

**NeuLog™**  
Neuron Logger  
Sensor Network Technology

**User Guide  
For Browser Mode**



# **NeuLog™**

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## **Sensor Network Technology**

# **User Guide**

# **For Browser Mode**

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# Chapter 1 – Introduction

## 1.1 About data-loggers and sensors

In science experiments various values are measured, such as temperature, light, sound, voltage, current, distance, velocity, acceleration, oxygen percentage in air or in solution, pH etc.

Most of the measured values are analog, which change successively. The device that measures them is electronic so the value is changed into an electrical signal, and is called sensor or transducer. There is a specific sensor for each value.

The electrical signal is then converted into digital form in order to be displayed or computerized by a component called ADC (Analog to Digital Converter).

Digital numbers are changed in steps. The ADC resolution determines the size of the steps. When the steps are small, the resolution is higher and the accuracy is higher.

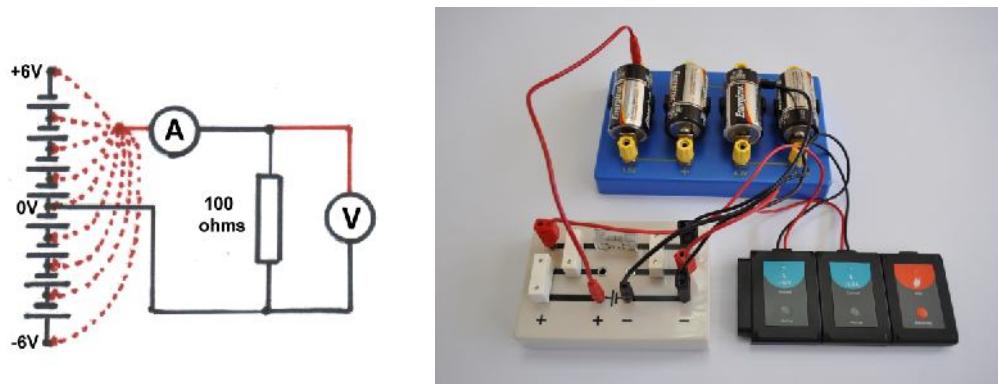
A data-logger is a device that includes an ADC for reading values from several sensors and recording this data in its internal memory. Usually, it has a display for viewing the measured values graphically. The data-logger can be connected to a PC for exporting the recorded data to Excel files or for saving it in files and viewing it on the screen.

The data-logger's capability is characterized by the number of sensors that can be connected to it simultaneously, its memory size, its ADC resolution level and its sampling rate. Its inputs are suited to all available sensors and also to those which will be developed in the future.

The data-logger software analyzes all available sensors.

## 1.2 About logger sensors

The logger sensors system is rather different from almost all other educational data-loggers in that its sensors incorporate their own individually programmable microprocessors and have memory. Hence, each sensor can be viewed as a data-logger in its own right, it records and stores data independently and can be referred to as a logger sensor but within this guide they will just be called sensors.



**Figure 1-1 Voltage-Current Measurement Experiment**

In order to program the sensors, they need to be connected to a Monitor Display Unit (MDU). The MDU can be any kind of PC (Windows, MAC, Linux), tablet (IPAD or Android) or NeuLog viewer. The connection can be by wire using the USB module or wirelessly using the RF module or through the WiFi module. Tablets are connected to the sensors through the WiFi module.

The MDU is the monitor and the display unit only. Data is stored in the sensors themselves. The PC can save the experiments in hard disk and can load saved experiments at off-line mode.

The sensors can be connected singly or in a chain. The order of connection does not matter and they can be added or removed from the chain without affecting the others.

Depending on their use, sensors can be powered directly from the MDU. However, they can also be powered individually or in chains by a Battery Unit.

One chain of sensors can be divided into more chains by adding RF communication modules to all the sensors' chains allowing remote connection of up to 30m (in open space).

12 bit resolution is provided for most sensors and sampling rates vary from 10000 per second to 1 per hour, depending on the sensor concerned. The rates available for each sensor match well to their likely use. Experiment durations are from 25ms to 31 days, depending on the sensor and the sampling rate. A Trigger setting with Pre-trigger is available through which sampling starts and data is displayed from just before the Trigger operated.

## 1.3 Plug and play system

The philosophy behind logger sensors is a "plug and play" system. Connect the experiment's required sensors to the MDU (Monitor Display Unit) and perform the experiment with intuitive software.

There is no need to study data logger operation. All the measurements, the recording and

The total memory of the system is increased since each sensor has its own memory.

Each sensor has its own micro-controller (tiny computer), so it can control and adapt even the hardware to different functions. This is why many of the logger sensors have several ranges or different types of measurements that are usually done by more than one sensor.

The built-in software in the logger sensor can be upgraded at any time using software (without opening the sensor module).

## 1.4 Modes of operation

The Logger Sensors system has two modes of operation: **On-line experiment** and **Off-line experiment**.

**On-line experiment mode** is where the sensors are connected to the MDU, programmed, and remain connected as the data is fed back continuously in real-time. All sensors gather data at the same rate, are triggered together (a choice has to be made of which sensor to trigger from) and run for the same time.

On-line experiment mode enables also collection of data at particular stages of the experiment instead of continuously. The **Single-step** mode (sometimes known as 'snapshot') can be used when measurements are taken while some of the experiment variables are changed manually, like changing the source voltage in an electrical circuit, volume in a pressure-volume experiment or adding drops into solutions, etc.

**Off-line experiment mode** is where the sensors have been programmed by connection to the MDU with different Sampling rates and Experiment durations. The sensors are then disconnected from the MDU and put into battery-powered chains (or singly) to collect their data on the pressing of the sensors' Start/stop buttons. However, in this mode, each sensor can be programmed independently to be triggered to record data as well as having their Start/stop buttons pressed at different times. Five experiments can be stored in each sensor.

Reconnection of the sensors to the MDU is required to upload the data and analyze it. However, all graphs would be overlaid on the longest Time axis with  $t = 0$ s being where each sensor appears to have been triggered. Hence it does not take into account the time differences between the pressing of any sensors' Start/stop buttons and their independent triggering.

The sensors can remain connected to the MDU at **Off-line experiment mode**. As before, the sensors can be programmed with different sampling rates and experiment durations. Again, each sensor can be programmed independently to be triggered to record data. Starting and stopping can be done either by clicking on relevant icons on the MDU or by pressing the Start/Stop buttons on the sensors. Data is then uploaded in order to display and analyze it.

Collected data (in both modes) is stored in the sensors' internal memories, to be displayed as required on the MDU. Each sensor has an ID number that can be changed, when necessary, through software. This would be needed if you were using an array of the same type of sensor, i.e. several temperature sensors, and needed to see what was happening on each one. All sensors are automatically recognized by the system.

## 1.5 Data display and analysis

The computer's display of data can be in the form of a graph, a table or both, plus a digital display of each sensor's current value e.g. 20°C, 8.95V, 20.9%. The default graph display is of what the sensor measures (Y-axis) plotted against Time (X-axis) but, as mentioned in an earlier paragraph, it is possible to plot XY graphs in which one sensor's data is plotted against another's.

Graphs can have their axis scales pre-selected, can be zoomed to maximize their display in the Y-axis direction, or have small areas selected and zoomed to allow examination in more detail. The graphs of each sensor can be overlaid and their Y-axes moved to convenient positions on the screen.

A best-fit line/curve facility is provided to overlay the graphs, and extrapolation to zero of best-fit straight-line graphs is available. Areas under graphs can be easily calculated for use in determining such a quantity as Impulse from a Force-time graph. Graph plotting can be in 'points only' or in 'a joined up line' and a set of grid-lines can optionally be added.

A number of mathematical functions [ $\log(A)$ ,  $\ln(A)$ ,  $\sqrt{A}$ ,  $A^2$ ,  $1/A^2$ ,  $(A+B)$ ,  $(A \cdot B)$ ,  $(A/B)$ ,  $(1000 \cdot A \cdot B)$ ,  $(A \cdot K)$ ,  $(e^A)$ ,  $(10^A)$  and  $(A/K)$ ] are available with which to convert data, where A and B are the variables and K a constant. The function A/B would be useful in generating data (and a graph) of the resistance of a filament light bulb, where A is the voltage across the bulb and B the current flowing through it.

These functions allow one to deal with most data processing. The data can also be exported into a spreadsheet for further manipulation and processing.

Triggering is available to start data-logging when a particular sensor's measured value falls or rises below or above a set level. When triggering has been selected, a Pre-trigger display is made available on the graphs and in the tables so that sensor values just before the triggering took place can also be seen. This is particularly useful when looking at how the voltage across a coil changes when a magnet falls through it.

Worksheets, incorporating setup details, photographs and diagrams, can be developed and displayed, and saved with or without a Setup Configuration.

**Note:**

**Additional features will be incorporated in later versions of Logger Sensors and some more sensors will be developed. Revised versions of the software will be provided free to download as they become available.**

## 1.6 About this User Guide

This User Guide was designed to go through one complete chapter at a time.

Instructions to do things are indicated by a bullet •.

Because the measured data is processed in the logger sensor, the software treats each sensor in the same manner except the photo-gate sensor.

The NeuLog™ software is very rich and at the same time intuitive. It is very simple to use.

There are two types of NeuLog™ programs. One is a version for PC with Windows and its icon is . The second is for any PC (Windows, MAC, Linux) using the PC default browser and its icon is .

This manual describes the NeuLog™ program for browser mode through few sensors.

## 1.7 Safety instructions

- Read and understand these entire instructions before proceeding.
- Keep these instructions.
- This equipment is **not** designed to perform in an environment where failure may result in accident or injury.
- This equipment is designed to operate and perform in an educational environment. It is not designed to be used in a medical, marine or industrial environment.
- Disconnect module before servicing for any reason. Servicing should be performed by **QUALIFIED PERSONNEL ONLY!**
- Do not operate a module if it is broken or if components are revealed for any reason.
- Do not operate module with damaged cord, wires or electrical parts. Use only cords supplied with the module.
- Use only power source approved by SES or enclosed with the training system.
- The USB module is also an approved power source for the NeuLog™ modules.
- Use modules only to measure the parameters for which they are designed as specified on the module label.
- Do not attempt to measure values exceeding those specified on the module label, particularly voltage and current.
- Clean only with a dry cloth.
- Do not install near any heat sources such as radiators, heat registers or other apparatus that produce heat.
- Unplug the module during lighting storms or when not used for long periods of time.

## 1.9 Environmental conditions

- Do not expose modules to any kind of liquid.
- Operating temperature: 0°C to +40°C.
- Humidity: up to 95% at 35°C.



### Power requirements:

- Battery module (rechargeable batteries) or computer USB outlet

## 1.10 FCC Radio frequency interference statement

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

Scientific Educational Systems Ltd. is not responsible for any radio or communication interference caused by using other than specified or recommended cables and battery or by unauthorized changes or modifications to this equipment. Changes or modifications not expressly approved by the manufacturer could void the user's authority to operate the equipment.

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

1. This device may not cause harmful interference
2. This device must accept any interference received, including interference that may cause undesired operation.

# Chapter 2 – Basic Setup

## 2.1 Installation

**The software and drivers must be installed before connecting any modules to the PC.**

- Open the setup file on the CD you received with the system.
- Follow the instructions on the screen. The installation process is straightforward and the required drivers are installed automatically.

The installation is composed of two parts: NeuLog™ software installation and USB driver installation. After the installation process is completed, the Logger Sensors software is ready to use.

### Notes:

Upgrading the software can be done at any time. Installing the upgraded software just replaces the relevant files, so uninstalling the software before upgrading is not necessary.

When upgrading the software, the USB driver installation can be skipped by clicking the 'Cancel' button.



The NeuLog™ shortcut icon  should appear on the PC desktop.

## 2.2 NeuLog sensors with tablet through WiFi

Most of the tablets do not have USB port and this is why we cannot connect the USB module to them.

Instead, we use a WiFi module, called **WiFi-201**. This module comes with the NeuLog software in it. This software can be run under any browser.

This mode of operation has some more advantages. One can operate the system and run the experiments and many others can view his results and screens.

What are the options of this mode of operation and how to run the software until we get the main screen, is described in **appendix B**.

If you are using the **WiFi-201 module**, use the instructions in Appendix B until you get the NeuLog software main screen and continue from section 2.3.

## 2.3 Logger sensors main screen

- Double-click the **NeuLog™** shortcut icon  to display the following:



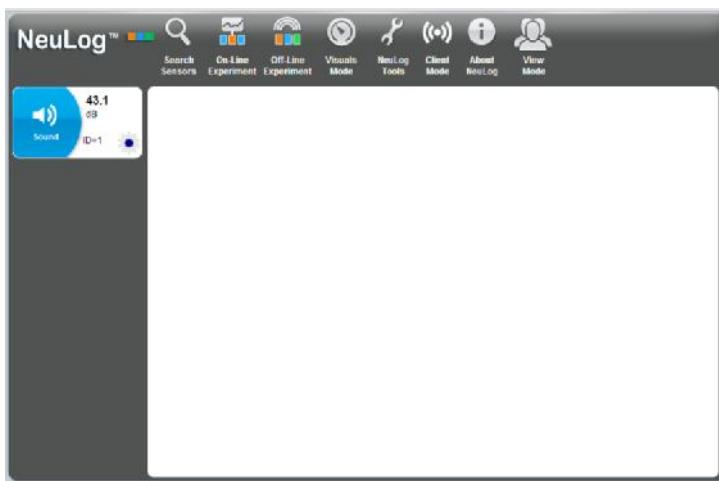
The NeuLog™ software is an intuitive program that guides the user how to use through the screen icons. Please, do not be afraid to play with the system. This is the main idea of the NeuLog™ system – use it and have fun.

## 2.4 Connecting a sensor

- Connect the USB Bridge module  to a USB port on the PC with the USB-mini USB cable.
- Connect the Sound sensor  to the USB Bridge module .

Each module has two connecting sockets – a female socket at one side and a male socket on the other side. The sockets enable you to connect the sensor modules in a chain.

- Click on the **Search Sensors** icon  in the Main-icon bar. The program will scan and display the connected sensor's Module box, in this case that of the Sound sensor, automatically in the Module window on the left-hand side of the screen as shown below:



- During the search, a **Stop** button  appears at the end of the search bar. This button can be used in order to stop the search when all the connected sensors are identified.

The program starts automatically in the **Search for sensors** mode so, if you run the program whilst modules are connected to the PC, their presence will be scanned for and their Sensor Module boxes will be displayed in the Module window.

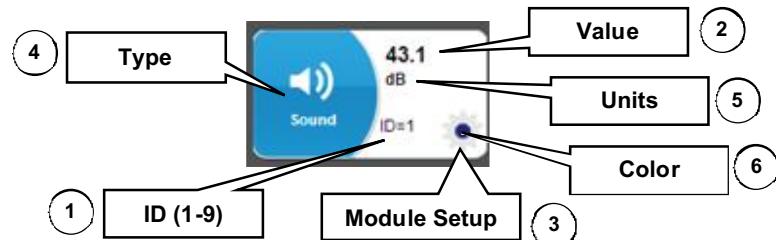
If you add or remove sensors from a chain of sensors you must rescan by clicking on the **Search Sensors icon** .

Any newly detected Sensor Module boxes are displayed vertically in the Module window.

The software strives to achieve maximum intuition; only the buttons that are relevant to each stage is shown. The BACK button brings you back to the previous step.

This is the "plug and play" method. Connect the sensors to the PC through the USB module, click **Search Sensors** and the system is ready to use.

