ULAB DATALOGGER
USER'S MANUAL
DESCRIPTION D007

Figure. The **U**LAB datalogger

For our international customers…
Check the CMA International website (www.cma.science.uva.nl/english) for the latest version of this manual, updates of the **U**LAB firmware, and updates of Coach 5 software products.

Aan onze Nederlandse gebruikers…
ULAB wordt standaard uitgeleverd met Engelse firmware en Engelse handleiding.
U kunt de laatste versie van de Nederlandse **U**LAB-handleiding en de **U**LAB-firmware, en de nieuwste update van Coach 5 downloaden van de CMA-website (www.cma.science.uva.nl), rubriek 'Ondersteuning'.

ULAB User's Manual v1.1 (for firmware version 1.01), Rev. September 23, 2003

Authors: Ewa Mioduszewska, Vincent Dorenbos

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I. Introduction

ULAB is an easy to use, portable, graphic data collection system, which can be used in a variety of ways in the classroom or in the field. It can be used:
- as a versatile multimeter, for direct display of physical quantities measured by sensors connected to **U**LAB;
- as a stand-alone datalogger for measurements independent of the computer with real-time display of measured data on the **U**LAB screen;
- as an interface connected to a PC computer with real-time display of measured data on the computer screen.

The **U**LAB datalogger is equipped with *FLASH* memory, which allows easy updating of the internal operating system software (firmware), the operating language and the sensor library. It allows storing up to 250,000 measurement points (512 KB) in multiple sets of data. The system can sample up to 6 sensors simultaneously, in sampling rates as high as 100,000 samples per second. A wide variety of sensors is available for connection to **U**LAB.

Reading directions for this manual

Chapter II provides all basic information about **U**LAB and its components.

Chapter III describes the use of **U**LAB as a stand-alone datalogger.

Chapter IV describes the use of **U**LAB with the computer and the Coach software.

Chapter V describes the utility programs to display **U**LAB's screen image on the computer and to update **U**LAB's firmware.

Chapter VI provides detailed technical specifications of **U**LAB.

Read Chapter VII in case of troubles …

Appendix I lists all CMA sensors available for **U**LAB

Appendix II lists the sensors available in **U**LAB's sensor library

Appendix III provides a Quick Start Reference for experienced users.

II. Getting acquainted

In this chapter you can learn basic operations of **U**LAB like the functions of the buttons, providing power, connecting sensors.

1. ULAB components

The **U**LAB package contains of the following items:
- **U**LAB datalogger
- Power supply
- USB cable
- PC serial cable
- Carrying bag
- User's Manual.

The **U**LAB datalogger is provided with:
1. A graphical LCD display consisting of 128 by 64 pixels;
2. A keypad with 10 buttons;
3. Four analog inputs to connect sensors with BT (*British Telecom)* plugs. These inputs have two measurement ranges between 0 and 5 V or between -10 and 10 V. All inputs can be used simultaneously as counter inputs;
4. Two digital inputs to connect ultrasonic and digital sensors;
5. A bus for the USB connection;
6. A bus for the serial port connection;
7. A bus for the external power supply.
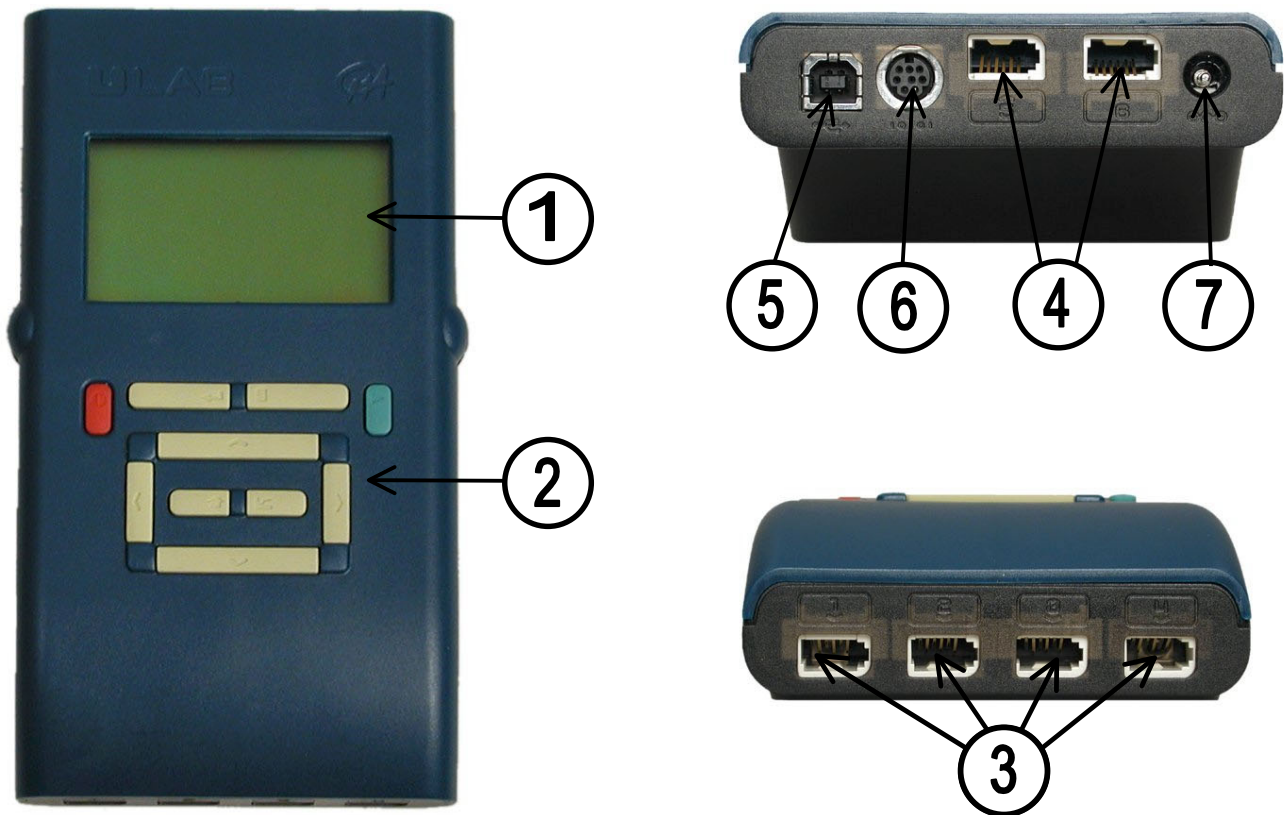
Figure. The different parts of **U**LAB (top view, rear view & front view). The numbers refer to the text.

2. ULAB's buttons

The **U**LAB keypad consists of the following buttons:
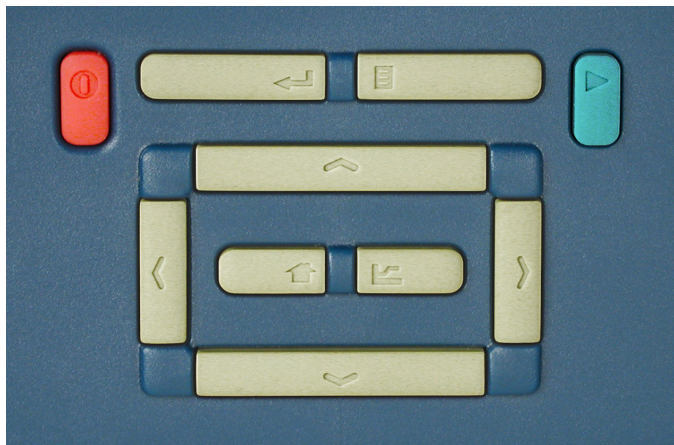
Figure. ULAB's keypad

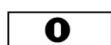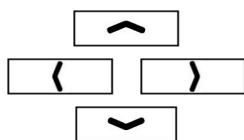|	
0	ON/OFF button for turning power on and off. This button is sunk to prevent pressing it by accident. To turn ULAB off, keep this button pressed about 3 seconds before releasing. When this button is pressed briefly, then it functions as the ESC button in menus and selection lists.
↵	SELECT/CONFIRM button for activating highlighted items
☰	MENU button for activating and closing a menu
▶	RUN button for starting and stopping a measurement
🏠	HOME button for returning to the Home Screen
⊾	GRAPH button for turning the graph on and off
⌃ ⟨ ⟩ ⌄	ARROW buttons for navigation: up, left, right and down

3. ULAB's operating system

ULAB is equipped with internal operating software (firmware). This menu-driven operating system can be used to select sensors, setup measurements, record and view the measured data.

The firmware is stored in FLASH memory that does not lose its storage capabilities when power is removed or lost. During normal operation, the user cannot change the information stored there. The FLASH technology, however, allows easy update of ULAB's operating system with the most recent version.

As new functionality becomes available, you can download the software from the CMA website to your computer and update your ULAB. Check the CMA website (www.cma.science.uva.nl/english) for updates. Directions for downloading and updating are given in Chapter V.

4. Computer and software requirements

To use ULAB with the computer you need the Coach 5 version 2.3 software running on a Pentium II computer with Windows 95/98/2000/XP or NT system software with at least 32 MB RAM and unused serial or USB port.

5. Attaching ULAB to the computer

ULAB's computer connection busses are located at its rear side.

5.1 Serial connection

- Plug the round mini-DIN end of the serial cable into the serial bus on ULAB.
- Plug the other end (9-pin plug) of the cable into the serial port on the computer.

ULAB supports the following baudrates: 9600, 19200, 38400, 57600 and 115200 (default baudrate). If you want to change the baudrate or the COM port number, you can do it during installation of the Coach software, or later, in the main menu of Coach, under the option *Tools>Install hardware drivers*.

5.2 USB connection

- Plug the square end of the USB cable into the USB bus on ULAB.
- Plug the other end of the USB cable into the USB port on the computer.

Coach automatically detects USB connection. It is not necessary to specify any hardware settings.

6. Providing power to ULAB

ULAB is powered by internal rechargeable batteries (located at the bottom of ULAB) or by AC power. When the external power adapter is not connected then ULAB uses its batteries.

To use **U**LAB with the AC power supply:
- Plug the round plug of the power adapter into the bus on the rear side of **U**LAB.
- Plug the power supply into the outlet.
- The batteries must be inside other way **U**LAB will not function.

The batteries are automatically charged after plugging the power supply into the outlet. The batteries are also charged when **U**LAB is connected to the USB port on the computer. In this case the charging process is slower than when using power supply. Depending on the type and number of used sensors **U**LAB functions between 4 and 10 hours on a single battery charge.

Warning: Use **only** the included 5-V power supply otherwise **U**LAB can be damaged.

7. Connecting sensors

Analog and digital sensors can be connected to inputs of **U**LAB. All inputs can be used simultaneously.

7.1 Analog sensors

Four input channels for analog sensors (CH1 – CH4) are located at the front side of **U**LAB. The analog channels accept British Telecom-style plugs with a right-hand connector[1]. All inputs have 2 measurement ranges: 0 to 5V and –10 to 10V.

7.2 Counters

All analog inputs of **U**LAB can be used (simultaneously) as counter inputs. Sensors which generate pulses such as the Geiger-Müller Ionizing Radiation Sensor (CMA art. nr 029) or the Smart Pulley (CMA art. nr. 0386) can be directly connected to these inputs.

Sometimes it is useful to count signal changes of an analog sensor as pulses, e.g. to measure how often the screen is refreshed (using a light sensor as counter) or to measure the rate with which your heart-beats (using a heartbeat sensor as a counter). With **U**LAB it is possible to define analog sensors as counters. If the analog signal of such a sensor crosses a specified value (threshold) in a predefined direction, the counter is incremented by one.

