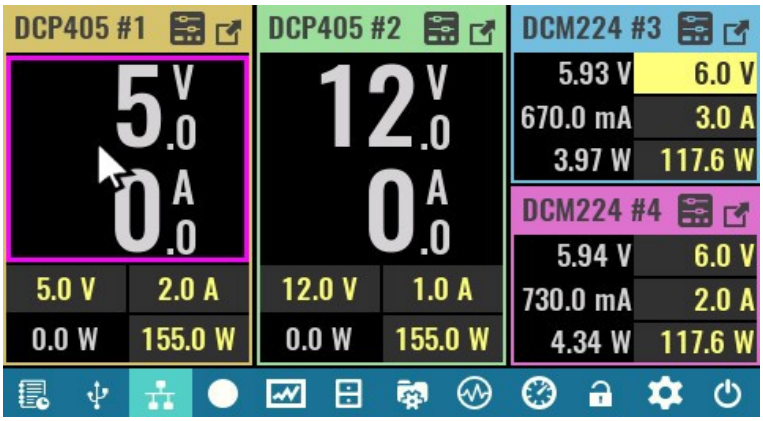
The USB keyboard is partially supported so that the following functions are enabled:

- [Tab] + [Space]/[Enter] as navigation and selection
- [Print Scrn] for taking screenshot
- [Home] returns to home page
- [Esc] can be used as exit/cancel option
- Numeric keys [1] to [6] as Ch1 to Ch6 output state toggle (on/off)

**SCPI**

```
SYSTem:COMMunicate:USB:MODE HOST
```

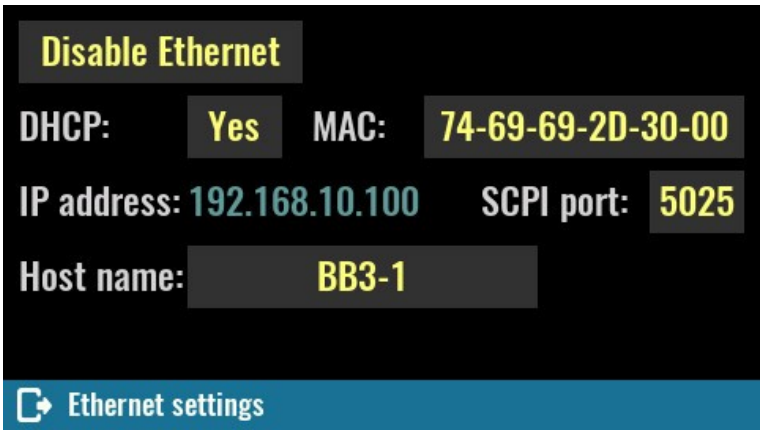
When a USB mouse is used for navigation, the clickable item on which the cursor is positioned will get a magenta box.



**OTG**
"On-the-go" mode allows detection of USB ID pin (set by USB cable or adapter) and adopt its USB mode and class in accordance with detected device.
For example if mouse is connected with OTG adapter cable, the USB *Mode* will be set automatically to Host and *Class* to HID and mouse cursor will appear.


**SCPI**
```
SYSTem:COMMunicate:USB:MODE OTG
```

## 8.3. Ethernet




**Enable/disable**
Defines activity of the serial interface. When LAN cable is disconnected or network communication is not yet established, *Connecting …* will be displayed until communication is established again.

**SCPI**
```
SYSTem:COMMunicate:ENABle
{<bool>}, ETHernet
```

**DHCP**
Enable or disable the DHCP mode. In DHCP mode, the DHCP server in the current network assigns network parameters (*IP address*, *DNS* address, *Gateway* address and the *Subnet mask*). Assigned IP address will we displayed, and cannot be changed.
When DHCP is disabled all network parameters have to be entered manually using the *Edit static address* as described below.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:DHCP {<bool>}
```

**MAC**
Defines Ethernet MAC address, a unique identifier assigned to Ethernet interface for communications at the data link layer of a network segment.
Any combination of six hexadecimal values is allowed separated by "-". The Ethernet connection will work as long as two different machines in the LAN don't have the same MAC address.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:MAC {<mac_address>}
```

**SCPI port**
Defines Ethernet communication port for SCPI connections. Default port is 5025.

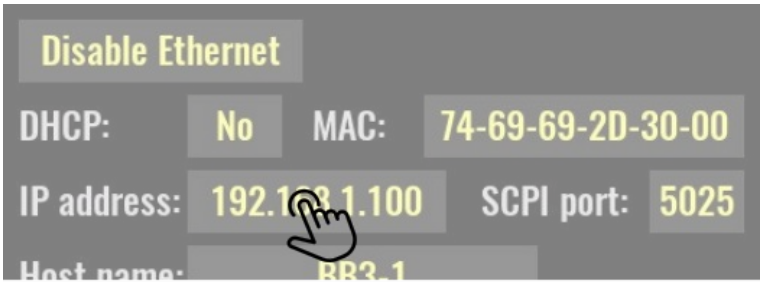
**SCPI**
```
SYSTem:COMMunicate:ETHernet:PORT {<number>}
```

**Host name**
Defines local area network (LAN) connection unique host name. Host name could contains up to 63 alphanumeric characters. "-" is allowed only if is not used as the first character. Space is not allowed and default name is *EEZ-BB3*.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:PORT {<number>}
```

### 8.3.1. Static LAN settings (DHCP disabled)

The parameters that follows should be defined when *DHCP* is not selected. All values should be specified in IPv4 address format (four values from 0 to 255 separated by dots).




**IP address**
Static local area network (LAN) address of the BB3.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:ADDRess {<ip_address>}
```

**DNS**
IP address of the DNS (Domain Name Service) server that translates domain names into IP addresses.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:DNS {<ip_address>}
```


**Gateway**
IP network gateway address for accessing the EEZ BB3 from outside the current sub-network.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:GATEway {<ip_address>}
```

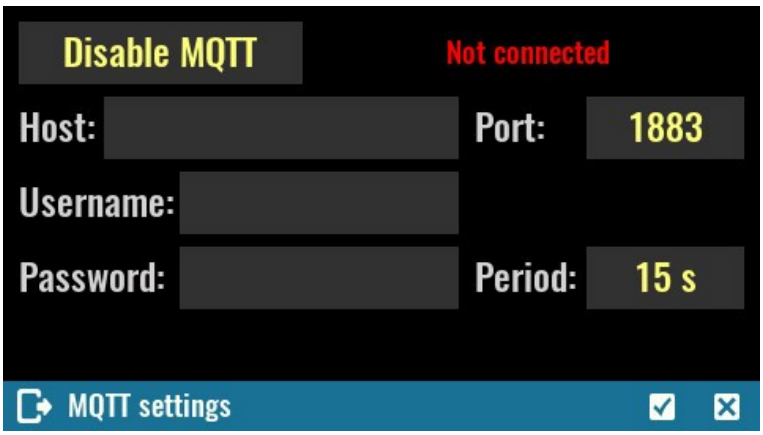
**Subnet mask**
IP network subnet mask. The subnet mask is used to determine if a client IP address is on the same local subnet.

**SCPI**
```
SYSTem:COMMunicate:ETHernet:SMASk {<mask>}
```

## *8.4. MQTT*

When MQTT is enabled, the following parameters should be defined to establish communication:

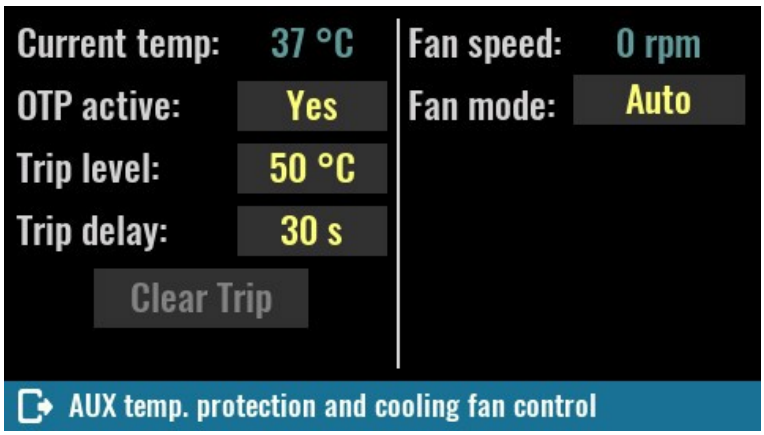
- *Host* – The name of MQTT server (aka broker)
- *Port* – TCP/IP port for MQTT communication (standard port is 1883)
- *Username* – login name of a valid account on the MQTT server
- *Password* – login password of a valid account on the MQTT server
- *Period* – MQTT messages publishing frequency




**SCPI**
```
SYSTem:COMMunicate:MQTT:SETTings {<address>}, {<port>}, {<user>},
```

```
{<password>}, {<period>}
```

## 8.5. System temp and fan




**Current temp.**
The "system" temperature is measured on the AUX-PS module and can be used for over-temperature protection (OTP).

**SCPI**
```
MEASure:TEMPerature? AUX
```

**OTP active**
Enable or disable over-temperature protection associated with the system (AUX) temperature sensor.

**SCPI**
```
SYSTem:TEMPerature:PROTection:STATe
```

**Trip level**
Set the over-temperature protection (OTP) value in degrees Celsius (°C). Default value for this sensor is 45 °C.

**SCPI**
```
SYSTem:TEMPerature:PROTection {<temperature>}
```

**Trip delay**
Specifies how long the temperature should be equal to or higher than the set *trip level* for the protection to activate.

**SCPI**
```
SYSTem:TEMPerature:PROTection {<temperature>}
```

**Clear trip**
When protection is activated (tripped), this condition will be latched and further usage of the EEZ BB3 will be disabled until protection is cleared.

**SCPI**
```
SYSTem:TEMPerature:PROTection[:HIGH]:CLEar
```

**Fan speed**
Current fan speed indicator stated in rpm (revolutions per seconds). The diagnosed fan fault will be also displayed here.

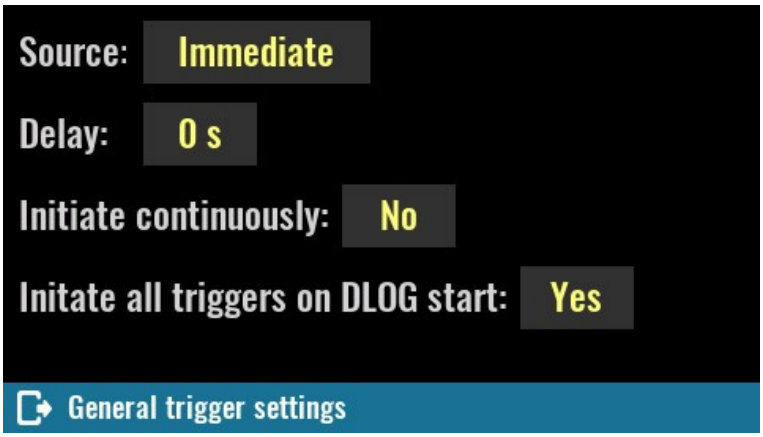
**Fan mode**
The fan is controlled by default with firmware algorithm (*Auto* mode) that takes into account measured temperature on all temperature sensors and measured output currents (i.e. the higher the output current, the sooner the fan speed will increase).

*Manual* mode can be selected for e.g. fan testing purpose when firmware speed control algorithm is completely bypassed.

**Set speed to**
This option becomes available when manual mode is selected. Default value is 100 % (full speed).

**SCPI**
```
SYSTem:FAN:STATus?
SYSTem:FAN:SPEed?
```

## 8.6. General trigger settings

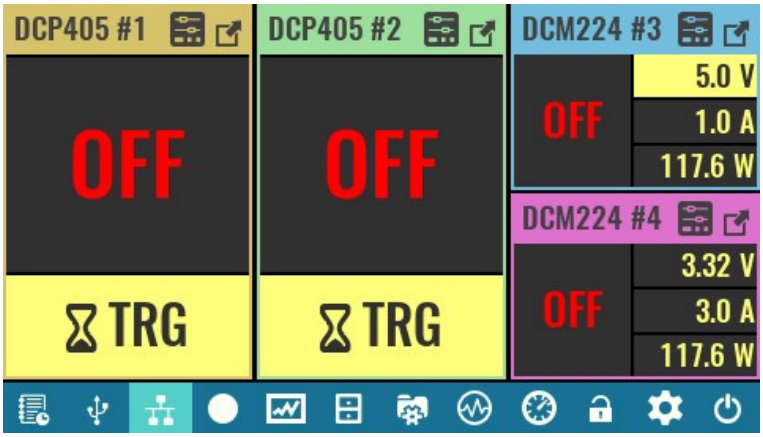



The BB3's triggering system allows a change in output state, voltage and current or start internal data logging when receiving a trigger from selected trigger source.

One common triggering system is used to control all available channels, but will only affect those channels that are not in *Fixed* trigger mode (see *Channel trigger settings* for channel trigger mode settings).

**Source**

- *Bus* – enables LAN and serial (via USB) triggering using the **TRG* command. When this mode is selected, *TRG* text will blink when you turn on channels that have triggers defined (e.g. *List* or *Step*).
- *Immediate* – the EEZ BB3 executes a complete trigger operation immediately after executing the *INITiate* command without delay.
- *Manual* – allows you to manually trigger with the User SW (if assigned this function, see *User SW*) or by selecting the flashing TRG text that will appear on the screen as it shows the example in the picture to the right (Ch2 to Ch4 have triggers defined).
- *Pin<n>* – selects a digital port pin configured as a trigger input. <n> specifies the pin number.




SCPI

```
TRIGger[:SEQuence]:SOURce {<source>}
```

**Delay**

Sets the time delay between the detection of an event on the specified trigger source and the start of any corresponding trigger action on the channel output.

SCPI

```
TRIGger[:SEQuence]:DELay {<delay>}
```

**Initiate continuously**

This option defines whether the trigger system is continuously initiated or not. When set to OFF, the system remains in the IDLE state until it is set to ON or an *INITiate:IMMediate* command is received. Once it is set to ON, the trigger system will be initiated and exit the IDLE state. On completion of each trigger cycle, the trigger system immediately commences another trigger cycle without entering the IDLE state.

When this option is set to OFF, the current trigger cycle will be completed before entering the IDLE state. The return to IDLE also occurs as the result of an *ABORt* or **RST* command.

SCPI

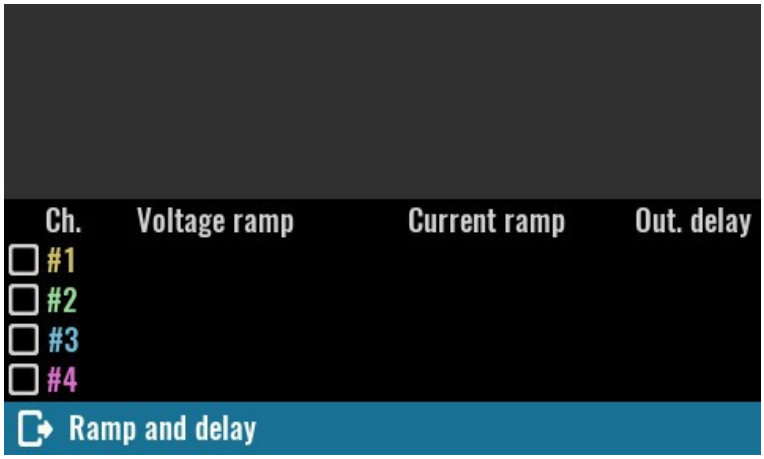
```
INITiate:CONTinuous {<bool>}
```

**Initiate all triggers on DLOG start**

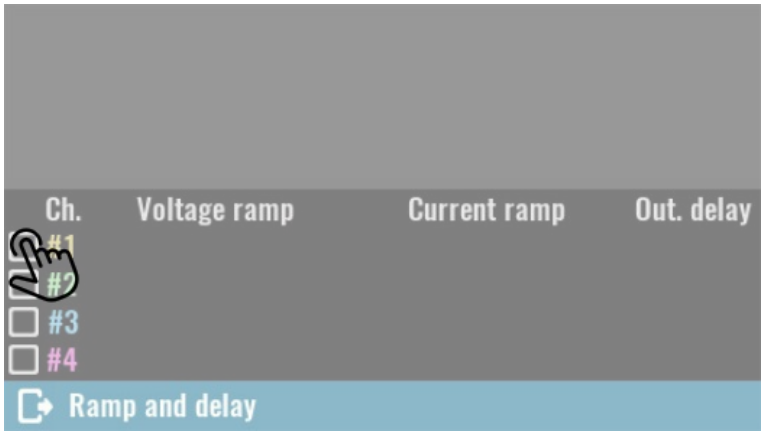
This option allows all resources for which the trigger is not set to *Fixed* to be activated with the start of data logging. Once data logging starts, it is possible to change the trigger mode of resources without affecting data logging.

## 8.7. Ramp & delay

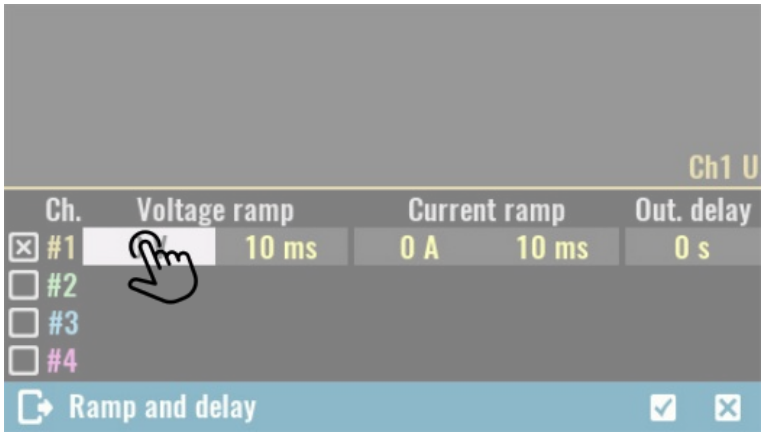
This page will show all output channels that have support for ramp and delay.



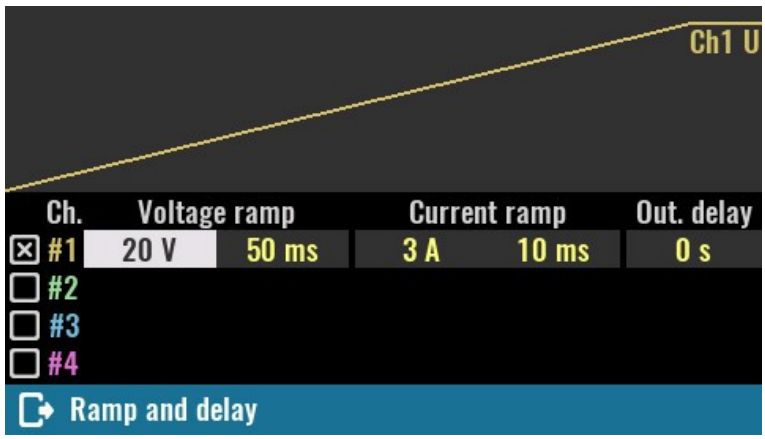

Select the channel you want to define ramp and delay settings for.



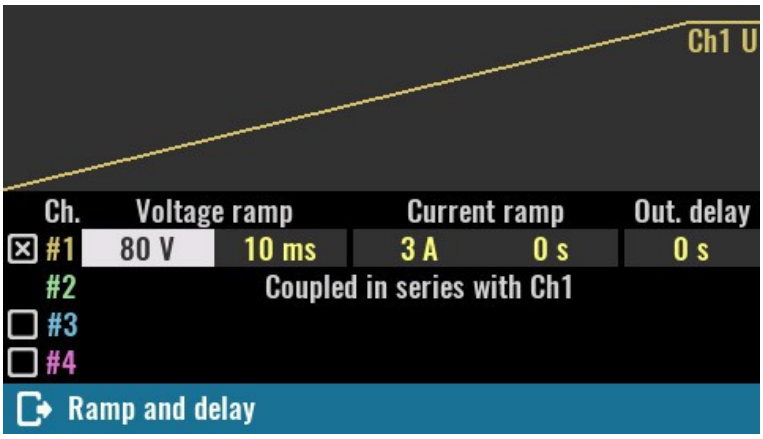

Tap on the parameter that you want to set (e.g. voltage).



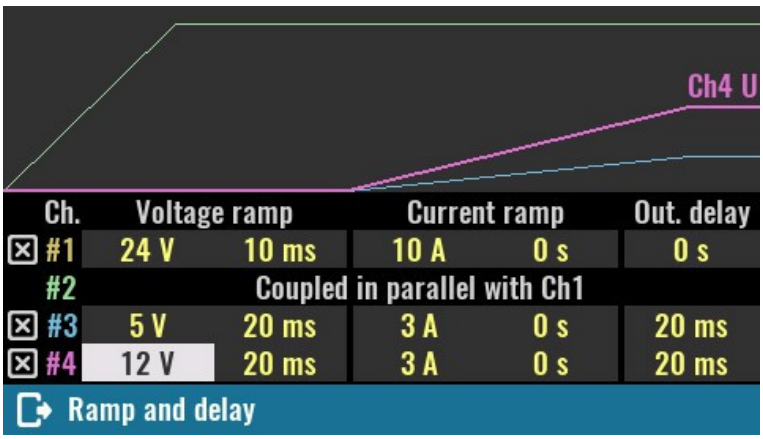

The graph above the list shows the output profile of the selected channel.



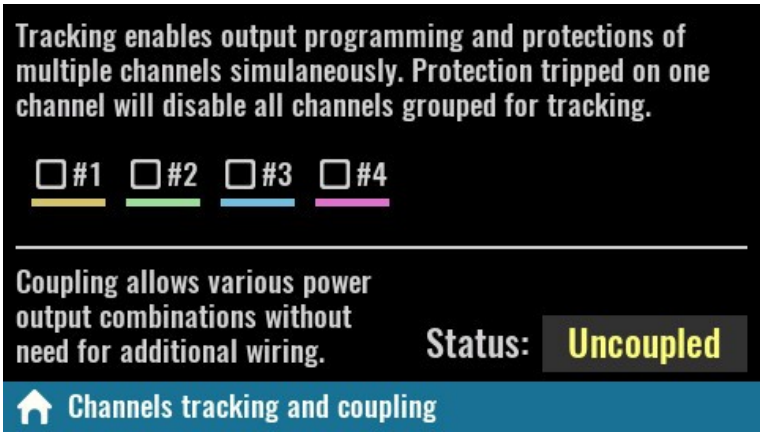
The channel list will reflect coupling in series. For example, the voltage ramp is able to be set at twice the value (up to 80 V).




This screenshot shows an example of a complex ramp and delay setup where the first two output modules are coupled in parallel and the last two modules turn on after a delay of 20 ms.




## 8.8. Tracking




Tracking is a convenient way to manage two or more channels simultaneously, i.e. there is no “master-slave” configuration, when changes can only be made via the master channel.
Only one tracking group can be set up. Channels that are in the tracking group will be able to define the following parameters at the same time:

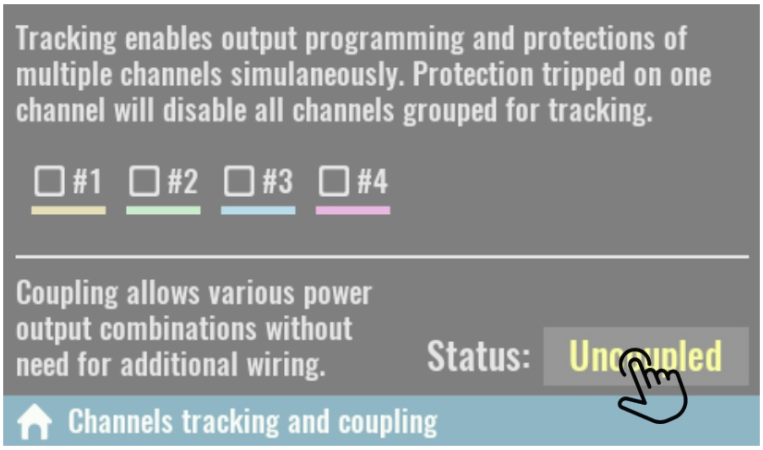
- Output set current and limit
- Output set voltage and limit
- Output power limit
- OCP, OVP, OTP and OPP parameters (activity, delay, status)
- Tripped protection clear
- Trigger type, source and delay
- Output list definitions (dwell, current, voltage)

When channels are in a tracking group, some of their options will be disabled (e.g. calibration). The *Untrack* option can be used for clear selections and will become visible only if two or more channels are selected.

SCPI

```
OUTPut:TRACk[:STATe] (@<chanlist>)
```

### 8.8.1. Power outputs coupling




Coupling provides a safe and convenient way to combine power outputs to increase capacity and offer output configurations.

Four power relays are used to combine the power outputs, avoiding the possibility of poor connections or accidental loss of connection, which could have detrimental effects on the connected load.

Furthermore, in the case of coupling into series or parallel, when doubling the output values, this will be taken into account, thus avoiding errors in the interpretation of the set and measured values.
By default all outputs are independent, i.e. separated from each other and “floating” or isolated in reference to MCU ground or PE (Protection Earth) potential.

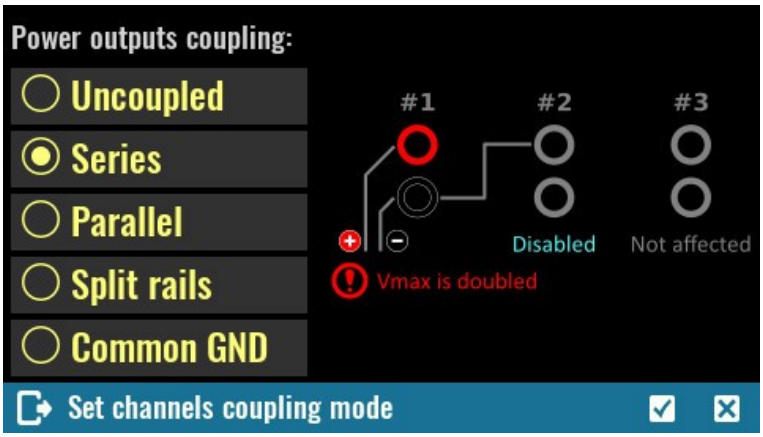
*Please note that regardless of the set coupling mode all channel outputs will remain isolated from the MCU ground and PE.*

SCPI

```
INSTrument:COUPle:TRACking NONE
```

**Series**
Coupling is series is only possible between DCP405 modules on the first two slots. When coupled, the output connectors of the module in slot 2 will be disabled, and the output voltage on the connectors of the module in slot 1 will be able to be set to twice the value (i.e. 80 V for DCP405).

The maximum output current will remain unchanged (5 A).




Access to the module in slot 2 will be disabled on display. All set and measured output voltage and power values shown on the display for the module in slot 1 will be doubled.

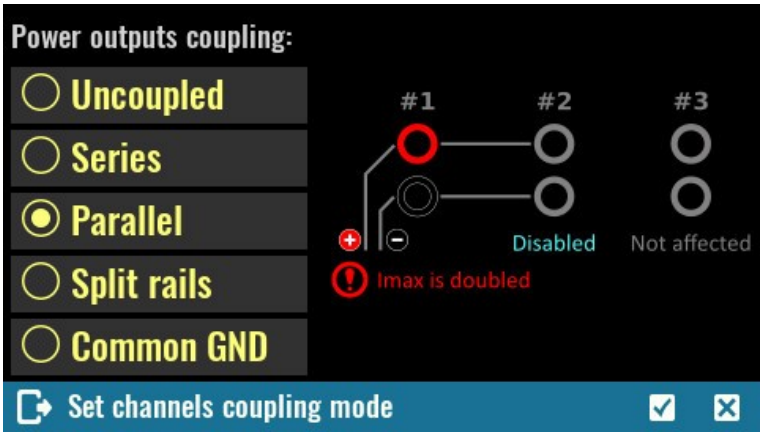
*Please note that according to many standards, voltage of 50 V and above are considered to be hazardous regardless of additional factors such as air humidity and temperature, skin moisture, etc. Take all necessary precautions when the set output voltage exceeds this value.*

SCPI

```
INSTrument:COUPle:TRACking SERies
```

**Parallel**
Coupling is parallel is only possible between DCP405 modules on the first two slots. When coupled, the output connectors of the module in slot 2 will be disabled, and the output current on the connectors of the module in slot 1 will be doubled (i.e. 10 A for DCP405).

The maximum output voltage will remain unchanged (40 V).

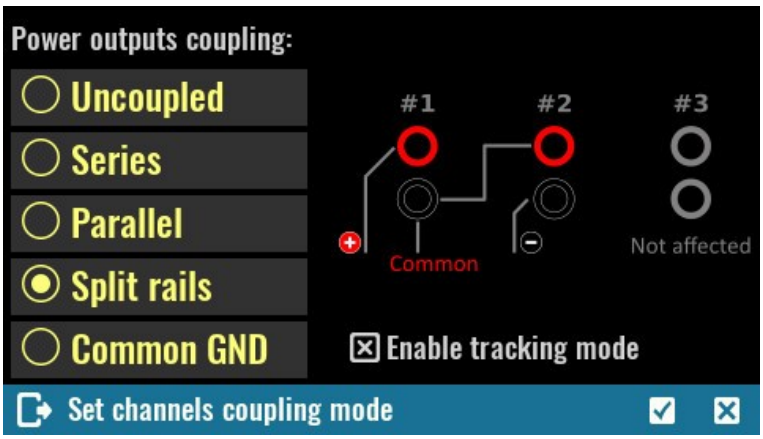



Access to the module in slot 2 will also be disabled on display. The set and measured output current

and power values shown on the display for the module in slot 1 will be doubled.

SCPI
```
INSTrument:COUPle:TRACking PARallel
```

**Split rails**
This type of coupling is similar to serial coupling except the output of both channels is still active and the coupling between the first and second channels is used as a common ground. In this way, a symmetrical output is obtained where Vout + of the first channel represents a positive rail and Vout of the second negative rail.

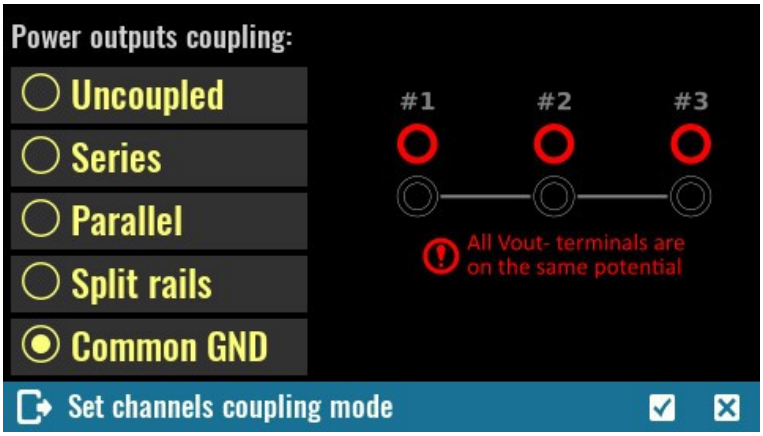



Channels can still be individually controlled, but since this configuration often requires the same output values (e.g. for powering operational amplifiers) a default is offered that places these two channels into a tracking group.

SCPI
```
INSTrument:COUPle:TRACking SRAil
```

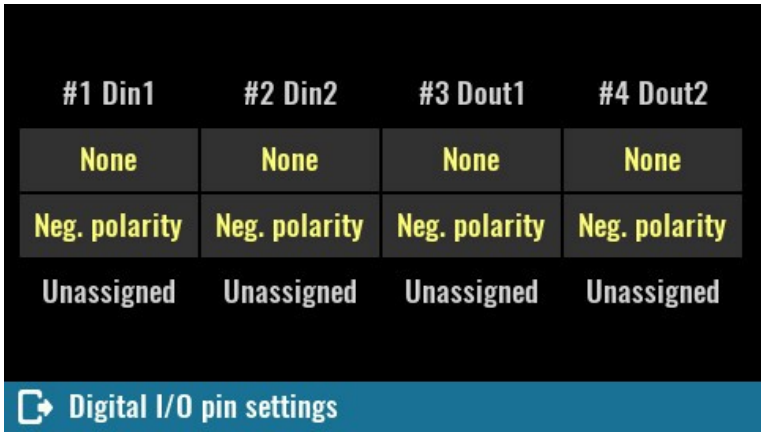
**Common GND**
This is the simplest way of coupling the output and results in the connection of Vout- all channels on all slots to a common potential.
As mentioned in the beginning, the Vout- coupled output potential will still not be at the MCU ground or PE potential.

*This coupling is not required for Vout- connections between two channels on the DCM220 because they are already internally connected.*

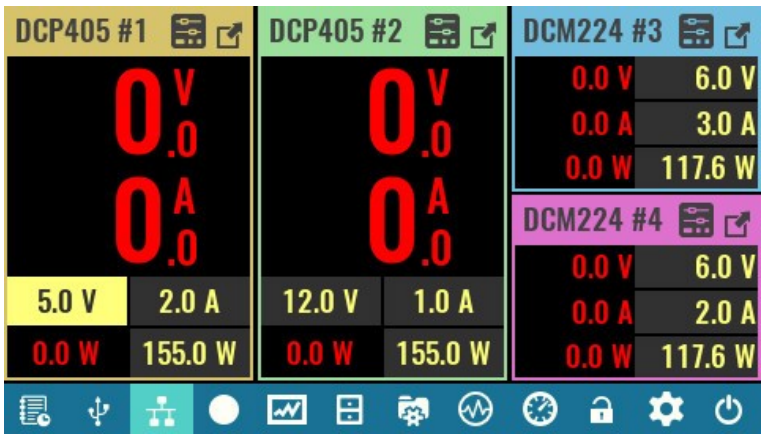



SCPI
```
INSTrument:COUPle:TRACking CGND
```

## 8.9. Digital I/O settings




Two protected/buffered digital input pins plus two digital output pins are available on the EEZ BB3 front panel. Their function and polarity can be set on this page which also displays their current state.




**Function**
Input pins may be assigned with one of the following functions:

- *Input* – The pin is in digital input mode.
- *Inhibit* – When pin is configured as an inhibit input, a true signal at the pin will disable all power output channels.
  If the channel outputs were turned on, all output values will flash in red when entering inhibit mode, as shown in the figure to the right.
- *System trigger* – When configured as a trigger input, the pin can be selected as the source for trigger signals.
- *UART RX* – The pin becomes a UART receiver (see subsection 8.10.1 below).

Output pins could be assigned with one of the following functions:

- *Output* – The pin is in digital output mode.
- *Fault* – pin functions as an isolated fault output. The fault signal is true when any output is in a protected state (from OCP, OVP, OTP, OPP) or Fan fault is detected.
- *Channel ON couple* – pin synchronizes channel output state.
- *Trigger output* – This allows a BUS trigger to be sent to any digital port pin that has been configured as a trigger output. A trigger out pulse (100 ms) is generated when the state is on and a bus trigger is received. A BUS trigger is generated using the **TRG* command.
- *PWM* – (Dout2, pin 4 only) when selected, a square wave will be generated with set frequency from 0.03 Hz to 5 MHz and duty from 0 to 100 %.
- *UART TX* – The pin becomes a UART transceiver (see subsection 8.10.1 below).

SCPI

```
SYSTem:DIGital:PIN<n>:FUNCtion {<function>}
SYSTem:DIGital:OUTPut:PWM:FREQuency {<pin>}, {<frequency>}
SYSTem:DIGital:OUTPut:PWM:DUTY {<pin>}, {<duty>}
```

**Polarity**

- *Pos* – a logical true signal is a voltage high at the pin. For trigger inputs and outputs, positive means a rising edge.
- *Neg* – a logical true signal is a voltage low at the pin. For trigger inputs and outputs, negative means a falling edge.

SCPI

```
SYSTem:DIGital:PIN<n>:POLarity {<polarity>}
```

**State**
Current state of all digital inputs and outputs are displayed in this section. If the pin function is not yet defined, the displayed state will be *Unassigned*.

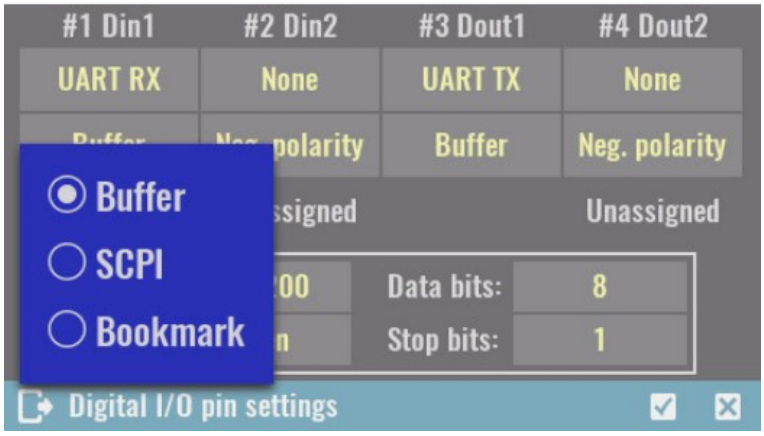
SCPI

```
SYSTem:DIGital:INPut:DATA? {<pin>}
SYSTem:DIGital:OUTPut:DATA? {<pin>}
```

### 8.9.1. UART settings

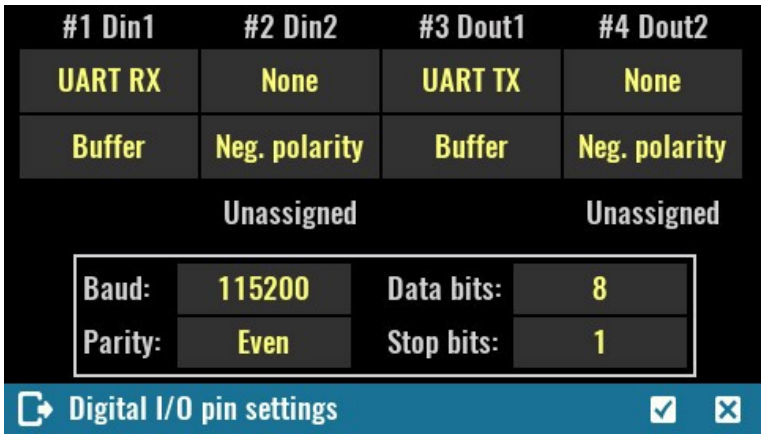

Configuring a DIN1 pin for a UART will automatically change the DOUT1 pin function and vice versa. It is possible to define the UART operating mode as well as the communication parameters.

- *Buffer* – data received via the UART is not interpreted as SCPI but stored in input buffer which can be retrieved by using the SYSTem:COMMunicate:UART:RECeive? query
- *SCPI* – received data via UART will be passed to the SCPI parser and interpreted. In this mode, the external device can take control of BB3.
- *Bookmark* – the received string will be added as a new bookmark to the active DLOG session.




SCPI

```
SYSTem:COMMunicate:UART:MODE {<uart_mode>}
SYSTem:COMMunicate:UART:RECeive?
SYSTem:COMMunicate:UART:TRANsmit {<string>}
```




**Baud:**
Communication speed in bits per second (baud). Select from a list of available speeds.

**Data bits:**
Data size in bits. Select from a list of available sizes.

**Parity:**
Parity check, could be *None*, *Even* or *Odd*.

**Stop bits:**
Number of stop bits, select 1 or 2.

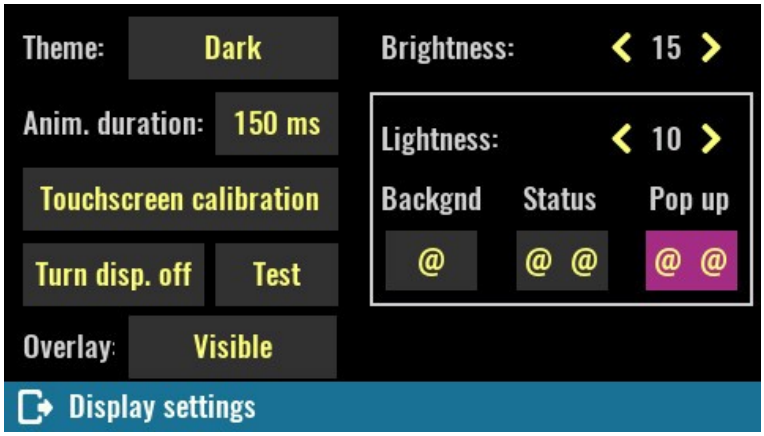
SCPI

```
SYSTem:COMMunicate:UART:BAUD {<baud>}
SYSTem:COMMunicate:UART:DATA {<data>}
SYSTem:COMMunicate:UART:PARIty {<parity>}
SYSTem:COMMunicate:UART:STOP {<stop>}
```

## 8.10. Display settings

Display color theme selection, brightness, luminosity, animation duration and status of display can be selected on this page.

An option for entering screen calibration (that is run by default on first start) is also available.




**Theme**
The EEZ BB3 comes with three color themes that apply to every page. The default theme is *Dark*.

**Anim. duration**
Define how long the animation effect lasts when transitioning between pages. Default is 250 ms. Set this parameter to 0 ms if you want to disable the effect.

**Brightness**
Controls the intensity of the display backlight. The range of the parameter is 1 to 20, where 20 is full intensity and 1 is backlight off. Default value is 10.

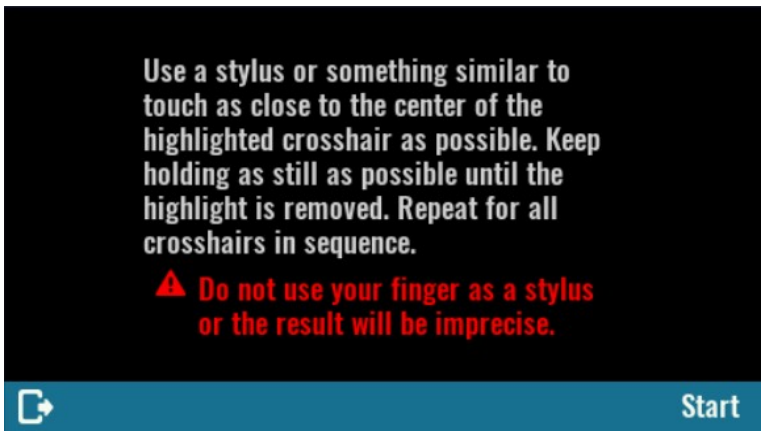
SCPI
```
DISPlay:BRIGhtness {<value>}
```

**Lightness**
This parameter defines the lightness of displayed colors if they are represented in so called HSL color space (hue, saturation, lightness). By increasing this value all colors will appear “lighter” or washed away. Similarly, when decreased all colors will appear “darker” or more dull. Lightness is not affected when set to 10. However, due to limitation of the LCD display (color representation is reduced to 16-bit) a default value is set to 5 to effectively compensate color difference.
The effect of changing this parameter can be observed by the color of three screen “widgets” (*Background*, *Status*, *Pop up*).

**Touchscreen calibration**
Screen calibration is required to give the firmware the necessary information about its geometry, which will increase the accuracy of data entry.

*Initiate this procedure as necessary if you notice that the accuracy of data entry is no longer satisfactory.*

*New screen calibration can be initiated also by touching the screen anywhere and hold for more then 15 seconds.*




SCPI
```
CALibration:SCReen:INIT
```

For a successful calibration, you have to use stylus or similar rounded tip object and touch the three dots on the screen as accurately as possible.

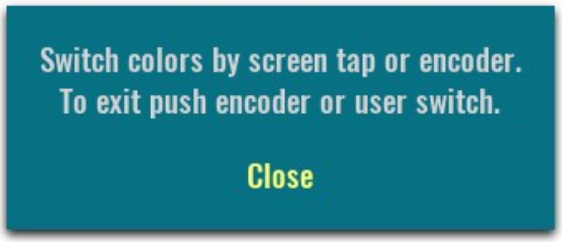

After successfully defining the three points, a new page will appear where you can choose between saving calibration data, repeating or canceling the calibration.

On the same screen is possible to test precision by touching the surface beyond the options mentioned.

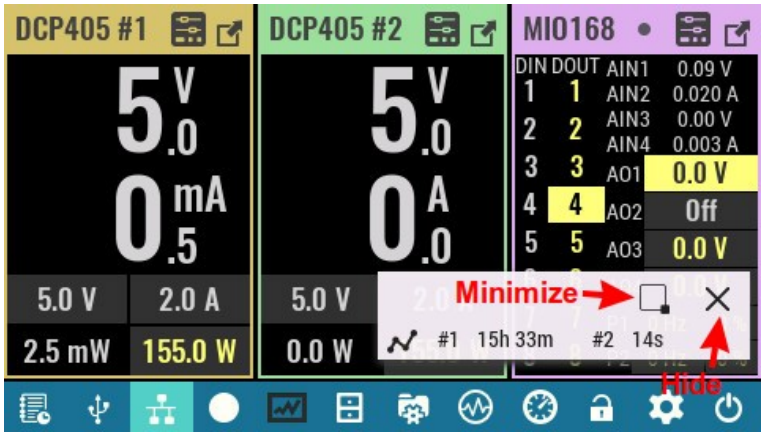

**Turn display off**
By turning display off user interaction is no longer possible. To reactivate it, you have to touch and hold anywhere on the display for a short time.

SCPI
```
DISPlay OFF
```

**Test**
Display test is used to detect defective pixels (aka deal pixels).
After the initial message, with each subsequent touch, the entire screen will be painted in primary colors (red, green, blue) following by white. It will be easy to notice if any of the pixels are defective.



**Overlay**
Determines whether overlay information is displayed or not. When set to *Visible* then overlay information will have the option to *Minimize* or *Hide*. If *Hide* icon is tap and hold for 3 seconds the overlay menu will dissapear and *Overlay* state will be changed to *Hidden*. Here you can make it visible again.
When *Minimize* is selected the icon will change to *Maximized* and the overlay information will remain visible on the screen in minimized form.




## 8.11. Labels & colors

Displays a new page where you can customize the labels and colors of the currently installed modules.


**Change label**
It is possible to define a label for each module. The default label is the name of the module and the ordinal number of its resource (eg DCP405 # 1 if the DCP405 power module is installed in slot 1).
Selecting this option will display the keyboard for entering a new label up to 10 characters long.

In case the peripheral module has additional resources (e.g. relays, analog and digital inputs and outputs) that can be labeled, an additional option will appear to access such resources as shown in the figure on the right when for example PREL6, SMX46 and MIO168 modules are installed.

SCPI
```
SYSTem:SLOT:LABel {slot}, {label}
```

**Pick color**
The header and frame module or resources (as in the case of a DCM module that has two) displayed on the screen will get a default color that can be replaced with one from the 24 color palette.

Once the color has been changed on a new arrival on this page, the **Default** option will also appear at the bottom in case you want to return to the original color.


SCPI
```
SYSTem:SLOT:COLor {slot},
{color}
```

*IMPORTANT: Changes to* Labels & Colors *depend on the user profile selected. If it is Profile 0 and you want the changes to be visible during the next power up then make sure that the* Autorecall on Power-on *option is set (see User profiles).*

## 8.12. Sound settings


**Sound**
When the beeper is enabled, the EEZ BB3 generates audible sound in any of the following situations:

- the power is turned on or off
- when error occurs during local (via display) or remote operation
- self-test is failed or
- any of the protection functions are tripped.

SCPI
```
SYSTem:BEEPer:STATe {<bool>}
```

**Click sound**
Select this option to enable or disable generation of an audible “click” sound as confirmation of selected item on the screen.

SCPI
```
SYSTem:BEEPer:KEY:STATe {<bool>}
```

## 8.13. Date & time


**Date**
Sets the date of the system clock (RTC). Specify the year, month, and day.

SCPI
```
SYSTem:DATE {<year>},
{<month>}, {<day>}
```

**Time**
Sets the time of the system clock (RTC). Specify the hours, minutes, and seconds.

SCPI
```
SYSTem:TIME {<hours>}, {<minutes>}, {<seconds>}
```

**Zone**
Defines time zone as offset from GMT.

SCPI
```
SYSTem:TIME:ZONE {<zone>}
```

**DST**
Determines Daylight saving time (DST) rules used in your region. The following rules may apply: *Europe*, *USA* or *Australia.*

SCPI
```
SYSTem:TIME:DST {<rules>}
```

**AC mains**
Set the frequency of your AC mains here. This parameter determines the PLC (power line cycle) used for A/D conversion in modules such as MIO168 (default value is 50 Hz).

SCPI
```
SYSTem:LFRequency <frequency>
```

**Format**
Sets one of the possible four combination of date, month, year and 12/24 hour that is used for e.g. displaying datetime of the file when accessing it from the File manager.

**SCPI**
```
SYSTem:DATE:FORMat {<format>}
```

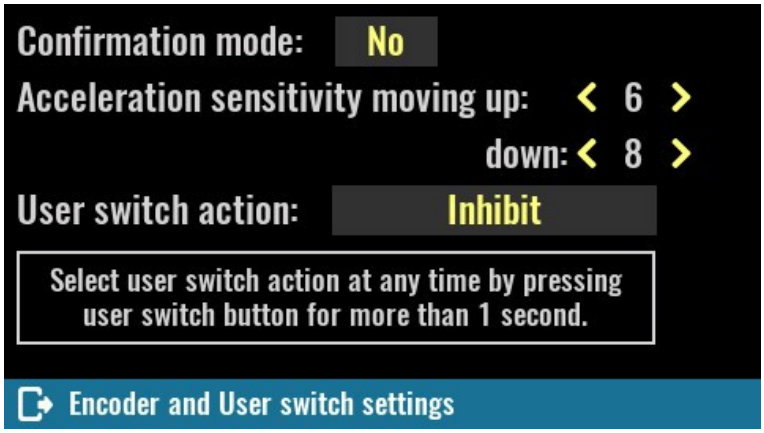
**Enable / Disable NTP**
Internal clock synchronization with NTP server can be enabled or disabled. When enabled, a *NTP server* entry field will be displayed.
The NTP communication requires active Ethernet connection.
List of most appropriate and available NTP servers is available at ntppool.org

**SCPI**
```
SYSTem:COMMunicate:ENABle {<bool>}, NTP
```

**NTP server**
NTP service server network address. The EEZ BB3 will try to establish connection with the selected NTP server on every power up (hard reset), when **RST* is issued or once per day.

**SCPI**
```
SYSTem:COMMunicate:NTP {<server>}
```

## 8.14. Encoder & User sw

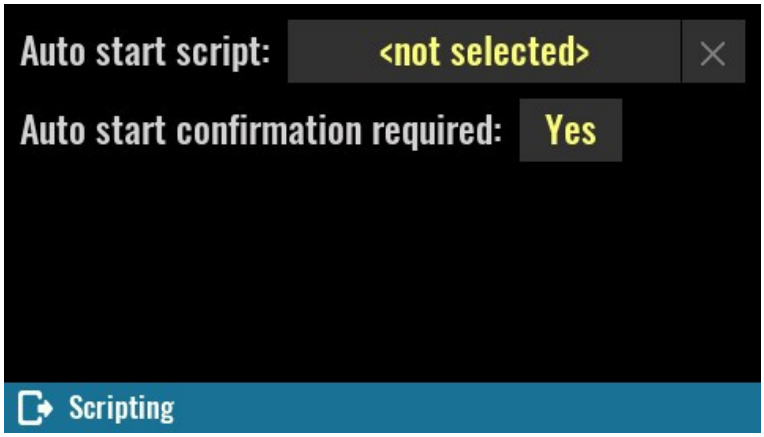



**Confirmation mode**
The encoder comes with a tactile switch and if this mode is selected then it will be used to confirm the newly changed value. By definition, the mode is not enabled which means that pressing the switch will instead move the "cursor" to the next editable field.

**Acceleration sensitivity moving up/down**
The rotation speed of the encoder is measured and defines in what steps the selected value will change.
The reaction (sensitivity) to increasing the rotation speed in one direction or the other (increasing values or decreasing values) can be set by these parameters.

**User switch action**
Opens a menu with functions that can be assigned to the user switch on the front panel. See *User SW*.

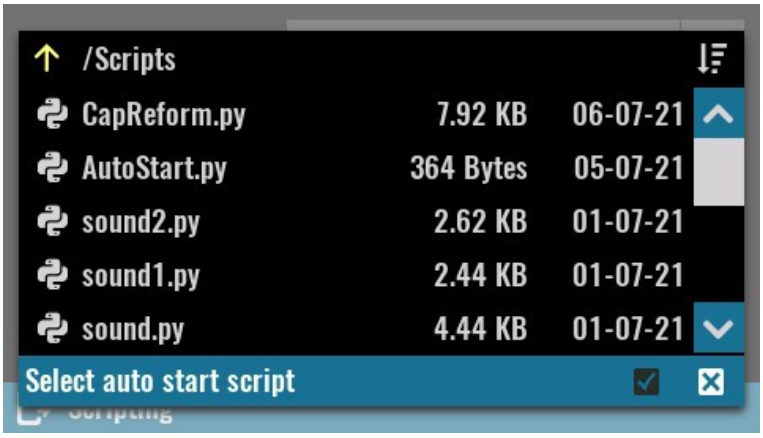
## 8.15. Scripting




On this page it is possible to define which MicroPython script will run on the startup.

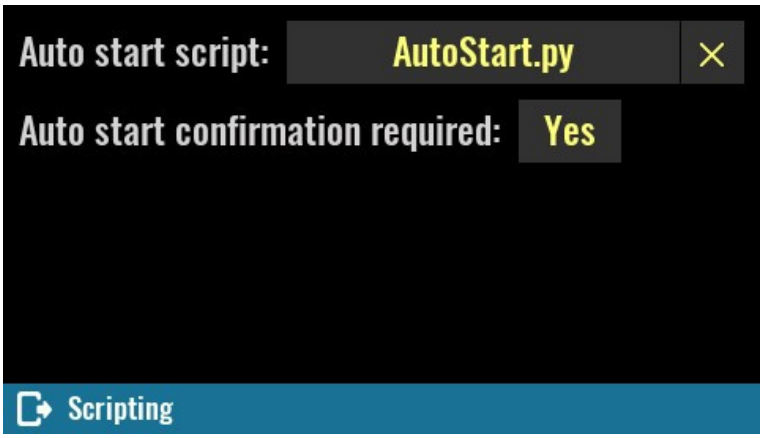
**Auto start script:**
The name of the MicroPython script to run.

When the name field is selected, the contents of the SD card *Scripts* folder are displayed by default.