## 2.5 Sensor module box



1. **ID** – Displays the sensor's ID. Up to 9 sensors of the same type can be connected in a chain.
  2. **Value** – Displays the sensor's numerical value.
  3. **Module Setup** – Opens the sensor's setup window.
  4. **Type** – Displays the sensor's type (Light, Temperature, etc.).
  5. **Units** – Displays appropriate units of measurement (lx for a Light sensor, °F or °C for a temperature sensor, etc.).
- Pressing on the sensor symbol opens the parameter window (Module Setup) for that particular sensor.



- The measurement range of the sensor is set by the Range button.



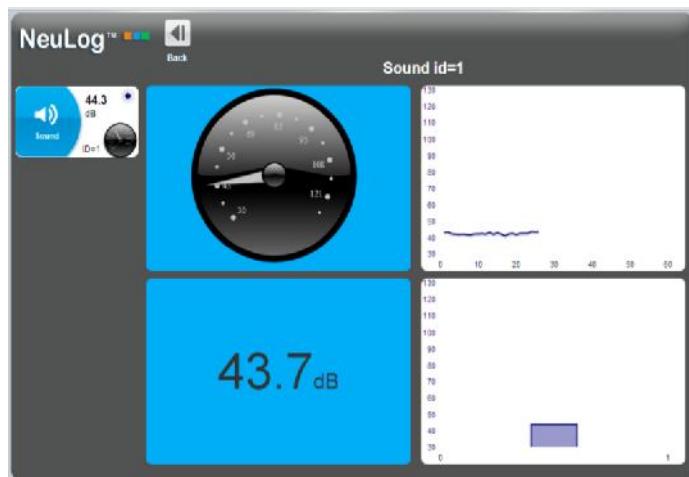
- The parameter setup screen displays several buttons (such as zero, calibrate, etc.) as shown for the force sensor as in the following illustration.



## 2.6 Visuals Mode

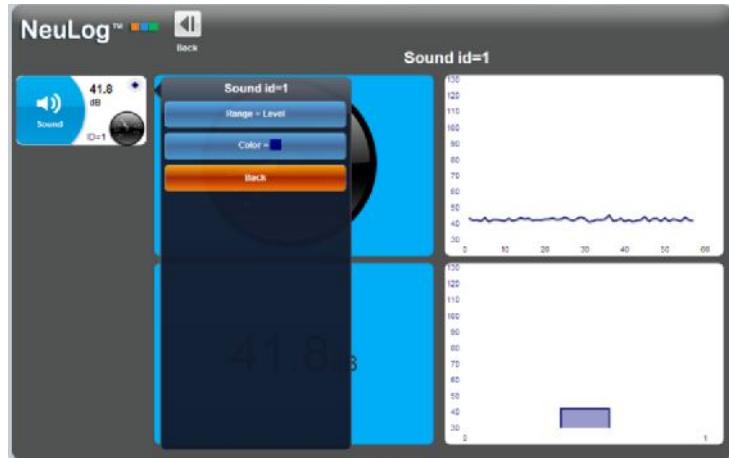


- Pressing the Visuals Mode button will display the Visuals screen, which is divided into four windows that show the samples in various display modes:
  - Bar graph
  - Digital measurement display
  - Analogue meter
  - Accumulative graph that shows a new sample every second. The graph shows the last minute.



- To change the sensor for which its results are displayed, press on the analog meter symbol that appears on each sensor.

- To enter the change parameters screen for a specific sensor, press on the symbol associated with that sensor.

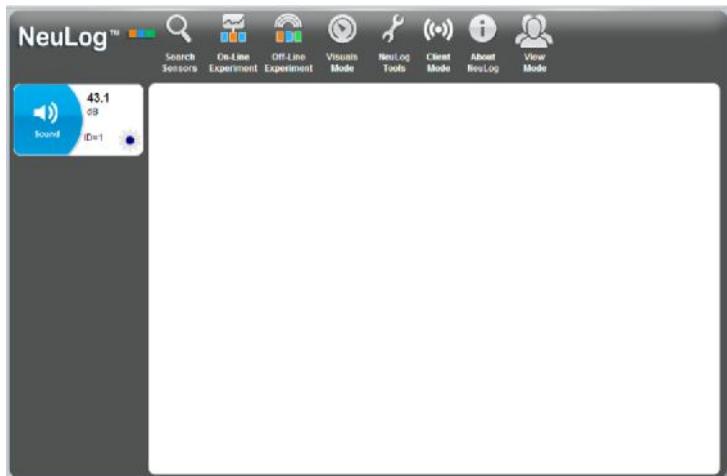


- Press Back to return to the main screen.

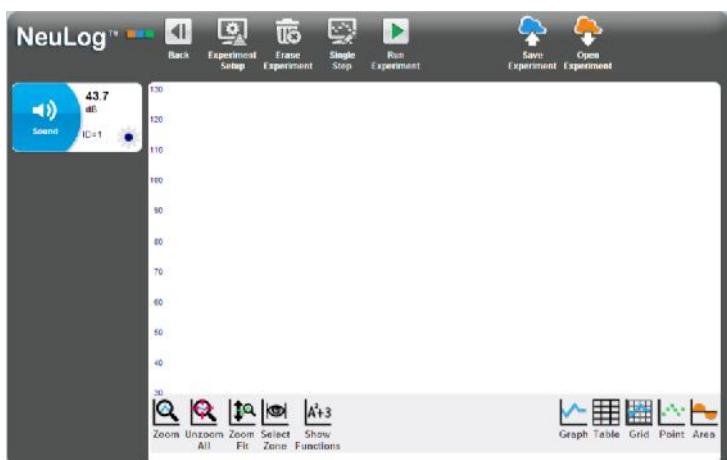
# Chapter 3 – On-line Experiment Mode

In this chapter you will run an experiment with the temperature sensor in order to see and use the features of the **On-Line Experiment** mode. In this mode, the experiment is controlled by the PC. Results are recorded and displayed in real-time.

- Connect the USB Bridge module  to a USB port on the PC.
- Connect the Sound sensor  to the USB Bridge module .
- Double-click the **NeuLog™ shortcut icon**  to display the following.

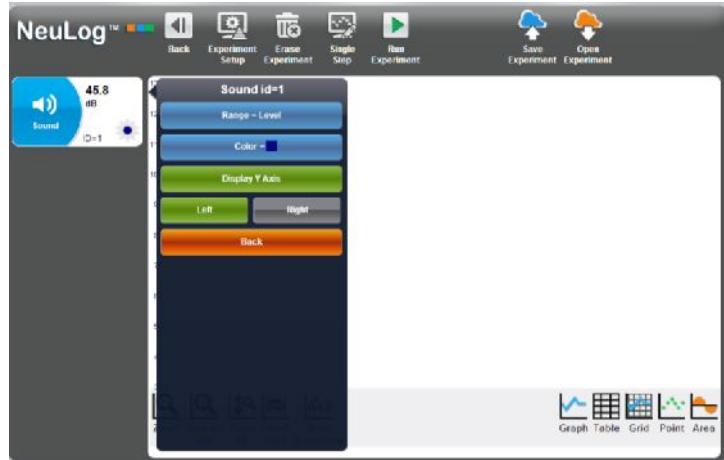


- During the search, a **Stop** button  appears at the end of the search bar. This button can be used in order to stop the search when all the connected sensors are identified.
- Click on the **On-Line Experiment icon**  to display the On-Line experiment screen below.



### 3.1 Module and Experiment Setup

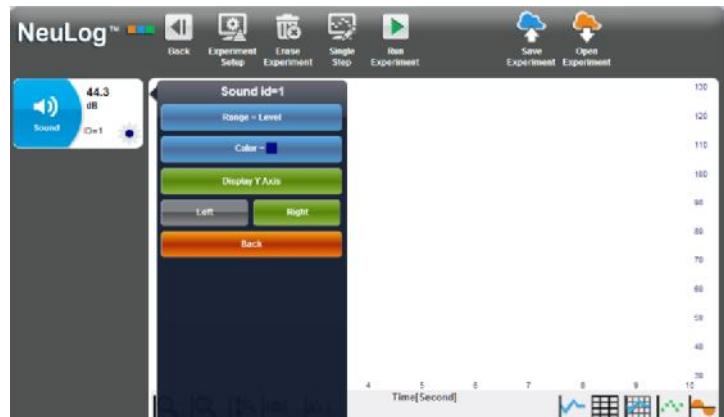
- Pressing on any sensor displayed on the left column brings up a window with the following functions.



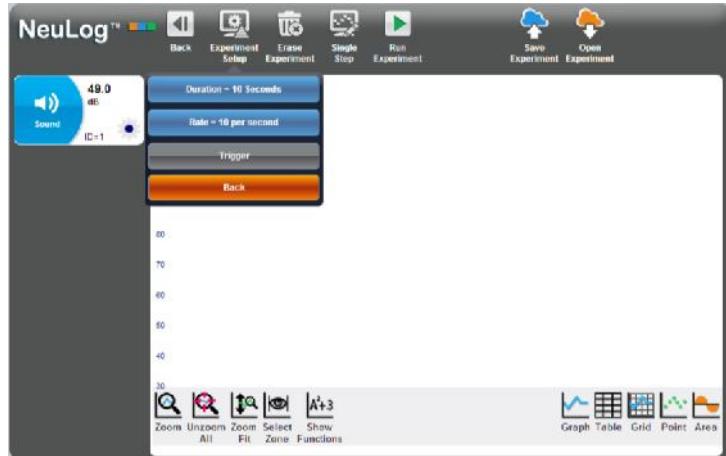
- You can change the color of the graph by pressing on the **Color** button.



- Pressing on the **Display Y axis** button allows the Y axis of the sensor to be displayed or hidden. To move the Y axis position of the graph, press on either the Right or Left buttons. Pressing on the **Right** button, moves the axis position to the right side of the graph. More than one axis can be displayed on each side of the graph.



- Pressing on **Experiment Setup** in the on-line mode opens a window to define the experiment setups that includes: **experiment duration**, **sample rate** and **trigger** for all of the sensors.



- To change the duration of the experiment, use the **Duration** button.

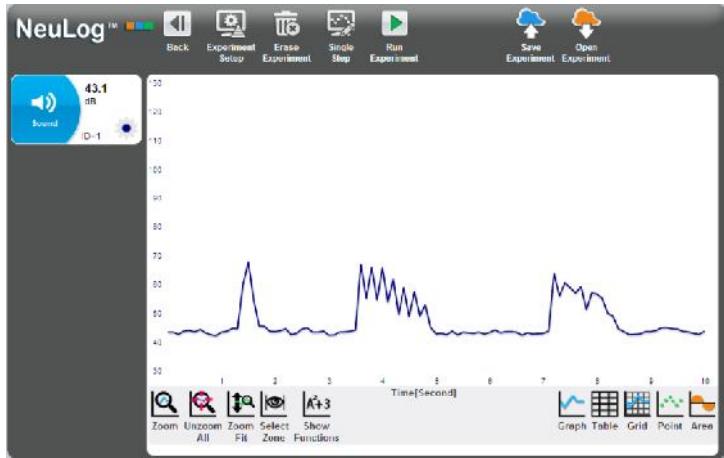


- Use the **Rate** button to change the sample rate.



## 3.2 Running On-Line Experiment

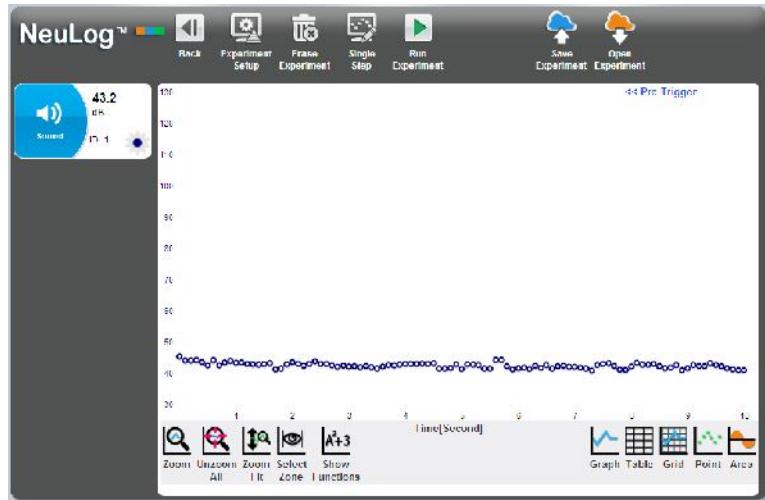
- Press on the **Run Experiment** button to run an experiment. While running an experiment, the **Stop Experiment** button is displayed. The experiment graph is built online. The experiment can be stopped before it is finished by pressing the "Stop Experiment" button.



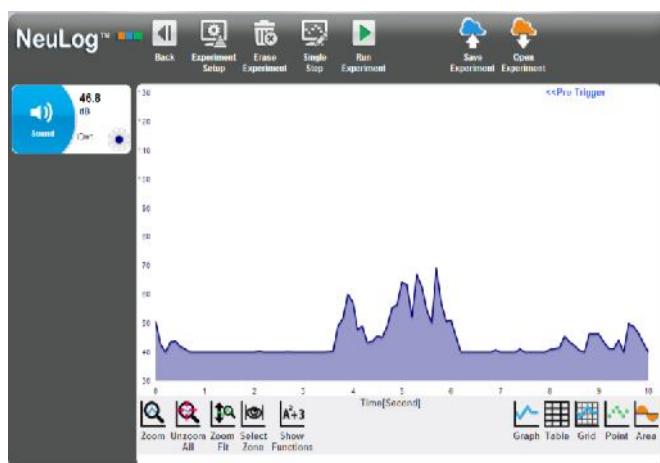
- Press on the **Grid** button to add vertical and horizontal lines to a graph. After pressing on the Grid button, it becomes **UnGrid**. Pressing on it will remove the grid.



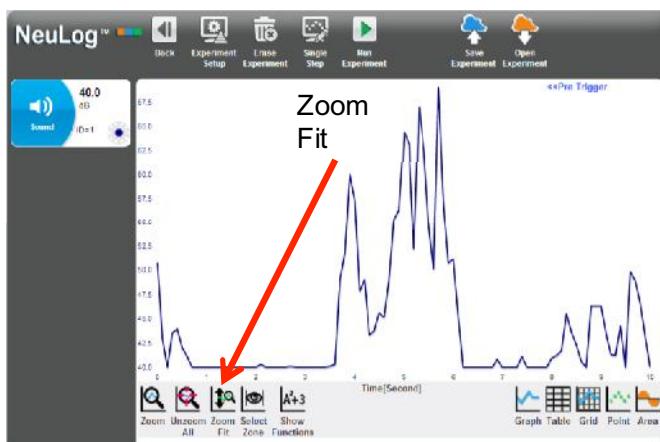
- To convert a graph to a series of points, press on the **Point** button. To return to the regular graph mode, press on the **Graph** button.



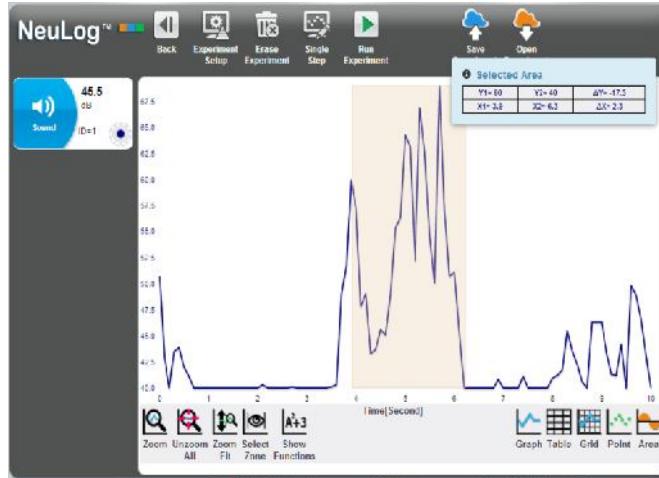
- To show the area below the graph, press on the **Area** button. Press on the **Graph** button to cancel this command.