7.3 Digital sensors

Two input channels for digital sensors (CH5 and CH6) are located at the rear side of **U**LAB. Two digital sensors or two Ultrasonic Motion Detectors can be connected to these inputs. The digital channels accept British Telecom-style plugs with a left-hand connector. Notice that analog and digital sensors are "keyed" differently, preventing them from being connected to the wrong port.

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[1] All CMA sensors purchased after January 2001 are provided with British Telecom plugs and can be connected directly to ULAB.

7.4 Sensor recognition

ULAB automatically identifies sensors when they are connected to **U**LAB input channels and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor. This greatly simplifies the setup procedures for many experiments. **U**LAB recognizes *Intelligent* and *Auto-id* sensors[2].

- An *Intelligent sensor* has a memory chip with information about the sensor. Through a simple protocol (I^2C) the sensor communicates with **U**LAB and transfers its data (name, quantity, unit and calibration) to the datalogger.
- An *Auto-id sensor* is equipped with a specific sensor resistor, which allows automatic identification of the sensor and using proper sensor data.

When a sensor is physically plugged into an input channel of **U**LAB then **U**LAB automatically detects the sensor and acts as follows:

- **U**LAB recognizes the connected sensor as an *Intelligent* sensor and displays calibrated signal values measured by the sensor. User can overrule this setting by selecting another sensor from the **U**LAB Sensor Library. (See chapter III, § 4.1).

or

- **U**LAB recognizes the connected sensor as an *Auto-id* sensor with sensor information stored in the **U**LAB Sensor Library and displays calibrated signal values measured by the sensor. User can overrule this setting by selecting another sensor from **U**LAB's library. (See chapter III, § 4.1).

or

- **U**LAB recognizes the connected sensor as another type of sensor (*Auto-5V* or *Auto-10 V*) and displays signal voltage values measured by the sensor. To calibrate the measured signal the user has to select the proper sensor from **U**LAB's Sensor Library.

When a sensor is physically disconnected from **U**LAB then it acts as follows:

- **U**LAB stops to display signal values of detected sensors (*Intelligent, Auto-id, Auto-5V* and *Auto-10V* sensors)

or

- **U**LAB keeps displaying signal values of user-selected sensors. The values remain in the screen and can be removed only by selecting the option *None* from **U**LAB's Sensor Library.

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[2] The complete list of sensors can be found in Appendix 1.

## III. Using ULAB as a stand-alone datalogger

ULAB is able to collect and store measurement data independently of the computer. This is very useful for remote data collection e.g. outside the school. Setting up an experiment is easy and can be performed completely via **U**LAB's keypad. The measurement results are presented on **U**LAB's display in the form of a graph or a table.

As a standalone device **U**LAB can work in two modes:
1. *Multimeter mode* - in this mode, **U**LAB displays the actual measured values of connected sensors as (large) digits or in graphical form. Measurements are not stored.
2. *Logging mode* - in this mode experiments can be setup and performed. Measurements are stored in **U**LAB's memory.

Both modes and their **U**LAB's Screens are described in §2 and §3 of this chapter. In §4 is described how to setup experiments with **U**LAB. As a start an overview is given of a typical measurement procedure with **U**LAB.

1. Quick measurement procedure with ULAB

1. Press ⬜**O**⬜ to switch **U**LAB on.
   After the introductory screens the Home Screen appears. **U**LAB is in Multimeter mode.
2. Connect sensors to input channels of **U**LAB.
   In Multimeter mode **U**LAB constantly checks its input channels and detects connected sensors. Depending on the type of connected sensor **U**LAB displays:
   - calibrated values for *Intelligent* sensors, and for *Auto-id* sensors defined in the local **U**LAB Sensor Library[3];
   - voltage values for other sensors. To display calibrated values, select the sensor from **U**LAB's Sensor Library: highlight the channel to which the sensor is connected, press ⬜↵⬜ and select the sensor.
3. In Multimeter mode real-time measured values are displayed. Data are presented in a digital form in the Home Screen or after pressing ⬜⬔⬜ in a graphic form in the Multimeter Graph Screen. In this mode data are **not** stored.
4. If you want to store the measured data, press ⬜▶⬜. **U**LAB collects data according to the Experiment settings. The default Experiment settings are a time-based measurement with a time span of 10 s and a sample rate of 50 samples per second. You can interrupt data collection before the measuring time is reached by pressing ⬜▶⬜ again or by pressing briefly ⬜**O**⬜.
5. The measured data are displayed in a table. Use ⬜⬔⬜ to toggle between the table and the graph. Use the cursor keys to scroll through the data in the table or to scan

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[3] The default sensor library in **U**LAB is described in Appendix II.

the data in the graph after the measurement is finished.

6. To repeat your measurement, press ⬛▶. The measurement data of a previous run are stored automatically in a data file named Run# (where # is a number between 1 and 99). See §4.3 for deleting data files.

7. Press ⬛🏠 to return to the Home Screen.

8. Press ⬛⊟ to activate the Experiment-Settings Menu where you can change the measurement settings and view stored data. (See §4.1).

2. Multimeter Mode

After turning ULAB on, it displays briefly the Title Screen and the Help Screen. After it the Home Screen appears. ULAB is in the multimeter mode and automatically detects connected sensors, identifies the channels to which they are connected, loads calibrations for recognized sensors and shows the current readings. Readings of active channels are updated with frequency of 4 Hz. The real-time displayed data are not stored in ULAB's memory.
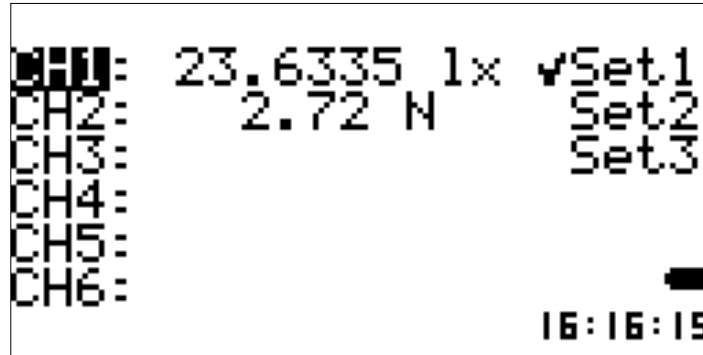
2.1 The Home Screen

The Home Screen is the main screen of ULAB. It is the central point of ULAB operation. Pressing ⬛🏠 always brings you back to the Home Screen except during the measurement runs.

In the Home Screen, a *cursor* can be moved with ⬛⌃ / ⬛⌄ / ⬛⟨ / ⬛⟩ to highlight any item in the screen. The figure on the next page shows the Home Screen layout and a description of all screen elements.

In this Screen the additional user interactions can be performed:

- By pressing ⬛↲ the Multimeter Graph Screen opens where the real-time collected data are displayed in a graph.
- By pressing ⬛⊟ the Experiment-Settings Menu opens. This menu allows viewing and modifying Experiment settings. If a computer set is active [✓Set#] then its settings are displayed.
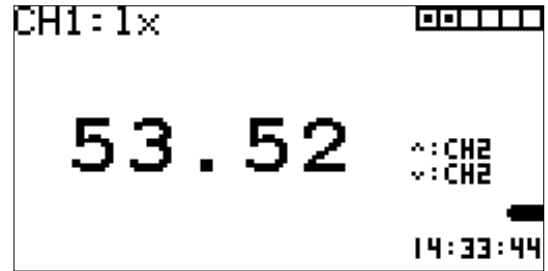
| LEFT the listing of all input channels [CH1], [CH2], …[CH6]	MIDDLE the real-time signals of the connected sensors e.g. [23.6335 lx]	RIGHT the computer Experiment settings indicated as [Set1], [Set2], [Set3]
Pressing ⏎ when a channel is highlighted activates **U**LAB's Sensor Library. This is only necessary for sensors that are not automatically recognized by **U**LAB. **U**LABs Sensor Library consists of 42 predefined sensors (see Appendix 2). To select a sensor from the sensor library: - highlight a desired channel with ⌃ / ⌄ - activate the library with ⏎ - highlight a sensor in the library with ⌃ / ⌄ - confirm selection with ⏎.	*Intelligent* sensors are automatically recognized and their calibrated signals are displayed. A*uto-id* sensors are automatically recognized if they are defined in **U**LAB's Sensor Library. Then calibrated signals are displayed. Other sensors are automatically detected and their voltage signals are displayed. These sensors have to be defined by selecting the calibration information from **U**LAB's Sensor Library (see description in the left column). Pressing ⏎ when a signal value is highlighted activates the Large Digits Screen.	This part of the screen is activated only when Experiment settings have been uploaded from the computer. The experiment settings consist of measurement method, measurement settings and sensor information. Maximal 3 Experiment settings can be uploaded to **U**LAB. Pressing ⏎ when a set is highlighted activates the set [✓Set#] and its settings. Pressing ⏎ when an activated set is highlighted deactivates it [Set#]. At the bottom, right corner of the **U**LAB screen, the following items are displayed: - the computer connection indicator - the battery indicator - the clock.

2.2 The Large Digits Screen

The Large Digits Screen displays the real-time measured values with large digits. To open this screen:

1. If needed press ⬆ to return to the Home Screen.
2. Highlight a sensor signal value with ⌃ / ⌄ / ⟨ / ⟩.
3. Press ↵.

```
CH1:1x                    ⊡□□□□□
        53.52           ^:CH2
                        v:CH2
                           ▬
                        14:33:44
```

At the right side of the screen some extra information like the sensor connections display[4], the battery indicator, and the clock, are displayed. In this Screen the following user interactions can be performed:

- By pressing ⊟ the Large Digits Menu opens.
- By pressing ⌃ / ⌄ the displayed value cycles among the signals of the connected sensors.
- By pressing ⊑ the Multimeter Graph Screen can be toggled on and off.
- By pressing ⬆ the Home Screen returns.

The Large Digits Screen has its own specific menu that appears after pressing the Menu ⊟ button. This menu consists of the following options:

[Dgt] - to specify the number of decimal digits to display:
   1. Highlight [Dgt] with ⌃ / ⌄.
   2. Select it with ↵.
   3. Select a number from the selection list: [0], [1], [2], [3] or [4].
   4. Confirm with ↵.

[MnMx] - to turn on and off an extra display with information about a measured signal:
   1. Highlight the value of the [MnMx] option (either [On] or [Off]) with ⌃ / ⌄.
   2. Select it with ↵. When [On] is selected then the following items appear:
      MIN: - the minimum signal value with respect to a reset point
      MAX: - the maximum signal value with respect to a reset point
      AVG: - the average signal value with respect to a reset point.
   3. Use [Reset] to reset the time moment from which minimum, maximum or average values are determined.

The Large Digit Screen Menu closes by pressing ⊟ again.

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[4] On the sensor connections display the following symbols are used: ⊡ - indicates an active channel, □ - indicates a non-active channel, ⊔ - indicates a trigger channel, ■ - indicates a pulse source channel.