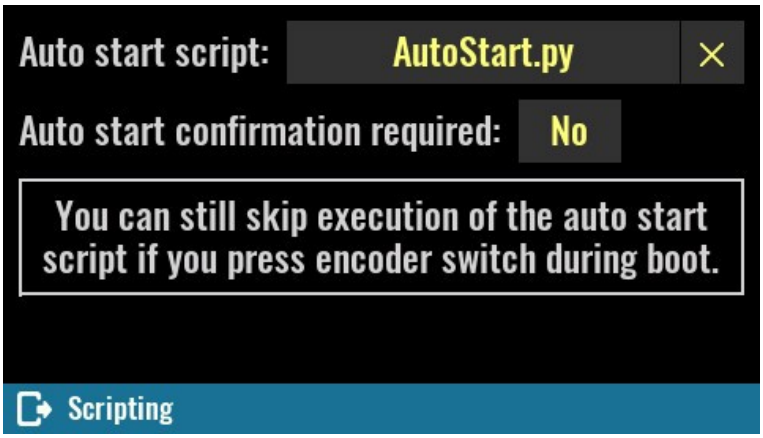

The currently defined script can be replaced with another by tapping the script name. Use the X button to completely remove the auto start script.

*Important: the auto start script is saved in the user profile so it is possible to define different startup scenarios. If you change the name of the script, don't forget to save it in the selected auto recall user profile (if profile 0 is not selected).*

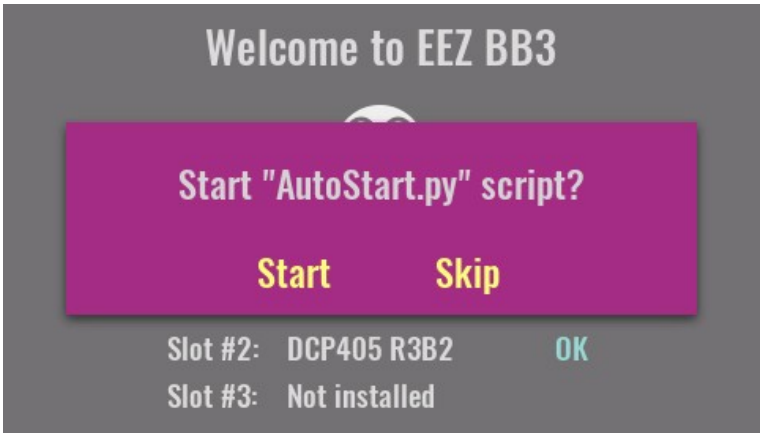



**Auto start confirmation required:** Use this parameter if you want additional confirmation of running the selected script on the startup.

If *No* is selected, then it will still be possible to skip the script on startup by pressing the encoder switch during startup (i.e. when the Welcome page is displayed).



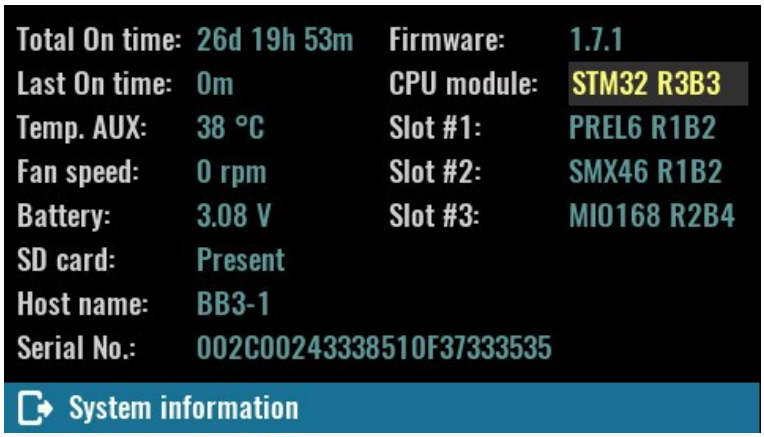

If the *Yes* option is selected, a dialog box will be displayed during startup.



A different dialog box will appear if the *No* option is selected and the encoder switch is pressed during startup. If *yes* is selected here, the currently set auto start script will no longer be selected.


## 8.16. System information

The page summarized various system information and contains a list of all recognized modules.




**Total On time**
Total active time of the EEZ BB3 (i.e. MCU module). Resolution is 1 minute and this information is stored every 10 minutes in non-volatile memory. Therefore it's possible that up to
10 minutes is lost after restart caused by a power outage or ungraceful power shutdown.

SCPI
```
SYSTem:CPU:INFOrmation:ONTime:TOTal?
```

**Last On time**
This query returns time passed after last activation of the EEZ BB3. Resolution is 1 minute and this information is stored every 10 minutes in non-volatile memory. Therefore it's possible that up to 10 minutes is lost after restart caused by a power outage or system reset.

SCPI
```
SYSTem:CPU:INFOrmation:ONTime:LAST?
```

**Temp. AUX**
The "system" temperature is measured on the AUX-PS module and can be used for over-temperature protection (OTP). See *System temp & fan*.

SCPI
```
MEASure:TEMPerature? AUX
```

**Fan speed**
Current fan speed indicator stated in rpm (revolutions per seconds). Any diagnosed fan faults will be also displayed here. See also *System temp & fan*.

SCPI
```
DIAGnostic:FAN?
```

**Battery**
Current voltage of the RTC (Real-time-clock) lithium 3 V coin battery (CR2032, Ø20 x 3.2 mm).

SCPI
```
SYSTem:MEASure?
```

**SD card**

Information about presence of mass-storage media (i.e. micro SD card).

SCPI
```
MMEMory:INFOrmation?
```

**Host name**
Local area network (LAN) connection host name.

SCPI
```
SYSTem:COMMunicate:ETHernet:PORT {<number>}
```

**Serial No**
The EEZ BB3 (MCU module) serial number.

SCPI
```
*IDN?
```

**Firmware**
The EEZ BB3 (MCU module) firmware version number.

**CPU module**
The model name and version of the MCU module.

*IMPORTANT: Here you can choose for which version of the MCU module the system firmware will be activated. In case of choosing the wrong version of the module BB3 will not be functional which can be manifested with various problems in communication with peripheral modules. If you are not sure whether the correct version is selected, you can find the version label on the MCU module itself, e.g. r2B4 or r3B3.*

*If after a reboot you have problems with the r2B4 MCU that you accidentally set to r3B3, connect to BB3 via EEZ Studio using a USB connection and execute the DEBUG 33 command from the instrument terminal.*

SCPI
```
SYSTem:CPU:MODel?
```

**Slot #<n>:**
The model name and version of all detected modules.

SCPI
```
SYSTem:SLOT:MODel? {<slot>}
```

# 9. System functions

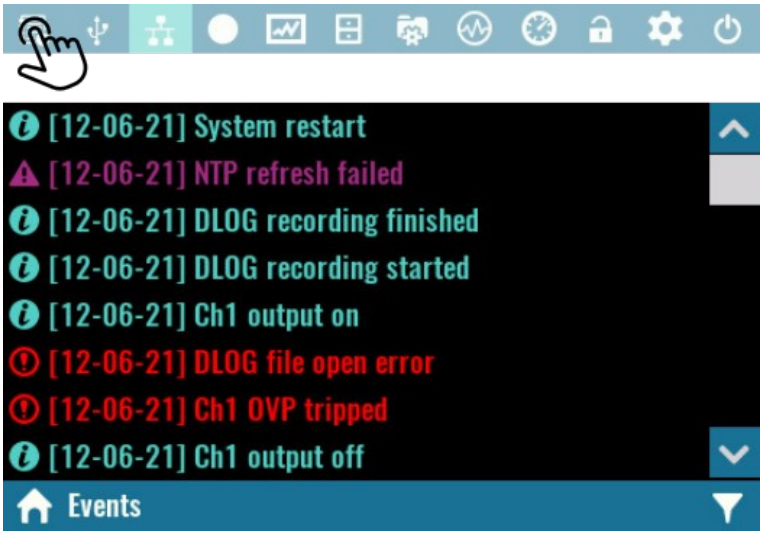
Functions that are not related to a specific module or channel are called system functions and most are accessible from the status bar of the home page. In this section the following functions will be discussed:

- Event viewer
- Tracking
- File manager
- User profiles
- Function generator
- Display views
- Display lock / unlock
- Power / Reset control
- User SW

## *9.1. Event viewer*

During operation, EEZ BB3 will record the time of events of certain user activities, as well as events that require user attention (i.e. warnings and errors). Events are saved in an event log that can be accessed by tapping the event view icon. The number of events stored in the event log is limited only by available space on the SD Card.

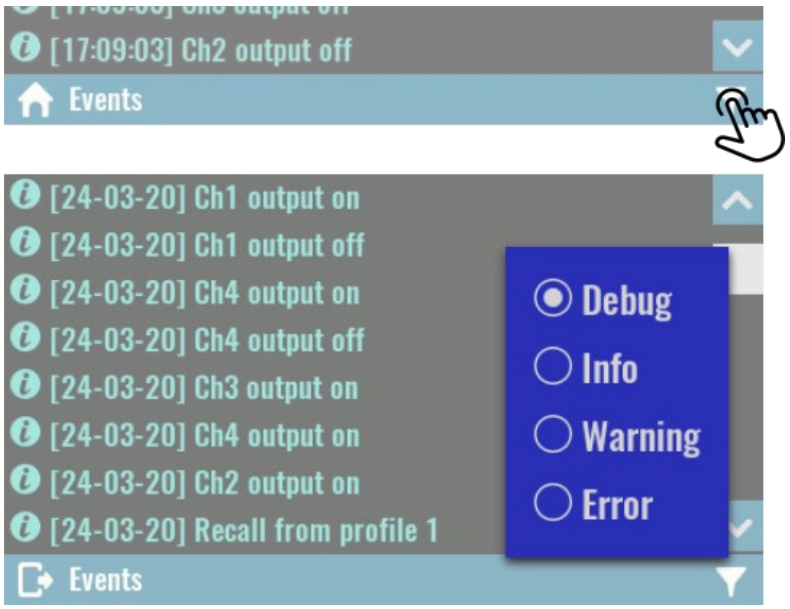
The appearance of a new event that requires user attention and occurred after the last review of the event log will result in a change in the color of the icon.



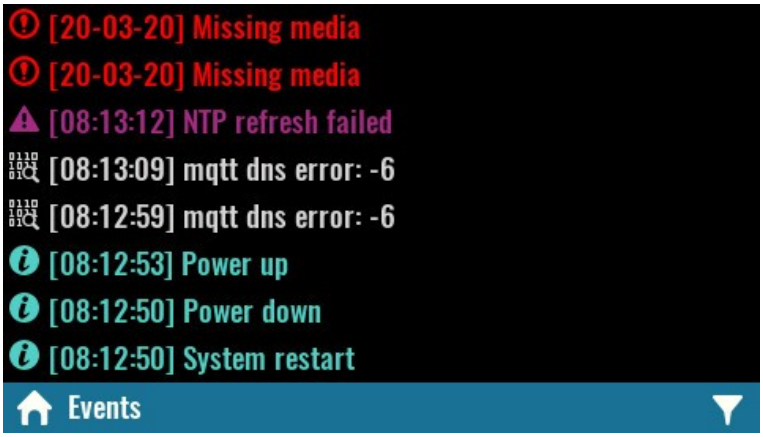

*If SD card is not present or dysfunctional only the latest 50 events will be accessible via Event viewer. That events will not be written to non-volatile memory, and will be lost after the restart.*

### 9.1.1. Events filtering

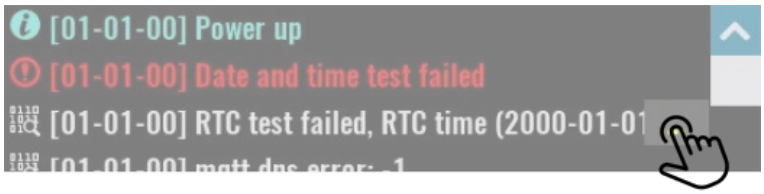
Four types of logged events exists and their appearance in the event viewer depends of the selected filter. The *Debug* filter represents the most comprehensive view that contains all type of events will *Error* filter allows appearance of error messages.

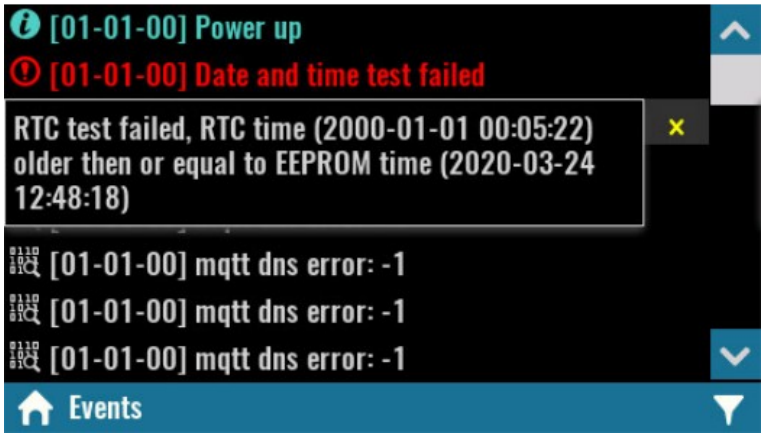


Events types identification is simplified by using different icons and colors.



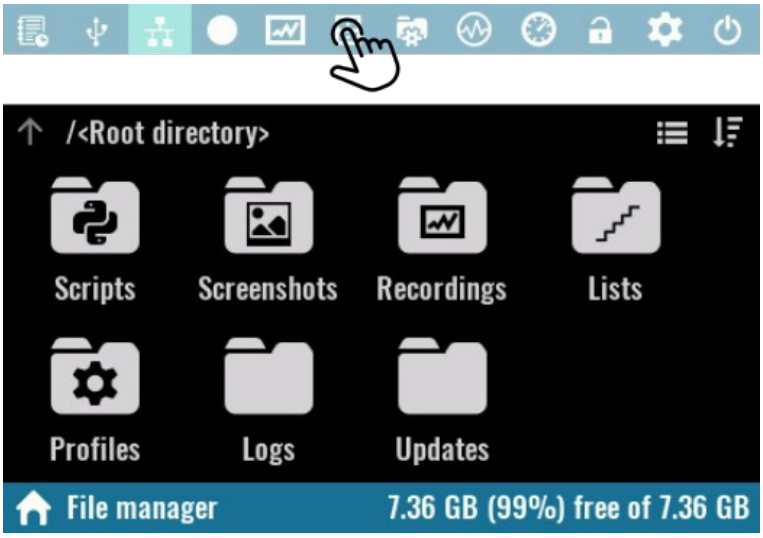

If the content of the message cannot be displayed in one line due to its size, an expansion option will appear.



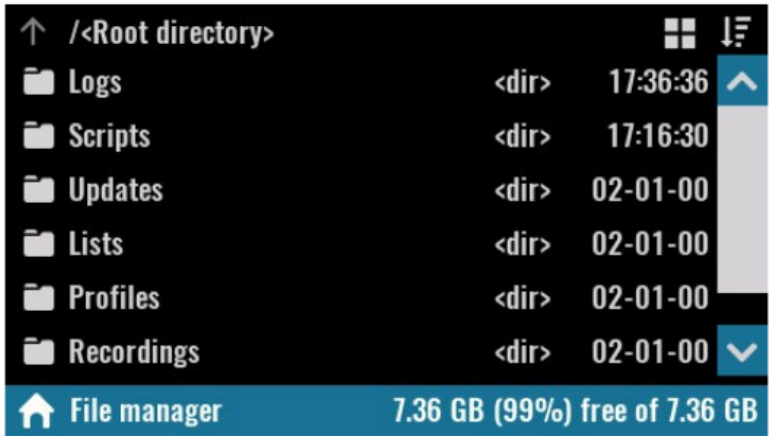

## 9.2. File manager

File manager lets you access and work with files on a SD card. The working data is organized into multiple folders (directories) as follows:

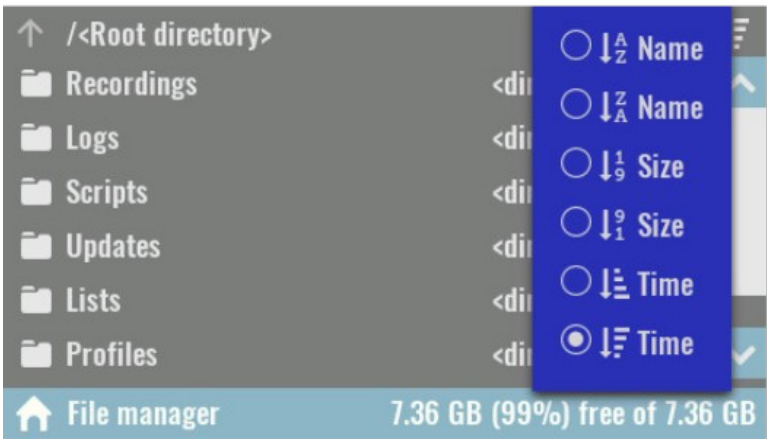



- *Scripts* – contains MicroPythons scripts (.py files) and related resources (.res files )
- *Screenshots* – contains all screenshots taken (see *User SW*)
- *Recordings* – data logging function use this folder to store recorded data
- *Lists* – contains program lists that can be executed on the selected channel
- *Profiles* – location for user profiles
- *Logs* – recorded events that are accessible via Event viewer.
- *Updates* – contains firmware binary images that can will can be selected from module's firmware download section.

Folders and files in File manager can be displayed as list.

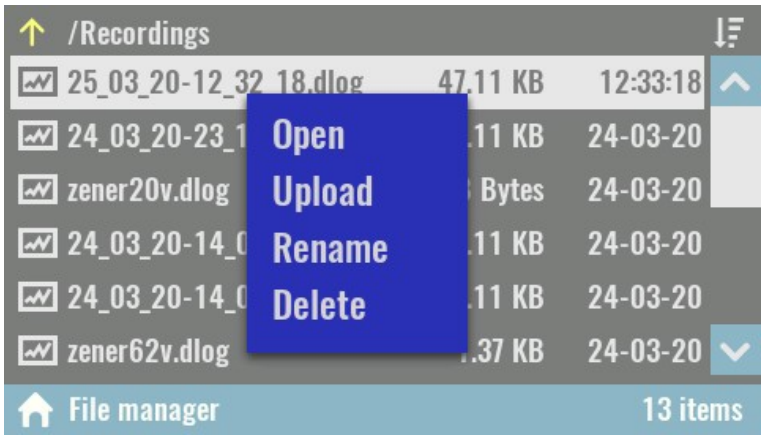

Files and folders displayed can be sorted by name, size and time in descending order and ascending order. Selecting the *Sort* icon will display a menu through which you can select the sorting method.


SCPI

```
MMEMory:CATalog?
MMEMory:CATalog:LENgth?
MMEMory:INFOrmation?
MMEMory:TIME? {<filename>}
```

Clicking on a file name will open a menu whose options will be enabled or disabled depending on the file type and whether a computer connection is established.




**Open**
Displays an image in .jpg format, or opens a viewer for logged data in .dlog format

**Upload**
Initiates file transfer to the computer. If the file is large, the progress percentage will be displayed.

SCPI

```
MMEMory:UPLoad? {<filename>}
```

**Rename**
Rename a file or folder.

SCPI

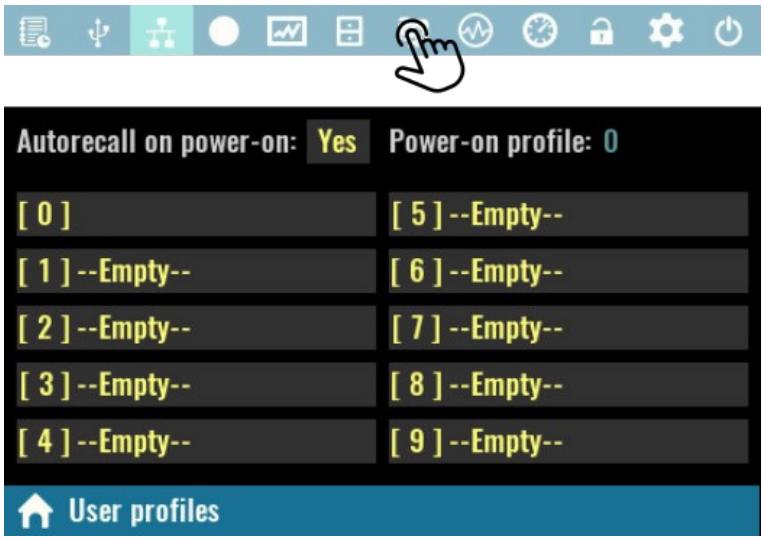
```
MMEMory:MOVE {<source>}, {<destination>}
```

**Delete**
Deleting a file or folder.

SCPI
```
MMEMory:DELete {<filename>}
```

## 9.3. User profiles

User profiles are used to store and recall system parameters and parameters of installed modules.
There are 10 profiles available that are displayed by number and name.



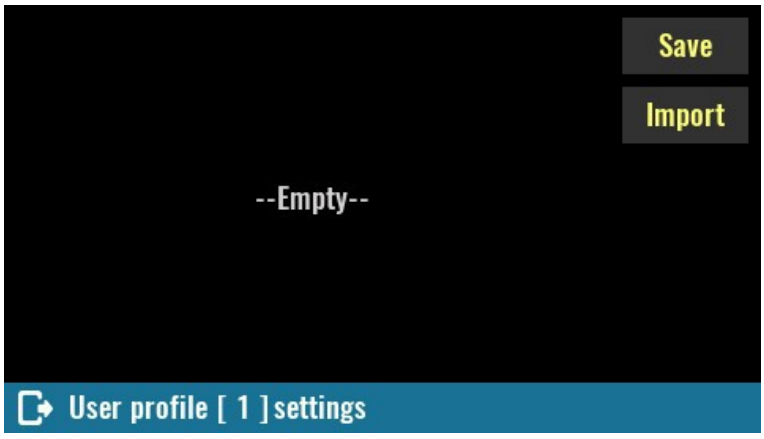

The profile 0 has a special status, i.e. it contains the current parameter states. Its name cannot be defined, but when a recall is made from a profile, it will receive its name.

SCPI
```
MEMory:STATe:CATalog?
```

**Autorecall on power-on**
Defines whether or not to load parameter states from the selected user profile at power up.
When selected, a *Power-on profile* number is also displayed, that is set by default to user profile 0.
If this option is off, the power up parameters will be set to initial values (i.e. “factory settings”).
*Parameters stored in an empty user profile cannot be selected as an auto-recall profile.*

SCPI
```
MEMory:STATe:RECall:AUTO ON
```

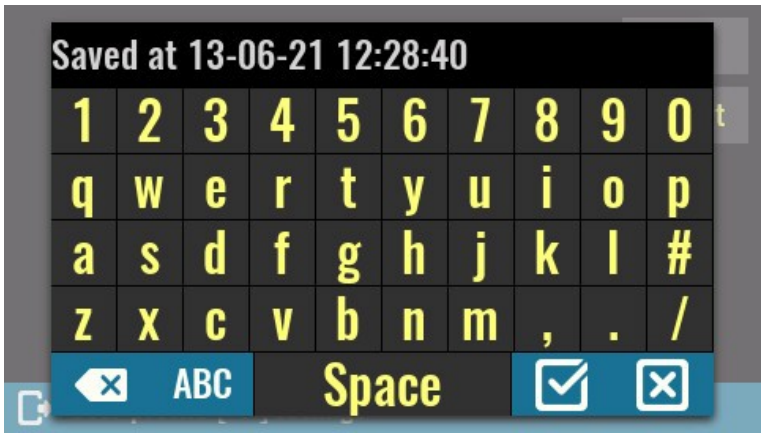
**Save**
Saving the parameter state can be done in an empty user profile or one that has already been used.
The following system states and parameters will be stored in non-volatile memory at the position of the selected user profile:




- Calibration status
- Output enable state
- Output track state
- Channel coupling state
- Remote sense state
- Output set voltage, voltage limit, and voltage step
- OVP status, and OVP delay
- Output set current, current limit, and current step
- OCP status and OCP delay
- Output power limit, OPP level, OPP status and OPP delay
- OTP level, OTP status and OTP delay
- Power on state

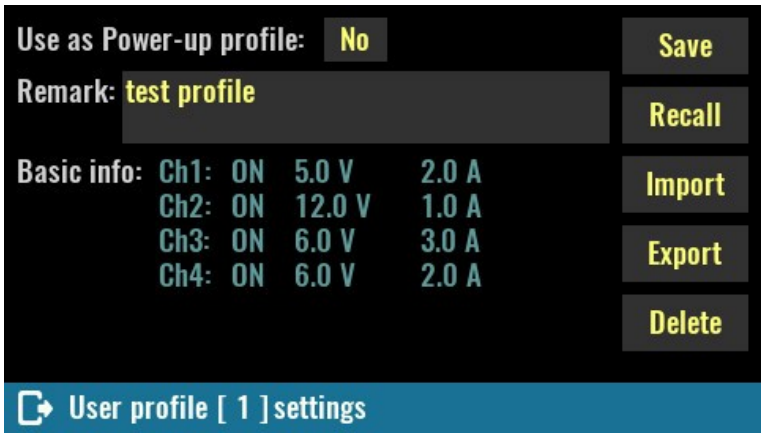
SCPI
```
*SAV {<profile>}
```

When saving a user profile, it is necessary to define its name (i.e. *Remark* as shown on next picture). In case of saving to an empty user profile, the name will be offered as a combination of *Saved at* and the current date and time. If saved to previously used profiles, an existing name will be offered.




SCPI
```
MEMory:STATe:NAME
{<profile>}, {<name>}
```

**Use as Power-up profile**
Specifies whether the initial states will be loaded or not from the profile if the *Autorecall on power-on* option is selected.




SCPI
```
MEMory:STATe:RECall:SELect
{<profile>}
```

**Recall**
Use this option to load immediately the parameter status from user profile.

SCPI
```
*RCL {<profile>}
```

**Delete**
Empty user profile and reset its name (remark) to *–Empty--*.

SCPI
```
MEMory:STATe:DELete {<profile>}
```

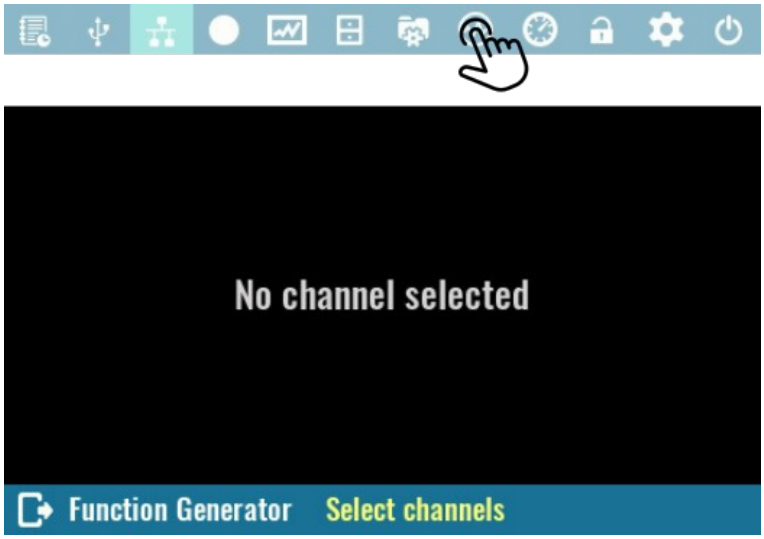
## 9.4. Function generator

A simple built-in function generator makes it easy to define some common waveforms on sourcing channels such as DCP and DCM power modules or analog outputs on SMX and MIO modules. It can also be used to define patterns on the digital outputs of the MIO module.

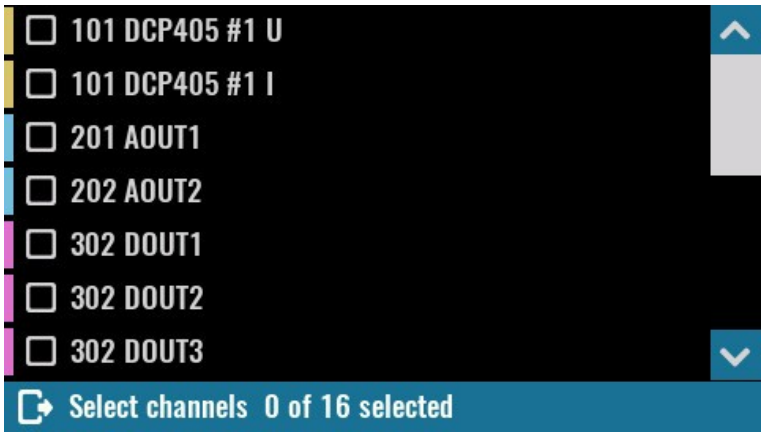
*IMPORTANT: since the function generator dynamically changes the voltage and current, make sure that they are within the limits that the connected load can withstand. If it is a sensitive load, it is recommended to set voltage and current limits (see Channel protections section) because the function generator will take them into account (together with set max. power) while it is active.*

See also the *Hardware OVP* section to find out how it can affect this function.

When open the Function generator choose the *Select channels* option to display a list of all resources supported in the current firmware version will appear.

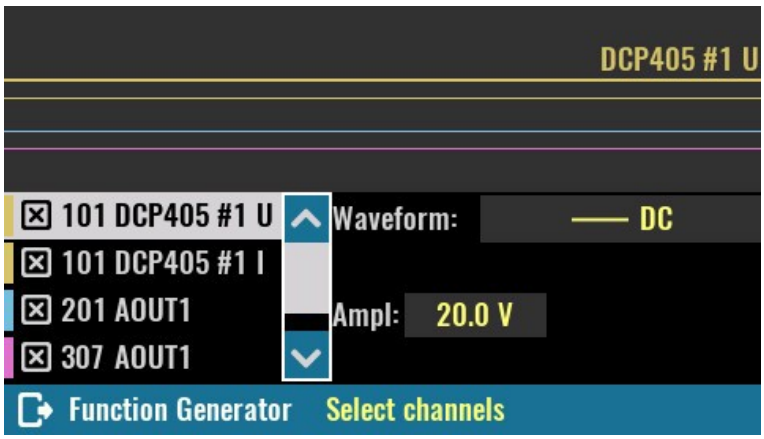



In the example in the picture on the right, these are the DCP (current and voltage) two analog outputs on the SMX and the digital and analog outputs of the MIO module.

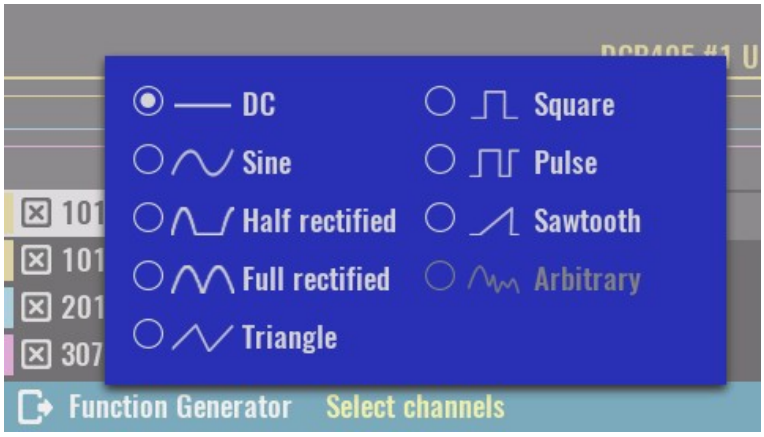



Upon confirmation, the selected resources will appear in the list of the main configuration page of the function generator.

Using checkboxes, you can choose which resources will be displayed, which can give a clearer view if more resources with e.g. significantly different frequencies are selected.




**Waveform:**
The waveform shape can be selected separately for each of the selected resources from the list of currently supported shapes:




- *DC* – this is the default shape that generates a signal with a constant amplitude
- *Sine* – generating a sinusoidal signal. It is possible to define amplitude, offset and phase shift.
- *Half rectified* – useful for simulating a discrete power rectifier with the difference that both its voltage and current can be controlled. Positive half of the AC wave is passed, while the negative

half is blocked. Adding DC offset is also possible if needed.
- *Full rectified* – similar to half rectification but both half of the AC wave is passed with positive polarity (it corresponds to the absolute value function in mathematics).
- *Triangle* – symmetrical triangular signal
- *Square* – a rectangular signal that has a duty cycle fixed at 50%.
- *Pulse* – a rectangular signal with variable duty cycle (default is 25%).
- *Sawtooth* – asymmetrical triangular signal with gradual rising edge and steep falling edge

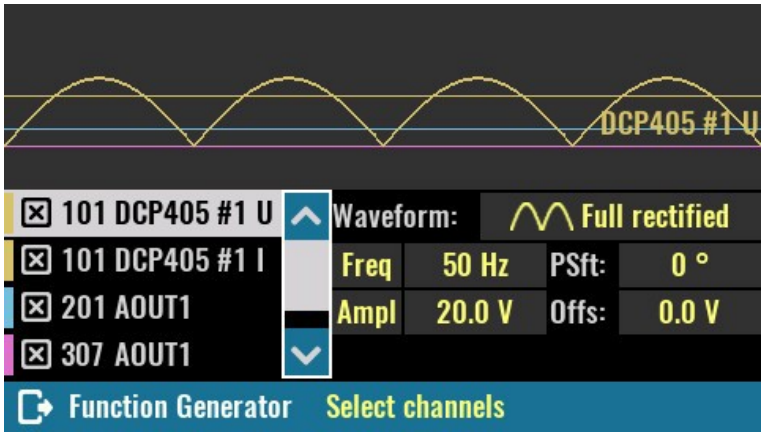
*Important notice: don't expect that a combination of say two half rectified signals shifted 180 degrees in phase will result in a bipolar (AC) signal. This is not possible with single quadrant DC sources such as DCP or DCM no matter how you connect their outputs (at best you can get a full rectified signal, at worst damage to one or both power channels).*

*Due to the technical limitations on the modules as well as the way the signal is generated, signal distortions as well as jitter can be expected. The final appearance of the generated signal should therefore be checked on an oscilloscope. Also note that generating signals on power channels can generate audible sound.*

SCPI

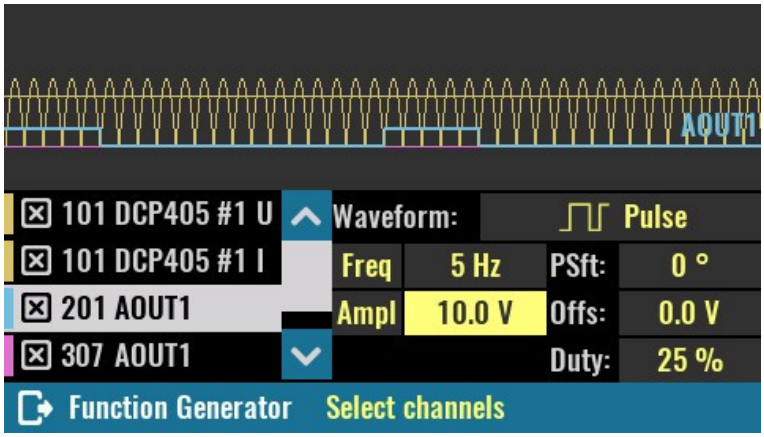
```
[SOURce[<n>]]:VOLTage:FUNCtion:SHAPe {DC|SINe|HALFrectified|FULLrectified|
TRIangle|SQUare|PULSe|SAWTooth}
[SOURce[<n>]]:CURRent:FUNCtion:SHAPe {DC|SINe|HALFrectified|FULLrectified|
TRIangle|SQUare|PULSe|SAWTooth}
SOURce:FUNCtion:SHAPe {DC|SINe|HALFrectified|FULLrectified|TRIangle|SQUare|
PULSe|SAWTooth}
SOURce:DIGital[:OUTPut]:FUNCtion:SHAPe {pin}, {SQUare|PULSe}
```

Depending on the selected waveform shape, it will be possible to set one or more of the following parameters:

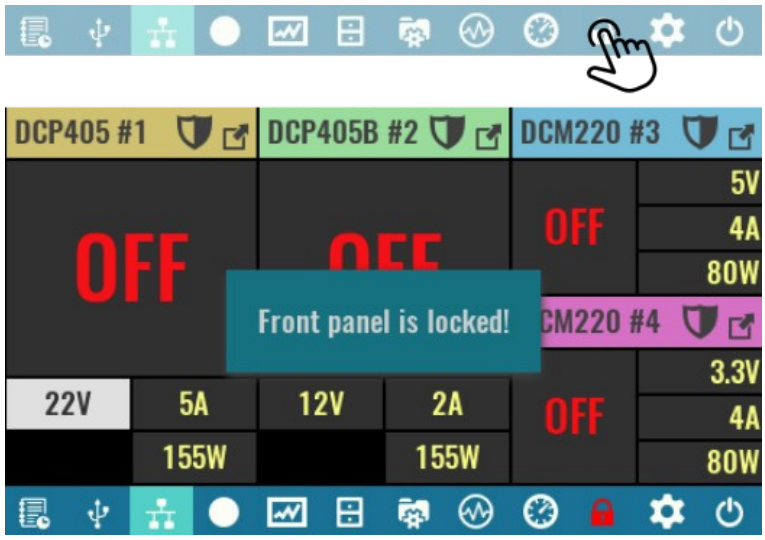



- *Freq* / *Period* – frequency or period of generated signal. The maximum value depends on the selected resource.
- *Ampl* / *Min* – the amplitude of the generated signal (this is always a positive value). In case that *Min* is selected, then depending on the selected resource it can be positive and negative value (e.g. analog outputs of MIO modules which are all bipolar).
- Offs / Max – the offset can be set when *Ampl* is selected and determines the DC level of the signal center. For example, if the amplitude of the voltage sinusoidal signal on the DCP channel is 20 V, in order to generate a complete period it will be necessary to set the offset to 10 V or more. For a smaller offset the lower half of the signal period will be zero, i.e. it will completely disappear if the offset is set to 0. Also on the other side if the offset increases above 30 V the positive half will start to be set to max. value (40 V) until it completely disappears at an offset of 40 V. The *Max* can be used in combination with the *Min* option. It specifies the maximum value of the generated signal.
- Psft – phase shift (0 - 360 degrees) of the signal that is repeated periodically (all except *DC*).
- *Duty* / *PWdt* – Duty cycle of the pulse waveform when the frequency is set (0 to 100%) or pulse width when the period is set.
- *Mode* – choice of generating Voltage or Current (MIO module AOUT1 and AOUT2 only).

When more than one periodic signal is defined, the display will adapt to the signal with the lowest frequency so that two of its periods are displayed.




## 9.5. Display lock / unlock




Tap the *lock* icon (hold about 3 sec) to lock display. When locked the icon changes color and lock state is saved in non-volatile memory. Therefore, the front panel remains locked even after power is cycled.

SCPI
```
SYSTem:KLOCk
```

Unlocking is performed by tap on the lock icon (hold about 3 sec), and may require system password for unlock if it is defined.

SCPI
```
SYSTem:LOCal
```

## 9.6. Power / reset control


**Default (*RST)**
Initiate so-called soft reset procedure. All outputs are set to OFF, and voltage and current are programmed to 0.

SCPI
```
*RST
```

**Standby**
Results in disconnecting of AC power for all installed peripheral modules.

Standby mode keeps the MCU module powered that is indicated with the *Standby* indicator on the front panel. The power up can be initiated by tap and hold action anywhere on the screen.

SCPI
```
SYSTem:POWer OFF
```

**Restart**
This action is equivalent to recycling input power. On power up all modules will be initialized, self test will be performed and initial values will be set depending on the selected user profile and *Autorecall on power-on* status as defined in *User profiles*.

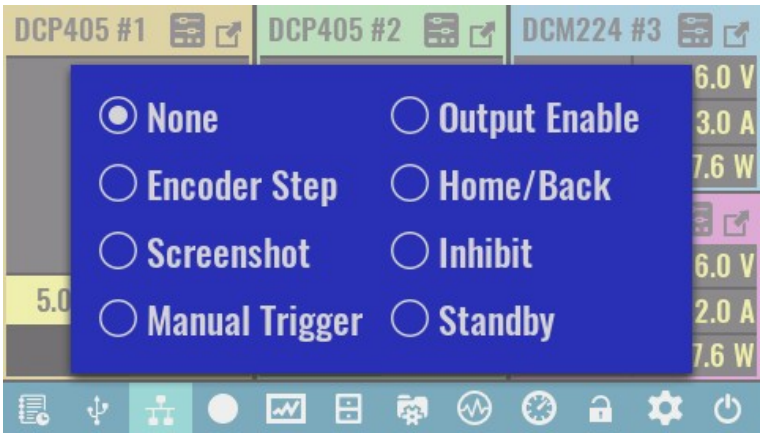
SCPI
```
SYSTem:RESet
```

**Shutdown**
Initiates a graceful shutdown that ensures that the latest information are stored in non-volatile memory. Wait until a message appears on the screen that EEZ BB3 can be safely turned off.

**Display off**
While the display is off, future user interaction will be disabled until it is turned on again. Turn the display back on by tap and hold action anywhere on the screen.

SCPI
```
DISPlay OFF
```

## 9.7. User SW




**None**
If selected, no function is assigned to the user switch. A short push of the user switch will open the menu showing available options. Press the button once again if no changes is needed.

Once an option is assigned to the user switch it will be necessary to press and hold the button for about 1 second for the menu to reappear.

**Encoder Step**
Cycle through the sensitivity of the encoder to change the selected output value (voltage, current or power). Initially, the encoder is set to *Auto* mode when the change will depend on the speed at which it will rotate. Its turn sensitivity in one direction or the other can be changed in the *Encoder settings*.

**Screenshot**
Take screenshots of current screen content and save to SD card in the *screenshots* folder. The image will be saved in jpeg format and its name formatted as *yyyy_mm_dd-hh_mm_ss.jpg*

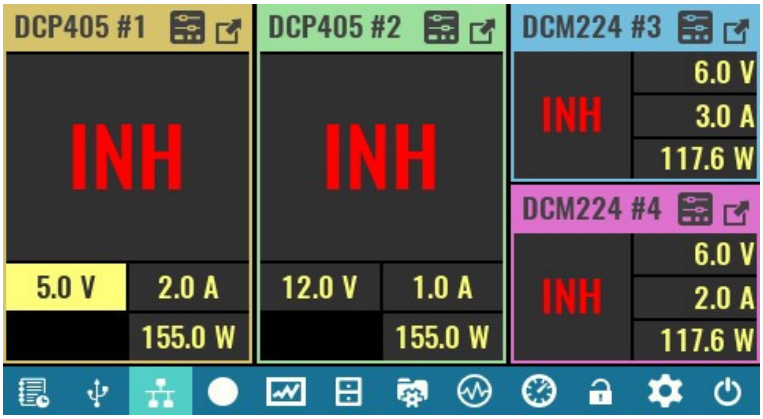
*Taking a screenshot is not possible while DLOG recording is in progress.*

**Manual Trigger**
Allows the user switch to be used to initiate the trigger system (see *General trigger settings*).

**Output Enable**
When two or more channels are in tracking mode, this option allows their outputs to be switched on and off simultaneously

**Home/Back**
When this option is selected, user switch can be used as an option to return to the previous or main page. It can also be used to exit maximized channel view.

**Inhibit**
This option is selected by default, when user switch can be used to enter inhibit mode when all active outputs will be temporarily disabled that is indicated with INH text. To exit inhibit mode, you will need to press the button once again.



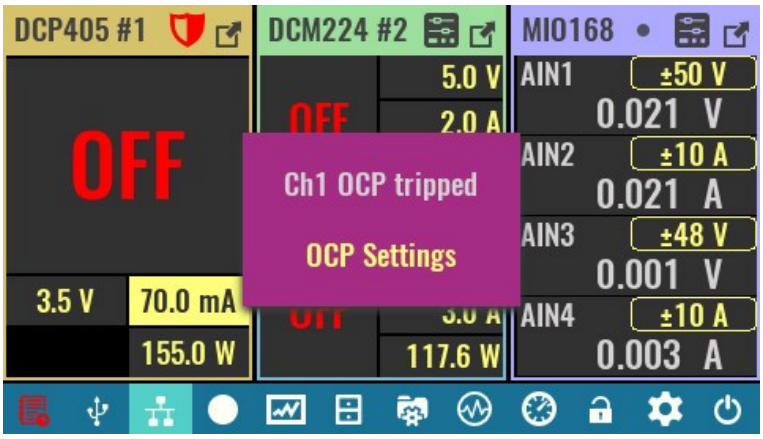
**Standby**
If EEZ BB3 is turned on and this option is selected, the first time a button is pressed, it goes into standby mode. The next time the button is pressed, it exits standby mode.

# 10. Channel protections

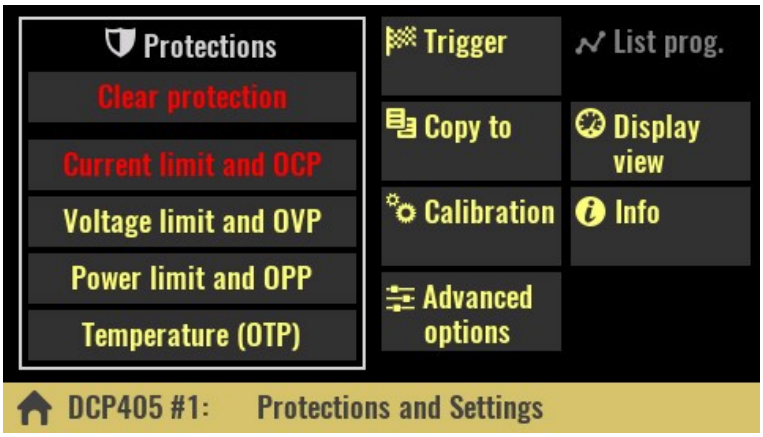
Power modules are designed with multiple protection functions to avoid various unexpected conditions, for example output values exceeding the set limits which (if unchecked) could cause permanent damage to a connected device or the power module itself.

Clearing an activated protection mode, disabling protection modes or setting protection mode parameters may be accessed via *Protections* section on the *Channel protection and settings* page.

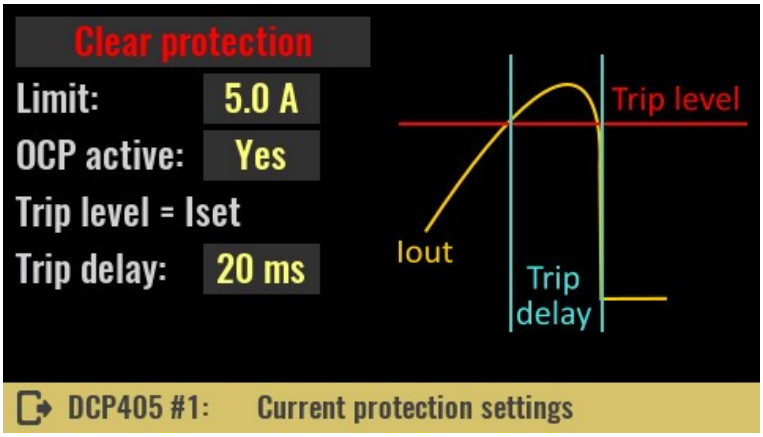
If any of enabled protections tripped, as for example over-current protection, popup message will appear and channel settings icon will be changed to shield icon colored in red.




**Clear protection**
Use this option on *Protections and Settings* page to clear all tripped protections so that channel outputs can be re-enabled as needed.
The status of active protections is not affected by this option.



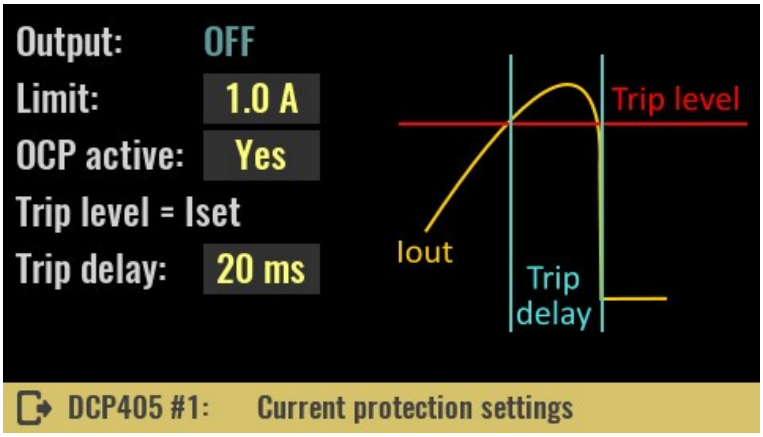

The same option could be used from tripped protection settings page to clear related protection trip.




SCPI

```
OUTPut:PROTection:CLEar
CURRent:PROTection:STATe OFF
POWer:PROTection:STATe OFF
VOLTage:PROTection:STATe OFF
SYSTem:TEMPerature:PROTection:STATe OFF, <sensor>
```

## 10.1. Current limit and OCP




**Limit**
Defines the max. value of the output current that the user will be able to set. The initial value is max. current the module can source (e.g. 5 A for the DCP405 module).

*Changing the limit will also affect graphical views (vertical bar, horizontal bar and YT views), if the display settings of the channel is set to* Limit *(see Display view page). For example, if the limit is set to 1 A, this value will become 100% of the scale instead of only 20% when the limit is at 5 A.*

SCPI
```
CURRent:LIMit {<current>}
```

**OCP active**
The OCP (Over-Current Protection) feature is software protection that will activate when drawn current reaches the set value of the allowed output current. This is a software version of what is known as e-fuse or electronic fuse. A protection mode trip will be recorded in the event log and the channel output will be turned off.

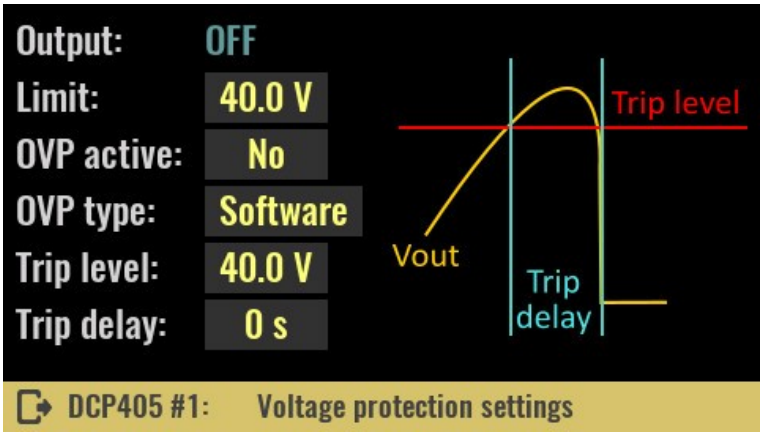
Use this option to turn OCP on or off. If OCP is off, if the output current reaches the set value ($I_{set}$) the channel will switch from CV to CC mode without turning off the channel output.

SCPI
```
CURRent:PROTection:STATe {<bool>}
```

**Trip delay**
If the OCP is enabled and the output current reaches the set value ($I_{set}$), an OCP trip will occur at the earliest after the set delay time expires.

SCPI
```
CURRent:PROTection:DELay {<time>}
```

## 10.2. Voltage limit and OVP




**Limit**
Defines the max. value of the output voltage that the user will be able to set. The initial value is max. voltage the module can source (e.g. 40 V for the DCP405 module).

SCPI
```
VOLTage:LIMit {<voltage>}
```

**OVP active**
The OVP (Over-Voltage Protection) is software protection that will activate when output voltage reaches the programmed value. Protection trip will be recorded in the event log and the channel output will be turned off.

Turns OVP on or off. If OVP is off (which is default), when the output voltage reaches the set value ($U_{set}$) the channel will enter the CV mode (which is normal behavior if the connected load does not draw more current than the maximum set). Therefore, when activating OVP without load or with connected load that draws less than the set current, the channel will enter CV mode and the OVP will immediately trip. To avoid this the channel should be in CC mode prior to the output being turned on.

SCPI
```
VOLTage:PROTection:STATe {<bool>}
```

**OVP type**
Selection between software (SW) and hardware (HW) OVP is only possible with DCP405 modules.

SCPI
```
VOLTage:PROTection:TYPE SW
```

**Trip level**
The trip level value may be greater than or equal to the set voltage ($U_{set}$) and determines the value of the output voltage at which the OVP will trip. In case the set value of the output voltage increases, the trip level will automatically increase.
For example, if the trip level was set at 10 V while the output voltage was also at 10 V and its value increased to 12 V, the trip level value would also increase to 12 V. But, if the voltage drops to say 5 V, the trip level will remain unchanged.

Max. trip value is 0.5 V greater than max. output voltage (40.5 V for DCP405 or 20.5 V for DCM220 module).

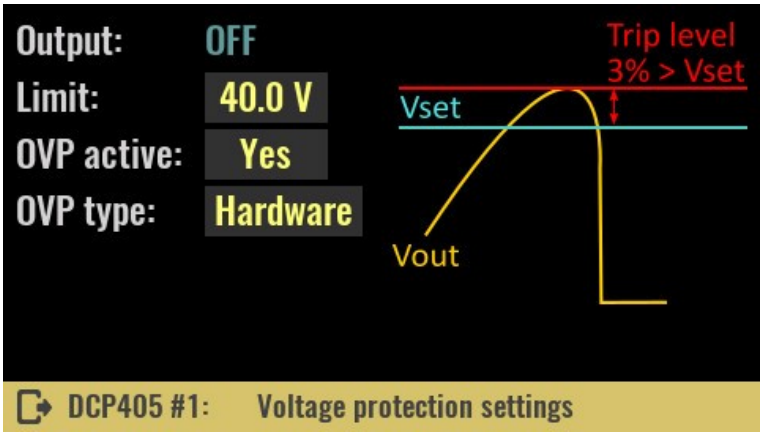
SCPI
```
VOLTage:PROTection {<voltage>}
```

**Trip delay**
If the OVP is enabled and the output voltage reaches the set *trip level*, an OVP trip will occur at the earliest after the set delay time expires.

SCPI
```
VOLTage:PROTection:DELay {<time>}
```

## 10.3. Hardware OVP

The DCP405 module also contains hardware OVP (or HW OVP) that works on a slightly different principle. Unlike software OVP where it is possible to adjust the trip level, with this protection the trip level is automatically set at approximately 3% above the set voltage output. The response rate (i.e. trip delay) also cannot be changed, but the OVP circuit will respond as quickly as possible.




