DATA LOGGER APP

for fx-CG50

USER'S GUIDE

CENTRE FOR MICROCOMPUTER APPLICATIONS

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Author: Ewa Kedzierska, Lubomir Salanci,

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

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I. GETTING STARTED

1. Introduction

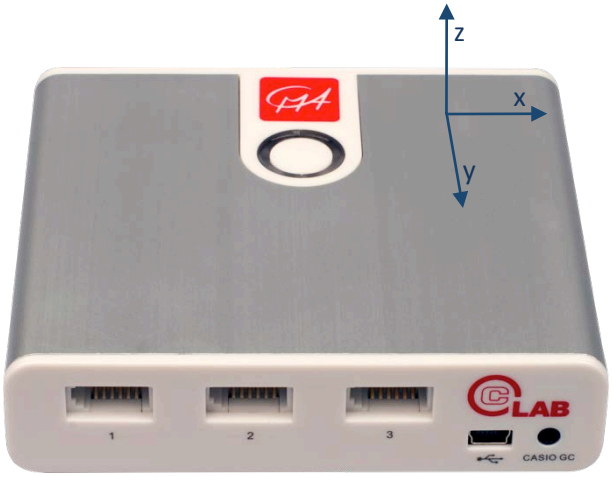
Data Logger application for Casio fx-GC50 calculator (called in this manual Data Logger App) is a menu-driven calculator application, designed to support data collection with the **C**LAB data logger.

CLAB is an easy-to-use data logger for Mathematics, Science and Technology Education that can be used with CASIO Graphic Calculators, with a PC computer and standalone, in the field and in the classroom.

CLAB is equipped with its own processor and memory, enabling measurements at sampling rates up to 100 000 Hz with accurate independent timing.

For connecting sensors **C**LAB has three analog BT sensor inputs with input voltage ranges 0 .. 5 V and -10 .. 10 V. These inputs support CMA sensors and automatically identify these sensors.

Additionally **C**LAB has a built-in 3-axis Accelerometer, which measures acceleration in 3 ranges: -20 .. 20 m/s^2, -40 .. 40 m/s^2 and -80 .. 80 m/s^2 in the x, y and z directions. This sensor can be used in combination with other external sensors.



When connected to an fx-GC50 calculator **C**LAB can be controlled by the Data Logger App running on the calculator. The collected data are transferred to the calculator and the measurement can be followed and analyzed on the calculator. The Data Logger App allows:

- configuring experiments - define sensors, a measurement method and its settings,
- collecting data via connected sensors ,
- graphing and analyzing of the collected data,
- storing data in Lists and in csv format,
- managing pre-define experiment setups.

To be able to work with the Data Logger App the **C**LAB firmware has to be updated at least to version **2.31**. To update your **C**LAB go to the CMA website, select Support > Product Support > CLAB > Updates, download the latest version of the CLAB Update program (at https://cma-science.nl/supportpage/product-support/product-support-clab-updates) and perform the update.

2. Connecting CLAB to fx-GC50 calculator

To connect **C**LAB to an fx-GC50 calculator you need a data communication cable with 3-pin jack connectors (SB-62). This cable is provided with your CASIO Graphic Calculator.

Calculator 3-pin Port
for communication with CASIO Graphic Calculators

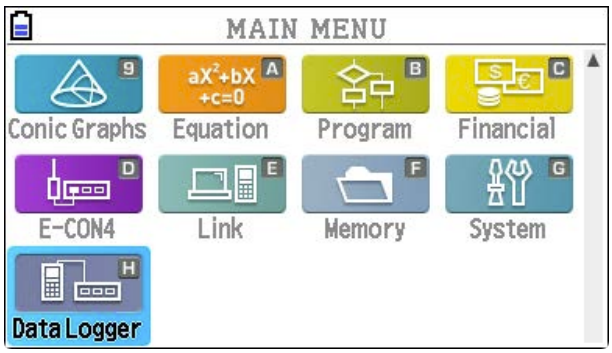
To connect CLAB to a CASIO fx-GC50

- Connect one end of the data communication cable with 3-pin jack connectors to your fx-GC50.
- Connect the other end of the cable to the CASIO GC port on your **C**LAB.
- Turn on **C**LAB and your fx-GC50.

3. Starting Data Logger App

To start Data Logger App on your fx-GC50 calculator press the [MENU] key and select the **Data Logger** App icon.

As long as there is no communication between **C**LAB and the calculator the app displays **CLAB disconnected**. When there is no communication it is not possible to perform any measurements with **C**LAB but some of menu options will work.
If you experience such communication problems make sure that both plugs of your communication cable are fully inserted in the communication ports and your **C**LAB is turned on.



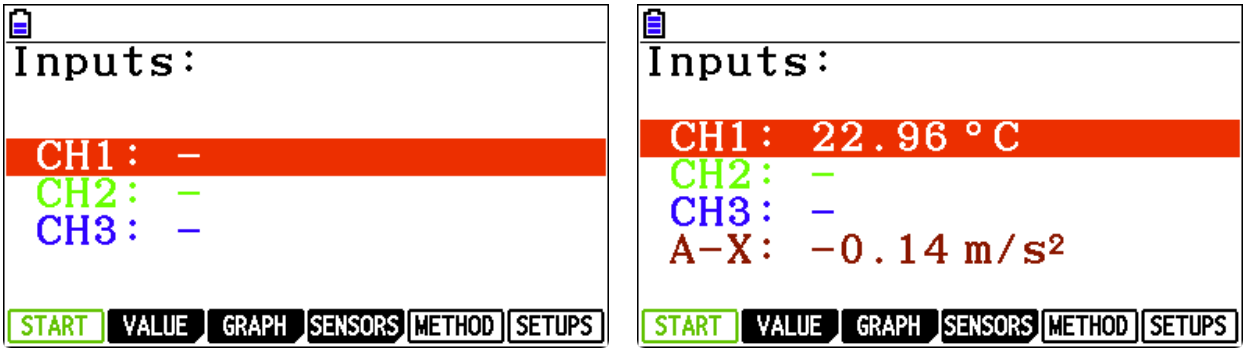
II. Data Logger App Screens and Menus

1. HOME Screen

When the communication between **C**LAB and the fx-CG50 calculator is established properly then the HOME screen is displayed, which:

- gives an overview of all **C**LAB inputs and enabled accelerometer channels, and
- offers the HOME Menu.

When a sensor is connected or an accelerometer channel is enabled then live measurements of the sensor are displayed.



Left: No sensors connected, no accelerometer axis enabled.
Right: The temperature sensor is connected to input channel 1 and the accelerometer in X direction is enabled.

The HOME Menu offers the following:

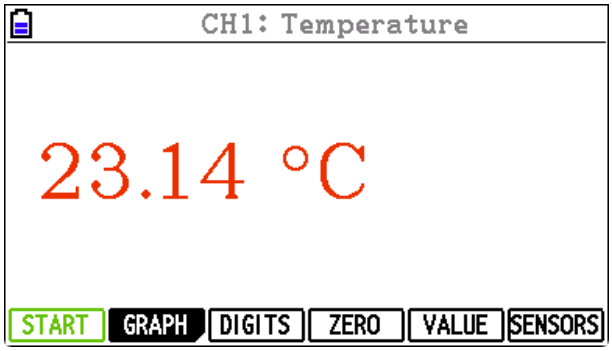
START [F1]	Starts the measurement (for details see below)
VALUE [F2]	Opens the VALUE Screen (for details see page 7)
GRAPH [F3]	Opens the GRAPH Screen (for details see page 8)
SENSORS [F4]	Opens the SENSORS Screen (for details see page 15)
METHOD [F5]	Opens the METHOD Screen (for details see page 21)
SETUPS [F6]	Opens the SETUPS Screen (for details see page 24)

2. START

Selecting the START [F1] menu option starts the measurement according to the set experiment settings. This option is present in few other screens: VALUE, GRAPH and SENSORS.
The measurement stops when the specified duration time has been reached (time-based method) or the number of data samples collected (manual method).
To abort the measurement before it is finished press the [EXIT] key.

***Warning**: Starting a new measurement overwrites the existing data by the new data without any warning. If you like to keep the collected data save it before you start a new measurement!*

3. VALUE



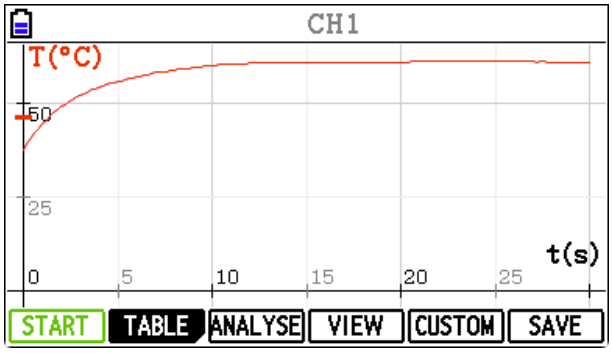
The VALUE screen displays real-time measured values in large digits. The live readings are **not stored** in the calculator memory.
Additionally this screen offers possibility to adjust the value measured by the sensor. If the sensor value is too high or too low, you can shift the sensor calibration through a third point defined by a value. This feature can be used for example to improve the sensor's accuracy when the sensor's factory calibration measures a different value than expected.
For some experiments it can be useful to set the sensor value to zero. For example when you set the equilibrium force of a mass on a spring connected to a force sensor to zero, then forces with respect to the equilibrium position can be measured.