2.3 Multimeter Graph Screen

The Graph Screen in Multimeter mode graphs the real-time measured signals. The displayed data are not stored. To open the Graph Screen:

1. If needed press [▲] to return to the Home Screen.
2. Press [↵].
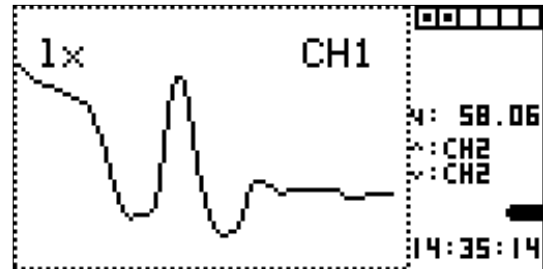
The graph shows how the signal varies over time. By default, the y-axis displays the maximum range of the sensor.

At the right side of the screen some extra information like the sensor connections display[5], the battery indicator, and the clock, are displayed. In this Screen the following user interactions can be performed:

- By pressing [≡] the Graph Menu opens.
- By pressing [▲] / [▼] the displayed graphs cycles among the signals of the connected sensors.
- By pressing [↵] the Large Digits Screen can be toggled on and off.
- By pressing [▲] the Home Screen returns.

The Graph Screen has its own specific Graph Menu that appears after pressing [≡]. This menu consists of the following options:

[Zoom] - to zoom the graph (only works in vertical direction):
1. Highlight [Zoom] with [▲] / [▼].
2. Select it with [↵]. The cursor starts to blink.
3. Zoom the graph in or out with [▲] / [▼]. Confirm with [↵]. It can happen that the graph disappears from the screen. Use [Move] to place the graph back on the screen.

[Move] - to move the graph:
1. Highlight [Move] with [▲] / [▼].
2. Select it with [↵]. The cursor starts to blink.
3. Move graph up or down with [▲] / [▼]. Confirm with [↵].

[Reset] - to return the graph setting to its default values:
1. Highlight [Reset] with [▲] / [▼].
2. Select it with [↵]. When the message: **[Reset Done]** appears, the graph is set back to its default settings.

The Multimeter Graph Menu closes by pressing [≡] again.

---

[5] See footnote 4, page 15.

3. Logging mode

After pressing the Run [▶] button, ULAB starts to collect data according to the Experiment settings (detailed description in the next paragraph).

For triggered measurements the measurement starts automatically when trigger conditions are fulfilled.

For the manual type of measurements, the message [Press [↵] To Take a Sample] appears. Every time you press [↵], a single reading is taken.

The Run [▶] button works only in the Home Screen, the Large Digits Screen and the Multimeter Graph Screen. The measurement can be interrupted at any time by pressing [▶] again or pressing briefly [O].

During a measurement the data are displayed by default in the table. Pressing [↖] displays the graph. The clock displays the lapsed measurement time. The data of each measurement are stored automatically in ULAB's memory in a Run data file. The ULAB memory can contain up to 99 Run files. These files are accessible from the [Data] tab of the Experiment-Settings Menu.

3.1 The Table Screen

The Table Screen displays the data stored according to the Experiment settings. This screen opens automatically after starting the measurement.

At the right side of the Table Screen some extra information like the sensor connections display[6], the number of a current run, the battery indicator, and the clock, are displayed.

i	t:s	CHI:1x	
493	9.840	25.880	
494	9.860	25.782	Run8
495	9.880	25.782	
496	9.900	25.782	
497	9.920	25.636	::CH2
498	9.940	25.733	>:CH2
499	9.960	25.684	
500	9.980	25.782	
501	10.000	25.782	00:00:10

In this Screen the following user interactions can be performed (after the measurement is finished):

- By pressing [▤] the Table Menu opens.
- By pressing [⌄] / [⌃] one can scroll through the data in the table. By keeping the button pressed scrolling will go faster.
- By pressing [〈] / [〉] the displayed sensor column cycles among the signals of the connected sensors.
- By pressing [↖] the Graph Screen can be toggled on and off.
- By pressing [⌂] the Home Screen returns.

The Table Screen has its own specific menu that appears after pressing [▤]. This menu consists of the following options:

[Time dgt] - to specify the number of decimal digits for the time column display:
1. Highlight [Time dgt] with [⌃] / [⌄].
2. Select it with [↵].

---

[6] See footnote 4, page 15.

     3. Select a number from the selection list: [0], [1], [2], [3] or [4].

     4. Confirm with ⏎.

[CH dgt] - to specify the displayed number of decimal figures in the sensor column display:

     1. Highlight [CH dgt] with ⌃ / ⌄.

     2. Select it with ⏎.

     3. Select a number from the selection list: [0], [1], [2], [3] or [4].

     4. Confirm with ⏎.

The Table Menu closes by pressing ▤ again.

3.2 The Graph Screen

The Graph Screen displays the data stored according to the Experiment settings. To open this screen:

1. Press the Run ▶ button to start a measurement.

2. In the Data Table Screen press the Graph ⬑ button.
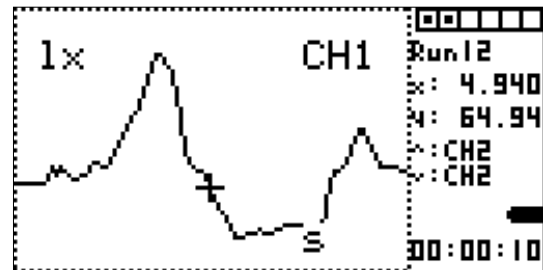
At the right side of the Graph Screen some extra information like the sensor connections display[7], the number of a current run, the coordinates of a selected point, the battery indicator, and the clock are displayed. In this Screen the following user interactions can be performed (after the measurement is finished):

- By pressing ▤ the Graph Menu opens.
- By pressing ⌃ / ⌄ the displayed graph cycles among the connected sensors.
- By pressing ⟨ / ⟩ the cross cursor can be moved along the graph to read coordinates of measurement points. The coordinates of the selected point (x,y) are displayed at the right side of the screen.
- By pressing ⬑ the Table Screen can be toggled on and off.
- By pressing ⌂ the Home Screen returns.

The Graph Screen has its own specific Graph Menu that appears after pressing the Menu ▤ button. This menu is very similar to the Multimeter Graph Menu with some small differences in the Zoom function.

    [Zoom] - to zoom a selected part of the graph:

     1. Highlight [Zoom] with ⌃ / ⌄.

     2. Select it with ⏎. The cursor starts to blink.

     3. Move the cross cursor to the point around which you want to zoom out.

     4. Zoom graph in with ⌃ (vertical) / ⟩ (horizontal) or zoom out in with ⌄ (vertical) / ⟨ (horizontal). Confirm with ⏎ when you are ready. It

---

[7] See footnote 4, page 15.

can happen that during zooming the graph disappears from the screen. Use the [Move] option to place the graph back on the screen.

[Move] - to move the graph:
1. Highlight [Move] with [⌃] / [⌄].
2. Select it with [↵]. The cursor starts to blink.
3. Move the graph with [⌃] / [⌄] / [❮] / [❯].
4. Confirm with [↵].

[Reset] - to return the graph setting to its default values:
1. Highlight the [Reset] option with [⌃] / [⌄].
2. Select it with [↵]. When the message: [Reset Done] appears, the graph is set back to its default settings.

The Graph Menu closes by pressing [▤] again.

4. Preparing Experiment Settings

The measurements are stored according to the experiment settings, which consist of:
- sensor information (which sensor is connected to each channel)
- the measurement method (time-based, event-based or manual)
- the measurement settings (measuring time, sample rate and trigger conditions).

The Experiment settings can be prepared manually directly on ULAB by using its buttons. The default ULAB Experiment settings are:
- Sensors: sensors detected by ULAB or selected from the ULAB sensor library
- Measurement mode: Time-based measurement
- Time span: 10 s
- Sample rate: 50 per s.

The experiments settings can also be prepared on the computer by using the Coach software to define settings and upload them to ULAB. This procedure is described in *Chapter IV. Using ULAB with a computer*.

To open the Experiment Settings Menu:
- If needed press [⌂] to return to the Home Screen.
- Press [▤].

The Experiment Settings Menu consists of three tabs:
1. /Sensors\ - for viewing and defining sensors and their connections,
2. /Method\ - to select the measurement method and prepare measurement settings,
3. /Data\   - for management of the data files [Runs].

Use [❯] / [❮] to highlight one of the tabs. Its menu appears below the tab bar. To change a menu item:
- Highlight the item with [⌃] / [⌄] / [❮] / [❯].
- Press [↵].
- Select the value/item from the selection list and confirm with [↵].

4.1 Sensors

The /Sensors\ tab opens the Sensors Menu in which sensor connections can be viewed or modified, sensors can be selected and the function of each channel can be defined.

```
/Sensors\Method Data
CH1:Light 0-200    anl
CH2:Force5N 0362   anl
CH3:
CH4:
CH5:
CH6:
```

In this Screen all channels are listed. A brief description of the connected sensors appear behind the channel name.

To change a sensor connection or add a sensor connection:

- Highlight the desired channel [CH1], [CH2] … or [CH6] with ⌃ / ⌄ .
- Select with ↵ . The **U**LAB Sensor Library appears.
- Highlight the desired sensor with ⌃ / ⌄ .
- Confirm the selection with ↵ .

The Analog input channels [CH1], [CH2], [CH3], [CH4] can have three functions:

1. Analog channel [anl] - to display the analog value measured by sensor.
2. Counter [cnt]   - to display the number of pulses counted by the sensor.
3. Frequency [frq]   - to display the frequency of pulses counted by the sensor.

The channel function is displayed behind the sensor description. To modify a channel function:

- Highlight the 3-letter function descriptor with ⌄ / ⟩ .
- Select with ↵ . A selection list appears.
- Highlight the desired function and confirm with ↵ . After selecting the [Counter] or [Frequency] options, additional items regarding the pulse definition appear:
    - The threshold value, which the signal has to pass to be counted (by default 50% of the sensor's measurement range)
    - The direction in which the threshold should be passed (by default increasing ↑).
    Highlight an option and select the value (in % of the sensor's measurement range) or direction ([up], [down], [both]) from the selection list.

4.2 Method

The /Method\ tab opens the Measurement Setting Menu which allows selecting the measurement type and measurement settings. Every measurement type has its own specific settings.

To select a measurement type:

1. Highlight the value of the option [Type] with ⌃ / ⌄ .
2. Select with ↵ . The Measurement Type Menu appears. There are three measurement types available [TimeBased], [EventBased] or [Manual].
3. Highlight the desired option with ⌃ / ⌄ .
4. Confirm with ↵ . Which menu options will appear depends on the selected measurement type.

Time-based measurement

Time-based measurement is a measurement type in which the readings are taken at regular time intervals according to the sample rate (the number of measurements per unit of time). Time is the independent variable; the measured quantities are the dependent variables. Most measurements (approx. 90%) are of this type.

With trigger settings you can specify signal conditions for one channel from which ULAB automatically can start a measurement. There are two trigger settings, which completely determine the state of the signal on the trigger channel:

- the trigger level of the signal
- the trigger direction at which the signal passes the trigger level.

Once the measurement is started (by pressing ▶), ULAB starts recording when the trigger settings are fulfilled. When triggering is used it is possible to log also a number of samples before the trigger settings are fulfilled. For this option you can specify which percentage of the total time should be the pre-trigger time.