SCPI
```
VOLTage:PROTection:TYPE HW
```

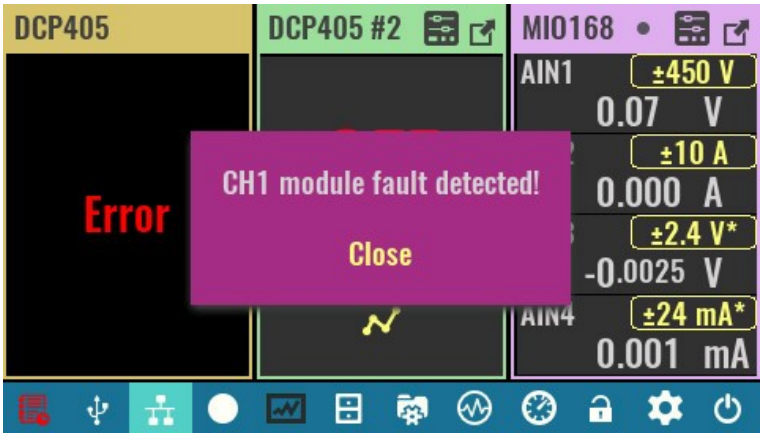
Please note that there are situations where the HW OVP can trip even though everything is fine with the DCP405 module. This is the case of “down” programming, i.e. quickly setting the voltage from higher to lower values. To understand why this could happen one needs to know the working principle of HW OVP. At the heart of this protection is a fast comparator that compares the set (U_SET) and measured output voltage (U_MON). If the U_MON is greater than about 3% of U_SET the comparator will activate a crowbar that will short-circuit the output and the channel will turn off.
At the initial voltage setting (from zero to U_SET value) U_MON has no reason to be greater than U_SET at any point unless we have some abnormal situation, e.g. unusually large overshoot (DCP405 is faulty) or let's say a significantly higher input voltage is connected: let's say a 12 V battery, and U_SET is set to a significantly lower value of 3 V.
However, in case the output voltage is higher than zero, say 20 V and we want to lower it to 10 V, in the case of an ideal DC source this would happen instantaneously and U_MON could not be higher than U_SET at any time. Since the DCP405 is not ideal, although it can lower the voltage very quickly thanks

to the down-programmer circuit and even though it has a small $C_{out}$, it can still happen that the down-programmer fails to discharge the $C_{out}$ fast enough, so reducing U_MON will delay setting a new (lower) U_SET. If this difference happens to exceed 3% the HW OVP will trip. The chance of this happening is higher the higher the $C_{in}$ of the device that the DCP405 powers.

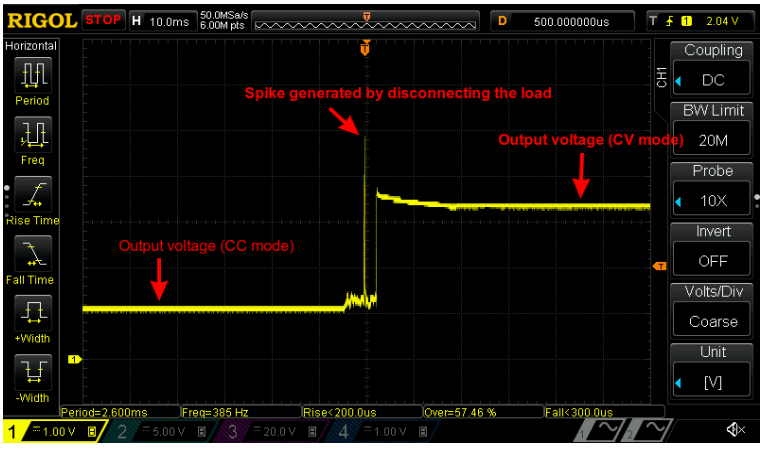
*For the above reason, you may need to turn off the HW OVP or activate the SW OVP when using program lists or function generators.*

*Important note: The DCP405 power module can be used to charge batteries. In this case, never connect the battery to the output terminals while output is disabled and HW OVP is enabled! As soon as the output is enabled, it will certainly lead to the HW OVP tripping, which in case the battery is insufficiently discharged, can result in drawing currents of the order of several tens of amperes.*
*Firmware 1.7.4 solves this problem when the* Prohibit output enable if external voltage detected *option is enabled (see* System protection *page).*

The third OVP control is software based and will emulate HW OVP in case none of the two protections described above are active.
In this case, any measured voltage (U_MON) greater than approx. 3% of the set (U_SET) will turn off the power output and set the module to error mode.
This is the final over-voltage protection that should turn off the output of the DCP405 module in case the previous two were not active.



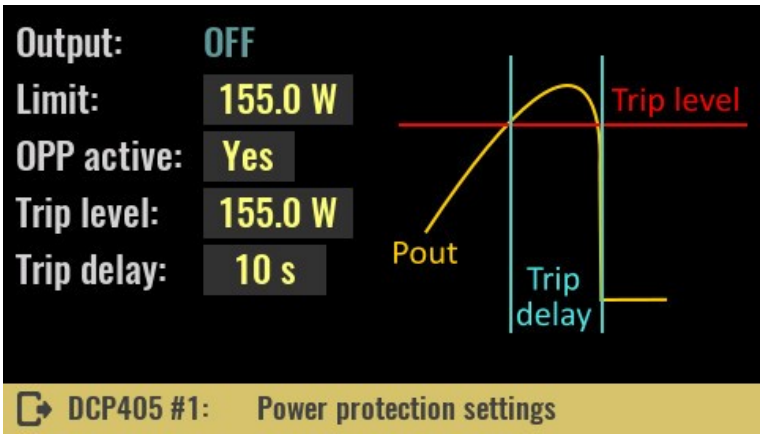

Note that there is a possibility for a "false positive" situation here. One example is when the output was in CC mode, then the output voltages (U_MON) will be less than the set voltage (U_SET). If the load is suddenly disconnected due to connecting wire inductance, a spike may be generated that may exceed the set voltage value (U_SET). The module will go into error mode even though everything is fine with it. This is a warning that such a practice should be avoided, and that the output enable/disable option should be used.




## *10.4. Power limit and OPP*

**Limit**
Defines the max. value of the output power that the user will be able to set. The initial value is max. power the module can source (e.g. 155 W for the DCP405 module).

SCPI
```
POWer:LIMit {<power>}
```




**OPP active**
The OPP (Over-Power Protection) is software protection that will activate when output power reaches the programmed value. Protection trip will be recorded in the event log and the channel output will be turned off.

SCPI
```
POWer:PROTection:STATe {<bool>}
```

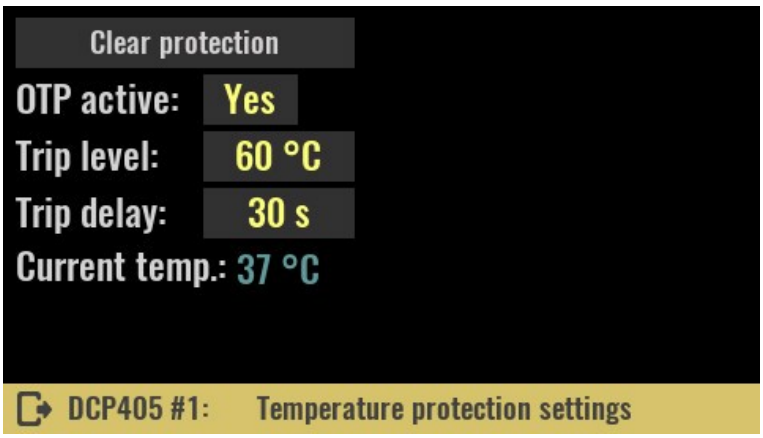
**Trip level**
The trip level value may be less than or equal to the set *limit* and determines the value of the output power at which the OPP will trip. When the power *limit* is set to a lower value, the trip level will also decrease.

SCPI
```
POWer:PROTection {<power>}
```

**Trip delay**
If the OPP is enabled and the output power reaches the set *trip level*, an OPP trip will occur at the earliest after the set delay time expires.

SCPI
```
POWer:PROTection:DELay {<time>}
```

## 10.5. Temperature (OTP)




**OTP active**
The OTP (Over-Temperature Protection) is software protection that will activate when the temperature measured on the channel's temperature sensor is equal to or greater than the set *trip level* value for a duration of *trip delay*.

Protection trip will be recorded in the event log and the channel output will be turned off.

*Dual channel modules like the DCM220 have two temperature sensors, one for each channel.*

SCPI
```
SYSTem:TEMPerature:PROTection:STATe {<bool>} [, <sensor>]
```

**Trip level**
The trip level value may be less than or equal to the set *limit* and determines the value of the measured temperature at which the OTP will trip.

SCPI
```
SYSTem:TEMPerature:PROTection {<temperature>}, <sensor>]
```

**Trip delay**
If the OTP is enabled and the temperature reaches the set *trip level*, an OTP trip will occur at the earliest after the set delay time expires.

SCPI
```
SYSTem:TEMPerature:PROTection:DELay {<delay>}, <sensor>
```

# 11. Special channel functions

The channel *Protections and settings* page also provides access to various additional features as follows:

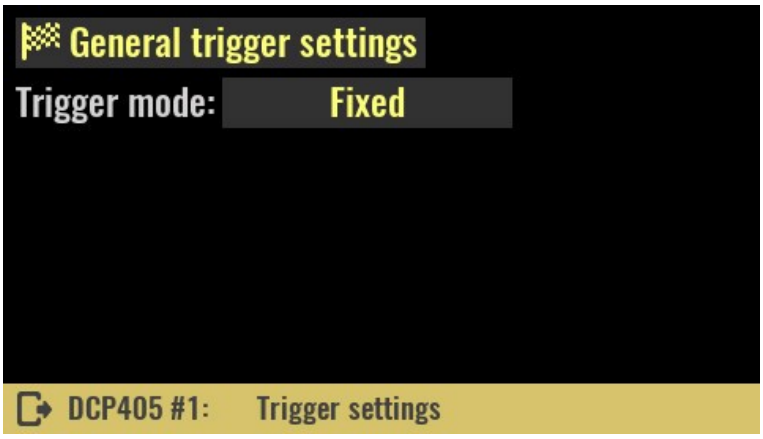
- Trigger
- List programming
- Display view
- Calibration (see *Power modules calibration*)
- Info
- Advanced options (DCP405 only)

## 11.1. Channel trigger settings

**General trigger settings**
A shortcut to *General trigger settings* page where you can adjust general settings related to the trigger system, like trigger source, delay or whether the trigger system is continuously initiated or not.

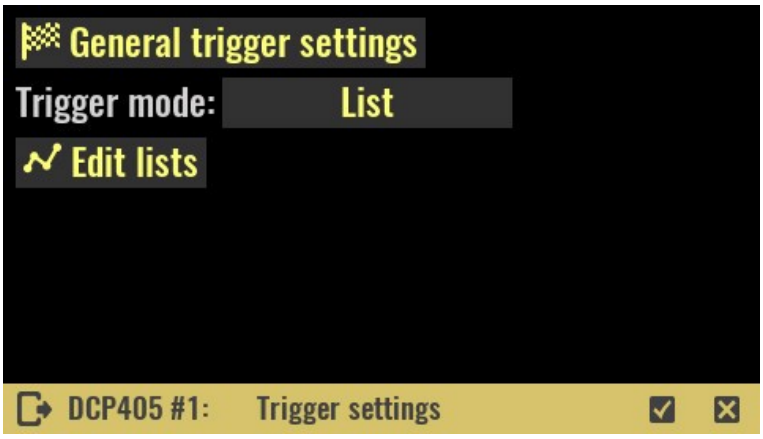
**Fixed**
Channel output state and values will remain at the immediate value, i.e. the channel is not affected by the triggering system.

SCPI
```
CURRent:MODE FIX
VOLTage:MODE FIX
```

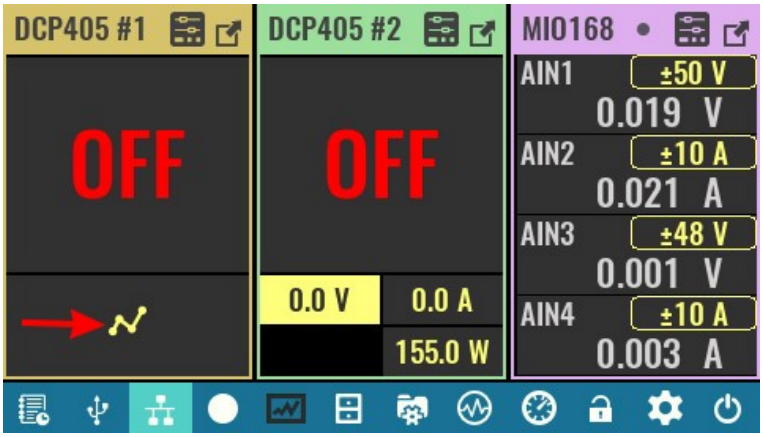



**List**
Channel output state and values will change according to the defined sequence of output voltages and currents of specified duration (see *List programming*).

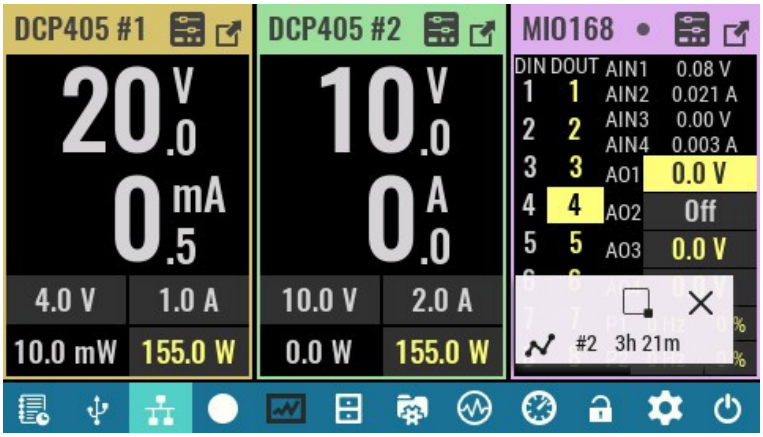
SCPI
```
CURRent:MODE LIST
VOLTage:MODE LIST
```



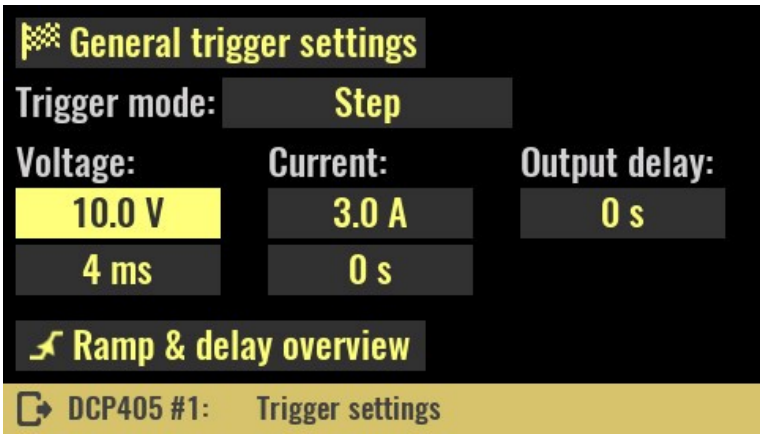

When trigger list is active, channel's output voltage and current set options will be replaced with the *list* icon that leads directly to the channel trigger settings page (i.e. the page shown above).



When executing the list, if there is at least one step that lasts 5 or more seconds, an overlay with countdown information will be displayed.
The example shows that a step is being performed on the second channel and that it has 3 hours and 21 minutes left to complete.




**Step**
Channel output state and values goes to the step level when a trigger occurs.




SCPI
```
CURRent:MODE STEP
VOLTage:MODE STEP
```

**Voltage:**
Programmed new value to which the output voltage will be set when the trigger system is initiated.

SCPI
```
VOLTage:TRIGgered {<voltage>}
```

The time value – set in the cell below the voltage value - defines how long the output voltage will take to reach the set value. If 0 is entered, the output voltage will be set in the shortest possible time (constrained by the current limit specified - i.e. if the current limit is set to a low value, it will take longer to reach the output voltage due to charging of the capacitor on the power output and input capacitor of the connected load). For a controlled output voltage ramp, values from 2 ms to 10 s can be used.

SCPI
```
VOLTage:RAMP:DURation {<duration>}
```

**Current:**
Programmed new value to which the output current will be set when the trigger system is initiated.

SCPI
```
CURRent:TRIGgered {<current>}
```

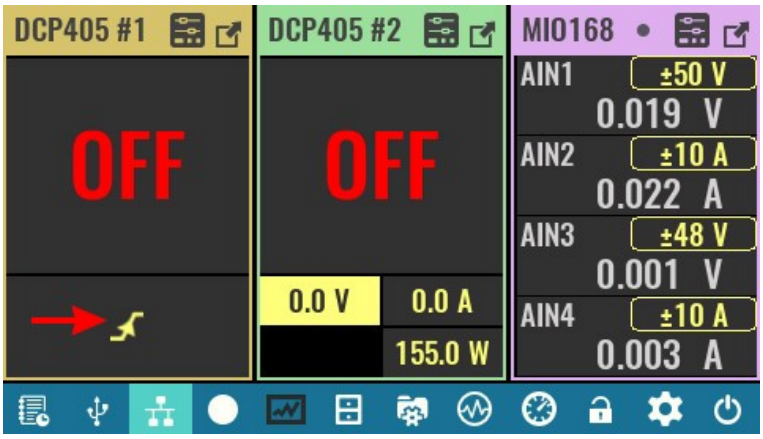
Value in the cell below defines how much time will take that output current limit reach set value. When set to 0, the output current limit will try to set in the shortest possible time. For a controlled output current limit ramp, values from 2 ms to 10 s can be used.

SCPI
```
CURRent:RAMP:DURation {<duration>}
```

**Output delay:**
Output turn on delay in seconds after the trigger system is initated. Delays from 2 ms to 10 ms can be specified.

**Ramp & delay overview**
A shortcut to *Ramp & delay* page where output voltage and current ramp and delay parameters can be viewed and edited on the single place.

When trigger step is active, channel's output voltage and current set options will be replaced with the *step* icon that leads directly to the channel trigger settings page (i.e. page shown above).



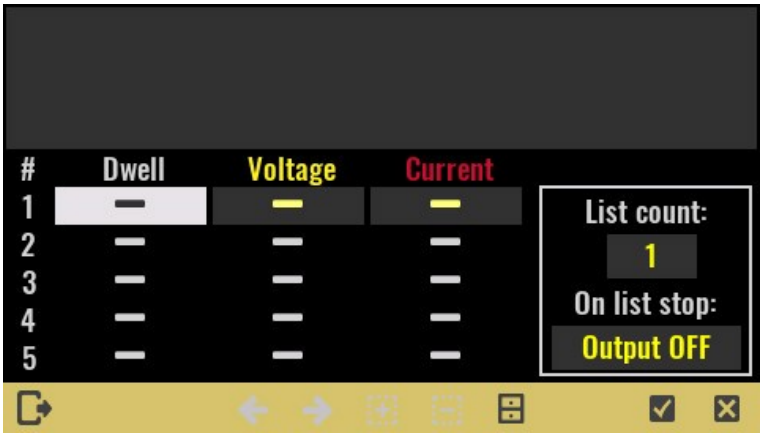

## 11.2. List programming

*IMPORTANT: since the list programming dynamically changes the voltage and current, make sure that they are within the limits that the connected load can withstand. If it is a sensitive load, it is recommended to set voltage and current limits (see Channel protections section) because they will be taken into account (together with set max. power) while list programming is active.*

See also the *Hardware OVP* section to find out how it can affect this function.

**Overview**
The list programming editor makes it easy to set multiple output voltages and currents that will be set in sequence.

A program list can have up to 256 steps with equal or varying duration or time intervals (*dwells*).

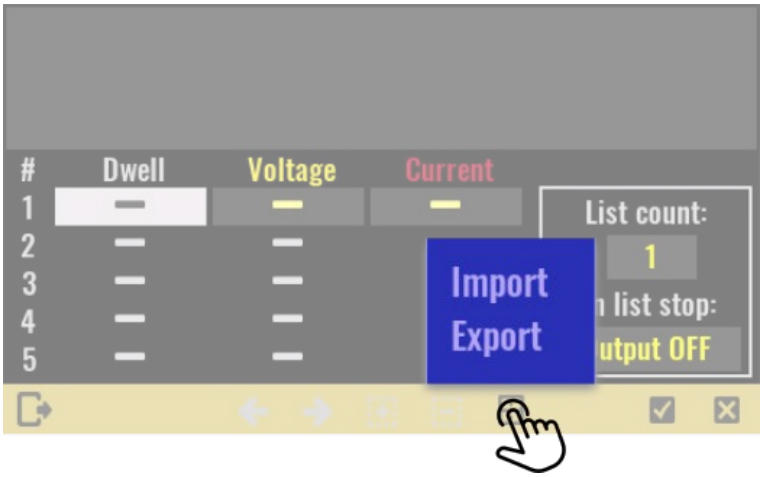



Entering a new or editing an existing value will require a tap on the cell when the numeric keypad will open. A preview of the entered sequences will be displayed at the top of the page.

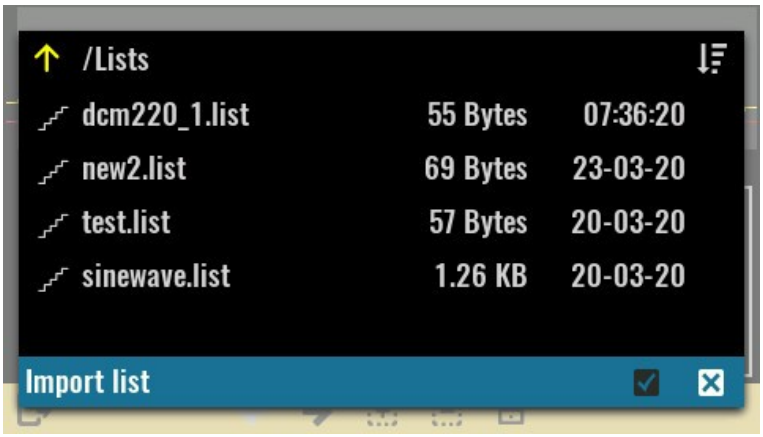
If the values of voltage and current defined in the list exceed the currently active limits, the list will be interrupted at the first step with too high value. For example, if the output voltage is limited to 10 V, and the list has the following steps: 5, 15, 20, 30 V, the list execution will be interrupted when the 15 V step is reached.

The number of steps in the program list is 256. The list editor displays 5 steps at a time, and when at least one cell in each of first five steps is filled, a navigation arrow will be enabled in the status bar to move to the next five steps.

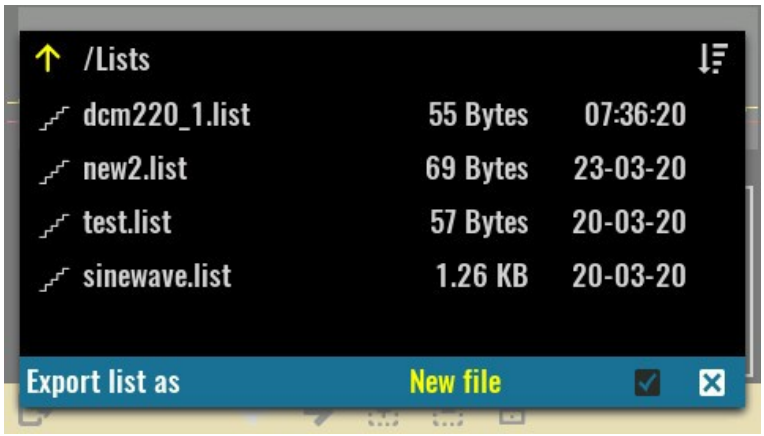
**List import and export**
An already defined list can be imported or exported. The storage location is the Lists folder on the SD card.
Selecting the file manager icon will open a menu to export or import the list.



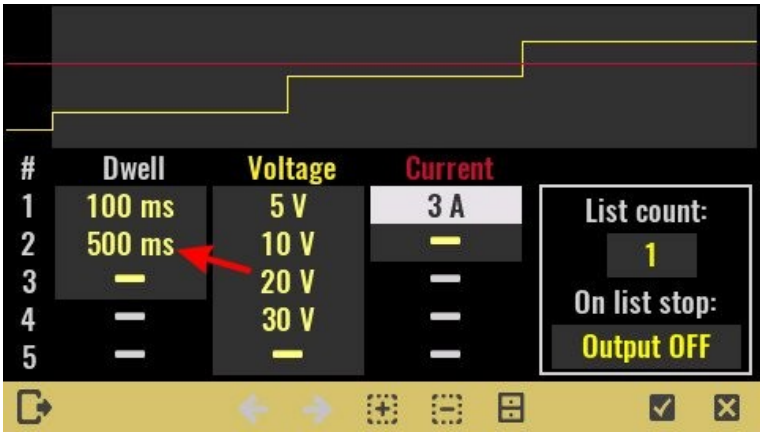

If you import a list, the contents of the Lists folder will be displayed.




While exporting list can overwrite existing list or saved in a new file by choosing *New file* option.




A programming list can have "symmetric" and "asymmetric" columns. A symmetric column is used when the minimum two different values need to be defined. For example, if a four-step list has a first step of 100 ms and all others of 500 ms, then it will be necessary to enter 100, 500, 500, 500 ms. However, if the output voltage and current in all steps will have the same duration, e.g. 100 ms, then it will only be necessary to enter 100 ms in the first cell and the rest will be able to remain blank.




The picture above shows an example of an incorrectly defined list that has more than one dwell value, but less than the number of defined steps. So, either 500 ms should be deleted in the second row (marked with arrow) or dwell values for the remaining cells should be entered.

**Dwell**
Dwell is the time that the output will remain at a specific step. Dwell times can be programmed from 0 through 65535 seconds.

*If the dwell is set to 0 ms, the firmware will try to spend the shortest possible time in this step, but there is no minimum duration that can be guaranteed (it depends on the current load of the microcontroller).*

SCPI
```
LIST:DWELl {<time>}
```

**Voltage**
This column contains the voltage values for each step.

SCPI
```
LIST:VOLTage {<voltage>}
```

**Current**
This column contains the current values for each step.

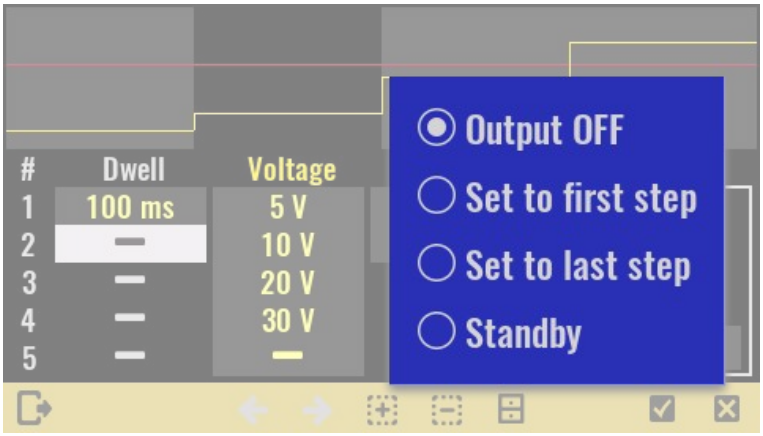
SCPI
```
LIST:CURRent {<current>}
```

**List count**
Sets the number of times that the list is executed before it is completed. The list count range is 1 through 65535 or it could be set to *infinity* (∞ sign on the numeric keypad) to execute a list continuously.

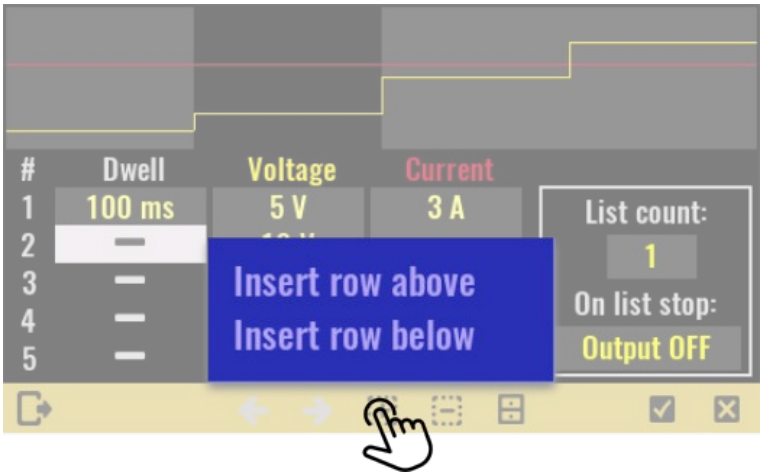
SCPI
```
LIST:COUNt {<count>}
```

**On list stop**
Define channels condition when programming list execution is not prematurely stopped (e.g. with ABORt command or by user action).

SCPI
```
TRIGger:EXIT:CONDition
{<condition>}
```



### 11.2.1. Inserting a new step

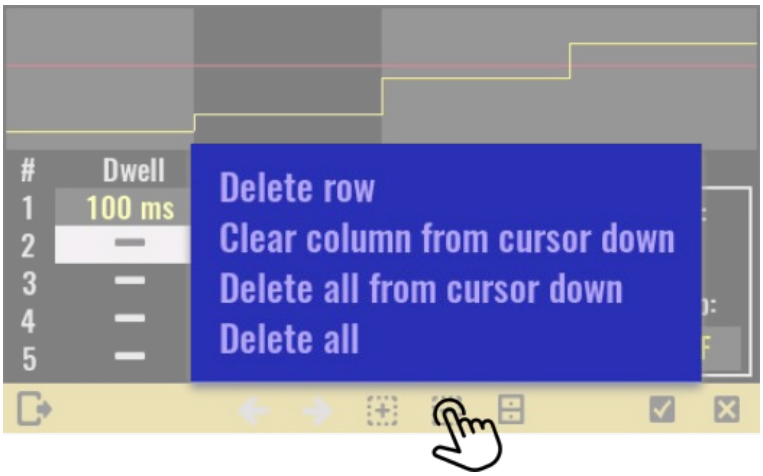



Inserting a new line is possible by selecting the + icon on the status bar when the menu with the options described below will open.

**Insert row above**
Lets you add a new step above the current cursor position. All values from the step the cursor was on will be copied to a new step.

**Insert row below**
Lets you add a new step bellow the current cursor position. All values from the step the cursor was on will be copied to a new step.

### 11.2.2. Deleting of list items




Deleting part or all of the list is possible by selecting the - icon on the status bar when the menu with the options described below will open.

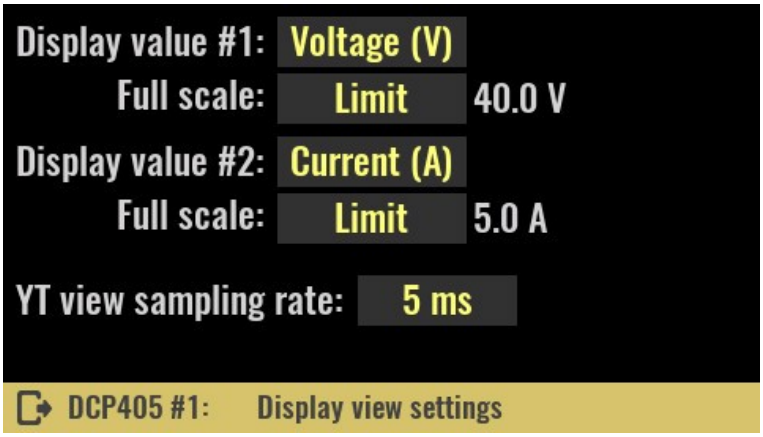
**Delete row**
Deleting a row at the cursor position. The row must have at least one value entered to be deleted.

**Clear column from cursor down**
Deleting only the contents of the column from the cursor position down.

**Delete all from cursor down**
Deletes the contents of all rows from the cursor position down.

**Delete all**
Delete all contents of the list.

## *11.3. Display view*




**YT view value #1**
YT view provides a graphical view of two measured output channels at the same time. The selected values are displayed in different colors. By definition, voltage is shown as the first value and current as the second value. Through this menu, it is possible to set a new value that will be displayed in the color of the first value.

SCPI
`INSTrument:DISPlay:TRACe1 {<value>}`

**Full scale**
This parameter defines the full scale value when displaying output values on bar graphs and YT view. Possible values are:

- *Maximum* – the max value that can be obtained is set (for example for the voltage on the DCP405 module it is 40 V)

- *Limit* – full scale is a user-set limit, for example 25 V out of a possible 40 V in the case of a DCP405 module
- *Auto* – it will dynamically monitor the user set value and increase it by 10%. For example for set 1 A, this will be 1.1 A
- *Custom* – setting the full scale to a user-defined value that must be positive and not greater than the maximum possible (e.g. 5 A to display the current on the DCP405 module).

SCPI
```
INSTrument:DISPlay:SCALEe1 {<scale_range>}
INSTrument:DISPlay:SCALEe2 {<scale_range>}
```

**YT view value #2**
use this menu to set a new output value that will be displayed in a color of the second value.

SCPI
```
INSTrument:DISPlay:TRACe2 {<value>}
```

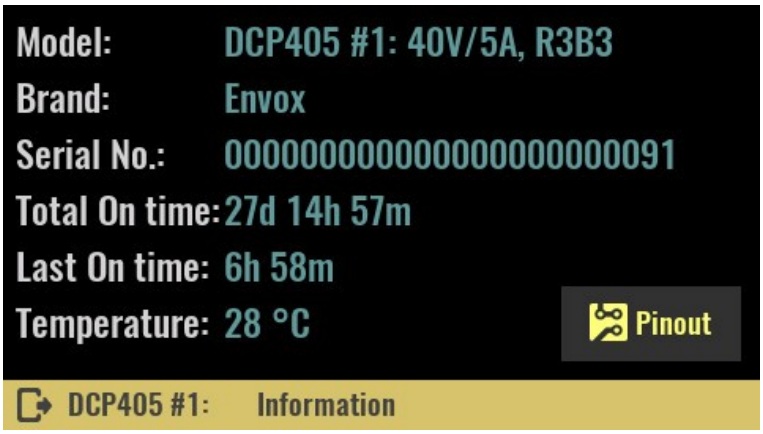
**Swap values**
Swap the positions of the selected display values.

SCPI
```
INSTrument:DISPlay:TRACe:SWAP
```

**YT view sampling rate**
This option swaps the position of the selected output values.

SCPI
```
INSTrument:DISPlay:YT:RATE {<duration>}
```

## 11.4. Info




**Model**
Displays module's model name and version. In the case of a two-channel module, the same model name and version will be displayed for both channels.

SCPI
```
SYSTem:CHANnel:MODel?
```

**Brand**
Module manufacturer name

**Serial No**
On-board MCU serial number (e.g. not applicable to DCP405)

**Total On time**
Channel's total active time, i.e. the time it was powered on. Resolution is 1 minute and this information is stored every 10 minutes in module's non-volatile memory. Therefore it's possible that up to 10 minutes is lost after restart caused with power outage or system reset.

SCPI
```
SYSTem:CHANnel:INFOrmation:ONTime:TOTal?
```

**Last On time**
Displays the elapsed time since the channel was last powered on. Resolution is 1 minute and this information is stored every 10 minutes in module's non-volatile memory. Therefore it's possible that up to 10 minutes is lost after restart caused with power outage or system reset.

SCPI

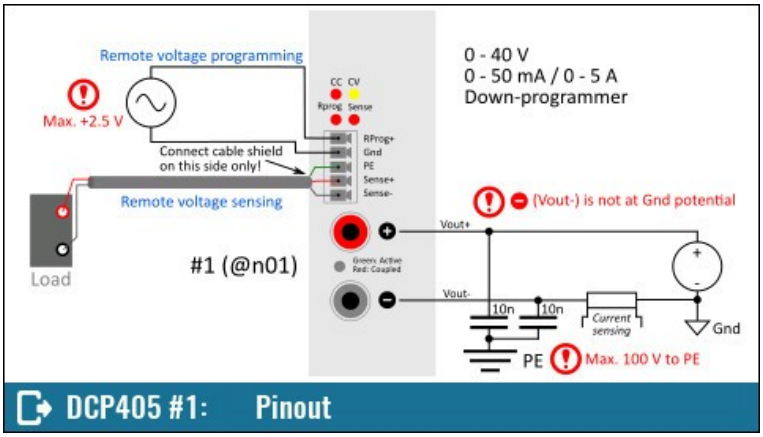
```
SYSTem:CHANnel:INFOrmation:ONTime:LAST?
```

**Temperature**
Returns the temperature read on the channel's temperature sensor. The two-channel module has two separate temperature sensors, so the measured values will not necessarily be the same.

*All temperature sensors are periodically tested. When sensor does not pass the test, programmed output current is automatically limited to 2 A. If load draws more then 2 A, output current will be set to zero.*

SCPI
```
MEASure:TEMPerature? {<channel>}
```

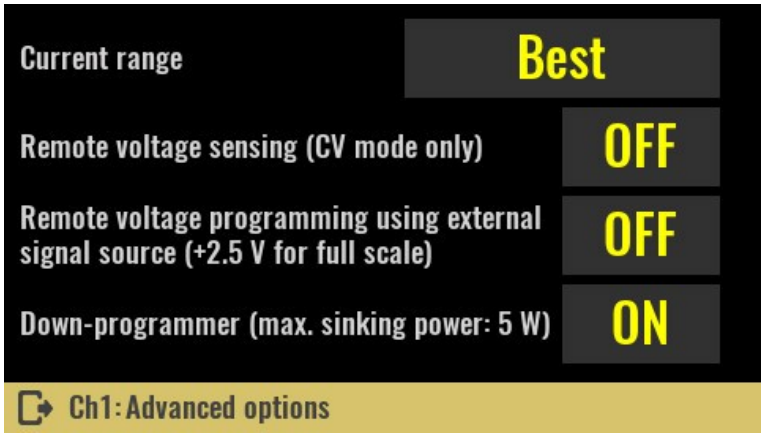
**Pinout**
Displays the connection diagram to the module terminals.




## 11.5. Advanced options

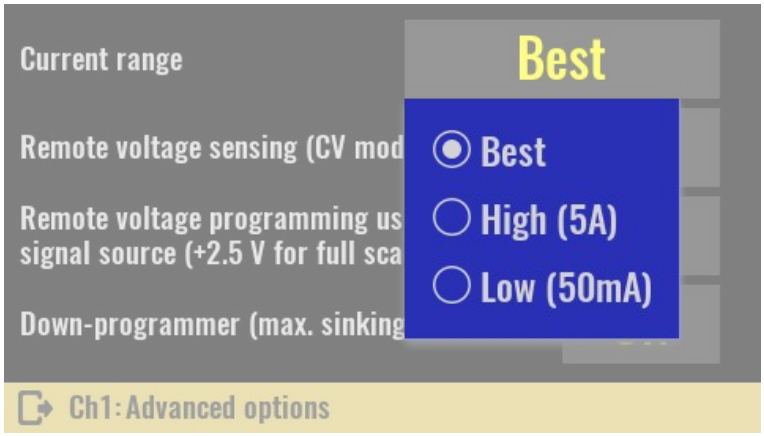
The DCP405 module, in addition to its *Hardware OVP*, comes with the following advanced features:

- Dual current ranges
- Remote voltage sensing (RSense)
- Remote voltage programming (RProg) and
- Down-programmer (DP)

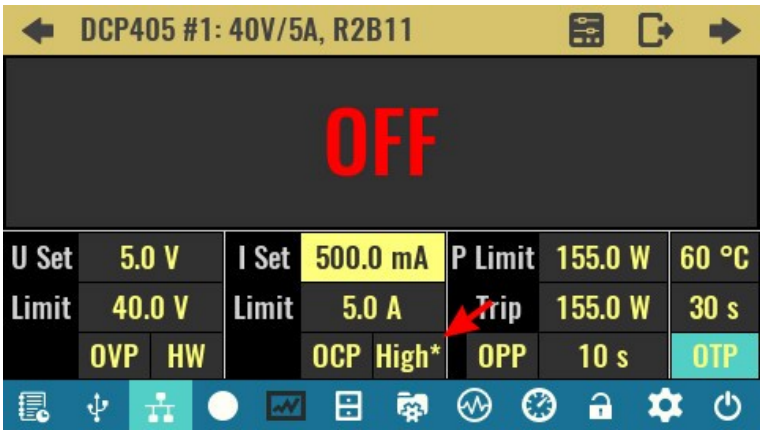



### 11.5.1. Current range

**Best (default)**
The DCP405 module has two current ranges. This option allows the current limit to be set in the best possible resolution. This will automatically activate a lower range for a set current limit of less than or equal to 50 mA, and a higher range for a current limit of more than 50 mA.



If the current range is set to *Best*, when the channel is in maximized view, an asterisk will be displayed next to the indication of the currently selected current range. In this way, it will be possible to distinguish whether the current range is a result of *Best* or manual selection.




SCPI
```
CURRent:RANGe DEF
```

**High (5A)**
Sets the current range to 5 A. Therefore set output current limit could be anything between 0 and 5 A.

SCPI
```
CURRent:RANGe 5
```

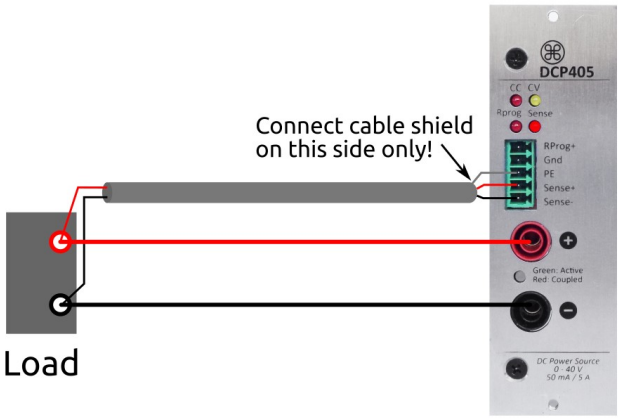
**Low (50mA)**
Sets the current range to 50 mA. Therefore set output current limit could be anything between 0 and 50 mA. If the previous current limit was above 50 mA, the new limit will be set to 50 mA.

SCPI
```
CURRent:RANGe 0.05
```

*Important: when power module is operating in CC mode, and load is changed dynamically that current vary between low and high current range, switching between ranges will generates voltage overshoots due to finite switching speed. Set current range manually in that case to avoid voltage overshoots. This problem does not exist if the current is changed dynamically using a list programming or function generator: while they are active, the current range will be set from* Best *to the range that is in line with the largest programmed current.*

### 11.5.2. Remote voltage sensing

The main purpose of the remote (external) sensing function is to ensure that the programmed voltage is accurately delivered to the load in such a way as to cancel the voltage drop caused by the long and thin cables used to connect the load.




Remote sensing needs to connect the power leads from the output terminals to the load and the sense leads from the sense terminals to the load.

Remote sensing cables should be twisted-pair and preferably shielded. When shielded, only one end needs to be connected to an PE potential.

Any noise picked up on the sense leads also appears at the power output and may adversely affect the voltage load regulation. Twist the sense leads to minimize external noise pickup and run them parallel and close to the load leads. In noisy environments it may be necessary to shield the sense leads. When shielded, only one end needs to be connected to a PE potential (at the module end only). Do not use the shield as one of the sense conductors.

The switching between internal and remote (external) voltage sensing is carried out under the control of a firmware that controls a small signal relay. For this reason no special wiring is required to select a

sensing point. The choice of external sensing is indicated by the *RSense* indicator on the front panel of the module.

*Please note that if the wiring to a load is long, the phase shift caused by the inductance and capacitance of the wiring could become significant and could generate instability. In that case add a small capacitor on the load end of the cable to prevent oscillation.*

An integral part of the remote sensing function is the reverse polarity protection, which will turn off the output immediately in case of incorrect connection of sense inputs (i.e. Sense+ to Power-, Sense- to Power+ or both).

*Keep in mind that reverse polarity protection is effective only for output voltage set above 1.5 V.*

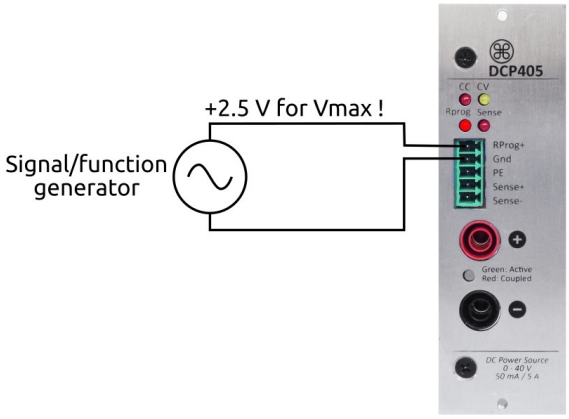
When the remote sensing is active, the OVP senses the voltage at the sensing points (load) and not the output terminals.

SCPI

```
VOLTage:SENSe EXT
```

### 11.5.3. Remote voltage programming

Remote voltage programming allows the output voltage to be set from an external source like signal/function generator. The input sensitivity is 16 V/V so the control voltage should not exceed 2.5 V.




When this mode is set, the firmware will automatically activate the OVP and set it to max. value (40.5 V).

*Remote voltage programming will not be possible if the channel is coupled in series or in parallel with another module or tracking mode is active.*

SCPI

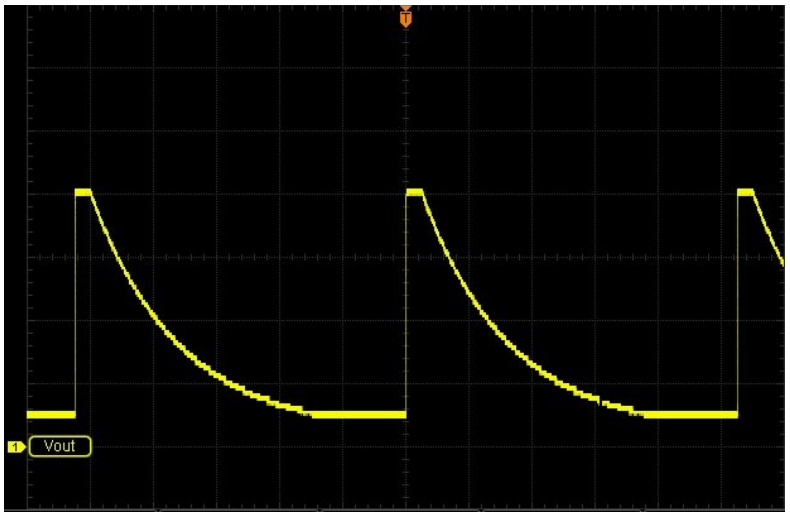
```
VOLTage:PROGram EXT
```

### 11.5.4. Down-programmer (DP)

The down-programmer (DP) can be thought of as an internal load across the power module's output terminals that helps bring the output voltage down quickly.

The primary function of the DP is to discharge the output capacitor but in some cases this feature may be used as a load to the connected device. The ability to rapidly transition from a higher to a lower constant voltage level also greatly improves the power module's output response time.

When DP is active its continuous current sinking is limited by firmware to 2 W.



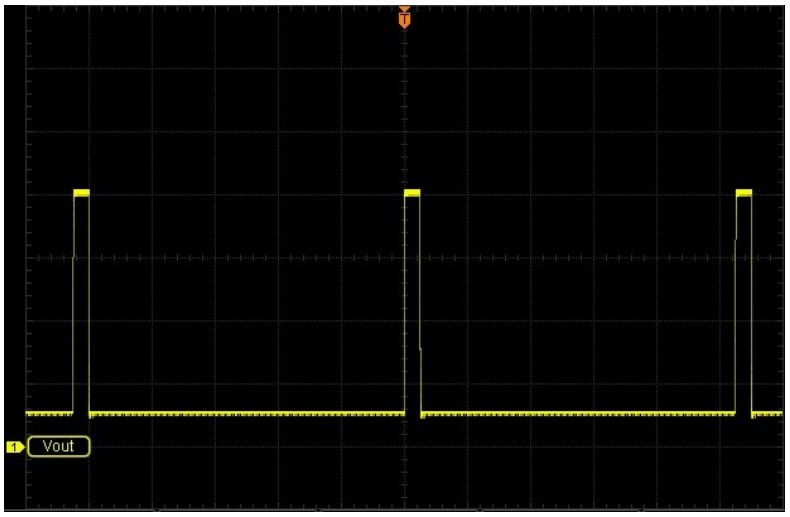

*Output voltage without load and with DP disabled*

However, it can sink over 2.5 A in short time that is sufficient for rapidly down-programming the output capacitor together with majority of loads connected to the output.

*The DP state is relevant only while the channel output is turned on.*

SCPI

```
OUTPut:DPRog {<state>}
```




*Output voltage without load and with DP enabled*

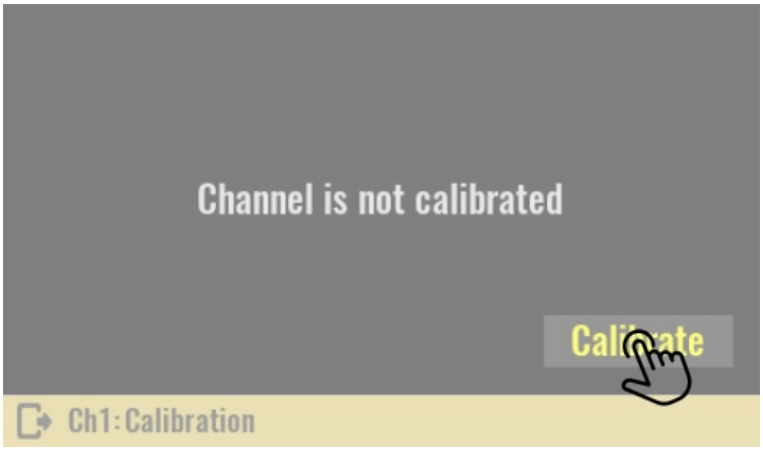
# 12. Power modules calibration

This section gives an overview of the calibration features of the power modules. Recommended calibration interval for power modules is 1 year. This will ensure that power modules remains within specification for the next calibration interval.
For optimum calibration results the following condition are recommended:

- The calibration ambient temperature is stable and between 20 °C and 30 °C.
- Ambient relative humidity is less than 80 %
- Allow a one hour warm-up with no load connected
- Use short and thick cables to connect test setups

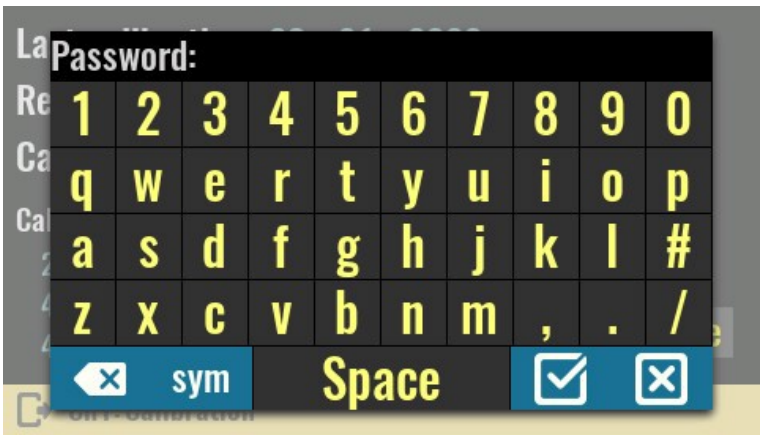
## *12.1. Start calibration wizard*

The procedure for first calibration and subsequent recalibration is identical. If the module has not yet been calibrated or the calibration data has been deleted (using the SCPI command) the *Channel is not calibrated* message will be displayed.




SCPI
```
CALibration:CLEar
{<password>}
```

Calibration is a multistep process that results in slight adjustments to output voltage and current so that programmed and measured values are as accurate as possible.
Calibration involves entering the difference between set (programmed) and measured values for at least two points within the allowable output range.
The default values displayed at the start of the process can change as can the number of measuring points (up to 20).



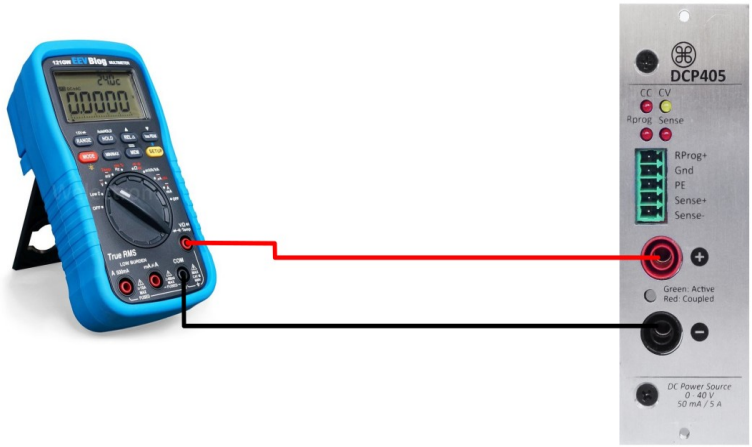

Only one channel can be calibrated at a time. Within the same calibration session both output voltage and current can be calibrated for the currently selected channel. The calibration procedure can be canceled at any step when entered data will be simply ignored.

The calibration process begins by selecting the *Calibrate* option for the currently selected channel.
The initial calibration password is **eezbb3** and should not be confused with a *system password* that is not set by default.

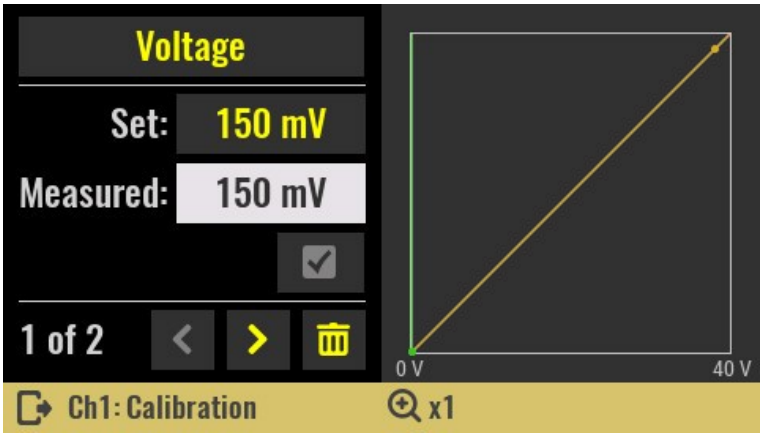
SCPI
```
CALibration ON, {<password>}
```

## 12.2. Voltage calibration setup

For voltage calibration, disconnect all loads from the power module and connect a digital multimeter (DMM) across the output terminals.
Make sure that the power module is in the CV mode.

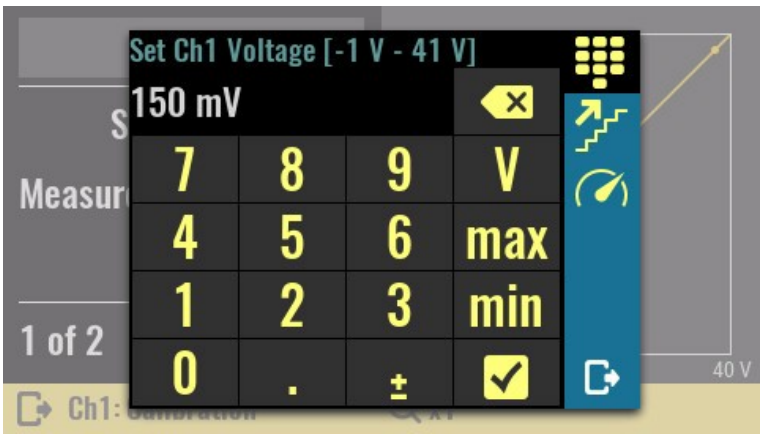



### 12.2.1. Voltage calibration steps




This is the first step of the calibration procedure. The *Voltage* is selected for calibration, and the first voltage point is *Set* to 150 mV.