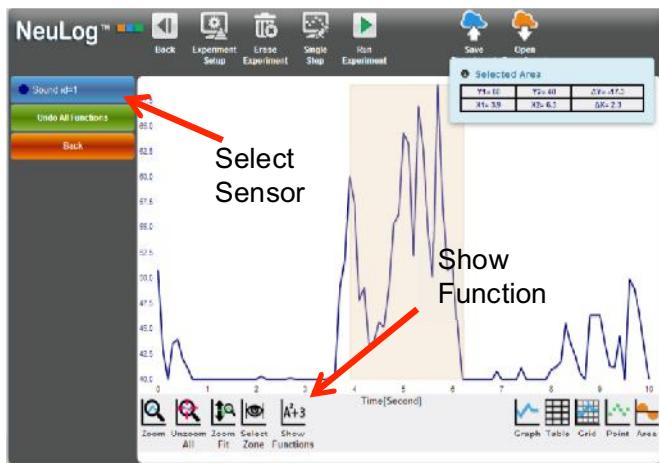
- The **Zoom Fit** button adapts the graph axes and expands them accordingly.



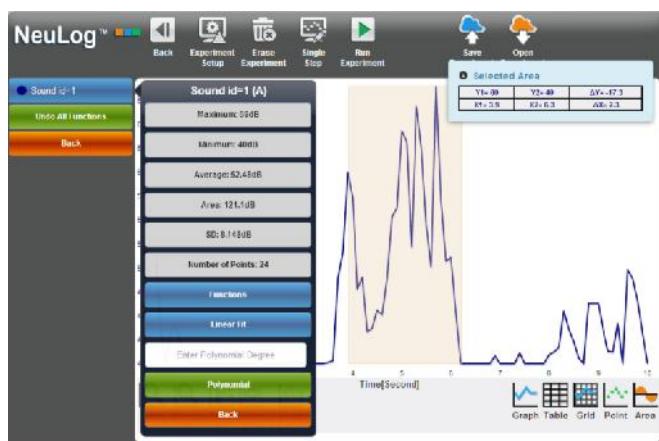
- Press on the **Select Zone** button to choose the segment of the graph of interest. The result of the expanded graph segment is shown below.



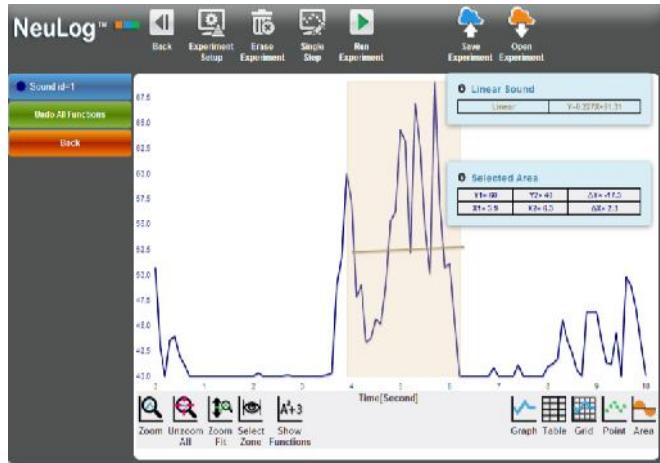
- The **Show Functions** button fits a desired mathematical function to the results. After pressing this button, you need to select the sensor to apply the mathematical function.



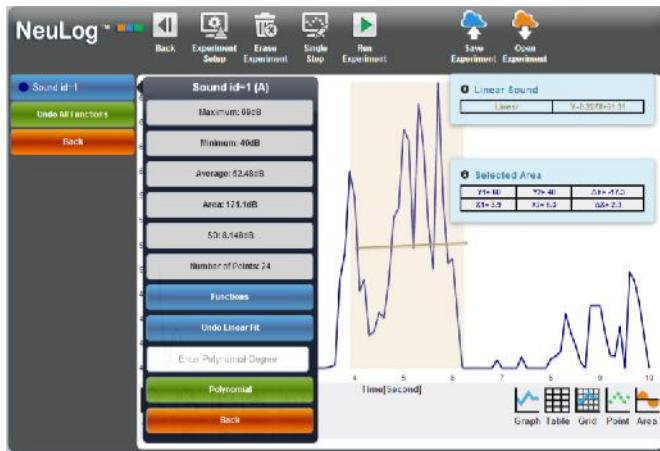
- After selecting the sensor, the statistical analysis of the chosen segment will be displayed and the area beneath the graph (or the entire graph if a particular selection is not done) as well as the buttons for the functions to be applied to the graph.



- The graph displayed after pressing on the **Linear Fit** button is shown below.



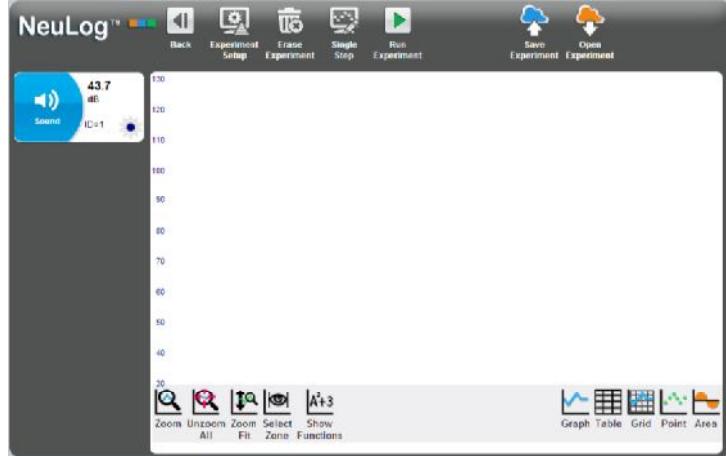
- To cancel the function selected, press on the **Undo Linear** button.



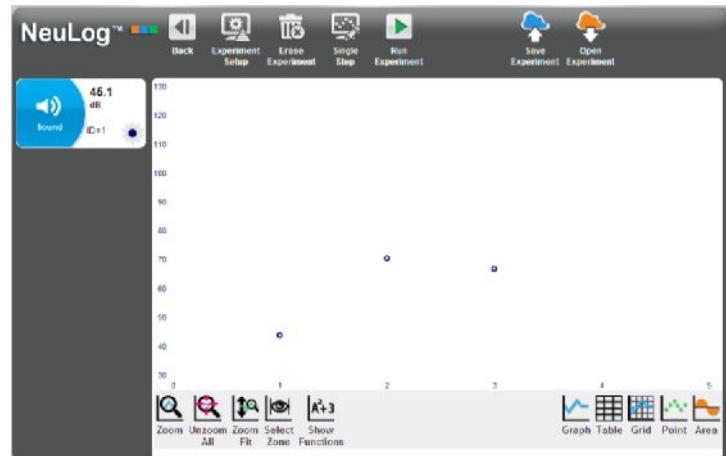
- Pressing on the **Functions** button displays all the available mathematical functions. You can scroll down the list of functions.



- To erase the graph and all the results displayed on the screen, press the **Erase Experiment** button

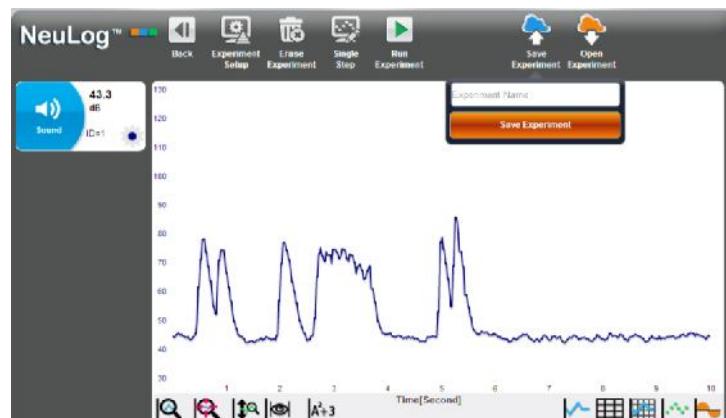


- Every time you press on the **Single Step** button, the connected sensors are sampled once.

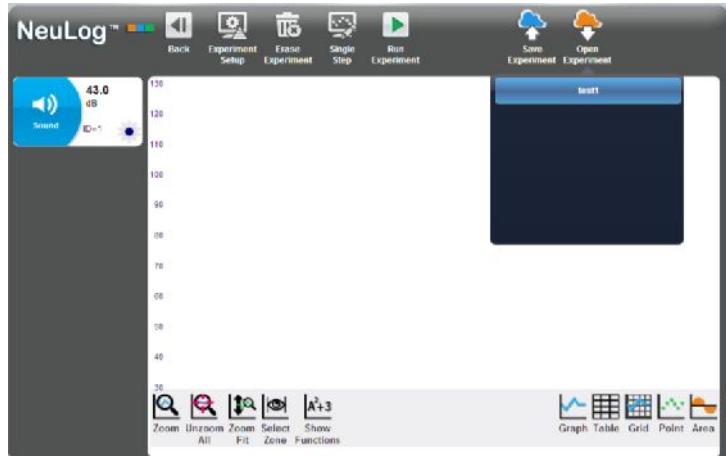


### 3.3 Save and Open

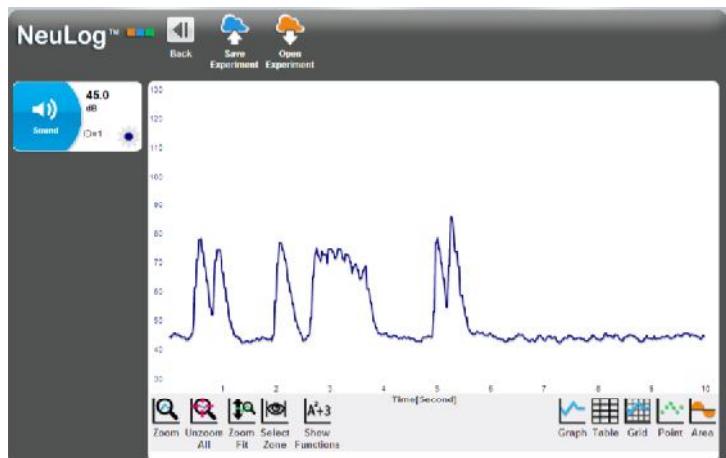
- Erase the experiment and **Run** a new one.
- To store the results of an experiment in a file, press the **Save Experiment** button, enter the name of the file and press on the orange **Save Experiment** button.



- To load an experiment, press on the **Open Experiment** button. Then the names of the saved files are displayed as individual buttons with the names of each file written on them. The program waits for you to press on one of the file buttons.



- After loading the experiment, the program loads the data and displays it in a graph. The On-Line menu bar is replaced by the "load experiment" menu bar, which allows saving and loading experiments only. The sensors showed on the left are the sensors from the loaded file.



- Return to the main screen by pressing the back button and to search again for the connected sensors by pressing on the **Search Sensors** button



### 3.4 Experiment with Trigger

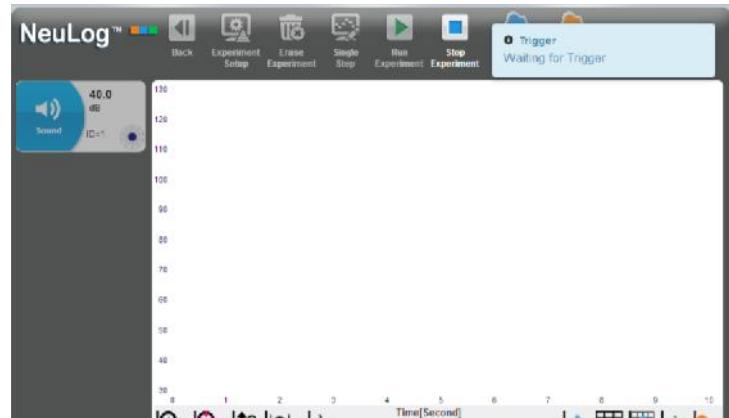
- Experiments which are defined to start with a trigger, will start only after the value of a specific sensor will exceed a predefined measured signal level. The trigger can operate on either a rising or falling sensor signal. The screen for defining parameters for an experiment with a trigger is shown below.



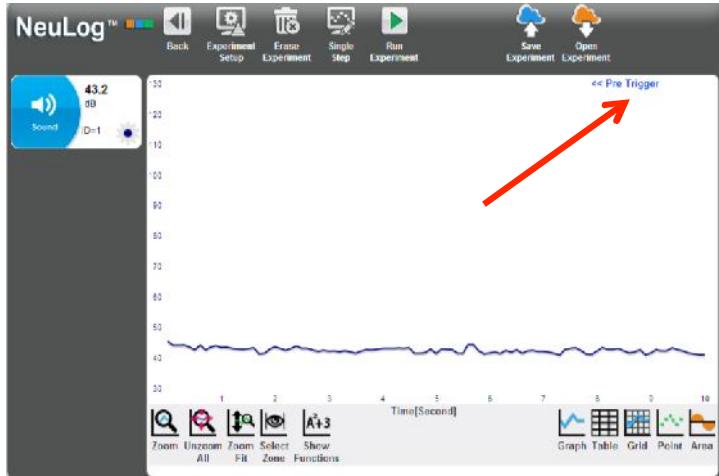
- The following shows the experiment setup menu after the experiment parameters including the trigger have been defined.



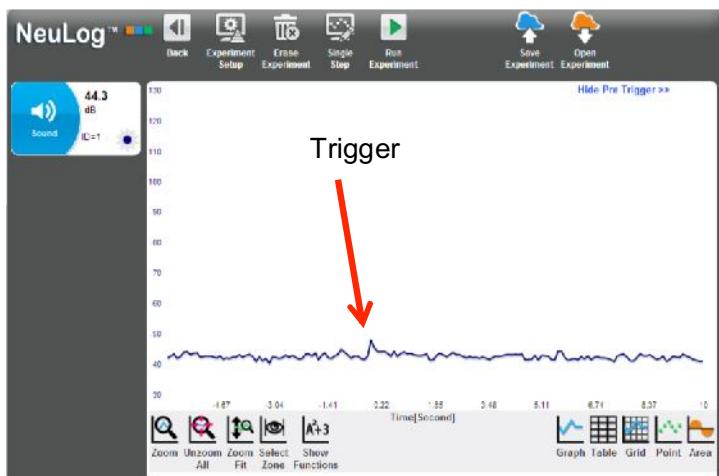
- The following screen is displayed with the **Waiting for Trigger** message when waiting for trigger to start sampling.



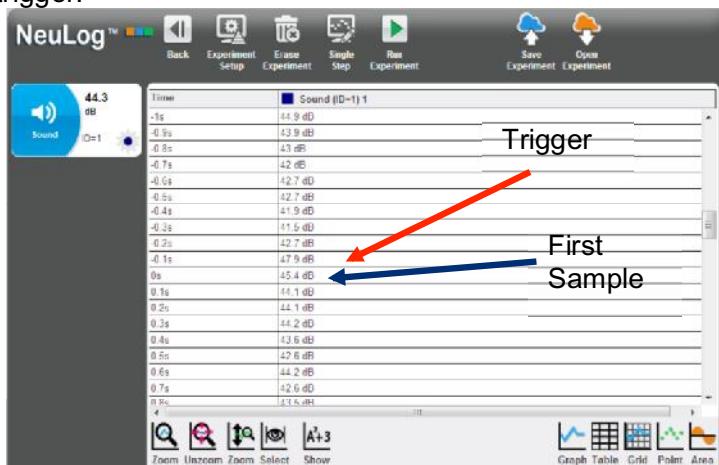
- The system saves samples also before the trigger is received. After the running of the experiment, a button appears that permits widening the display of measured samples before the trigger.