The Time-based measurement menu consists of the following options:

```
           /Method\
Type: TimeBased
TimeSpan:  10  s
SampRate:  50  per s
TriggerChannel:None
```

[TimeSpan] - to set the duration of the measurement time (the value and unit have separate selection lists)

[SampleRate] - to set the sample rate (the value and unit have separate selection lists)

[TriggerChannel] - to select a Trigger channel and define Trigger conditions. By default the measurement is not triggered, the option [None] is selected. To define the trigger settings:

1. Highlight [None] with ⌃ / ⌄.
2. Select it with ↵. The selection list displays a list of active channels.
3. Select the trigger channel with ⌃ / ⌄ and confirm with ↵.
4. Now additional options appear to set the trigger direction ([↑ (up)],

```
           /Method\
Type: TimeBased
TimeSpan:  10  s
SampRate:  50  per s
TriggerChannel:CH1
Direction:↑
Level:50%
PreTriggerTime:0%
```

[↓ (down)], [↕ (both)], the trigger level (value in % of the total sensor measurement range) and the pre-trigger time (in % of the total time span).

Event-based measurement

Event-based measurement is a measurement type in which readings are taken each time a pulse (event) is received on a given input channel. The pulse is the independent variable; time and the other measured quantities are the dependent variables. It is possible to change the pulse settings, i.e. to specify the conditions when a signal is considered to be a pulse. An example of such an experiment is a titration experiment in which the falling droplets generate pulses, at which moment the pH or temperature is

measured.

The measurement is stopped when the specified number of samples is reached or when the maximum duration is reached.

The Event-based measurement menu consists of the following options:

[PulseSource] – to specify the pulse settings:
1. Highlight [None] or [CH#] with ⌃ / ⌄ .
2. Select it with ⏎ . The selection list displays a list of active channels.
3. Select the pulse source channel and confirm with ⏎ . Now additional options appear in the menu to set the threshold direction ([↑ (up)], [↓ (down)], [↕ (both)] and threshold level (in % of the total sensor measurement range).

[Nr Events] - to set the number of samples to be measured.

[Max Time] - to set the maximum duration for the measurement (the value and unit have separate selection lists).

```
          /Method\
Type:EventBased
PulseSource:CH1
Direction:↑
Level:50%
Nr Events:10
Max Time:100 s
```

Manual measurement

Manual is a measurement type in which a single sample is measured (for all channels) each time the Select button ⏎ on **U**LAB is pressed. The measurement is stopped when the specified number of samples is reached or when the maximum duration is reached.

```
          /Method\
Type:Manual
Nr of Samples:10
Max Time: 10 min
```

The Manual measurement menu consists of the following options:

[Nr of Samples] – to specify the number of manually taken samples.

[Max Time] - to set the maximum duration for the measurement (the value and unit have separate selection lists).

4.3 Data

The /Data\ tab opens the Data Menu in which the available memory can be checked and stored data can be viewed, selected and removed.

In the screen the status of the **U**LAB memory and all data files (Runs) are listed. Each data file is stamped with its size, date and time of recording.

```
Sensors Method/Data \
Free Memory 96%
Run9  0.5k  0306  15:33
Run8  0.5k  0306  15:32
Run7  0.3k  2205  09:39
Run6  1.0k  2205  09:25
Run5  0.2k  2005  18:50
Run4  0.5k  2005  18:48
```

To clear **U**LAB's memory:
1. Highlight [Free Memory] with ⌃ / ⌄ .
2. Select with ⏎ . The menu with the following options appears:
   [Delete All] – to remove all data files
   [Del Older Than 1 Day] – to remove data files older than 1 day

    [Cancel] – to return to the Data Menu without deleting any data.
To view or delete a data file:
1. Highlight the desired [Run] file with ⌃ / ⌄.
2. Select with ↵. The menu with the following options appears:
    [Graph] – to display the data in the graph
    [Table] – to display the data in the table
    [Info Sensors] – to display an overview of sensor connections
    [Delete] – to delete the data file
    [Cancel] – to close this menu.
3. Highlight the desired option with ⌃ / ⌄. Confirm with ↵. What will happen depends on the selected option:
    – Selecting [Graph] displays the graph of the selected data file. User options available on this screen are described in Chapter IV, § 2.2.
    – Selecting [Table] displays the graph of the selected data file. User options available in this screen are described in Chapter IV, § 2.1.
    – Selecting [Info Sensors] displays an overview of sensors and its connections of the selected data file. Pressing briefly ⊙ closes this overview.
    – Selecting [Delete] removes the selected Run from the list with all Runs.
    – Selecting [Cancel] closes menu and returns to the Data Menu.
Depending on the size of the data file ULAB can contain up to 99 runs. The files are numbered from 1 to 99; RUN1 is the oldest file.

5. Other ULAB settings

5.1 The Clock Screen

ULAB is equipped with an internal clock. The time is displayed in the lower right corner of most ULAB Screens. To set the date and clock:

```
DataLogger CMA
Version:V0.45
Date:36-06-2003
Time:16:12:23


Restore Defaults
```
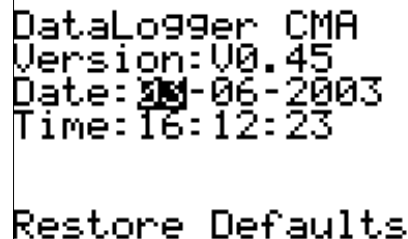
1. Turn ULAB on.
2. When the Title Screen appears press ⊟. The Clock Screen appears.
3. Highlight a date or time element with ⌃ / ⌄ / ⟨ / ⟩.
4. Press ↵. The cursor starts to blink.
5. Select the desired value with ⌃ / ⌄ and confirm with ↵.
6. Repeat this procedure for all items.

To restore ULAB's factory settings proceed as follows:
1. Select the option [Restore Defaults].
2. Confirm with ↵.
3. Press ▲ to return to ULAB's Home screen.
With this procedure the memory of ULAB will be erased, including the measurement runs, the user-made Experiment settings and the computer Experiment settings (if uploaded).

5.2 The Help Screen

After the Title Screen **U**LAB displays its Help Screen for few seconds. To keep the Help Screen, press ⬛ when the Screen is active. Press ⬛ to open the Home Screen.

```
↵     select / confirm
⊟     menu on/off
▶     start / stop
▮     home screen
⊵     graph on/off
◆◆▸   left up down right
```

6. Tutorial: temperature measurement with ULAB

Using this step-by-step tutorial you can perform your first measurement with **U**LAB. This tutorial guides you through a simple measurement with a temperature sensor.

Materials

- **U**LAB
- CMA Temperature sensor (art. nr 0511) which is an auto-id sensor
- 250-ml beaker and 100 ml hot water

Measurement procedure

1. Turn **U**LAB on by pressing ⬛. **U**LAB displays its introductory Screens followed by the Home screen.
2. Plug the CMA Temperature sensor (0511) into input channel 1. **U**LAB automatically identifies the temperature sensor and displays the sensor readings in °C.
3. To see the real-time graph press ⬛. The data are not stored in the memory yet.
4. Press ⬛ to return to the Home Screen.
5. Fill a beaker with hot water and place the temperature sensor in the water.
6. Press ⬛ to start a measurement. **U**LAB records data according to its default measurement settings (a time-based measurement with a time span of 10 s and a sample rate of 50 samples per second). The measurement stops as soon as the time span is reached. You can interrupt the data collection earlier by pressing ⬛ again.
7. During the measurement the data are displayed in a table. Press ⬛ to toggle between the measurement table and the measurement graph.
8. Use the cursor keys to scroll through the data in the table or to scan the data in the graph.
9. Evaluate your results. If needed you can change the Experiment Settings by pressing ⬛ in the Home Screen.

IV. Using ULAB with a computer

To use ULAB in combination with a computer you need a PC computer with the Coach software.[8] There are two ways that ULAB can be used with the computer and Coach:

On-line use

In an on-line situation, ULAB stays connected to the computer (via a COM or USB port) throughout the measurement. Sampled data are transferred in real time to the computer. The course of the measurement can be followed directly on the computer screen in Coach.

Off-line use

In an off-line situation, ULAB is disconnected from the computer during the measurement process. The measurement is performed according to ULAB Experiment settings or uploaded Coach Experiment settings. Sampled data are stored in ULAB's memory. These data can be downloaded to the PC for further data analysis and processing afterwards. Advantages of the Off-line mode are that measurements are possible in all kinds of locations and that during long-term measurements the computer stays available for other tasks.

In §1 of this chapter basic information about the Coach 5 program is given. A typical measurement procedure with ULAB and Coach is described in §2.

1. Working with Coach

Extensive information on working with Coach 5 can be found in the Coach User Manual *Guide to Coach 5* and in the on-line Coach Help System. This paragraph describes only those Coach features/functions relevant for measurements with ULAB.

Starting Coach 5

Install Coach on your computer according to the *Coach 5 Installation Guide*. To start Coach 5 in Windows 95/98/NT/2000/XP/ME click on the Windows *Start* Menu, move to *Programs* and select *CMA Coach 5 > Measurements > CMA ULAB*.

Hardware settings

Make sure that the ULAB driver is installed during the Coach installation[9] (see the Coach *Installation Guide*). To change the ULAB driver settings in Coach:
- Select *Tools > Install hardware drivers* in the Start menu or Project menu of the Author version or press the *Install hardware button* in the Start menu of the Student

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[8] As it is s possible to develop your own software to control ULAB (for example in LabView or Java) the description of the command list and the data formats for ULAB are available on request from CMA.

[9] The ULAB driver (ULAB.DLL) should be added to the drivers in the column labeled *To install.*

version.

- Select the **U**LAB driver (ULAB. DLL) in the column labeled *Installed.*
- You do not have to make any settings when using the USB connection.
- When using the serial connection specify the port number and the baudrate (default 115200).
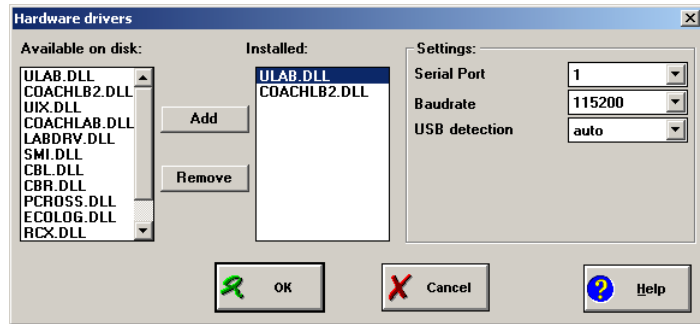
Figure. Hardware settings window

Opening a Project in Coach

In Coach, a project is a set of related Activities. An Activity is an individual exercise that a student can perform. The list of projects is displayed automatically after starting Coach or by clicking the *Open Project* button.

- Select the Project that you wish to open.
- Click *OK*.

Opening an Activity in Coach

The list of activities is displayed automatically after opening a project or by clicking the *Open Activity* button.

- Select the Activity that you wish to open.
- Click *OK*.

Important Coach Activity buttons

Coach is controlled mainly via the buttons in the toolbar or by right clicking items on the screen. Here follows an overview of the most important buttons. Tool tips in Coach with a short explanation are also available.