The VALUE Menu offers the following options:

START [F1]	Starts a measurement (for details see page 6)
GRAPH [F2]	Opens the GRAPH Screen (for details see page 8)
DIGITS [F3]	To set the number of decimal digits
ZERO [F4]	To set the current measured by the sensor value to zero
VALUE [F5]	To set the current measured by the sensor value to another value
SENSOR [F6]	Opens the SENSORS Screen (for details see page 15)
RESET [F5]	Appears after ZERO or VALUE option has been used and allows to reset to value to the value according to its original calibration

- Use the [UP] and [DOWN] cursor keys to browse through the displays of input channels CH1, CH2, CH3 and the enabled channels of the accelerometer.
- To reset the sensor value to zero select ZERO [F4]. The readings of the sensor will be adjusted accordingly. Select RESET [F5] when you want to remove the new calibration.
- To set the sensor value to another value select VALUE [F5]**,** type in a value and confirm with [EXE]. The readings of the sensor will be adjusted accordingly. Select RESET [F5] when you want to remove the new calibration.

4. GRAPH



The GRAPH screen displays the data collected during the measurement.
A standard graph, the sensor quantity versus time (time-based measurement) or the sensor quantity versus index (manual measurement) is created automatically after a sensor has been identified or manually selected from the Sensor Library and when the accelerometer is enabled. Additionally user can define up to 3 custom graphs.

The GRAPH Menu offers the following options:

START [F1] Starts measurement (for details see page 6)

TABLE [F2] Opens the TABLE Screen (for details see page 9)

ANALYSE [F3] Displays the ANALYSE menu with a number of data analysis tools (for details see page 9)

VIEW [F4] Allows defining the settings of the displayed graph (for details see page 12)

CUSTOM [F5] Allows defining the settings of the custom graphs, after 3 graphs has been created the option disappears (for details see page 13)

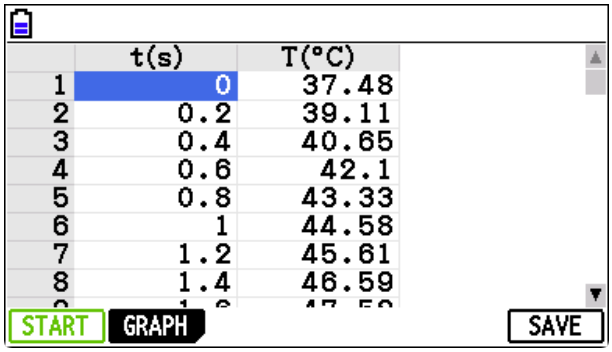
SAVE [F6] Allows saving the collected data in lists or in csv format (for details see page 14)

On starting a new measurement collected data are displayed in graph(s). During the measurement the graphs are automatic zoomed to give the best fit to the screen.

- Use the [UP] and [DOWN] cursor keys to browse through the graphs.
- Use the [+] and [-] keys to zoom in and out.
- Use the [x] and [/] keys to zoom in and out only the vertical direction.
- Use [x10^x] and [(-)] keys to zoom in and out only the horizontal direction.
- Use [8] and [2] keys to move the graph up and down.
- Use [4] and [6] keys to move the graph left and right.
- To reset the graph to its original auto-fit use the [AC] key or select VIEW [F4] and RESET [F6].

4.1. TABLE

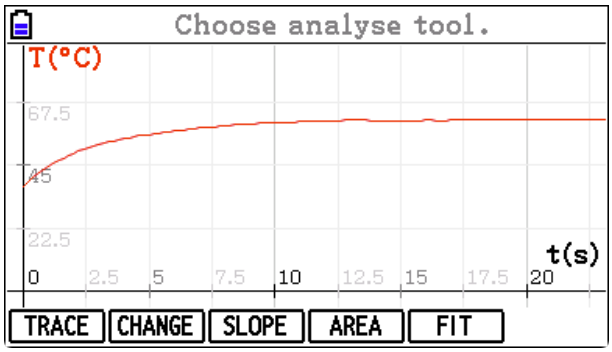
The Table displays the collected data in the table with columns, like index, time, and quantities measured via sensors or typed manually. Note that when starting a new measurement, the existing data is overwritten by the new data without any warning.



- Use [UP] and [DOWN] keys to go through the rows of the table.
- [SHIFT] + [UP] or [SHIFT] + [DOWN] to move cursor for one page up or down.
- Use the [LEFT] and [RIGHT] cursor key to go through the table columns.
- Select GRAPH [F2] or the [EXIT] key to return to the GRAPH Screen.
- Select SAVE [F6] to save the collected data in LISTS or in CSV format. In case of the csv format you can give the file a name.
- Follow instructions given at the top of the graph.
- Use [AC] key to reset the graph.

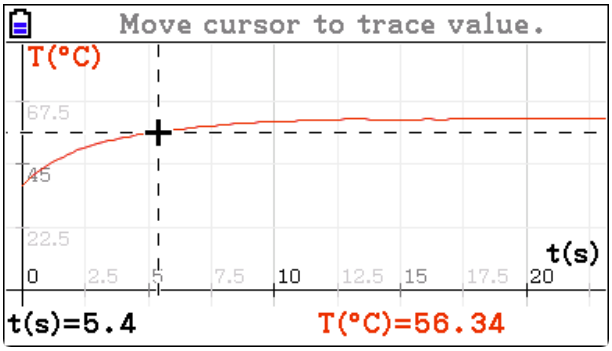
4.2. ANALYSE

By selecting the ANALYSE option a set of menu options – tools for data analysis - appears. Using these options does not change the original data but analysis info is temporarily shown.
The following tools are available:



TRACE

The TRACE option allows scanning coordinates of the data points in a graph.

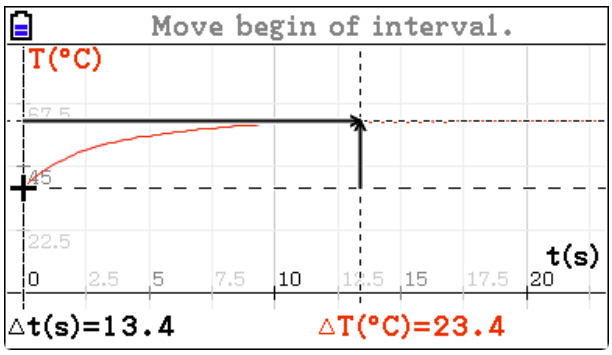


- Use the [LEFT] and [RIGHT] cursor keys to move through the data points in the graph.
- The coordinates of the selected point are displayed below the graph.
- Press the [EXIT] key to leave the TRACE option.

Note: Because of the calculator's memory scanning data via TRACE maybe very slow for graphs with a lot of data points. Longer pressing the keys moves cursor faster.

CHANGE

The CHANGE option allows calculating the change in the values of data between two points. Vectors in horizontal and vertical directions indicate the magnitude and direction of the changes.



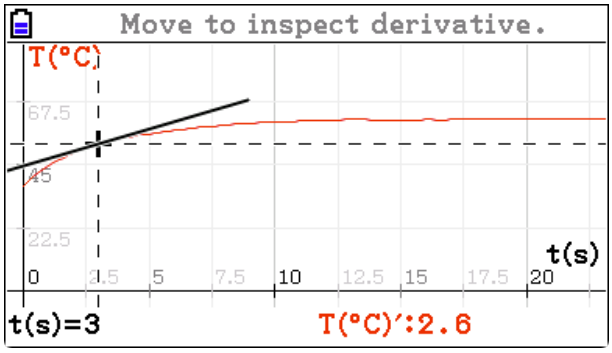
The numerical differences between the data values for each variable are shown below the graph.

You can toggle between the crossed lines defining the start and end points of the change by using the [EXE] key.

- When the cross defining the start point is selected use the [LEFT] and [RIGHT] cursor keys to select the start point. Accept with [EXE].
- Now the cross defining the end point is selected. Use the [LEFT] and [RIGHT] cursor keys to set the position of the end point.
- The difference values are shown below the graph.
- Press the [EXIT] key to leave the CHANGE option.

SLOPE

The SLOPE option is used to draw the tangent line and display the tangent value in the selected point.



- Use the [LEFT] and [RIGHT] cursor keys to select the point.
- The tangent line for the selected point is displayed on the graph and the slope value is displayed below the graph.
- Press the [EXIT] key to leave the SLOPE option.

Note: The implemented derivative is smoothed (it is important for noisy signals), smoothing is done in such way that several points from surround are averaged, for some signals and some points this may produces unexpected results.