- The following shows the screen after expanding the display to show samples taken before and after the trigger.



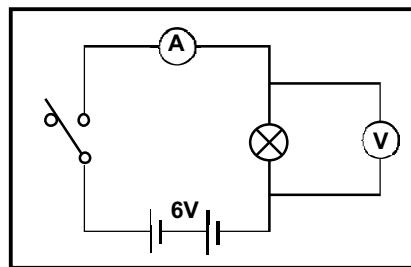
- Press on the **Table** button to display in a table the samples from an experiment before and after the trigger.



## 3.5 Experiment with more than one sensor

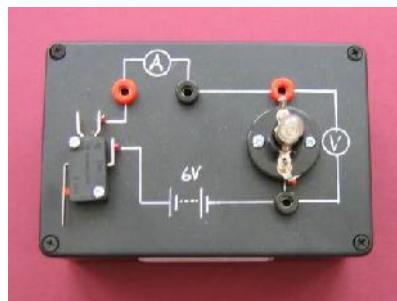
There are a number of experiments in which two sensors are used and their data plotted, not against Time, but with what the two sensors have measured plotted against each other. Examples of this are graphs of (i) the Voltage across a component (e.g. resistor, light emitting diode or bulb) against the current flowing through it and (ii) the Pressure of a fixed mass of gas (at constant volume) against the Temperature of that gas. In the following experiment you will be looking at the first of these two examples as a small filament light bulb is switched on.

You will be connecting up the circuit shown below.



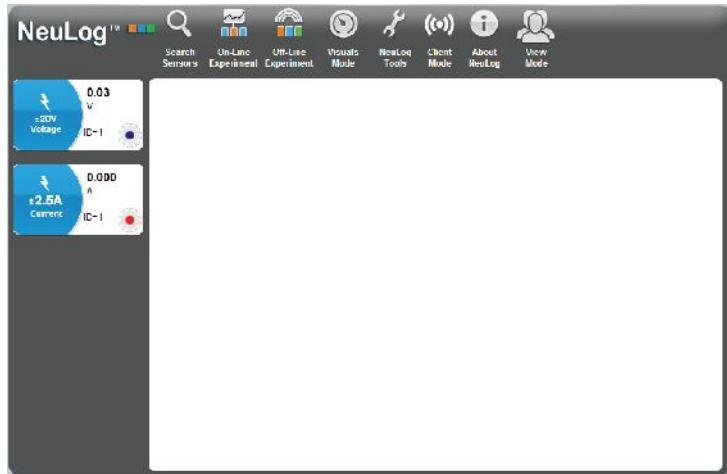
**Circuit diagram**

This circuit is ideally mounted on a box so that there are sockets available for the sensors to be plugged into. The ideal switch is a micro switch with lever and the bulb an m.e.s. tubular 6.5V 300mA. The battery should be a 6V one and here it has been placed inside the box. A photograph of such a setup is shown below.

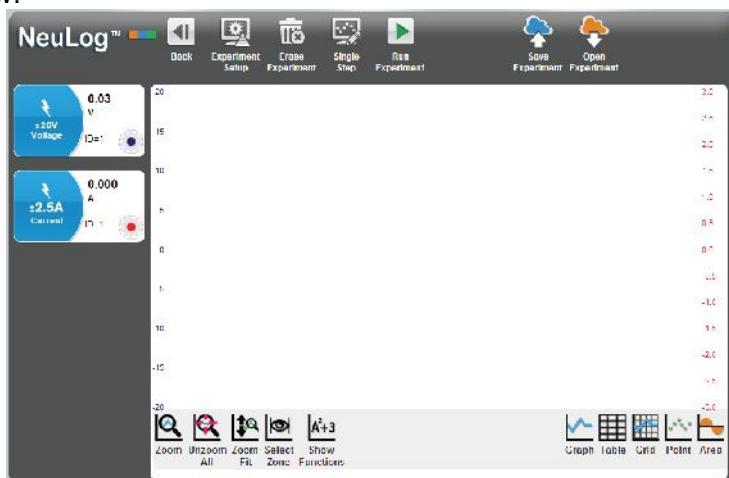


- Connect a **Voltage sensor**  to the **USB Bridge module** .
- Connect a **Current sensor**  to either the **USB Bridge module**  or to the **Voltage sensor** .
- Plug the Voltage sensor's red and black 4mm plugs into the sockets across the bulb, red plug to red socket and black plug to black socket.
- Plug the Current sensor's red and black 4mm plugs into the other two sockets, red plug to red socket and black plug to black socket.

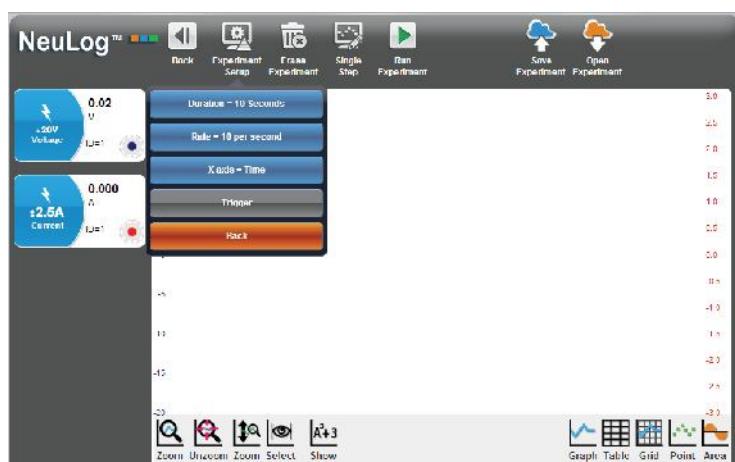
- Enter the NeuLog™ main screen and click on the **Search Sensors** icon so that the Voltage and Current sensor modules are displayed as shown below.



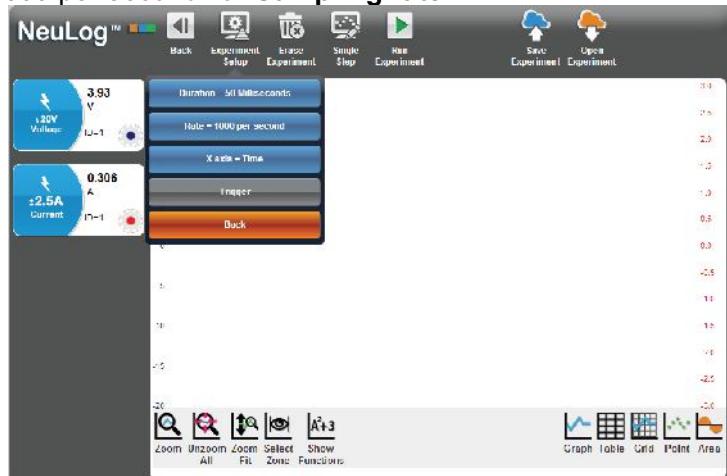
- Click on the **On-line Experiment icon** in the Main-icon bar to display the Graph window below.



- Click on the **Experiment setup icon** in the Sub-icon bar to display the Experiment setup – Options tab window below.

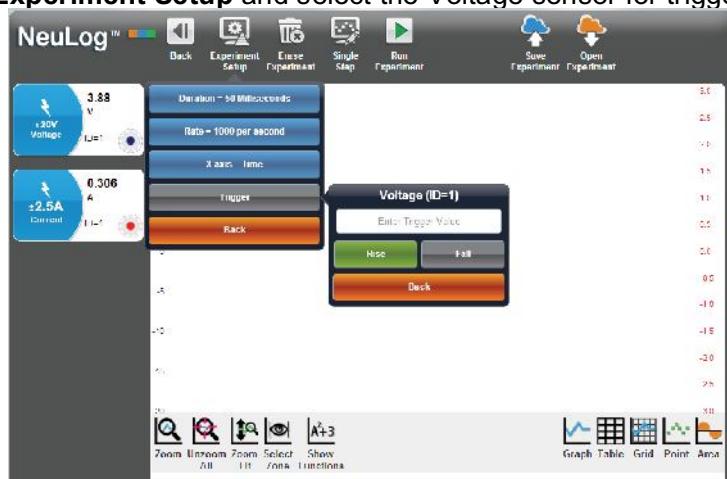


- The switching **on** of the bulb is a very fast event, so select '50 milliseconds' for **Experiment duration**.
- Now select '1000 per second' for **Sampling rate**.



With such a fast event you will need to use the **Trigger** to begin the data logging.

- Click on the **Experiment Setup** and select the Voltage sensor for trigger



To trigger the start of sampling you will make use of the rise in voltage across the bulb as the switch is closed.

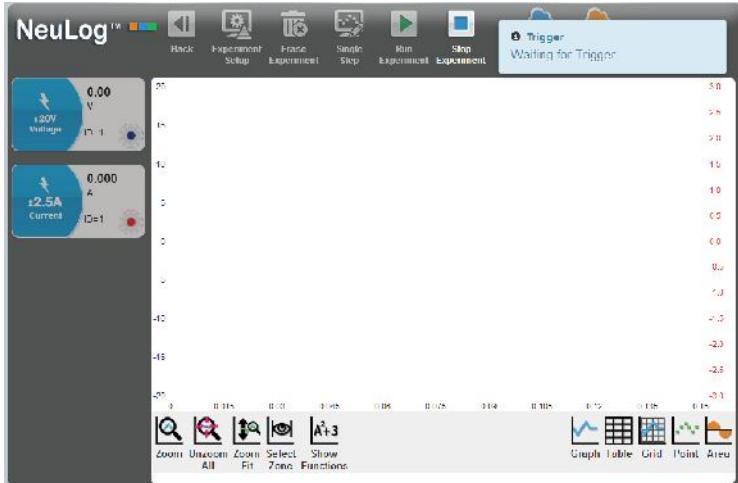
- Set the trigger parameters to **Voltage 1** sensor, **Rise** and **0.1V** as shown below.



Alternatively you could have set the Trigger so that it is based on the Current sensor, Current 1, rising to a level of say 5mA.

At this stage it is useful to first see each of the graphs plotted against Time.

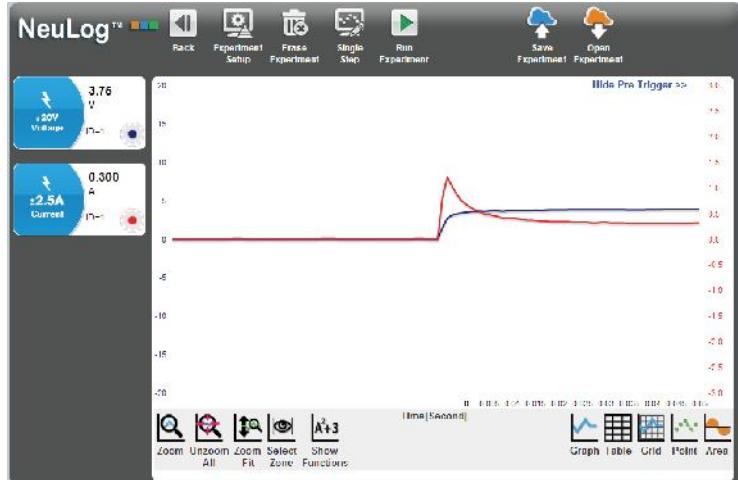
- Click on the **Run experiment icon** . The message 'Waiting for Trigger' will be displayed on the screen.



- Now close the switch and hold it closed for a second or so and graphs similar to those below should be plotted.

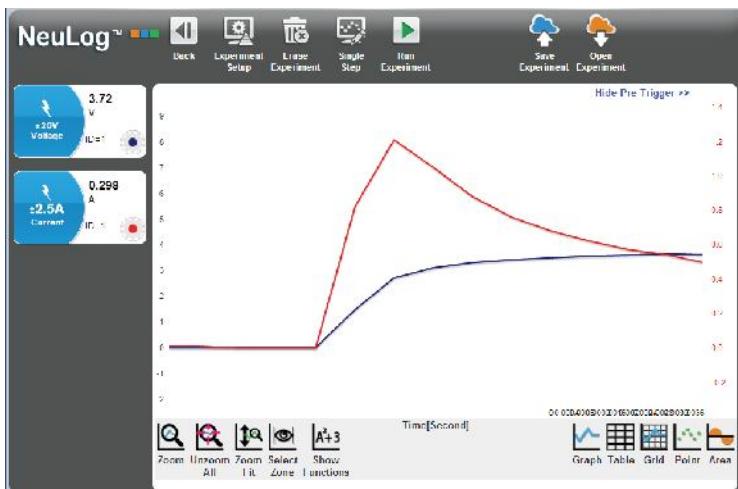


- Click on the **Pre-trigger button**  to expand the graphs so that they display what was happening to the current through the bulb, and the voltage across it, just before and at the moment, the switch was closed.



The interesting section of the above graphs is obviously just before the bulb was switched **ON** to when the bulb was fully lit where the two graph-lines level off. So it is useful to be able to examine this section in more detail and you will see how to do this on the following page.

 Click on the **Zoom window icon**  . Select the area before and after the triggering point until you get the screen as follows.



### 3.5.1 Using the Functions – Math tab

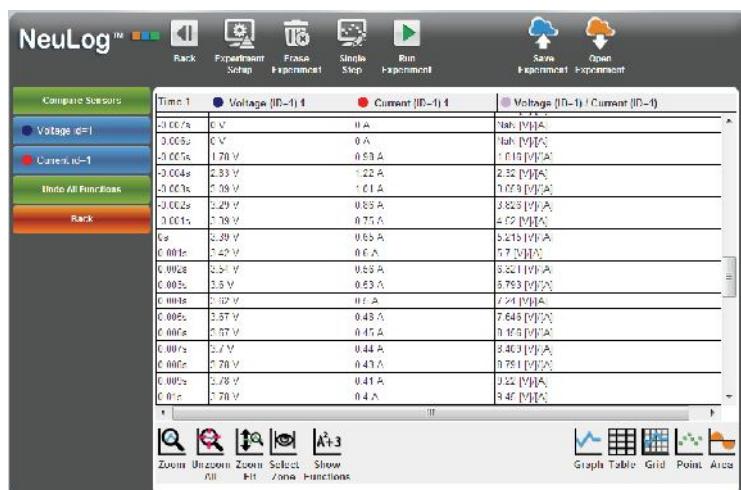
With both voltage and current data available you can now obtain a graph of how the resistance of the bulb changed with time by generating a graph of (voltage across the bulb ÷ current flowing through the bulb) plotted against Time. The math tab window of the functions window provides a number of mathematical functions with which to generate new data from the existing data (in this case, to calculate the resistance of the bulb).

- For the case that there are more than one sensor, it is possible to analyze the measured results with mathematical functions for two sensors. After pressing on the **Show Functions** button, the **Compare Sensors** button is displayed. This button will allow you to select one sensor as sensor A and a second sensor as sensor B. You then can select a mathematical operation on both of them.

Select the **voltage sensor** as sensor A and the **current sensor** as sensor B.



- Click on the **A/B** button and you should now see displayed the original graphs of Voltage against Time and Current against Time, and an additional graph (in blue) of Voltage/Current against Time as shown below.



- Press on the Graph button to turn the table to graph.

We can see how the resistance of the bulb goes up when the bulb turns on.