	Open an Activity	to open an Activity
	Open / Save a Result	to open and save results
	Print	to print the whole screen
	Show/Hide Panel	to show or hide the datalogger panel on the screen
	Measurement settings	to change a measuring time and frequency, trigger conditions
	Start to start a measurement on-line	
	Stop to interrupt a measurement on-line	

Take measurement
to take a single reading on-line

Replay

Send settings to upload the experiment settings to the datalogger
Get result to download the measured data from the datalogger

Yellow buttons
to display meter, value, graph, table, and
to select text, pictures, videos, notes or links to Internet
pages

Help
to open online help
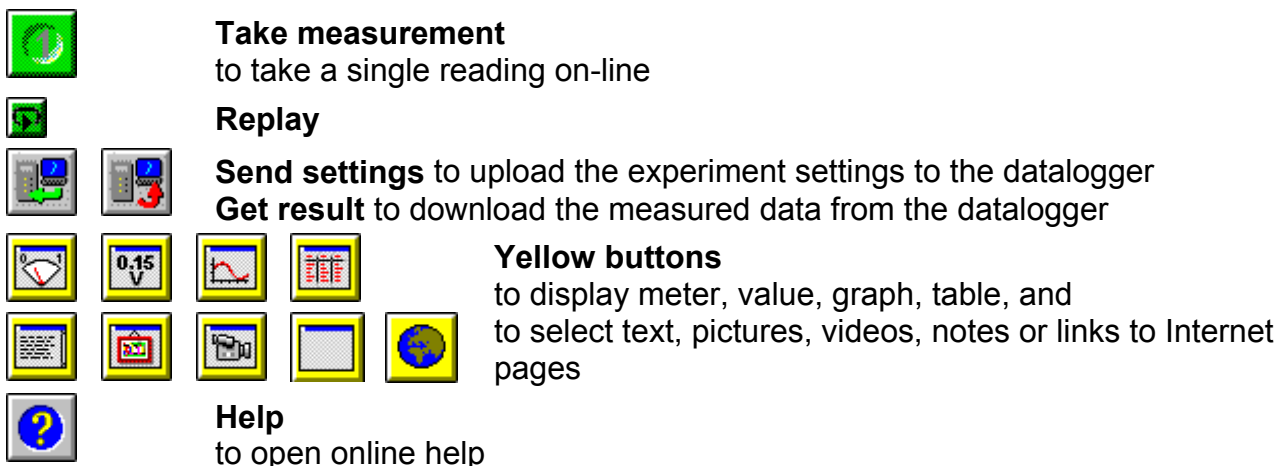
On-line Coach Activity for ULAB

In this type of Coach Activity only the green *Start* button is available. During the on-line measurement ULAB stays connected to the computer, collects data and sends it to the computer after each point is taken. The measured data appear real-time on the computer screen.

When Coach communicates on-line with ULAB then the small computer icon 🖳 is displayed on the ULAB screen and the ULAB buttons are inactive. In this mode Coach acts as the *Master* and ULAB as its *Slave*.
The data measured in the on-line Activity are not stored in the ULAB memory and should be saved in Coach.

Off-line Coach Activity for ULAB

In this type of Coach Activity as well the *Send settings* and *Get result* buttons as the green *Start* button are available. So, Off-line activities can be used as well to set up ULAB for remote data collection as for on-line measurements[10]. By clicking the green *Start* button the on-line measurement is started. By clicking the *Send settings* button the Experiment settings (measurement settings and sensor information) are uploaded to ULAB. Then ULAB can be disconnected from the computer and remote measurements can be performed. After the measurements have finished, ULAB is reattached to the computer. By clicking the *Get result* button, the contact between ULAB and the computer is re-established and the measurement results will be downloaded to Coach.

Automatic sensor detection for ULAB activities

For Coach Activities with ULAB, two kinds of sensor icons are used: *normal* and *detected*.
Normal sensor icons can be selected from the Coach sensor library, placed on the Sensor palette or on the screen Panel by the user. Detected sensor icons are used for

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[10] To set an on-line Activity to Off-line, check in Coach the *Off-line measurement c*heckbox, under *Options > Activity options*.

sensors automatically recognized by **U**LAB (see Chapter III, § 4.4). These sensor icons exist only on the on-screen **U**LAB panel and cannot be moved by the user. When the mouse cursor is placed above a detected sensor icon then the tool tip hints that it is a [detected sensor] (see the figure below).
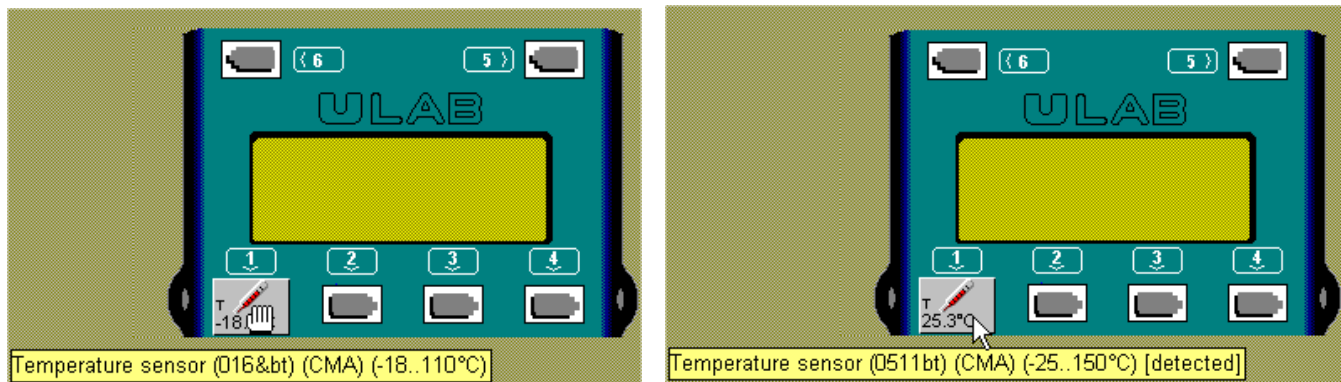
Figure. A normal (left) and detected (right) temperature sensor. The shape of the mouse cursor indicates that the normal sensor icon can be moved while the detected sensor cannot.

When a sensor is physically connected to an input channel of **U**LAB then, depending on the current settings on the on-screen **U**LAB Panel, Coach acts as follows (usually within few seconds):

1. ***there is no sensor icon on this Panel input*** - then the sensor icon corresponding to the detected by **U**LAB sensor appears on that Panel position;
2. ***there is a normal sensor icon on this Panel input*** - then nothing happens, the normal sensor icon remains on the screen panel. **U**LAB follows the Coach calibrations.

When a sensor is physically disconnected from an input channel of **U**LAB then, depending on the current settings on the on-screen **U**LAB Panel, Coach acts as follows (usually within few seconds):

1. ***there is a detected sensor icon on this Panel input*** - then the detected sensor icon disappears from the Panel;
2. ***there is a normal sensor icon on this Panel input*** - then the normal sensor icon remains on the Panel without any change. **U**LAB follows the Coach calibrations.

When the user tries to replace a detected sensor icon by dragging a normal sensor icon on it then the question *Replace the currently connected sensor?* appears on the computer screen. Clicking *Yes* replaces the detected sensor icon by the normal sensor icon. Again **U**LAB follows the Coach calibrations.

2. Computer measurements with ULAB and Coach

Exemplary Activities for ULAB are available after installation of Coach 5. These Activities are described in the *Coach Workbook*. Most of them combine on-line and off-line measurements; as well the green *Start* button as the *Send settings* and *Get results* buttons are available. In some Activities sensors are already connected to the right inputs of the datalogger Panel, in other Activities one can use automatic sensor detection or choose a normal sensor icon from the Sensor palette and drag it to the an input of the ULAB panel.

2.1 A typical measurement procedure in Coach

1. Connect ULAB to the computer. Turn ULAB on.
2. Connect sensors to ULAB.
3. Start Coach and open a Project and an Activity.
    If the Activity is defined for another interface (e.g. CoachLab II) then the warning message *Coach cannot initialize the panel CoachLab II …* appears on the screen. Click the *Select other* button. From the list of available Panels select *ULAB* and click *OK*. If you want to keep this Activity for ULAB you have to save it in Author mode (by pressing <F2>).
4. Follow the instructions in the Activity. If needed change the Experiment settings (Measurement settings and sensor connections).
5. For an on-line measurement, click the green *Start* button to start a data collection. The course of your measurement can be followed in real-time on the computer screen. During the on-line measurement ULAB displays the message [Measurement Running].
6. To prepare ULAB for a remote experiment, upload the Coach Experiment settings to ULAB by clicking the *Send settings* button in Coach. When the upload process is completed Coach briefly displays the message *The Experiment settings have been sent successfully*. The uploaded computer Experiment settings are placed as [Set1] and automatically selected ✓.
    (Maximal 3 Coach Experiment settings can be stored in ULAB. When 3 sets are already placed in the ULAB memory then the next uploaded set is stored as [Set1] and the old [Set1] becomes [Set2], the old [Set2] becomes [Set3], and the old [Set3] is deleted.
    It is possible to activate one of the Sets in the Home Screen of ULAB.
7. After uploading the settings, disconnect ULAB from the computer and turn it off. When you are ready to perform your measurement, turn ULAB on. Automatically the last uploaded Experiment settings are selected; if needed select other Experiment settings (Coach or ULAB settings). Start the measurement by pressing ▶ .
    Detailed information about working with ULAB as a standalone device can be found in Chapter III.
8. After the remote measurements have finished, you can download the measured data

to Coach for further processing. Reconnect **U**LAB to the computer. If necessary first start Coach and open an Activity.

9. Click the *Get result* button in Coach. The *Retrieve Data* window appears on the screen. All data files (together with the file id, date, time and size) stored in **U**LAB's memory are listed in this window.
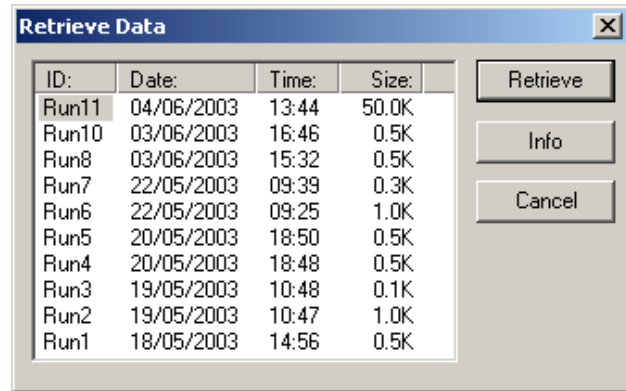
10. Select the Run you want to upload. By clicking the Info button an overview of the Experiment settings of the selected Run are shown.
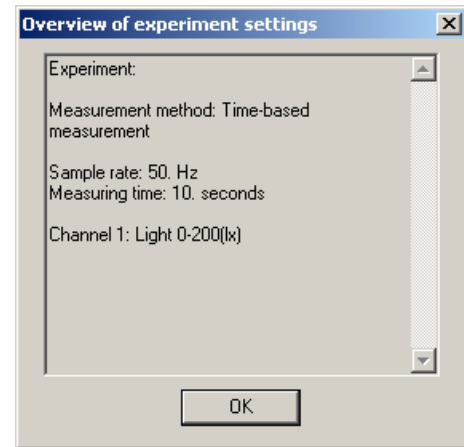
11. Click the Retrieve button to download the measured data to Coach. When the Experiment settings of the received results do not match the Experiment settings in Coach then the message appears on the screen.
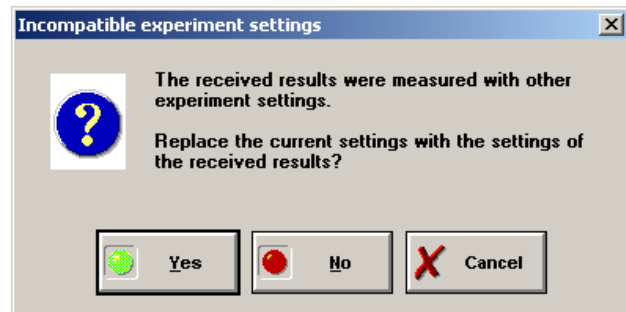
12. Click *Yes* to replace the current Coach settings with the settings of the received results. If the Experiment settings contain a user-defined sensor, which is not in the current Coach settings, then a blank sensor icon appears on the Panel. It is no longer possible to start a measurement or upload Experiment settings, until the blank sensor icon is replaced by a normal sensor icon.