*IMPORTANT: it is possible that module for the set 150 mV gives a voltage very close to zero or is even slightly negative. If this is the case, set the new step to e.g. 200 or even 250 mV (follow the procedure described below) that the output voltage is at least 50 mV.*



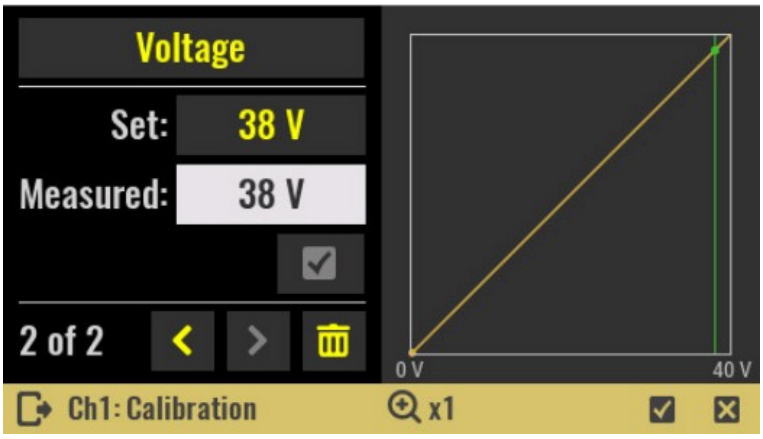

**Set:**
Displays output value that will be programmed for currently selected calibration point.

*This value is shown for information only. Instructions for deleting or changing the total number of calibration points is described below.*

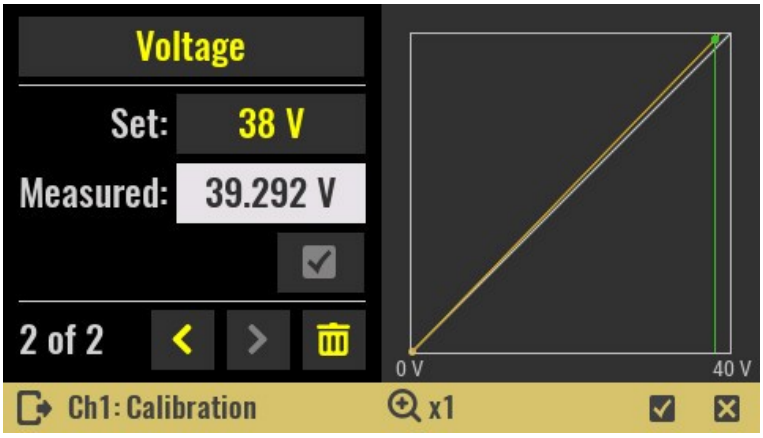
**Measured:**
The numeric keypad will be displayed by selecting this option. The value displayed on the external DMM should be entered with an arbitrary number of decimal places. Save the calibration data by selecting the *Confirm* icon.

SCPI
`CALibration:VOLTage:LEVel`

Move to the next calibration point using the right navigation icon. Measure the voltage and enter it into the *Measured* field.

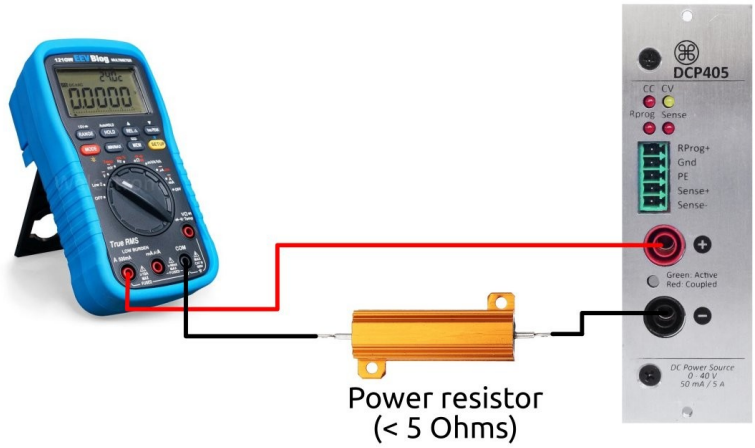




After each entry of the measured value for the set calibration points, it will be possible to see the change in the graph to the right, i.e. the deviation of the calibration curve (yellow) from the ideal curve (white).

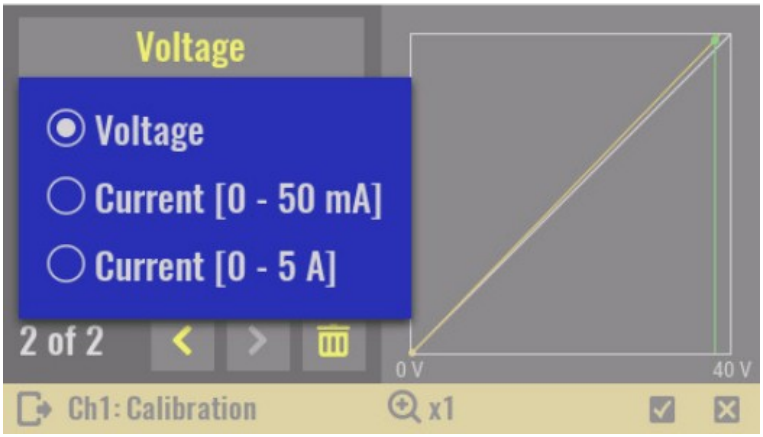



## 12.3. Current calibration setup

For current calibration, connect an appropriate power resistor (less then 5 Ω) in series with DMM set to current measurement.



Tap on the *Voltage* button to open a menu from which you can select the current range.

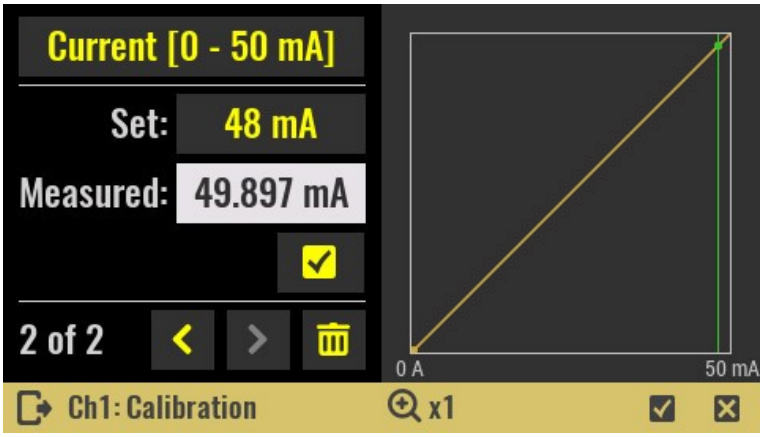

If the power resistor is of the appropriate value and properly connected, the power module will enter CC mode. Otherwise, a warning sign will be displayed that the output is still in CV mode.


Enter the measured value for the first point and select *Confirm* button.

SCPI

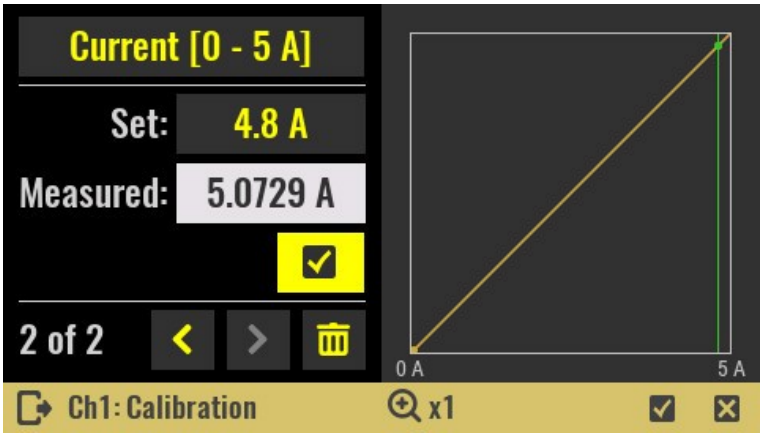
```
CALibration:CURrent:LEVel
```


Move to the next calibration point using the right navigation icon and enter measured value for the next point and select *Confirm* button.



After calibrating the low range current, repeat the same procedure for the high range and enter the measured value for the first point.


Once again move to the next calibration point using the right navigation icon and enter measured value for the next point.



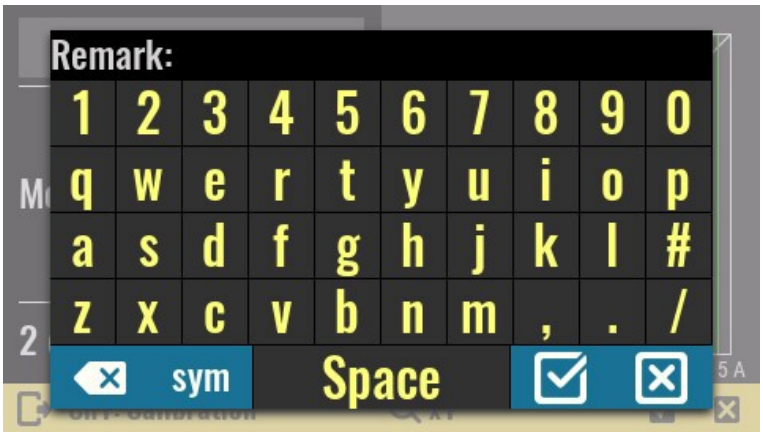

### 12.3.1. Deleting existing and adding new calibration points

Any calibration point can be deleted by selecting *Trash* icon or new calibration point can be added by simply entering a new value in calibration point *Set* field. The maximum number of calibration points for any selected parameter (i.e. voltage, low range current or high range current) is 20.

### 12.3.2. Save calibration parameters

The final step is to save the calibration parameters. Upon confirmation, the calibration parameters are written to non-volatile memory within the power module; calibration parameters are retained even if the power module is moved to another slot.

The last parameter that can be set during calibration is remark. The remark has two parts:




- a mandatory one that is system defined (a datetime stamp in format *yyyymmdd*) and
- an optional one that can be up to 32 characters long that contains a description of the calibration (eg only voltage is calibrated, etc.)

SCPI

```
CALibration:SAVE
CALibration:REMark {<user remark>}
```

After the calibration is successfully complete the calibration information will be displayed.


**Calib. enabled**
This option defines whether calibration parameters are used to set and read-out voltage and current output values. It can only be enabled when at least one of the calibration ranges (i.e. voltage, current high or low range) is successfully stored.

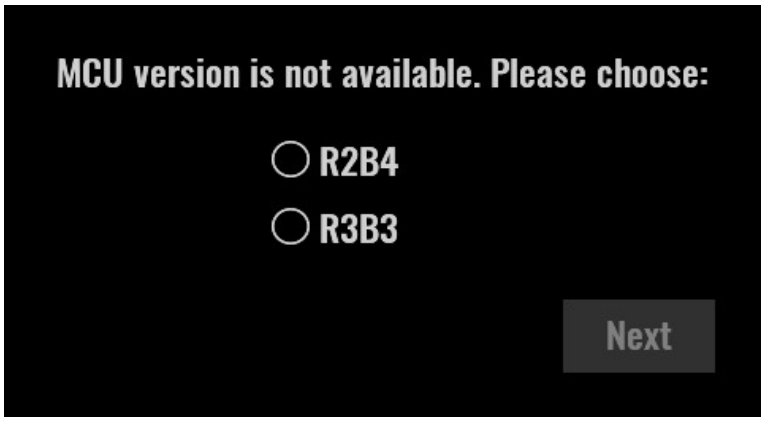
SCPI

```
CALibration:STATe ON
```

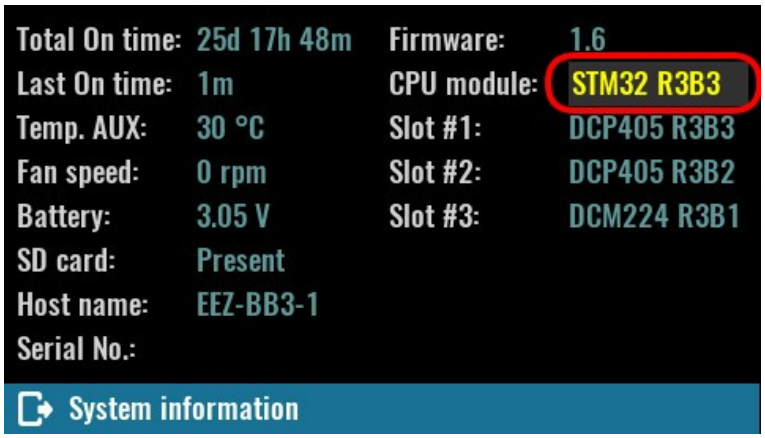
# 13. Firmware upgrade

The EEZ BB3 (i.e. MCU module) firmware is not protected and can be upgraded when a new version is released. In addition, some of the peripheral modules (e.g. DCM220) have their own MCU, which is also advisable to upgrade with newer versions. The upgrade procedures for these firmware are different as described in this chapter.

*Important notice: If you are upgrading the firmware from a version older than 1.6 to 1.6 or later according to the instructions below, the following message will appear on the first restart only:*




*If you got BB3 as a kit through a Crowd Supply crowdfunding campaign and the color of the MCU module PCB is green, choose r2B4 (the newer version of r3B3 has a PCB in blue). If you accidentally select the wrong revision of the MCU module, you can correct it later on the System information page.*




## *13.1. MCU module firmware upgrade*

This section describes the procedure for downloading firmware to EEZ BB3 (i.e. MCU module) from Linux and Windows operating systems using the USB DFU (*Device Firmware Upgrade*). Regardless of the operating system, the following steps will be required:

1. Disconnect any connected loads from all outputs and make sure that UART port (DIN1/DOUT1) is not used. Unplug also USB cable if connected.
2. Download the latest firmware available at https://github.com/eez-open/modular-psu-firmware/releases

**Table of content:**



### 13.1.1. Linux

The procedure described below is made on Ubuntu 18.04 LTS and may be somewhat different with other Linux distributions. DFU is an official USB device class specification. It is natively supported by

Linux. Therefore, no additional driver will need to be installed.

1. Turn power off using the power switch on the front panel.

   **MCU r2B4 (i.e. green PCB):**
   Keep the BOOT0 switch pressed while turning the power on. The BOOT0 switch is located in the lower left corner of the front panel. If the BOOT0 switch has been pressed long enough, EEZ BB3 enters DFU mode.

   **MCU r3B3:**
   Keep the USER switch (right of encoder knob) pressed while turning the power on. EEZ BB3 enters DFU mode.

   The existing firmware will be deactivated and the Welcome page will *not* be displayed. The cooling fan will stop spinning after few seconds.
2. Now connect EEZ BB3 to PC using USB cable. The connector on the EEZ BB3 side should be of USB Mini type.
3. You can check if Linux correctly identified EEZ BB3, which must be in DFU mode. Open the *terminal* application and enter:

   ```
   lsusb
   ```

   A list of all connected and recognized USB devices will be displayed. If EEZ BB3 is properly connected and enters DFU mode a red marked line should appear.

   ```
   Bus 004 Device 002: ID 174c:55aa ASMedia Technology Inc. ASM1051E SATA
   6Gb/s bridge, ASM1053E SATA 6Gb/s bridge, ASM1153 SATA 3Gb/s bridge
   Bus 004 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
   Bus 003 Device 002: ID 046d:c077 Logitech, Inc. M105 Optical Mouse
   Bus 003 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
   Bus 002 Device 001: ID 1d6b:0003 Linux Foundation 3.0 root hub
   Bus 001 Device 108: ID 0483:df11 STMicroelectronics STM Device in DFU
   Mode
   Bus 001 Device 103: ID 1a40:0101 Terminus Technology Inc. Hub
   Bus 001 Device 003: ID 04d9:1400 Holtek Semiconductor, Inc. PS/2
   keyboard + mouse controller
   Bus 001 Device 006: ID 8087:0025 Intel Corp.
   Bus 001 Device 004: ID 046d:081b Logitech, Inc. Webcam C310
   Bus 001 Device 002: ID 1a40:0101 Terminus Technology Inc. Hub
   Bus 001 Device 001: ID 1d6b:0002 Linux Foundation 2.0 root hub
   ```
4. Install *dfu-util* (you need sudo access rights):

   ```
   sudo apt install dfu-util
   ```
5. Run *dfu-util* in folder where firmware image is downloaded:

   ```
   dfu-util -a 0 -D bb3.dfu
   ```
6. Wait until the firmware image download is complete. A typical *dfu-util* output is shown below.

   ```
   dfu-util 0.9

   Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
   Copyright 2010-2016 Tormod Volden and Stefan Schmidt
   This program is Free Software and has ABSOLUTELY NO WARRANTY
   Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

   Match vendor ID from file: 0483
   Match product ID from file: 0000
   Opening DFU capable USB device...
   ID 0483:df11
   Run-time device DFU version 011a
   Claiming USB DFU Interface...
   Setting Alternate Setting #0 ...
   Determining device status: state = dfuERROR, status = 10
   dfuERROR, clearing status
   Determining device status: state = dfuIDLE, status = 0
   ```

```
dfuIDLE, continuing
DFU mode device DFU version 011a
Device returned transfer size 2048
DfuSe interface name: "Internal Flash  "
file contains 1 DFU images
parsing DFU image 1
image for alternate setting 0, (2 elements, total size = 901464)
parsing element 1, address = 0x08000000, size = 504
Download     [=========================] 100%          504 bytes
Download done.
parsing element 2, address = 0x08000200, size = 900944
Download     [=========================] 100%       900944 bytes
Download done.
done parsing DfuSe file
```

**7** Disconnect USB cable and recycle power using the front panel power switch.

Alternatively it is possible to download .hex firmware image:

**1** First, the .hex firmware image has to be converted into .bin format. If the firmware file name is bb3.bin, use the following command:

```
objcopy --input-target=ihex --output-target=binary bb3.hex bb3.bin
```

**2** `dfu-util -a 0 -s 0x08000000:leave -D bb3.bin</code>`

Wait until the firmware image download is complete. A typical *dfu-util* output is shown below.

```
dfu-util 0.9

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Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

dfu-util: Invalid DFU suffix signature
dfu-util: A valid DFU suffix will be required in a future dfu-util
release!!!
Opening DFU capable USB device...
ID 0483:df11
Run-time device DFU version 011a
Claiming USB DFU Interface...
Setting Alternate Setting #0 ...
Determining device status: state = dfuERROR, status = 10
dfuERROR, clearing status
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 011a
Device returned transfer size 2048
DfuSe interface name: "Internal Flash  "
Downloading to address = 0x08000000, size = 919352
Download     [=========================] 100%       919352 bytes
Download done.
File downloaded successfully
dfu-util: Error during download get_status
```
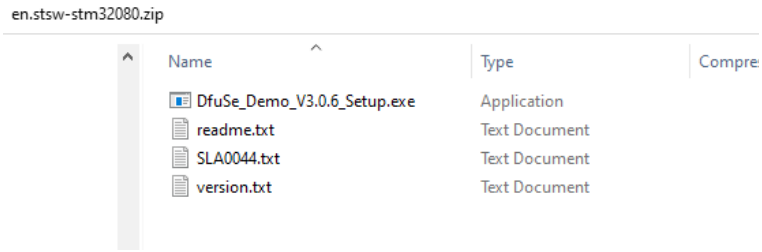

### 13.1.2. Windows

1 Visit the following page https://www.st.com/en/development-tools/stsw-stm32080.html and select *en.stsw-stm32080.zip* download. You may be required to register and login on the ST web site first.

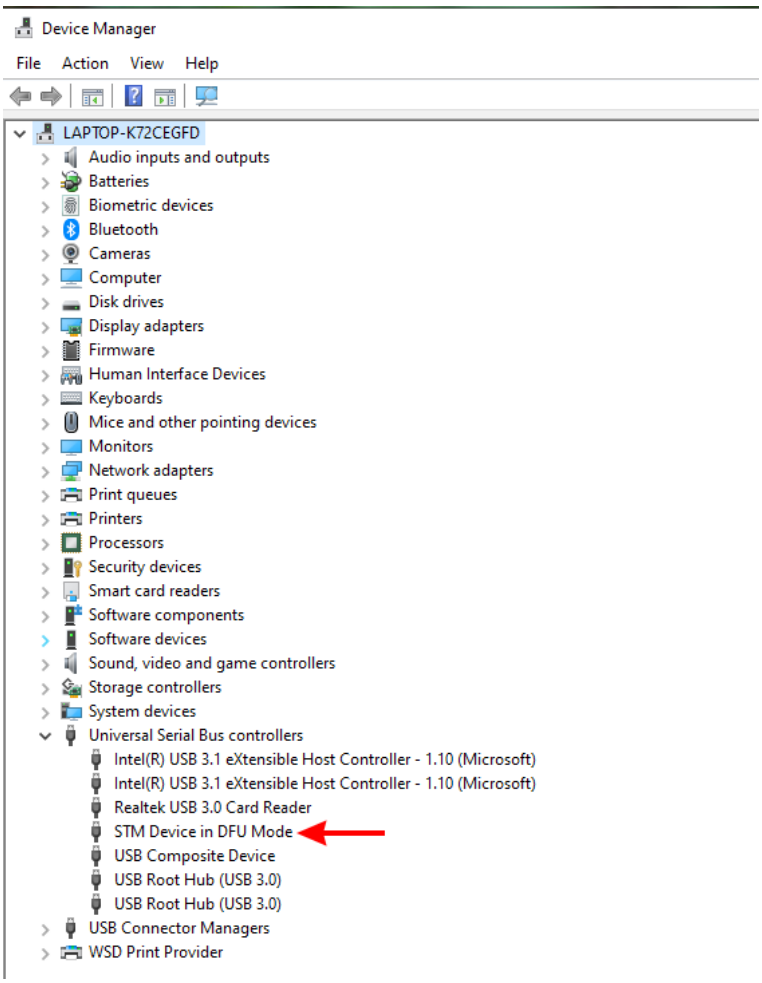

2 Unzip *en.stsw-stm32080.zip* and start installation of *DfuSe_Demo_V3.0.6_Setup.exe*




3 Connect EEZ BB3 to your PC using a USB cable. The connector on the EEZ BB3 side should be of USB Mini type.

4 Turn power off using the power switch on the front panel and keep the BOOT0 switch pressed when power is turned on. The BOOT0 switch is located in the lower left corner of the front panel. If the BOOT0 switch has been pressed long enough, EEZ BB3 enters DFU mode and the existing firmware will be deactivated and the Welcome page will not be displayed. The cooling fan will stop spinning after few seconds.

5 Check if Windows recognizes the EEZ BB3 as a device in DFU mode. It should be listed in *Device Manager* under *Universal Serial Bus controllers* section as *STM Device in DFU mode*.



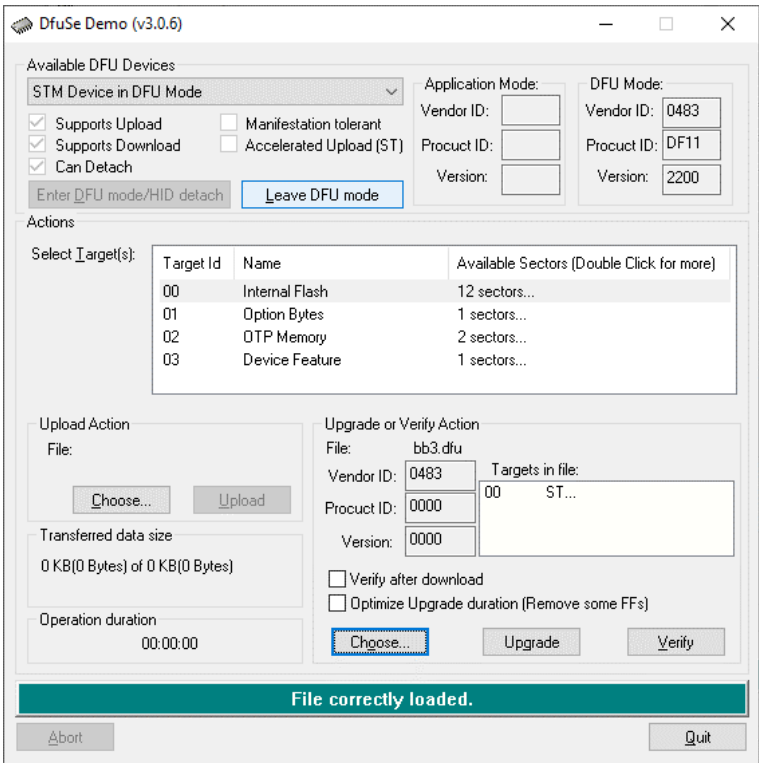

If the EEZ BB3 USB is not recognized you have to install its driver manually from the following location (64-bit):

*C:\Program Files (x86)\STMicroelectronics\Software\DfuSe v3.0.6\Bin\Driver\Win7\x64*

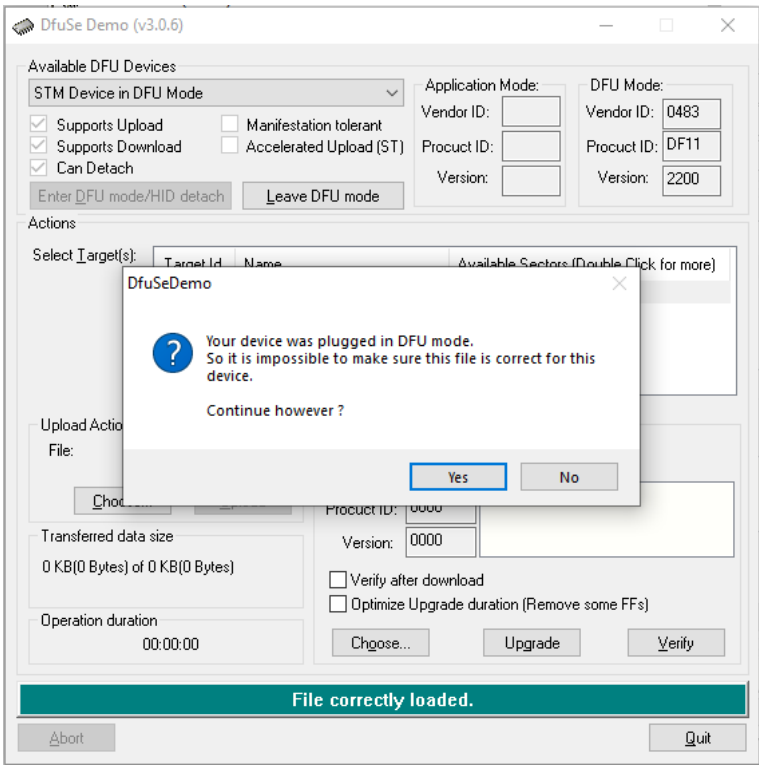
or for 32-bit at

*C:\Program Files (x86)\STMicroelectronics\Software\DfuSe v3.0.6\Bin\Driver\Win7\x86*

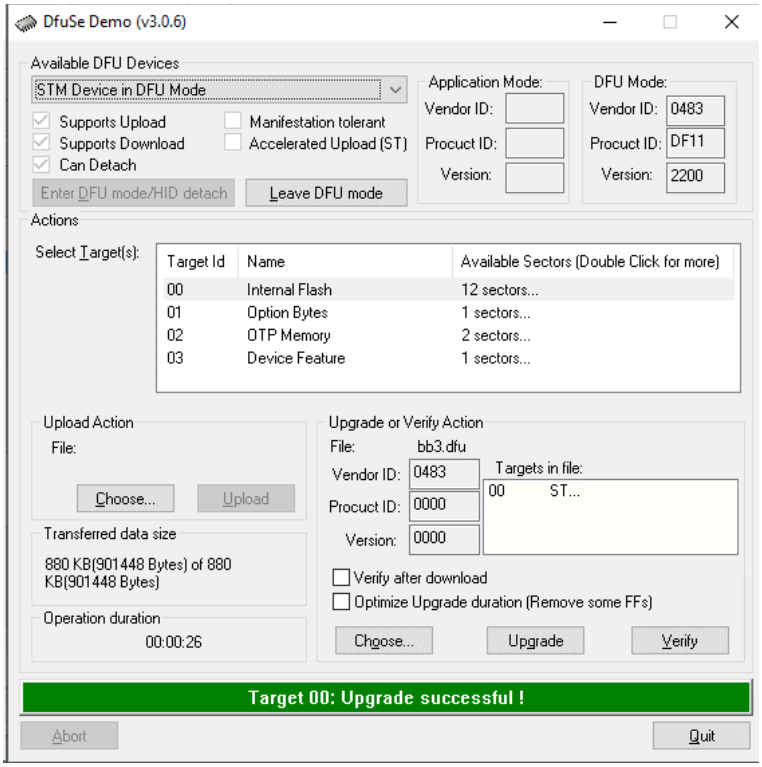
**6** Start the *DfuSe Demo*, select the *Choose* button under *Upgrade or Verify Action* section to load *bb3.dfu* firmware image.
A message should appear if firmware image is loaded successfully.




**7** Select the *Upgrade* button under the same *Upgrade or Verify Action* section and select *Yes* when message box with question appears.



8 Wait until the firmware upgrade is complete.




9 Disconnect USB cable and recycle power using the front panel power switch.

### 13.1.3. Mac OSX

1 Press *Command+Space* and type

```
Terminal
```

2 Run in Terminal app:

```
ruby -e "$(curl -fsSL
https://raw.githubusercontent.com/Homebrew/install/master/install)"
< /dev/null 2> /dev/null
```

If the screen prompts you to enter a password, please enter your Mac's user password to continue. When you type the password, it won't be displayed on screen, but the system would accept it. So just type your password and press *Enter/Return* key. Then wait for the command to finish.

3 Start installation:

```
brew install dfu-util
```

4 Run *dfu-util* in folder where firmware image is downloaded:

```
dfu-util -a 0 -D bb3.dfu
```

5 Wait until the firmware image download is complete. A typical *dfu-util* output is shown below.

```
dfu-util 0.9

Copyright 2005-2009 Weston Schmidt, Harald Welte and OpenMoko Inc.
Copyright 2010-2016 Tormod Volden and Stefan Schmidt
This program is Free Software and has ABSOLUTELY NO WARRANTY
Please report bugs to http://sourceforge.net/p/dfu-util/tickets/

Match vendor ID from file: 1209
Match product ID from file: 2018
Opening DFU capable USB device...
ID 0483:df11
Run-time device DFU version 011a
Claiming USB DFU Interface...
```

```
Setting Alternate Setting #0 ...
Determining device status: state = dfuERROR, status = 10
dfuERROR, clearing status
Determining device status: state = dfuIDLE, status = 0
dfuIDLE, continuing
DFU mode device DFU version 011a
Device returned transfer size 2048
DfuSe interface name: "Internal Flash  "
file contains 1 DFU images
parsing DFU image 1
image for alternate setting 0, (2 elements, total size = 1201048)
parsing element 1, address = 0x08000000, size = 504
Download    [=========================] 100%          504 bytes
Download done.
parsing element 2, address = 0x08000200, size = 1200528
Download    [=========================] 100%      1200528 bytes
Download done.
done parsing DfuSe file
```

6 Disconnect USB cable and recycle power using the front panel power switch.

## 13.2. Peripheral module firmware upgrade

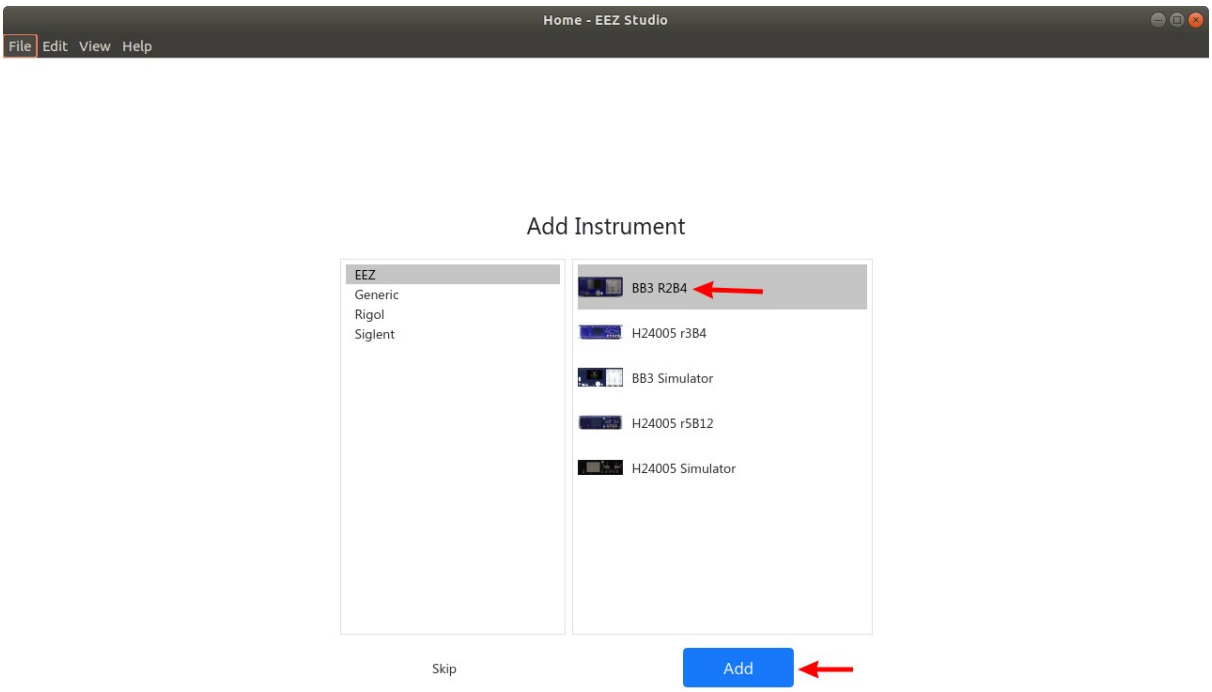
Upgrading the peripheral module firmware can be done in two ways by following the step by step procedures described below. As with the MCU module firmware upgrade, disconnect any connected loads from all outputs because after the firmware upgrade is complete, all peripheral modules will be reset.

### 13.2.1. Using EEZ Studio to upgrade peripheral module firmware

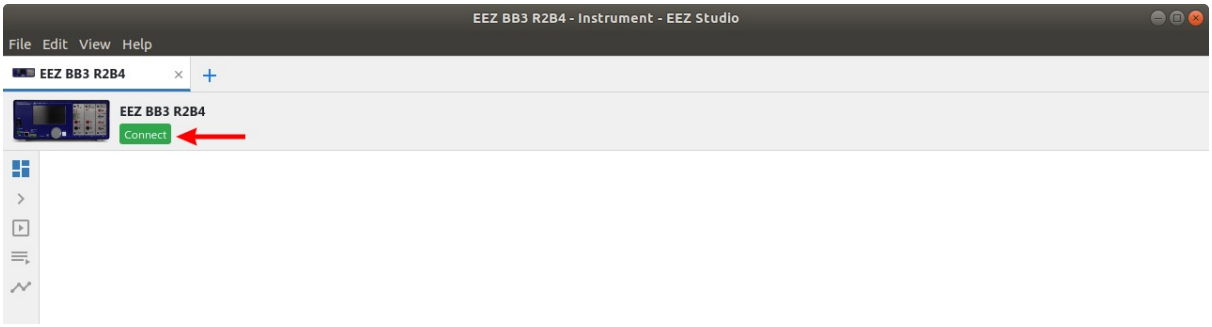
1 The easiest and fastest way to upgrade the firmware on a peripheral module is through EEZ Studio. When EEZ Studio is installed and communication with EEZ BB3 is established, it is a one-click action. If EEZ Studio is not installed, download the latest EEZ Studio available at https://github.com/eez-open/studio/releases and install it on your computer.

*Important: A EEZ BB3 MCU module firmware version 1.1 or later is required to use this method and the computer on which EEZ Studio is running should have an active internet connection.*

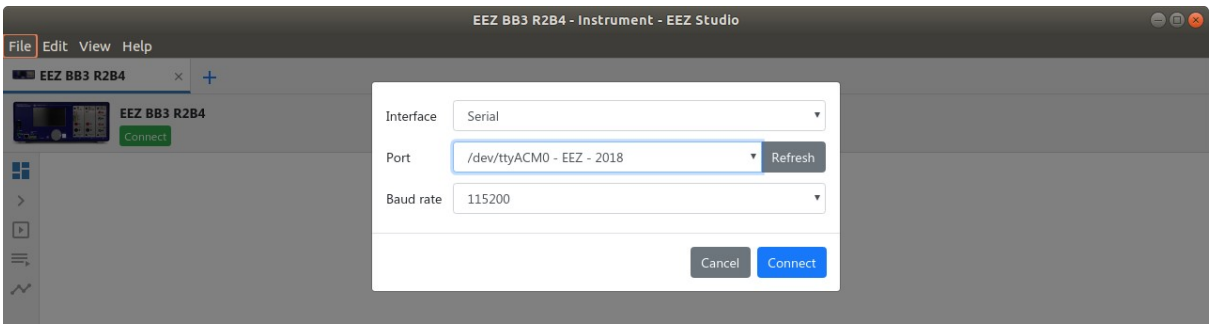
2 Start EEZ Studio and add EEZ BB3 from the list of preinstalled instruments on the *Home* page.




3 Select *Connect* option to open connection menu.

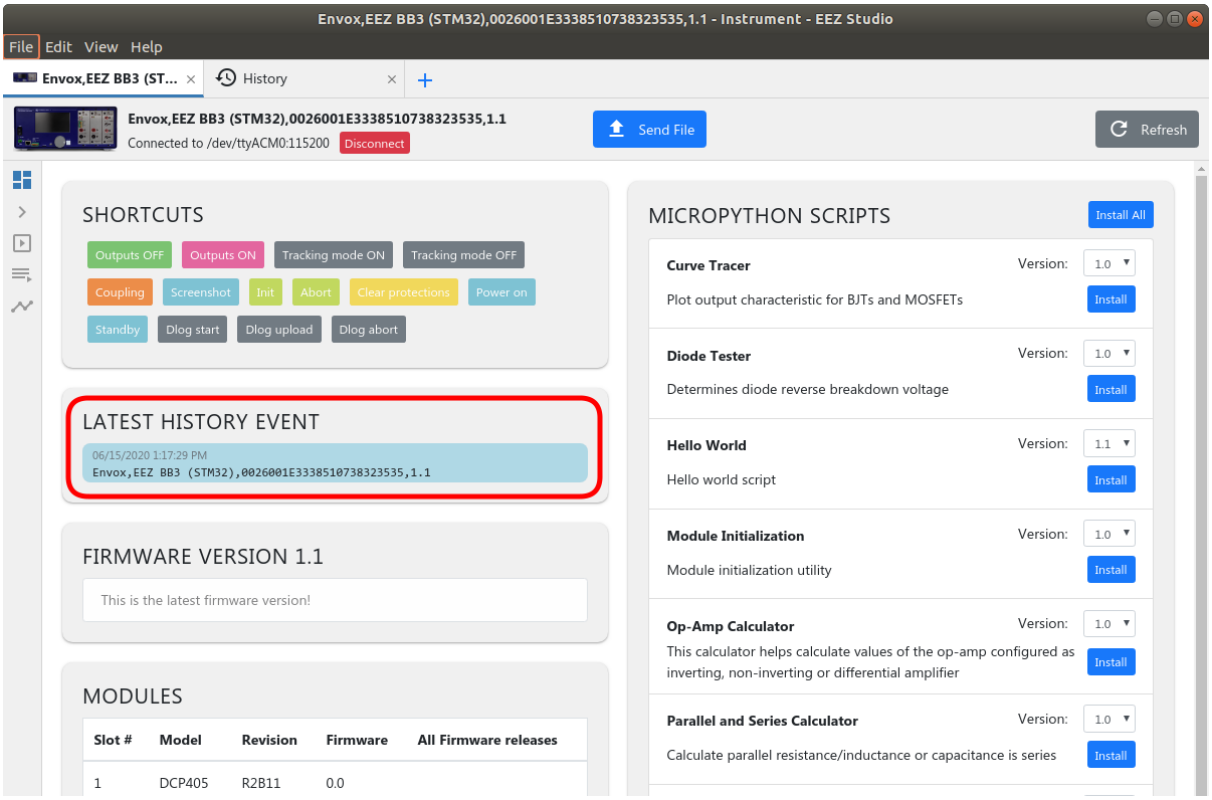



**4** Select connection type, for USB choose *Serial* from *Interface* combo box. Click on *Refresh* button if *EEZ - 2018* is not visible in the list of serial terminals.

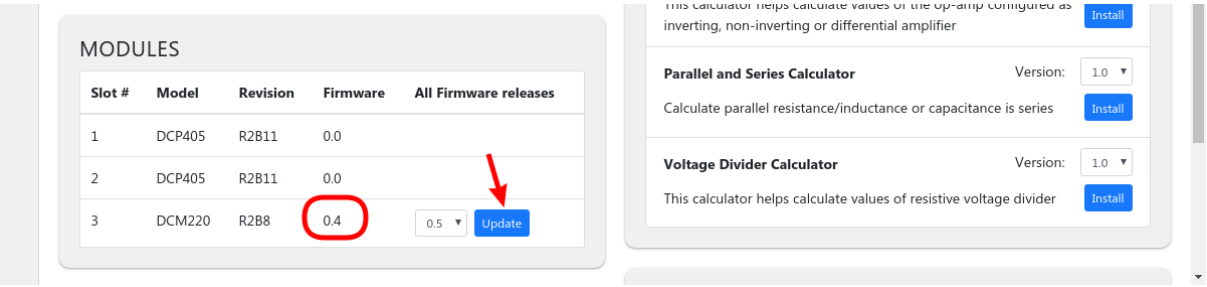



When *Ethernet* is selected as communication interface, the *Server address* has to be defined. Enter here EEZ BB3's IP address (See *Ethernet* settings).

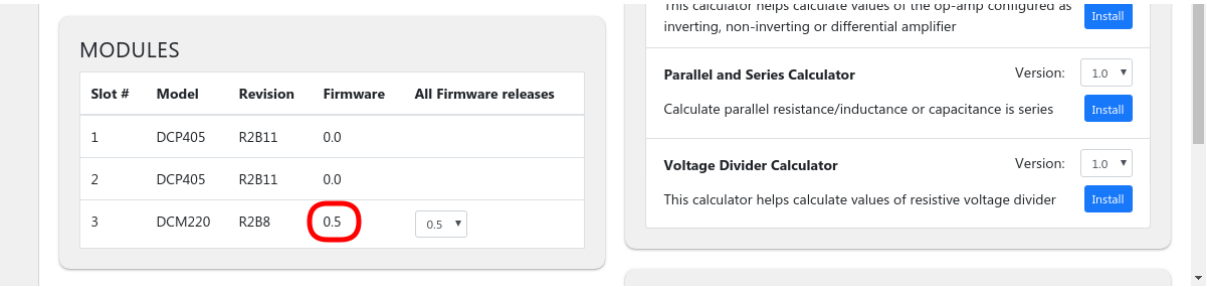
Successfully established connection is indicated by receiving identification string as response to **IDN?* SCPI query that EEZ Studio will send automatically to the EEZ BB3 over the selected interface. The identification string can be seen in the *Latest history event* section.




**5** Scroll down to the Modules section where all recognized installed modules are visible. For modules that have an MCU, the version of the installed firmware will be displayed in the *Firmware* column. To download another firmware version, it will be enough to choose the one you want, click on the *Update* option and wait a few moments.



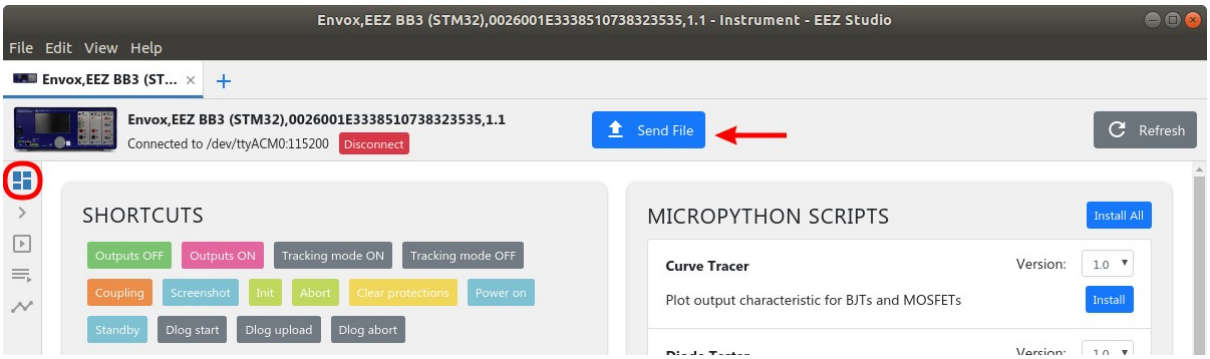

6 When the download is successful, the displayed firmware version will also be updated.



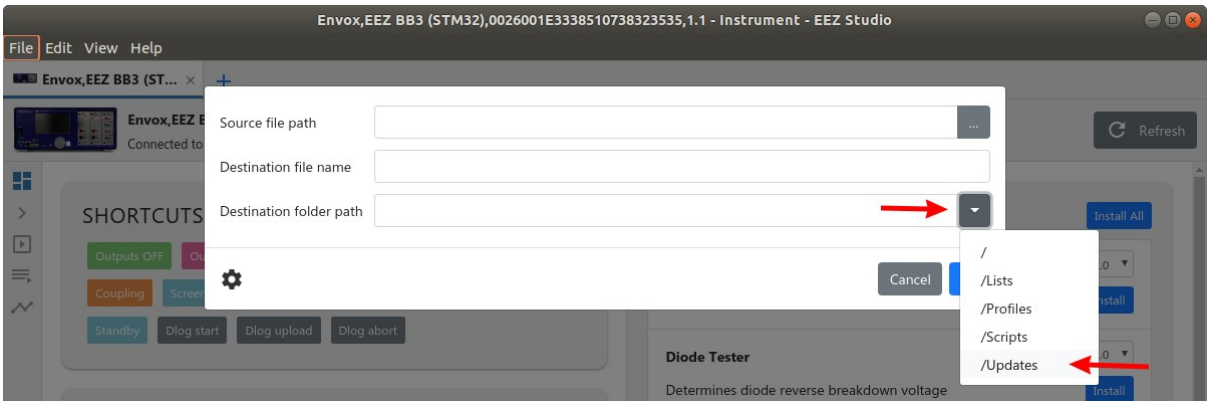

### 13.2.2. Upgrade peripheral module firmware using GUI on EEZ BB3

1 Visit https://www.envox.hr/eez/eez-bench-box-3/firmware.html for a list of all existing modules. Download the .hex file for the module whose firmware you want to upgrade.

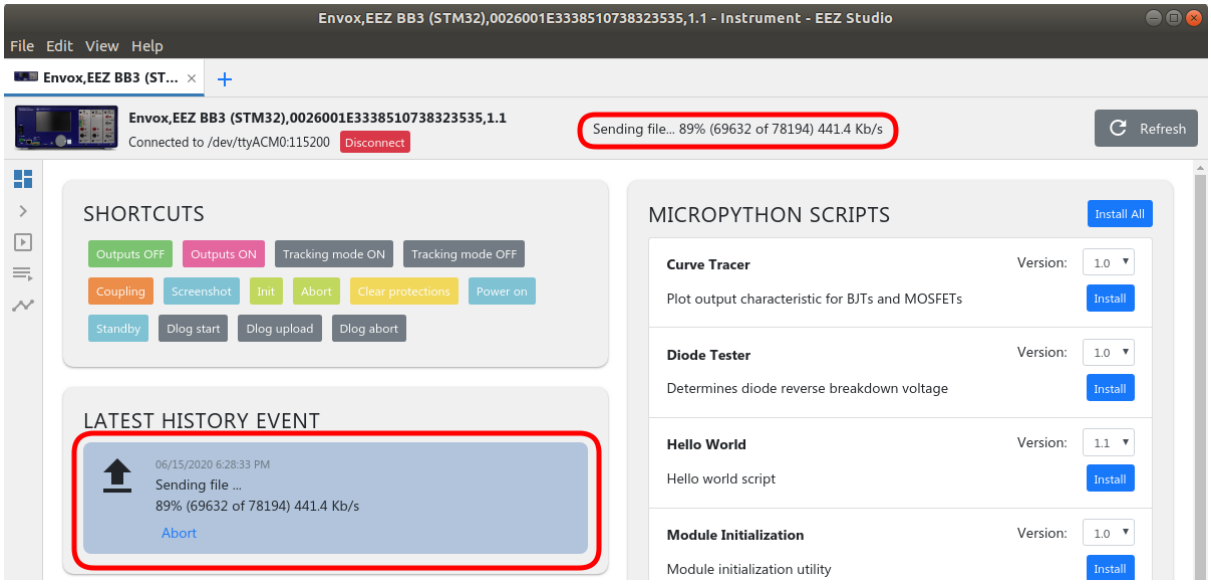
2 The selected .hex file will need to be transferred to the */Updates* folder on the EEZ BB3 SD card. Since there is currently no option to mount the SD card as a USB mass storage you will need to remove the SD card and insert it into the SD card reader of your PC and skip to step ⑤. Alternatively, you can do this using the EEZ Studio and *Send file* option.




3 Make sure the *Destination folder path* is set to */Updates* otherwise the peripheral module will not be able to find the firmware image file.

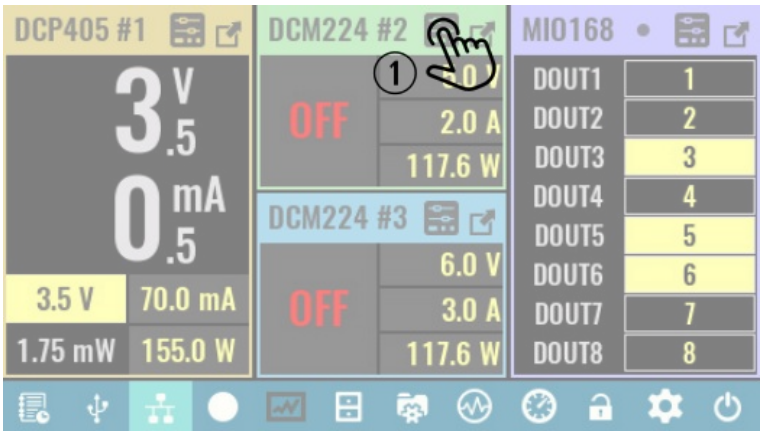



4 Wait until the file transfer is complete.

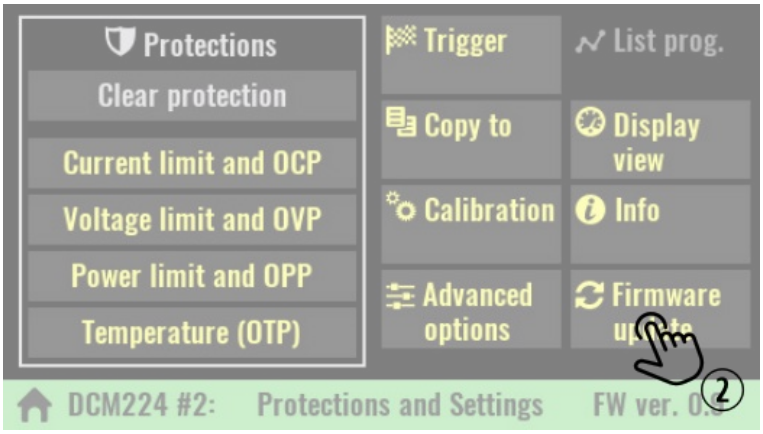



**5** The procedure can now be continued on EEZ BB3 side. In the case of a dual channel DCM220 or DCM224 power module, it does not matter which channel will be used to get to the *Protection and Settings* page. In the example shown, a channel two was used.

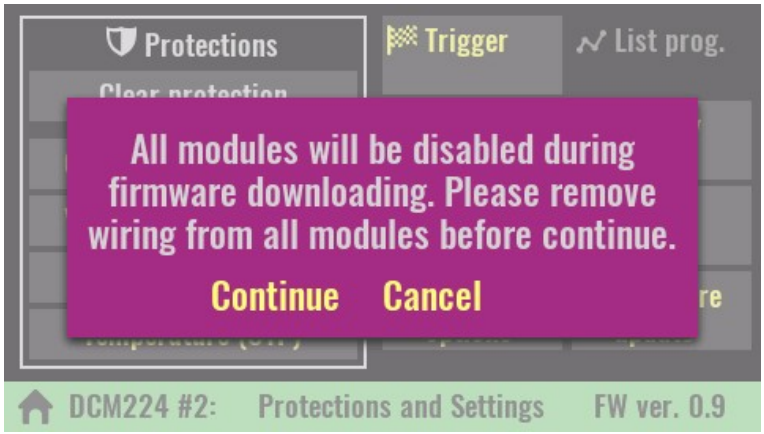
First you need to tap on *Settings* icon.



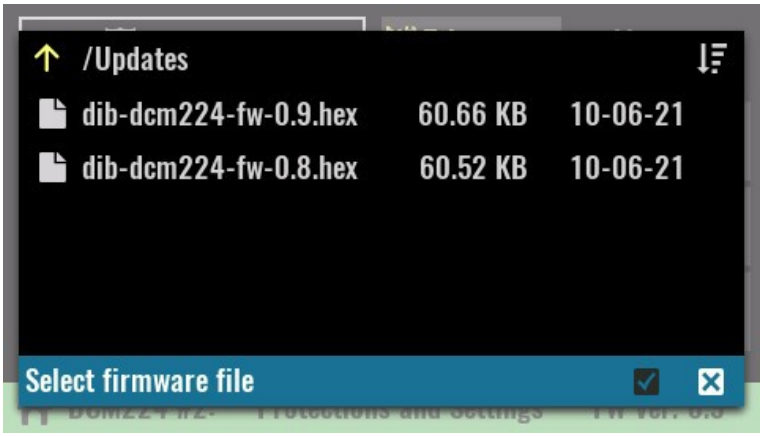

**6** On the *Protection and Settings* page you can see the latest version of the firmware (*FW ver.*).




**7** Selecting the *firmware update* option will first display a warning message.



**8** Finally, you will need to select the file that has been transferred and wait for the firmware download to complete.