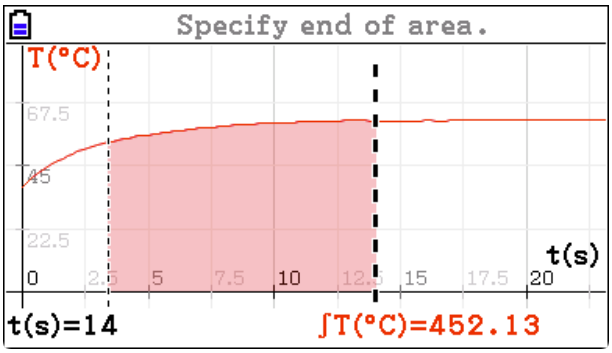
AREA

The **AREA** option is used to determine an area between the displayed graph, the horizontal axis and two boundary lines.

You can toggle between the vertical lines defining the borders of the area by using the [EXE] key.

- Select the line defining the left border of the area and use the [LEFT] and [RIGHT] cursor keys to set the left border. Press [EXE].

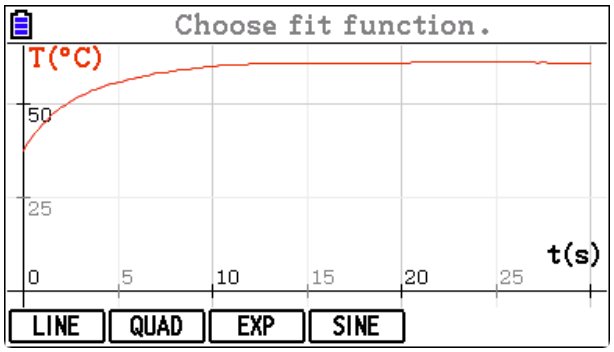
- Now use the [LEFT] and [RIGHT] cursor keys to set the right border.
- The selected area under the graph is indicated. The value of the selected area is displayed below the graph.
- Press the [EXIT] key to leave the AREA option.



FIT

The FIT option allows approximating the data in the graph with a standard mathematical function. You can choose from the following functions:

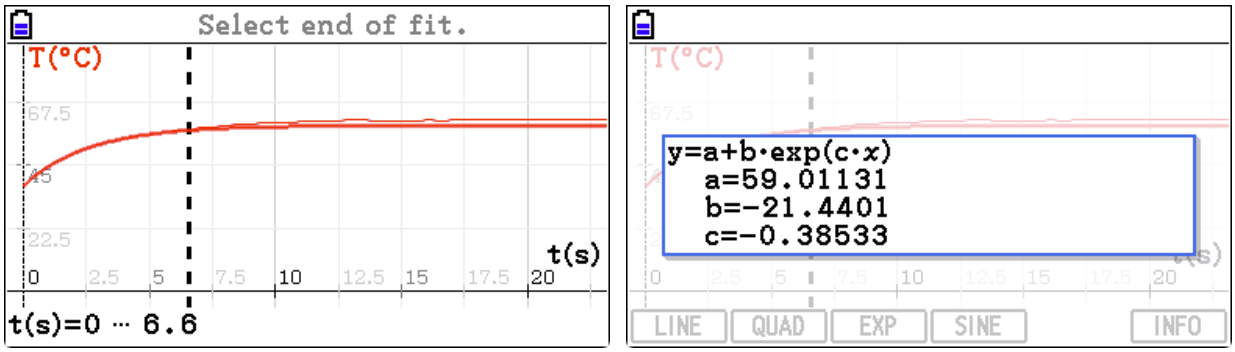
- LINE – linear function
- QUAD – quadratic function
- EXP – exponential function, and
- SINE – sinus function



The more sophisticated fit-functions can be applied by taking data into LISTS and use in the Statistics app.

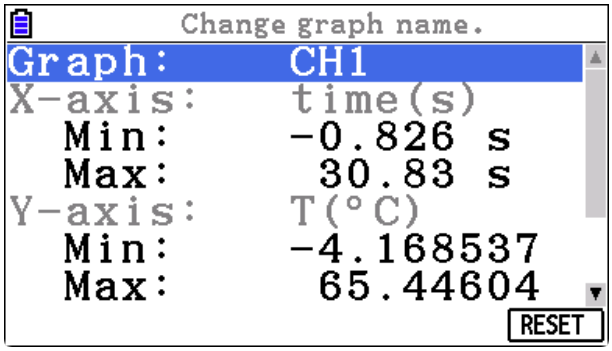
To fit the data:

- Select a type of function.
- Select the area to fit. Toggle between the left and the right vertical border defining the fitting range with the [EXE] key. The information on the position of the fit borders is displayed below the graph.
- Use the [LEFT] and [RIGHT] cursor key to move the selected vertical border. The best-fit function for the selected fit-range is drawn.
- When you are satisfied with your fit press the [EXIT] key to leave the fitting screen.
- Select the INFO [F6] option to display the coefficients of the fit-function.



Left: The temperature measurement fitted with the exponential function.
Right: The detailed information about the exponential function-fit displayed via the INFO option.

4.3. VIEW



The options of the VIEW screen allow defining the graph properties of the standard and custom graph(s):

Graph: Graph name (by default standard names for example e.g. CH1 or Custom 1 are used)
X-axis: Quantity (unit) along the horizontal X-axis
Min: minimum value for the horizontal X-axis
Max: maximum value for the horizontal X -axis
Y-axis: Quantity (unit) along the left vertical Y-axis
Min: minimum value for the left vertical Y -axis
Max maximum value for the left vertical Y -axis
COLOR: Color of the graph line
SHAPE: Way the graph line and its points are drawn
Y2-axis: Quantity (unit) along the vertical right Y –axis, shown only for custom graph(s)
GRID: Grid visibility

To edit graph properties

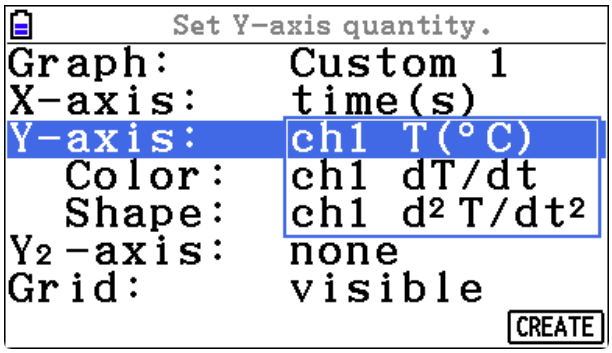
- Use the [UP] and [DOWN] cursor keys to scroll and select an option to edit.
- Press the [EXE] key, type a new name/value or select an option via the menu and accept with [EXE].
  1. Quantities displayed along X and Y-axis for standard graphs cannot be changed.

2. Quantities displayed along X, Y-axis and Y2-axis for custom graphs can be selected from a list. In the list all measured quantities and calculated 1st and 2nd derivatives are given.
   - For Motion detector BT55i the first derivative is indicated as **v** (velocity) and second derivative as **a** (acceleration).
   - For internal accelerometer a resultant acceleration **a**, calculated according to the formula $a=sgrt(a_x^2+a_y^2+a_z^2)$, is listed.

- Use the RESET [F6] option to reset the settings to the original graph.
- Use the DELETE [F5] option to delete a custom graph.

4.4. CUSTOM

The CUSTOM option allows user to create new custom graphs (maximum 3). The option disappears after 3 custom graphs has been defined



Graph: To set graph name by default *Custom* is used
X-axis: To set Quantity (unit) along the horizontal X-axis
Y-axis: To set Quantity (unit) along the left vertical Y-axis
COLOR: To set the color of the line in graph
SHAPE: To select a way the graph and its points are drawn
Y2-axis: To set Quantity (unit) along the right vertical Y –axis
GRID: To set the grid visibility

To edit custom graph properties

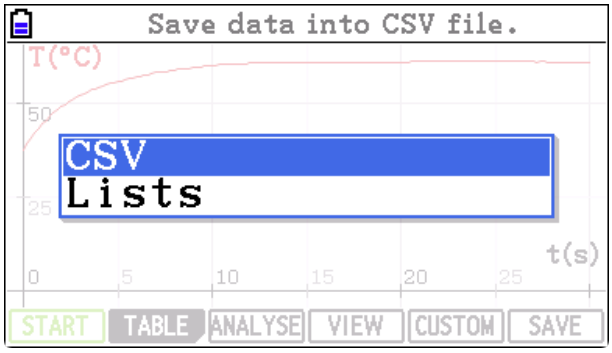
- Use the [UP] and [DOWN] cursor keys to scroll and select an option to edit.
- Press the [EXE] key, type a new value or name and accept with [EXE] again or use the menu option at the bottom of the screen.
- Quantities displayed along X-axis, Y-axis and Y2-axis for custom graphs can be selected from a list.
  - When other than time quantity is selected along the X-axis then the option Order appears. This option allows selecting the order of the data displayed along X-axis, according to its measurement time - by time (default) or according to its growing values - by values (this can be desired for creating graphs for quantities changing randomly in time).
  - In the list all quantities measured and 1st and 2nd derivatives are possible to select.
  - For Motion detector BT55i the first derivative is indicated as **v** (velocity) and second derivative as **a** (acceleration).
  - For internal accelerometer a resultant acceleration acc, calculated according

to the formula acc = sgrt(a_x^2+a_y^2+a_z^2), is listed.