13. After downloading, the data appear in a Diagram and Table and can be saved in Coach.

14. Analyze the data. All processing and analysis tools of Coach are available from the Diagram and Table Tool menus (right click the diagram/table window or click the *Hammer* button.

3. Tutorial: temperature measurements with ULAB and Coach

Guided by this step-by-step tutorial you can perform your first temperature measurements with ULAB and a computer.

Before you start make sure that the Coach 5 software is installed on your computer and you are able to connect ULAB to your computer by means of the PC serial cable or the USB cable. Make sure that Coach has the correct ULAB driver settings (communication port, its number and baudrate).

3.1 On-line temperature measurement

In this experiment you are going to investigate temperature variations of water in a beaker. During this on-line measurement, ULAB is connected to the computer. ULAB collects the temperature data, displays the measured data on the screen in a graph, a table and as a digital value. The measured value is also displayed on the sensor icon on the ULAB Panel.

Materials

- ULAB
- PC computer with the Coach 5 program
- CMA Temperature sensor (art. nr 0511)
- 250-ml beaker and 100 ml hot water

Measurement procedure

1. Connect ULAB to the computer.
2. Turn ULAB on by pressing [0].
3. Start Coach 5. Open the project *ULAB - 1. Tutorial* and select the activity *On-line temperature measurement*.
4. Plug the CMA Temperature sensor (0511) in input channel 1 on ULAB.
5. The temperature sensor will be recognized by ULAB and its icon will appear automatically on the ULAB Panel on the computer screen. If you use another temperature sensor then drag its icon from the sensor palette to input 1 of the ULAB screen panel.
6. The measured temperature value is displayed in digital form in the Value window and on the sensor icon. Determine the room temperature.
7. Fill a beaker with hot water and place the temperature sensor in the water.
8. The predefined measurement settings are (check by clicking the *Measurement settings* button): measuring time = 3 minutes, sampling frequency = 50 per second. Click the green button to start a measurement.
9. To see a graph and data table click the *Hide panel* button.
10. The measurement stops after the measuring time is reached or by clicking the red stop button.
11. Analyze the measured data. All processing and analysis tools of Coach are available from the Diagram and Table Tool menus (right click the diagram/table window or

click the *Hammer* button.
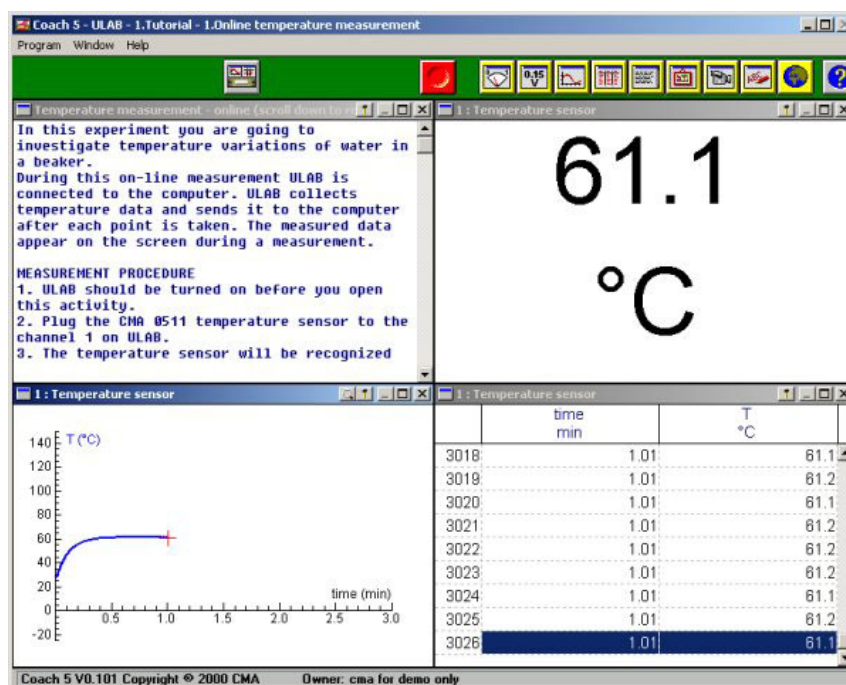
3.2 Off-line temperature measurement

In this experiment you are going to investigate temperature variations of water outside the classroom. During this off-line measurement, **U**LAB is disconnected from the computer. The Experiment settings are uploaded to **U**LAB and the measured results are downloaded to Coach after the data collection is completed.

Materials
- **U**LAB
- PC computer with the Coach 5 program
- CMA Temperature sensor (art. nr 0511)
- 250-ml beaker, 100 ml hot water, refrigerator

Measurement procedure
1. Connect **U**LAB to the computer.
2. Turn **U**LAB on by pressing ⬜ **O** ⬜.
3. Start Coach 5. Open the project *ULAB - 1. Tutorial* and select the activity *Off-line temperature measurement*.
4. Plug the CMA Temperature sensor (0511) to the input channel 1 on **U**LAB.
5. The temperature sensor will be recognized by ULAB and its icon will appear on the **U**LAB Panel on the computer screen. If you use another temperature sensor then drag its icon from the sensor palette to the input 1 on the **U**LAB screen panel.
6. The measured temperature value is displayed in digital form in the Coach Value-window and on the sensor icon.

7. The predefined measurement settings are (check by clicking the *Measurement settings* button) measuring time = 3 minutes, sampling frequency = 50 per second.
8. Upload the Experiment settings to ULAB by clicking the *Send settings* button.
9. When Coach displays that the Experiment settings have been transferred successfully, you can disconnect ULAB from the computer. You can measure temperature of hot water in a beaker or measure temperature outside of the classroom for example inside a refrigerator (do not forget to cover ULAB in its case).
10. Start the measurement by pressing ▭▶▭.
11. When data collection is complete re-connect ULAB to the computer.
12. Start Coach and open the activity. Press the *Get result* button. Select the measurement run from the list. Click the Retrieve button and wait a few moments while Coach retrieves the data. The measured data appear on the screen in the Diagram.
13. Analyze the measured data. All processing and analysis tools of Coach are available from the Diagram and Table Tool menus (right click the diagram/table window or click the *Hammer* button0.
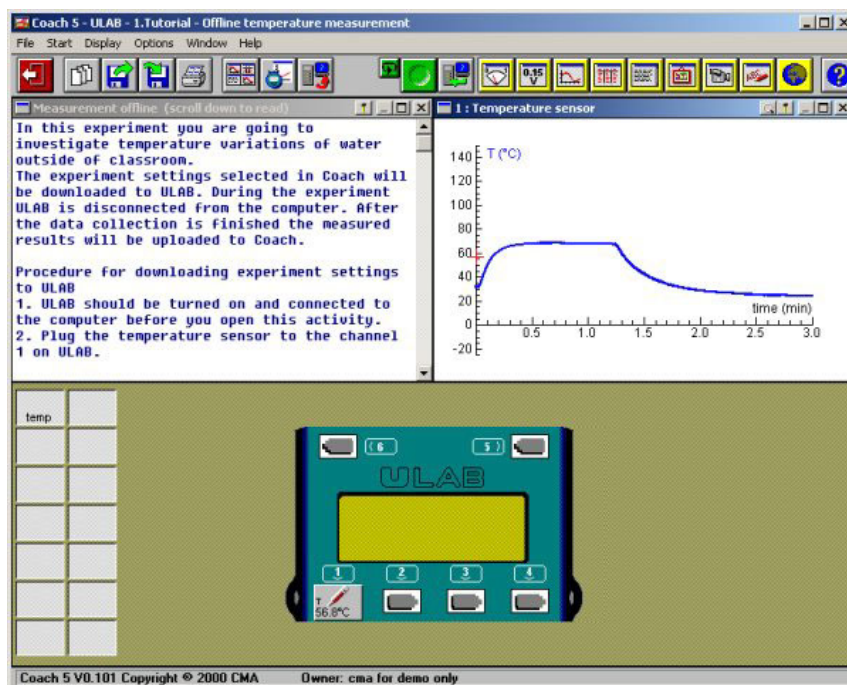
3.3 Manually-triggered temperature measurement

The Coach project *ULAB - 1.Tutorial* consists of another two tutorial Activities: *3. Manually-triggered measurement on-line* and *4. Manually-triggered measurement off-line*. Perform these activities to learn how to perform manually-triggered measurement with ULAB and Coach. The text included in the Activities will guide you step-by-step through the measurements.

V. ULAB utility programs

Two additional and simple utility programs for displaying **U**LAB screen and upgrading ULAB firmware are available. Both programs are located in the Coach 5 folder.

1. ULAB View

ULAB View is a program which sends the image of the **U**LAB screen to the computer screen. In this way all students can easily follow teacher demonstrations.
ULAB View is easy to use. Simply connect **U**LAB to the computer and turn it on. Click ULABView.exe file in the Coach 5 folder. The program automatically displays the current **U**LAB screen. Such a screen display can be captured and saved as a bitmap file
 (*.bmp) by pressing the <F2> key or by left clicking. A *Save as…* dialog appears to store the BMP. This feature is very useful for creating teaching materials.
Close the program by clicking the Close button in the upper right corner of the ULAB-View window.

2. ULAB Update

ULAB Update is a program to update the internal operating system software of **U**LAB (firmware). The **U**LAB firmware file has the following format **U**LAB*.hx2 where * stands for the firmware version. With a firmware update it is e.g. possible to add new functionality to **U**LAB.
The file corresponding to the firmware installed on **U**LAB can be found after installation of the Coach 5 program (in the Coach 5 folder). The newest version of the firmware can be downloaded from the CMA website: http://www.cma.science.uva.nl.

To update **U**LAB:
1. Download the newest version of the firmware file and save it to the Coach 5 folder.
2. Read the documentation accompanying the firmware update to know what changes in **U**LAB functionality are implemented.
3. Connect the power supply to ULAB and plug into the outlet.
4. Connect **U**LAB to the computer and turn it on.
5. Start the **U**LAB Update program by double clicking the ULABUpdate.exe file in the Coach 5 folder.
6. Under *ULAB connection* select the port to which the datalogger is connected (USB or COM port).
7. Press the *Start update* button.
8. From the list of available firmware files select the downloaded firmware file ULAB#-*.hx2 (# - the firmware version number; * - the firmware language).
9. The following message appears *Updating the firmware clears all data in ULAB's memory. Update the ULAB firmware using ULAB. hx2?*
10. Pressing *Yes* starts the update process. At the end of this process **U**LAB will reset itself.

11. When the firmware is updated then the message appears: *The firmware update process has been completed successfully. ULAB is updated to firmware version *.*

VI. Technical specifications of ULAB

ULAB is a small handheld computer dedicated to the task of data collection. It contains a microprocessor that can communicate with a PC computer. This chapter gives detailed technical specifications of ULAB.

1. Connection to the computer

1.1 USB connection

ULAB can be connected to the PC using a standard USB cable[11].

1.2 Serial connection

For data transmission ULAB is connected to the computer via an RS-232 serial cable. Always use the included cable to prevent malfunction. The pin configuration of the serial cable is described in the table below.

