WiLab Data-logger 002

User's Guide

CENTRE FOR MICROCOMPUTER APPLICATIONS

http://www.cma-science.nl

For our international users
Check the CMA website https://cma-science.nl for the latest version of this manual and updates of Coach programs and apps.

Aan onze Nederlandse gebruikers
WiLab wordt standaard uitgeleverd met Engelse handleiding.
U kunt de laatste versie van de Nederlandse handleiding en de nieuwste updates van Coach programma's en app's downloaden van de CMA-website https://cma-science.nl.

WiLab User's Guide ver. 1.2, September 2019

Author: Ewa Kedzierska

CMA
A.J. Ernststraat 169
1083 GT Amsterdam
The Netherlands
info@cma-science.nl
https://cma-science.nl

TABLE OF CONTENTS

I. INTRODUCTION

1. About WiLab

The CMA WiLab is an easy-to-use data-logger for STEM Education that can be used for measurement and control. WiLab offers two types of connectivity:

- **wired** via USB cable for computers (Windows and Mac), and Android tablets (via OTG cable),
- **wireless** via Bluetooth®[1] for tablets (iPad, Android) and Chromebooks.

WiLab is equipped with its own processor and memory, enabling measurements at high sampling rates of up to 100 000 Hz with accurate independent timing. It has FLASH memory to allow easy upgrade of the internal software (firmware) and to store measured data.

For connecting sensors WiLab has two analog BT sensor inputs, which support CMA sensors. CMA offers a wide range of sensors, which can be connected to these inputs. Additionally WiLab has two controllable built-in devices, a buzzer and a LED, which can be used in simple control experiments.

To use WiLab, you need the Coach 7 or Coach 7 Lite program running on your computer or Coach 7 or Coach 7 Lite app running on your tablet or Chromebook.

2. Items included with WiLab

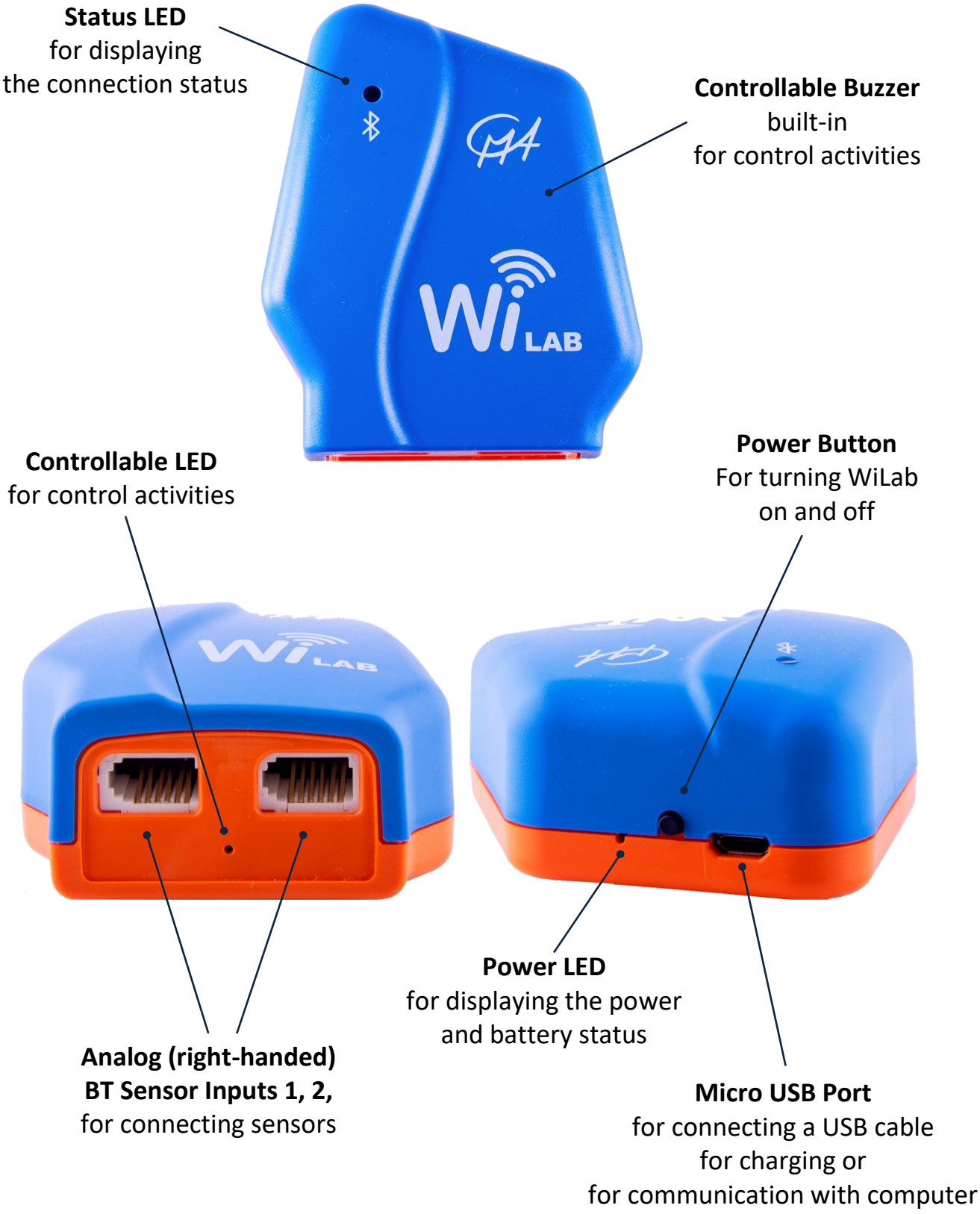
The following items are included with WiLab:

- USB cable for connecting WiLab to a USB port or to the USB power adapter.
- USB Power Adapter for powering WiLab and charging its battery.
- User's Guide.

[1] *Bluetooth® LE 4 and 5*

II. GETTING STARTED

1. WiLab overview



2. Power button

The small Power button located at the back of WiLab is used to turn it on and off.

To turn WiLab on

- Briefly press the Power button.
- While WiLab is starting the Power LED blinks red. When the starting procedure is finished (circa 3 seconds) this LED turns green, blue or red depending on the battery level.
- Now WiLab checks its connection:
  - If it **detects** a USB connection then the Status LED becomes green showing that WiLab is ready for measurement via USB.
  - If it does **not detect** a USB connection it turns Bluetooth on. The status LED starts blinking blue (max. 5 minutes) and stops blinking - becomes blue when Bluetooth communication is established.
- After the connection is established you are ready to use WiLab for measurements.

Connecting WiLab to a USB of a computer or a power supply automatically turns WiLab on.

To turn WiLab off

- Press and hold the Power button for 2 to 5 seconds and release when the Status LED turns off.
- When WiLab is not connected to power and is inactive (no communication, no measurements) for longer than 15 minutes then it automatically turns off to save its battery.
- If WiLab is connected to a USB of a computer, a tablet or a power supply it will restart automatically.

The detailed operations of the Power button:

WiLab Status	POWER BUTTON	ACTION
OFF	Press briefly	Turns WiLab on Battery LED starts blinking red and after 3 s it shows the battery level. Then WiLab checks its connection. The Status LED indicates the status of connection.
ON	Press briefly	In case of no connection turns Bluetooth on The Status LED starts blinking blue (max. 5 minutes) and becomes blue when Bluetooth communication is established.
ON	Press and hold for 2-5 seconds and release when the Status LED turns off	Turns WiLab off In case WiLab is powered, WiLab will turn on automatically
ON	Press and hold for more than 8 seconds	WiLab will reset itself and turn on again. (Hardware Reset)
OFF	Press 3 times shortly within 2 seconds	Turns WiLab on and will stay in Bootloader Mode for 30 s. WiLab is ready for Firmware update Battery LED is blinking Red

3. Power LED

The **Power LED** is located at the rear of the WiLab and indicates power and battery level.

Power LED	WiLab State
OFF	WiLab is turned off and not being charged
ON The LED color depends on the battery level: Green: battery full Blue: battery good Red: battery low	WiLab is turned on Battery level is between (circa) 80% and 100% Battery level is between (circa) 20% and 80% Battery level is less than 20% and needs to be charged
ON Blinking Red	WiLab is in Bootloader Mode and ready for a Firmware Update

During charging WiLab is always on. This is necessary to show the battery level.