## 3.6 Plotting an XY graph

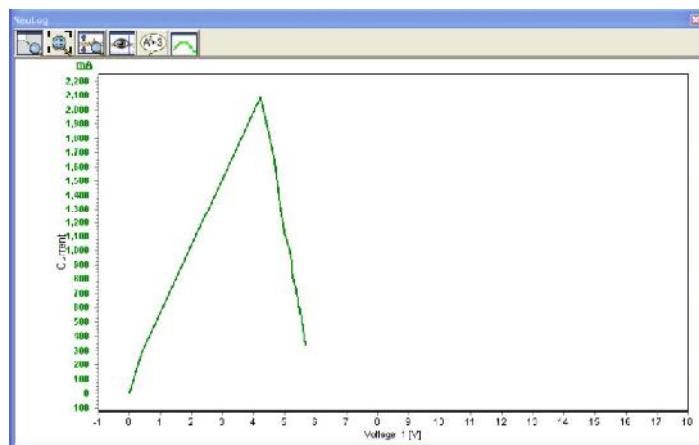
Up until this point, running the experiment has resulted in graphs of 'Voltage across the bulb' and 'Current through the bulb against Time' being plotted separately. This done, you can now plot what is known as an **XY graph** with the 'Voltage across the bulb' on the X-axis and the 'Current through the bulb' on the Y-axis.

- Another display option for more than one sensor is to plot the measured results for one sensor along the X axis (instead of time); all the other sensors will be plotted on the Y axis in relation to the X axis. Click on the **Experiment Setup** button.



- Click **Voltage** button.

You should now see that you have a graph window displayed with **Voltage** along the X-axis and **Current** along the Y-axis.



Alternatively you could have plotted the graph with Voltage along the Y-axis and Current along the X-axis.

This graph shows us that until 4V the bulb acts as a constant resistance.

The bulb resistance increases and the current goes down when the bulb turns on.

## 3.6 Single step mode

An experiment can be run taking and recording measurements only when you wish to do so.

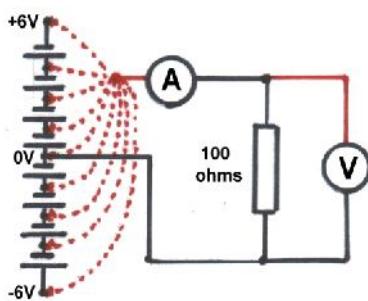
This is known as **Single Step mode** and is accessed from the **Single step icon**  on the Sub-icon bar. In this mode data will only be collected from the sensor(s) on each click of the **Single step icon** .

This mode will be used when what is, or are being measured, are discontinuous or do not change as a function of Time. It may be that you wish to record the temperatures of a range of different soil or sand samples that have been exposed to the Sun for an hour. You would

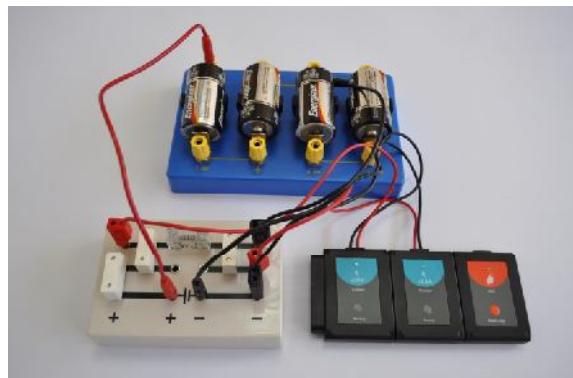
simply insert a Temperature sensor  into each sample in turn and record their temperatures into a table by repeatedly clicking on the **Single step icon** . A graph of the data would probably not be useful, though if one was plotted its X-axis would display as a Counter (1, 2, 3, 4 etc.). Here the table is more important.

**Single step mode** can be used when you need to collect sensor readings at specific values. You could investigate how the current through a  $100\Omega$  resistor, a diode, a 6V MES filament bulb and a light emitting diode (led), vary with applied voltages of approximately 0V,  $\pm 1.5V$ ,  $\pm 3V$ ,  $\pm 4.5V$  and  $\pm 6V$ , provided simply by two sets of cell holders. Such a setup does not require a continuously variable voltage supply and so is easier to provide multiple sets for class use. By finally setting up **XY graphs** with the data and overlaying these with a (best-fit) **Linear-fit line**, it can be seen which of the components obeyed **Ohm's Law**. The following instructions are for investigating a  $100\Omega$  resistor.

- Construct the circuit shown in the diagram and photograph below, but leaving the red lead (dotted line) from the Current sensor to the battery disconnected.

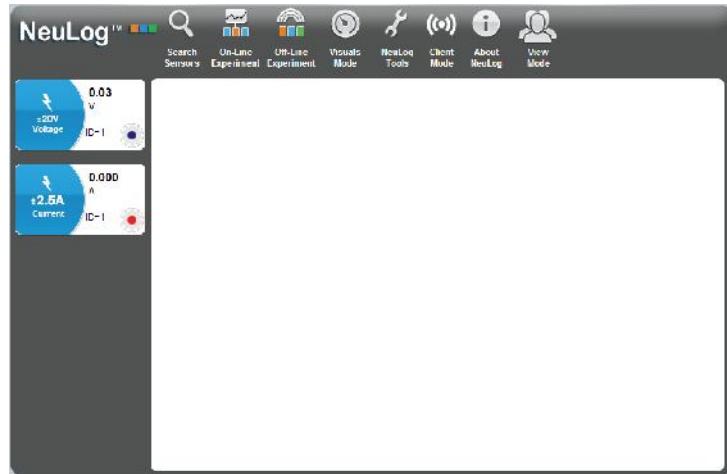


Circuit Diagram

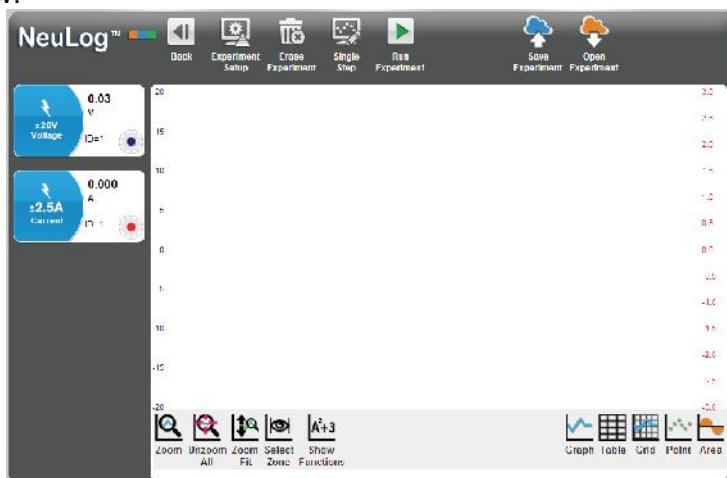


Apparatus Setup

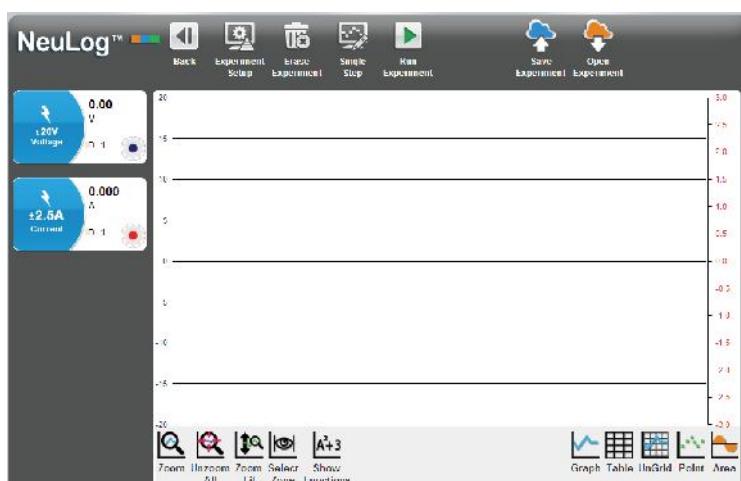
- Enter the NeuLog™ main screen and click on the **Search Sensors** icon so that the Voltage and Current sensor modules are displayed as shown below.



- Click on the **On-line Experiment icon** in the Main-icon bar to display the Graph window below.



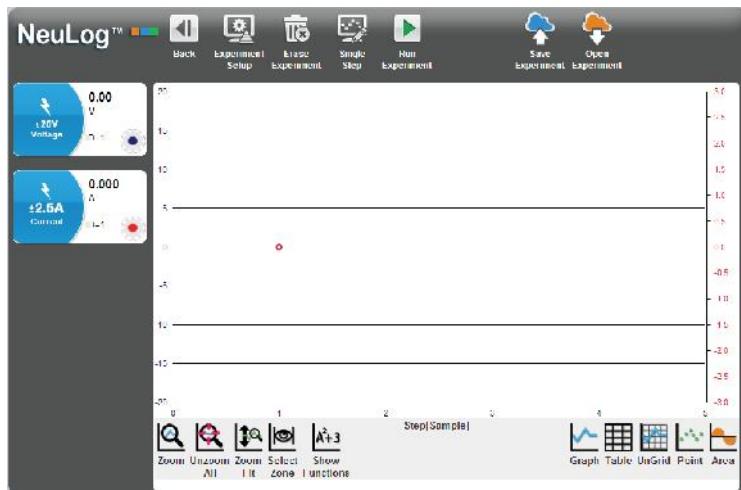
- Press on the **Grid** button to add vertical and horizontal lines to a graph. After pressing on the Grid button, it becomes **UnGrid**. Pressing on it will remove the grid.



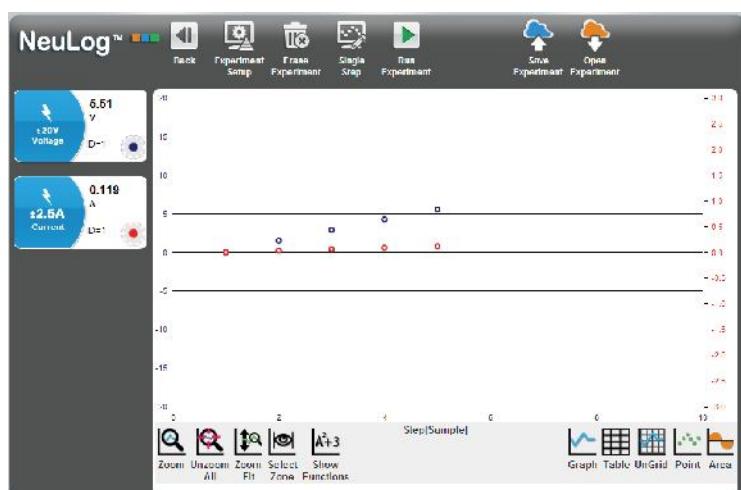
- Connect the Voltage sensor's red plug into the 0V socket of the lower cell holder.

The Voltage Sensor's Module box should now display a value around '0V' and the Current Sensor's Module box a value around 'A'.

- Click on the **Single step icon**  in the Sub-icon bar and the first plot will be displayed as shown in the Graph window below.



- Now move the Voltage sensor's red plug into the 1.5V socket of the lower cell holder.
- Click on the **Single step icon**  in the Sub-icon bar.
- Repeat the process of moving the Voltage sensor's red plug into the +3V, +4.5V and +6V sockets of the cell holders, clicking on the **Single step icon**  in the Sub-icon bar after each move.
- You should have a graph similar to that shown below.



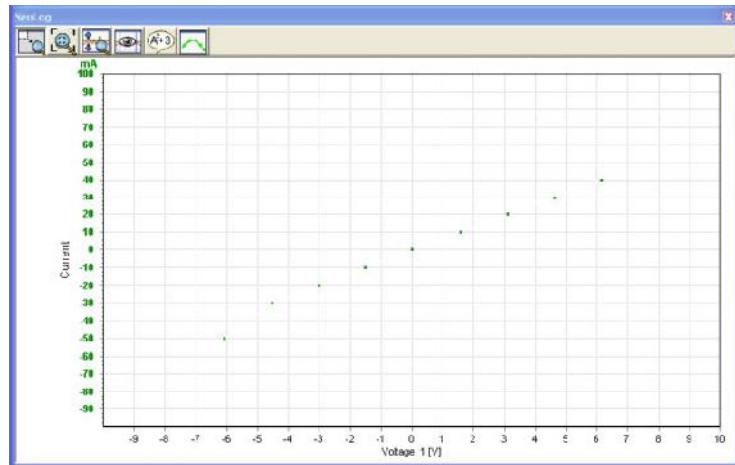
- Remove the Voltage sensor's red plug from the 6V socket of the upper cell holder.

- Another display option for more than one sensor is to plot the measured results for one sensor along the X axis (instead of time); all the other sensors will be plotted on the Y axis in relation to the X axis. Click on the **Experiment Setup** button.

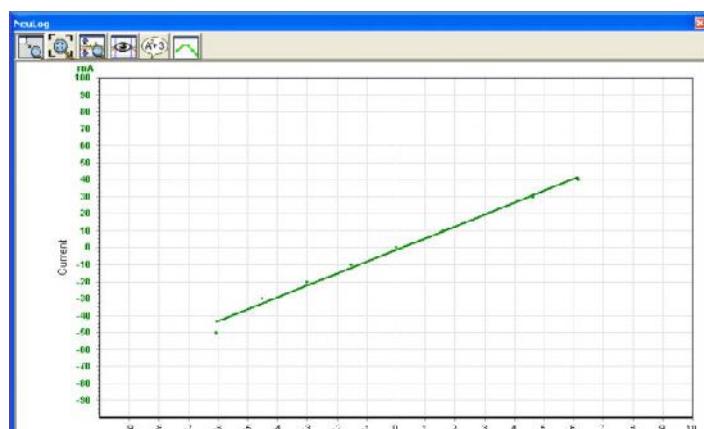


- Click **Voltage** button.

You should now see that you have a graph window displayed with **Voltage** along the X-axis and **Current** along the Y-axis.



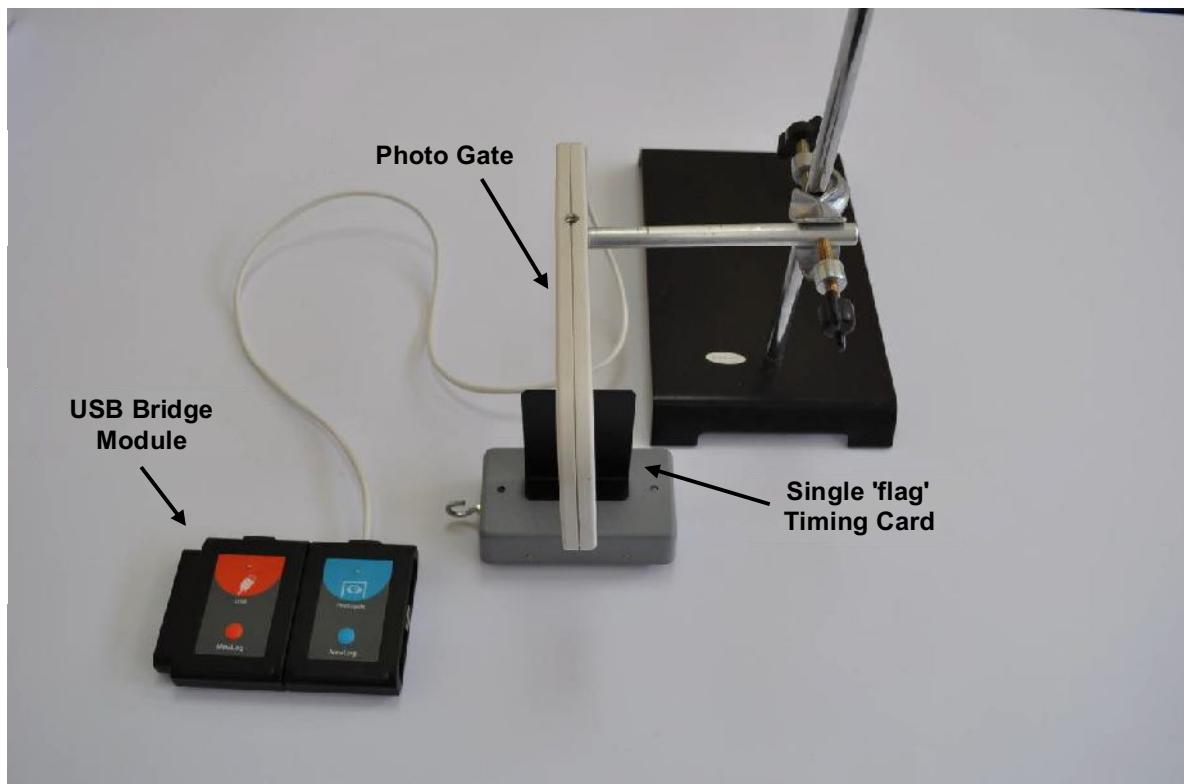
- Now click on the **Show functions icon**  to display the Functions tab window with 'Linear-fit' as shown below.