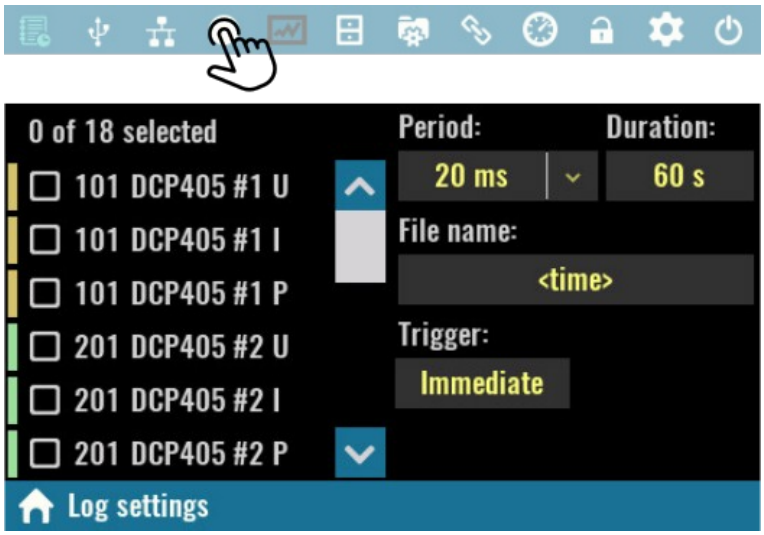


# 14. Data logging

EEZ BB3 provides simple data logging (DLOG) of both analog and digital signals coming from installed modules. Logged data is stored on the SD card and can be viewed while the logging is in progress or upon completion or termination of logging.
Finally, it will be possible to transfer logged data to a computer using the EEZ Studio application or using similar applications using SCPI commands.

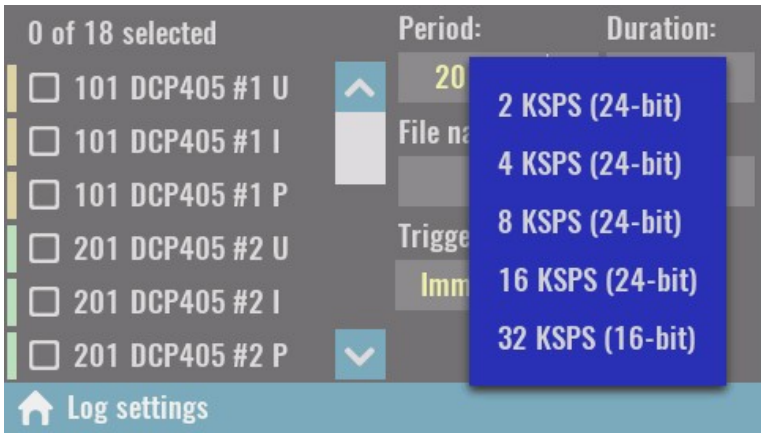
## 14.1. Data logging

To start data logging, tap on the *DLOG* icon, when a menu will open with the following options:



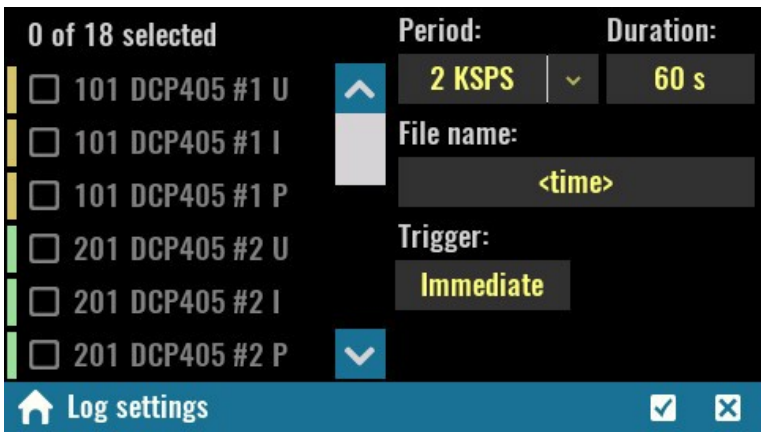

Scrollable list of all available measurement targets, e.g. voltage, current and power for each power channels (DCP and DCM modules), SMX and MIO modules analog outputs, MIO modules digital outputs, etc.

**Period:**
Specifies the sampling rate of data logging, i.e. the time between two measurements to be recorded. For example, if the period is 20 ms, this means that measurements will be taken 50 times per second.




When the MIO module is installed, a list for selecting sampling rates supported by the installed AFE will also appear.

*If one of the MIO sampling rates is selected, it will disable the resources of all power modules because they do not support such speeds.*

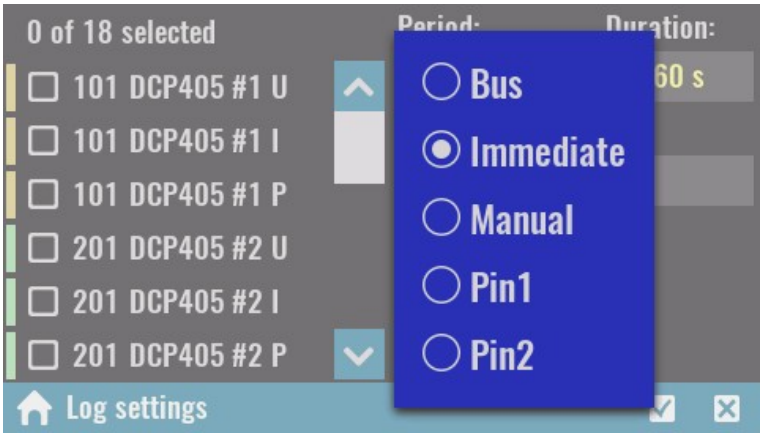



**Duration:**
Max. duration of data logging. If you want continuous data logging, enter infinity (∞) from keypad. Logging can be interrupted at any time with a new tap on the *DLOG* icon when its color has changed to red. Once interrupted data logging cannot be resumed.

**File name:**
The name of the file where the logged data will be stored. The file with the name entered will be created on the SD card in the *Recordings* folder. If the file name is not entered, the current time and date will be used in the following format: *yyyy_mm_dd-hh_mm_ss.dlog*.

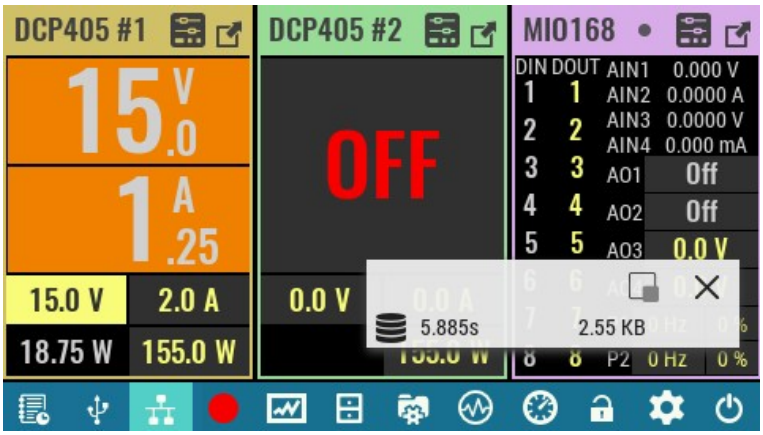
**Trigger:**

Data logging can be initiated by various trigger events. See *General trigger settings* for more information.




The *Start* option triggers data logging when the color of the *DLOG* icon will change to red.
From the *DLOG viewer*, you can return to the main page, and the color of the resources given to the log will be changed for a better indication.

Data logging can be interrupted at any time, and cannot last longer than the *Duration* set. If duration infinity (∞) is selected, logging will continue while EEZ BB3 is active and will be limited by free space available on the SD card.



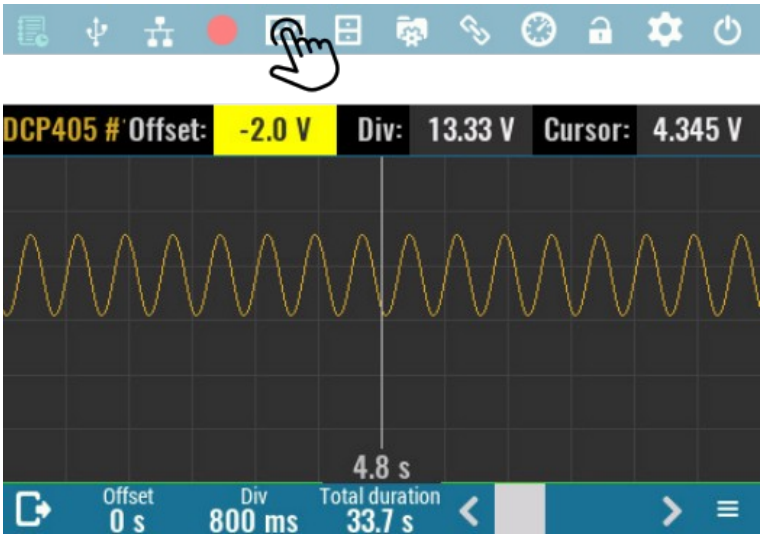

During data logging, a floating (“overlay”) menu will appear that will be able to move anywhere on the screen, minimize or close. It's displaying the elapsed time and data size.

## 14.2. Displaying recorded data

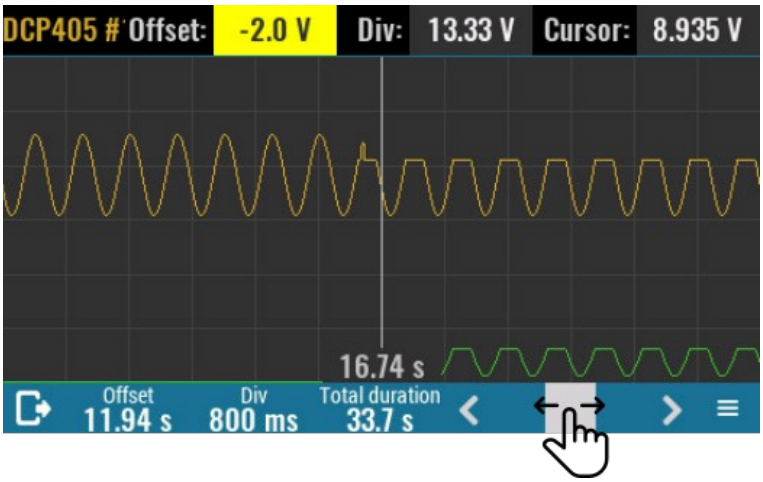
*DLOG viewer* lets you view recorded data while data logging is in progress. In this case, the recorded data will be displayed at the rate at which it was sampled (i.e. if the period is set at half a second, then new data will also appear every half a second).

The status bar will show information about the elapsed time and data size, as well as a *DLOG* icon that can terminate logging early.

To return to the main page, use the *Home* icon.



When logging is completed or terminated early, the *DLOG viewer* will open automatically. It will now be possible to scroll through the recorded data using the following controls:

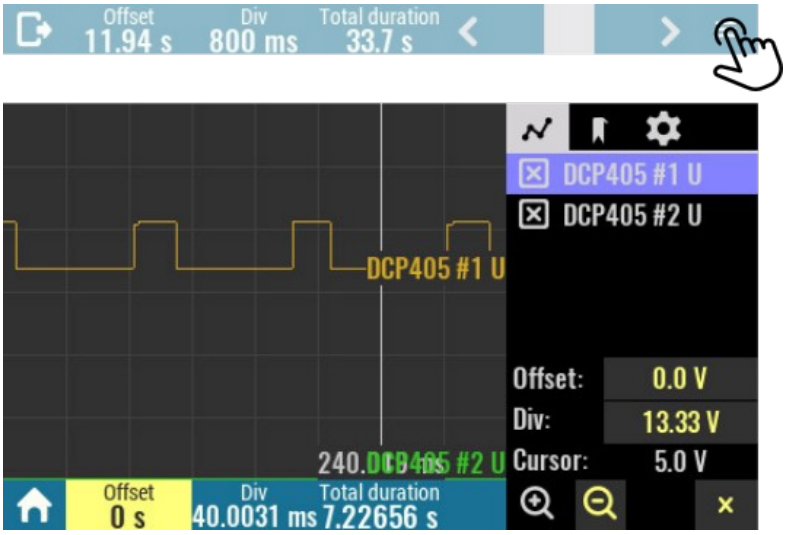



**Time offset**
Position on timeline from start of measurement. Moving along the timeline is possible by directly entering a new value with a numeric keypad, using an encoder knob, or using a scroll bar on the right side of the status bar.

**Time div**
Logging data display area has 12 x 6 cells graticule that helps to determine time duration and measured amplitude more easily. This parameter defines the duration of one time division. The minimum duration is 800 ms and is determined by screen resolution and displaying principle (i.e. minimum one pixel per sample).

**Total duration**
Displays the total duration of logged data in seconds.

The *DLOG viewer* has in its right down corner an icon that provides access to a multi-tab section.



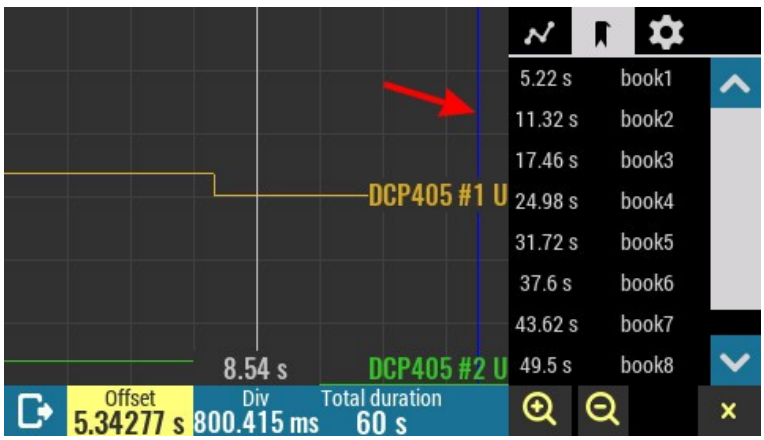

The *Graph* section displays a list of all logged resources, by default all are selected as visible.

**Offset:**
Change the Y-axis offset of the currently selected graph.

**Div:**
Change the Y-axis division of the currently selected graph.

**Cursor:**
Displays value of on the cursor position of the selected graph.

The *Bookmark* section contains a list of the positions and names of all bookmarks added during datalogging. Bookmarks can currently only be added using the SCPI command.
Bookmarks are shown in the graph with vertical blue lines.




SCPI

```
SENSe:DLOG:TRACe:BOOKmark
<bookmark>
```

The *Settings* section contains general graph settings as well as an option to transfer the DLOG file to a PC.

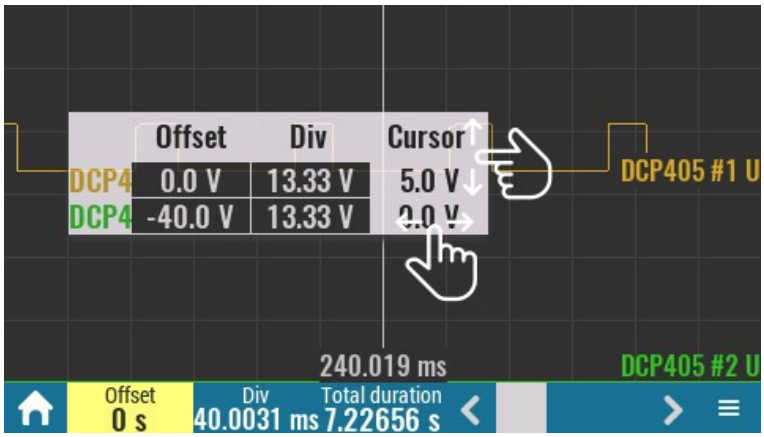

**Legend:**
Specifies whether or not the legend of the displayed DLOG graph is displayed. If the legend is selected to be visible it will be necessary to close the DLOG settings first.

- *Hidden* – not displayed
- *Float* – displays an "overlay" menu that can be moved around the screen as shown in the figure below.
- *Dock – default selection, the single row legend is docked to the top of the screen.*

**Show labels**
Displays units on the right end of the trace.

**Auto Scale**
Reset *Offset* and *Div* values for the all traces to initial values.

**Scale to fit**
Maximize the view of all data traces.




**Upload**
Transfer logged data to the EEZ Studio. This option is available only if active connection exists (via USB or Ethernet).

**Zoom in / Zoom out**
Changes the time division (X-axis) in increments of 2x

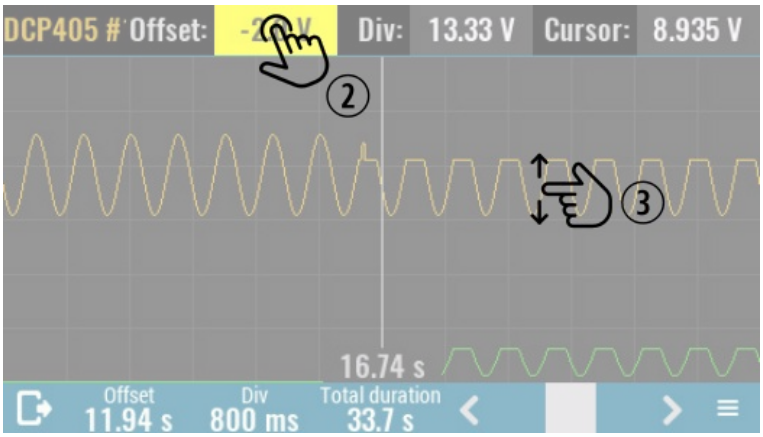
**Close**
Close this menu.

When opening the *DLOG viewer* will sort all recorded traces one above the other for better visibility. However, this order can be changed as desired by changing the *Offset* parameter of each displayed trace. Trace y-axis offset can be changed in the following way:

1. Tap on the desired trace *Offset* cell on the *Legend* menu.

2 Tap once again if you'd like to enter exact value of the new offset. The numeric keypad will appear and any value within displayed range can be entered (e.g. -100 to 100 V as shown below).

*Offset* value define trace position in reference to the middle of the viewing area that represents 0 V.





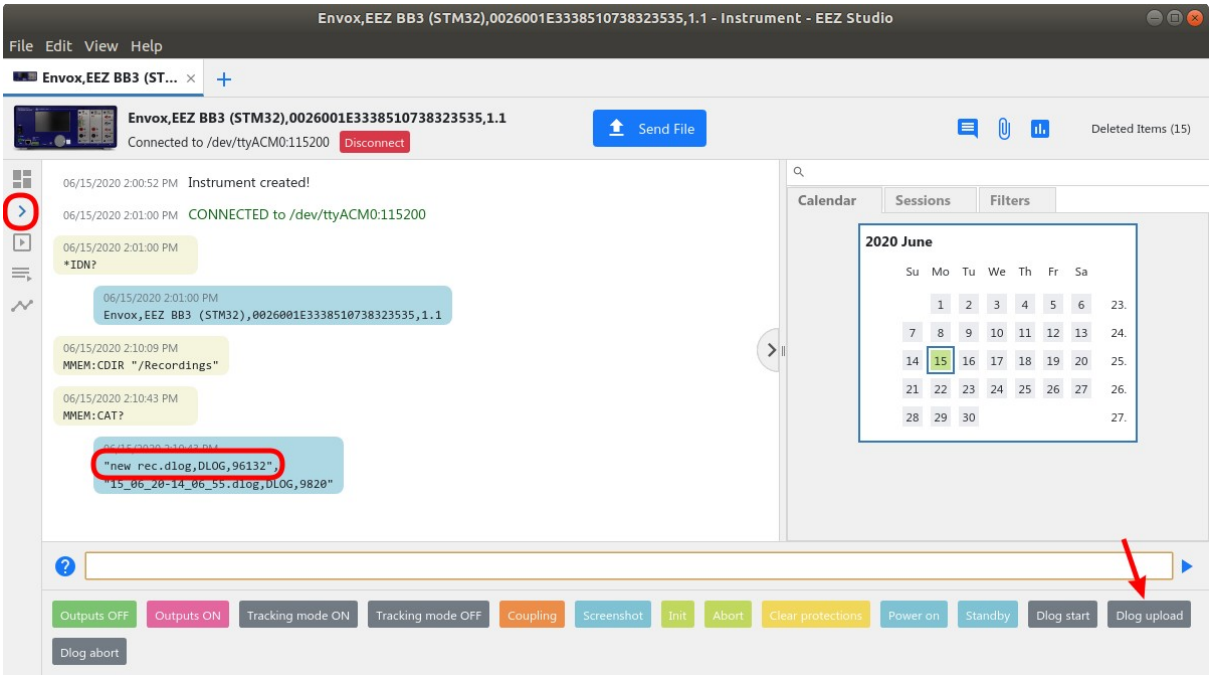
3 The trace offset can be also changed by simply tap on trace and move it new position. While moving displayed *Offset* value will change accordingly.

Trace amplitude can be changed in the similar way by changing its *Div* value in the *Legend* menu.

## 14.3. Logged data transfer to a computer

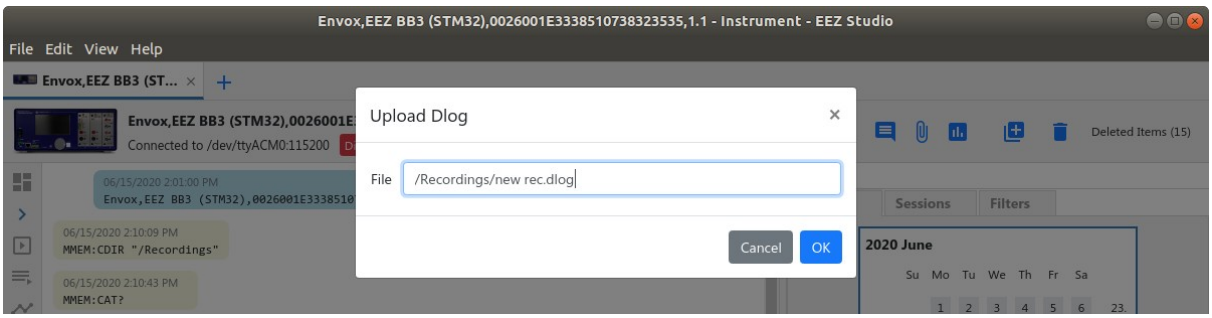
1 Start EEZ Studio or, if not already installed, follow the installation steps as described in *Using EEZ Studio to upgrade peripheral module firmware* section.

2 Data log files are stored into *Recordings* folder on the SD card. To access that folder switch to the terminal tab by selecting the icon of the same name on the left and enter *MMEM:CDIR "/Recordings"*. The *MMEM:CAT?* query returns all data log filenames.

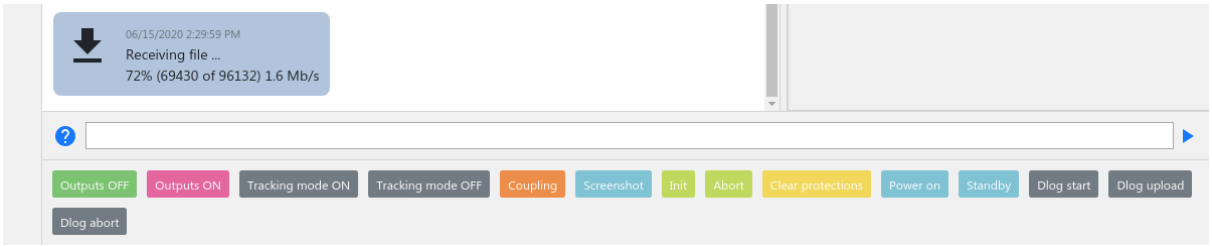



Select *Dlog upload* javascript from the list of the shortcuts.

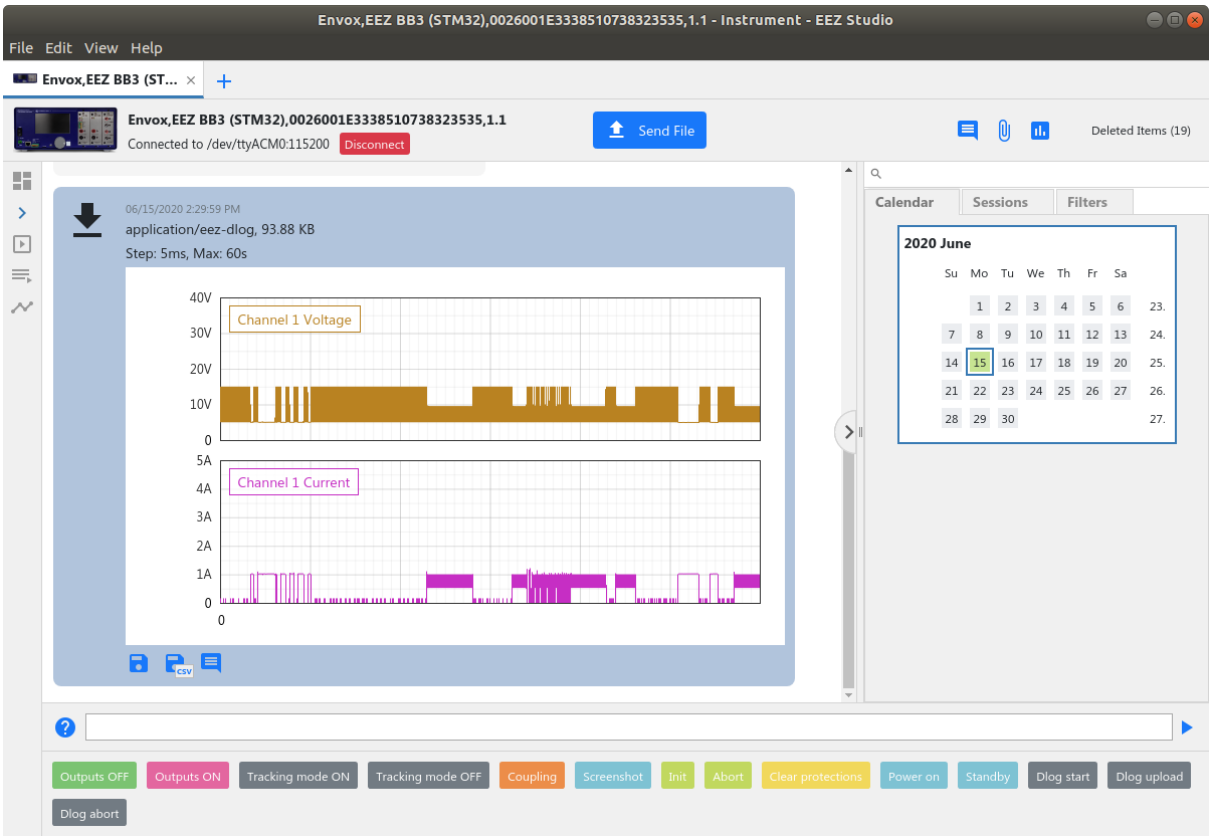
**3** Enter the data log file name:



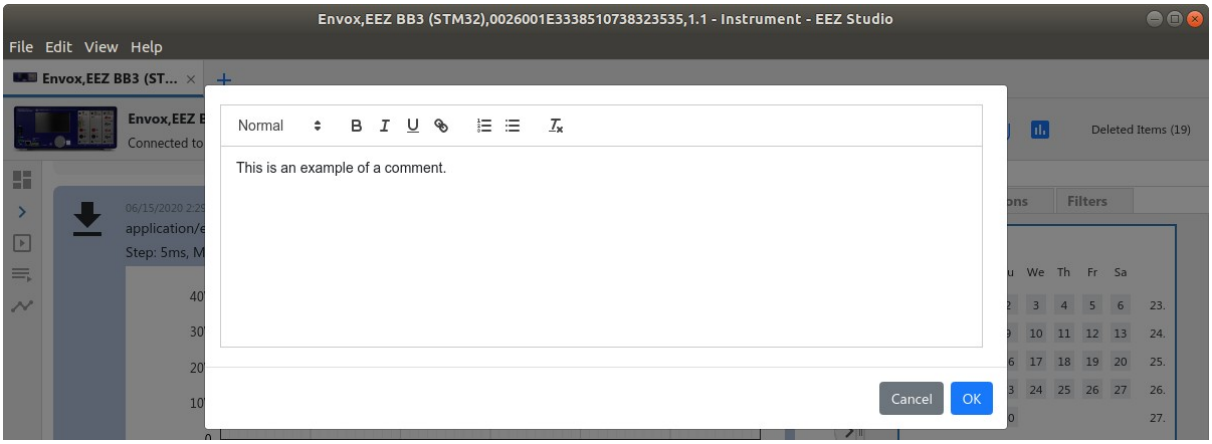

**4** An upload progress bar will be displayed.




**5** Data log will appear as new item in the SCPI session view. You can open it for further analysis with double click.




An arbitrary comment can be added by selecting the *Comment* icon when new entry form will appear:

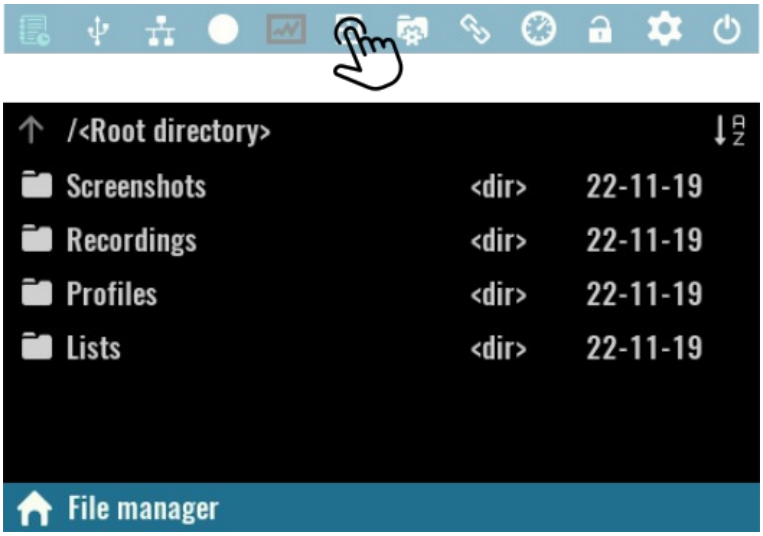



Once added, comment can be modified or deleted by hover mouse on comment area when two new icons will appear:

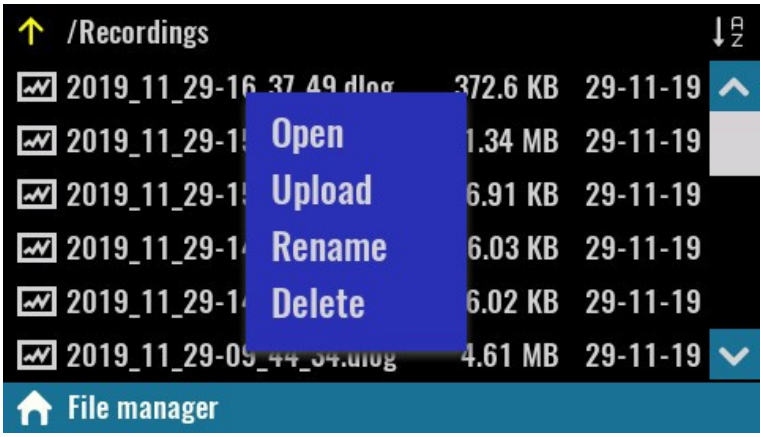

## 14.4. Initiate data log transfer on the EEZ BB3

Transferring the data log to the EEZ Studio can be initiated on the EEZ BB3, too. Before initiating the transfer, make sure that the connection with the EEZ Studio is established as described in steps 1 to 4 in previous section.

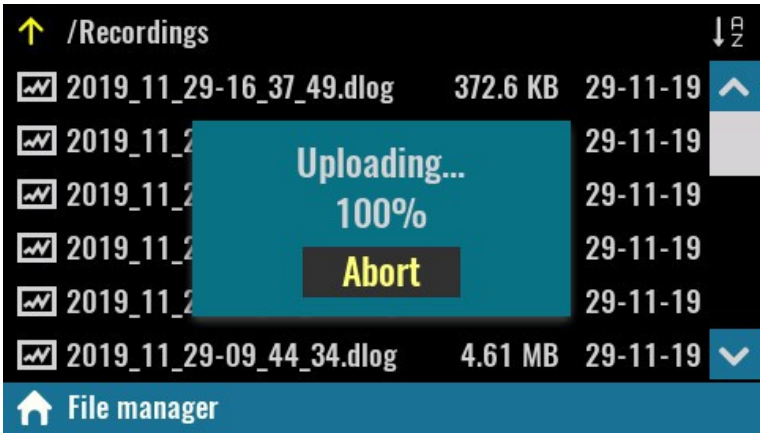
1 Open the *File Manager* and move to *Recordings* folder.




2 *Click on desired data log file and select Upload option from the menu.*




3 Wait until the data transfer is complete.




## 14.5. Establishing serial (via USB) communication with a Linux computer

EEZ Studio users on a Linux computer may receive a series of error messages every time they successfully connect to EEZ BB3 via the serial interface. The reason for this is the existence of a *Modem manager* application that will send a series of modem commands to the connected device (EEZ BB3 in this case). The EEZ BB3 has ability to interpret only SCPI commands and therefore on each modem command it will response with an error message.

If the *Modem Manager* application is not needed (i.e. there is not other serial devices connected on the computer) it can be simply deinstalled with the following command from the *Terminal* application:

```
sudo apt-get remove modemmanager
```

However, if you want to keep the *Modem Manager*, it can be configured to avoid sending unnecessary modem commands to the connected EEZ BB3 in the following way:

1 Start *Terminal* application and enter the following command to determine which filter policy *Modem Manager* is using on your system by viewing its status:

```
sudo systemctl status ModemManager
```

```
● ModemManager.service - Modem Manager
   Loaded: loaded (/lib/systemd/system/ModemManager.service...
   Active: active (running) since ...
   ...
   CGroup: /system.slice/ModemManager.service
           └─644 /usr/sbin/ModemManager --filter-policy=strict
```

2 *Modem Manager* filter policy has to be changed from *strict* to *default*. Use your favorite text editor like *gedit* to make that modification:

```
sudo gedit /lib/systemd/system/ModemManager.service
```

Additionally you can add under *[Service]* section the following line:

```
Environment="MM_FILTER_RULE_TTY_ACM_INTERFACE=0"
```

3 After changing the service file, reload the *systemctl* configuration and restart *Modem Manager*:

```
sudo systemctl daemon-reload
sudo systemctl restart ModemManager
```

Optionally you can check once again the *Modem Manager* filter policy that should be like this:

```
● ModemManager.service - Modem Manager
   Loaded: loaded (/lib/systemd/system/ModemManager.service...
   Active: active (running) since ...
   ...
   CGroup: /system.slice/ModemManager.service
           └─1010 /usr/sbin/ModemManager --filter-policy=default
```

# 15. MQTT

MQTT (*Message Queuing Telemetry Transport*) is a lightweight publish/subscribe messaging protocol designed for M2M (machine to machine) communication. MQTT is fast becoming one of the leading protocols for IoT (internet of things) deployments.

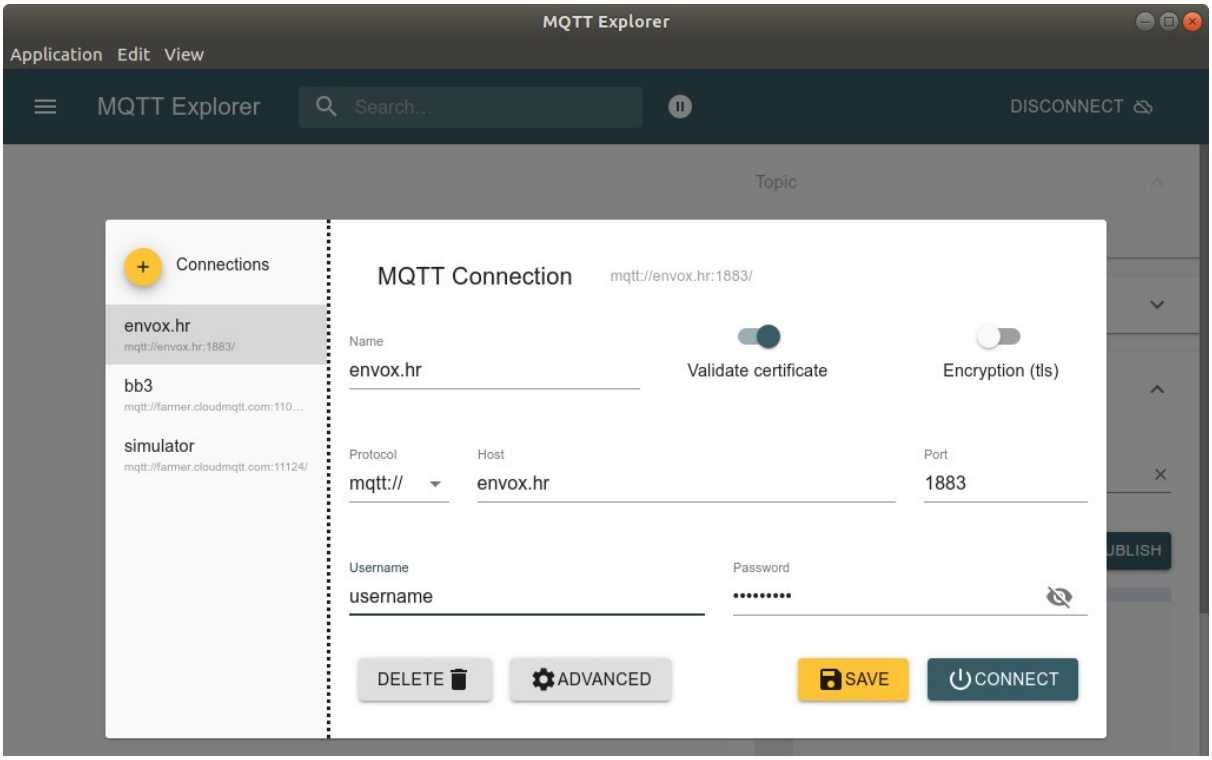
Thanks to MQTT support, EEZ BB3 can be easily and securely remotely monitored and controlled. Furthermore, EEZ BB3 can be integrated into existing IoT infrastructure.

For efficient and fast deployment, it is recommended to familiarize yourself with the basic terms of the MQTT protocol. An example of an interaction with EEZ BB3 via the MQTT description protocol is described below using the MQTT Explorer application which is available for free at https://mqtt-explorer.com/

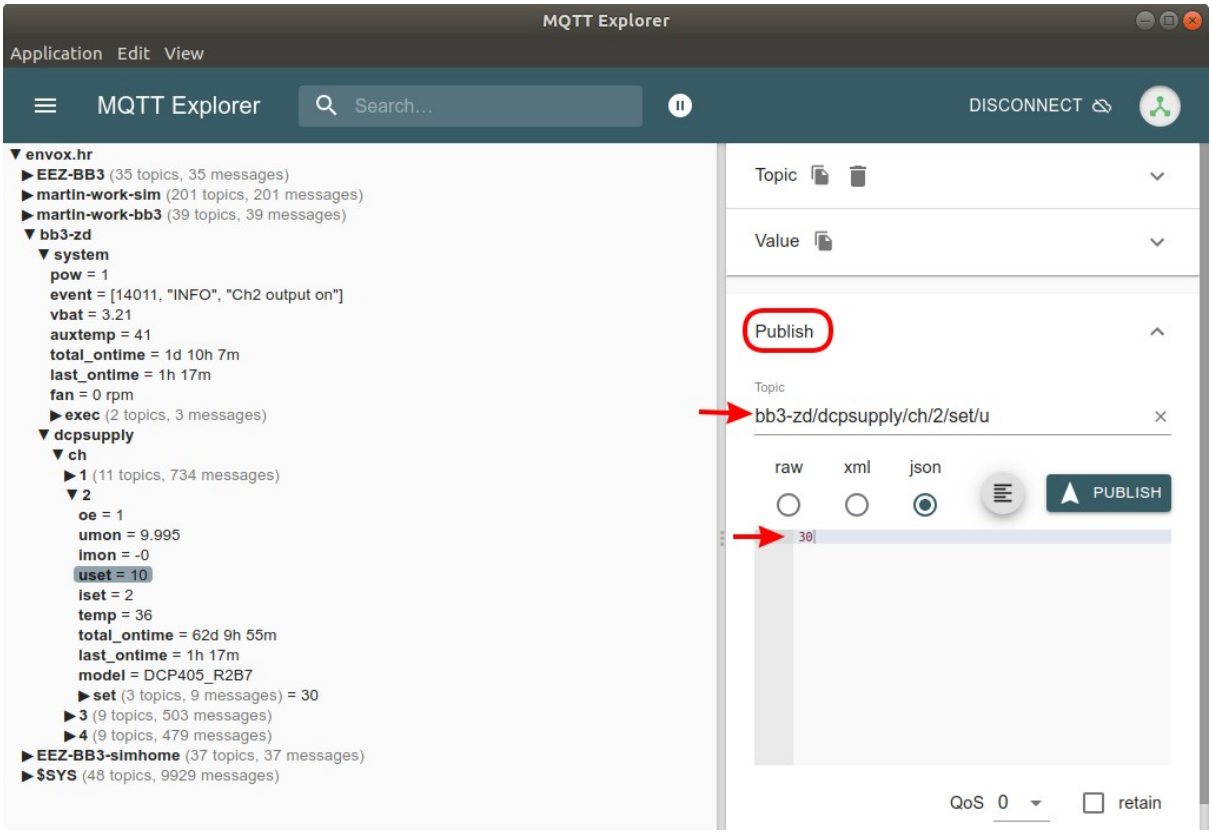
*Please note that topics are case-sensitive, i.e. <hostname>/system/exec/restart is not equal to <hostname>/system/exec/RESTART.*

## 15.1. Set channel parameter using subscribe topic

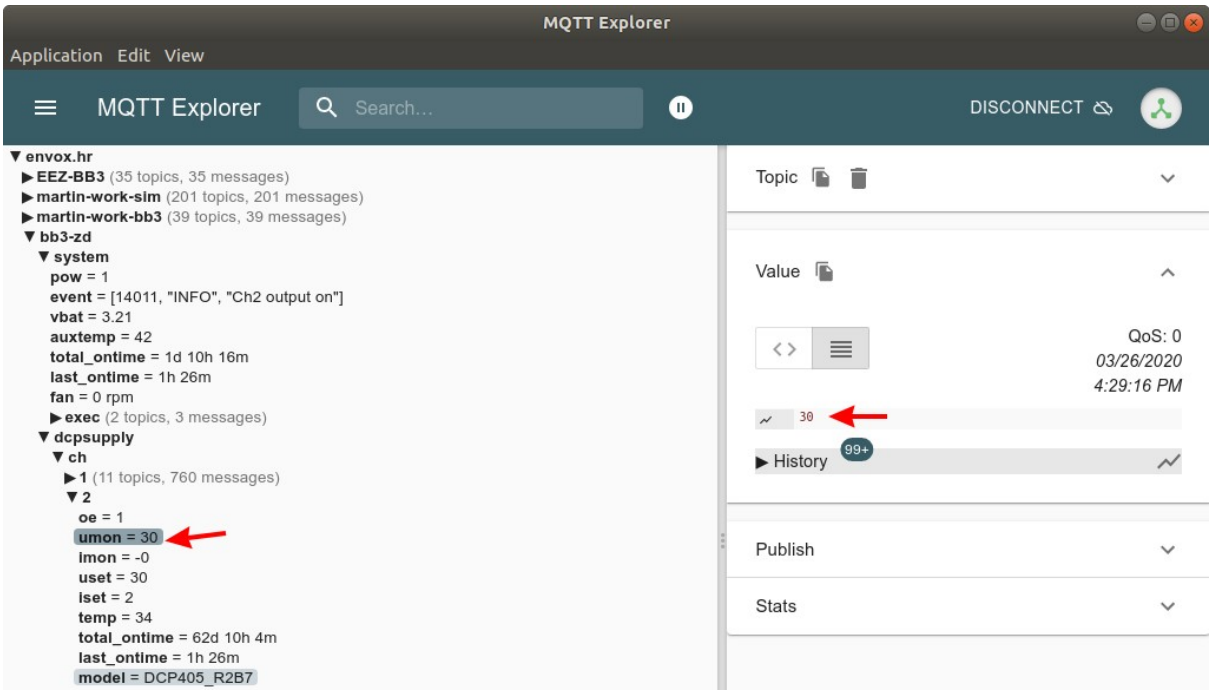
1 Start *MQTT Explorer* and enter parameters for connection to your MQTT server (aka broker): *Name*, *Protocol*, *Host*, *Port*, *Username* and *Password*.




2 For example, if we want to set the output voltage on a channel, it will be necessary to type in the *Publish* section as topic *<hostname>/dcpsupply/ch/<ch>/set/u*. In this example, the hostname is *bb3-zd* and to set the output voltage on channel 2 it will be necessary to type as topic *bb3-zd/dcpsupply/ch/2/set/u*, set its value to *30* (type is *json*) and click on the *Publish* button.

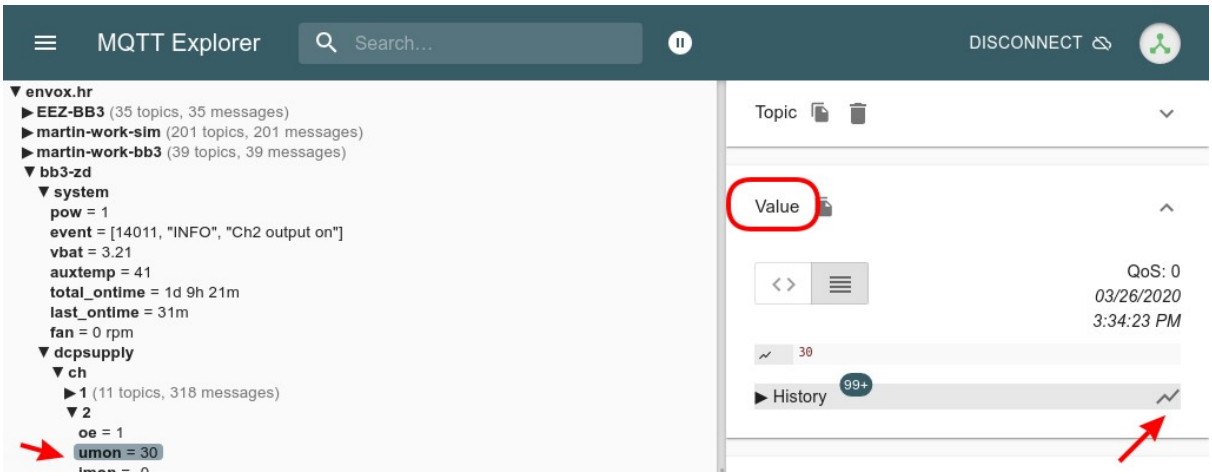



3 The newly set output voltage value will be visible after the topic *bb3-zd/dcpsupply/ch/2/umon* is refreshed.

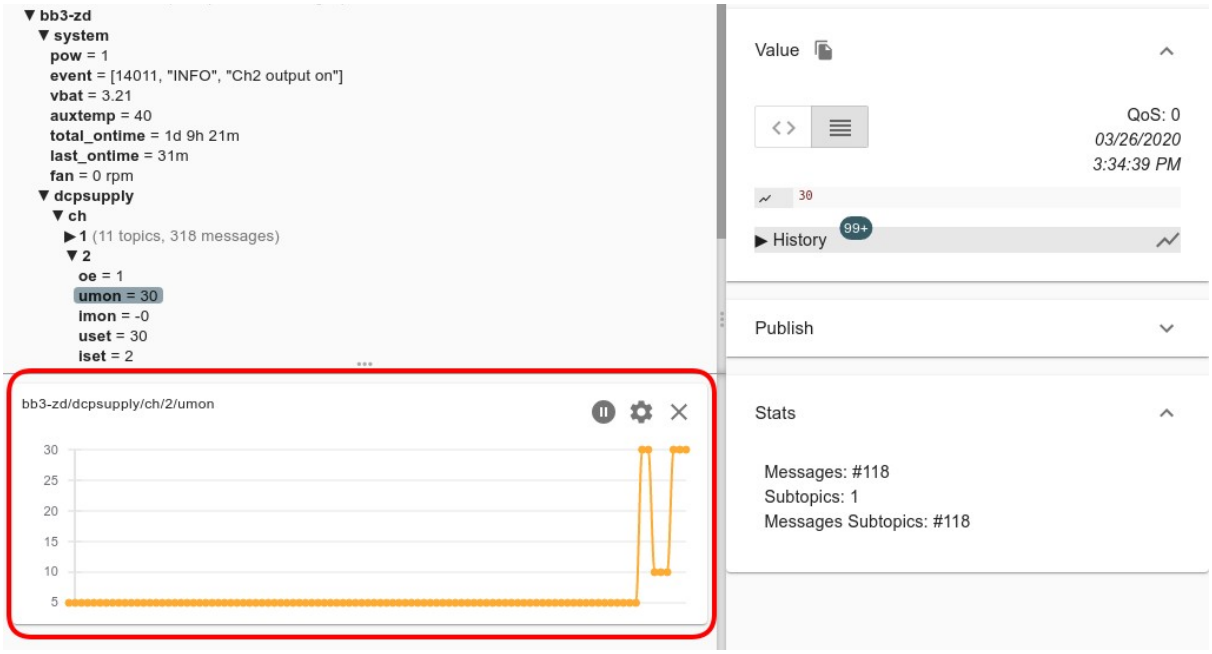



## 15.2. Drawing a topic graph

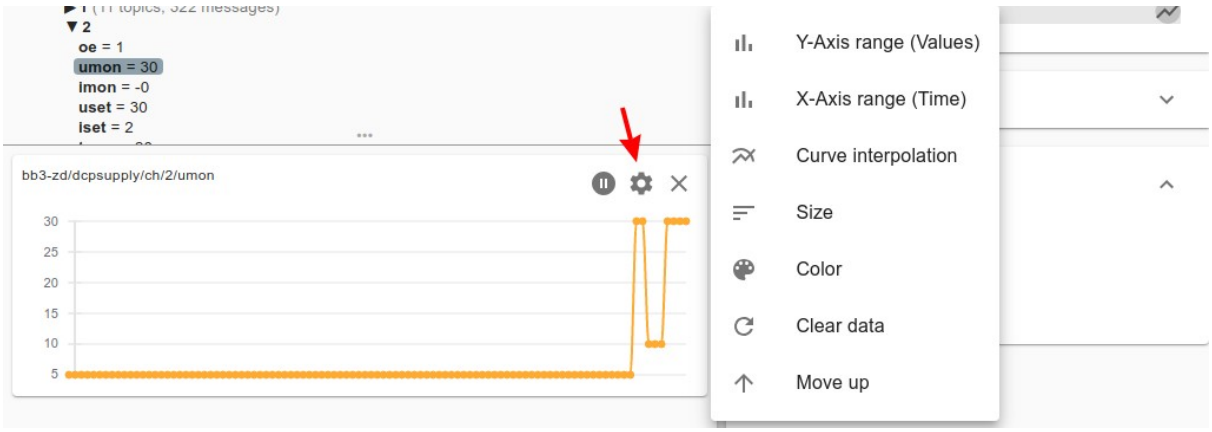
1 Select a topic of interest, and click the graph icon in the *History* section




**2** The default settings graph will appear below the topic list.




**3** Graph settings can be changed by selecting the *settings* icon.



## 15.3. Publish topics

### 15.3.1. System

| Topic | Description |
|---|---|
| *<hostname>/system/pow* | Returns 0 when EEZ BB3 enters standby mode, or 1 when in active mode |
| *<hostname>/system/event* | Latest message from the event log formatted as [<event_id>, <event_type>, <event_message>].<br>For example: [14011, "Info", "Ch2 output on"] |
| *<hostname>/system/pow/battery* | RTC battery voltage |
| *<hostname>/system/pow/auxtemp* | AUX sensor temperature |
| *<hostname>/system/pow/fan* | Cooling fan status and speed |
| *<hostname>/system/pow/total_ontime* | Total active time of the EEZ BB3 (MCU module). Resolution is 1 minute |
| *<hostname>/system/pow/last_ontime* | Duration since the EEZ BB3 was turned on. Resolution is 1 minute |

### 15.3.2. Dcpsupply

| Topic | Description |
|---|---|
| *<hostname>/dcpsupply/ch/<ch>/oe* | Status of the channel output |
| *<hostname>/dcpsupply/ch/<ch>/uset* | Returns set output voltage |
| *<hostname>/dcpsupply/ch/<ch>/iset* | Returns set output current |
| *<hostname>/dcpsupply/ch/<ch>/umon* | Measured output voltage |
| *<hostname>/dcpsupply/ch/<ch>/imon* | Measured output current |
| *<hostname>/dcpsupply/ch/<ch>/temp* | Measured channel temperature |
| *<hostname>/dcpsupply/ch/<ch>/total_ontime* | Channel total active time. Resolution is 1 minute |
| *<hostname>/dcpsupply/ch/<ch>/last_ontime* | Duration since the last on time. Resolution is 1 minute |

## 15.4. Subscribe topics

### 15.4.1. System

| Topic | Description |
|---|---|
| *<hostname>/system/exec/restart* | Sending 1 initiates EEZ BB3 restart |
| *<hostname>/system/exec/power* | Send 0 to enter standby mode, or 1 to return back |
| *<hostname>/system/exec/initiate* | Initiate trigger system by sending 1 |
| *<hostname>/system/exec/abort* | Abort trigger system by sending 1 |
| *<hostname>/system/exec/display/window/text* | Displays pop-up message on the EEZ BB3 display |
| *<hostname>/system/exec/display/window/text/clear* | Use to clear text message sent as described above |
| *<hostname>/system/exec/profile/recall* | Recall user defined profile by sending profile number (0 to 9) |

### 15.4.2. Dcpsupply

| Topic | Description |
|---|---|
| *<hostname>/dcpsupply/ch/<ch>/set/oe* | Sets channel output state: 1 to On or 0 to Off |
| *<hostname>/dcpsupply/ch/<ch>/set/u* | Sets output voltage |

| | |
|---|---|
| *<hostname>/dcpsupply/ch/<ch>/set/i* | Sets output current |

# 16. Scripting with MicroPython

One of the prominent features of BB3 is support for MicroPython scripting. Thanks to MicroPython scripting it will be possible to add new functionality without intervening in the BB3 firmware and compromising its performance. Scripting opens up the possibility of creating a whole range of new applications from tasks to automate the programming of individual peripheral modules, to useful utilities such as various parameter calculators that do not require working with modules at all, but can be useful and at hand.