8-pin male mini DIN (ULAB)		DB-9pin female (Computer)	
3	TD (Transmitted Data)	2	RD (Received Data)
5	RD (Received Data)	3	TD (Transmitted Data)
4	GND (Signal Ground; common)	5	GND (Signal Ground; common)
All other pins are not connected			

2. Power supply

ULAB is powered by 2 internal NiMH batteries (1.2 V, 2700 mAh). The batteries can be charged via the included external 5-V power adapter or via the USB connection. We strongly recommend **not to use any other power supply**.

If power supply is connected to ULAB the batteries will be charged regardless if ULAB is on or off. It takes about 12 hours to fully charge a discharged battery. However, if current-demanding sensors are connected, the available current for charging will be less (or even zero).

Supplying ULAB and charging the batteries via USB will only occur if ULAB is switched on **and** if the USB hub has ensured to be able to deliver a current of 500 mA. The charging time will be approximately the same as when using the external power supply. The batteries cannot be overloaded, so it is no problem if the external supply stays connected for a longer time. In order for ULAB to start up, it is necessary that the

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[11] To use the USB connection you need a Pentium II computer with Win98 Second edition, Win2000 or higher.

batteries is not fully depleted; if so, wait a few moments so the external supply can charge the battery a bit. With fully-depleted batteries, charging via the USB is not possible.

2.1 Lifetime of the batteries

ULAB functions (continuously) for approximately 10 hours on a fully charged battery provided there is little current drawn by connected sensors. If current-demanding sensors are connected (like the Ultrasonic Motion Detector or CO_2 sensor), the ULAB battery may give up after 4 hours of continuous use.

If measurements are performed with long inter-sample times (i.e. 10 seconds or more), ULAB switches itself off between the samples. Battery charge may last up to several months now, depending on the sample rate and on the time the sensors need to power up prior to the sampling moment. E.g. if the sensors need power prior to sampling 1 second before sampling, battery charge will be 15,000 – 36,000 samples (depending on the current demand of the sensor(s)).

With normal use the batteries have a lifetime of several years.

3. Analog to Digital Conversion

3.1 Resolution

ULAB uses a 12-bit ADC. The 12-bit resolution results in a voltage resolution of 1.22 mV for the 0-5V range, and 4.9 mV for the -10 to +10V range.

3.2 Sample rate

The maximum sample rate depends on the number of used channels and the way the channels are used. The following table gives an overview:

Number of inputs used	Maximum sample rate
One analog input	100 kHz
Two analog inputs	10 kHz
Three analog inputs	4 kHz
Four analog inputs	4 kHz
One counter	4 kHz sampling; 2 kHz max. signal frequency
Four counters	4 kHz
One counter + one analog input	4 kHz
One motion detector	50 Hz
Two motion detectors	25 Hz
One motion detector + analog input(s)	50 Hz
One motion detector + counter input(s)	not possible

4. Memory

ULAB is equipped with 128 KB of Flash (non-volatile) memory and 512 KB of SRAM (volatile) memory. Flash memory contains:

- the **U**LAB internal operating system (firmware)
- the local (permanent) sensor library
- several other **U**LAB parameters.

SRAM contains:

- computer Experiment Settings (up to 3 sets)
- sensor definitions used in the experiments
- measured data files – Runs which can consist up to a total of 250,000 data points (max. 100,000 per Run).

If **U**LAB is switched off, all memory contents - Flash and SRAM - are maintained. SRAM is maintained as long as the battery is not completely depleted; Flash is always maintained. However, the Flash memory can be rewritten to update the local sensor library and the firmware.
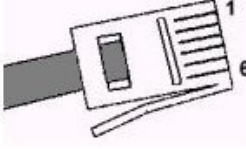
5. Display

ULAB has a graphic LCD display of 128 by 64 pixels which shows the menu-driven internal program and measurement data (values, graphs and tables).

6. Inputs

6.1 Analog inputs

The four analog input ports labeled 1-4 are used for analog sensors with right-hand BT connectors with the following pin-outs:

Pin	Analog Input 1 - 4
	Right-hand connector
1	Vin
2	Ground
3	Vres[1]/I2C[3] data
4	Auto-ID[2]/I2C[3] clock
5	+5 V DC
6	Vin-low

Note:
The BT plug has two signal pins V_{in} (pin 1) and V_{in-low} (pin 6). The input range of pin 1 is -10V to +10V, and of pin 6 is 0 to +5V.
In the Coach software it is possible to select the range i.e. to select the pin of which the signal will be taken (see the Coach Help System, keyword 'Input range'). The default range is 0 to +5 V (pin 6). This applies to sensors with BT plugs connected to an input channel of **U**LAB.
For connected sensors with 4-mm plugs via adapter art. nr. 0519 always the standard range 0 to +5 V (pin 6) is taken, regardless of the software settings. (In this adapter there is no connection between the yellow lead and pin 1).

[1] Vres - Output reference voltage (pull-up resistance 15 kΩ) for resistance measurements.
[2] Auto-id (pull-up resistance 10 kΩ) - Auto-id sensor detection data input. The BT inputs have the possibility for automatic sensor recognition.
[3] For (I^2C) communication between **U**LAB and intelligent sensors.

	V_{in} (pin 1)	V_{in-low} (pin 2)
Inputs	Input 1- 4	Input 1-4
Input signal	Analog data	Analog data
Input range	-10 to +10 V	0 to +5 V
Resolution (12 bit)	4.9 mV	1.2 mV
Input impedance	100 kΩ	100 kΩ
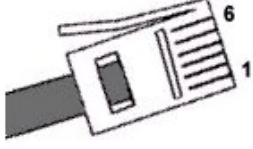
6.2 Analog inputs as counters or as event-source

All analog inputs can be selected to function as a counter or as input for event-based measurements. The analog signals are sampled each 250 μs and evaluated if below or above the specified threshold. Hence the requirement for the analog input signal is that this signal is above the threshold for at least 250 μs and also below the threshold for at least 250 us. This implies a maximum pulse or event frequency of 2 kHz, in case the signal is perfectly symmetrical.
In case of event-based measurements, time stamps of the measurement points are also available from the **U**LAB's memory (time resolution = 0.5 ms). If used as a counter, because of the above mentioned signal requirements, the maximum count-rate is 2000 counts per second (if symmetrical signal).

6.3 Digital inputs

The digital input ports labeled 5 and 6 are used for connection of digital sensors (for example ultrasonic motion detectors or photogates) with a left-hand BT connector. The digital channel can also be used for connection of an up/down counter (e.g. a bi-directional pulley) or for general input or output[12] (4 bits per port). The left-hand BT connector has the following pin-outs:

Pin	Sonic Input 5 and 6
	Left-hand connector
1	Echo (input)[1] / I/O[3]
2	Init (output)[2] / I/O[3]
3	Auto - ID / I/O[3]
4	+5 V DC
5	Ground
6	I/O[3]

[1] Echo - Ultrasonic motion detector input, TTL signal
[2] Init - Distance initialization signal, TTL signal
[3] I/O: these 4 pins can be configured for digital input or output

7. Dimensions

Size: 189 mm x 105 mm x 50 mm
Weight: approx. 0.42 kg

8. Warranty

ULAB is guaranteed completely for product quality during 12 months after the date of purchase. Any damage caused by operation contrary to the prescriptions in this manual is excluded from this guarantee.

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[12] Not supported yet.

VII. Troubleshooting tips

Problem when working with ULAB	Cause/Solution
Impossible to switch **U**LAB on.	Batteries are fully depleted. • Charge the batteries via the included external power supply. In case it does not solve the problem make sure that the batteries make proper contact. • Carefully unscrew the bottom part of **U**LAB. • Place the batteries correctly in the holders.
Coach is not able to communicate with the connected **U**LAB interface on opening a Coach Activity or Result. This is the case when: 1. the hardware settings in Coach are not correct; 2. there is no interface connected to the computer; 3. the Activity/Result is developed for another interface than **U**LAB; 4. the communication between interface and computer is lost. A dialog box tells that 'Coach cannot initialize the **U**LAB panel'.	Ad. 1. In Coach click the Install-Hardware button to check if the **U**LAB driver is installed (ULAB.dll appears in the column labeled 'Installed'). Check the selected serial port number (COM) and baudrate. USB is detected automatically. Ad. 2. Connect **U**LAB to the computer. Ad. 3. Click the button 'Select other' and select 'ULAB' from the list. **Note:** If the Activity author did not defined 'Alternative panels' then this button does not appear. In this case click 'Ignore' and switch the Panel in the Activity (see the Coach help, keyword 'Select other Panel'). Ad. 4. Reset **U**LAB by switching it off and on. Open the Activity/Result again.
Coach is not able to communicate with **U**LAB in an Activity (you can see that the values on the Sensor icons do not change at all for a longer period of time. Normally, these values always fluctuate a little bit due to noise.)	Reset **U**LAB. • Right click the on-screen ULAB Panel and select the option 'Reset Hardware'. • You may combine this with resetting **U**LAB by switching it off and on.
The measurement values displayed on the Sensor icon or in a Window are not realistic.	You have probably used a Sensor icon, which does not correspond to the actual sensor connected to **U**LAB. • Check the ToolTip with the description of the Sensor icon, or look up the sensor information in the CMA Hardware help. • Replace the sensor icon.

Appendix I. Sensors which can be used with ULAB

ULAB allows the use sensors which produce an output voltage in the ranges 0 to +5V or -10 to +10V. All CMA sensors (see the list below) can be directly connected to ULAB. Older CMA sensors with 4-mm plugs can be connected to ULAB with the adapter 4-mm to BT (CMA art. nr 0519).

Vernier and Texas Instruments sensors with BT connectors can be directly connected to ULAB. Older Vernier sensors and sensors of other brands such as Pasco or Fourier System can be connected with a proper adapter (e.g. from DIN plug to BT plug).

In the table below you find the list of CMA sensors, which can be used with ULAB.

Nr.	CMA Sensors	Type
013	Angle sensor (0 .. 270°)	
014	Light sensor (0 .. 200 lx)	
0141i	Light sensor (0 .. 10 lx)	Intelligent
0142i	Light sensor (0 .. 200 lx)	Intelligent
0143i	Light sensor (0 .. 150 klx)	Intelligent
015	Sound sensor (-5 .. 5 Pa)	
016	Temperature sensor (-18 - 110 °C)	
017i	Sound sensor (-45 .. 45 Pa)	Intelligent
0210i	Differential Voltage sensor (-10 .. +10V)	Intelligent
0212i	Differential Voltage sensor (-500 .. +500mV)	Intelligent
0221i	Differential Current sensor (-5 .. +5A)	Intelligent
0222i	Differential Current sensor (-500 .. +500mA)	Intelligent
023i	Pressure sensor (0.. 7 bar)	Intelligent
024	Magnetic Field sensor (-100 .. 500 mT and -10 .. 50 mT)	
025i	Relative Humidity sensor (0 .. 100%)	Intelligent
028	EKG-set in combination with light sensor (014 or 142i)	
029	Geiger-Müller Ionizing radiation sensor (for beta and gamma radiation)	
030i + 31	Ph-sensor (ph amplifier 030i + pH electrode 031) (0 .. 14 pH)	Intelligent
032	Baro sensor (0-1100 mbar)	Intelligent[13]
033	Light sensor with 3 ranges (0-600, 0-6000, 0-150000 lx)	Intelligent[13]
0341	Gas Pressure sensor (0-210 kPa)	Intelligent[13]
035	Thermocouple temperature sensor (-30 - +1400°C)	Auto-id
03517	Motion Detector (0.4 .. 6 m)	Auto-id
0357	CO_2 sensor (0 .. 5000 ppm)	
0358	Colorimeter (red, green, blue)	
0362	Force sensor with two ranges (±5N and ±50N)	
037	Heartbeat sensor	
0375	Exercises Heart Monitor sensor	

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[13]Older types of this sensor may not work as intelligent sensor.