4. Status LED

The **Status LED** is located on the top of WiLab and indicates the status of communication. The table below describes possible states.

STATUS LED	WiLab State
OFF	WiLab is not connected to USB and Bluetooth is turned off
ON Green	USB communication established WiLab is ready for data collection
ON Blinking Blue	Bluetooth is active and advertising itself
ON Blue	Bluetooth communication established WiLab is ready for data collection

III. WORKING WITH WILAB

1. Powering WiLab

An internal rechargeable battery (3.6 V, 960 mAh) powers WiLab. The Power LED indicates the battery level when WiLab is turned on. During charging WiLab is always on to show the battery level. WiLab is delivered with its battery partially charged. The device will work as long as the battery provides power or it is powered via the power adapter. At the moment when the battery level becomes critical (lower than 20 %) the Power LED turns red. If you continue working without charging, the device will shut down. A fully discharged battery requires up to 4 hours of charge time to become fully charged. But within 3 hours the battery will be charged at least up to 90 %.

To charge battery

Use only the USB cable and USB power adapter delivered with your WiLab.

- Connect the USB cable to the micro USB port of WiLab.
- Connect the other end of the USB cable to a USB power adapter and plug the USB power adapter into a standard power outlet.

or

- Connect the other end of the USB cable into a free USB port of your computer or your tablet. Note that the efficiency of charging via a USB port, is limited by the maximal current provided by a USB socket (500 mA for USB 2.0 and 800 mA for USB 3.0. On tablets the maximum current can be significant lower.

Battery life will depend on the sensors and features used but typically you can expect to use WiLab at least 4 hours (in case of 2 sensors connected) up to 8 hours without recharging it. To save power turn off WiLab when you do not need it. To prolong battery life, automatic power down turns WiLab off after 15 minutes of inactivity.

The life of the battery is more than 300 full (0 to 100%) charging cycles. If charging cycle is not full e.g. 30% to 60% it will last more charging cycles. Exposure to temperature over 35^{o}C will significantly reduce battery life. To replace battery use **only** the approved rechargeable batteries provided by CMA.

Notes:

- *WiLab can be used while the battery is being charged.*
- *WiLab typically consumes about 150 mA. If you connect two sensors then power consumption can be higher.*
- *When the USB port does not provide enough power, WiLab will not be charged or charging will be significantly slower.*

2. Communication with WiLab

WiLab can communicate with a computer or a tablet:

- wired via a USB port for computers (MAC, Windows, tablets with USB port), or
- wireless, via Bluetooth (iPad, Android tablet, Chromebooks).

2.1. USB

To use the USB communication use the provided USB cable. Plug one end of the cable with the micro USB connector into the WiLab and the other end into a USB-port of a computer or a tablet. In case of tablet you may need a special OTG adapter cable. The Status LED becomes green when the USB connection has been established. In case WiLab is connected to the USB port WiLab will always choose for the USB communication. You need to disconnect WiLab from the USB to be able to activate Bluetooth.

2.2. Bluetooth

Bluetooth is a short-range wireless communications technology for exchanging information. WiLab is equipped with Bluetooth Low Energy Insight ISP1507 module, which supports Bluetooth 4 and Bluetooth 5 with compatible devices. The benefits of Bluetooth 5 are: range, speed, and bandwidth. The wireless range of Bluetooth 5 maxes out at 120 meters, compared to 30 meters for Bluetooth v4.2.

WiLab identifier

Every WiLab has a unique identifier of 4 characters. This identifier is located at the bottom of the WiLab.

This identifier allows choosing the WiLab you want to connect to.

To activate Bluetooth

- If needed disconnect WiLab from a USB port. When WiLab is connected to a USB port then it is not possible to turn Bluetooth on.
- After the starting procedure of WiLab is finished or the Power button is pressed, WiLab ''advertises'' itself as a Bluetooth device to host devices nearby. This lasts 5 minutes and during this period the Status LED is blinking blue.
- If during this "advertising" period a connection is made by Coach 7 running on a host device with this WiLab, the wireless communication will be established and the Status LED will stop blinking and turn blue.
- Briefly press the Power button to turn Bluetooth advertising on again for 5 minutes.