- Use the CREATE option to create your new custom graph.
- Once the custom graph is created you can edit its properties or deleted via the VIEW option.
- After three custom graphs has been created the menu option CUSTOM disappears.

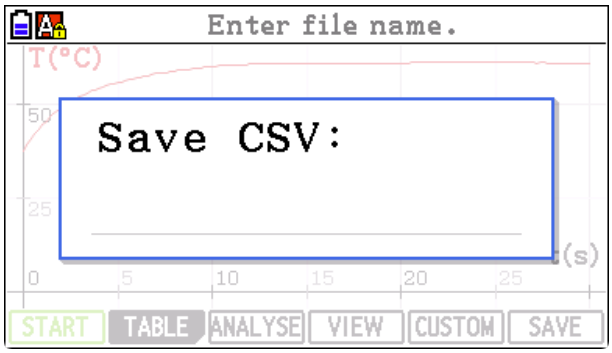
4.5. SAVE

Via the SAVE option the collected during the experiment data can be saved in files in CSV format or in Lists.



- when saving via the SAVE option on the TABLE screen the entire table is saved if one cell or whole table is selected or, when a column is selected, time/index and the column saved.
- When saving via the SAVE option on the GRAPH screen the data of actual displayed graph are saved, quantities displayed along X-axis, Y-axis and 2nd Y-axis if exists.

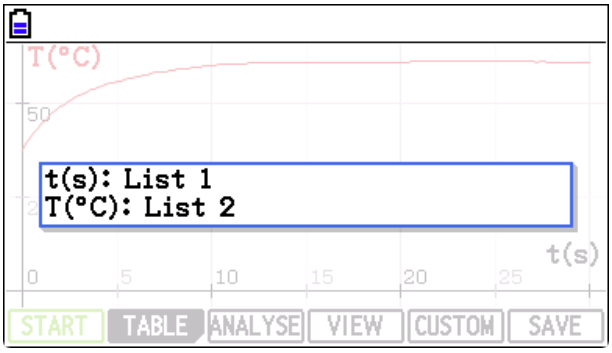
CSV



The CSV format is a comma-separated values (**CSV**) **file**, it is a delimited text **file** that uses a comma to separate values. Each line of the **file** is a data record. Depending on the language selected under Main Menu > Language the separators are set to dot and comma for English and Chinese, and to comma and semicolon for French, German, Portuguese and Spanish.
When the **CSV** is selected then the app asks for a file name. After confirmation file is stored into DataLog\exports folder on the calculator.

Lists

Lists are internal calculator data structures. The data are transformed into Lists in the following way:

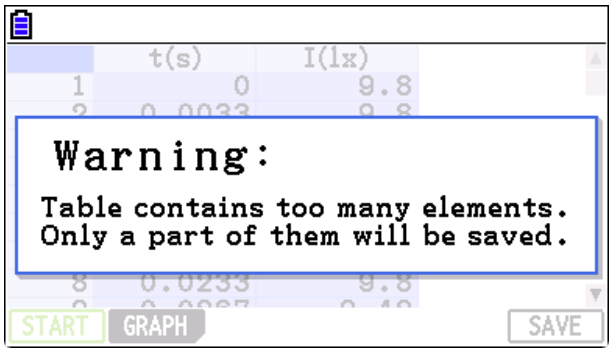


- time-based measurement: List 1 generally refers to time and List 2 onwards to the sensors connected in channels 1 to 3.

- manual measurement: List 1 generally refers to index and List 2 onwards to the sensors connected in channels 1 to 3 and to the quantities typed in via entries .

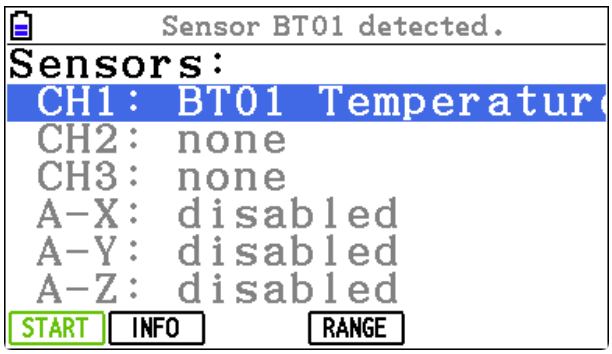
The data in Lists can be used with other calculator application for example with **Statistic**, which offers additional tools to analyze the data.

Warning:



- The next saved Lists overwrite previous data but if there were List 1, List 2 and List 3 and a new table has only 2 columns, only List 1 and List 2 will be replaced by new values, List 3 will not be deleted.
- The memory for list is quite limited and maximum number of list elements (list length) is 999. If a table has 5000 rows, only the first 999 rows can be put into lists.

5. SENSORS



The SENSORS screen displays information about connected sensors and enabled accelerometers. It allows to:

- enable the internal accelerometer in X, Y and Z direction,
- manually select a sensor from the Sensor Library,
- select a different then default sensor range (if available), and
- create a custom sensor.

The SENSORS Menu offers the following options:

START [F1] Starts measurement (for details see page 6)

INFO [F2] Opens the screen with sensor information (for details see page 18)

LIBRARY [F3] To select a sensor from the Sensor Library. This menu option is present only for channels to which no sensor is connected (none is displayed) or a manually selected sensor from library is connected. Sensors selected form the library are indicated by sign * in front of the channel name (for details see page 18)

RANGE [F4] To select another sensor range (for details see page 19)

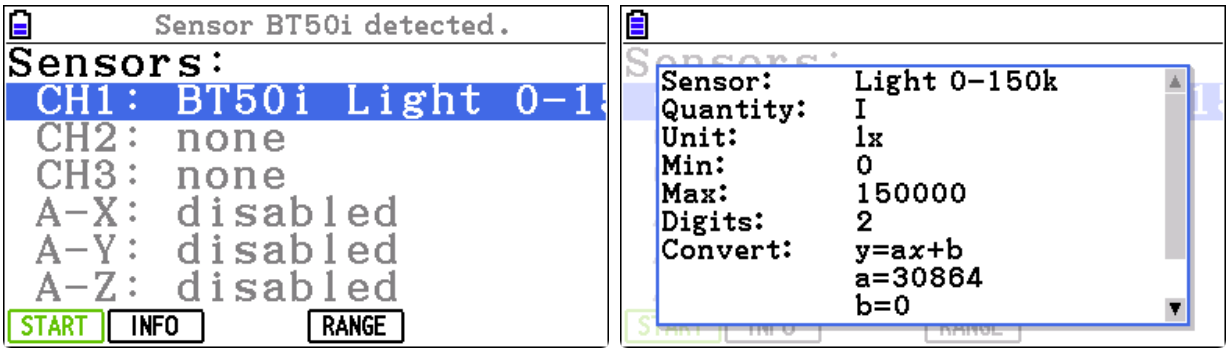
CUSTOM [F5] To create and select a custom sensor (for details see page 19)
REMOVE [F6] To remove the sensor selected from the Sensor Library

5.1. Detection and selection of sensors

CLAB automatically detects sensors when they are connected to the sensor inputs and tries to identify the connected sensors. Most CMA sensors will be automatically identified. Some older CMA sensors or sensors connected via the sensor adapter (e.g. CMA 4-mm to BT adapter 0519) will be not identified and need to be manually selected from the Sensor Library. It is also possible to create a custom sensor.

A. Automatically identified sensors

When the connected sensor is identified the live reading of the sensor are shown on the HOME screen and the sensor id and its name are shown on the SENSORS screen. By default the calibration stored in the sensor EEPROM memory is used.



Left: The CMA Light sensor BT50i is automatically identified.
Right: The detailed sensor information is shown after selecting INFO.

Warning

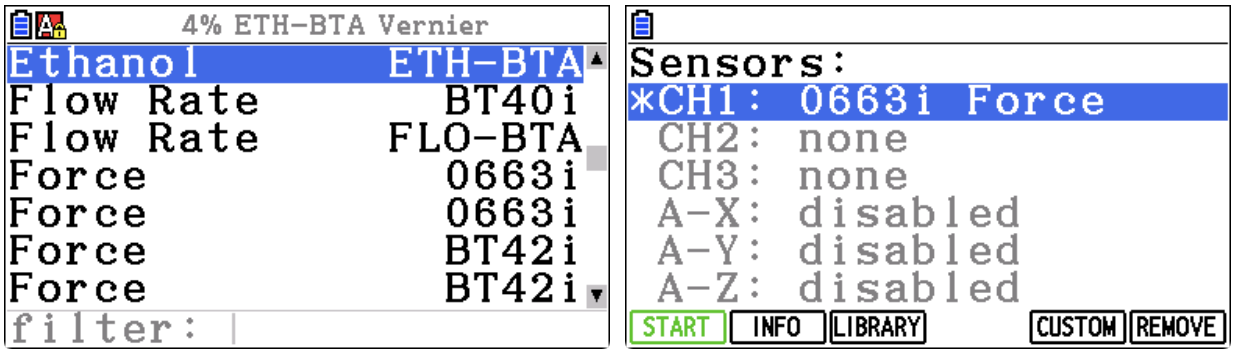
Some sensors cannot be automatically detected with CLAB even if they are equipped with an EEPROM memory. This is because they draw too much power. These are for example CMA Force sensors BT42i or 0663i. In case a sensor is not detected you have to select it from the Sensor Library.