### 3.7 Using photo gates

Photo gates are used to measure the Time(s) for which their infrared beams are interrupted. By inputting the length(s) of timing cards passing through photo gates, both Velocity and Acceleration can be calculated too.

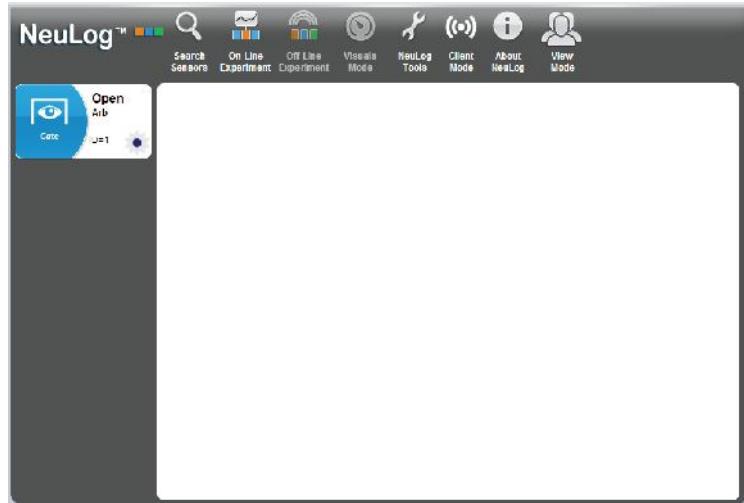
Cut out, as accurately as possible, two timing cards from black plastic card, one with a single 100mm 'flag' and another with two 50mm 'flags' separated by a 40mm gap as shown below, and another with at least three 'flags' of the same or different size and spacing.



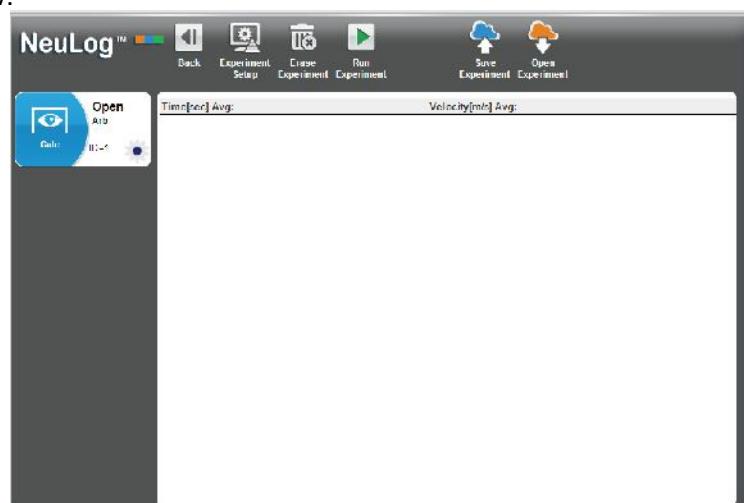
- Attach a Single 'flag' timing card to a model car.
- Place the model car on an approximately 20° sloping runway and temporarily secure it in position.
- Fix a photo gate sensor on a retort stand using a bosshead and position it half-way down the runway and such that the timing card will interrupt its beam.
- Connect the **Photo gate sensor** to the **USB Bridge Module** .

The arrangement of the equipment should be much like that in the photograph above.

- Enter the **NeuLog™** main screen and click on the **Search Sensors** icon so that the Photo gate sensor module displays in the Module window as shown below.



- Click on the **On-line Experiment icon**  in the Main-icon bar to display the Table shown below.



- Click on the **Experiment setup icon**  and the Photo Gate modes of operation will appear.

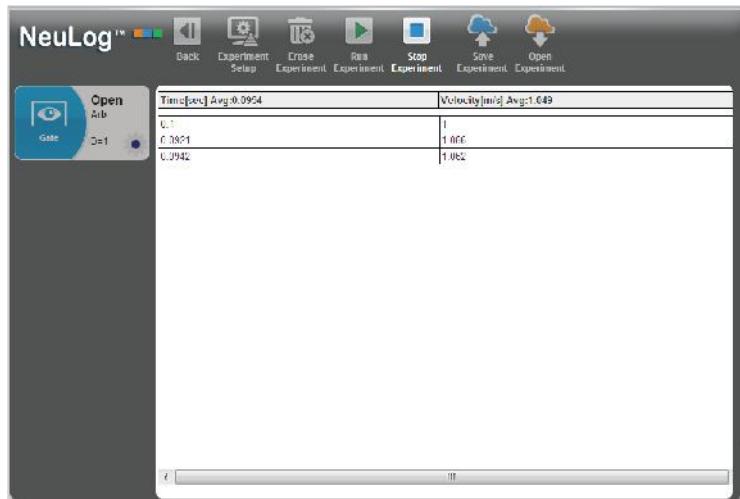


### 3.7.1 Velocity with Single Gate

- Click on the **Velocity with Single Gate** button and set the flag width (X[mm]) to 100.



- Press **Save** and then **Back**.
- Click on the **Run experiment icon** in the Sub-icon bar. Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took to pass through it.
- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below. Note that an average value is provided too.

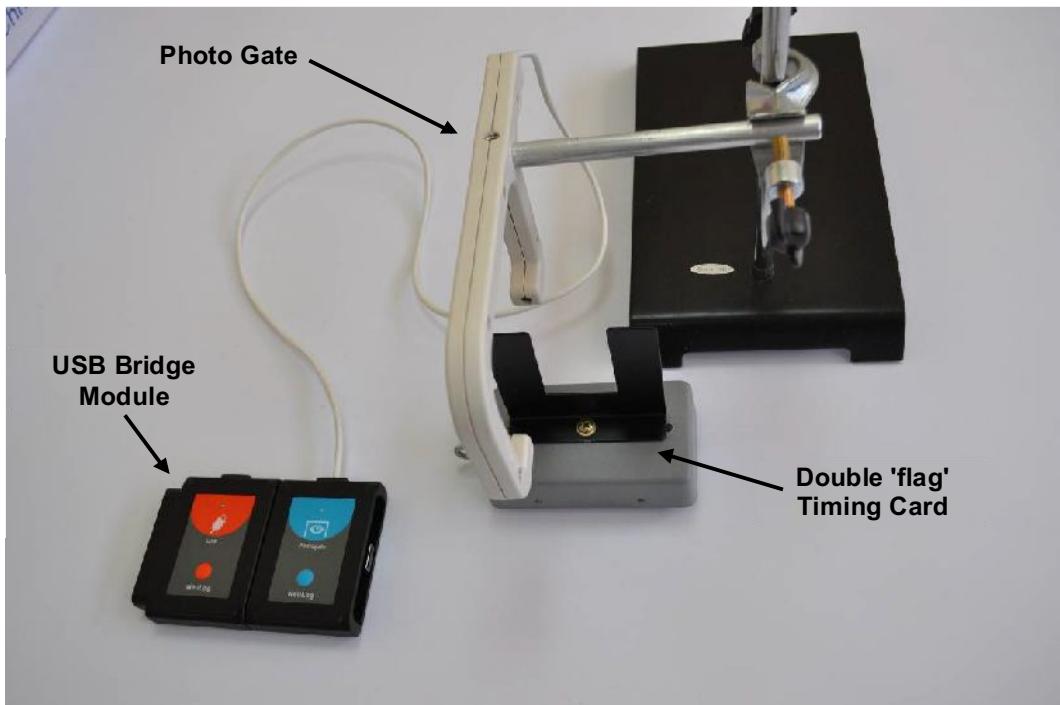


Note that the Table also has velocities recorded as well as times.

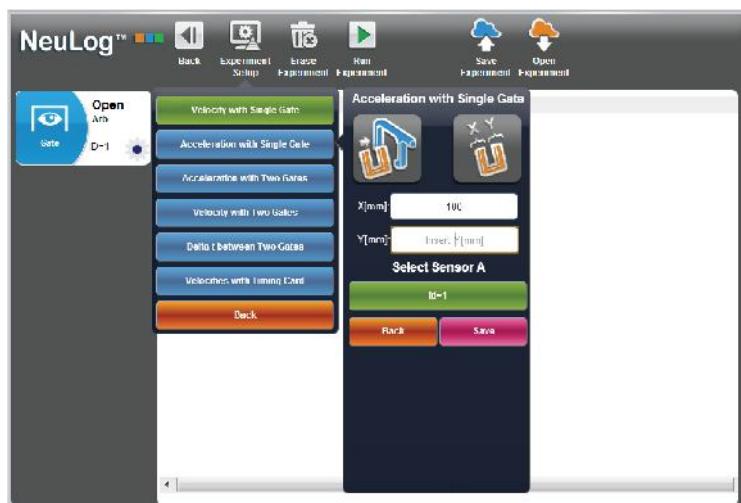
- Click on the **Stop experiment icon** in the Sub-icon bar.
- Click on the **Clear experiment results icon** in the Sub-icon bar.

### 3.7.2 Acceleration with Single Gate

The apparatus used here is almost the same as in Time and Velocity mode, with the exception of the use of a Double 'flag' timing card instead of a Single 'flag' version. A photograph of the setup is shown below.



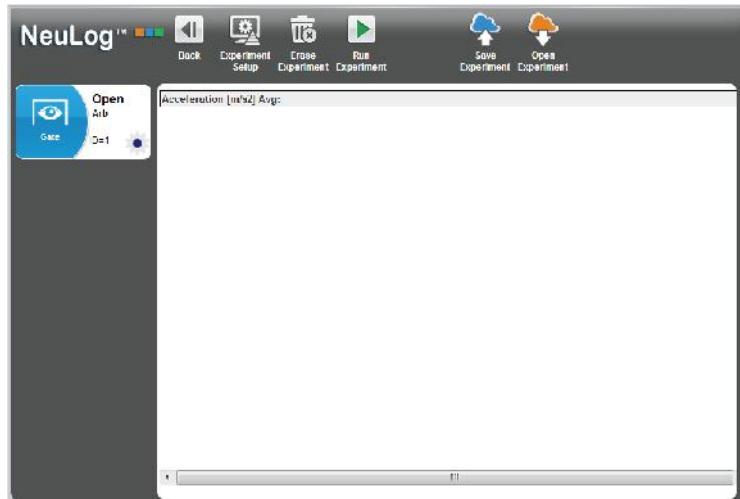
- Attach a Double 'flag' timing card to the model car.
- Now click on the **Acceleration with Single Gate** on the Experiment Setup.



- The system measures the velocity of each flag and divides the difference between the velocities by the time between the flags. Enter the values '50' as 50mm is the width of both of the 'flags'.

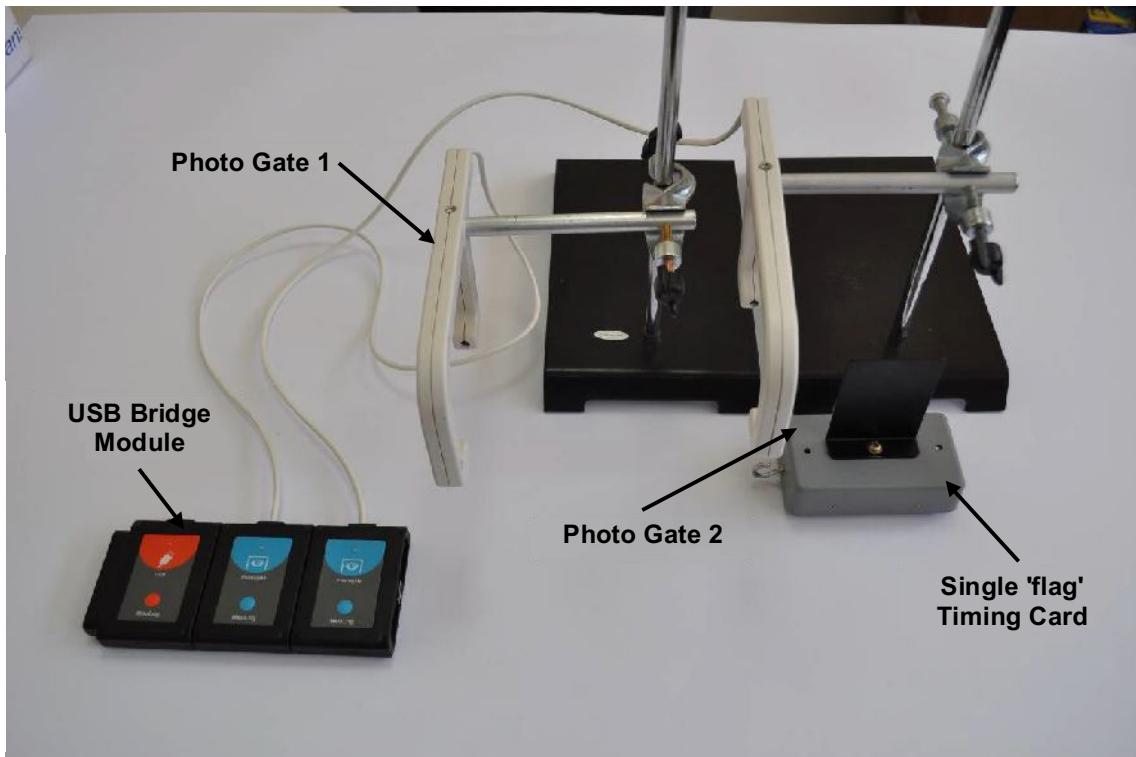
Click on the **Run experiment icon**  in the Sub-icon bar. Let the model car run through the photo gate to display the first measurement.

- Repeat **twice** more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below.



- Click on the **Stop experiment icon**  in the Sub-icon bar.
- Click on the **Clear experiment results icon**  in the Sub-icon bar.

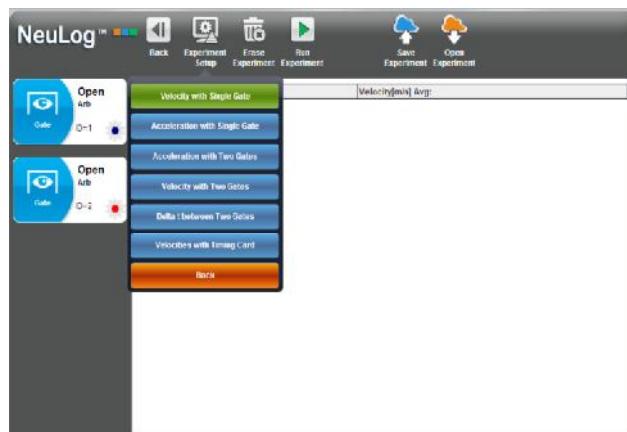
### 3.7.3 Acceleration with Two Gates



- Replace the Double 'flag' timing card by the Single timing card again.
- Connect a further **Photo gate**  to the **USB Bridge module**  and mount its gate slightly lower down the runway. Again check that its height is correct for the timing card being able to break its beam.

The apparatus should appear much as in the photograph.

