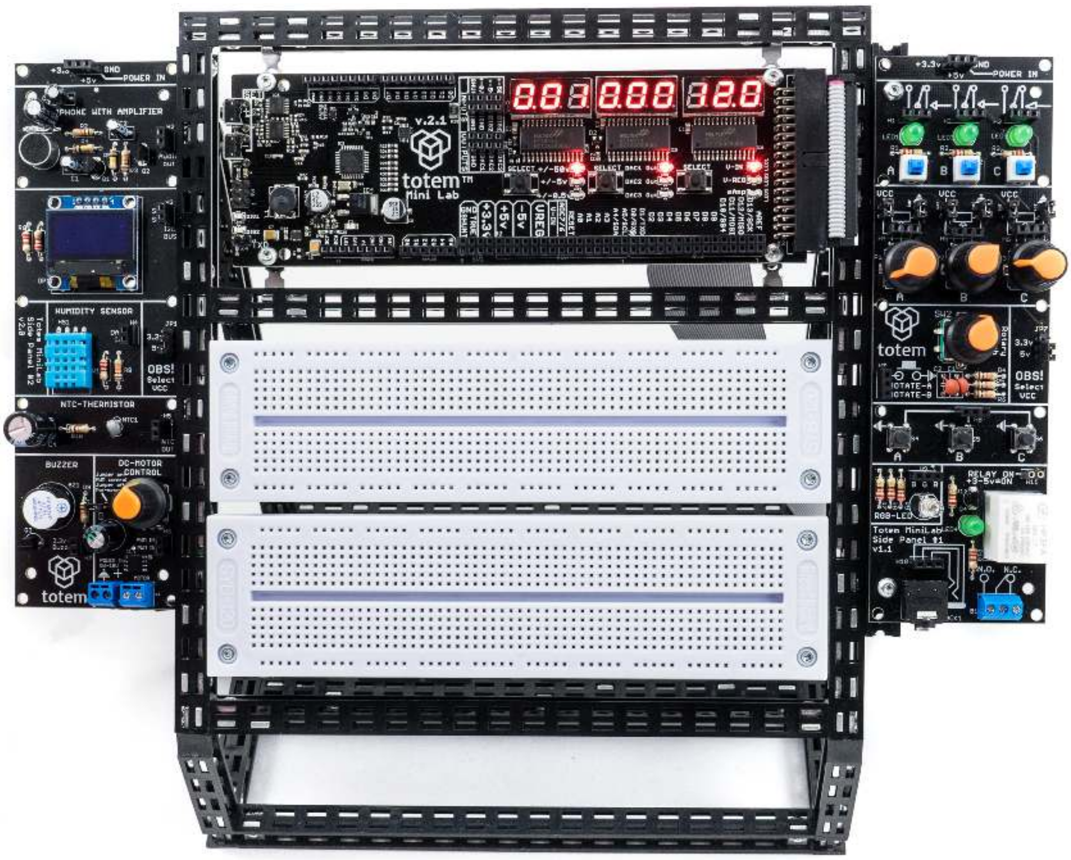
totem

# MiniLab User Guide



Totem by UAB Aldrea

*ver 1.1*

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# Introduction

We at Totem congratulate you on getting your first electronics laboratory! Totem MiniLab contains all the necessities for starting your path in the world of electronics and programming. This document will guide you through all the steps in getting to know your MiniLab, setting it up and learning about all of its capabilities.

Using MiniLab should be simple and fun! While building it, we tried to address and improve all the negative parts about prototyping — no longer you'll have to deal with messy wiring, fragile connections and headaches of where to mount every separate part of your experiment.

MiniLab is meant to be used together with Totem construction system which allows users to build solid workbenches with integrated breadboards, as well as available expansion boards which can expand the capabilities of the MiniLab even further.

## Who is it for

Our main goal with MiniLab is to make a platform which would give an easy and approachable way for students and young makers communities to build up on, using it as a stepping stone into the world of electronics and programming.

While not intended to be used in place of a professional level equipment, MiniLab has its own advantages — small size, speed of setup and versatility could find its place in any makers shop.

## What's in the box

In the MiniLab kit you'll find:

- **TotemDuino** - our improved version of Arduino UNO platform,
- **LabBoard** - a capable experimentation and measuring platform,
- **34-pin flat cable** — use it to connect TotemDuino and LabBoard together,
- **Collection of Totem construction parts** — for building Totem workbench.
- **Voltage adapter** — to power MiniLab from the mains,
- **Breadboards** — to extend your experimentation area,
- **Breadboard cables** — short male to male cables useful for experimentation,
- **Building instructions** — suggested use of Totem parts for building a workbench where everything neatly mounts together.

# Overview

MiniLab at its core consists of two main parts - LabBoard and TotemDuino. In this chapter, their main attributes are presented together with a quick feature list. While the best functionality is achieved when using them together connected via supplied flat cable, they can fully function on their own, keeping in mind that some functionality such as TotemDuino connections will not be available without main TotemDuino board.

## LabBoard

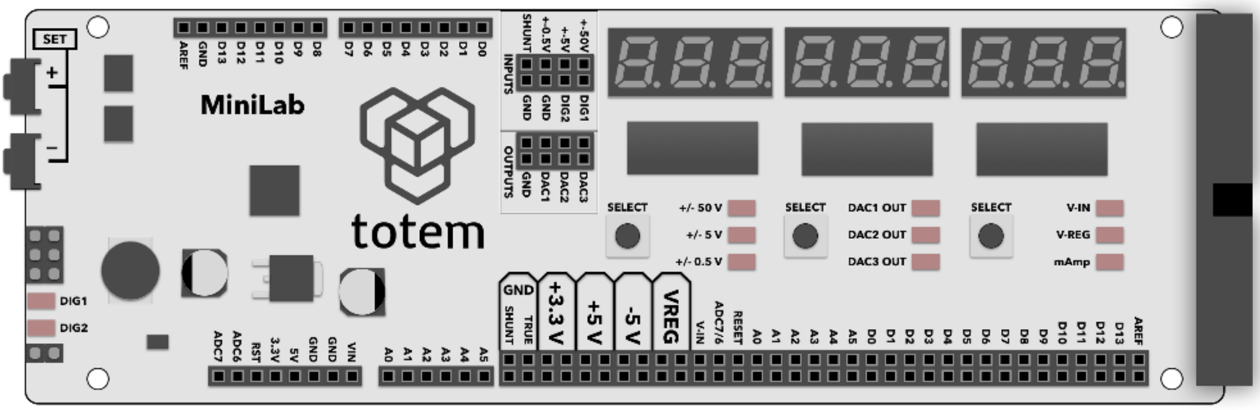


Fig. 1 MiniLab board overview

This board has a dual use — firstly it can be used as an expansion board to the TotemDuino system, offering easily accessible input and output connections, and secondly — it is a measuring and testing unit, containing such modules as:

- **Digital to Analog converter** — a 3 channel, 12 bit converter, capable of outputting a pre-set voltage in the 0-2.5V range.
- **Voltage measure** — three inputs in the +-0.5 V, +-5V and +-50V range.
- **Current measure** — sensing current up to 800 mA.
- **Frequency meter** — digital signal frequency measurement module, capable of signals up to 1 MHz.
- **Pulse counter** — digital signal pulse counter, counting up to 999999999 pulses in a signal.
- **Pulse generator** — unit capable of generating finite or infinite series of pulses, with programmable pulse width and period.

# TotemDuino

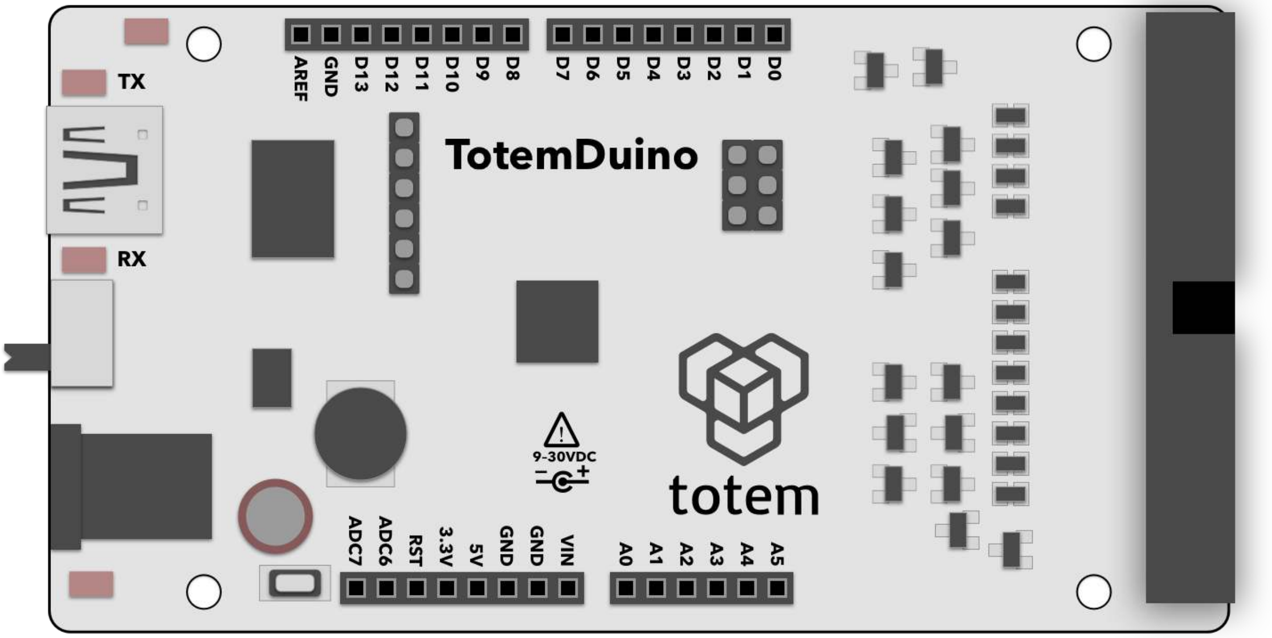


Fig. 2 TotemDuino board

TotemDuino expands upon the great Arduino UNO platform idea. While it is kept fully backwards compatible with Arduino, a lot of additional features are included as well, such as:

- **Output protection** — nothing limits creativity as the fear of making a mistake and breaking something. TotemDuino comes with all of its output pins going into LabBoard protected against over-voltage or short-circuit conditions. No experiment could go wrong this way!
- **Expansion port** — a 34 pin flat-cable connection connects to the LabBoard for easy pin access.
- **Powerful 5 V regulator** — you'll be less likely to run out of power while experimenting with higher power loads such as motors.
- **Selectable microcontroller logic voltage** — as the world progresses from 5 V towards 3.3 V logic voltage, TotemDuino can work with both just by the flip of a switch, without the need for any additional adapters or converters.

# Using MiniLab

In this chapter all of the main features of the MiniLab are explained and a usage example is provided for each of intended use-case. Features discussed here do not affect TotemDuino, and work independently from it, so no matter what code or experiment you're working on at a given time, all of the LabBoard features are still available to use.

If used together with suggested Totem construction system, MiniLab is mounted in the workbench style system, which allows easy access to all of available pins, as well as breadboard work area.