0376	Dissolved Oxygen sensor (0 .. 14 mg/l)	Intelligent[14]
0381	Relative Humidity sensor (0 .. 100%)	
0382	Conductivity sensor (0 .. 200 μS, 0 .. 2000 μS, 0 .. 20000 μS)	Intelligent[14]
0384	Current sensor (-0.8 .. 0.6mA) (I/V set)	Auto-id
0384	Voltage sensor (-8 .. 6V) (I/V set)	Auto-id
0385	Low g accelerometer ($\pm$ 5g)	
0386	Smart Pulley (includes of photogate)	
0391NH4	Ammonium (NH_4^+) electrode with integrated amplifier	Intelligent[14]
0391Ca	Calcium (Ca^{2+}) electrode with integrated amplifier	Intelligent[14]
0391Cl	Chloride (Cl^-) electrode with integrated amplifier	Intelligent[14]
0391NO3	Nitrate (NO_3^-) electrode with integrated amplifier	Intelligent[14]
0511	Temperature sensor (-20 - 125 °C)	Auto-id
0513	Light sensor (0 .. 10 W/m^2)	Auto-id
0515	Voltage sensor (-10.. 10V)	Auto-id

An **Intelligent** sensor has a memory chip with information about the sensor. Through a simple protocol (I^2C) the sensor communicates with **U**LAB and transfers its data (name, quantity, unit and calibration) to the datalogger. **U**LAB automatically displays the calibrated values in the right unit on its screen.

CMA delivers these sensors with standard calibrations. In the near future a special program will be available to enable replacing of the default calibration in EEPROM of the sensor by a calibration done by the user. This will be done while the sensor is connected to the **U**LAB datalogger. In this way the sensor can have it's own, precise calibration.

An **Auto-id** sensor is equipped with a specific sensor resistor, which allows automatic identification of the sensor by the **U**LAB datalogger.

Appendix II. Default Sensor Library of ULAB

For intelligent sensors **U**LAB reads the sensor information from the sensor EEPROM. For other types of sensors **U**LAB uses its local sensor library. By default this library consists of approximately 40 of the most used sensors (see the list below). Sensors that are not available in the **U**LAB sensor library can be selected in Coach and uploaded with the Experiment settings to the datalogger. In the near future CMA will offer a special program to select and upload a user-defined sensor library (based on the full Coach sensor library).

In the table on the next page you find the list of sensors with the sensor identification name used in **U**LAB sensor library together with its full description.


[14] Older types of this sensor may not work as intelligent sensor.

| Nr.	Name in ULAB	Sensor description
Analog sensors for channels [CH1], [CH2], [CH3], [CH4]		
1	`Accel5g 0385`	Low g accelerometer ($\pm$ 5g) (CMA art. nr 0385)
2	`Angle    013`	Angle sensor (0 .. 270°) (CMA art. nr 013)
3	`Baro     032`	Baro sensor (0.. 1100mbar) (CMA art. nr 032)
4	`CO2     0357`	CO_2 sensor (0 .. 5000 ppm) (CMA art. nr 0357)
5	`ColBlue 0385`	Colorimeter (CMA art. nr 0358)
6	`ColRed  0385`	Colorimeter (CMA art. nr 0358)
7	`ColGreen0385`	Colorimeter (CMA art. nr 0358)
8	`Cond200 0382`	Conductivity sensor (0.. 200 μS/cm) (CMA art. nr 0382)
9	`Cond2k  0382`	Conductivity sensor (0.. 2000 μS/cm) (CMA art. nr 0382)
10	`Cond20k 0382`	Conductivity sensor (0.. 20000 μS/cm) (CMA art. nr 0382)
11	`Current 0384`	Current sensor (CMA art. nr 0384)
12	`ECG      028`	ECG-set (CMA art. nr 028)
13	`ExHeart 0375`	Exercises Heart Monitor sensor (CMA art. nr 0375)
14	`Force5N 0362`	Force sensor with two ranges ±5N (CMA art. nr 0362)
15	`Force50N0362`	Force sensor with two ranges ±50N (CMA art. nr 0362)
16	`GasPres 0341`	Gas Pressure sensor (0 .. 210 kPa) (CMA art. nr 0341)
17	`GMRadiat 029`	Geiger-Müller Ionizing radiation sensor (CMA art. nr 029)
18	`HeartBeat037`	Heart-beat sensor (CMA art. nr 037)
19	`Humidity0381`	Relative Humidity (0.. 100 %) (CMA art. nr 0381)
20	`ISE-NH4 0391`	Ammonium (NH_4^+) electrode with integrated amplifier (CMA art. nr 0391NH4)
21	`ISE-NO3 0391`	Nitrate (NO_3) electrode with integrated amplifier (CMA art. nr 0391NO3)
22	`ISE-Ca  0391`	Calcium (Ca^{2+}) electrode with integrated amplifier (CMA art. nr 0391Ca)
23	`ISE-Cl  0391`	Chloride (Cl^-) electrode with integrated amplifier (CMA art. nr 0391Cl)
24	`Light200 014`	Light sensor (0 .. 200 lx) (CMA art. nr 014)
25	`Light   0513`	Light sensor (0 .. 10 W/m^2) (CMA art. nr 0513)
26	`Magn500x 024`	Magnetic Field sensor (-100 .. 500 mT) (CMA art. nr 024)
27	`Magn50x  024`	Magnetic Field sensor (-10 .. 50 mT) (CMA art. nr 024)
28	`Oxygen  0376`	Dissolved Oxygen sensor (0 .. 14 mg/l) (CMA art. nr 0376)
29	`pH       030`	pH-sensor (amplifier + electrode 031) (CMA art. nr 030)
30	`Pressure 034`	Pressure sensor (0 ..7 bar) (CMA art. nr 034)
31	`Pulley  0386`	Smart Pulley (CMA art. nr 0386)
32	`Sound    015`	Sound sensor (CMA art. nr 015)
33	`Temp     016`	Temperature sensor (-18 ..110 °C) (CMA art. nr 016)
34	`Temp    0511`	Temperature sensor (-25 ..125 °C) (CMA art. nr 0511)
35	`Thermcoup035`	Thermocouple temperature sensor (-30 - +1400°C) (CMA art. nr 035)
36	`Voltage 0384`	Voltage sensor (CMA art. nr 0384)
37	`Voltage  5V`	Voltmeter (Generic)
38	`Voltage 10V`	Voltmeter (Generic)
Digital sensors for channels [CH5], [CH6]		
39	`Dig. Counter`	Digital Counter (for Digital sensors e.g. Photogates or Radiation sensors)
40	`Motion 03517`	Motion Detector (0.4 .. 6 m) (CMA art. nr 03517)
41	`Rotary Low`	Digital Rotary Motion Sensor (360° per turn)
42	`Rotary High`	Digital Rotary Motion Sensor (1440° per turn)

Appendix III. A Quick Reference Guide of basic ULAB procedures

Home screen – Press [🏠] *at any time to come back to the Home screen. (p. 8 lists all buttons)*

Help Screen – Press [▤] during the display of the Help screen to keep the Help on the screen. Press [🏠] to go back to the Home screen.

Canceling actions – Briefly press [O].

Sensors – **U**LAB recognizes many sensors on connection and automatically displays data in the right units. If a sensor is not recognized the data is initially displayed uncalibrated in V. Manually select the correct sensor from **U**LAB's library (see below) to display calibrated values.

Change items – Select editable items with the arrow keys (highlighted=selected). Press [↵] to open the selection list or submenu for that item. Select with up/down. Confirm list item with [↵]. Briefly press [O] to cancel any action.

Status information – The right side of the Large-digits, Graph and Table screens display status information about connected channels and the way these channels are measured, the battery status, computer connection; the clock and screen-specific information (e.g. co-ordinates). See the different screen-menus.

Multimeter mode – As soon as a sensor is connected, **U**LAB displays actual measurement values with a frequency of 4Hz for all active channels. (p. 13)

Large-digits screen – In the Home screen select one of the channel values with the arrow keys and press [↵]. Use Up/Down to cycle through all connected channels. (p. 15)

Large-digits menu
Press [▤] in the Large-digits screen. Options are:
[Dgt]   to set the number of decimals of the value between 0 and 4;
[MnMx] to display the minimum, maximum and average values since the last reset.
[Reset] to set a new starting point for the [MnMx]-values (only if MnMx=On). (p. 15)

Graph screen – Press [⊾] to see the graph. In Multimeter mode the graph displays the current values with a 4Hz frequency. Use Up/Down to select another channel. In Logging mode [⊾] toggles between table and graph. The Status information displays the x,y-co-ordinates of the selected point. (p.18)

Graph menu
Press [▤] in the Graph screen. Options are:
[Move]   to move the graph;
[Zoom]   to zoom in or out (Up/Down for vertical direction; Left/Right for horizontal direction);
[Reset]   to reset the zoom factor.(p.18)

Table screen – The Table screen is only available in Logging mode. It is the default screen after starting a measurement with [▶]. Toggle with [⊾] between the graph and the table. (p.17)

Table menu
Press [▤] in the Table screen (p.13). Options:
[Time dgt] to set the time's number of decimals;
[Ch dgt]   to set the number of decimals for the current channel. (p. 17)

Experiment-settings menu – Press [▤] in the Home screen. Choose the tab *Sensors* to view connected sensors or to select a sensor from **U**LAB's sensor library. Choose the tab *Method* to view or change the measurement settings (method; duration; sampling frequency; trigger settings). (p. 19)

Logging mode – Press [▶] to start storing data according to the current Experiment settings. (p.17)

Add sensor – In the Experiment-settings menu go to the tab 'Sensors'. Select a channel with the arrows. Press [↵] to open the library and select a sensor. (Not all sensors are in **U**LAB's library. If a sensor is not available, calibration of the data can be done afterwards in Coach). (p. 19)

Sensor modes – Press [🏠]. Press [▤]. Select tab *Sensors*. Highlight 3-letter code behind desired sensor. '**anl**' – sensor measures analog values; '**cnt**' sensor measures counts; '**frq**' – sensor measures frequency. Press [↵]. Select mode.

Measurement method Press [🏠]. Press [▤]. Select tab *Method*. Highlight the Type and press [↵]. Select TimeBased (default); EventBased or Manual. Set the other fields.

ULAB and Coach (on-line mode) – **U**LAB functions as a normal interface with real-time display of measured data. Computer is master, **U**LAB slave (**U**LAB displays 🖳, buttons are locked). Recognized sensors appear automatically in Coach.

ULAB and Coach (off-line mode) – Send Experiment settings from Coach (**U**LAB connected; a Set appears); do the experiment (**U**LAB not connected); Retrieve data in Coach (**U**LAB connected).

Set date and time – Press [▤] right after switching ULAB on. Highlight any date or time element. Press [↵]. Change blinking value with Up/Down. Press [↵]. Press [🏠]. (p.23)

Reset ULAB to factory settings – Press [▤] right after switching on **U**LAB. Highlight Restore Defaults. Press [↵].

Firmware update – Run ULABUpdate.exe (default in C:\CMAC5). Follow the instructions on the screen.

ULAB Screen view – Run ULABview.exe (default in C:\CMAC5) to transfer **U**LAB screens to the computer screen (2s refresh rate).