B. NOT automatically identified sensors

When a connected sensor is not automatically identified (an older type of sensor or a sensor whose EEPROM memory cannot be read) then there are no live readings and **none** is shown on the SENSORS screen. The sensor has to be selected from the Sensor Library. The Sensor Library offers a number of CMA and Vernier sensors. To set up sensor manually:

- Select a channel to which you want to assign a sensor (the channel has to be empty or has to have another manually selected sensor assigned to it).
- Select LIBRARY [F3].

- Browse and select the desired sensor.
- Confirm with [EXE].
- The manually selected sensor get the * sign in front of the channel to which the sensor is assigned.



Left: The sensors are ordered alphabetically in the Sensor Library.
Right: CMA Force sensor 0663i is selected from the Sensor Library and assigned to Input channel 1.

Warning

Auto-detection **will not work** for channels, to which a manually selected sensor is assigned (indicated by *). The sensor information of the assigned sensor **overrules** the definition of a physically connected sensor even if it is a sensor, which can be automatically identified.

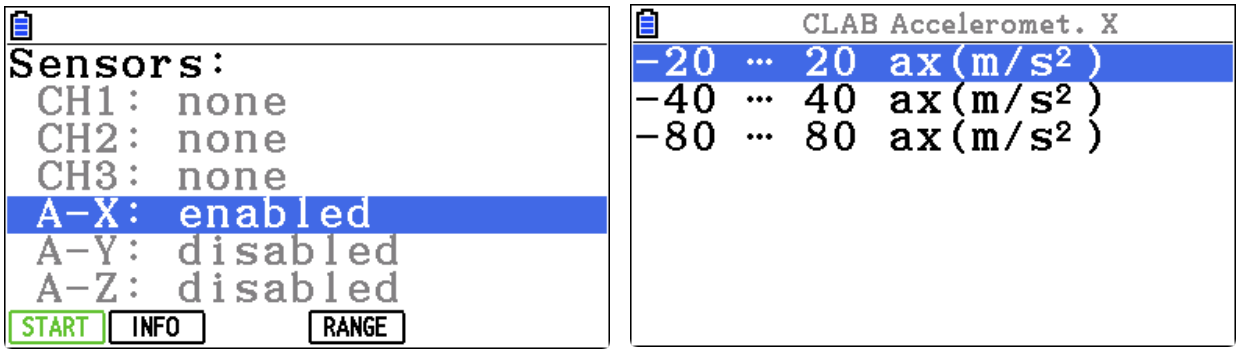
C. Custom sensors

Users can create their own sensors and add them for use in App. Use the CUSTOM option to define your custom sensors (for details see ….).

D. Internal accelerometer

By default all three accelerometer directions A-X, A-Y and A-Z are disabled.
To enable/disable an accelerometer:

- Select the desired accelerometer direction A-X, A-Y or A-Z.
- Press [EXE] to enable/disable it.
- Use the RANGE option to select another accelerometer range.



Left: The internal accelerometer in the direction X is enabled.
Right: The ranges available for the internal accelerometer.

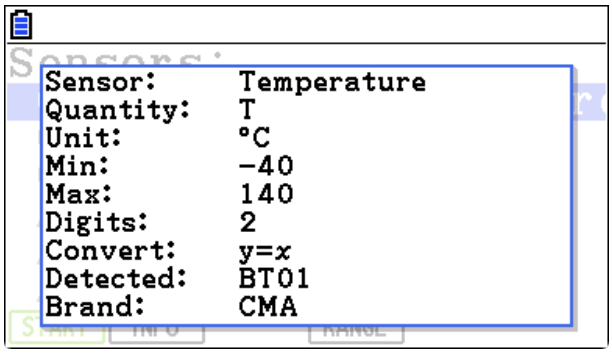
Please note that it is not possible to use different ranges for different accelerometer directions, the same range is used for all three directions.

After a sensor is physically disconnected from **C**LAB the following can happen:

- The detected sensor automatically disappears.
- The manually assigned sensor remains and stops to display live readings. To remove such a sensor, go to the SENSORS screen, select the sensor and select REMOVE [F6].

5.2. INFO

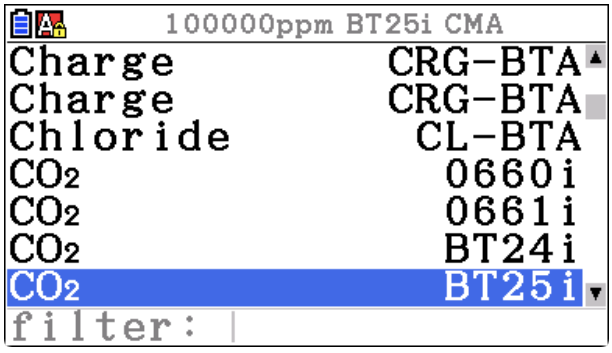
INFO displays the following information about the selected sensor (here as an example the CMA Temperature sensor BT01 is used):



Sensor:	Temperature sensor
Quantity:	T
Unit:	°C
Min:	-40
Max:	140
Digits:	3
Convert:	y=x
Detected:	BT01
Brand:	CMA

5.3. LIBRARY

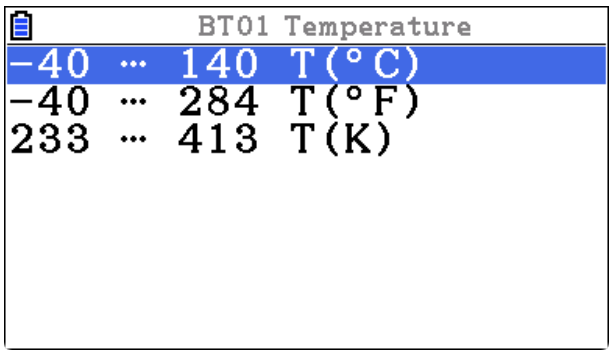
When a sensor is not automatically detected it may be selected from the Sensor Library. The Sensor Library consists of CMA and Vernier sensors, which are sorted alphabetically according to the sensor name. Additional information (range, id and brand) is shown on the top of the screen when a sensor is selected.



To select a sensor:

- Use the [UP] and [DOWN] cursor keys to scroll and select a desired sensor.
- You may use the Filter to find the sensor you need.
- Press the [EXE] key to select the sensor.
- The sensor will be assigned to the desired channel.

5.4. RANGE



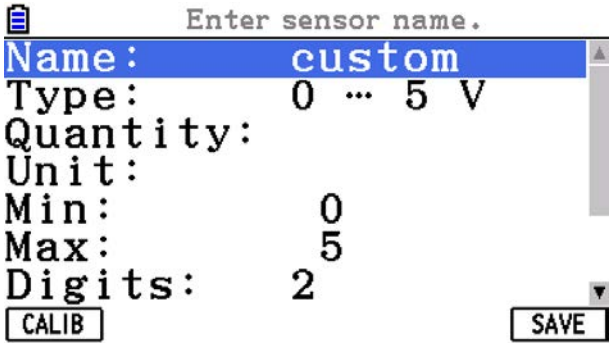
For sensors with EEPROM memory the factory calibration stored in the sensor is used as the default calibration. Some sensors have additional calibrations called Ranges. Such pre-defined sensor range can be selected via the RANGE option. For example:

- The temperature sensor BT01 has additional ranges in F or K.
- The Photogate BT63i is by default set to counter, but it has also other ranges like for a smart pulley x(cm) and for a drop counter V(ml).

5.5. CUSTOM

The CUSTOM [F5] option allows creating and calibrating a user-defined sensor. When there are no custom sensors then the screen is empty showing only the CREATE option.

To create your own sensor



- Select CREATE [F6] to display options defining the sensor:

  Name: Enter the sensor name

  Type: since analog inputs of **C**LAB measure voltage signal in two ranges, between 0 .. 5 V (default range) or -10 .. 10 V, it is important to indicate which voltage range is used by a new sensor.