3. Memory

3.1. RAM memory

WiLab is equipped with 128 KB of RAM memory to store the collected data. The maximum number of samples, which can be stored in this memory is 32 000 data samples. This means than when you use one sensor you will be able to collect 32 000 data points, and when you use two sensors 16 000 data points per measurement. This applies for **frequencies higher than 10 000 Hz**. For such frequencies measurement stops automatically when the memory is full, which can mean that the measurement is stopped before the measurement time is reached.

When using **USB** communication and the sampling frequency is lower than 10 000 Hz there is no sample limit, data are transferred in real-time as long as data transfer can keep up with data generation. This depends on the used USB.

When using **Bluetooth** communication and the sampling frequency up to 2000 Hz for one sensor and 1000 Hz for two sensors there is no samples limit either. Above those frequencies the 32k samples limit also applies.

3.2. Flash memory

WiLab is also equipped with Flash memory of 512 KB. Flash memory contains the WiLab internal software (firmware) and can be rewritten. As new functionality becomes available, you can update your WiLab.

To update firmware (only on a computer and via the USB)

- If needed download from the CMA website and install the latest version of Coach 7 program.
- Start Coach 7 and login as Author (default password 0000).
- Prepare WiLab for a firmware update:
  1) WiLab should be turned off and not connected to USB.
  2) Within 2 seconds press 3 times shortly the Power button.
  3) WiLab turns on and the Power LED starts blinking red. WiLab is ready for a firmware update.
  4) Connect WiLab to a USB port of the computer from which you like to update the firmware. You have now 30 seconds to start the update in Coach.
- In Coach 7 go to the menu option **Tools** > **Firmware Update**.
- Select WiLab and press **Update**.
- After the firmware update is completed, WiLab will restart automatically.

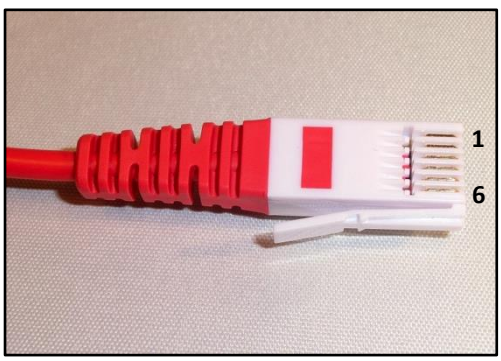
4. Sensor inputs

For connecting sensors WiLab has two analog (right-handed) BT sensor inputs. CMA BT sensors[2] including CMA Motion Detector BT55i (but excluding CMA digital Motion Detector 0664) can be directly connected to the sensor inputs of WiLab.

4.1. BT analog sensor plug

Sensors with analog (right-handed) BT plug can be connected to WiLab. The BT plug has 6 pins with the following connections:

Pin	Connections
1	Vin
2	Ground
3	Vres[1]/I2C[3] data
4	Auto-ID[2]/I2C[3] clock
5	5 V DC
6	Vin-low



[2] *Analog Vernier BT sensors can also be directly connected to WiLab. Older (4-mm) versions of CMA sensors can be connected via a 4mm to BT adapter (art. code 0519).*

[1] V_{res} - Output reference voltage (pull-up resistor 15 kΩ) for resistance measurements.
[2] Auto ID (pull-up resistor 10 kΩ) - Auto ID sensor detection input. The BT inputs have the possibility for automatic sensor recognition.
[3] For (I^2C) communication between WiLab and intelligent sensors.

	Vin	**Vin-low**
Inputs	1, 2	1, 2
Input range	-10 .. 10 V	0 .. 5 V
Resolution (12 bit)	4.9 mV	1.2 mV
Input impedance	100 kΩ	100 kΩ

Both sensor inputs can be (simultaneously) used as counter inputs. Sensors such as the CMA Photogate (art. code 0662i or BT633i) or CMA Radiation sensor (art. code 0666i or BT70i) are by default defined as counters. Other analog sensors can be used as counters after defining the counter conversion settings in Coach e.g. defining a heartbeat sensor to count heartbeats.

4.2. Sensor detection

WiLab supports sensor recognition and tries to identify sensors connected to inputs.