MicroPython is a lean and efficient implementation of the Python 3 programming language that includes a small subset of the Python standard library and is optimized to run on MCUs such as STM32 used in BB3. MicroPython aims to be as compatible with normal Python as possible to allow you to transfer code with ease from the desktop to a MCU or embedded system. For more information, visit the official micropython.org website.

This chapter will describe the procedure for creating a front-end GUI, deployment, and running a MicroPython script.

## *16.1. Distinctive features of BB3 MicroPython implementations*

In order to avoid misunderstandings and wrong expectations, the specifics of the MicroPython implementation should be explained first.

The implementation of MicroPython often means that MicroPython will take control of all hardware resources and processes. This is not the case with BB3 and it was done on purpose. Execution of the MicroPython script takes place in a separate thread controlled by FreeRTOS and has a lower priority than the main thread that is in charge of all vital system functions. This ensures that a faulty script cannot compromise basic functionality and can be aborted from the main thread.

When the execution of the MicroPython script is complete, its thread goes to sleep until the next call.

Although the lack of direct access to hardware resources from the MicroPython script may seem like a serious limitation, access is still possible but indirectly by using a large number of implemented SCPI commands and queries that cover all important aspects of working with hardware resources of the BB3 chassis and installed peripheral modules.

For this reason, to work effectively with MicroPython scripts, it is recommended to familiarize yourself with the SCPI command set, which is described in the *EEZ BB3 SCPI reference guide*.

The BB3 MicroPython implementation has another distinctive feature, and that is the ability to manage user interaction via a GUI in run time using custom made pages.

The creation of new GUI pages is made possible thanks to the EEZ Studio application, which is also used to create the entire BB3 GUI for the color TFT touch-screen display.

A step-by-step procedure on how to create a simple EEZ Studio project that the MicroPython script will be able to use in run time to interact with the user will be described below.

## *16.2. Sample MicroPython script*

As an example of using MicroPython scripting, it will be shown how to create a user form that will appear on the display and through which it will be possible to change the voltage on the first channel of the available power module. The required procedure is divided into three sections: creating an EEZ Studio project, writing a MicroPython script and MicroPython script deployment and execution.

### 16.2.1. Creating an EEZ Studio project

As a first step, make sure you have the latest version of EEZ Studio, which you can download at https://github.com/eez-open/studio/releases and install it on your computer.

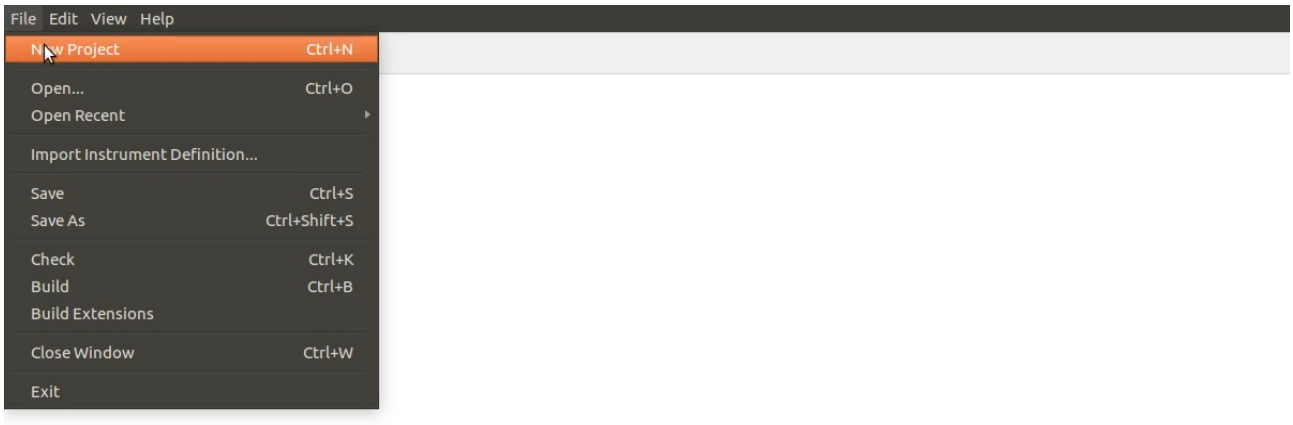



*Fig. 15: Open new project*

Start EEZ Studio and select the *New Project* option from the *File* menu (Fig. 15). A new window will open displaying the Setting general page as shown in Fig. 16.

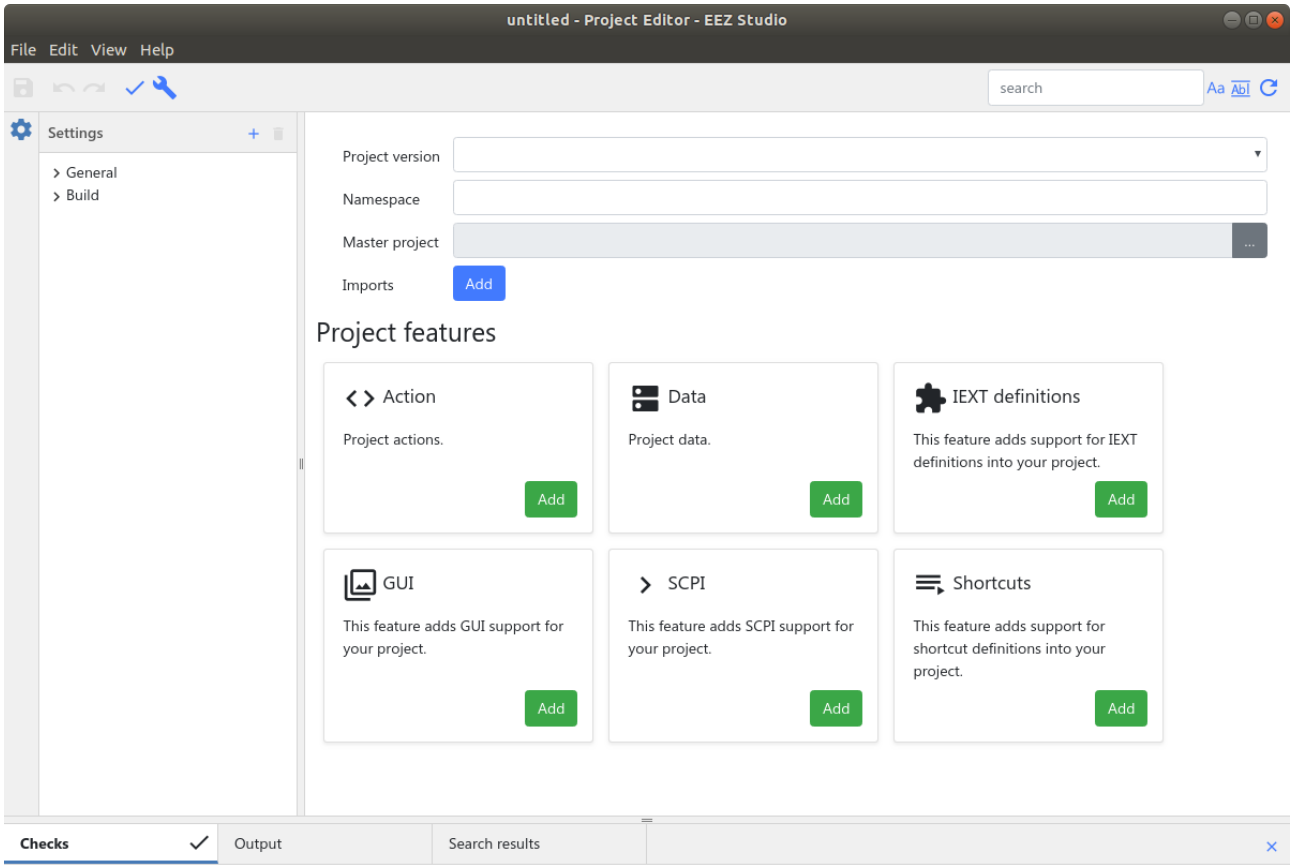



*Fig. 16: Newly added project Settings general page*

General settings contain the following parameters that will need to be defined:

- *Project version* – project version number
- *Namespace* – not currently used
- *Master project* – path to EEZ BB3 master firmware project
- *Project features* – determines which features will be used in the project.

Before you define the general parameters of the project, first save it to the desired destination. The extension of the EEZ Studio project is *.eez-project* and Linux users need to enter the name and extension when saving, in our case it will be *Hello World.eez-project.* When a project is saved its name will appear instead of *untitled* in the window header.

Now we can define the version of the project, which should be *V2.* Next, define the path to the master firmware of the project, i.e. to *modular-psu-firmware.eez-project* which can be found at the following link: https://github.com/eez-open/modular-psu-firmware/blob/master/modular-psu-firmware.eez-project. The easiest way is to copy the master project to the folder where the saved and newly created project is located. Access to the master project is required in order to gain access to styles, color themes and fonts so that the page we will create is in line with other content on the screen.
It remains to define the *Project features* that will be used to interact via the TFT touch-screen display. Since such interaction is based on the event-driven principle it will be necessary to define the following: GUI layout, allowed actions and data to be exchanged during the action (event). Therefore we need to choose (using *Add* button) the following three features: *GUI*, *Action* and *Data*.
If we have well defined all the above parameters, the General settings page will look like in Fig. 17.

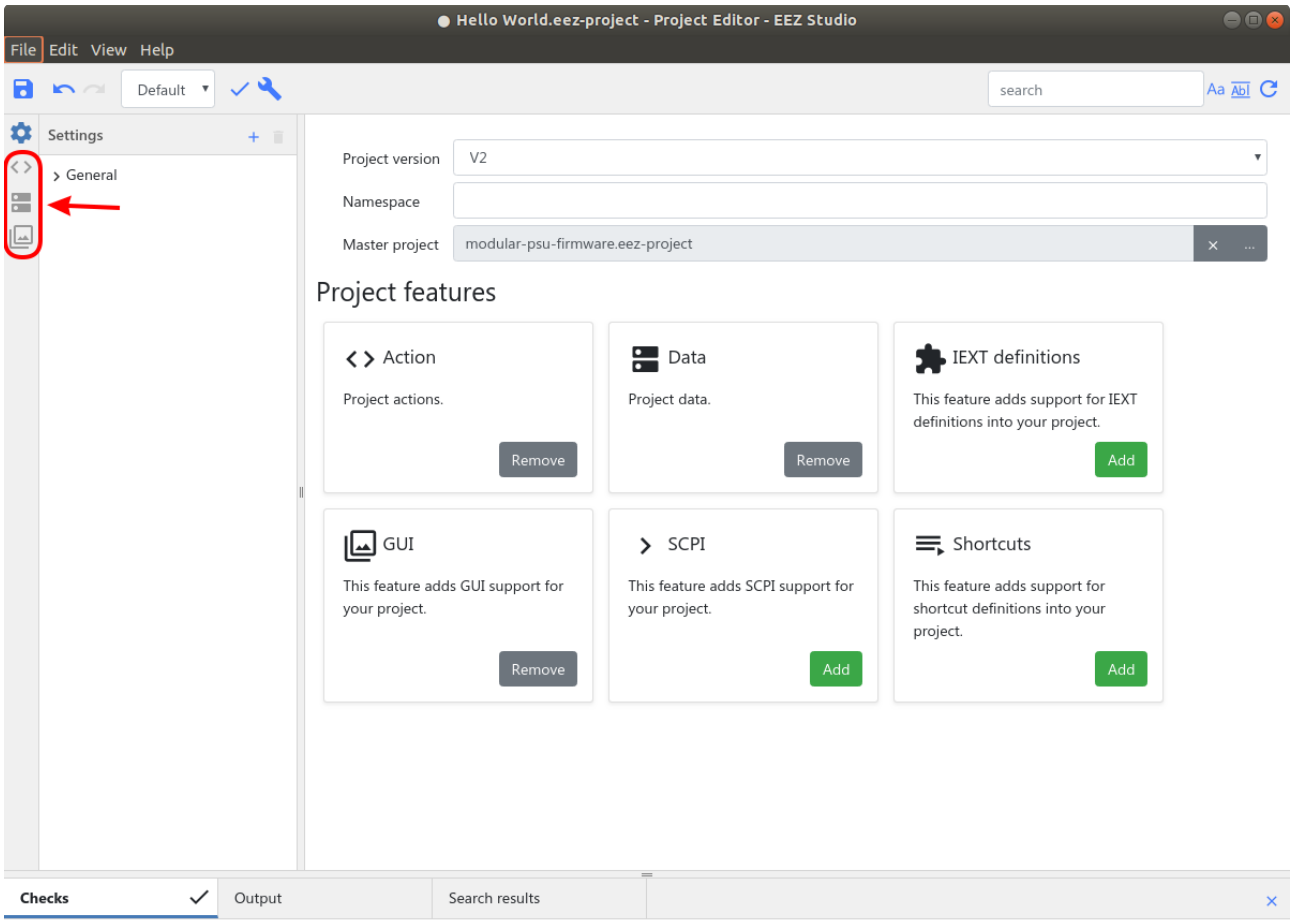



*Fig. 17: General settings page with defined project parameters*

Note that each of the selected *Project features* has added a new tab on the left side through which it will be possible to access the parameters of the selected feature.
To get the functional page that will be called from the MicroPython script it will be necessary to define the parameters via these three tabs that have appeared.
We will first define the names of the actions. For example, *input_voltage* to enter the desired output voltage, *set_voltage* to set the output voltage and *close* to close the page and stop execution of the MicroPython script. Use the + option to add all above mentioned actions by name, and leave default values of the other action parameters (i.e. *Description* and *Used in*). Once the action list is added it should look like in Fig. 18.

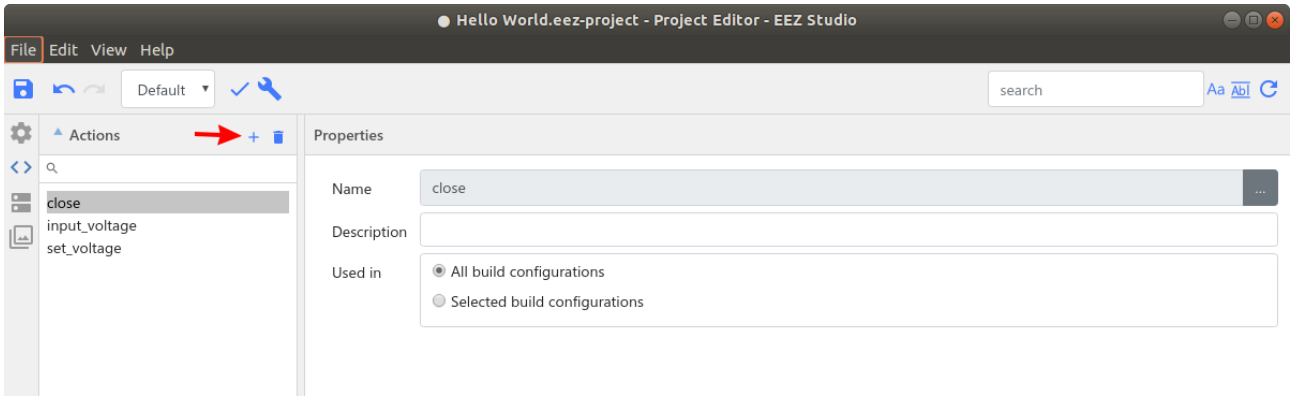



*Fig. 18: List of defined actions*

In the next tab we will define the data to be used for the actions. A minimum of three parameters will need to be defined for each data: name, type, and default value. These will be *can_set_voltage* as *Boolean*, default *0* (false) and voltage as *Float*, default *3.0 V*. The default value will appear in the GUI item when it is assigned a specific data. Properties of both data are shown in Fig. 19.

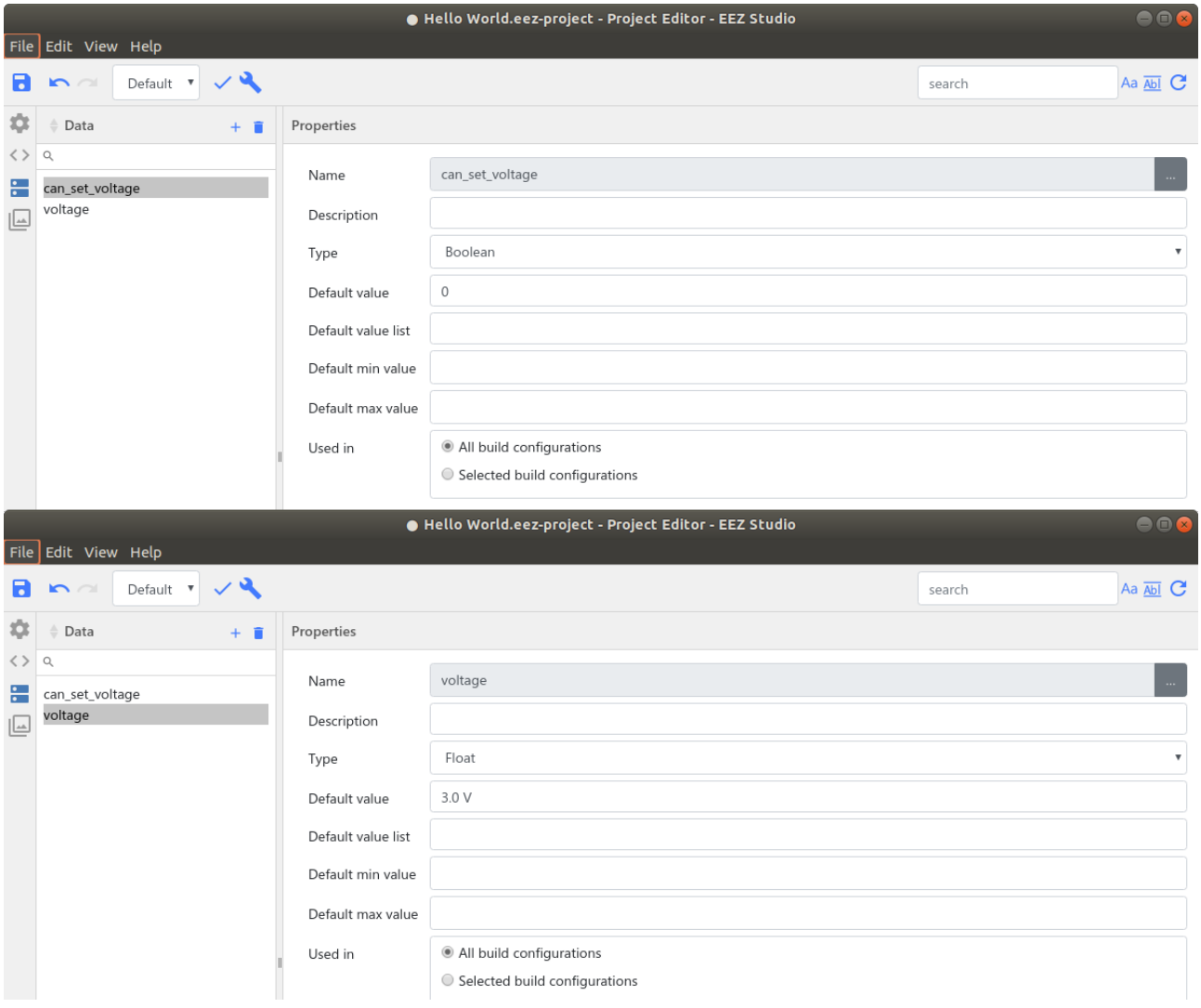



*Fig. 19: Defined project data*

The GUI section is the most complex and before describing the creation of the page, it is necessary to explain what it contains. The section without any defined page is shown in Fig. 20.
This section is divided into two subsections: *Pages (Layouts)* and *Bitmaps* which have corresponding tab icons. In our example, we will not use bitmaps, so that subsection will not be described.

*This section can also contain other subsections such as* Fonts *and* Styles*, however in our example this is not applicable because we chose to inherit the fonts and styles from the master project.*

*Pages (Layouts)* consists of the following sections:

- *Pages (Layouts)* – a list of names of defined pages
- *Page structure* – the tree structure of all widgets used. It can be used to quickly move widgets within a structure
- *Page preview* – a central space that has no title, and will get a tab with the name of the page for each selected page. It displays selected page widgets and can be used to select and move one or more selected widgets
- *Properties* – displays all parameters of the selected widget
- *Widget palette* – a menu with all currently implemented widgets. In our example, we will use the two most commonly used widgets: *Container* and *Text*.
- *Themes* – color theme list. In our example they are inherited from the master project

The procedure for defining a page is as follows: add a new page, insert the necessary widgets, and assign actions and data to the widgets as needed. We will add a new page using the + option in the *Pages (Layouts)* section.

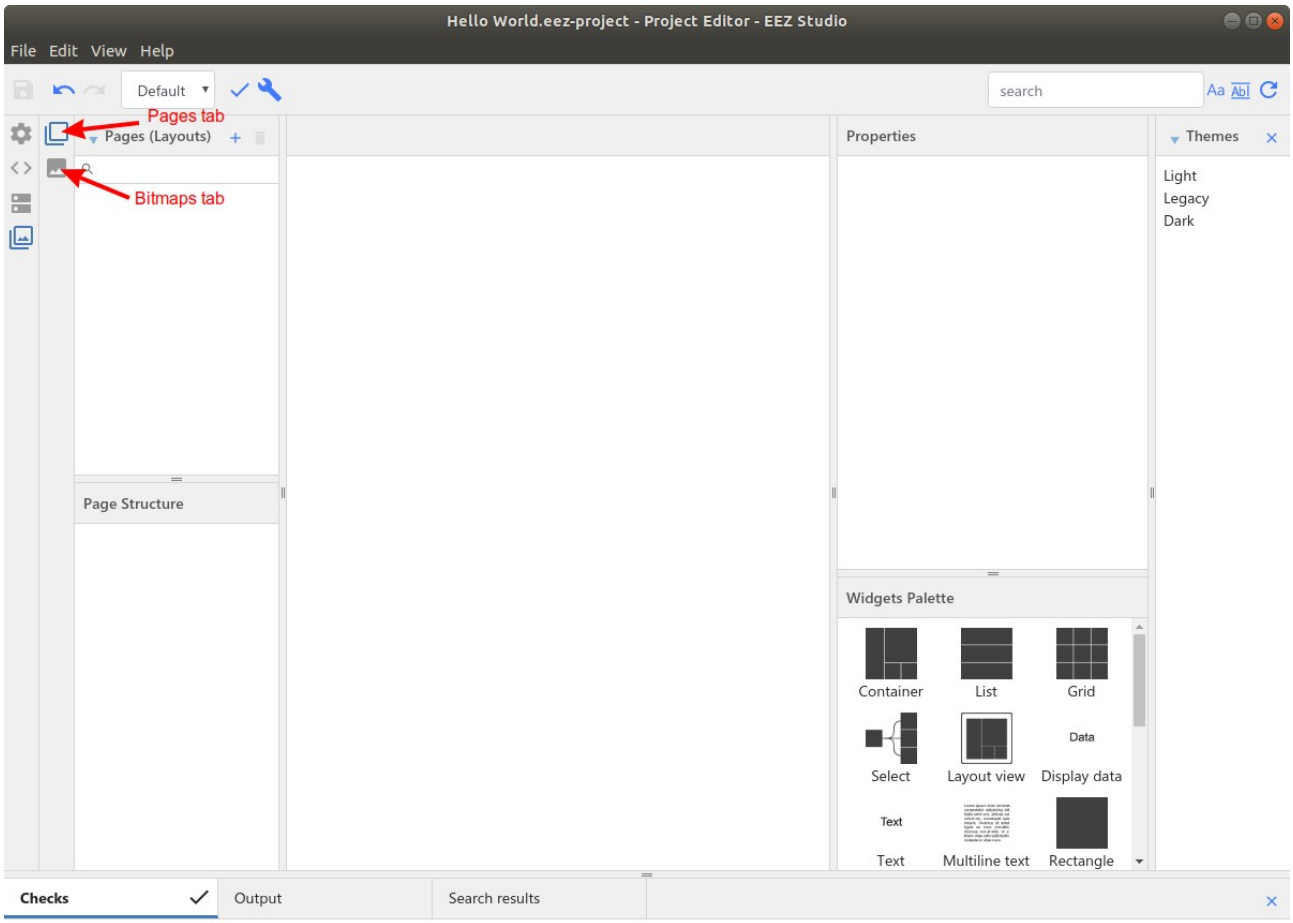



*Fig. 20: Empty GUI feature section*

The new items *Page* will appear and its *Properties* will be displayed. This will look like Fig. 21 (*Checks* and *Themes* sections are minimized for a simplified view). In *Properties* we can also see that the name is *Page* and we can change it to something else, say *Main* for which we will use [...] button at the right of the *Name* field.

We can now start inserting the widgets one by one. To do this, select the widget from the *Widgets palette* and drag & drop it to the central section (it may or may not be inside the page area since the final coordinates will be defined later).

As the first widget we will take one *Container* which, as its name suggests, is used to contain several

other widgets (including other containers) which simplify the organization of widgets and their manipulation.

The container may or may not have a defined name, and for its size and position we will use *Position and size* properties, so we will set:

- *Width* – **204**
- *Height* – **90**
- *Left* – **138**, if we want a container of these dimensions to appear in the middle, but we can also enter here equation like **(480 - 204) / 2** since these fields accept basic mathematical operations (480 because it is the width of the page, 204 because it is the chosen width of the container and we divide by 2 to center it).
- *Top* – **75**

*Note that the* Pin to edge*,* Fix size *and* Preview *options are intended for automatic positioning and have not yet been implemented.*

We will add a few widgets to this container. Adding a widget to an existing container can be done by dragging it in the desired container into the *Page structure* tree on the left. When positioning inside a tree structure, make sure that the purple marker is indented under the container to which you want the widget to belong (see Fig. 23).

*If no container is created, you can select one or more of existing widgets and insert it into the new container that will be created on that occasion. To do this, use the* Put in container *option from the right mouse button menu.*

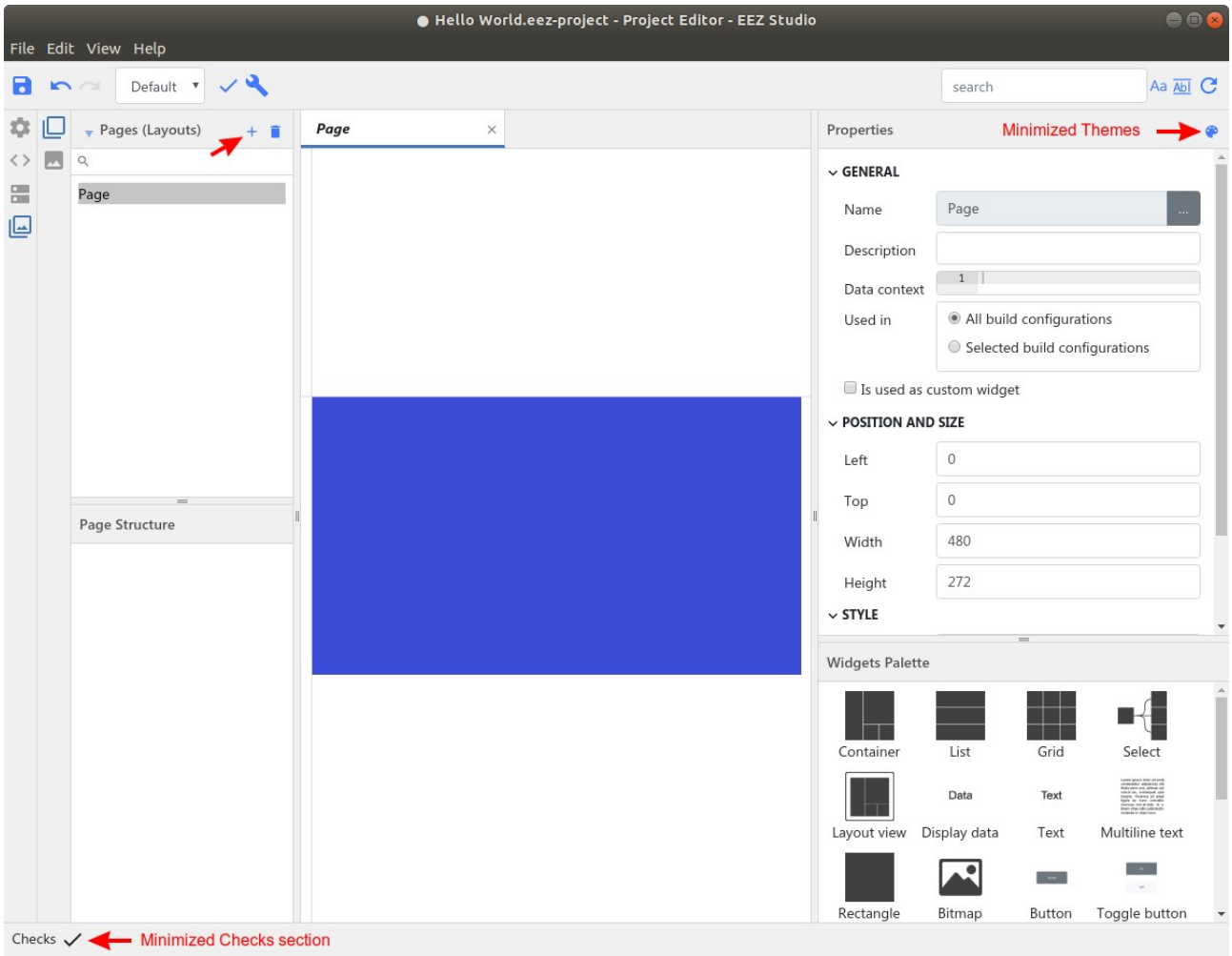



*Fig. 21: Newly created GUI page*

We will add the following widgets to the same container:

- *Text – Left*: **0**, *Top*: **0**, *Width*: **84**, *Height*: **40** (*Absolute position* will become 138, 75)
- *Text – Left*: **84**, *Top*: **0**, *Width*: **120**, *Height*: **40** (*Absolute position* will become 222, 75)

- *Button – Left*: **84**, *Top*: **50**, *Width*: ***120***, *Height*: **40** (*Absolute position* will become 222, 125)

In addition, we will create another container that will define the status line in which the exit option will appear, for this we will need:

- *Container – Name*: **Status line**, *Left*: **0**, *Top*: **240**, *Width*: **480**, *Height*: **32** (*Absolute position* will become 0, 240)
- *Text – Left*: **0**, *Top*: **0**, *Width*: **41**, *Height*: **32** (*Absolute position* will become 0, 240)
- *Text – Left*: **41**, *Top*: **0**, *Width*: **439**, *Height*: **32** (*Absolute position* will become 41, 240)

In the next step, we can define additional widget properties: their *Style* (i.e. fonts and colors) and *Specific* properties. Since we have chosen to inherit styles from the master project, only the styles defined there as exportable (i.e. have a defined *Id* in properties) will be available when [...] button is selected to the right of the *Normal style* input field. A new window will then open with a list of all available styles as shown in Fig. 24.
Using this option for widgets from the first container we will set the following:

- *Text – Normal style*: **default_M_left**, *Text*: **Voltage:**
- *Text – Normal style*: **edit_value_active_S_center**, *Text*: **(change to blank)**. The *Text* property can be left filled with default value (i.e. Text), but in that case the default value of the data that we will associate with that widget (3.0 V) will not be displayed on the page.
- *Button – Normal style*: **button_M,** *Disabled style*: **button_M_disabled**, *Text*: **Set**

For the widgets from the 2nd container we will set the following:

- *Text – Normal style*: **status_icon_enabled**, *Text*: **E** (please note that this style uses an icon font so the letter E is used because the Exit icon corresponds to that position)
- *Text – Normal style*: **status_title**, *Text*: **Hello World**

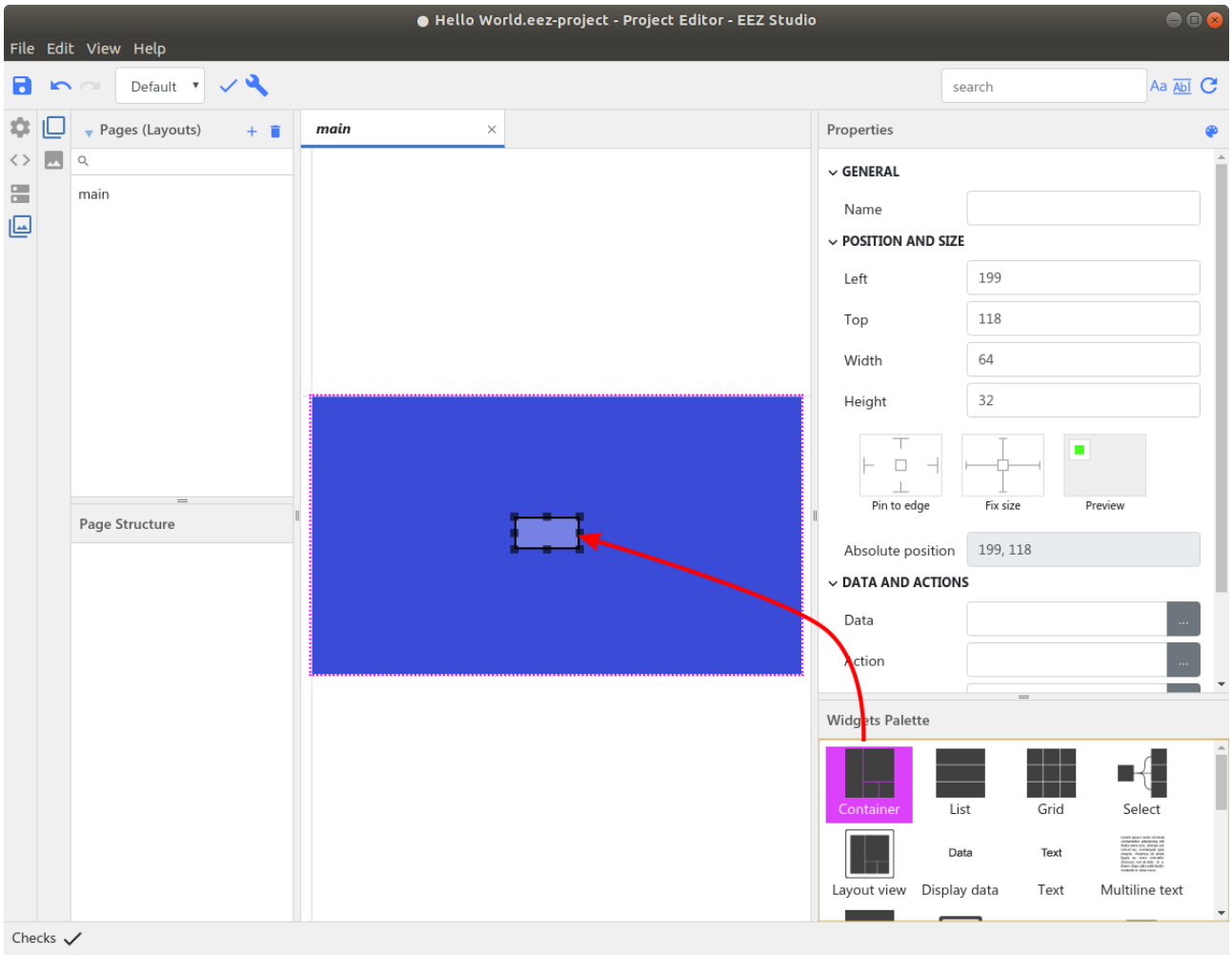



*Fig. 22: Adding container widget*

If you have done well so far you should have a fully defined page as shown in Fig. 25. It remains to set the action and data on certain widgets which we will do in the next step.

First container:

- *Voltage:* text widget is informative, and no action is expected on it. Therefore, its *Data* and *Action* fields should be left blank.
- The second text widget will be used to display the existing voltage and set the new voltage value at the CH1 output. For this reason, we will choose **voltage** for *Data*, and **input_voltage** for the *Action*, which we defined at the very beginning. To select *Data* and *Action*, we will use the corresponding [...] options to the right of the *Data and actions* properties input fields.
- We will use the *Set* button widget to confirm the entry and execute the part of the MicroPython script that will set the entered value. We leave the *Data* blank. As *Action* we choose **set_voltage**. This widget has another additional action property and that is *Enabled*. If there is a criterion during the execution of the MicroPython script that the button is enabled, we will be able to touch it, for which we will select the **can_set_voltage** from list of actions.

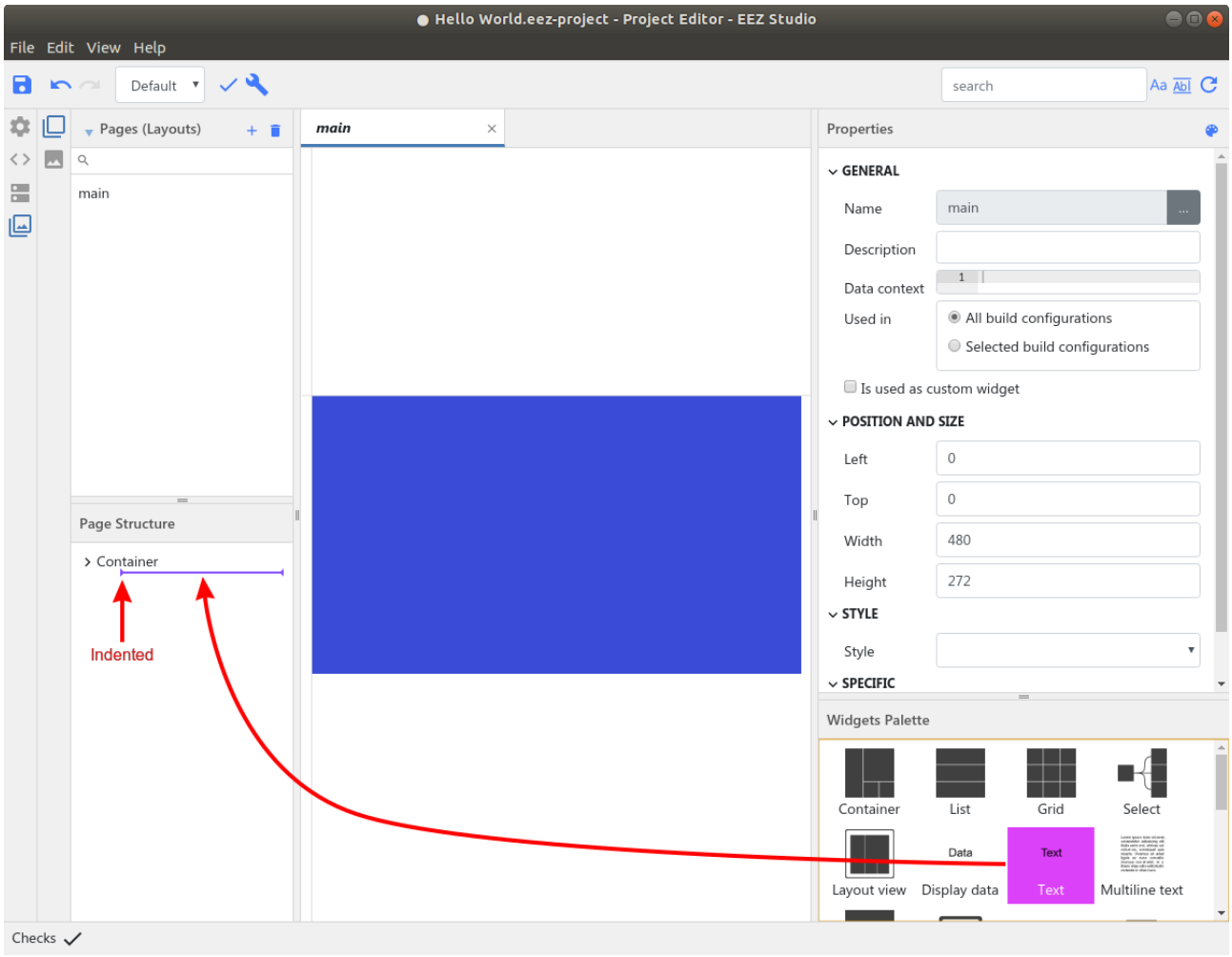



*Fig. 23: Inserting new widget into container*

Second container:

- The *E* text widget will be used to return from this page to the main page, which also means stopping further execution of the MicroPython script so the output voltage will not be set to the new value. For this reason, we will select here **close** as *Action*. *Data* field should be left blank.
- *Hello world* text widget is informative, and no action is expected on it. Therefore, its *Data* and *Action* fields should be left blank.

This completes the creation of the page to be used to interact with the MicroPython script. All we have to do is write a MicroPython script and deployment to BB3 which will be described below.

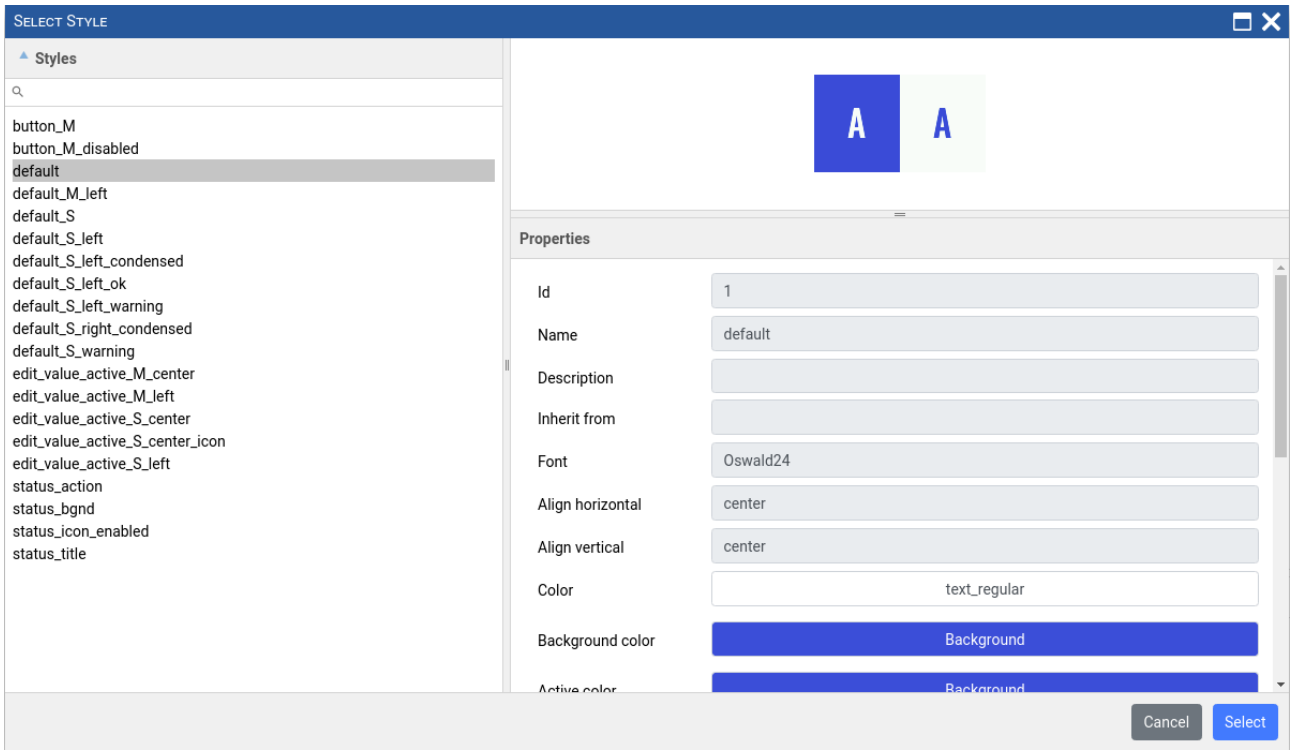



*Fig. 24: Inherited Styles selection*

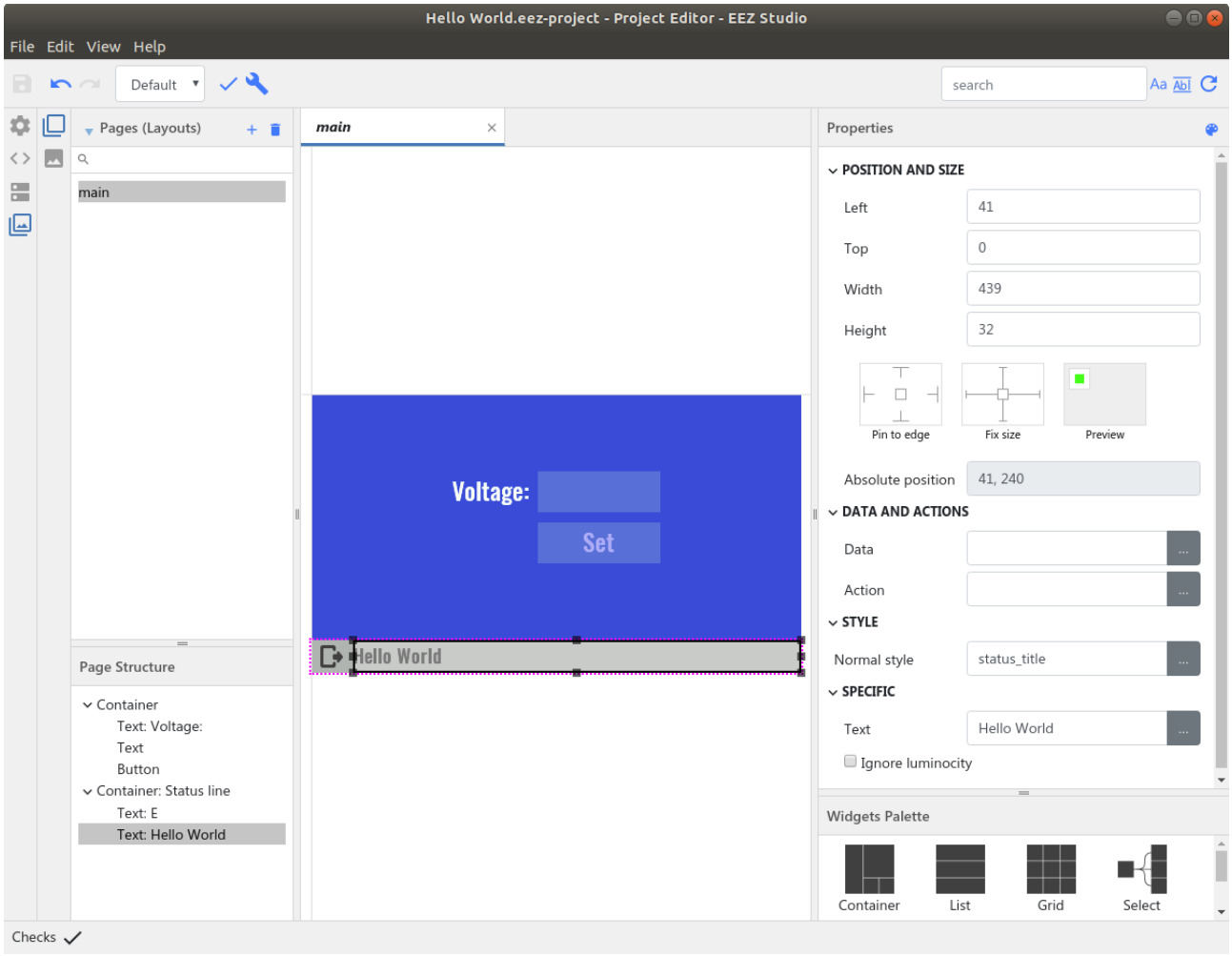



*Fig. 25: Page view with all widgets and defined styles*

### 16.2.2. MicroPython script

EEZ Studio does not currently offer the creation and editing of text files. Therefore, you can use your favorite text editor to write the MicroPython script listed below. The name of the MicroPython file should be *Hello world.py* to match the name of the EEZ Studio project.

| Code | Explanation |
|---|---|
| `# Hello, World!` | The text that will appear as a description of the MicroPython script when displayed on BB3 (see File manager section). |
| `from eez import scpi` | Include *scpi* function from *eez* module |
| `def input_voltage():`<br>`  global voltage, max_voltage`<br>`  value = scpi('DISP:INPUT? "",NUMBER,VOLT,0.0,' + str(max_voltage) + '.0,' + str(voltage))` | This is the implementation of the *input_voltage* action defined in the EEZ studio project. When one click on the *voltage* widget this function will be launched.<br><br>The SCPI command DIAG:INPUT? opens the input dialog on the screen where voltage can be entered. |
| `  if value != None:`<br>`  voltage = float(value)`<br>`  scpi('DISP:DIALog:DATA "voltage",FLOAT,VOLT,' + str(voltage))`<br>`  scpi('DISP:DIALog:DATA "can_set_voltage",INT,1')` | If *voltage* is entered then two data items are set: *voltage* to the entered value and *can_set_voltage* to 1 which means that voltage is entered and can be set on the channel, which results in the *Set* button widget being enabled. |
| `def set_voltage():`<br>`  scpi("INST ch1")`<br>`  scpi("VOLT " + str(voltage))` | Select CH1 as set its output voltage. |
| `def main():`<br>`  global voltage, max_voltage`<br>`  scpi("INST ch1")`<br>`  voltage = scpi("VOLT?")`<br>`  max_voltage = scpi("VOLT? MAX")` | Main program loop. SCPI command INST is used to select CH1 on power module and two SCPI queries that return currently set voltage (VOLT?) and max allowed voltage (VOLT? MAX). |
| `  scpi("DISP:DIAL:OPEN \"/Scripts/Hello World.res\"")` | Invoke *Hello World.res* file using the DISP:DIAL:OPEN that contains page created in EEZ Studio as discussed above. |
| `  try:`<br>`  scpi('DISP:DIAL:DATA "voltage",FLOAT,VOLT,' + str(voltage))`<br>`  while True:`<br>`  action = scpi("DISP:DIALog:ACTIon?")`<br>`  if action == "input_voltage":`<br>`  input_voltage()`<br>`  elif action == "set_voltage":`<br>`  set_voltage()`<br>`  break`<br>`  elif action == "close" or action == 0:`<br>`  break` | This is a dispatcher that asks via the SCPI command DISP:DIALOG:ACTION? which action the GUI requires to be performed.<br>The dispatcher is executed in a loop: when it receives from the GUI which action to perform, it executes it and asks again what the next action is.<br>If the detected action is *close* or 0 (this means that the firmware has requested closing the dialog) then the dispatcher loop is broken and goes to *finally* section described below. |
| `  finally:`<br>`  scpi("DISP:DIAL:CLOS")` | Execute SCPI command DISP:DIAL:CLOS to close last dialog window opened with the DISP:DIAL:OPEN command.<br>This section will be also executed in case of an error, i.e. exception. |
| `main()` | |

### 16.2.3. MicroPython script deployment and execution

Once we are done with the EEZ Studio project and the MicroPython script we are ready for deployment. In order for the page created in EEZ Studio to be used successfully on BB3, it must not contain any errors and should be "compiled". The *Check* and *Build* options are used for this, and Fig. 26. shows the result of the *Build* action in the *Output* tab. It will create in the same folder where the EEZ Studio project resource file *Hello world.res*.

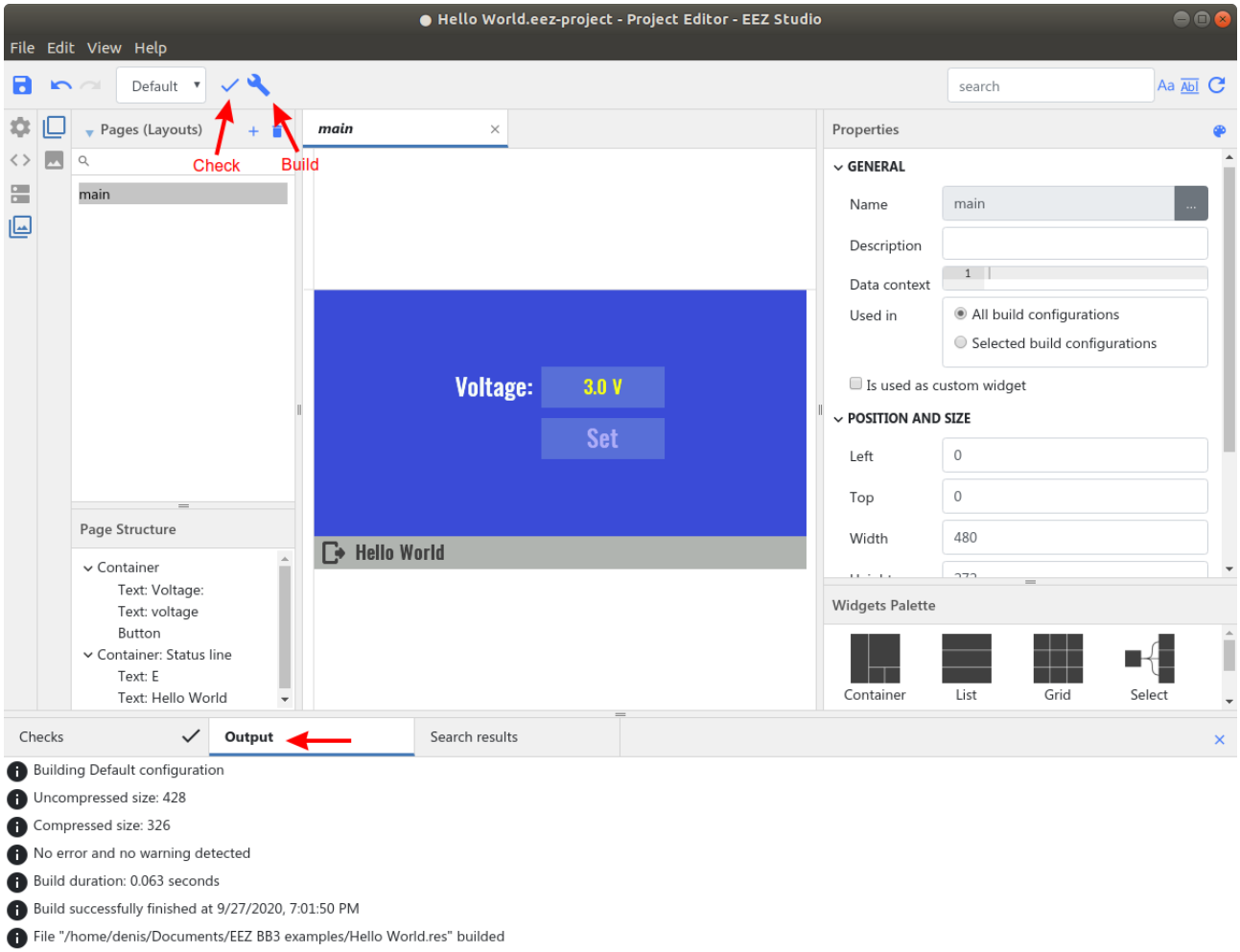



*Fig. 26: EEZ Studio project Check and Build options*

*Hello world.py* and *Hello world.res* files will now need to be downloaded to BB3 in the *Scripts* folder. We can also use EEZ Studio for this, but its ESW part used to communicate with SCPI instruments such as BB3. The procedure is the same as in the case of the Upgrade peripheral module firmware using GUI on BB3 section in Chapter 13. The download parameters of the MicroPython script are shown in Fig. 27. The same will need to be done for the resource file (*Hello world.res* ).