  Quantity: Enter the quantity name measured by the sensor

  Unit: Enter the unit

  Min: Set minimal value measured by the sensor

  Max: Set minimal value measured by the sensor

  Digits: Set the number of the decimal digits for display

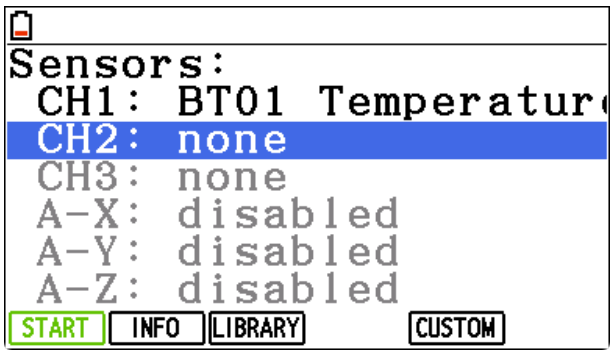
  Convert: Choose the calibration function.
  This is the mathematical relation between the voltage values produced by the sensor and the values of the quantity measured by the sensor.
  You can choose from:
  Linear ax + b,
  Quadratic $y = ax^2 + bx + c$, and

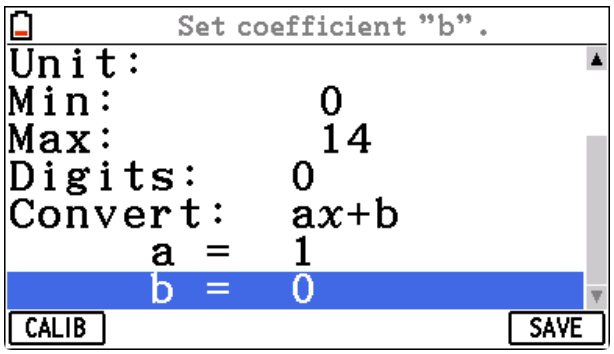
Logarithmic y = a + b* ln(x)
Define the function coefficients a, b, c by typing entering a new values or entering calibration points via the CALIB option.

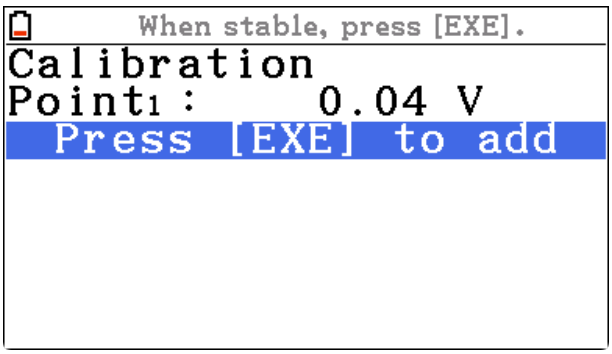
- If you prefer to calibrate your sensor select the CALIB [F1] option.
- Two calibration points are needed for linear and logarithmic calibrations and three calibration points are needed for the quadratic calibration.
  For each calibration point the sensor voltage value is measured and the value of the corresponding quantity has to be entered. The best fit through the calibration points for the selected function is calculated. Remember that to make such calibration the calibrated sensor has to be connected to **C**LAB and **C**LAB has to be turned on.
- Use the SAVE [F6] option to store your new custom sensor.
- Use the EDIT [F1] option to edit the properties of an existing custom sensor.
- Use the DELETE [F2] option to delete a custom sensor.

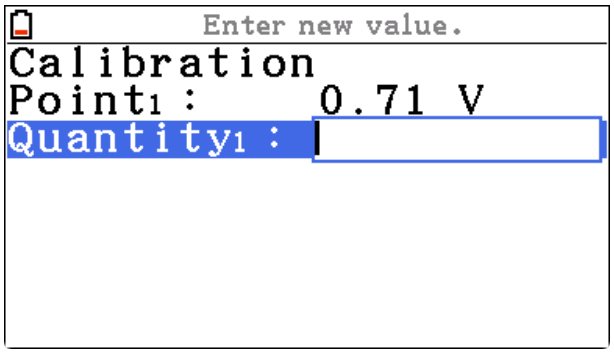
To calibrate your custom sensor

- Select empty channel, channel which displays **none**. Calibration will be performed for a sensor connected to this selected channel.
- Select CUSTOM [F5].
- Press CREATE [F6] to create a new custom sensor or select an existing sensor from the list.
- Plug in the sensor you want to calibrate to the selected input.
- Press CALIB [F1].
- The currently measured voltage value is displayed behind **Point$_1$.** If necessary wait for the voltage to stabilize and press the [EXE] key when you are ready to collect the first calibration point. Type in the corresponding quantity value. Repeat for the second and, if present, the third calibration point. If the measured voltages of calibration points are too close you will be not able to enter a next calibration point.
- When the calibration is finished the coefficients of the selected calibration function are modified accordingly.









Left: The voltage for the calibration Point$_1$ is measured; accept its value with [EXE].
Right: The respective quantity value has to be entered.

6. METHOD

The METHOD screen allows configuring the experiment: select a type of measurement, define measurement settings and a trigger condition.

CLAB - CLAB can work in two modes: connected or standalone.

A. Connected

In this mode, during the measurement **C**LAB remains connected to the calculator via a communication cable, and is controlled by the Data Logger app running on the calculator. The collected data are transferred in real-time to the calculator and the course of the measurement can be followed directly on the screen (limited to lower sampling frequencies). The recorded data **are not stored** in the **C**LAB's memory and should be saved in the Data Logger app.

B. Standalone

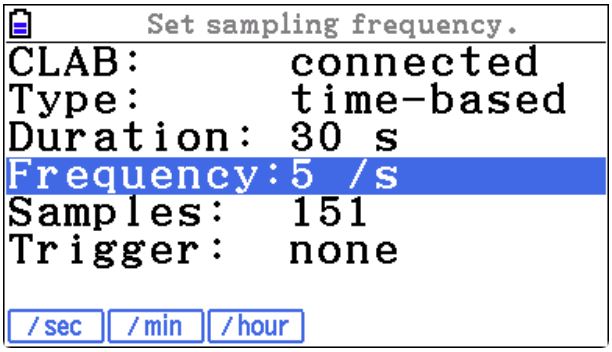
In this mode, during the measurement **C**LAB can be disconnected from the calculator, **C**LAB controls the data collection process - it collects and stores the measurement data. This is very useful for remote data collection e.g. outside the classroom. The experimental setup is prepared using the Data Logger app and uploaded to **C**LAB. The Power button of **C**LAB is used to start the measurement and its LEDs and a speaker give feedback about the status of the data collection. The measured data are stored in the **C**LAB memory and can be downloaded into the calculator after the measurement is finished.

Type - this option allows to select type of measurement: time-based or manual.

A. Type-based measurement

During the time-based measurement, measurements are taken at regular time intervals according to the defined sampling frequency rate.

A measurement is finished when its duration time has elapsed. Most measurements are of this type.



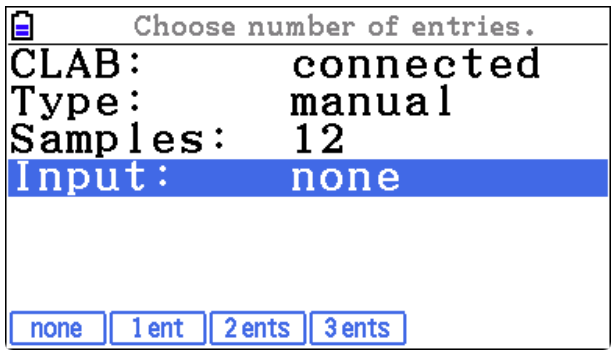
Examples of time-based measurements are:

- measurement with a temperature sensor of 100 values during 10 seconds (i.e. a sampling frequency of 10 Hz), or
- measurement with a sound sensor 0.2 s long with a sampling frequency of 40,000 Hz.

For very short measurements or when you want to start a measurement under specific conditions, you can start the measurement automatically by using the **Trigger** option.

B. Manual measurement (not available in the standalone mode)

During manual measurement a single measurement of value(s) measured by the connected sensor(s) is taken every time the [EXE] key is pressed.



Such measurement can be combined with keyboard entries then each time the [EXE] key is pressed, the value(s) measured but the connected sensor(s) are collected and the values of quantities defined by entries are typed in the respective fields.

The manual measurement is finished after the given number of samples is reached.

An example of such measurement is the Boyle's law experiment – pressure values are measured with a pressure sensor and the respective volume values are typed in.

Duration - to choose the length of the measurement, by default this is 10 s.

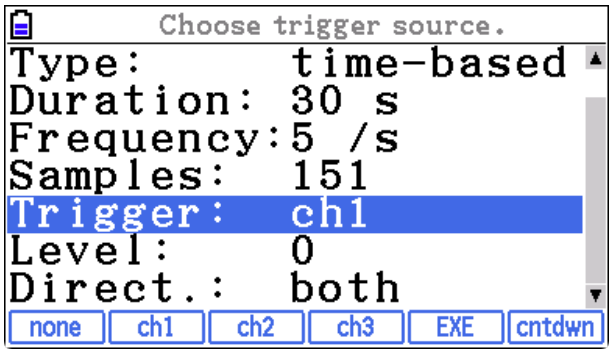
- Select the option and press the [EXE] key.
- Type in a value.
- Use the bottom menu to select the time unit: s, min, h.
- Accept with [EXE].

Frequency - to set the sampling frequency, by default this is 1/s (1 Hz).

- Select the **Frequency** option and press the [EXE] key.
- Type in the value.
- Use the bottom menu to select the frequency unit 1/s, 1/min, 1/h.

Samples - to set the number of samples taken during the measurement.

- Select the **Sample** option and press the [EXE] key.
- Type in the value.
- Accept with [EXE].



Trigger - to set a condition for automatic start of a measurement:

None – no triggering.