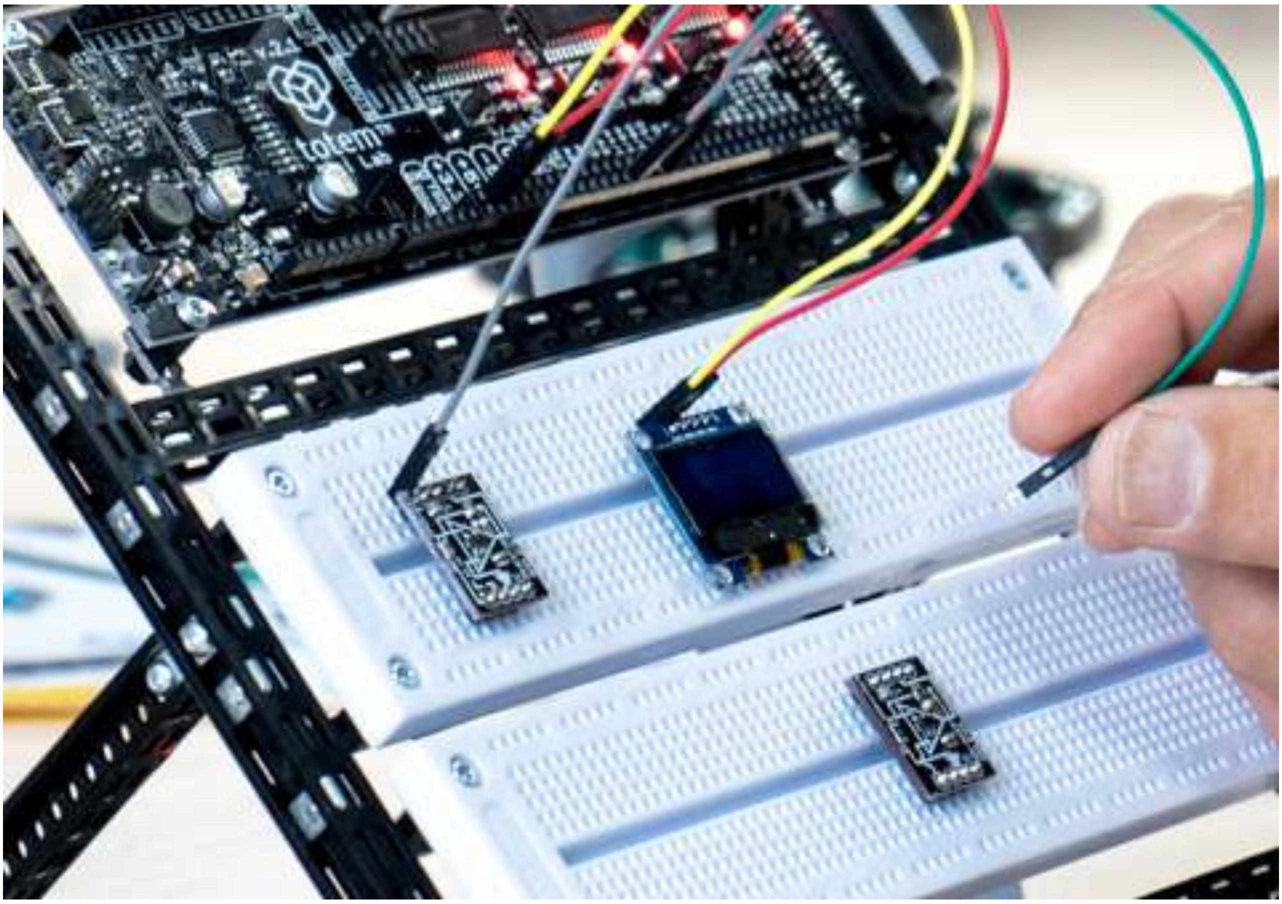

Fig. 3 An ongoing experiment on MiniLab workbench

## Powering up

MiniLab comes with a 12 V, 1.5 Amp external power supply. Internally, supply voltage is then regulated into several voltages needed to run various parts of the system. Each of these can be used during measurements or experiments, as they do have easily accessible pins that equipment can be connected to.

While MiniLab can easily use any of the available voltage for your experiments, digital signals going to and from TotemDuino shouldn't be higher than the currently selected running voltage for it. A selector switch on the TotemDuino board can set the supply voltage for the TotemDuino microcontroller either at 5 or 3.3 volts. This allows you to set the logic level interfacing with various external equipment that could only be used at one of these voltages without any additional voltage level converters. Refer to TotemDuino section for explanation on how to set the voltage.

Voltages that are available to use are:

- 12 V, 1.0 A — direct supply voltage,
- 5 V, 0.5 A — regulated supply voltage, shared with TotemDuino,
- 3.3 V, 0.25 A — regulated supply voltage, shared with TotemDuino and LabBoard processor,
- -5 V, 0.5 A — separate regulated voltage, for experimentation with operation amplifiers,
- 0..3.3 V programmable regulated voltage output, up to 0.35 A.

A power supply schematic is provided for reference:

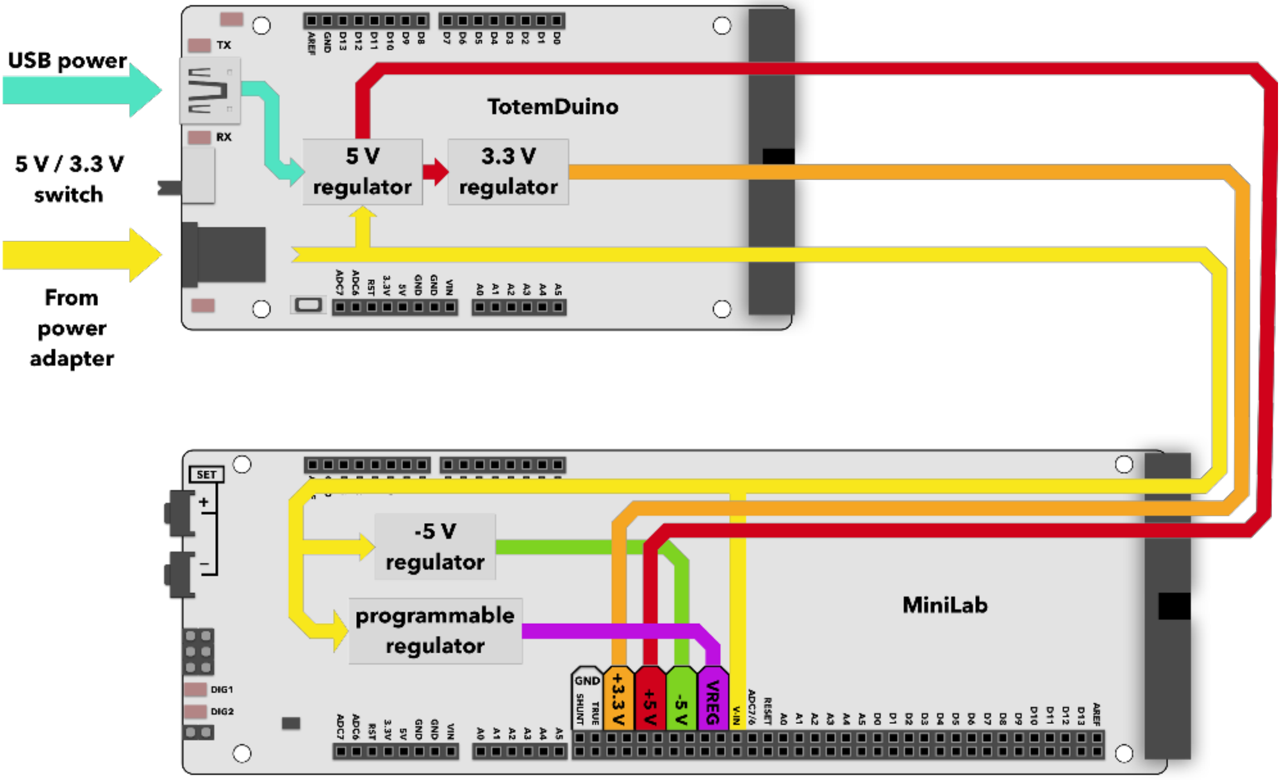


Fig. 4 Power regulators in MiniLab

It is possible to run only from USB power, but in that case modules relying on higher voltage, such as programmable regulator will not be available.

## Measuring voltages

LabBoard has a 3 channel voltage measurement module. Each has a pre-set measurement range:

- ± 0.5 V - best to be used when measuring small scale signals when maximum precision is required.
- ± 5 V - for measuring TTL logic level signals.
- ± 50 V - for external signal measuring.

Left display is used in the LabBoard for showing currently measured voltage. Currently active channel is selected with a button under the display, and the current active channel LED lights up.

Display shows value in millivolts when using ± 0.5 V channel, otherwise the output is in Volts. Blinking display indicates that currently measured voltage is negative.

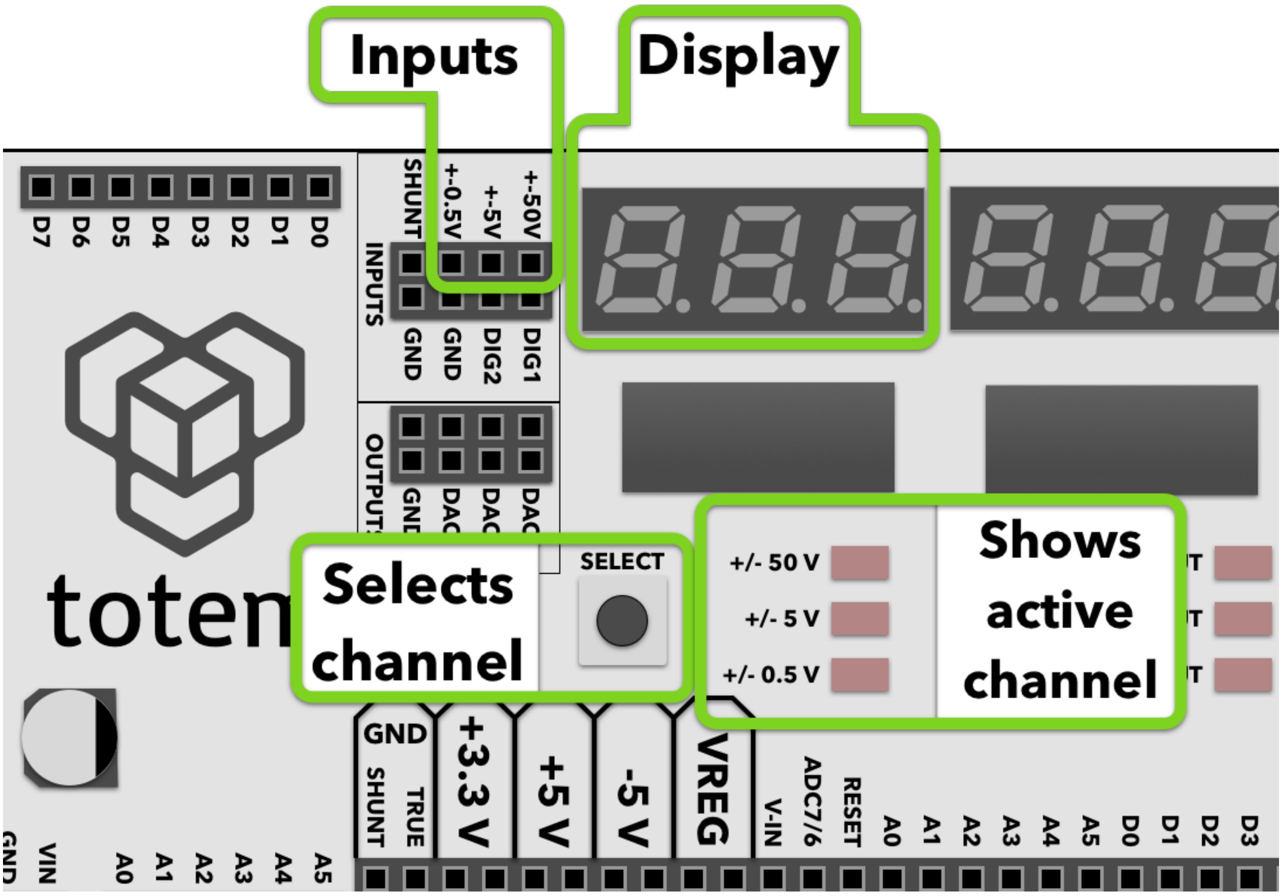


Fig. 5 Voltage measuring module

**Example**

1. Connect the ± 5 V input with a 3.3 Volt output.

2. Press the channel selector button until the ± 5 V input LED lights up.
3. Observe the display — it should indicate a value close to 3.3 Volts:

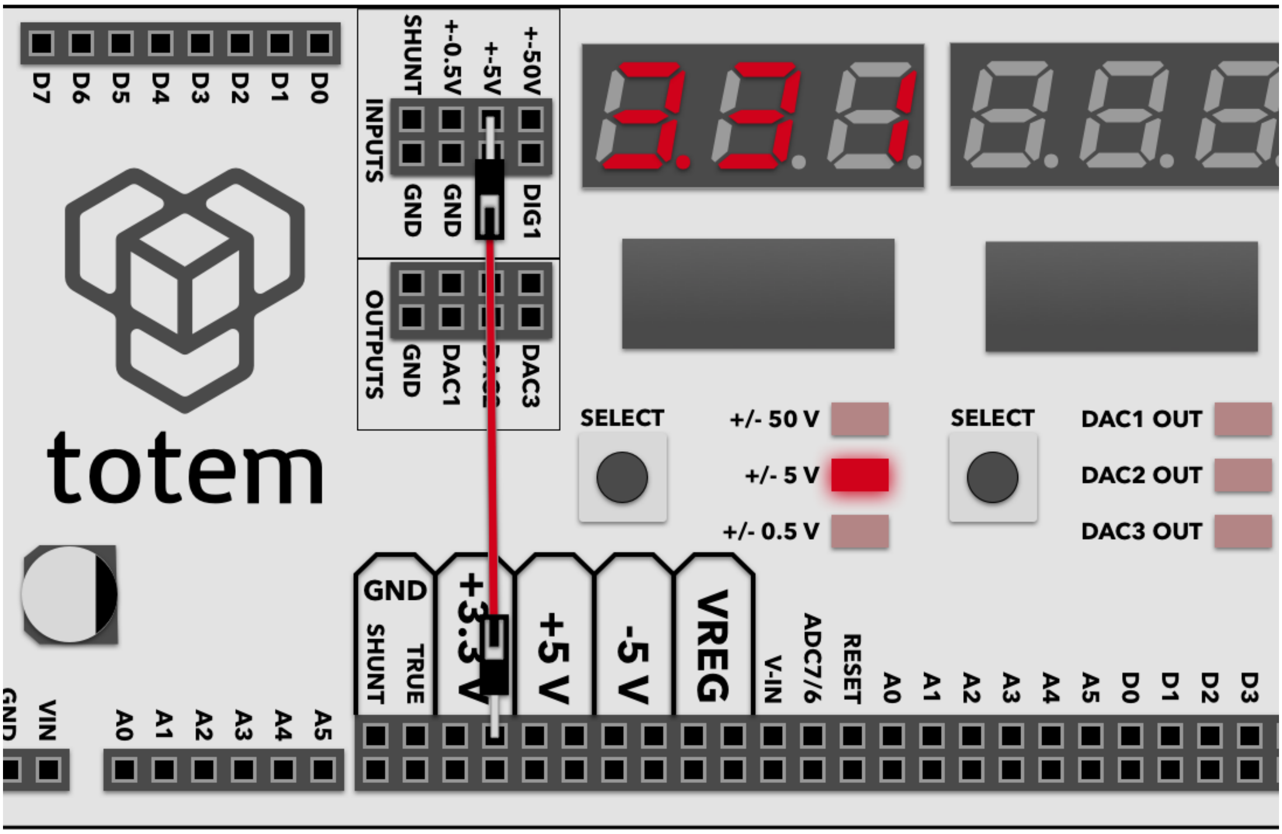


Fig. 6 Measuring one of the supply voltages

## Setting output voltage

Using inbuilt 3 channel Digital to Analog Converter (DAC) allows you to output any voltage in the 0..3V range, at up to 15 mA current. This is useful for experimenting with comparators or operational amplifiers, as they need various reference or input voltages.