- When Coach 7 **identifies** the connected sensor then its icon is automatically displayed on the WiLab screen panel in Coach. When the sensor is physically disconnected its icon disappears automatically.
- When Coach does **not identify** then its icon does not appear. This happens for some older CMA sensors or sensors connected via the CMA 4-mm to BT adapter art. code 0519. The user has to manually select the correct sensor from Coach Sensor Library. Right-click the empty sensor input on the WiLab screen panel, select **Choose from Library** and select the sensor from the list. After such a sensor is disconnected Coach keeps displaying the sensor icon. The sensor can be removed via the option **Remove** or by selecting another sensor from the Sensor Library.
- When a predefined sensor is already set up in an Activity/Result and Coach:
  - **identifies** the connected sensor as a different sensor then the sensor name becomes red, right-click the sensor icon and select **Exchange** to change the sensor to the connected one.
  - **does not** identify it then its name remains grey, right-click the sensor icon and **Confirm** to accept the pre-defined sensor or **Clear** to remove the connection.

4.3. Sampling rate

WiLab can sample up to two sensors simultaneously. The sampling rate depends on the number of sensors used during the data collection. For measurement via one input maximum sampling frequency is 100 kHz, for measurement via two inputs simultaneously 50 kHz. More detailed specifications are given in the table.

Used sensors	Maximum Frequency (and other high frequencies[3])
1 sensor	100 kHz (40 kHz, 20 kHz, 10 kHz)
2 sensor	50 kHz (20 kHz, 10 kHz)
Motion Detector	100 Hz
Converted signal e.g. counter	2.5 kHz signal is monitored at 10 kHz

5. Controllable Buzzer and LED

WiLab has two built-in actuators, a RGB LED located in the front and a buzzer located inside WiLab. RGB colors of the LED can be set to 16 intensity levels and the buzzer can generate 16 different tones.

IV. USING WILAB FOR DATA COLLECTION

Coach 7 and Coach 7 Lite as well for desktops as for tablets support measurements with WiLab. During such measurement WiLab stays connected to the computer/tablet via a USB cable or communicates wirelessly via Bluetooth. The collected data are transferred in real-time to the computer/tablet and the course of the measurement can be followed directly on the computer/tablet screen. The recorded data are not stored in the WiLab's memory and should be saved in Coach 7.

1. Software requirements

To collect data with WiLab you need:

- for Mac and Windows computers: the Coach 7 or Coach 7 Lite program, version 7.5 or newer, and
- for iPads, Android tablets and Chromebooks: the Coach 7 or Coach 7 Lite app, version 7.3 or newer.

Before you start using WiLab install the correct version of Coach 7, which can be downloaded from the CMA website.

[3] *Note that WiLab will accept only selected high frequencies.*

2. Connecting WiLab for the first time

WiLab is equipped with HID[4] USB for which a standard driver is available. The driver installation is automatically executed the first time WiLab is connected to the computer/tablet.

3. Establishing communication with WiLab

- Press the Power button shortly to turn WiLab on.
- The Battery LED is blinking red to show that WiLab is starting up. Bluetooth is off.
- When WiLab is connected to a USB port such connection is automatically detected. The Status LED is turning green. The device is ready to work via the USB port.
- If no USB connection is detected then the Bluetooth is automatically turned on and WiLab is advertising itself (constantly for 5 minutes) to surrounding host devices: computers, Chromebooks, and tablets. The Status LED is blinking blue.
- Start Coach 7.
- Open a ready-to-go Measurement or Control Activity or create a new Activity (in the Author mode only).
- The first time such an activity is opened Coach automatically searches for WiLabs (Bluetooth devices) nearby. When one or more WiLabs are present the connection is automatically established to the strongest, often the closest, WiLab.
- In case of creating a new Measurement Activity, by default the WiLab with the strongest signal is selected as the Interface. To see all detected WiLabs (if there are more than one) click the drop-down list behind **Interface**. The list of all WiLabs will be given. Select the desired WiLab.
- The Status LED turns blue when the Bluetooth connection is successfully established.
- Coach keeps the connection to the selected WiLab until WiLab is turned off or another WiLab is selected.

What to do when:

1. **I made a Bluetooth connection to a wrong WiLab**
   - Click the Tool menu of the Panel pane or right-click the WiLab screen panel and select **Change Interface**.
   - The list of all detected nearby WiLabs, sorted by the strength of the detected signal, from strongest to weakest, appears.