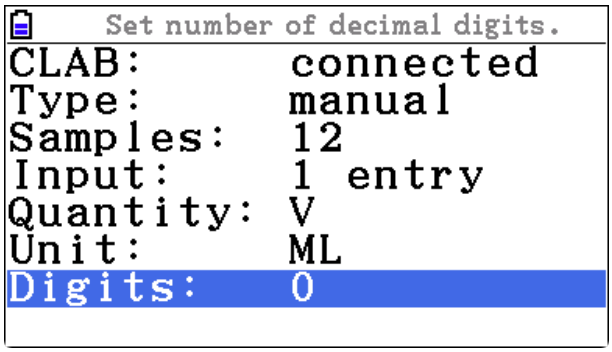
CH1, CH2, CH3 – triggering via a sensor connected to the selected input channel. When such triggering is selected then the trigger conditions, the trigger level and direction, determine the state of the signal on the trigger channel to automatically start the measurement.

EXE – pressing the [EXE] key starts the measurement.

CountDown – measurement starts after the defined via the Time option number of seconds. The [EXE] key can be used to start the measurement during counting down period.

Warning

It is **not** possible to trigger the measurement via sensors defined as counters such as CMA Photogates BT63i or 0663i and CMA Radiation sensor BT70i or 0666i. These sensors can be used for triggering only when they are set in their analog 0 .. 5 V range.



Input – to select keyboard entries:

None - only values of connected sensors are measured.

1, 2 or 3 entries – for defining quantities, which will be entered via the calculator keyboard. When one of these options is selected then for each entry the following has to be defined:

Quantity: enter a quantity name
Unit: enter a unit name
Digits: enter a number of decimal digits.

7. SETUPS

The SETUPS screen allows creating and managing experiment setups. A Setup stores channel configuration, sensors settings, method settings and graphs settings. The predefined Setup can be opened and the all needed settings loaded so the experiment can be started directly.

The SETUPS Menu offers the following options:

INFO [F1] Lists information about the Setup, its sensors and measurement settings

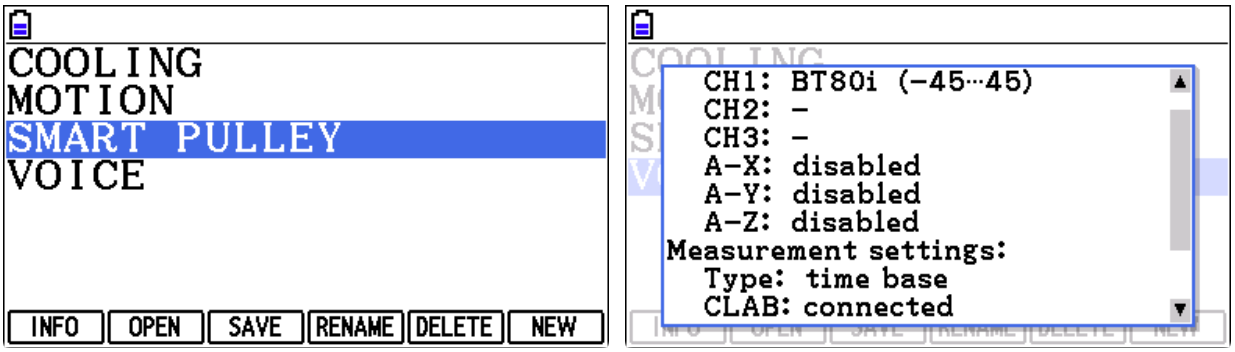
OPEN [F2] Loads the selected Setup and overwrites the existing settings

SAVE [F3] Saves the current settings in a Setup

RENAME [F4] Allows renaming the selected Setup name

DELETE [F5] Allows deleting the selected Setup

NEW [F6] Allows creating a new Setup, this action resets the all settings to the default settings



Left: The list of Setups created by a user.
Right: The detailed setup information displayed via the INFO option.

All setups files are saved on the calculator in DataLog\setups folder.

III. Typical Measurement Procedures

1. Typical procedure of the time-based measurement

1. Connect **C**LAB to your fx-CG50 via the communication cable and turn it on.
2. Turn your fx-CG50 calculator on and start Data Logger app.
3. If message 'CLAB disconnected' appears on the screen then there is a communication problem between **C**LAB and fx-CG50. Make sure that both plugs of your communication cable are fully inserted in the communication ports and your **C**LAB is turned on. If there is proper communication then the HOME screen shows the status of input channels.
4. Connect sensor(s) to the sensor input(s) on **C**LAB.
   - **C**LAB automatically detects the connected sensor(s) and displays the values currently measured by the identified sensors.
   - Sensors, which are not automatically identified, have to be selected manually from the Sensor Library. Select desired sensors from the library via SENSORS [F4] > LIBRARY [F3].
5. If you want to measure with the internal accelerometer you have to enable the accelerometer channels A-X, A-Y and A-Z via SENSORS [F4].
6. The values measured by the connected and enabled sensors are displayed in the HOME screen or in large digits via VALUE [F2]. Use the [UP] and [DOWN] keys to scroll through the active sensors.
7. The default measurement settings are:
   CLAB: connected
   Type: time-based
   Duration: 10 s,
   Frequency: 1 per s
   Trigger: none.
8. Press METHOD [F5] and setup your Time-based measurement (for details see page 21):
   - Define the measurement **Duration**.
   - Define the sampling F**requency**.
   - Is desired define the **Trigger** conditions.
   - Press [EXIT] to leave the Method settings.
9. Select START [F1] or press the [EXE] key to start your measurement.
   - When possible the data collected during the measurement are shown in real-time in graph(s) (quantities measured by connected or enabled sensors versus time).
   - By default the graph of the first channel, to which a sensor is connected, is displayed. If there are more graphs use the [UP] and [DOWN] keys to browse through them.

- The measurement stops when the specified duration time has been reached. To abort the measurement before it is finished use the [EXIT] key.
- For higher sampling frequencies there will be a delay between the moment of measuring data and the moment of displaying the data. The App shows the progress of downloading the collected data and when ready the data are shown in graph(s).

10. After the data collection is finished the data can be analyzed in TABLE [F2] or with analysis tools via ANALYSE [F3].
11. The data can be saved in Lists or CSV file.
12. The experiment settings can be stored as Setup for a future use.

2. Typical procedure of the manual measurement

1. Connect **C**LAB to your fx-CG50 via the communication cable and turn it on.
2. Turn your fx-CG50 calculator on and start Data Logger app.
3. If message 'CLAB disconnected' appears on the screen then there is a communication problem between **C**LAB and fx-CG50. Make sure that both plugs of your communication cable are fully inserted in the communication ports and your **C**LAB is turned on. If there is proper communication then the HOME screen shows the status of input channels.
4. Connect sensor(s) to the sensor input(s) on **C**LAB.
   - **C**LAB automatically detects the connected sensor(s) and displays the values currently measured by the identified sensors.
   - Sensors, which are not automatically identified, have to be selected manually from the Sensor Library. Select desired sensors from the library via SENSORS [F4] > LIBRARY [F3].
5. If you want to measure with the internal accelerometer you have to enable the accelerometer channels A-X, A-Y and A-Z via SENSORS [F4].
6. The values measured by the connected and enabled sensors are displayed in the HOME screen or in large digits via VALUE [F2]. Use the [UP] and [DOWN] keys to scroll through the active sensors.
7. The default measurement settings are:
   CLAB: connected
   Type: time-based
   Duration: 10 s,
   Frequency: 1 per s
   Trigger: none.
8. Press METHOD [F5] and setup your Manual measurement (for details see page 22):
   - Select **manual** as the type of measurement.
   - Define the number of **Samples** to collect.
   - Select the number of **Inputs** with **entries** from the calculator keyboard.

- For each entry define its **quantity**, **unit** and number of decimal **digits**.
- Press [EXIT] to leave the Method settings.

9. Select START [F1] or press the [EXE] key to start your measurement.
10. Press the [EXE] key to collect a data point from the connected sensor(s). In case an input entry is defined then enter the respective quantity value in a field, which appears after. If there are more entries then a field appears for each defined quantity.
11. The data collected during the measurement are shown in real-time in standard graphs (quantities measured by connected or enabled sensors or quantities typed in versus index). The graph of the first channel, to which a sensor is connected, is displayed by default. If there are more graphs use the [UP] and [DOWN] keys to scroll through them.
12. The measurement stops when the number of given samples is reached. To abort the measurement before it is finished use the [EXIT] key.
13. After the data collection is finished the data can be analyzed in TABLE [F2] or with analysis tools via ANALYSE [F3].
14. The data can be saved in Lists or CSV file.
15. The experiment settings can be stored as Setup for a future use.

3. Typical procedure of measurement with CLAB standalone

Warning

The limitation of working with **C**LAB in the standalone mode is that **C**LAB collects only one set of data. As the consequence the Data Logger App should be not used for other measurements or its Main Memory should be not erased before the collected in the experiment data are downloaded back to the calculator (otherwise the collected data will be removed).