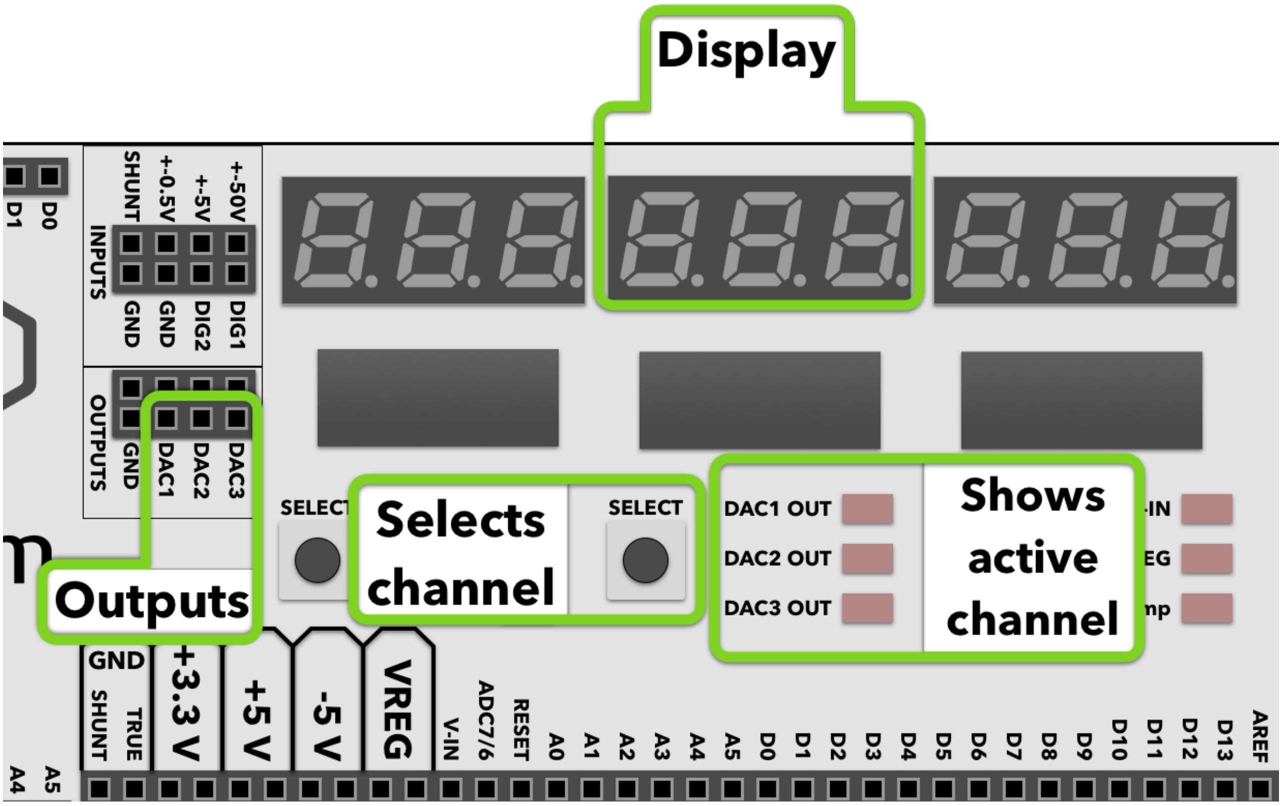


Fig. 7 Programmable output voltage

Middle display is used for showing the current output voltage for the active channel, which itself is indicated by the middle column of LED's. Pressing middle SELECT button allows you to change the active channels. To edit currently preset voltage, SELECT button must be held until LED starts blinking. Then SET+ and SET- buttons can be pressed to adjust currently selected channels voltage. All other inactive channels still keep the same preset voltage until it's changed by SET buttons on the side of the board.

**Example**

1. Connect the **DAC1** output to the ± 5 V voltage measuring channel input.
2. Using middle select button switch the current output channel until **DAC1 Out** LED lights up.
3. Using left select button switch the measure channel to ± 5 volts.
4. Hold **SELECT** button until **DAC1 Out** LED starts to blink.
5. Using **Set+** and **Set-** button change the output value of the DAC1 channel.
6. Observe that voltage measure display follows the same value as the DAC output one.

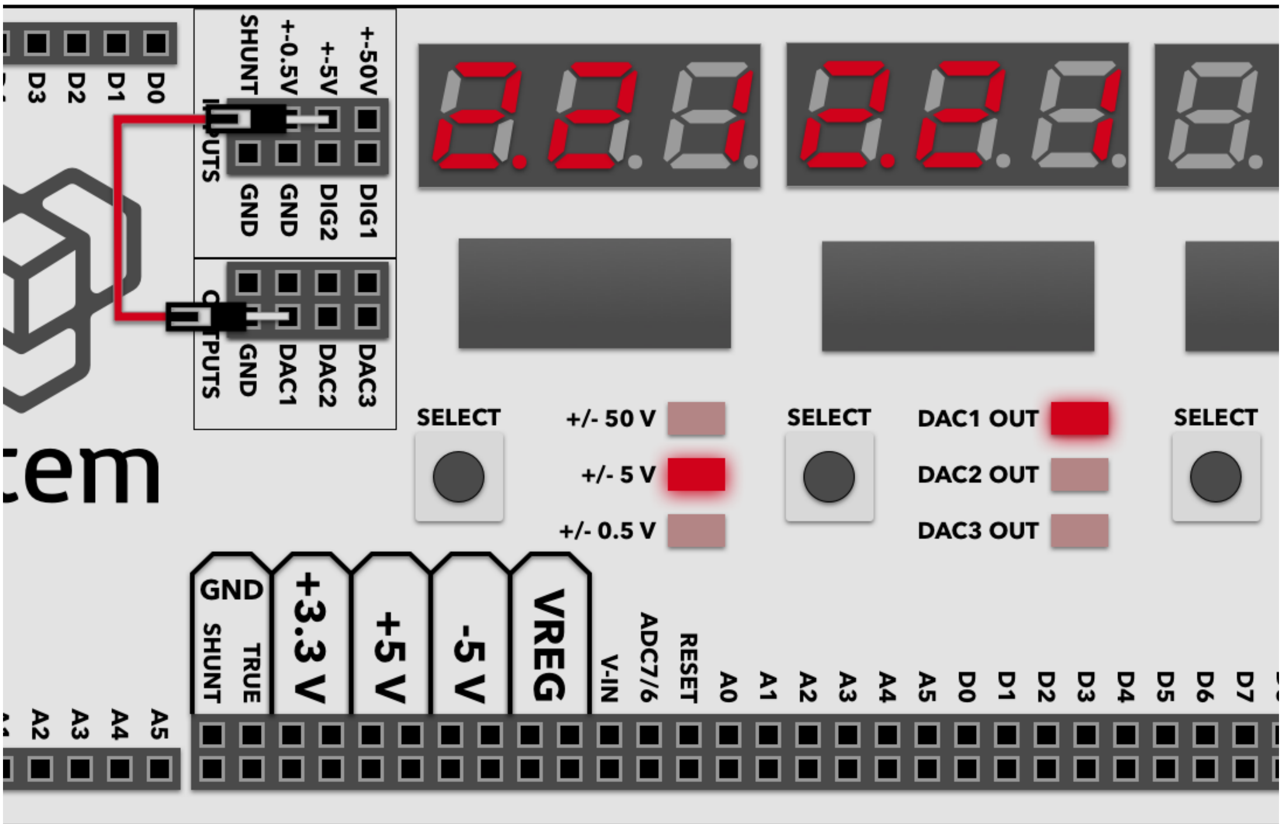


Fig. 8 Example usage of output voltage module

## Digital inputs

MiniLab has a two channel digital input module, meant to indicate the current logic state of the signal with an LED.

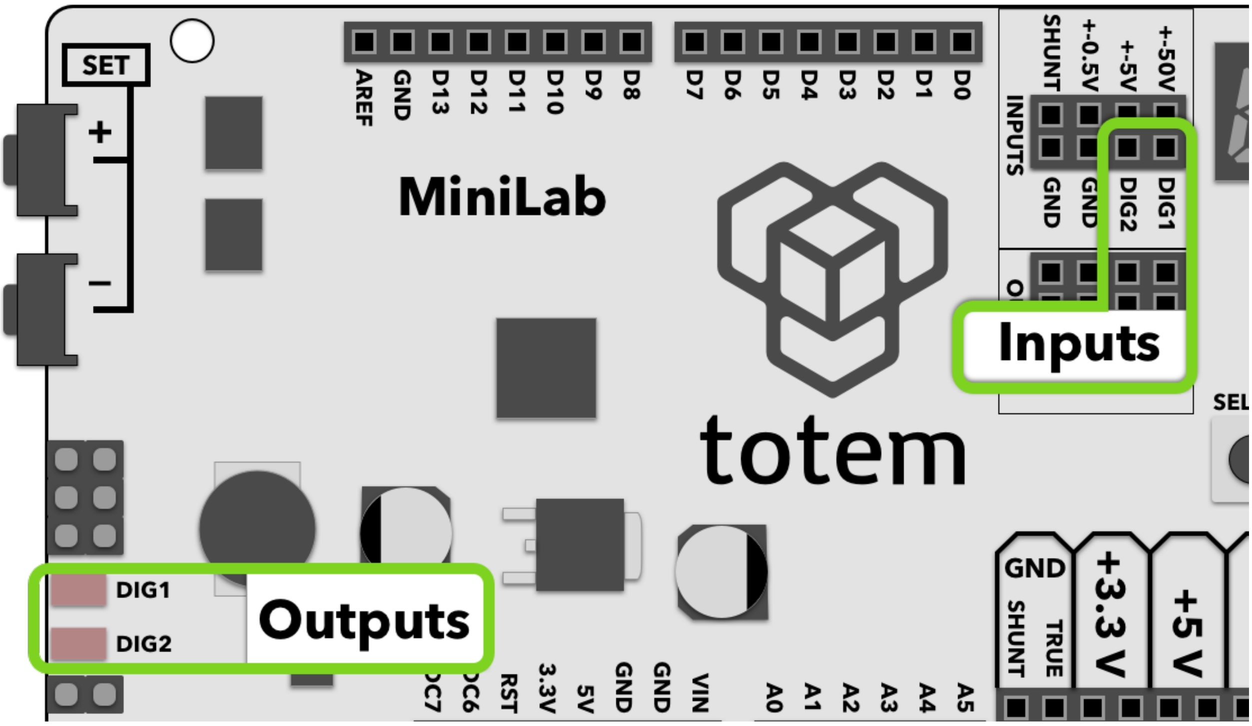


Fig. 9 Using digital inputs

0 to 6 Volts are accepted input range. A low input value (0..1.3V) turns of corresponding LED, where a high value (1.8V..6V) turns the LED on.