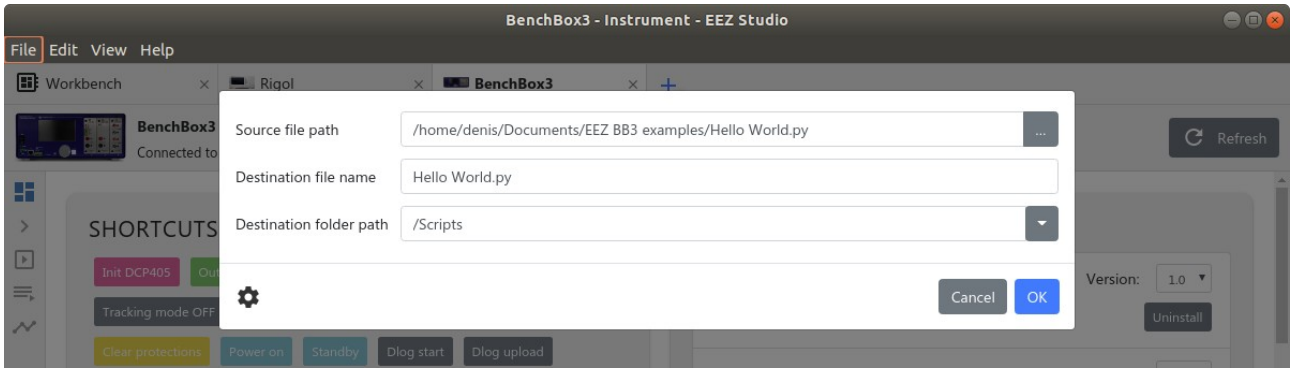



*Fig. 27: File transfer using EEZ Studio* Send File *option*

During execution, if the MicroPython script has an error, a message will appear as in Fig. 28. The show

debug trace log option leads to the event log viewer where more details about the error can be found (Fig. 29).

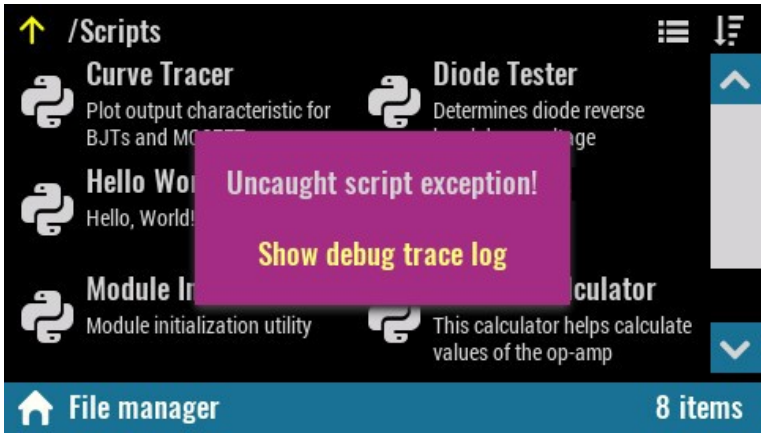



*Fig. 28: MicroPython script error message*

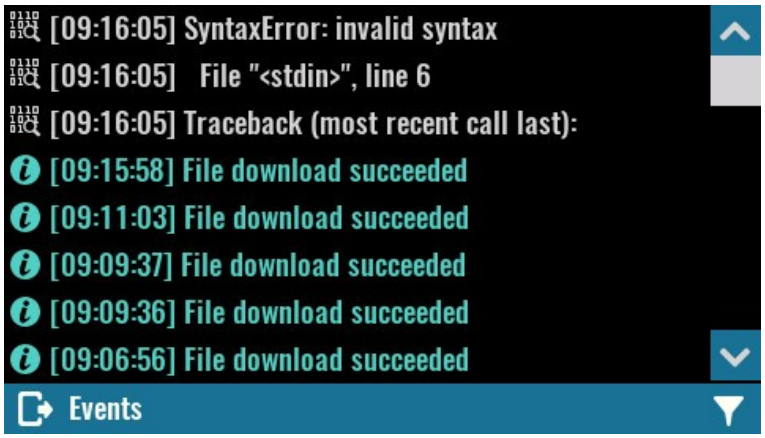



*Fig. 29: MicroPython script error details in event log*

*The current implementation does not offer a script debugger or the ability to modify the script on the BB3 side. During development, all MicroPython script modifications will need to be made to the computer side and the changes will need to be downloaded as previously shown.*

## 16.3. EEZ Python module

In our example the MicroPython script used *eez* module. The table below contains the names and descriptions of all the functions that the module contains. The current version of the module can be found at:
https://github.com/eez-open/modular-psu-firmware/blob/master/src/third_party/micropython/ports/bb3/mod/eez/README.md

For MicroPython references visit: http://docs.micropython.org/en/latest/reference/index.html

A list of currently implemented / enabled functions in BB3 firmware can be found at this link:
https://github.com/eez-open/modular-psu-firmware/blob/master/src/third_party/micropython/ports/bb3/mpconfigport.h

| Function name | Description |
|---|---|
| `eez.scpi(commandOrQuery)` | Execute any SCPI command or query. If command is executed, then None is returned. If query is executed, then it returns query result as integer or string. |
| `eez.getU(channelIndex)` | Returns measured voltage as float for the given channel index.<br><br>This is the same as MEASure[:SCALar]:VOLTage[:DC]? |

| | |
|---|---|
| | query. Use this function instead of SCPI query when performance requirement is critical. |
| `eez.setU(channelIndex, currentLevel)` | This function sets the immediate voltage level for the given channel index.<br><br>It is equal to [SOURce[<n>]]:VOLTage[:LEVel][:IMMediate][:AMPLitude] command. Use this function instead of SCPI command when performance requirement is critical. |
| `eez.getI(channelIndex)` | Returns measured current as float for the given channel index.<br><br>This is the same as MEASure[:SCALar]:CURRent[:DC]? query. Use this function instead of SCPI query when performance requirement is critical. |
| `eez.setI(channelIndex, currentLevel)` | This function sets the immediate current level for the given channel index.<br><br>This is the same as [SOURce[<n>]]:CURRent[:LEVel][:IMMediate][:AMPLitude] command. Use this function instead of SCPI command when performance requirement is critical. |
| `eez.getOutputMode(channelIndex)` | For the given channel index, returns:<br><br>• "CV" when channel is in Constant Voltage mode<br>• "CC" when channel is in Constant Current mode<br>• "UR" when channel is neither in Constant Voltage or Constant Current mode<br><br>This is the same as OUTPut:MODE? query. Use this function instead of SCPI query when performance requirement is critical. |
| `eez.dlogTraceData(value, ...)` | For current DLOG trace file, this function adds one point in time for each defined Y-axis. It expects one or more value arguments depending of how much Y-axis values are defined for currently started DLOG trace.<br><br>This is the same as SENSe:DLOG:TRACe[:DATA] command. Use this function instead of SCPI command when performance requirement is critical. |

## 16.4. MicroPython script examples

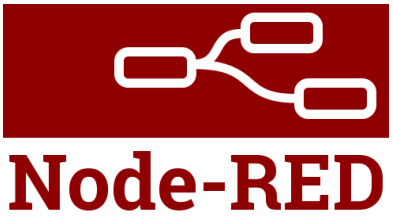
EEZ Studio communicates with SCPI instruments using the so-called IEXT (*Instrument EXTension*). IEXT for BB3 includes, among other things, several MicroPython scripts that can be easily transferred to BB3, as well as later updated if newer versions of BB3 IEXT include changes to MicroPython scripts. EEZ Studio projects and MicroPython scripts can be found at https://github.com/eez-open/modular-psu-firmware/tree/master/scripts

| Script name | Description |
|---|---|
| *Curve Tracer* | Plot output characteristic for BJTs and MOSFETs |
| *Diode Tester* | Determines diode reverse breakdown voltage |
| *Hello World* | The script used in the example previously described in this chapter |
| *Module Initialization* | EEZ peripheral module initialization utility |
| *Op-Amp Calculator* | This calculator helps calculate values of the op-amp configured as inverting, non-inverting or differential amplifier |

| | |
|---|---|
| *Parallel and Series Calculator* | Calculates parallel resistance/inductance or capacitance is series |
| *Voltage Divider Calculator* | This calculator helps calculate values of resistive voltage divider |

# 17. Node-RED integration

*Work in progress*




Node-RED is a free and open source flow based programming tool for event-driven applications that provides a browser-based editor that makes it easy to wire together program *flows* using the wide range of predefined *nodes* that perform a specific action.

The integration of EEZ BB3 with Node-RED allows the creation of complex automation tasks quickly and without the need for common procedural programming. This makes this solution suitable for use in ATE environments for benchtop development, lab testing automation or manufacturing floor quality assurance.

An additional advantage of this combination is that it is end-to-end open source and cross-platform which facilitates deployment in different environments and facilitates the sharing of test procedures.

Node-RED also includes support for Git which further simplifies team development and sharing.

This chapter will describe how to install Node-RED and a simple flow example to automate relay contact testing. The flow used is available at https://github.com/eez-open/node-red-relay-loop-test

## 17.1. Node-RED installation

Unlike the MicroPython integration described in the *Scripting with MicroPython* chapter where the MicroPython script is executed autonomously on EEZ BB3, in the case of Node-RED you will need to have a computer on which to execute it. To communicate with EEZ BB3 it will be necessary to establish a connection via the Ethernet interface. For this reason, it will be necessary to install Node-RED first.

Details of the installation can be found on the official Node-RED website at the following link https://nodered.org/docs/getting-started/local

In short, the installation can be summarized in the following few steps:

1. Node-RED requires a supported version of *NodeJS*.
   Download and install *NodeJS* for your operating system available at
   https://nodejs.org/en/download/

2. Open a terminal application (in Windows this is called the *Command prompt*) and start the *Node-RED* installation with the following command:

   ```
   npm install -g --unsafe-perm node-red
   ```

   Linux users requires root privileges, therefore the command has to include *sudo*:

   ```
   sudo npm install -g --unsafe-perm node-red
   ```

   *The same command can be used later to upgrade Node-RED to the latest version.*

   Linux users: if npm is not installed yet use command such as:

   ```
   sudo apt install npm
   ```

3. The same procedure is needed to install the *Node-RED dashboard*. Windows user need to enter the following command:

   ```
   npm install node-red-dashboard
   ```

   On Linux system enter:

   ```
   sudo npm install node-red-dashboard
   ```

4. Run the following command to ensure *Node.js* and *npm* are installed correctly:

   ```
   node --version && npm --version
   ```

   In response, you will receive versions number similar to:

   ```
   v12.19.0
   6.14.8
   ```

## 17.2. Node-RED running

Node-RED is also started from the terminal (command prompt). To start enter:

```
node-red
```

*Note that the terminal in which you started Node-RED must be active at all times for normal operation. If you want to exit, first press* Ctrl + C *and wait for the prompt to appear. You can then close the terminal application or run Node-RED again.*

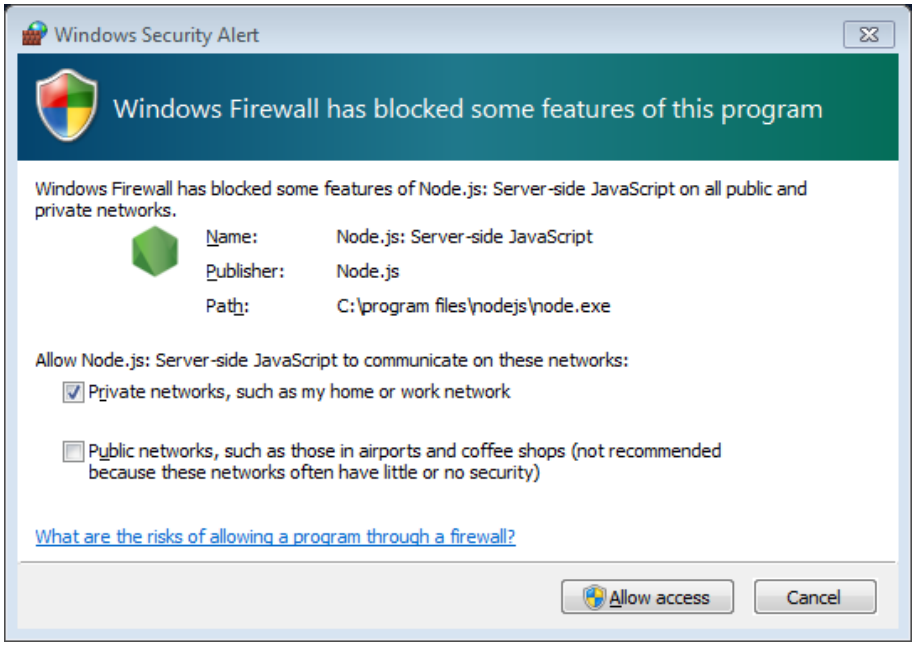
Welcome text similar to the one shown below will appear on Linux:

```
File  Edit  View  Search  Terminal  Help
            :~$ node-red
7 Oct 16:43:43 - [info]

Welcome to Node-RED
===================

7 Oct 16:43:43 - [info] Node-RED version: v1.1.3
7 Oct 16:43:43 - [info] Node.js  version: v12.19.0
7 Oct 16:43:43 - [info] Linux 4.15.0-118-generic x64 LE
7 Oct 16:43:43 - [info] Loading palette nodes
7 Oct 16:43:44 - [info] Dashboard version 2.23.2 started at /ui
7 Oct 16:43:44 - [info] Settings file  : /home/denis/.node-red/settings.js
7 Oct 16:43:44 - [info] Context store  : 'default' [module=memory]
7 Oct 16:43:44 - [info] User directory : /home/denis/.node-red
7 Oct 16:43:44 - [info] Server now running at http://127.0.0.1:1880/
7 Oct 16:43:44 - [info] Active project : new
7 Oct 16:43:44 - [info] Flows file     : /home/denis/.node-red/projects/new/flow.json
7 Oct 16:43:44 - [info] Starting flows
7 Oct 16:43:44 - [info] Started flows
```

Node-RED will also display the log of its activities in the terminal. The log output at the beginning provides information such as:

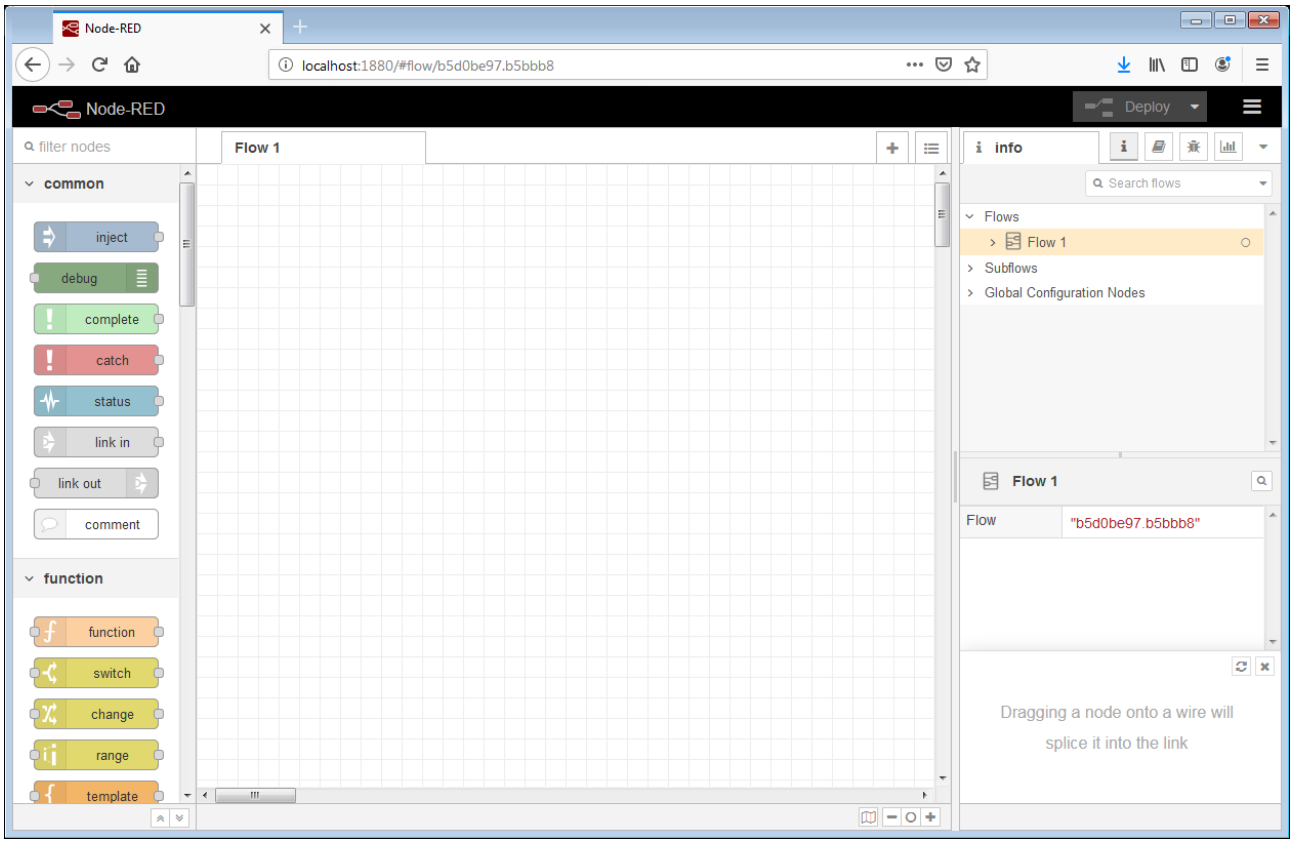
- The versions of Node-RED and Node.js
- Any errors hit when it tried to load the palette nodes
- The location of Settings file and User Directory
- The name of the flows file it is using, etc.

The first time you run node-RED on Windows, a firewall warning will appear. Confirm default settings by selecting the *Allow access* option.



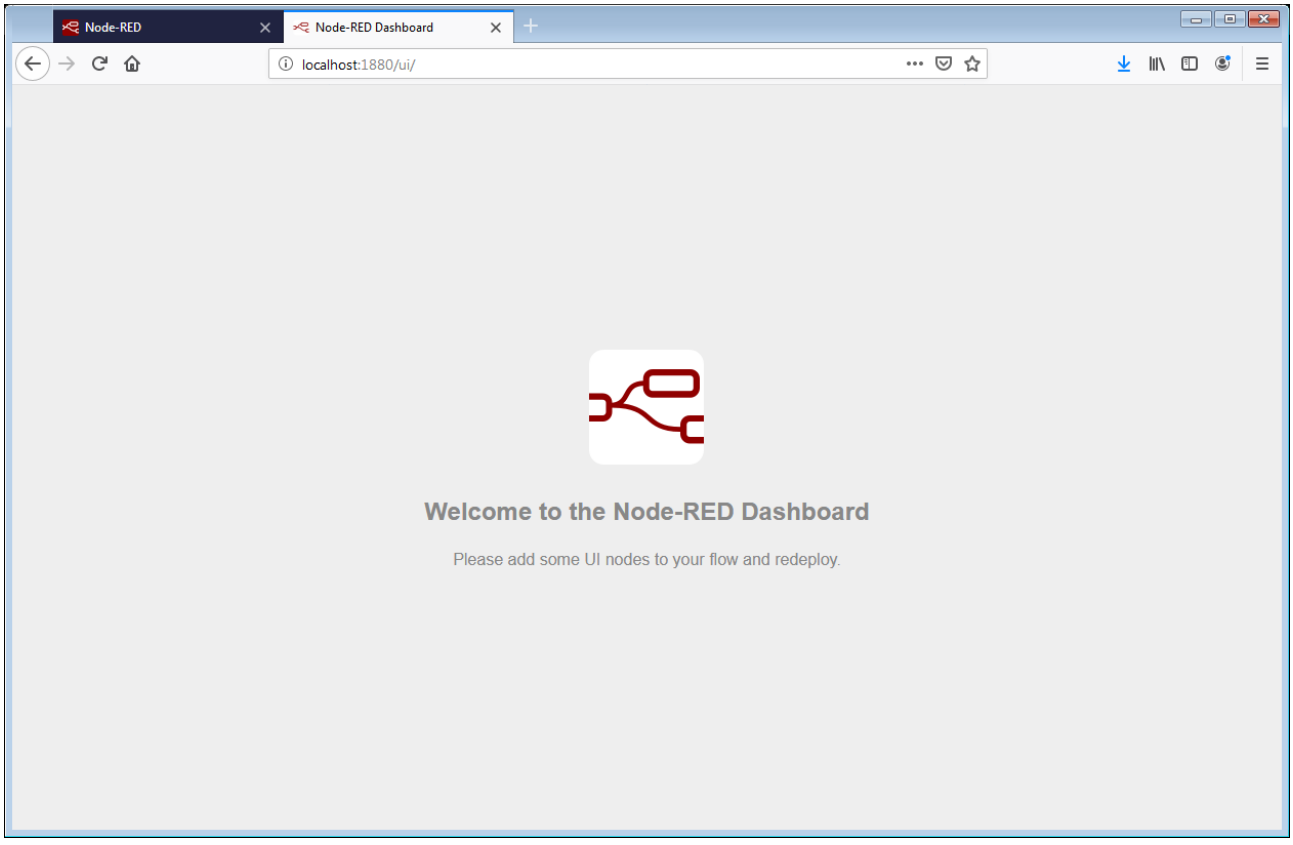

The Node-RED editor can be accessed using an internet browser by typing

`http://localhost:1880` or `http://127.0.0.1:1880`




The Node-RED editor will be available at the same address if we add `/ui` to the end, i.e.

`http://localhost:1880/ui` or `http://127.0.0.1:1880/ui`

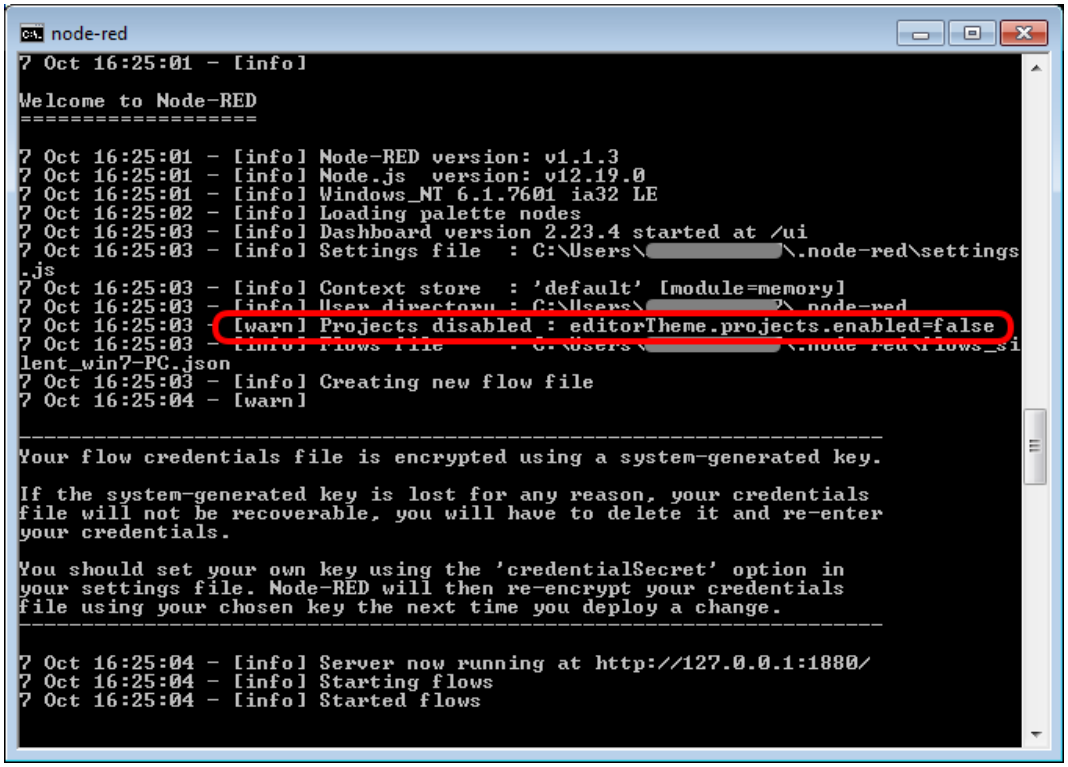



*Please note that, by default, the Node-RED editor is not secured – anyone who can access its IP ad-*

*dress can access the editor and deploy changes.*
*This will not be a problem as long as everything is running on local and trusted network.*
*For more details on how to secure Node-RED editor and dashboard visit: https://nodered.org/docs/user-guide/runtime/securing-node-red*

## 17.3. Working with projects

On the Node-RED official website, projects are presented as a new way to manage *flow* files. Rather than treat flows as a simple pair of files, they represent everything you need to create a redistributable Node-RED application.
It is important to know that projects are backed by a Git repository, meaning all of the files are fully version controlled and allow developers to use familiar workflows to collaborate with others.
Working with projects is not enabled by default and this is possible primarily because the git is required to be installed. Information about this can be seen when starting Node-RED:



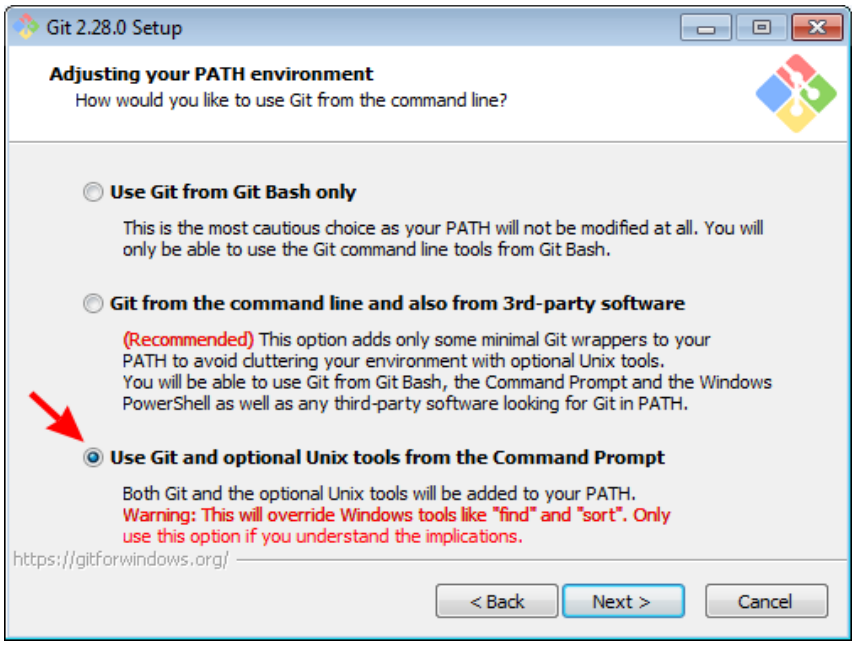

To enable projects it will be necessary to install *git* first. Git is also free and open source and can be downloaded from https://git-scm.com/downloads.
More information about the installation is available at https://git-scm.com/book/en/v2/Getting-Started-Installing-Git.

*Close Node-RED before starting the Git installation.*

For Ubuntu, this PPA provides the latest stable upstream Git version:

```
sudo add-apt-repository ppa:git-core/ppa
sudo apt update
sudo apt install git
```

In the case of Windows, you will need to download the installation and run the installation wizard. In principle, you can proceed to confirm all the default options. However, there is a possibility that after installing git you will not be able to run from the command prompt (because its location is not added to the PATH environment variable). If this happens you will need to reinstall Git and select the following option in the *Adjusting your PATH environment* step:




To check that the git is installed and can be run (i.e. that in the case of Windows the PATH environment variable is correctly modified) it will be enough to type in the command line:

```
git
```

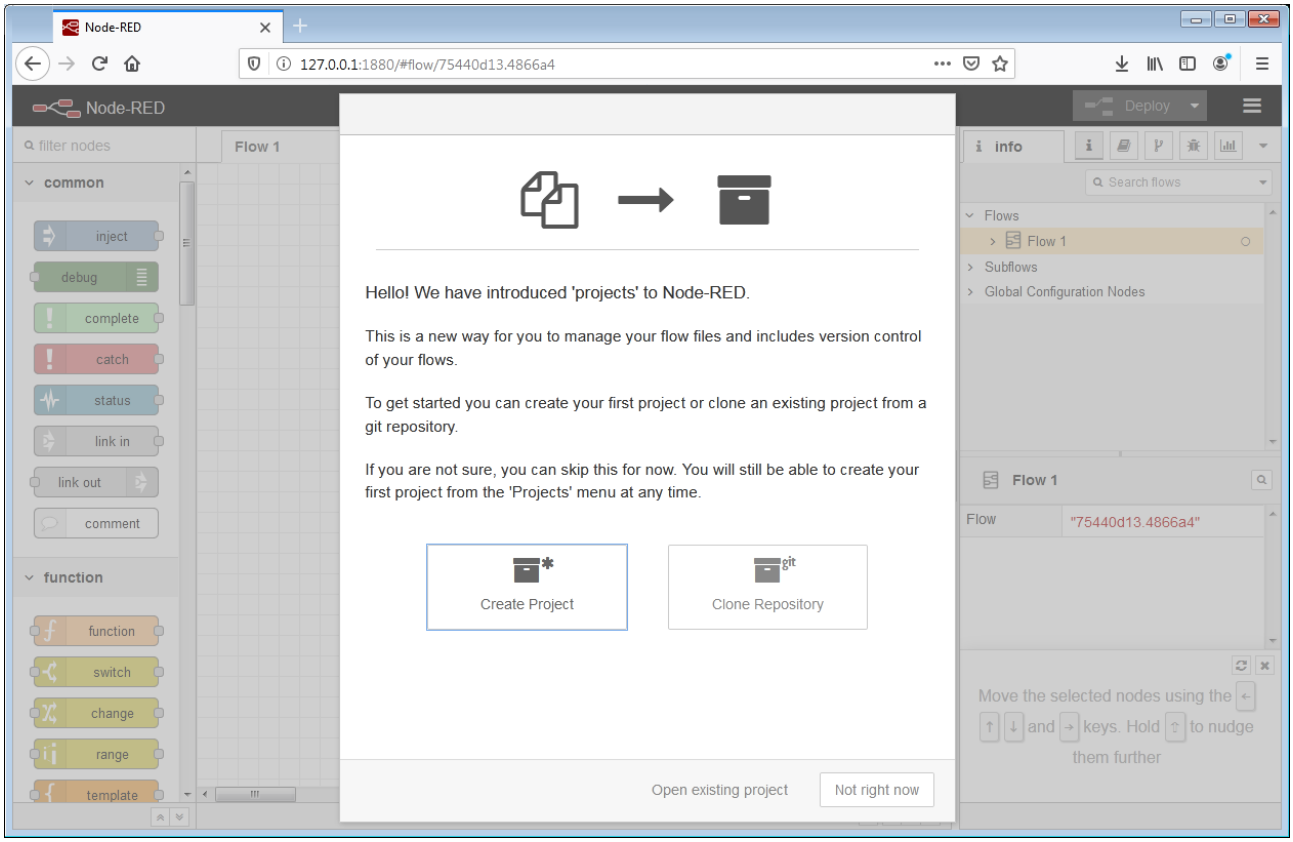
The final step to enabling projects is to modify the Node-RED *settings.js* configuration file.
The location of this file on linux is in the user home folder in the *.node-red* subfolder. Therefore you can use the following command:

```
cd ~/.node-red
```

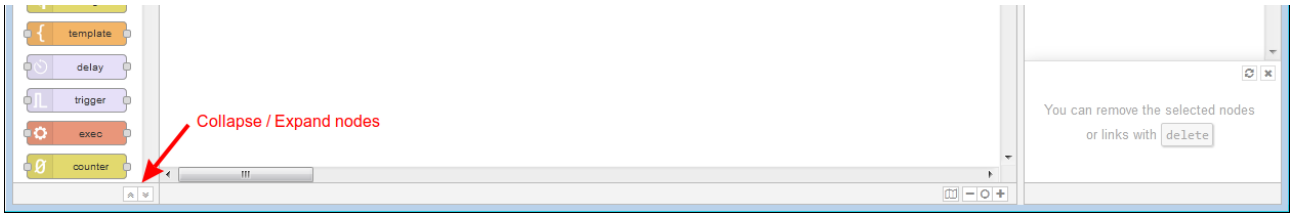
It's similar with Windows: look for it in *Users\<user name>\.Node-red*
In the *editorTheme:projects:enabled* section within the *module.exports* block, it is necessary to replace *false* with *true*:

```
// Customising the editor
    editorTheme: {
        projects: {
            // To enable the Projects feature, set this value to true
            enabled: true
```

After saving the change, run Node-RED once again and this time the following dialog will appear in the Node-RED editor (at 127.0.0.1:1880):




Now we can start making our test flow. Here, select the *Create project* option and type *relay-loop-test* as the project name. An empty workspace will open. The available nodes will be displayed in the list on the left. Since there are a large number of them you can use the *Collapse* or *Expand* options at the bottom left. In this case, you can get to the desired node by using the *Search* field at the top left.





The workspace editor allows you to work with multiple tabs and the first tab is called *Flow 1*. We can change its name as needed. Let's say we change it to *Main*. This will require a double click on the tab name (i.e. Flow 1) when a new dialog will open and we can enter a new name.

*Since Node-RED editor is a web browser application, it will not be able to right-click on any option.*

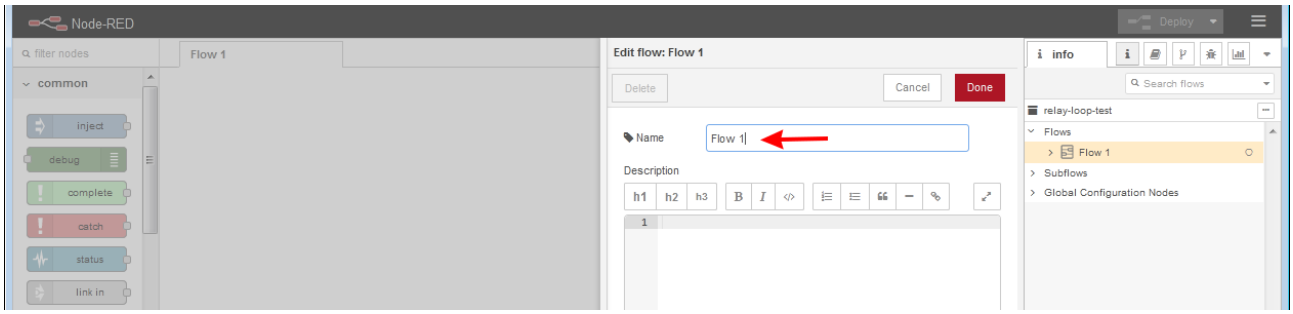



*Fig. 30: Change flow name*

## 17.4. Example scope and features

The scope of this example is to test changing states of one set of relay contacts at the time. The wiring diagram is shown in Fig. 31. One output from the power module (DCP or DCM) will be used to power the relay coil. A *DOUT1* output will be used to test the state change, which will be fed to the *DIN1* input via the relay contact. To increase immunity to external interference on DIN1 we will use a pull-down resistor.

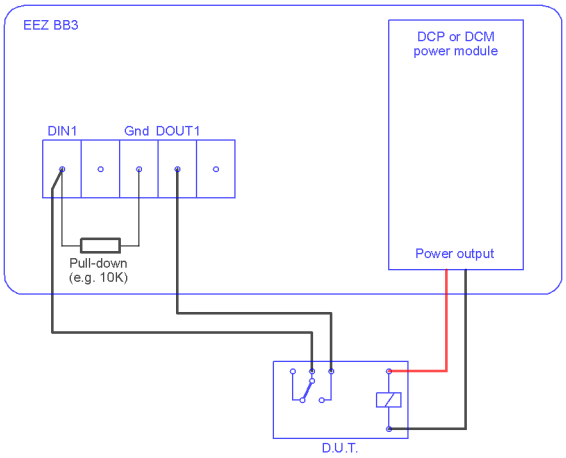



*Fig. 31: Wiring diagram*

The Node-RED dashboard will be used to interact with the test flow in which we want to have the following:

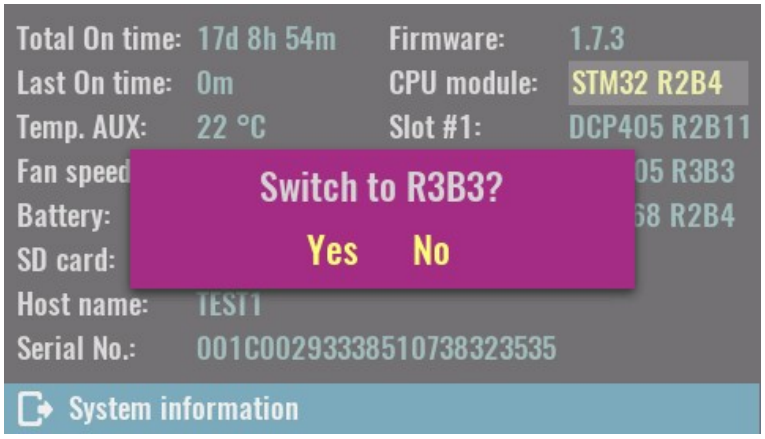
- Ethernet connection control
- Module identification in the first slot
- Setting the relay voltage (D.U.T.) and the break between the two tests
- Counters for Passed, Failed and Total number of tests
- Start and stop control and counter deletion
- Graphical display of results

*Work in progress*

# 18. Troubleshooting

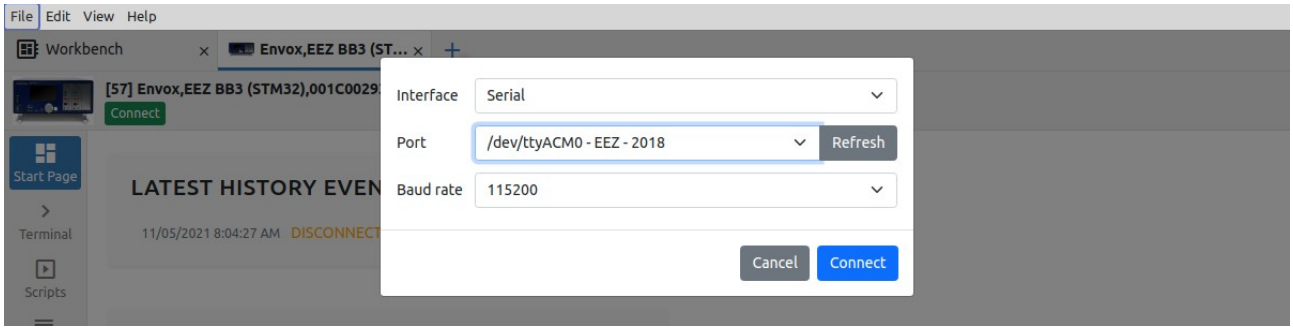
## *18.1. Wrong master MCU firmware revision selected*

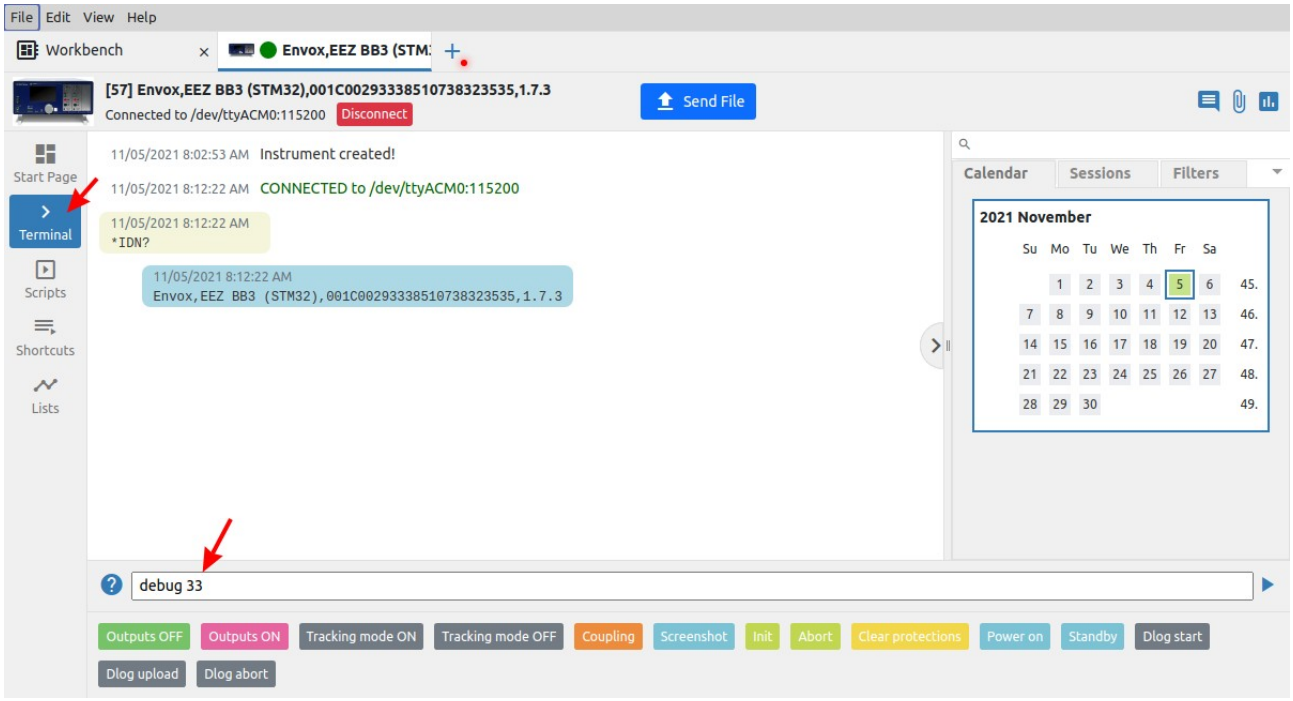
The EEZ BB3 comes with two different versions of MCU modules that also require slightly different firmware versions. As stated in Section 8.16. on the *System Information* page it is possible to check which version of the MCU module is selected. The version of the MCU module is also allowed to be changed on the same page. For example, if the r2B4 version is currently selected and you want to change it, a warning message will appear:




Of course you shouldn't change the version, however if you did it unknowingly, EEZ BB3 will restart and you can expect a black screen. Fortunately, this will not cause any damage, except that they will no longer be able to see anything on the screen, and not be able to go to the *System information* page to select the correct version.

This can be corrected by connecting to the EEZ Studio via a USB or LAN interface and executing the DEBUG 33 command in the *Terminal*. When the command is executed, the EEZ BB3 will restart and the MCU module version selection will appear on the screen.




File Edit View Help
Workbench
Envox,EEZ BB3 (STM
[57] Envox,EEZ BB3 (STM32),001C00293338510738323535,1.7.3
Connected to /dev/ttyACM0:115200
Disconnect
Send File
Start Page
Terminal
Scripts
Shortcuts
Lists
11/05/2021 8:02:53 AM Instrument created!
11/05/2021 8:12:22 AM CONNECTED to /dev/ttyACM0:115200
11/05/2021 8:12:22 AM
*IDN?
11/05/2021 8:12:22 AM
Envox,EEZ BB3 (STM32),001C00293338510738323535,1.7.3
Calendar
Sessions
Filters
2021 November
Su Mo Tu We Th Fr Sa
debug 33
Outputs OFF
Outputs ON
Tracking mode ON
Tracking mode OFF
Coupling
Screenshot
Init
Abort
Clear protections
Power on
Standby
Dlog start
Dlog upload
Dlog abort

# 19. MIO168 mixed I/O module

MIO168 is a versatile module that allows work with various analog and digital signals. The following features are built into the module itself:

- 8 x digital inputs with protections and two voltage levels
- 8 x digital output with protections with low-side switches (Ron = 550 mΩ, max. 550 mA)
- 2 x 12-bit voltage / current bipolar analog outputs
- 2 x 12-bit voltage bipolar analog outputs
- 2 x PWM outputs or power bias for external sensors (±15 V, max. 10 mA)

Additionally, the MIO module has connectors to accept different AFE (Analog front-end) expansion boards depending on the needs for measuring analog signals. The default expansion board is AFE3 which offers the following:

- 4-channel **simultaneous** 24-bit measurement (effective resolutions up to 18 bit, sampling rate up to 32 KSPS)
- AIN1: Hi-voltage **isolated** (floated) input, 2 measurement ranges (±50 V, ±480 V)
- AIN2: Hi-current **isolated** (floated) input, 2 measurement ranges (±1 A, ±10 A)
- AIN3: Hi-voltage input, 3 measurement ranges (±2.4 V, ±12 V, ±240 V)
- AIN4: Hi-current input, 3 measurement ranges (±24 mA, ±500 mA, ±10 A) share common GND with AIN3
- The current channels (AIN2 and AIN4) are equipped with two fuses: 1.25 A and 10 A.

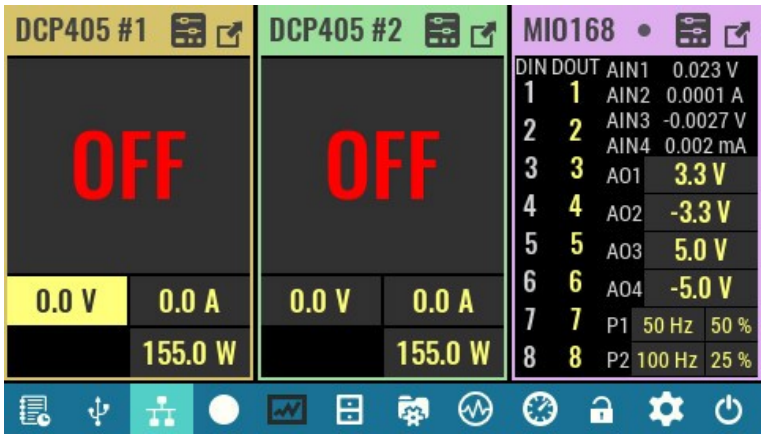
*As in the case of power modules (DCP and DCM) all MIO168 outputs and inputs are galvanically isolated from the main GND (i.e. MCU module), and the above mentioned AIN1 and AIN2 to AFE3 are further isolated from MIO168 GND.*

Module user instructions are divided into the following sections:

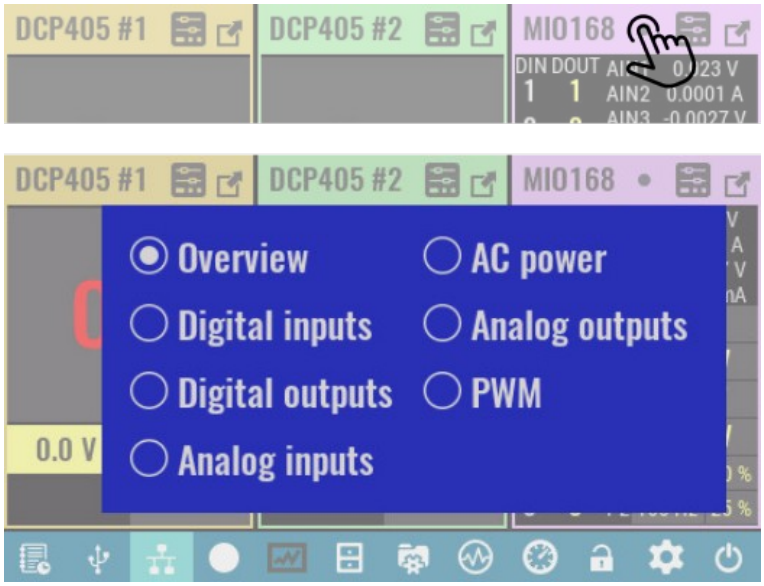


## 19.1. Display views

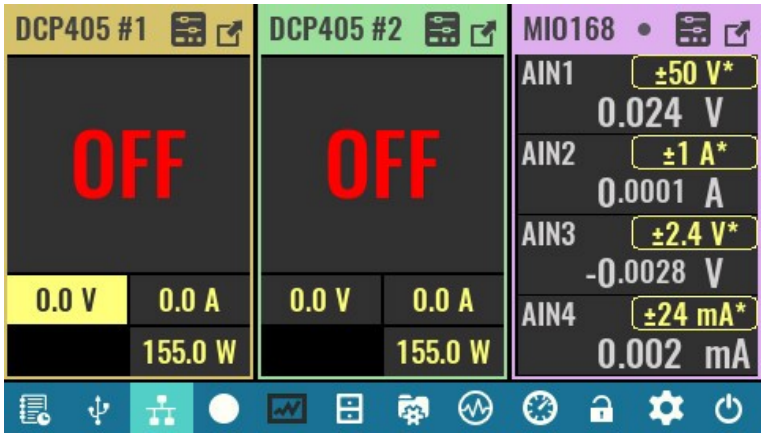
Unlike power modules that have 5 different display views, there are two available to display MIO168 parameters: *Numeric* (picture on the right) and *Horizontal bar* (picture below).

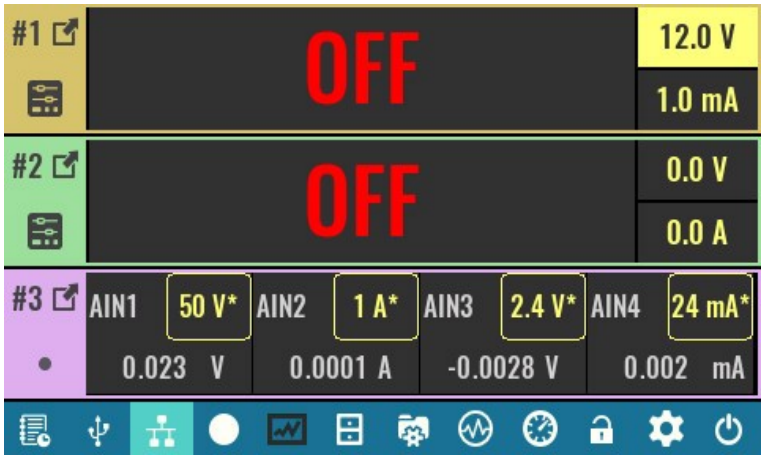



In both views, by default, all resources (channels) are displayed, which gives a good overview of all states. However, interaction with certain channels can be problematic due to limited touch area. If interaction with only one group of resources is desired, then a menu of all available channel groups can be displayed by clicking on the point icon.

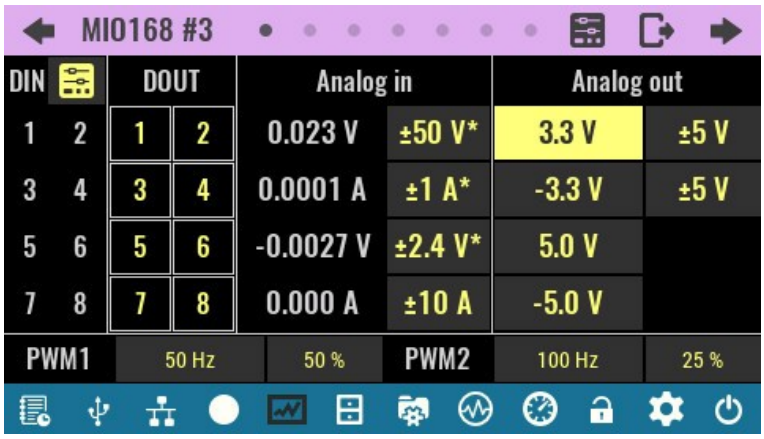



The image on the right is an example of a display of a group of *Analog inputs* for *Numeric* view, and the image below shows what they look like for *Horizontal bar* view.



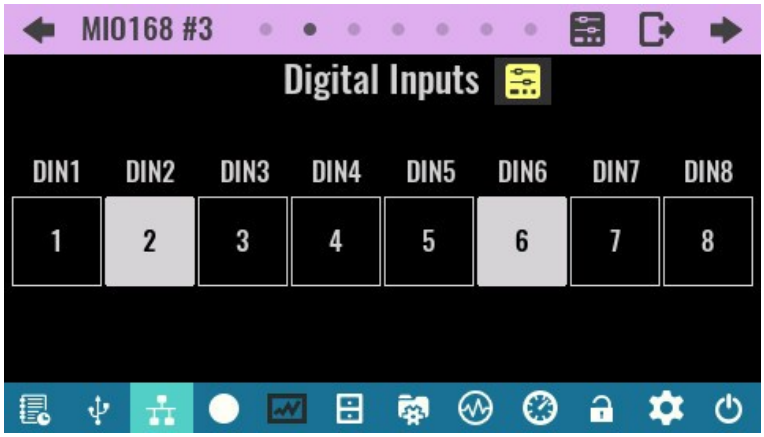



MIO168 module resources can also be displayed in full screen using the maximized icon. When maximized view is selected, navigation arrows to move between modules will be displayed at the top, as well as point icons for quick access to the desired channel group. The first point displays an overview of all resources, and the images that follow will show all channel groups also in a maximized view.




## 19.2. Digital inputs

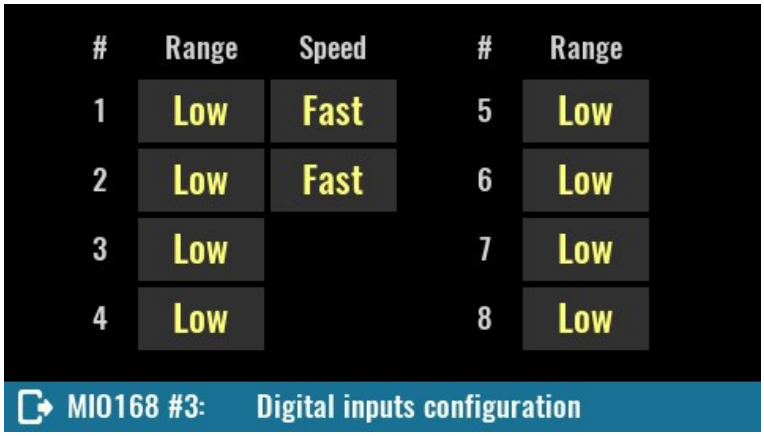
This page shows the status of all 8 digital inputs at the same time. If the input is in a logical High state it will be highlighted (DIN2 and DIN6 in our example).