[4] *Human Interface Device*

- Select a WiLab ID from the list. Coach will bond to this selected WiLab and this WiLab will not be available anymore to other hosts.

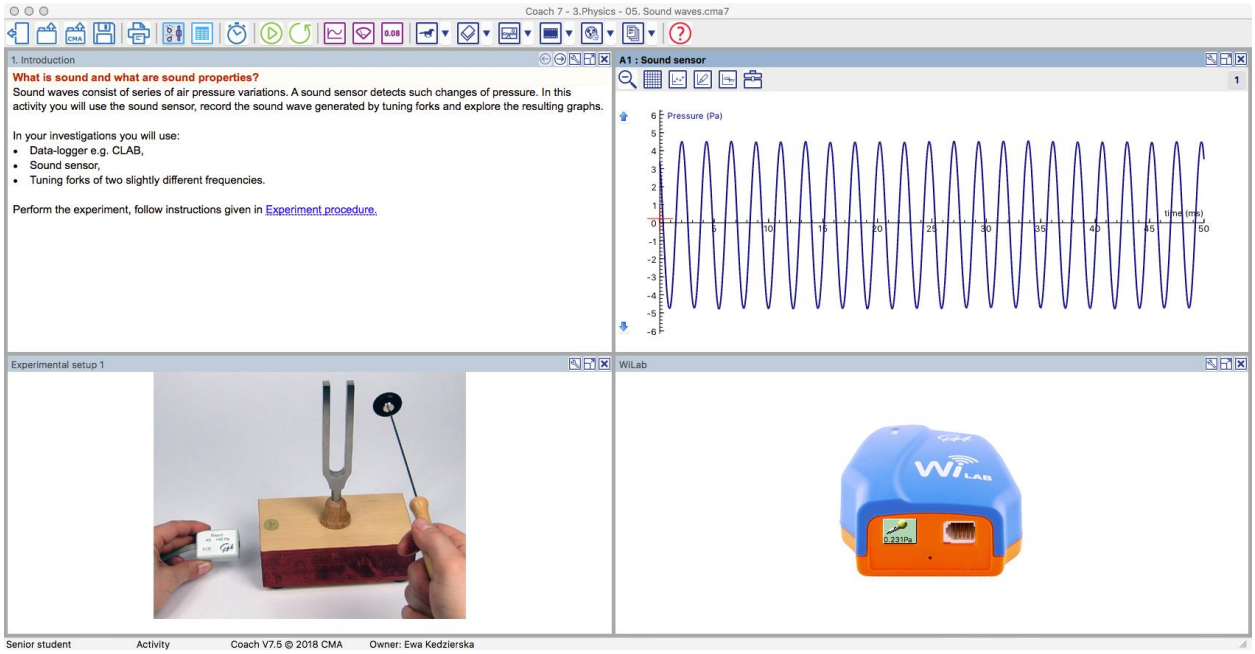
2. **I want to change communication** from the established Bluetooth communication to USB:
   - Turn off the bonded WiLab.
   - Connect to USB. WiLab turns on and automatically establishes the USB communication.
3. **Communication is lost** (no USB, no Bluetooth) and the Power LED turns red:
   - Reconnect WiLab to the USB port or briefly press the Power button to activate Bluetooth again.
   - Click the Tool menu of the Panel pane or right-click the WiLab screen panel and select **Reset Hardware**.

4. Typical measurement procedure in Coach

- Start Coach 7 or Coach 7 Lite.
- Connect WiLab to your host device via USB/Bluetooth. For detailed description on establishing the communication see the previous chapter.
- Open a ready-to-go Coach Measurement Activity[5]/Result or create a new Coach Measurement Activity (only for Authors).
- When WiLab is properly connected the WiLab screen panel is active in Coach.
- Connect sensor(s) to the sensor input(s) on WiLab.
- WiLab automatically detects the connected sensor(s) and displays the sensor icons of the identified sensors on the WiLab screen panel. Sensors, which are not automatically identified, have to be selected manually from the Coach Sensor Library.
- The measurement is executed according to the given measurement settings. Click to check these settings: measurement type, measuring time, sampling frequency and number of collected samples. Adjust these settings if needed.
- Follow the instructions given in the Coach Activity or directly start the measurement by clicking .
- In most cases, Coach automatically starts the measurement.
  - If triggering is enabled then the measurement is started automatically when the trigger conditions are met.
  - When the type of measurement is set to **Manual** then the **Manual Start** button appears in the Toolbar. Click this button to collect a single measurement. When keyboard input(s) is specified then the value of one or more quantities have to be typed in.