**Example**

1. Connect **DIG1** input with +5V output
2. Observe that **DIG1** LED follows the state of the input by lighting up.

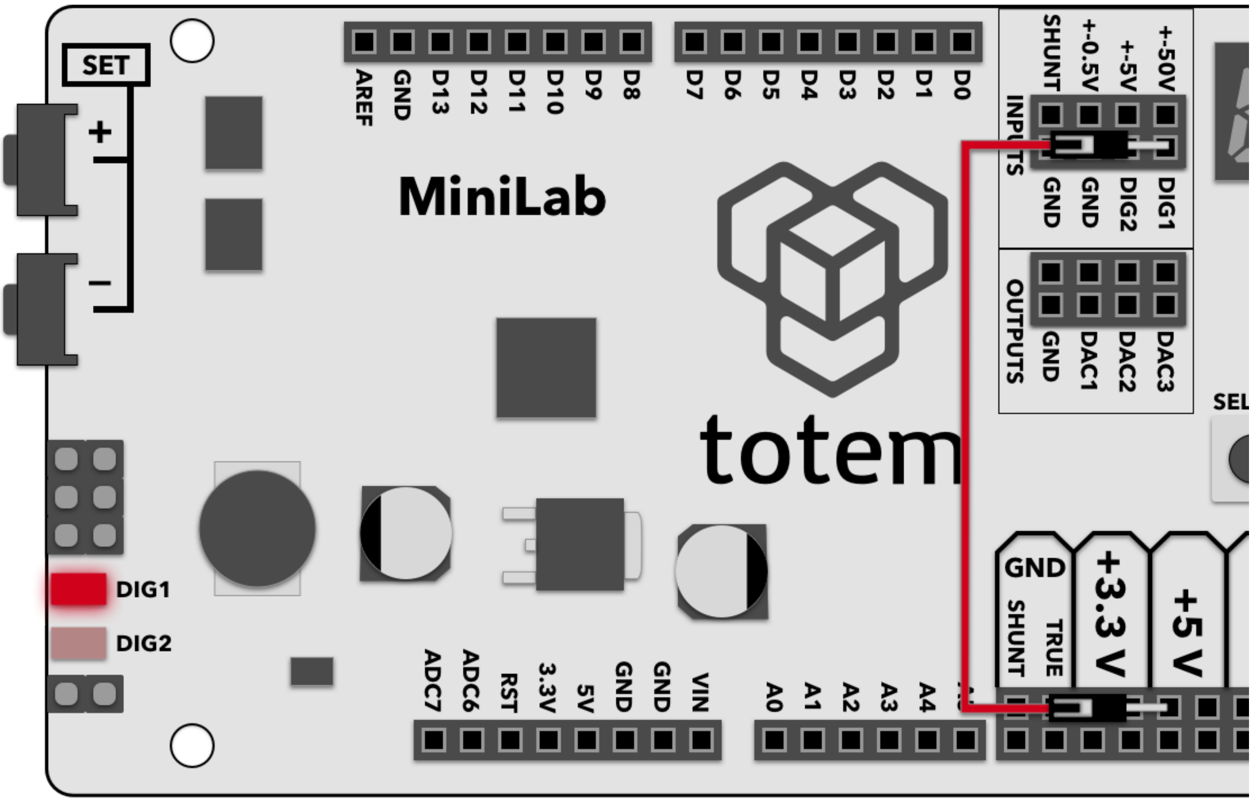


Fig. 10 Example usage of Digital input

## Frequency meter

This module allows to measure digital signal frequency in  0..1 MHz range. This is a special mode, which temporarily disables all other modules while this one is active.

To enter into frequency measurement mode, hold the **SET-** button until the display clears up and shows “H2”.

Frequency meter uses **DIG1** as its input. Only signals in the amplitude from 3.3 V to 5 V can be measured.

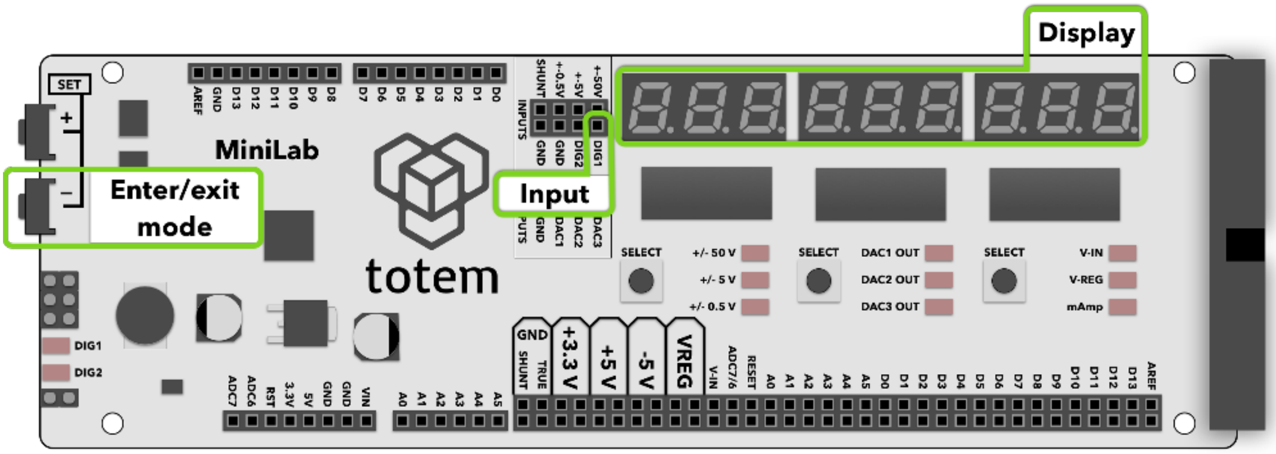


Fig. 11 Frequency measurement module

**Experiment**

1. First find a source digital signal with the frequency that you want to measure. As an example, you could use a “PlayMelody” sketch from Arduino webpage, which plays a tone on one of digital outputs.
2. Code the sketch to TotemDuino.
3. Connect the digital signal (in the “PlayMelody” example, **D9** is used) with the frequency meter input **DIG1** pin.
4. Observe that frequency meter measured a frequency (in the “PlayMelody” case it should be close to 524 Hz).

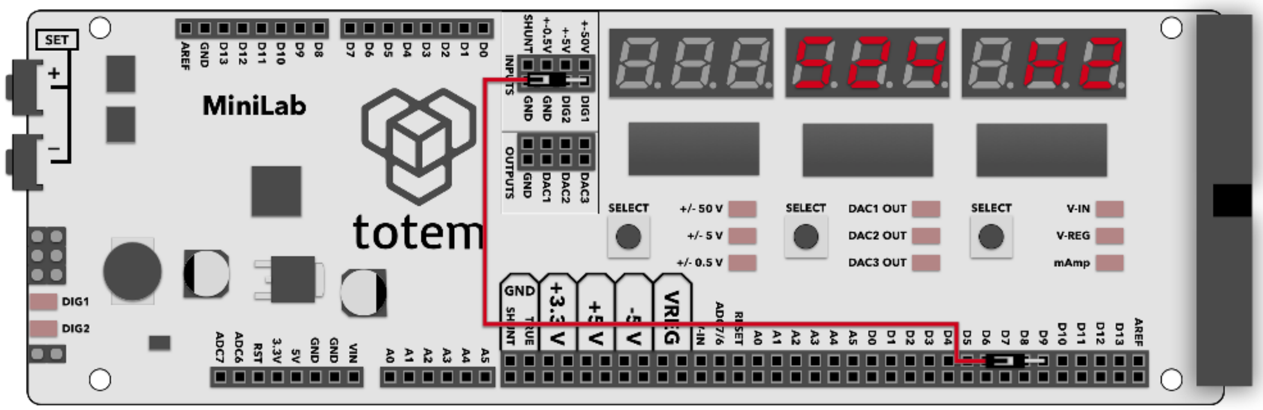


Fig. 12 Measuring 524 Hz signal with LabBoard

## Measuring current

TotemDuino has a current measuring module, which allows to measure current up to 800 mAmps. Rightmost display is used for showing current measurement result, when the current mode is mAmp (indicated by an LED). As the current sensor reuses the same hardware as used in voltage measurement module, you need to connect the signal from the shunt resistor with +-0.5 V channel:

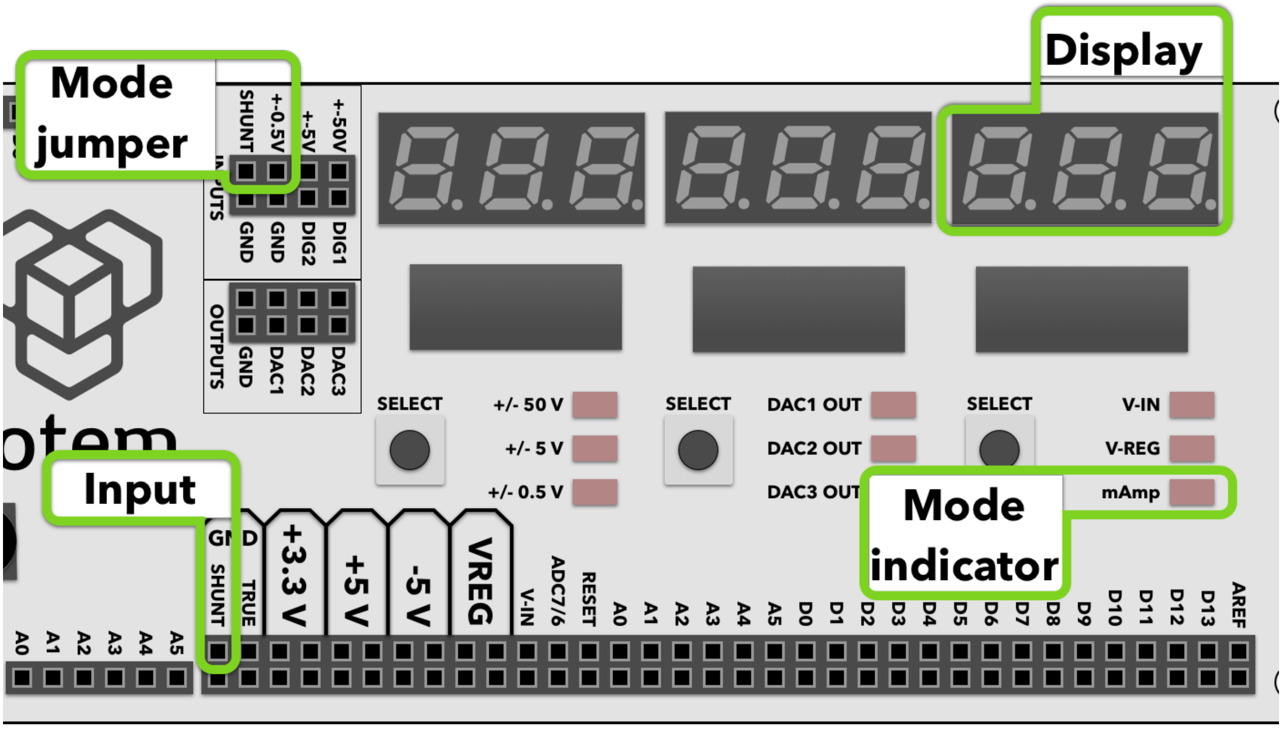


Fig. 13 Current measuring module

**Experiment**

1. Connect SHUNT and ± 0.5 V input together.
2. Connect any external circuit (in this example a 100 Ohm resistor is used), powering it from the LabBoard +5 V output, but instead of connecting negative end to ground, connect it to SHUNT ground pin.
3. Using right select button switch into mAmp mode.
4. Observe that it measures close to 5 mA.