SCPI

```
MEASure:DIGital[:BYTE]?
SENSe:DLOG:FUNCtion:DIGital[:INPut]?
```

By selecting the *Settings* icon, a new page appears on which the following can be defined (# indicates the digital input number):




**Range**
The inputs have two voltage ranges:

- *Low* (for +3.3/5 V logic levels) and
- *High* (for +12/24 V logic levels)

SCPI

```
SENSe:DIGital:RANGe <pin>,{LOW|HIGH}
```

**Speed**
Defines the time constant by selecting input capacitance. This only applies to DIN1 and DIN2.

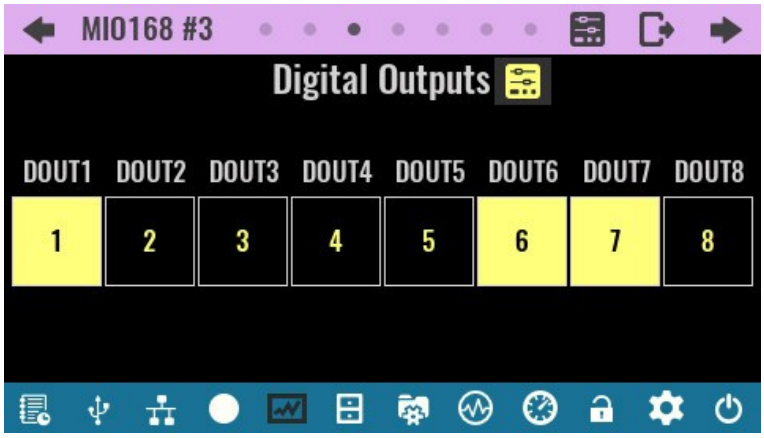
SCPI

```
SENSe:DIGital:SPEed
```

## 19.3. Digital outputs

*Important: digital outputs control low-side switches, i.e. when the output is active it will be connected to GND potential. For this reason, the other end of the load must be connected to the positive rail. Measuring the output voltage without a connected load (or pull-up resistor) will show no change.*

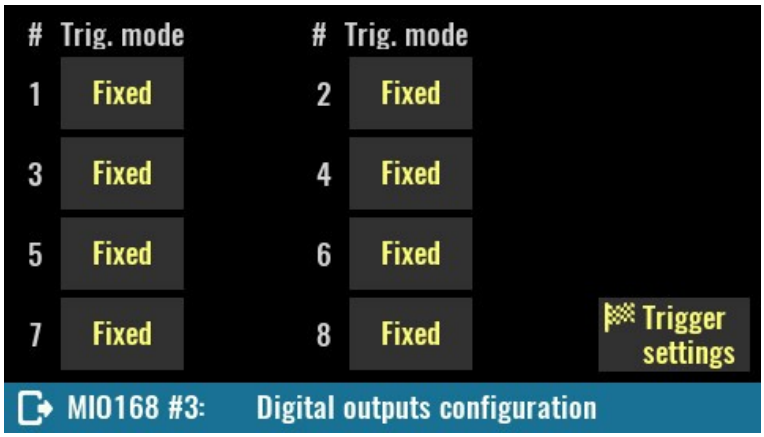
The digital output page allows you to view and set the status of all 8 outputs. The outputs that are active will be highlighted (DOUT1, DOUT6 and DOUT7 in our example).




SCPI

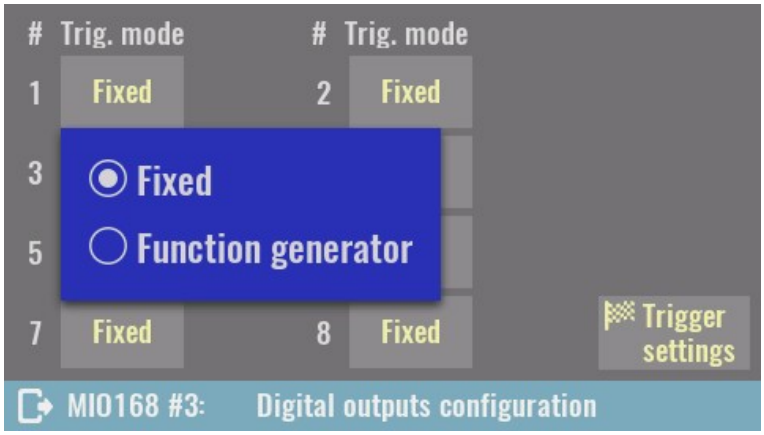
```
SOURce:DIGital:DATA[:BYTE]
{value}
```

The *Settings* page offers setting a trigger mode for each individual digital output and displaying general trigger settings (# indicates the digital output number).




**Trig. mode**

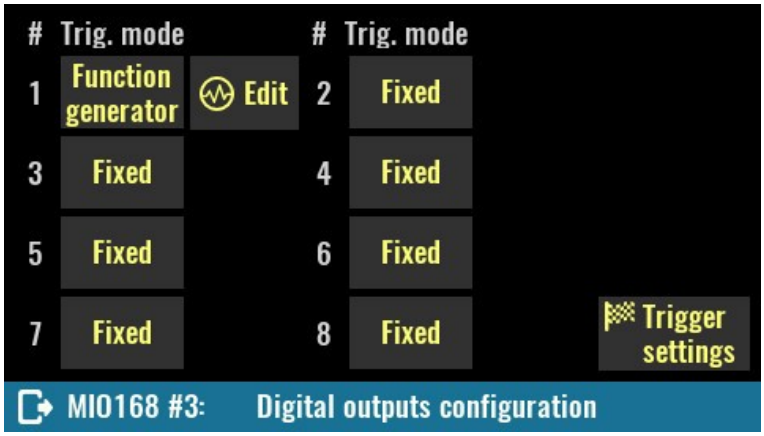
- *Fixed* – the output state will correspond to that set via the display or SCPI command
- *Function generator* – the output state is controlled by the function generator



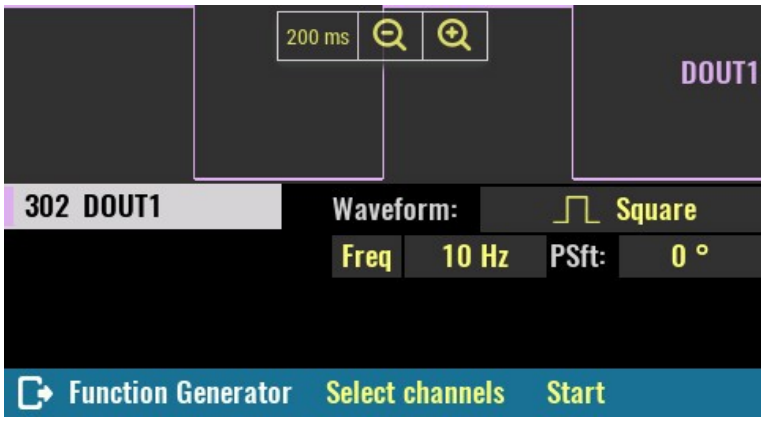

SCPI

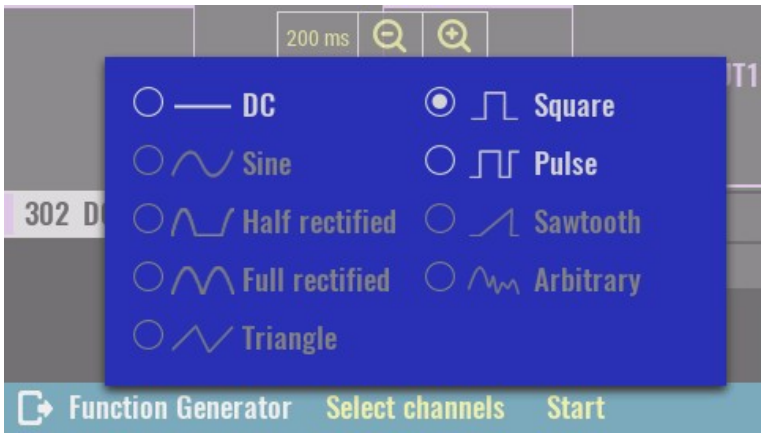
```
SOURce:DIGital:MODE {pin},
{FIXed|FUNCgen}
```

When the *Function generator* is selected, an additional *Edit* button will appear which opens the function generator settings.

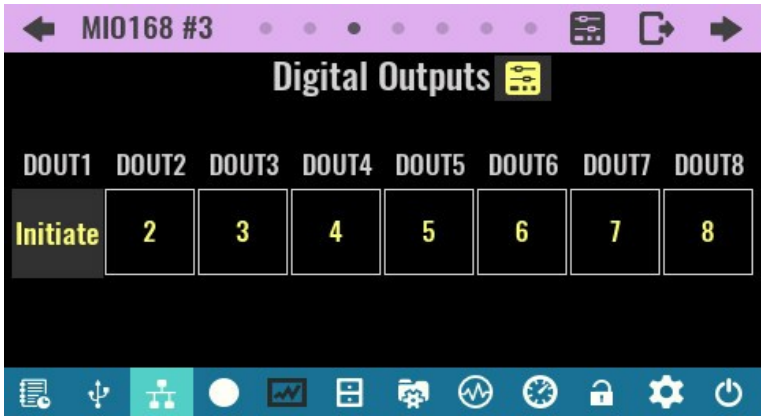


In the function generator settings it will be possible to define *Waveform* (*DC*, *Square* or *Pulse*), frequency (*Freq*) and phase shift (*PSft*).

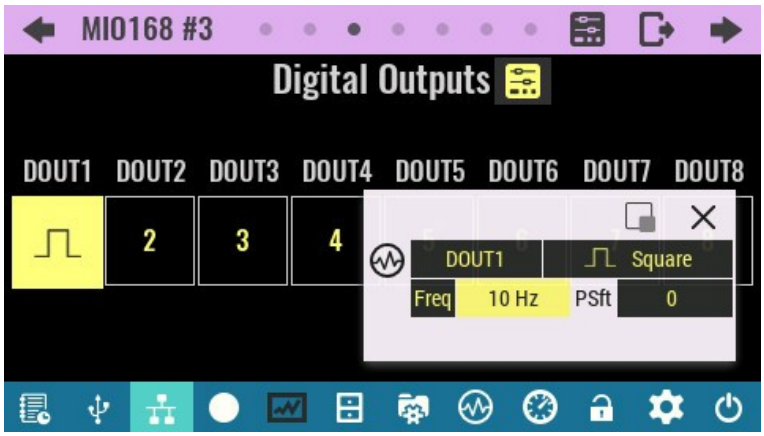



For a digital output that has a *Function generator* defined as trigger mode, the *Initiate* text used to start the function generator will appear.




When the function generator is started, the icon on the digital output will change and the overlay menu will appear.



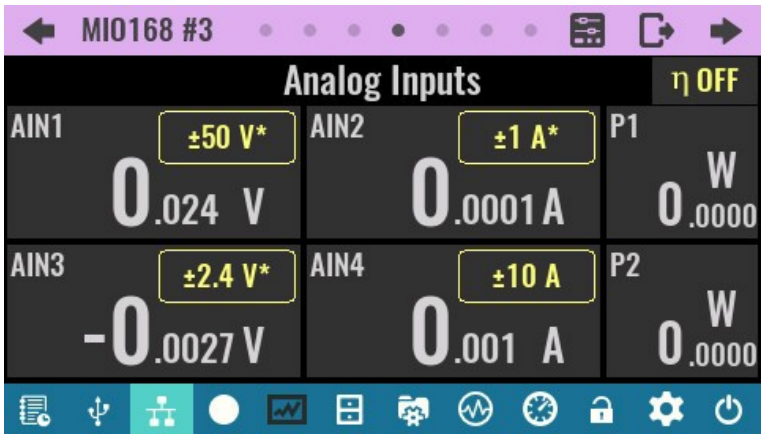

## 19.4. Analog inputs

When measuring values at analog inputs, averaging of multiple samples over the time defined with the NPLC parameter is used that can be set independently for each channel.
NPLC is number of power line cycles (e.g. 50 Hz in Europe, 60 Hz in North America). Voltage and current measurement resolution accuracy is reduced by power line induced AC noise. Using NPLC of 1 or

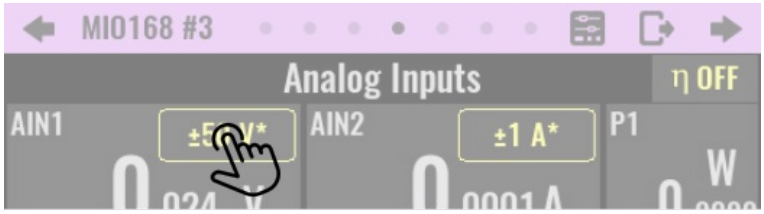
greater increases AC noise integration time, and increases measurement resolution and accuracy, however the trade-off is slower measurement rates.

This page displays the analog inputs detected on the installed AFE board. Since AFE3 has voltage (AIN1, AIN3) and current inputs (AIN2, AIN4), the calculated powers are also displayed as P1 = AIN1 * AIN2 and P2 = AIN3 * AIN4.

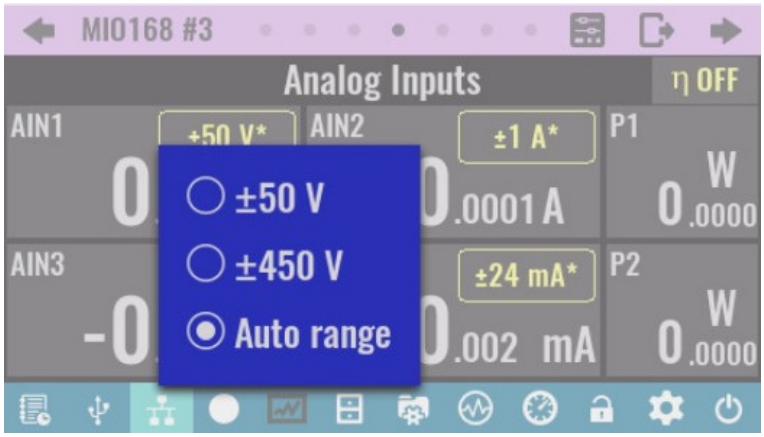
*Pay special attention when measuring power at the AIN3 and AIN4 inputs that share a common GND. The wiring diagram is shown in the description of the AFE3 expansion board.*




All channels that have multiple ranges have a selection button. If *Auto range* (software controlled) is selected, the currently selected range will be displayed and marked with an asterisk.




For additional analog input settings, see the *Settings* section below.

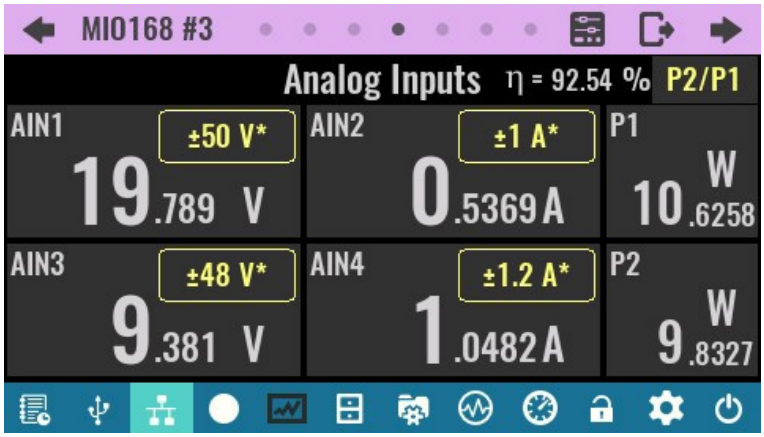



SCPI

```
SENSe:CURRent[:DC]:RANGe
{range}, channel
SENSe:VOLTage[:DC]:RANGe
{range}, channel
MEASure[:SCALar][:CURRent]
[:DC]?
MEASure[:SCALar][:VOLTage]
[:DC]?
```

Simultaneous measurement of voltage and current at four analog inputs gives the measurement of two powers (e.g. D.U.T. input and output power) which also allows the calculation of efficiency (η or eta) as a ratio of two powers.

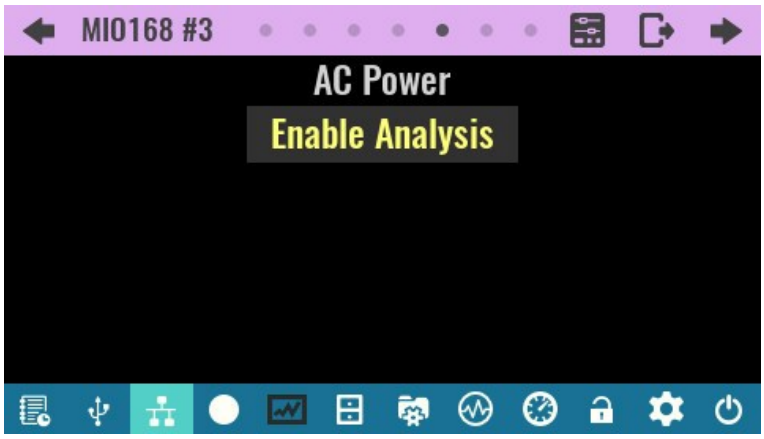
The button in the upper right corner allows toggling between *OFF* (efficiency is not calculated), *P1 / P2* and *P2 / P1*.



## 19.5. AC power analysis

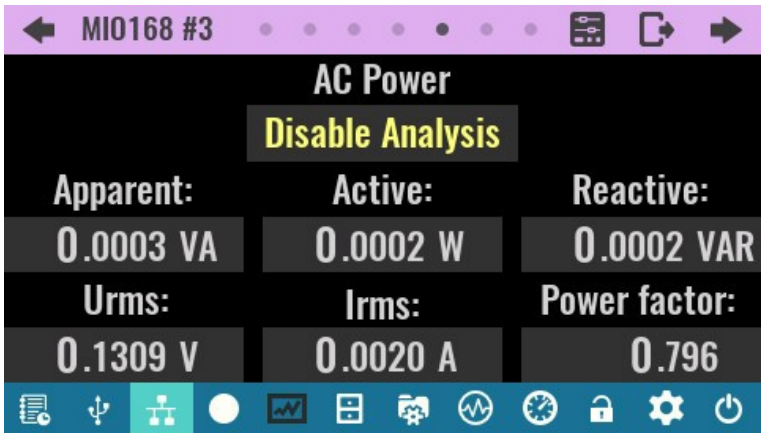
AC power analysis allows the calculation of several useful dynamic values related to the measured voltage and current on the first two analog channels of the AFE3 expansion board (i.e. AIN1 for voltage and AIN2 for current).

*When AC power analysis is enabled, the NPLC value is not taken into account (no averaging is done) and sampling is performed with max. speed (32 KSPS).*




The following values can be measured in real time when AC power analysis is enabled:

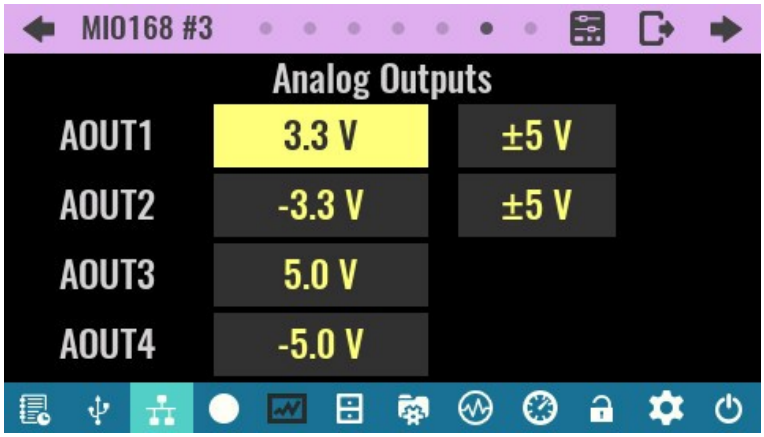
- *Apparent* power – product of the RMS values of voltage and current
- *Active* (real or true) power
- *Reactive* power
- *Urms* – voltage RMS value
- *Irms* – current RMS value
- *Power factor* – the ratio of the active power absorbed by the load to the apparent power flowing in the load




## 19.6. Analog outputs

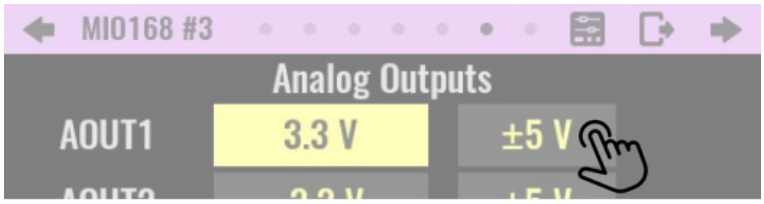
The analog outputs consist of two sections:

- two bipolar multi-range voltage / current outputs (AOUT1, AOUT2)
- two bipolar voltage outputs (AOUT3, AOUT4)



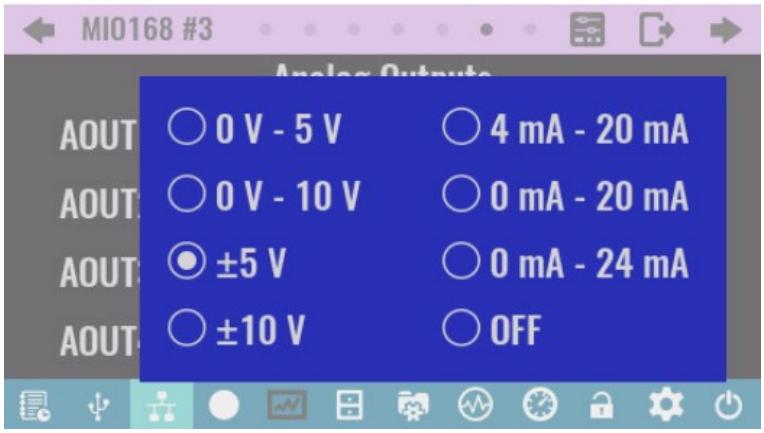
The first two outputs have an additional range selection button.

For additional analog output settings, see the *Settings* section below.




SCPI

```
SOURce:CURRent[:DC]:RANGe
{range}
SOURce:VOLTage[:DC]:RANGe
{range}
```

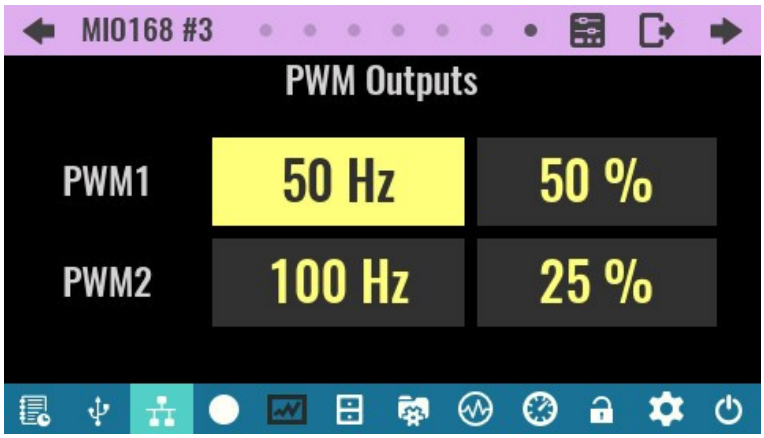



## 19.7. PWM generation

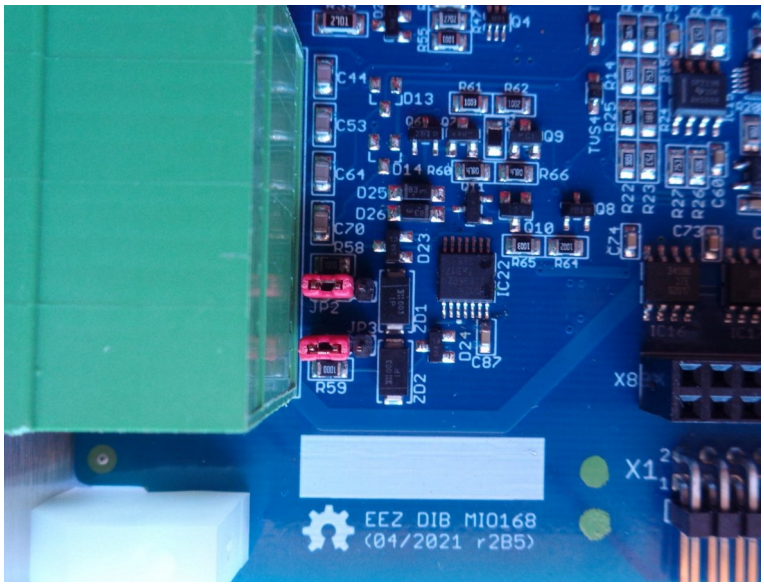
Two PWM outputs allow the generation of a rectangular signal with a defined duty cycle.

SCPI

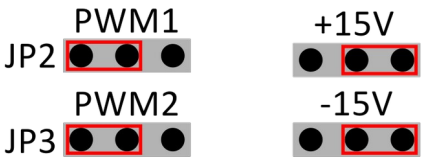
```
SOURce:PWM:DUTY {duty}
SOURce:PWM:FREQuency
{frequency}
```




*The PWM outputs are functional only if JP2 (for PWM1) and JP3 (for PWM2) are set as in the figure to the right (AFE expansion board removed) which is the factory setting.*

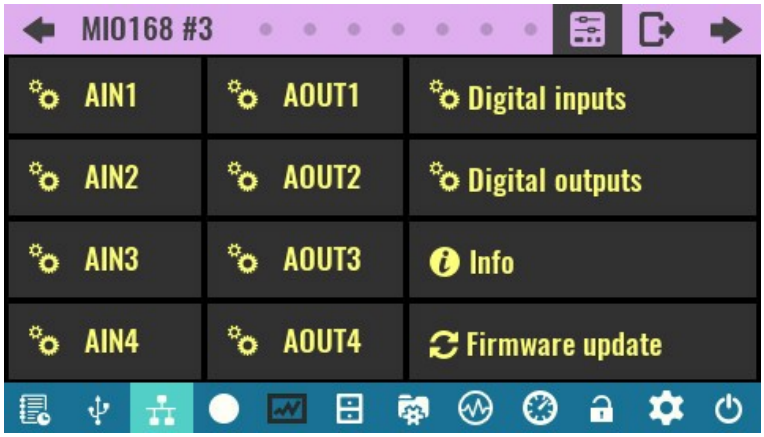


*If the PWM1 and PWM2 outputs are to be used as a bias power supply (+15 V at PWM1, -15 V at PWM2, max. 10 mA each) for external sensors it will be necessary to change the position of the jumpers.*




## 19.8. Settings

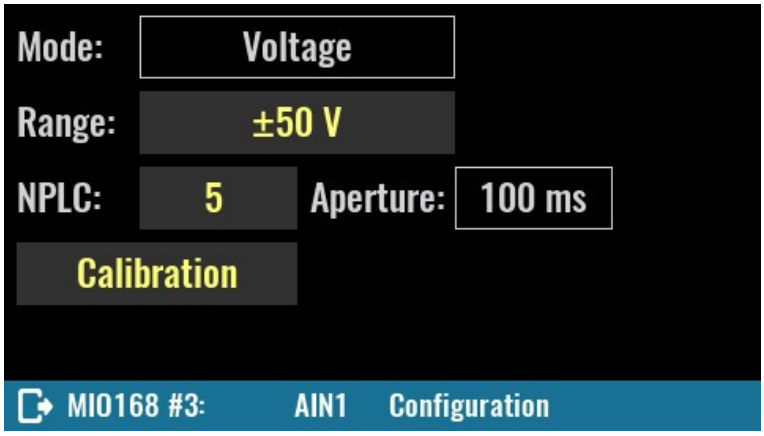
The Settings page allows access to the settings of all types of MIO168 module resources from one place.
It is the only way to access all the analog input and output settings listed below.




### 19.8.1. AIN settings

**Mode:**
Output mode selection (voltage or current). In the case of an AFE3 expansion board that does not offer two modes, the installed mode is displayed.

**Range:**
Channel range selection.




**NPLC:**
NPLC value for DC measurements. It can be from 0 to 25.

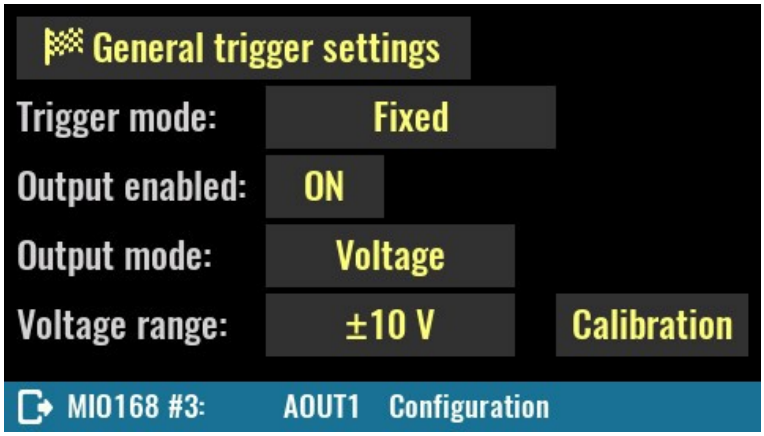
SCPI
```
SENSe:NPLCycles {cycles}
```

**Aperture:**
The shown aperture value is coupled to NPLCycles by the equation: APERture = NPLCycles / selected AC line frequency. For example, for NPLC of 5 and 50 Hz the integration time is 100 ms and for the same NPLC and 60 Hz the integration time is 83.3 ms. See also *Date & time* section.

SCPI
```
SENSe:APERture {period}
```

**Calibration**
Starts the calibration procedure for the selected voltage or current range. If the *Auto range* is selected, this button will not be displayed.

### 19.8.2. AOUT settings




Analog output settings in addition to shortcuts to *General trigger settings* and *Calibration*, also offers setting the following parameters:

**Trigger mode:**

- *Fixed* – the output state will correspond to that set via the display or SCPI command
- *Function generator* – the output state is controlled by the function generator

SCPI

```
CURRent:MODE {FIXed|FUNCgen}
VOLTage:MODE {FIXed|FUNCgen}
```

**Output enabled:**
Defines the state of the analog output (AOUT1 and AOUT2 only).

SCPI

```
OUTPut[:STATe] {ON|OFF}
```

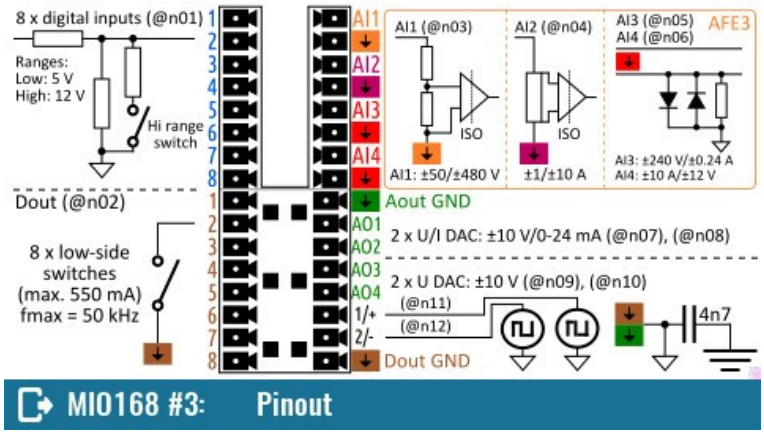
**Output mode:**
Defines the analog output mode (AOUT1 and AOUT2 only).

**Voltage/current range:**
Voltage range selection. Current range selection only applies to AOUT1 and AOUT2.

SCPI

```
SOURce:CURRent[:DC]:RANGe {range}
SOURce:VOLTage[:DC]:RANGe {range}
```


Module information page. The module parameters are displayed as in the case of other module types (see *Info* section). Specific to the MIO168 module is to display the *AFE version*. (3 stands for installed AFE3 expansion board).



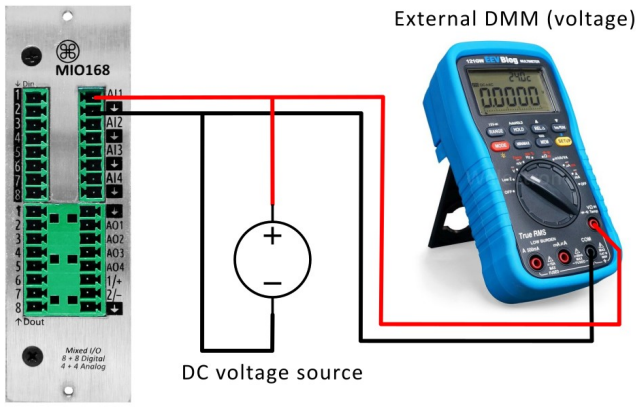

The *Pinout* image may vary depending on the AFE installed (pinout with AFE3 installed is shown).

## 19.9. Calibration

Calibration is required for analog outputs (on the MIO168 module) and analog inputs (on the AFE expansion board). The procedure is similar to the power module calibration described in *Power modules calibration*. Please note that the initial calibration password is **eezbb3**.

### 19.9.1. Analog input (AIN) voltage calibration

To calibrate the analog input, it will be necessary to connect an external DC voltage source to the input terminals of the AIN channel. An external voltmeter should be connected in parallel. Successful calibration will require two-point measurements. Since AIN channels accept bipolar signal, it is recommended that one measurement be with positive voltage and the other measurement with negative voltage. For a negative voltage it will be necessary to reverse the polarity of the connected external DC voltage source.

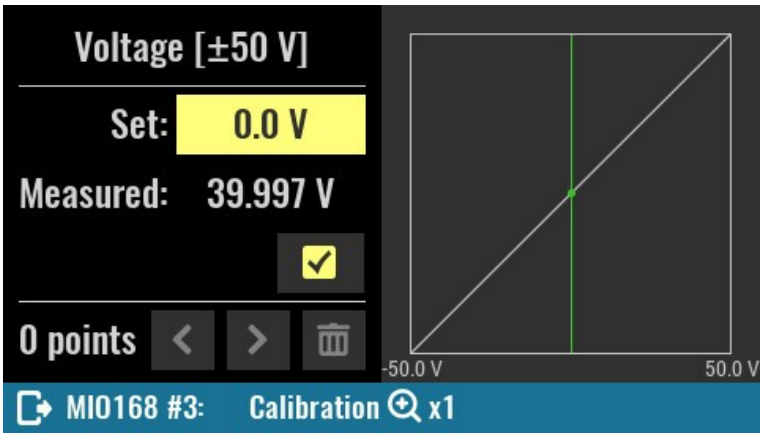



Calibration will need to be done for each range of each channel. In the case of AFE3 which has two ranges for AIN1 and AIN2, and three ranges for AIN3 and AIN4 it will be necessary to repeat the procedure 10 times.
The procedure for calibrating the first range (±50 V) of the AIN1 channel is described below as if it were being calibrated for the first time, i.e. as if there were no previous calibration points.

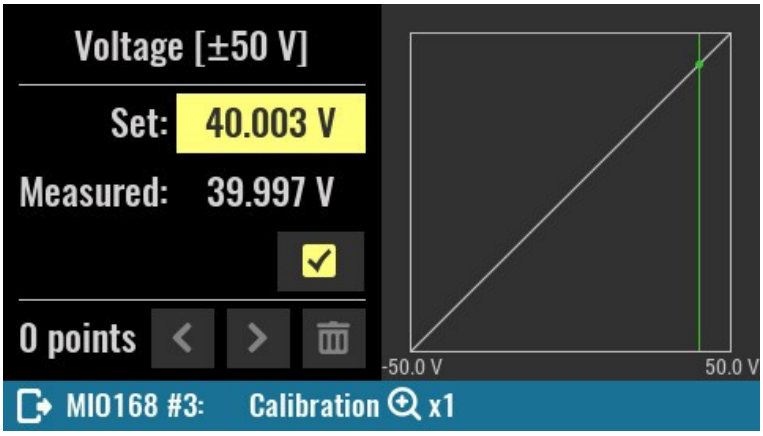
*If recalibration is performed, the simplest way is to delete the existing calibration points and follow the described procedure.*

1 After successfully entering the calibration password, a calibration page will appear showing the selected range to be calibrated.

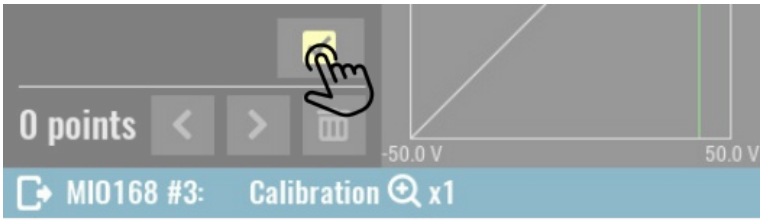
The number of calibration points is 0.




2 In the *Set* field, enter the voltage measured by the external DMM (40.003), and the read only *Measured* field displays the value measured by the AFE (39.997).

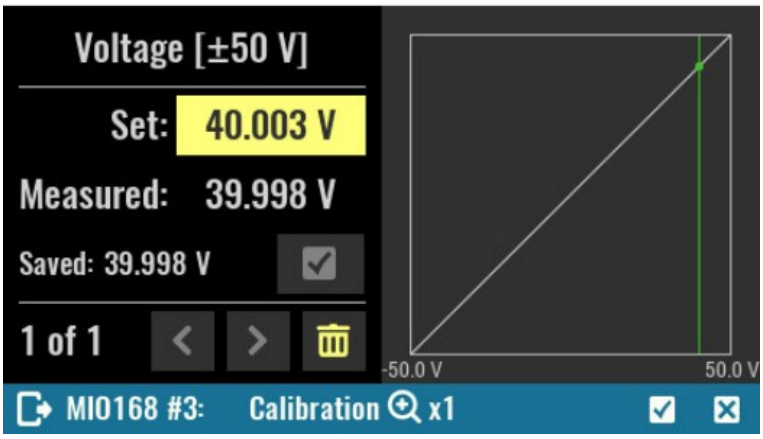


**3** Once the *Set* value for the first point is entered and we are satisfied with the value measured by the AFE, we can save the first point. As a confirmation, the *Save* button will be disabled and the text *Saved:* will appear.

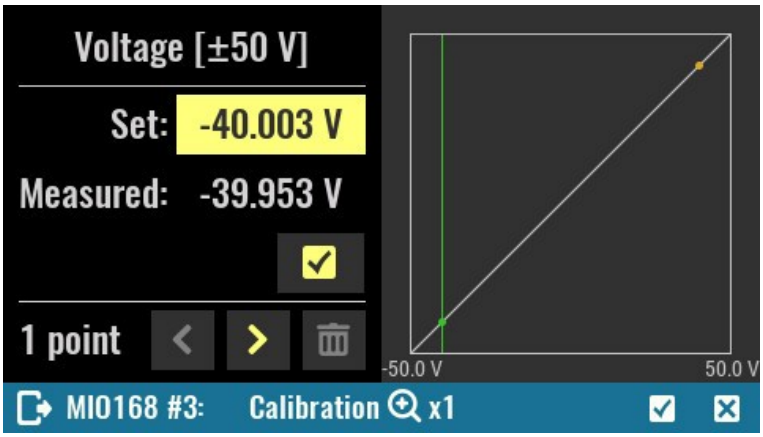



The number of calibration points changed from 0 to 1.

If we are not satisfied with the selected calibration point or its measured value, it can use the *Delete* button.

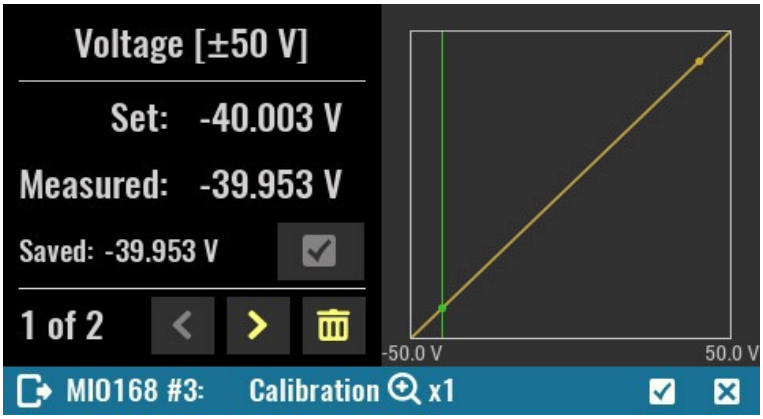



**4** We can now enter the second calibration point. If we simply reverse the polarity of the DC voltage source, and the external DMM has a negligible so-called turnover error then it is to be expected that the same voltage will be measured as in the previous case only with a different sign (-40.003 in our example).



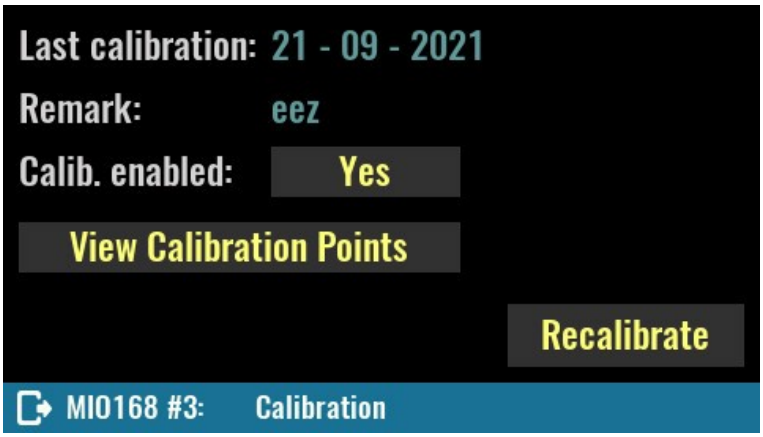

**5** Use the *Save* button again to save the second calibration point.

The number of calibration points changed from 1 to 2.



6 Once we have successfully added two calibration points, it is possible to complete the calibration and enter a remark (eez in our example).

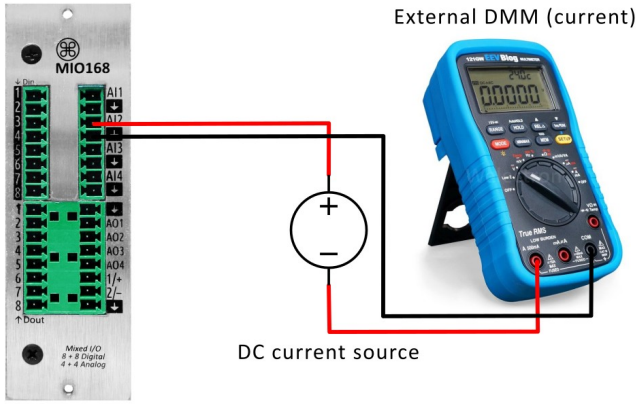

7 Upon completion of the calibration, a page will appear displaying the date and remark of the last calibration.
Here is also possible to disable usage of calibration parameters, display saved calibration points and start recalibration.




### 19.9.2. Analog input (AIN) current calibration

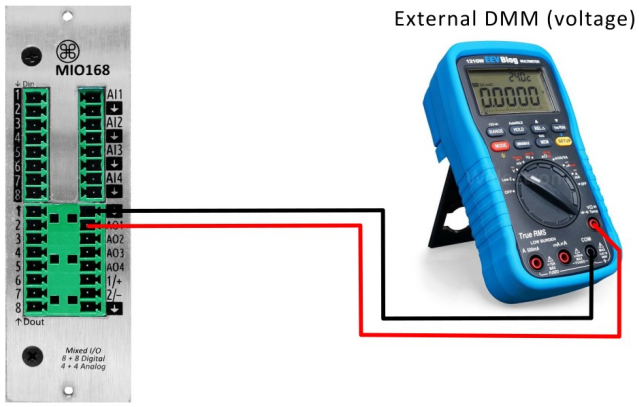
To calibrate the analog current inputs (AIN2 and AIN4 on AFE3) it will be necessary to connect an external DC current source in series with the external ammeter.

The calibration is identical to the procedure described above (steps 1 to 7).

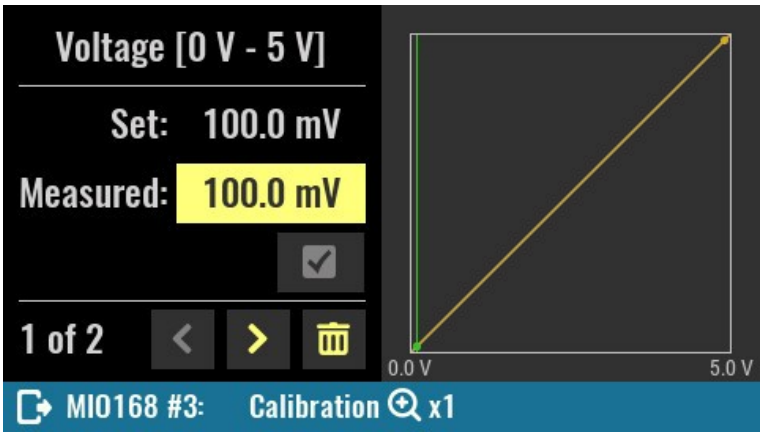


### 19.9.3. Analog output (AOUT) voltage calibration

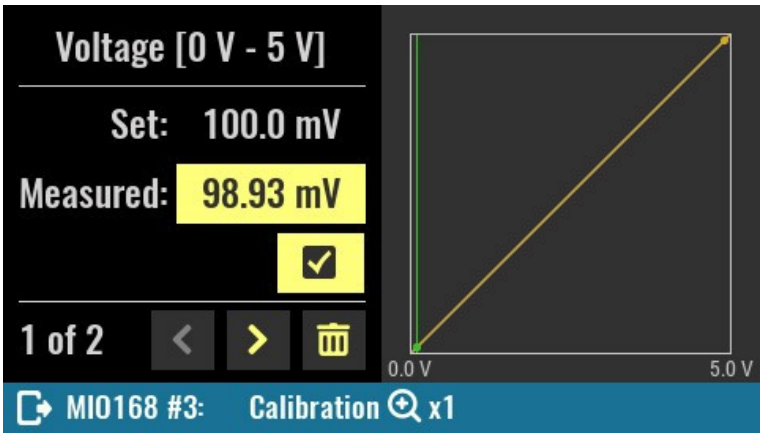
Voltage calibration of analog outputs will not require an external DC voltage source but only a directly connected external voltmeter.



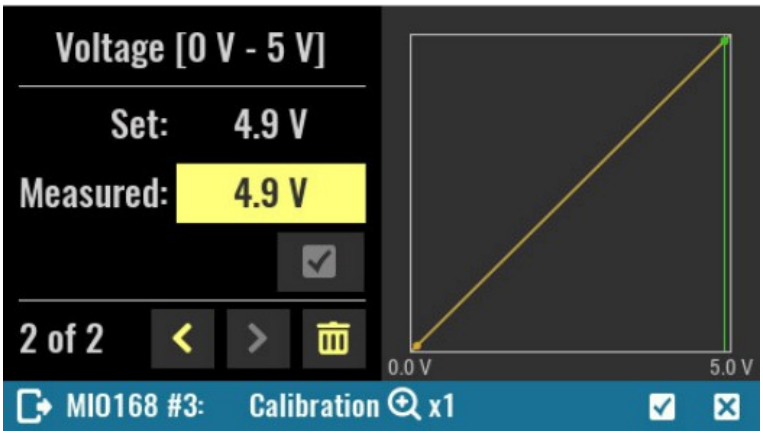

1 The calibration of the analog output voltage is similar to the calibration of the analog input with the difference that the calibration points are immediately set to 100 mV For the 0-5 V range calibration example, it will be 0.1 V and 4.9 V.



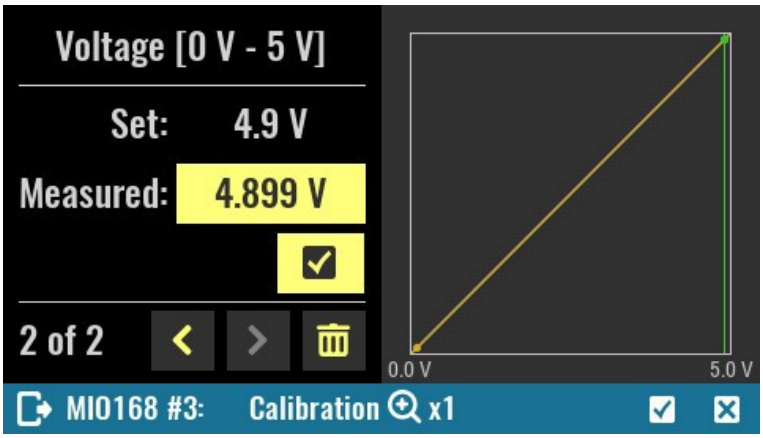

2 After entering the value measured by the external voltmeter (98.93 mV) we can save the calibration point using the *Save* button.



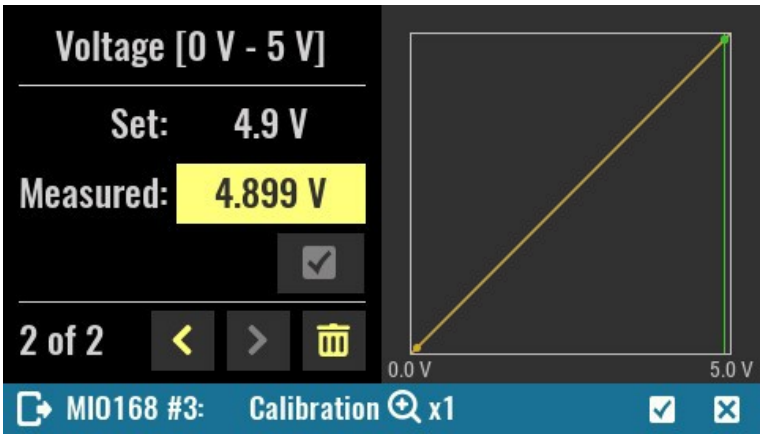
**3** To move to the second calibration point you will need to click on the right arrow button.


**4** Enter the measured value with the external voltmeter (4.899).



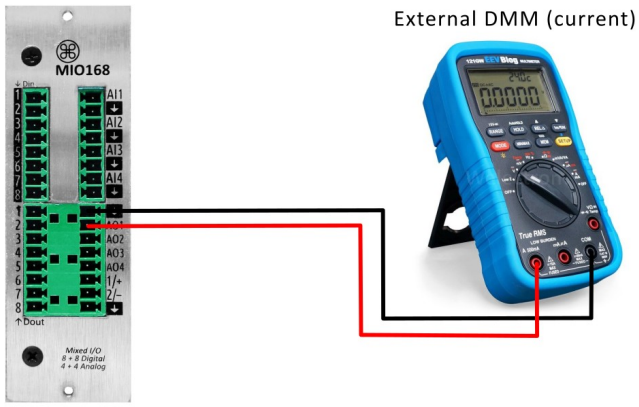

**5** Once the second calibration point has been saved, it is possible to complete the calibration by selecting the confirmation button.



### 19.9.4. Analog output (AOUT) current calibration

Current calibration of analog outputs (AOUT1 and AOUT2 only) will not require an external DC current source but only a directly connected external ammeter.

The calibration is identical to the procedure described above (steps 1 to 5).



# DECLARATION OF CONFORMITY

*(IZJAVA O SUKLADNOSTI)*

**We,** *(Mi)*

**ENVOX d.o.o.**
**Zagreb, Croatia**

**declare under our sole responsibility that the product**
*(izjavljujemo pod punom odgovornošću da je proizvod)*

| | |
|---|---|
| **Type, Model:**<br>*(Tip, Model):* | **EEZ BB3 STM32F7** |
| **Brand Name:**<br>*(Komercijalni naziv):* | **EEZ Bench Box 3** |
| **Product:**<br>*(Proizvod):* | **Modular test and measurement chassis**<br>*Modularna šasija za testne i mjerne module* |
| **Product Options:**<br>*(Varijante proizvoda):* | This declaration covers all options of the above product(s) with DCP405 and DCM224 power modules<br>*(Ova deklaracija uključuje sve varijante gore navedenog proizvoda s DCP450 i DCM224 perifernim modulima.)* |

**is in conformity with the essential requirements of Directives and regulations**

*(sukladan bitnim zahtjevima Direktiva i propisa):*

**Electromagnetic compatibility Directive ( 2014/30/EU ), LVD Directive (2014/35/EU), ROHS Directive (2011/65/EU), Ecodesign Directive (2009/125/EC), Regulation (EC) 278/2009**

*Pravilnik o elektromagnetskoj kompatibilnosti (NN br.28/2016), Pravilnik o električnoj opremi namijenjenoj za uporabu unutar određenih naponskih granica (NN br.43/2016), Pravilnik o ograničavanju uporabe određenih opasnih tvari u električnoj i elektroničkoj opremi (NN br.131/2013, 16/2014, 90/2014, 142/14), Pravilnik o utvrđivanju zahtjeva za ekološki dizajn proizvoda povezanih s energijom (NN br. 80/2013), Uredba (EK) 278/2009*

**by applying the following standards** *(primjenom slijedećih normi)*:

- **EN 61326-1:2013** (HRN EN 61326-1:2013) Emission limits-class A according to CISPR11, Immunity values according to table 2 except BURST test that comply with Criteria C
- **EN IEC 61000-3-2:2019** (EN IEC 61000-3-2:2019)
- **EN 61000-3-3:2013+A1:2019** (HRN EN 61000-3-3:2013)
- **EN 61010-1:2010** (HRN EN 61010-1:2010)
- **EN 62311:2008**

Supplementary Information:
This product is intended for use in a basic electromagnetic environment.
This is a sensitive measurement apparatus by design and may have some performance loss when exposed to ambient continuous electromagnetic phenomenon.

**The CE marking is affixed from the year** *(CE oznaka stavljena na proizvod)*: **2021**

| | | |
|---|---|---|
| **Zagreb, Croatia**<br>23.03.2021. | envox d.o.o. za proizvodnju i usluge Fallerovo šetalište 22a/I, Zagreb | Denis Kotlar |

envox

## RoHS Compliance Statement

Envox d.o.o. certifies that products supplied are in compliance with, and conform to the European Union's Restriction of Use of Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive 2002/95/EC and 2011/65/EU (RoHS2). Said products have no intentional addition of:

- Lead (Pb)
- Cadmium (Cd)
- Mercury (Hg)
- Hexavalent Chromium (Cr)
- Polybrominated Biphenyls (PBB)
- Polybrominated Diphenyl Ethers (PBDE)

Any trace impurities of these substances are below the threshold limits as specified by the RoHS directive; specifically Cr+6, Hg, Pb, PBB, PBDE do not exceed 1000 ppm (0.1%) and Cd does not exceed 100 ppm (0.01%).

This declaration is based upon the information provided by the material suppliers and assembly manufacturers used by Envox to manufacture these products. As such, Envox makes no independent representations or warranties, expressed or implied, and assumes no liability in connection with the use of this information.

This certification is valid unless superseded by a revised certification at a later date.

March, 22 2021

For more info visit: www.envox.eu
File repository: https://github.com/eez-open

Version: 1.09
Date: 2022-11-29