- Click on the **Search for sensors icon**  in the Main-icon bar.
- Click on the **On-line Experiment icon** .
- Click on the **Experiment setup icon**  and the Photo Gate modes of operation will appear.



- Click on the **Acceleration with Two Gates** button and set the flag width (X[mm]) to 100.



**NOTE:** When using two identical sensors, such as here with two photo gates, it is essential that they have differing Sensor IDs (above they are '1' and '2'). If you find that they have the same ID Number you will need to change one of them as shown in chapter 7, section 7.1. Note also that you do need to identify and select in "Choose photo gates' sequence" which photo gate is passed through first and which second. This is most easily done by noting the result of an obvious acceleration which should have a positive value – swap in Sensor IDs if it comes up negative.

- Press **Save** and then **Back**.
- Click on the **Run experiment icon** in the Sub-icon bar. Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took to pass through it.
- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below. Note that an average value is provided too.

Note that the Table also has velocities recorded as well as times.

- Click on the **Stop experiment icon** in the Sub-icon bar.
- Click on the **Clear experiment results icon** in the Sub-icon bar.

### 3.7.4 Delta with Two Gates

With the same apparatus shown above, we can measure the time pass between the two gates.

- Click on the **Delta with Two Gates** on the **Experiment Setup**.



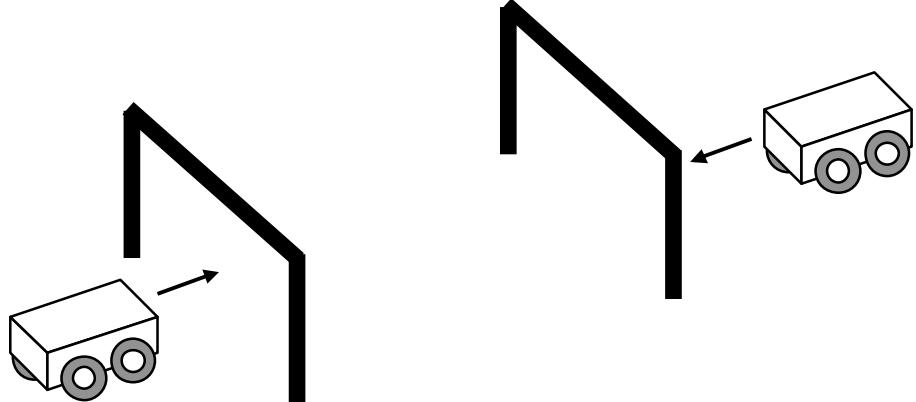
- Press **Save** and then **Back**.
- Click on the **Run experiment icon** in the Sub-icon bar. Mark the release position, let the model car run through the photo gate to display the first measurement in the Table of how long the Timing card took to pass through it.
- Repeat twice more, releasing the model car from the same position, to obtain a set of measurements similar to those shown below. Note that an average value is provided too.

Note that the Table also has velocities recorded as well as times.

- Click on the **Stop experiment icon** in the Sub-icon bar.
- Click on the **Clear experiment results icon** in the Sub-icon bar.

### 3.7.5 Velocity with Two Gates

The apparatus used here is almost the same as in Acceleration with Two Gates, with the exception of the use of two carts moving against each other. A picture of the setup is shown below.



- Attach a 'flag' timing card to each cart.
- Click on the **Velocity with Two Gates** on the **Experiment Setup**.



Fields for the carts' mass are opened too.

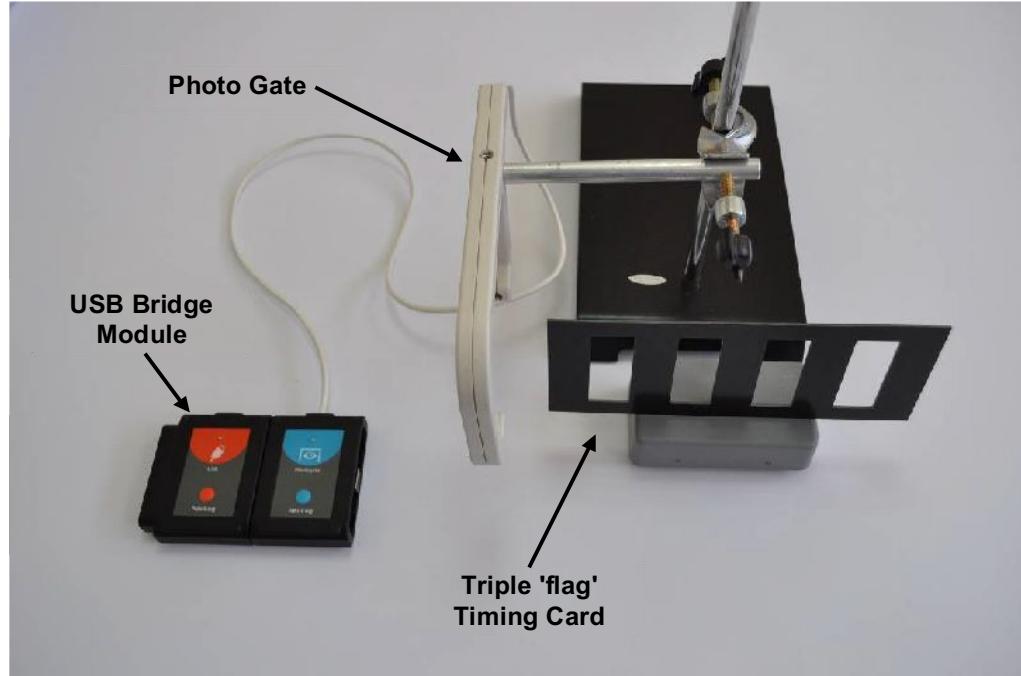
- Write flags' width and the carts' mass in the fields.
- Press **Save** and then **Back**.
- Click on the **Run experiment** icon
- Push two carts against each other so they will collide after they pass through the gates and then return again through the gates.

The table will show the velocity and the momentum of each cart before and after the collision.

- Click on the **Stop experiment** icon in the Sub-icon bar.

### 3.7.6 Velocities with Timing Card

This mode produces a graph showing how the digital status (0 or 1) of the photo gate changes with time as a timing card passes through.



The apparatus setup required now is much like that used for the Time and Velocity mode and is shown in the photograph in the previous page.

- Although for this experiment we need only one photo gate, both gates can be connected to the USB module. You just have to determine which one of them is used.
- Attach a Triple 'flag' timing card to the model car.
- Click on the **Velocities with Timing Card** on the **Experiment Setup**.



The width of the flags should be 50 mm.

- Select the experiment duration.

- Click on the **Run experiment** icon .
  - Pass run the model car with the multi-flagged timing card through the photo gate to obtain a table with the velocities of each flag.
- 
- Click on the **Stop experiment** icon  in the Sub-icon bar.
  - Click on the **Clear experiment results** icon  in the Sub-icon bar.
  - Disconnect the **photo gate**  from the **USB Bridge module**  but leave the **USB Bridge module**  connected to the PC.

# Chapter 4 – Off-line Experiment Mode

In this mode the experimental results are not displayed in real-time. The sensors are pre-programmed to perform measurements. The experiment setup, together with the last five data sets, is saved in each sensor's internal non-volatile memory.

**Off-line experiment mode** is where the sensors have been programmed by connection to the MDU (Monitor Display Unit) with different Sampling rates and Experiment durations. The MDU can be any kind of PC (Windows, MAC, Linux), tablet (IPAD or Android) or NeuLog viewer.

The sensors are then **disconnected** from the MDU and put into battery-powered chains (or singly) to collect their data on the pressing of the sensors' **Start/stop** buttons. However, in this mode, each sensor can be programmed independently to be triggered to record data as well as having their **Start/stop** buttons pressed at different times.

Reconnection of the sensors to the MDU is required to upload the data and analyze it. However, all graphs would be overlaid on the longest Time axis with t=0s being where each sensor appears to have been triggered. Hence it does not take into account the time differences between the pressing of any sensors' **Start/stop** buttons and their independent triggering.

At **Off-line experiment mode** the sensors could **remain** connected to the MDU. As before, the sensors can be programmed with different Sampling rates and Experiment durations. Again, each sensor can be programmed independently to be triggered to record data.

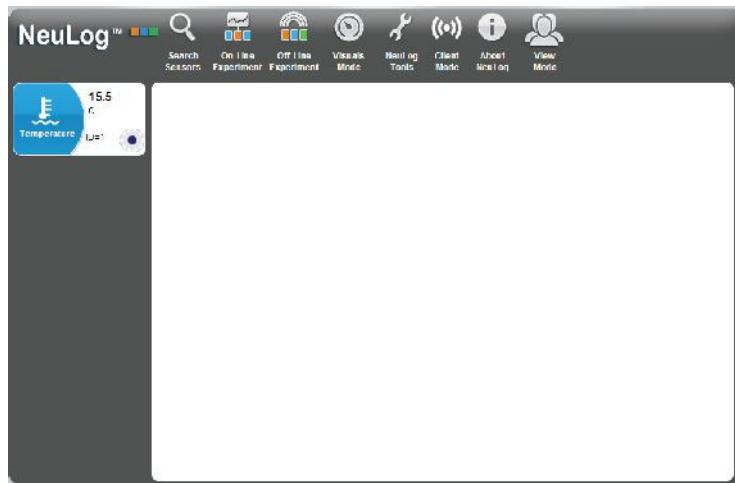
Starting is enabled by clicking the **Run Experiment icon**  on the PC or by pressing the **Start/Stop** buttons on the sensors, so all the sensors start at the same time. Stop the experiment by clicking on the **Stop Experiment icon**  on the PC, by pressing the **Start/Stop** buttons on the sensors, or wait for the experiment duration to be completed, so the experiment ends automatically.

Data is then uploaded in order to display and analyze it. However, all graphs would be overlaid on the longest Time axis with t = 0s being where each sensor appears to have been triggered.

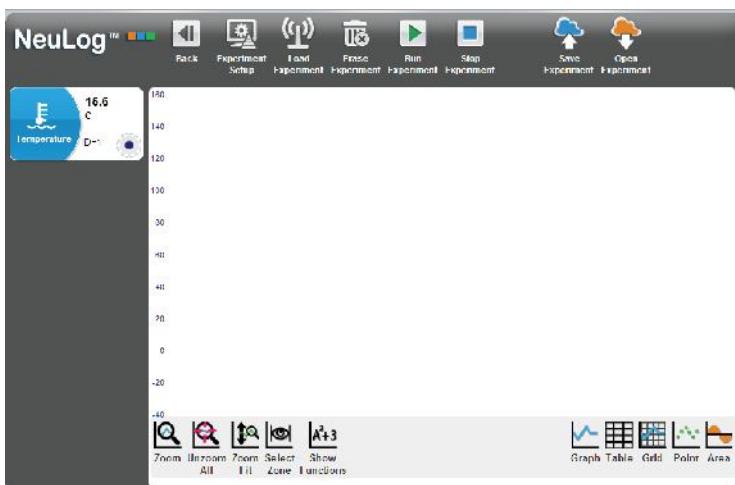
The activities in this chapter have been designed merely to show how to operate in this mode and its special features.

## 4.1 The off-line experiment mode menu

- Connect the USB Bridge module  to a USB port on the PC.
- Connect the Temperature sensor  to the USB Bridge module .
- Enter the NeuLog™ main screen and click on the **Search Sensors icon** to display the following.



- During the search, a 'stop' button appears at the end of the search bar. This button can be used in order to stop the search when all the connected sensors are identified.
- Click on the **Off-Line Experiment icon**  to display the Off-Line experiment screen below.



## 4.2 Off-line experiment with battery module

In this Off-line experiment mode you will be using sensor(s) whilst it/they are connected and powered by a **Battery module**  Each sensor can store up to 5 different experiments data.

Check first that this module's battery is OK by pressing its button and seeing that the red LED alongside it lights. If the LED does not light then you will need to recharge the unit.

The **Battery module**  is a rechargeable battery module that can be recharged by connecting it to the PC's USB socket via the **USB module**  USB cable. Check that.

The **Battery module**  has a LED and a pushbutton switch. The LED indicates whether the battery is charged enough or not when pressing the pushbutton. Check that.

### 4.2.1 Setting up a single sensor without a trigger

- Click the **Module Setup button**  of the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.



Note that this window is different from the one displayed in Section 3.1 for the On-line Experiment mode. The **Experiment duration** and **Sampling rate** have to be set up here, as does the use of a **Trigger**, although the Trigger is not being dealt with until Section 4.2.5.

#### NOTE:

It is essential that at least one change is made to the settings as only then are they downloaded into the Temperature sensor module's memory. If you only want the default settings you would need to change one of them and then go back to it. As you make changes an OK message will be displayed indicating that the change has been downloaded into the sensor's module memory.

- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** and to '30 seconds'.

- In this example the Trigger is **not** being used so check that the **Trigger** button is **Grey**.
- Press **Back**.
- Now disconnect the **Temperature sensor**  from the **USB Bridge module**  and plug it into the **Battery module** .
- If you have a digital display module (VIEW-101), you can connect it to the chain.

#### 4.2.2 Running a single sensor without a trigger

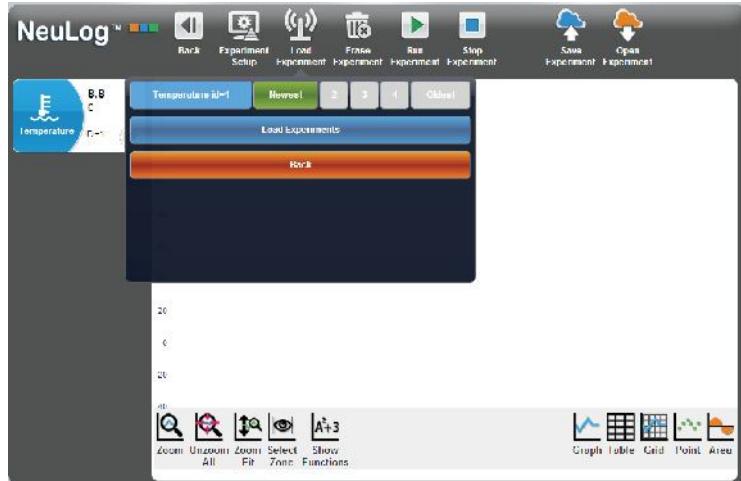
**NOTE: Take care. In this experiment you will be using hot water.**

- Pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Pour about 200ml of cold water at a temperature below that of the laboratory/room into another 250ml beaker.
- Press the **Start/Stop** button on the Temperature sensor. Its red light emitting diode (LED) will blink according to the sampling rate. The sensor will have started sampling the temperature 10 times per second for 30 seconds and is recording the data in its internal memory.
- After about 5 seconds insert the Temperature sensor rod into hot water.
- After about a further 10 seconds take the Temperature sensor rod out of the hot water and insert it into the cold water.

After 30 seconds, the red LED will turn **OFF**. The datalogging is complete. Pressing the **Start/Stop** button sooner would have also stopped the datalogging.

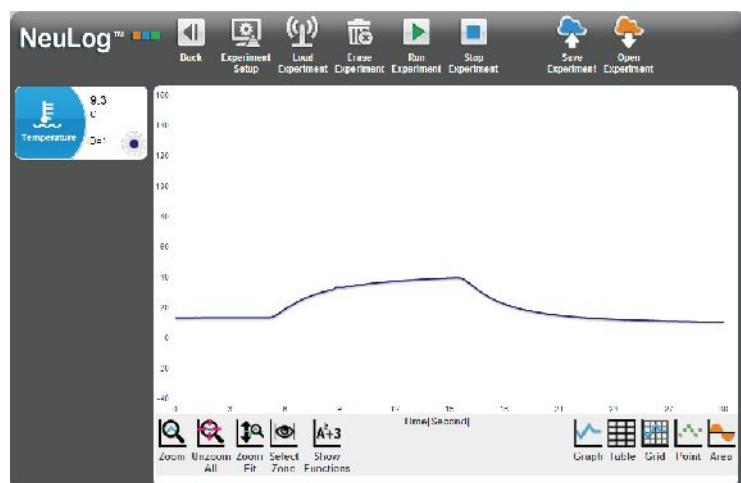
- Remove the Temperature sensor from the cold water.
- Unplug the **Temperature sensor**  from the **Battery module**  and reconnect it to the **USB Bridge module** .