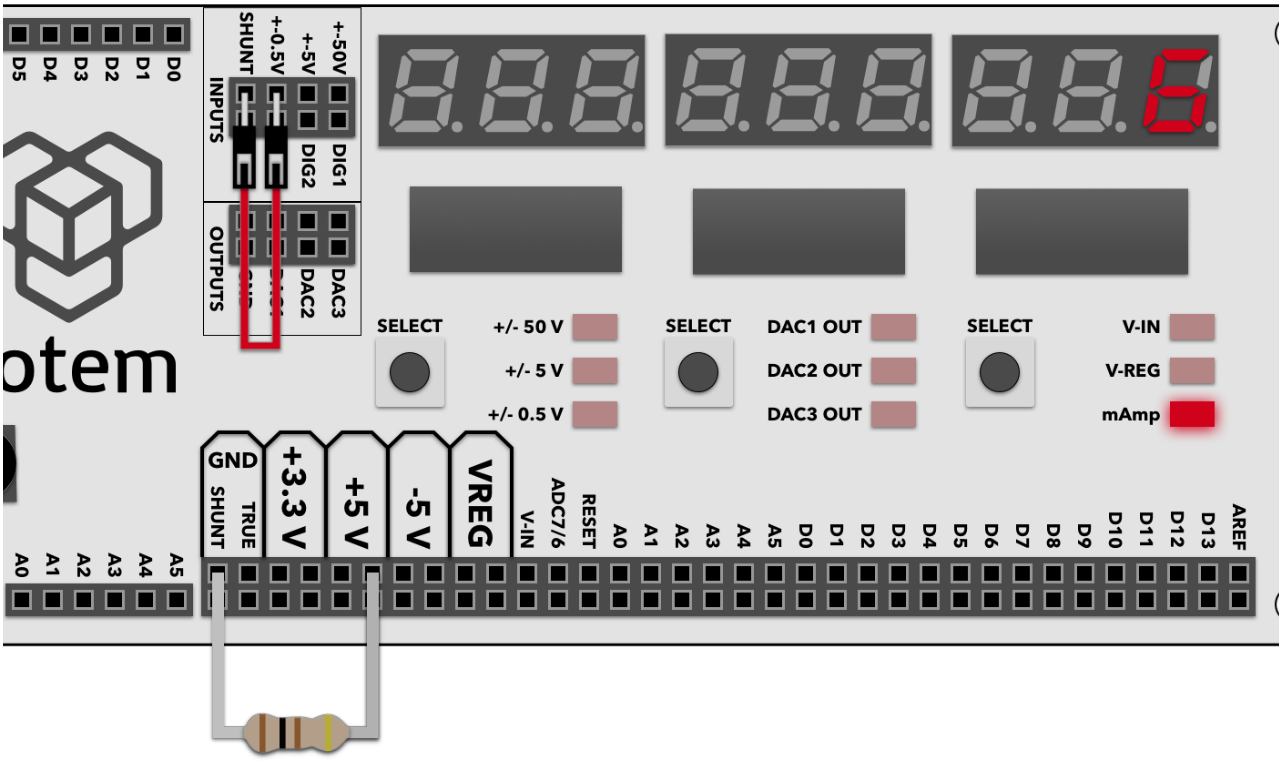


Fig. 14 Current measuring example using 100 Ohm resistor

## Setting programmable voltage output

LabBoard has a built-in variable voltage output module, capable of providing up to $V_{in}$ - 3 V at up to 500 mA. $V_{in}$ is the supply voltage for the MiniLab ($V_{in}$ = 12 V when using an included power adaptor).

Output for the regulator is marked with VREG symbol. The current output value in Volts is shown on the right display and can be changed with SET+ and SET- buttons when VREG mode is activated. The last set value persists even when the mode is changed, so once setup is done, it can be changed to measure current flowing from the VREG.

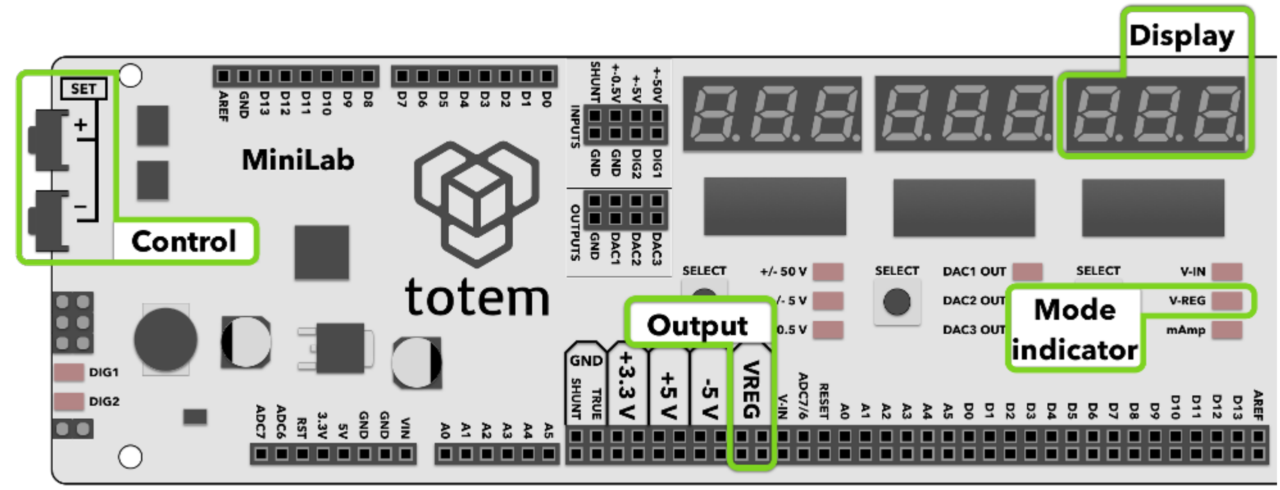


Fig. 15 Programmable regulated voltage output

**Example**

1. Connect VREG together with ± 50 V input.
2. Set the VREG voltage to some value.
3. Observe that the ± 50 V input measurement follows the VREG setting.

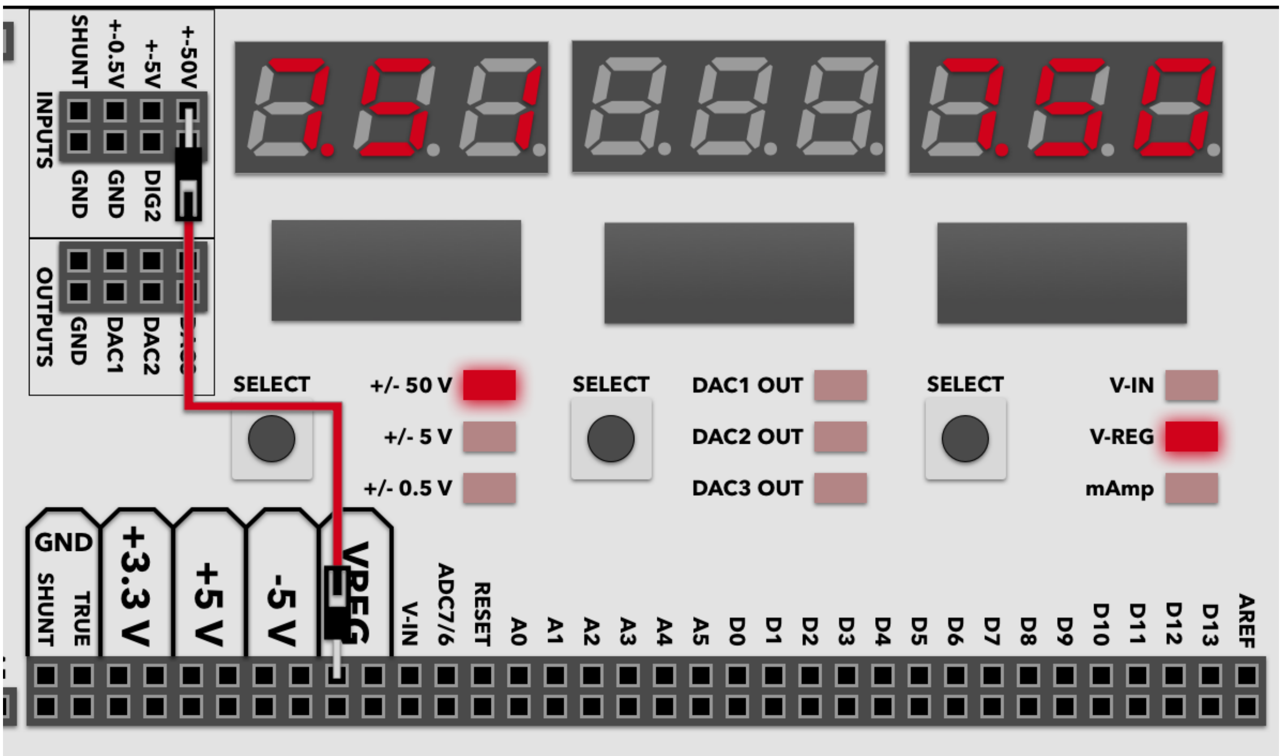


Fig. 16 Measuring programmable output voltage

## Using pulse counter

LabBoard has a special mode where digital pulses sent to DIG1 are counted. This works only with digital logic-level signals, and has a maximum frequency of 1 MHz.

Pulse counter mode is selected by holding STEP+ button for at least 3 seconds. When in this mode, all other features are deactivated. All three displays show the number of pulses counted, and up to 999999999 pulses can be registered.

To exit back from the pulse counter mode press STEP+ button.

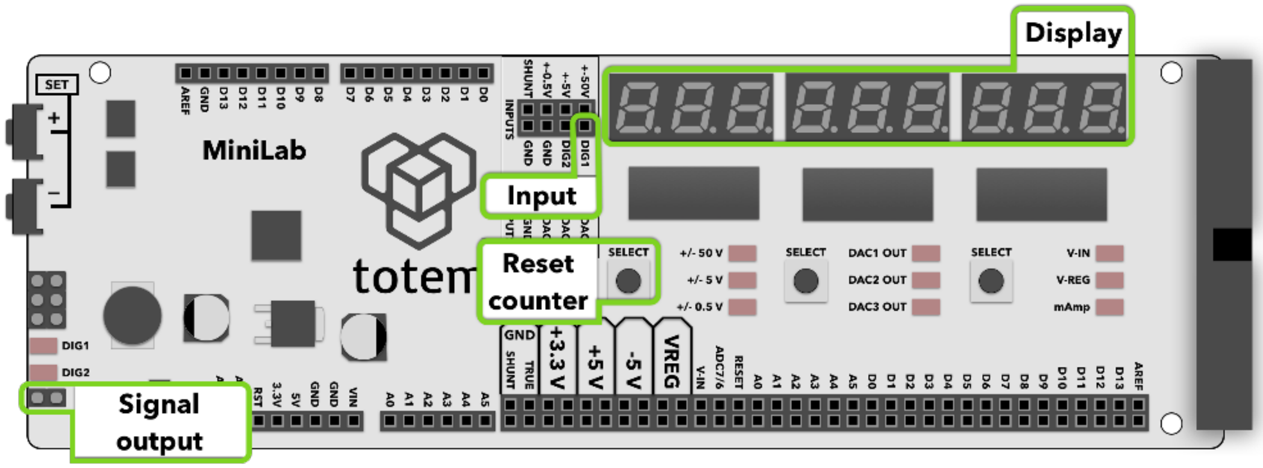


Fig. 17 Pulse counter module

### Example

1. Similarly to frequency measurement mode, here a digital signal is again needed. In this example a “blink” demo sketch is used, outputting 1 Hz signal.
2. Connect D9 output pin to DIG1 pulse counter input.
3. Enter pulse counter mode by holding SET+ button.
4. Observe that the counter increments every second.

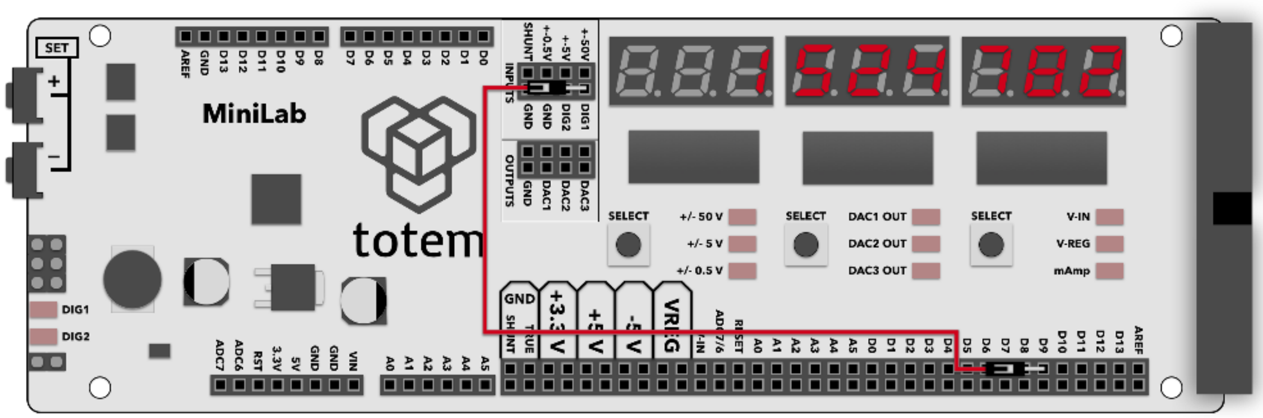


Fig. 18 Pulse counter experiment

## Generating pulses

LabBoard can also be used as a digital signal generator with programmable output signal period and pulse width. It can work in infinite mode, where signals are generated until stopped, or in finite mode, when only a preset number of pulses are emitted.

To enter generator mode, hold left **SELECT** button for at least 3 seconds. This will cause LabBoard to go into special signal generation mode. In this mode all other modules are paused, only the generator part is active.