[5] *Tutorials and examples of Activities are available in the Coach 7 programs and apps.*

- The measurement is stopped when the specified measurement time (time-based) or specified number of samples (manual) has been reached.
  If you want to interrupt the measurements process, click the red **Stop** button or press <***Esc***>.
- Save your result to a file via the **File** menu options **Save** or **Save As…**.



5. Working with the controllable Buzzer and LED[6]

WiLab has two built-in actuators, the RGB LED and the buzzer, which can be used in simple control experiments. These actuators can be controlled manually via the WiLab screen panel or via a control program.
The WiLab screen panel, which is shown in the Control Activities displays Buzzer and LED icons, which allows to manually control these built-in actuators. By default buzzer and LED are turned off.

Buzzer

- Click the buzzer icon to turn the buzzer on, click the icon again to turn it off.
- When the buzzer is active than a slider appears on the icon. With this slider on the buzzer icon you can change the buzzer sound. Click arrows up and down to select a sound tone.

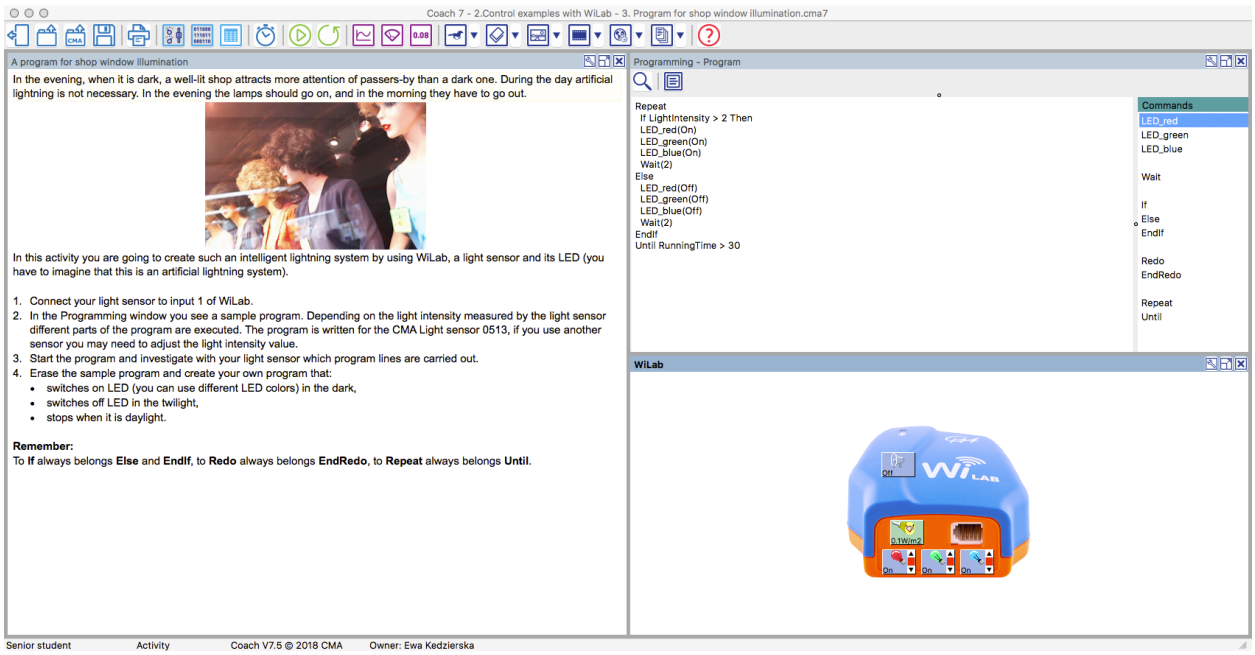
[6] *This functionality is available only on computers. It will be added to Coach 7 apps at the end of 2019.*

RGB LED

The RGB LED is located between the two sensor inputs of WiLab. Since it is possible to control colors of the RGB LED, this LED is represented by three icons: Red, Green and Blue. These icons can be used to set the color and light intensity level. The RGB LED will display the result of the settings of these LEDS.