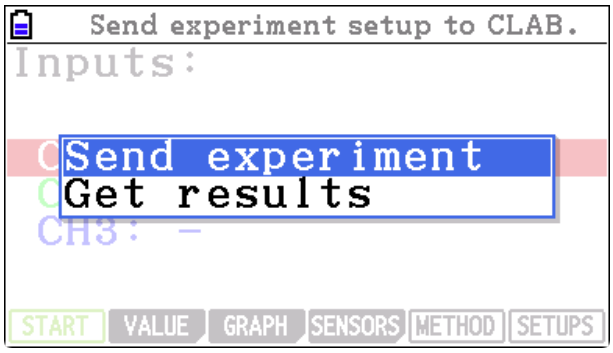
However it is allowed to turn off the calculator or start a new application, Data Logger app when started again will remember the last settings.

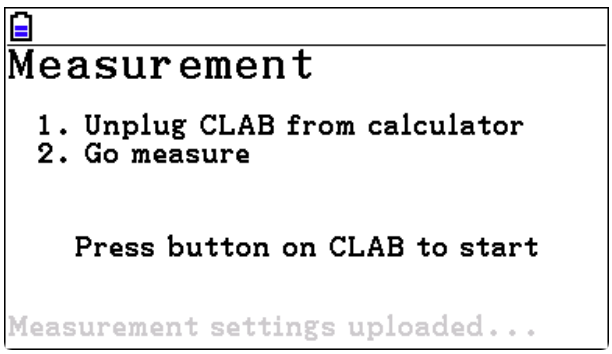
1. Connect **C**LAB to your fx-CG50 via the communication cable and turn it on.
2. Turn your fx-CG50 calculator on and start Data Logger app.
3. If message 'CLAB disconnected' appears on the screen then there is a communication problem between **C**LAB and fx-CG50. Make sure that both plugs of your communication cable are fully inserted in the communication ports and your **C**LAB is turned on. If there is proper communication then the HOME screen shows the status of input channels.
4. Connect sensor(s) to the sensor input(s) on **C**LAB.
   - **C**LAB automatically detects the connected sensor(s) and displays the values currently measured by the identified sensors.
   - Sensors, which are not automatically identified, have to be selected manually from the Sensor Library. Select desired sensors from the library via

SENSORS [F4] > LIBRARY [F3].

5. If you want to measure with the internal accelerometer you have to enable the accelerometer channels A-X, A-Y and A-Z via SENSORS [F4].
6. The values measured by the connected and enabled sensors are displayed in the HOME screen or in large digits via VALUE [F2]. Use the [UP] and [DOWN] keys to scroll through the active sensors.
7. The default measurement settings are:

   CLAB: connected
   Type: time-based
   Duration: 10 s
   Frequency: 1 per s
   Trigger: none.
8. Press METHOD [F5] and setup a measurement in the standalone mode:
   - Select **standalone** as the CLAB mode.
   - Define the measurement **Duration** and sampling **Frequency**.
   - Define trigger conditions, by default the **C**LAB Power button is selected for starting the remote measurement.
   - Press [EXIT] to leave the Method settings.
9. Select START [F1] or press the [EXE] key.
10. Select **Send experiment**.





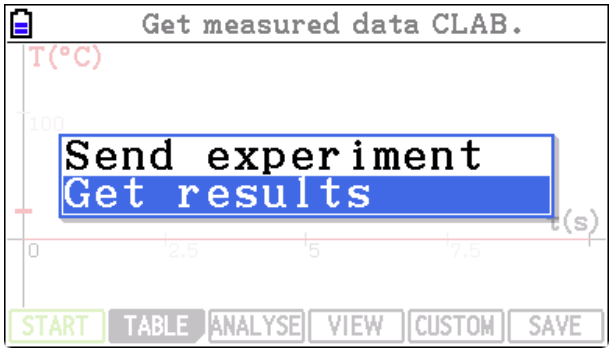
11. The right Measurement LED of **C**LAB becomes blue when **C**LAB is ready.
12. Now you can disconnect **C**LAB from your calculator.

    If you wish (for example there is a long time between preparation of the measurement and the start of the measurement) you can now turn your **C**LAB off. Settings are stored in the permanent memory of **C**LAB. After you turn **C**LAB on again the right measurement LED will show that it is ready for measurement.
13. Perform a measurement:
    - press the **C**LAB power button to start the measurement, or
    - if **Triggering** is enabled (the right Measurement LED is blinking blue) then the measurement is started when the trigger conditions are met. To force triggering manually, press the Power Button.

    The right Measurement LED blinks green during data collection. If you want to

stop the measurement, press the **C**LAB Power Button.

14. The data collection stops after the specified measurement time has been reached. The Measurement LED remains green to show that measured data are stored in the **C**LAB's memory. These data will stay in memory until new experiment settings are sent to **C**LAB.
15. Now you are allowed to turn off your calculator or use other application, but do not work with Data Logger app or erase the Main Memory of your calculator.
16. When you are ready re-connect **C**LAB to your calculator.
17. Select START [F1] or press the [EXE] key and select **Get results**.
18. Data will be downloaded into the calculator and shown in standard graph(s) (quantities measured by connected or enabled sensors versus time). The graph of the first channel, to which a sensor is connected, is displayed by default. If there are more graphs use the [UP] and [DOWN] keys to scroll through them.



19. After the data collection is finished the data can be analyzed in TABLE [F2] or with analysis tools via ANALYSE [F3].
20. The data can be saved in Lists or CSV file.
21. The experiment settings can be stored as Setup for a future use.

Notes

1. In a very rare situation it can happen that after the standalone measurement is performed **C**LAB does not start anymore. This can be caused by a problem with reading the stored data from the **C**LAB's memory. To force **C**LAB to start without reading the stored data press and hold the Power Button (3-4 sec) until the left Power LED becomes green then release the button.
2. For measurements:
   - with time measurements longer than 2 hours,
   - with sampling frequency of one sample per 2 minutes (or lower),
   - without use of Motion detectors BT55i,

CLAB is set into a Power-save Mode and will turn itself off between collecting single data samples. It awakes 2 seconds before a new sample has to be collected. Data are saved in **C**LAB memory in between. During the measurement a short press of the Power Button will wake CLAB up. It will stay awake until the next sample is taken and then go back to sleep again.

4. Typical procedure of measurement via Setup

1. Connect **C**LAB to your fx-CG50 via the communication cable and turn it on.
2. Turn your fx-CG50 calculator on and start Data Logger app.
3. If message 'CLAB disconnected' appears on the screen then there is a communication problem between **C**LAB and fx-CG50. Make sure that both plugs of your communication cable are fully inserted in the communication ports and your **C**LAB is turned on. If there is proper communication then the HOME screen shows the status of input channels.
4. Select SETUPS [F6].
5. Select the experiment setting the list. If can check the settings of the selected Setup via INFO [F1].
6. Connect predefined sensors.
7. Select START [F1] or press the [EXE] key.
8. Perform the measurement. The procedures of different measurement methods are described in the first three topic of this chapter.

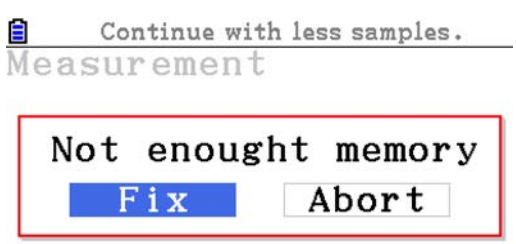
IV. APPENDIX

1. Application limitations

Limitations in the app	
Max. Number of points	30000
Max. Duration	356400 s
Max. Sampling frequency	1 sensor: 100000 Hz 2 sensors: 50 000 Hz 3 sensors: 15 000 Hz 1 Motion sensor BT55i: 100 Hz 2 Motion sensors BT55i: 20 Hz Counter functionality: 2500 Hz Sound sensor in decibel: 100 Hz Internal accelerometer: 400 Hz

In the METHOD screen the Data Logger app checks if the measurement according to the set values can be performed. If this not the case the program adjusts the set values.

If the number of used channels or selection of sensors is changed after the measurement settings has been defined then it may happen that the set sampling frequency exceeds its limit, then application will display **Not enough memory** with options **Fix** or **Abort** measurement. When **Fix** is selected then the application adapts the defined sampling frequency. It also adapts the number of **Samples** so, that measurement **Duration** does not change too much.



2. Display of measured data

Since the speed of data transfer between a calculator and **C**LAB is rather slow the real-time display of data in graphs is limited to lower sampling frequencies.

For example the data will appear in real-time in graphs for measurement:

- via 1 channel with the sampling frequency of 200 Hz,
- via 2 channels with the sampling frequency of 100Hz,
- via 3 channels with the sampling frequency of 50 Hz

For higher frequencies there will be a delay between the moment of measuring data and the moment of displaying the data. The delay depends on a number of data that need to be transferred. In such situations the Data Logger App automatically shows the programs of downloading. The data are displayed in

graphs after the downloading is completed.

3. Location of Data Logger files

Data logger app files are stored in the calculator's memory in:

Storage Memory:

- The application file "DataLog.g3a"
- The "DataLog" folder with folders:
  - sensors – for storing the custom sensors and
  - setups – for storing the experiment setups.

Main Memory:

- The System files,
- "@DataLog" folder for storing settings for example a new measurement properties