Once in the generator mode, all three screens turns off briefly, then "**PPP**" is presented on the leftmost screen. Pressing corresponding **SELECT** button enters into signal generation mode configuration screen. This is confirmation entry mode:

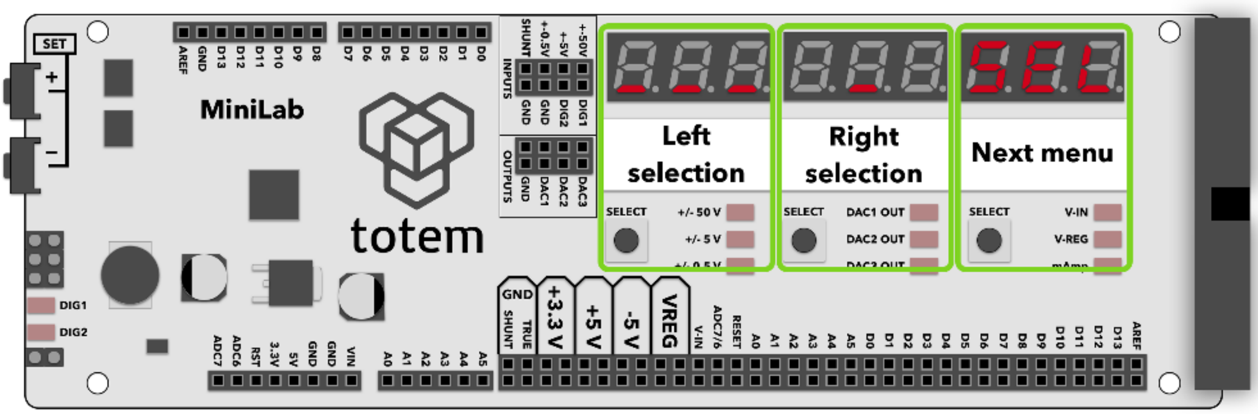


Fig. 19 Confirmation mode entry

While entering numerical value in numerical entry mode in the configuration menu, rightmost **SELECT** button always toggles over available configuration entry, middle and left **SELECT** are used for selecting currently active number (indicated by a blinking dot) to be adjusted with **SET+** and **SET-** buttons. This is a numerical entry mode:

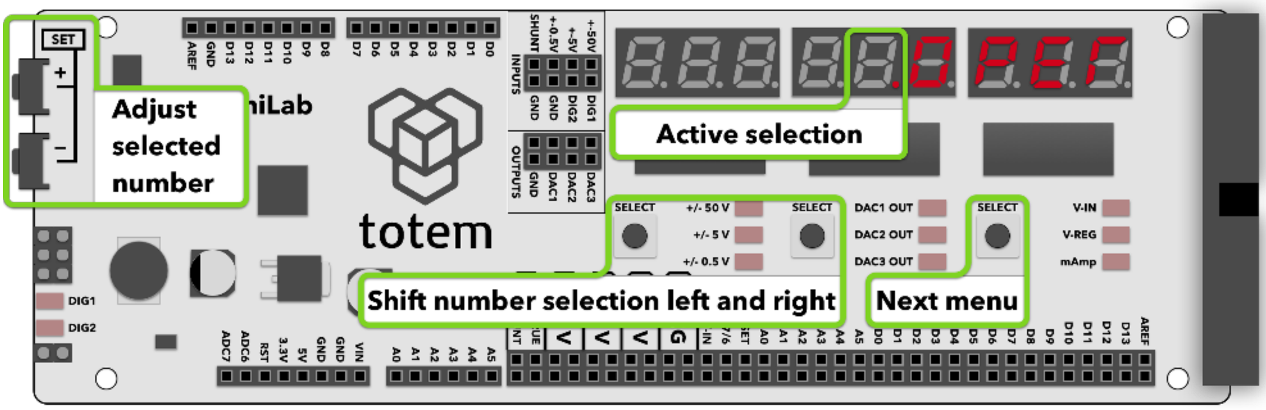


Fig. 20 Numerical mode entry

In the following list, all available menu entries are described. Refer to figures above describing how to orientate in the menu system.

1. **Delete settings / Exit mode** screen, confirmation mode type:

Fig. 21 Delete/Exit mode screen

**Left selection** — exit from pulse generation mode,

**Right selection** — Confirm deletion of previously entered values in pulse generation configuration

2. **Period setting** screen, numerical value parameter type:

Fig. 22 Period entry screen

**Active selection value** — current period in µs.

3. **Pulse width setting** screen, numerical value parameter type:

Fig. 23 Pulse width entry screen

**Active selection value** — current pulse width in µs. Mustn't be larger than period length.

4. **Pulse count setting** screen, numerical value parameter type:

Fig. 24 Pulse count entry screen

**Active selection value** — number of pulses to generate when in finite generation mode. This is ignored in infinite generation mode.

5. **Pulse mode setting** screen, confirmation mode type:

Fig. 25 Pulse mode screen

**Left selection** —start/stop infinite series of pulse generation with current settings. Once active, this is indicated by series of square symbols.

**Right selection** — start/stop finite generation of pulses, making number of pulses entered in pulse count menu. Once finished, indicate value goes back to a single underscore symbol. When active a single square symbol is shown.

**Example**

1. Enter pulse generation mode, select continuous pulse mode with following parameters:

**Period** = 30,000 µs

**Pulse width** = 15,000 µs

2. Enable infinite pulse mode by pressing corresponding mode button,
3. Connect generators output to an LED.
4. Observe that LED blinks, experiment by changing pulse width and see that LED dims or brightens. Now you've got a working PWM module.

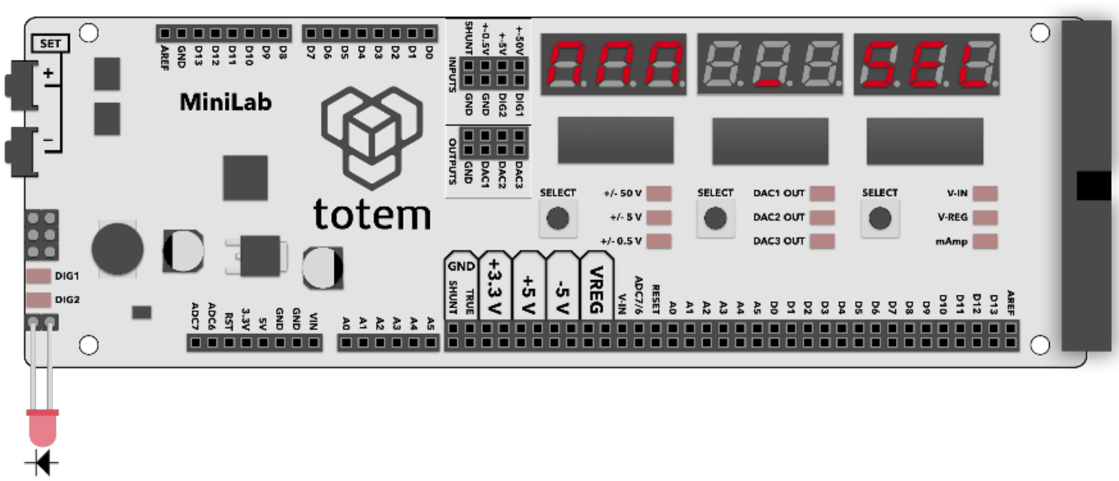


Fig. 26 Example pulse generation

# Programming with MiniLab

Second part of the MiniLab is contained in a TotemDuino board. It is a fully backwards with Arduino UNO platform, so all the great Arduino IDE can be used to write firmware for TotemDuino as well. In this chapter a quick guide on setting up MiniLab to be used with Arduino IDE will be presented, together with short example usage cases.

## Connecting MiniLab to your computer

Using a mini USB cable you can upload new firmware sketches into TotemDuino. It holds a complete backwards software compatibility with Arduino UNO boards, so Arduino IDE can be used to write programs for it. While you can use different programming environments to write firmware for it, using Arduino is one of the most friendliest and quickest way to start.

Firstly, install Arduino IDE to your computer — refer to official documentation for the Arduino IDE installation instructions, which can be found here:

https://arduino.cc/en/Guide/HomePage

Additional learning and introductory resources is recommended to use, such as:

- **What is an Arduino?**

https://learn.sparkfun.com/tutorials/what-is-an-arduino

- **What is a circuit?**

http://learn.sparkfun.com/tutorials/what-is-a-circuit

While TotemDuino works without any additional drivers with Windows10, previous versions of Windows might require manually downloading drivers for a communication chip used in it (PL-2303HXD). A latest version can be found at manufacturers website:

http://www.prolific.com.tw/US/ShowProduct.aspx?p_id=225&pcid=41

On macOS systems, driver will need to be manually installed for it to work:

http://www.prolific.com.tw/US/ShowProduct.aspx?p_id=229&pcid=41

After installation, TotemDuino serial port **/dev/cu.usbserial** should show up when connected:

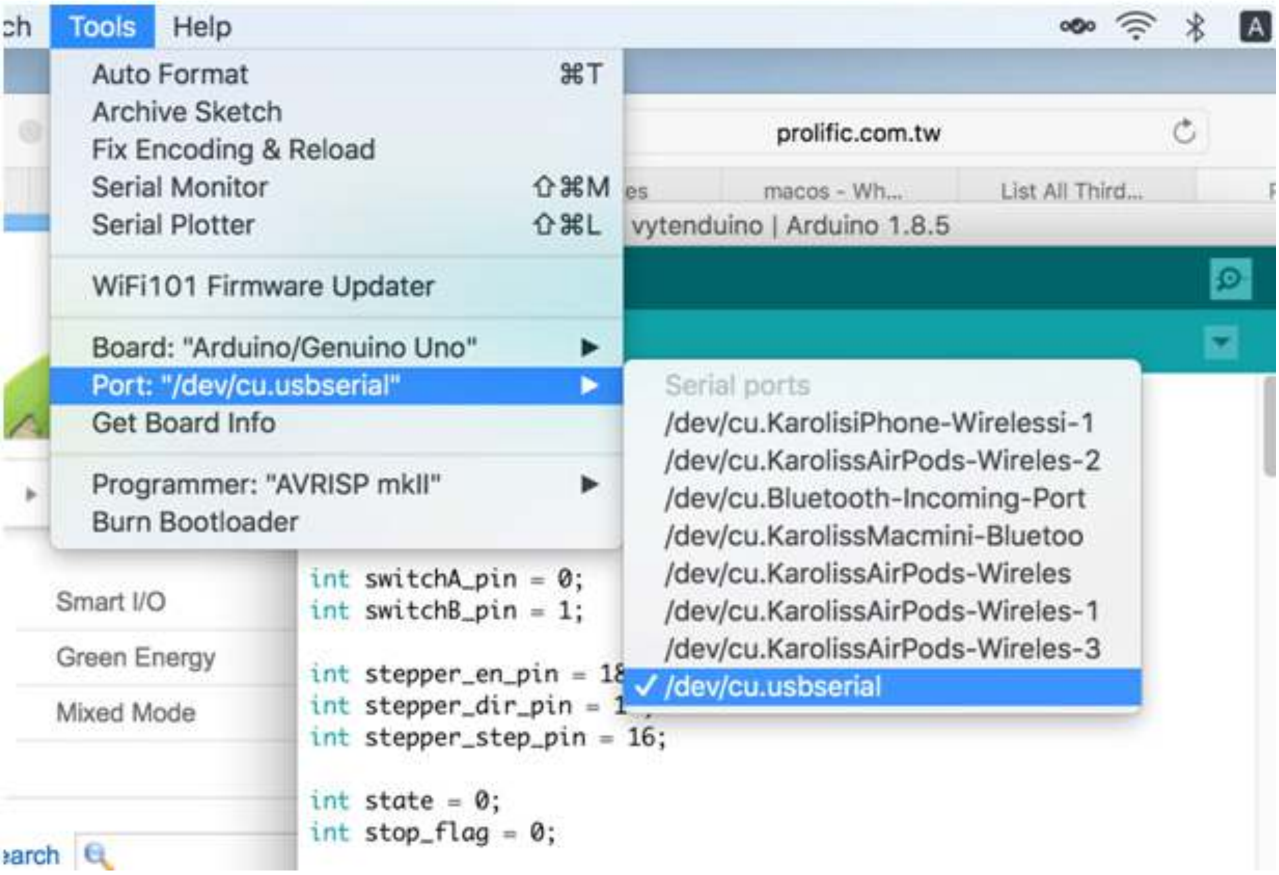


Fig. 27 Selecting TotemDuino board port

One note regarding macOS compatibility is that it's important to not unplug the device while it's being programmed. Doing so will cause the driver to get stuck, and further connected TotemDuino boards will not show up until computer is restarted.

On most Linux systems driver for the TotemDuino should be included in the system already, so no further steps are needed to be taken. If it's missing, or the device doesn't enumerate when connected, refer to your distribution manual on how to enable PL2303 kernel module. Tested distributions that include the driver are Debian (and derivatives such as Ubuntu) and Fedora.