To control each LED color:

- Click a color icon to turn the color on, click the icon again to turn it off.
- When the color is active than a slider appears on the icon. With this slider you can adjust the brightness of the selected color. Click up and down arrows to increase and decrease the color brightness.



V. TECHNICAL SPECIFICATIONS

1. Key features

PROCESSORS	PIC32MZ (512 kB SRAM)
MEMORY	128 kB of RAM 512 kB of Flash
POWER	Rechargeable battery Li-ion (3.7 V, 960 mAh) USB Power Adapter (100-240 V AC, DC 5V/1A)
STATUS INFORMATION	Power LED (rear) to indicate power and battery level Status LED (top) to indicate the communication status
CONNECTIVITY	Bluetooth® LE Insight ISP1507 ready for Bluetooth 5
COMPUTER CONNECTION	Micro USB port also used for powering
ADC RESOLUTION	12 bits
SAMPLING FREQUENCY	Max 100 000 Hz, via one input Max 50 000 Hz, via two inputs simultaneously
SENSOR INPUTS	Two sensor inputs, analog BT (right-handed) inputs
CONTROLLABLE OUTPUTS	Buzzer RGB LED, located between sensor inputs
SOFTWARE ON COMPUTER (WINDOWS, MAC)	Coach 7 Lite (free) Coach 7 (license needed), includes Author mode to create Activities for WiLab, Data-Video, Modeling and Animations
SOFTWARE ON TABLET (IPAD, ANDROID)	Coach 7 Lite (free) Coach 7 (license needed), includes Author mode to create Activities for WiLab, Data-Video, and Modeling

2. Working conditions and maintenance

For your safety and that of your equipment, follow these rules for handling and for cleaning WiLab, and for working more comfortably.

- Your WiLab is designed to be operated on a desk or hand-held.
- Your WiLab is not waterproof. Precautions must be taken to ensure that liquid cannot enter the unit.
- Do not expose WiLab to extreme heat or cold sources and to direct sunlight for extended periods of time.
- Operating WiLab outside the following ranges may affect performance:
    - Temperature: 5° to 40° C.
    - Relative humidity: 0 % to 90 % (noncondensing)
- Never force a connector into a port. When connecting a sensor, make sure that the sensor cable connector matches the sensor input, and that you have positioned the connector correctly.

- When cleaning WiLab, first turn it off and unplug the connected sensors and USB cable. Then clean with a soft, lint-free cloth. Avoid getting moisture in any openings. Do not spray liquid directly on WiLab.
- When charging the battery always use the provided USB power adapter.
- When replacing the battery, only use a WiLab replacement battery pack supplied by CMA. Make sure to handle it gently. Rough handling may cause the battery damage. Do not pull on wires. Pull only from the connectors at the ends of the wires. Dispose your old battery appropriately.

3. Warranty

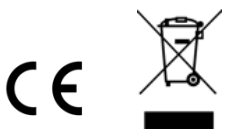
WiLab is warranted to be free from defects in materials and workmanship for a period of 24 months from the date of purchase provided that it has been used under normal laboratory conditions. This warranty does not apply if WiLab has been damaged by accident or misuse.
The WiLab battery is a consumable and is warranted to be free from defects in materials and workmanship for a period of 12 months from the date of purchase.

4. Battery precautions

- Do not place the battery in or near fire, on stoves or other high temperature locations such as direct sunlight. Doing so may cause the battery to generate heat, explode or ignite, or generate a toxic gas if placed in contact with fire.
- In the event the battery leaks and the fluid gets into one's eye, do not rub the eye. Rinse well with water and immediately seek medical care. If left untreated, the battery fluid could cause damage to the eye.
- Discard batteries according to local regulations.

5. Safety Information

WiLab is developed and produced in conformity with CE regulations.
This product shall be handed over to your local community waste collection point for recycle of the products.



This product is to be used for educational purposes only.
It is not appropriate for industrial, medical, research, or commercial applications.