## Using Arduino IDE

After installation, you should be greeted by default Arduino IDE window:

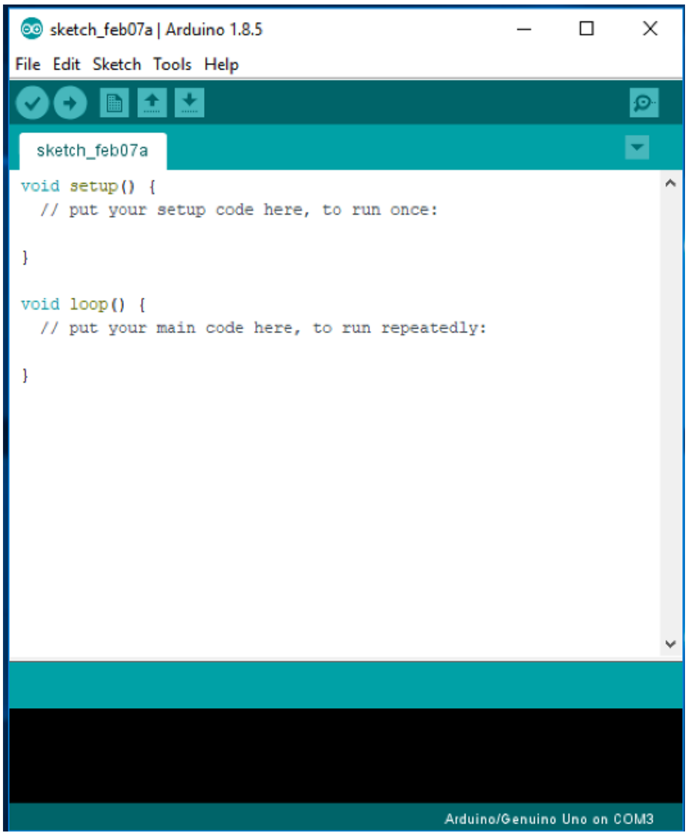


Fig. 28 Arduino IDE window

To work with TotemDuino, first you must choose the correct board for which code will be compiled, as well serial port, by which the compiled firmware will be uploaded to it. You can select the board by clicking **Tools-> Board**. In the drop-down menu, please select **Arduino/Genuino UNO** board:

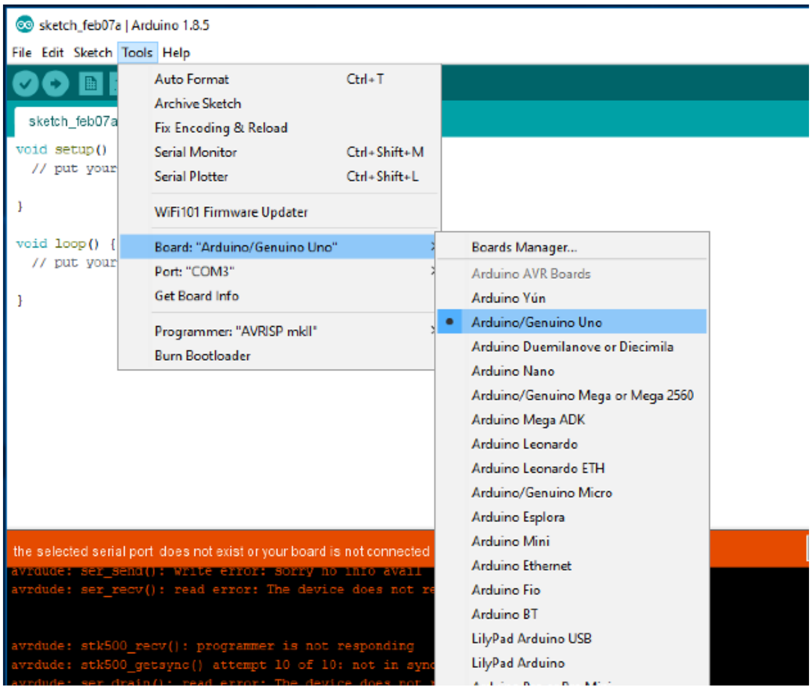


Fig.29 Board selection

Next, we'll select serial port. Because the number of available serial ports differ from one computer to another, and there's no way to know which port is the correct TotemDuino one, you might need to follow this procedure. First check what ports are available when TotemDuino is disconnected, and compare the list once you connect TotemDuino back. The newly appeared port will be the port that should be used. On most laptops there are no extra serial ports, so you might see TotemDuino port as being the only one available.

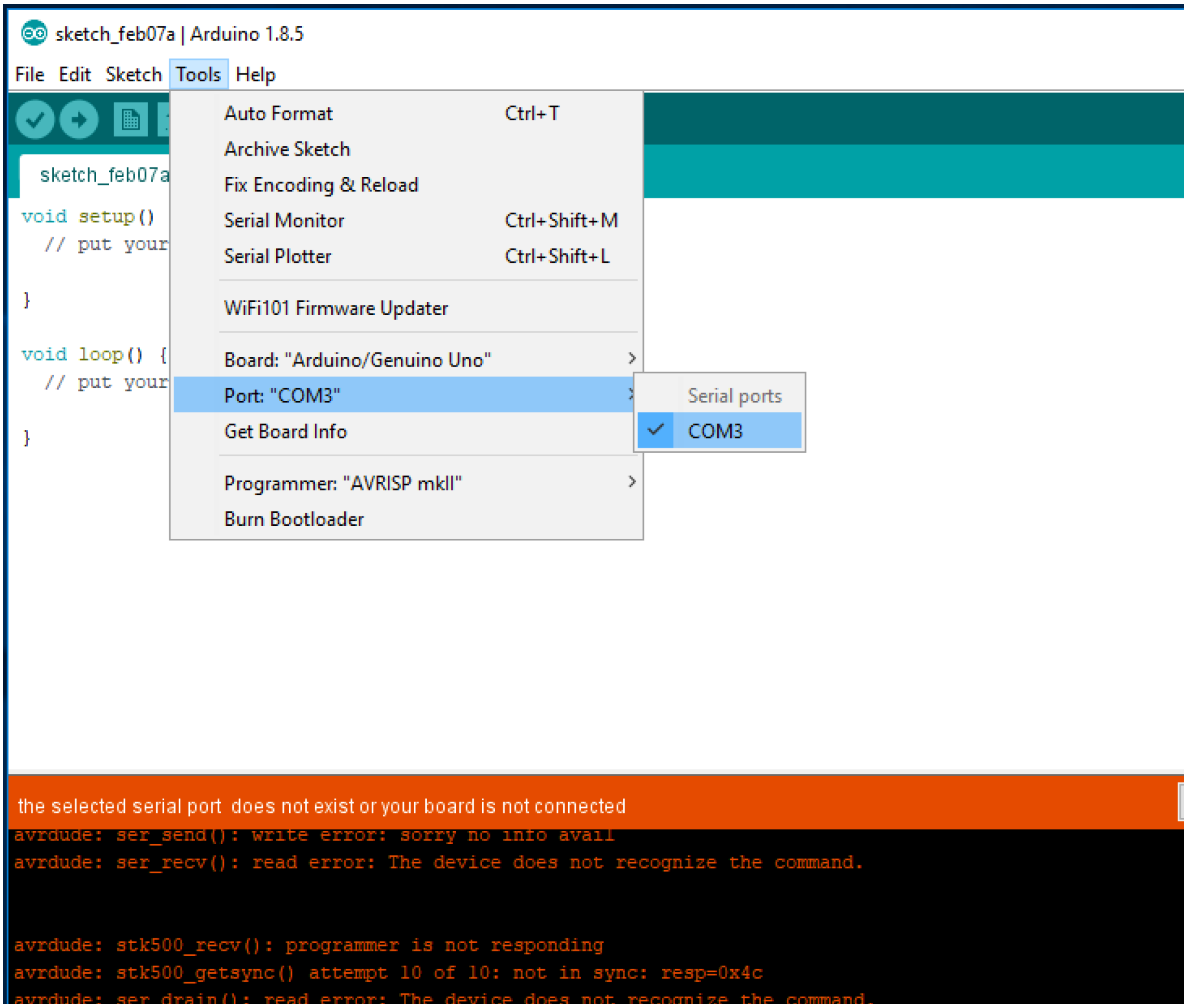


Fig. 30 Selecting TotemDuino serial port

Once that's done, we can start writing firmware for it. As always, its best to start with the basics, so first we should try to upload a simplest firmware which only blinks the onboard LED on the TotemDuino.

Using **File->Examples->01. Basics** drop-down menu select **Blink** example firmware:

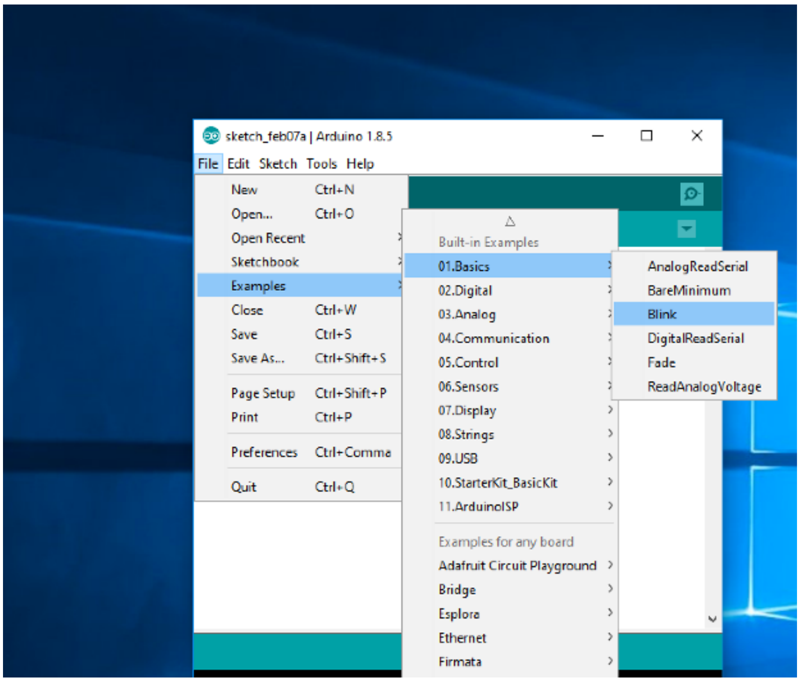


Fig. 31 Selecting example firmware

This will open a new Arduino IDE window with the source code of that firmware. Try to compile and write the firmware to TotemDuino by clicking **Upload** button (icon with right arrow):

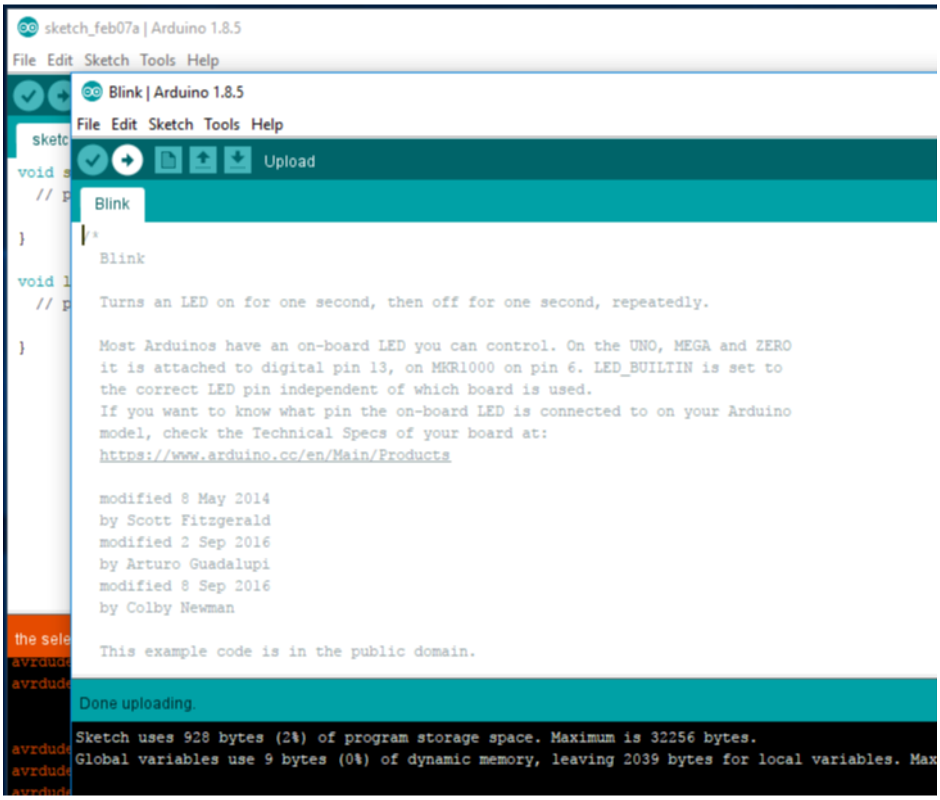


Fig. 32 Uploading firmware successfully

You should see a notification “Done uploading” in the bottom status bar. Now check if the firmware does what it’s supposed to:

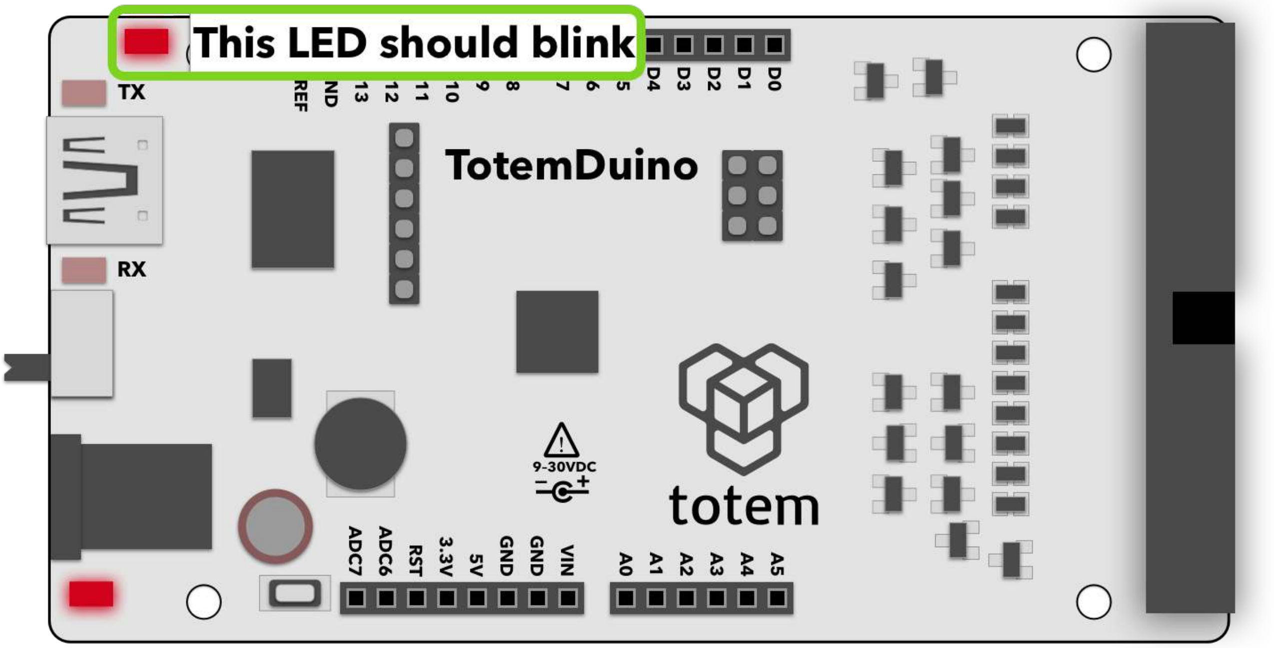


Fig.33 Example LED blink firmware

If the LED blinks, you got every bit working! Now you can start diving into the world of programming by exploring other examples or creating your own firmwares for it. You could plug external sensors, shields to bring even the craziest ideas to life.

TotemDuino tightly integrates with LabBoard, so it can help you debug problems with your code, measure the output signal frequency, pulses, or the LabBoard could be used as an input device, generating needed test signals for your TotemDuino.

Have fun!

# Expanding MiniLab

In this chapter several options on how to get even more from the MiniLab are discussed. We hope that this will give you a jumpstart of your own ideas on where else you could use your MiniLab. As MiniLab is a flexible and an always improving system, we would like to hear your opinions! Please write what you feel is missing (or could be improved!) from the MiniLab to info@totemmaker.net

## Using breadboards

In the MiniLab kit you will find several breadboards, that together with easily accessible MiniLab connections, arranged in a row can be accessed in a clean manner:

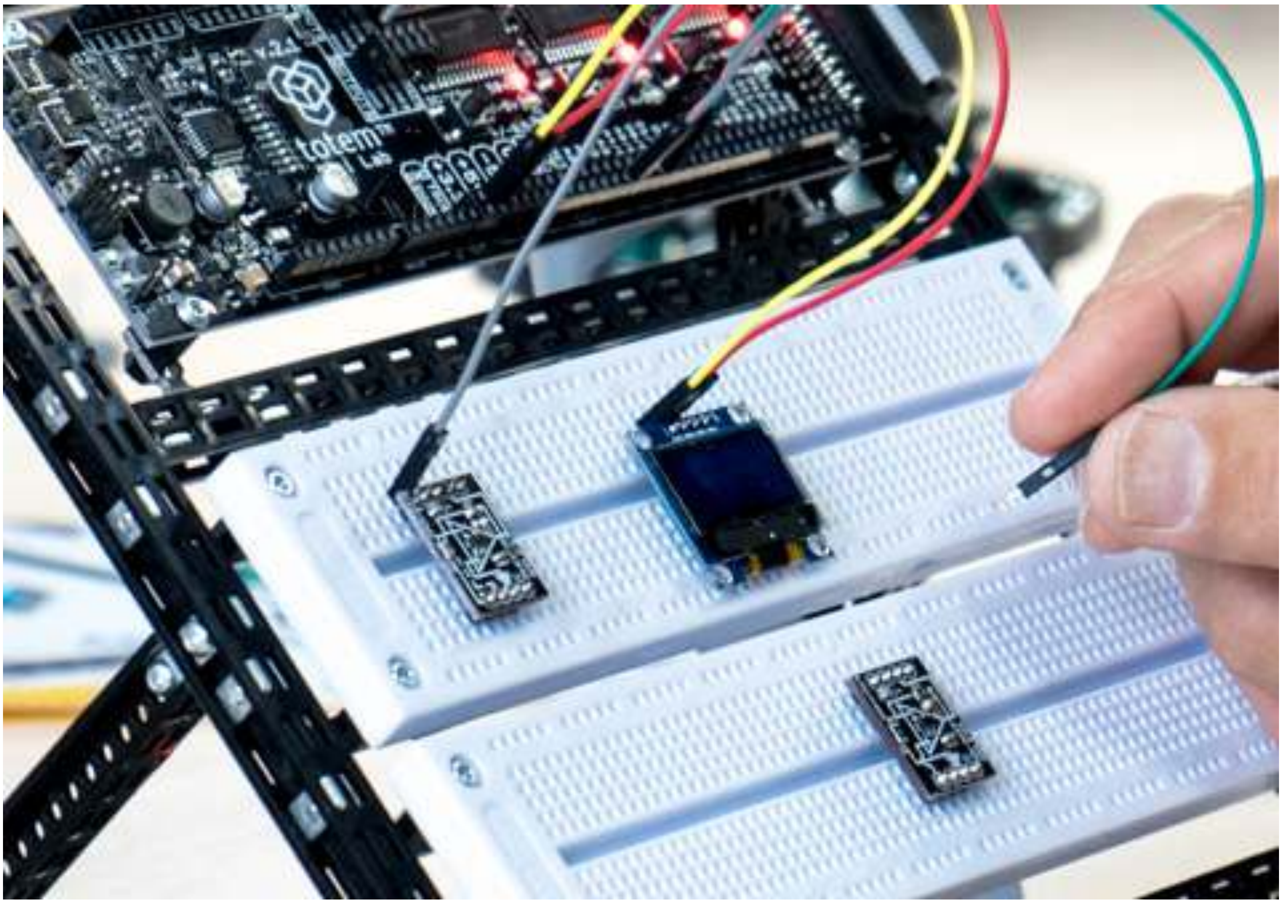

Fig. 34 Breadboard use in MiniLab

We suggest you to build the workbench from Totem construction parts where the breadboards are mounted just bellow the LabBoard, so it helps not only with the "containment" of the work area, but also gets rid of relative motion between breadboards and external components in more advanced use cases. This helps to prevent accidental wire disconnects which takes long time to find and creates a frustrating experience.

## Side panels

While MiniLab will work on its own, but you can easily expand it with side panels. A side panel is a collection of basic most commonly used electronics blocks that can be used together with MiniLab to even further extends it's abilities.

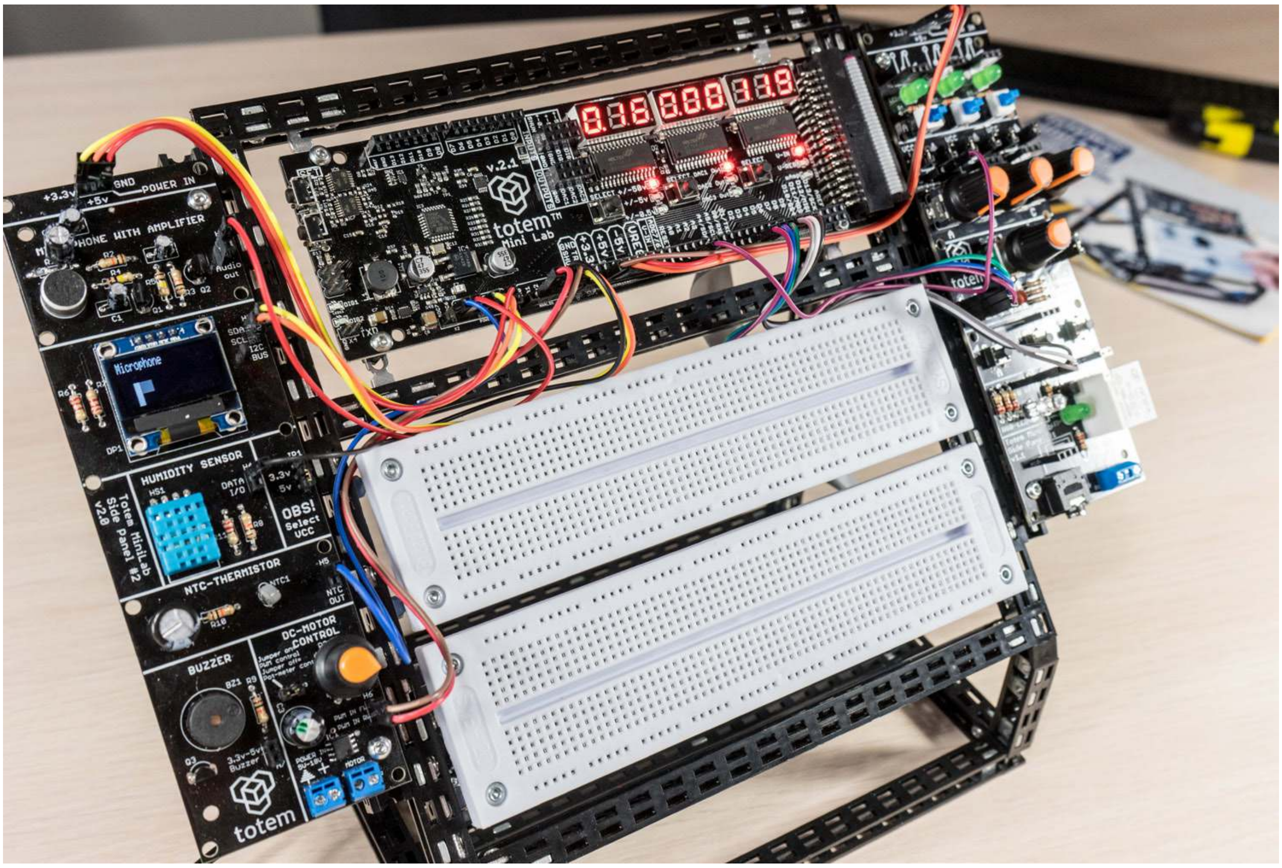


Fig. 35 Side panels

In the side panels you'll find:

- Switches, buttons
- Potentiometers
- Rotary encoder
- Relay module
- RGB full color LED
- Graphical OLED module
- Microphone module with integrated preamplifier
- Humidity sensor
- NTC temperature sensor

- Buzzer
- H-bridge DC motor driver

Together with each side panels you'll get a quick start guide on how to work with each of the module in the side panel together with code samples. While modules in side panels are indented to be self-contained and not rely on one another, this gives you a chance to experiment on integrating parts of it to build a connected system — as an example you could program it to control the DC motor by rotating the potentiometer and displaying the current value on the OLED screen or making a sound-activated relay switch.

Totem is always expanding the list of side panels that are designed to interface with MiniLab. Please check www.totemmaker.net for the latest list of their abilities and documentation. Together with documentation you'll be able to get drivers and sample firmware for each module of each side panel, so you can easily include them in your experiments.

# What's next

After getting to know MiniLab, you can expand it to your own wishes! Using MiniLab together with breadboards, you can easily experiment with new sensors, drivers and many more electronic devices, and measure or supply your own generated signals from LabBoard.

We hope that you'll never run out of inspiration while using MiniLab. For more ideas and projects, you're always welcome at http://totemmaker.net for new tutorials, projects and more!