- Check that the PC is still in Off-line Experiment mode and click on the **Load Experiment** icon  in the Sub-icon bar and note the following screen:



Clicking on Experiments will show the list of stored experiments in the sensor's memory (upto 5).

- Click on **Newest**, on the window, to upload the last stored experiment data and then click on the **Load Experiment** button.
- The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.



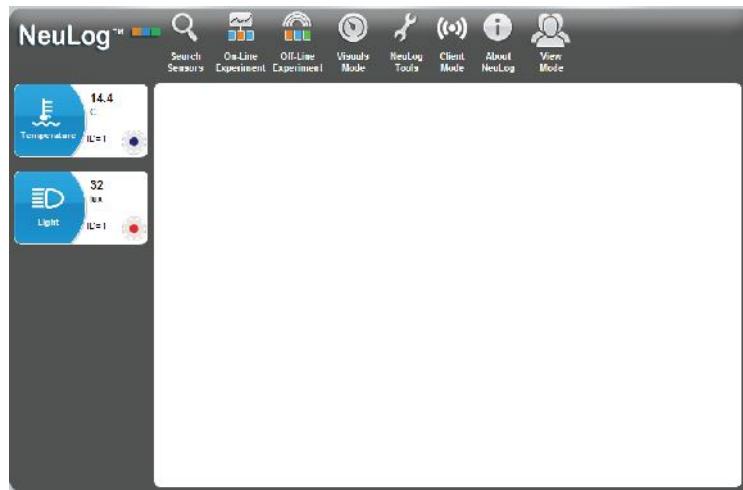
As in On-line mode, all the various Zoom, cursors, functions, point/line graph, clear experiment results, freeze graph and export to spreadsheet, facilities, are available via their icons.

You can upload an experiment, freeze it and upload another one.

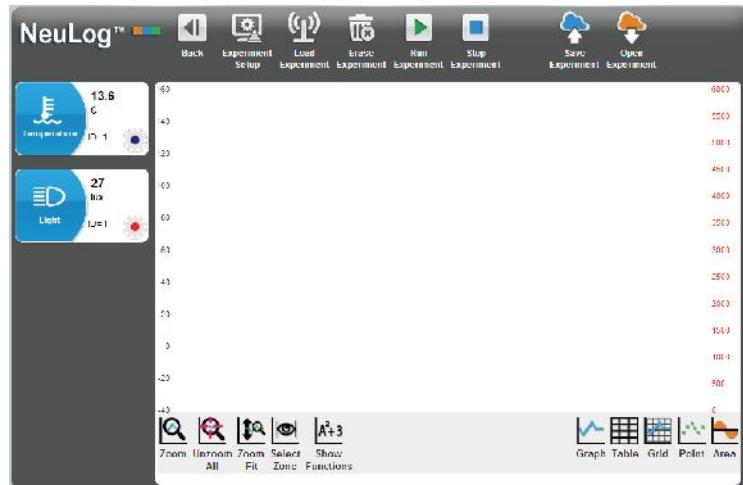
- Click the **Erase Experiment** icon  in the Sub-icon bar.
- Leave the **Temperature sensor**  and **USB Bridge module**  connected to the .

### 4.2.3 Setting up two sensors without triggers

- Additionally plug the **Light sensor**  to the **Temperature sensor**  or to the **USB Bridge module** .
- Go **Back** to the main screen and click on the **Search Sensors icon**  and Get the following screen.



- Click the **Off-line experiment icon**  in the Main-icon bar to display the window shown below.



- Click the **Module Setup button**  of the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.



- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** and to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **Grey**.
- Press **Back**.
- Click the **Module Setup button**  of the Light Sensor Module box to display the Light1 – Options tab window shown below.



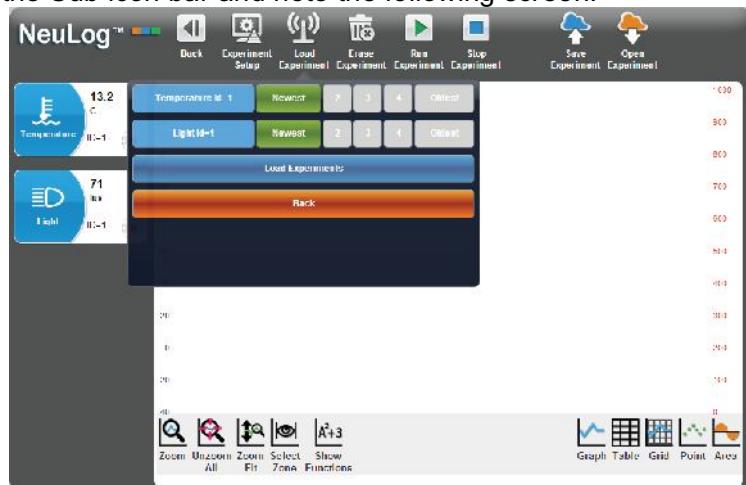
- Set the **Experiment duration** and to '1 minute'.
- Set the **Sampling rate** to '5 per second'.
- Check that the **Trigger** button is **Grey**.
- Press **Back**.
- Disconnect the two sensors from the **USB Bridge module**  and connect them to

#### 4.2.4 Running two sensors without triggers

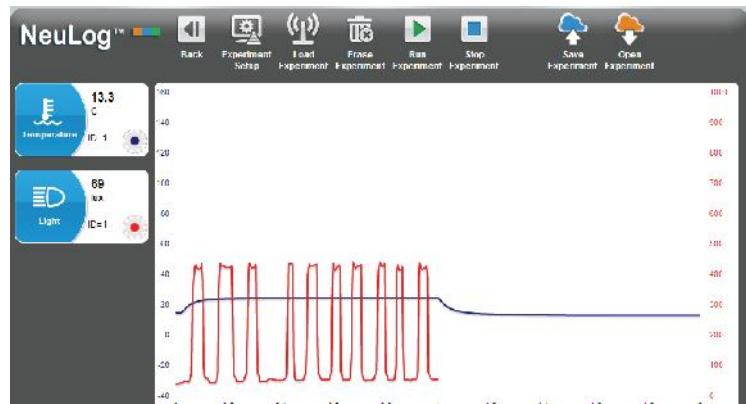
**NOTE: Take care. In this experiment you will be using hot water.**

- If not already available, pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Place the Temperature sensor's rod into the hot water and press the **Start/stop** button on the Temperature sensor.
- After about 1 minute press the **Start/stop** button on the **Light sensor**  and move it so that different levels of illumination are sensed.

- When both LEDs have gone out, disconnect the sensors from the **Battery module**  and reconnect them to the **USB Bridge module** .
- Check that the PC is still in Off-line Experiment mode and click on the **Load Experiment** icon  in the Sub-icon bar and note the following screen:



- Click on **Newest**, on the window, to upload the last stored experiment data for both sensors and then click on the **Load Experiment** button.
- The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.



Note that **both graphs** begin at **Time = 0.00 minutes** even though the Light sensor did not have its **Start/stop** button pressed until 1 minute after the Temperature sensor had its **Start/stop** button pressed. In this mode, the graphs do not take into account such time differences.

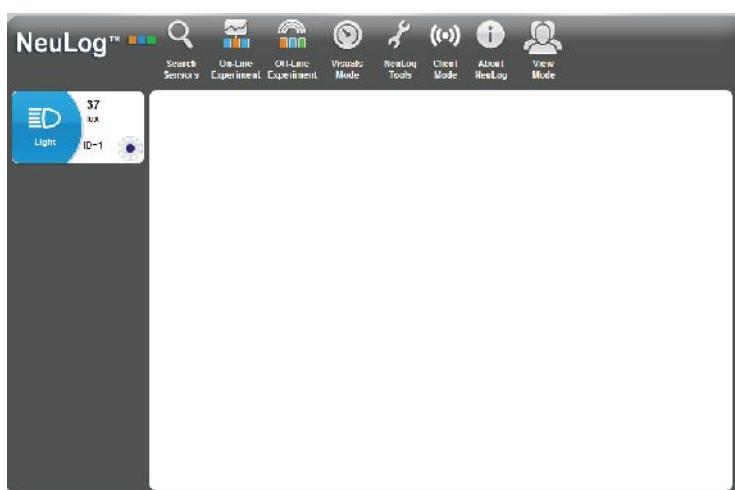
If you had selected **Temperature 1** experiment only, just the Temperature graph would have been displayed. Similarly if you had selected **Light 1** experiment, then just the light graph would have been displayed. Although not a sensible one to plot here, you could also have plotted an XY graph of Temperature against Illumination by clicking on the **Experiment setup icon**  in the Sub-icon bar and using one of its Graph tabs to arrange this.

- Click the **Erase Experiment icon**  in the Sub-icon bar.
- Disconnect the **Temperature sensor**  from the chain but leave the **Light sensor**  and **USB Bridge module**  still connected to the PC.

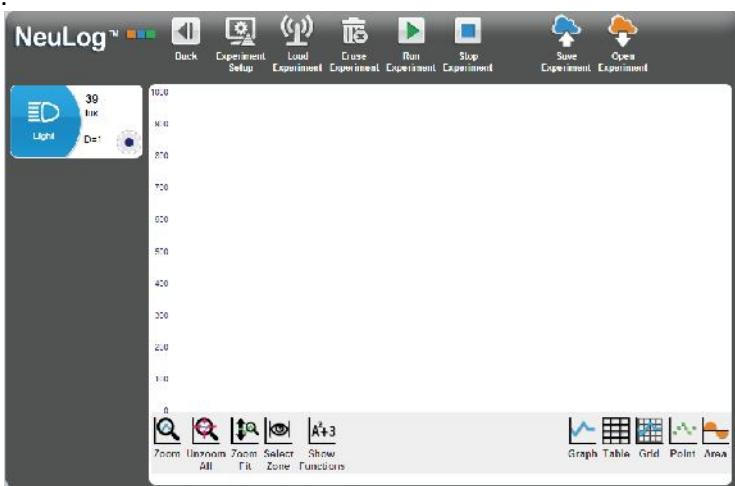
**NOTE:** The two sensors could also have been programmed and operated separately from each other. Uploading their data subsequently could then have been done (i) separately, in which case only that sensor's data would be displayed on a graph or (ii) both together, in which case both sets of data could be overlaid on the same graph if wished (or indeed uploaded separately).

#### 4.2.5 Setting up a single sensor with a trigger

- Go **Back** to the main screen and click on the **Search Sensors icon**  and Get the following screen.



- Click the **Off-line experiment icon**  in the Main-icon bar to display the window shown below.



- Click the **Module Setup button**  of the Light Sensor Module box to display the Light1 – Options tab window shown below.



- Check that the **Range** button is set to '1000 Ix'. Reset if necessary.
- Set the **Experiment duration** and to '1 second'.
- Set the **Sampling rate** to '100 per second'.
- Click on the **Trigger** button to display the Light 1 – Trigger tab window shown below.

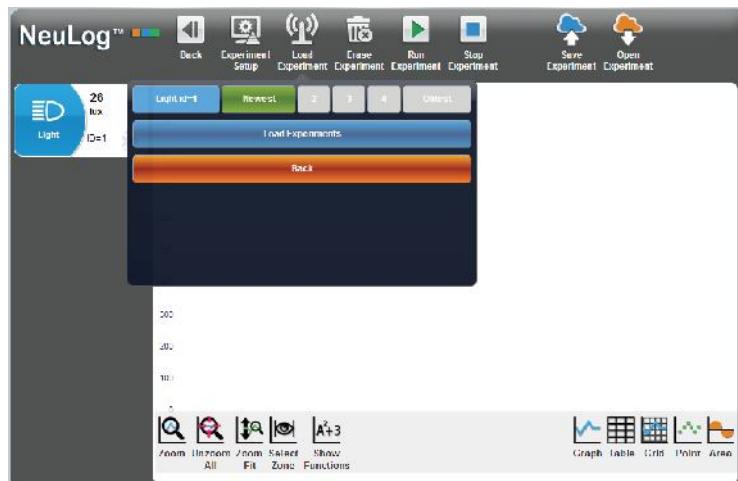


- Enter the **Trigger Value** '5'.
- Check that the **Mode** indicates 'Rise'.
- Press **Back** twice.

- Disconnect the Light sensor  from the **USB Bridge module**  and then reconnect it to the **Battery module** .

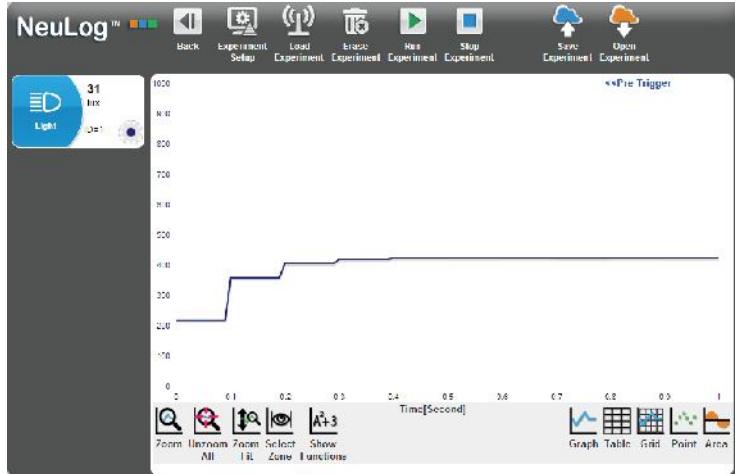
#### 4.2.6 Running a single sensor with a trigger

- Place a finger over the hole on the side of the Light sensor to stop any light from getting in.
- Push the **Start/stop** button on the Light sensor.  
The light sensor LED will blink fast twice with a distance between every two pulses. This means 'Waiting for trigger'.
- Point the sensor's access hole towards the light and then remove your finger from the hole.  
The blinking will stop.
- Disconnect the **Light sensor**  from the **Battery module**  and reconnect it to the **USB Bridge module** .
- Check that the PC is still in Off-line Experiment mode and click on the **Load Experiment** icon  in the Sub-icon bar and note the following screen:

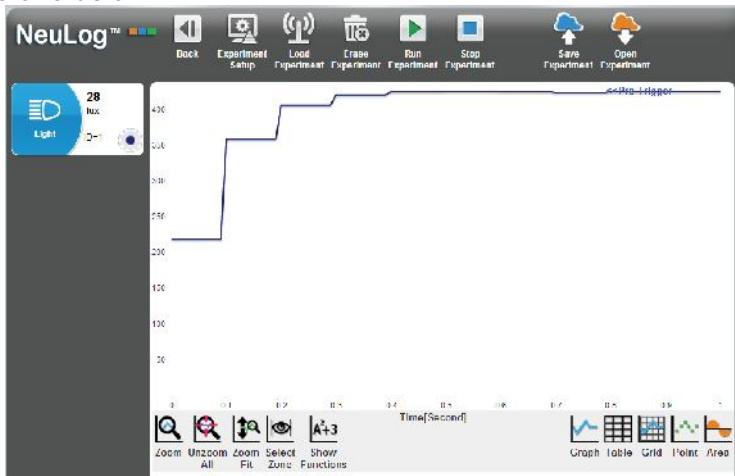


- Click on **Newest**, on the window, to upload the last stored experiment data for both sensors and then click on the **Load Experiment** button.

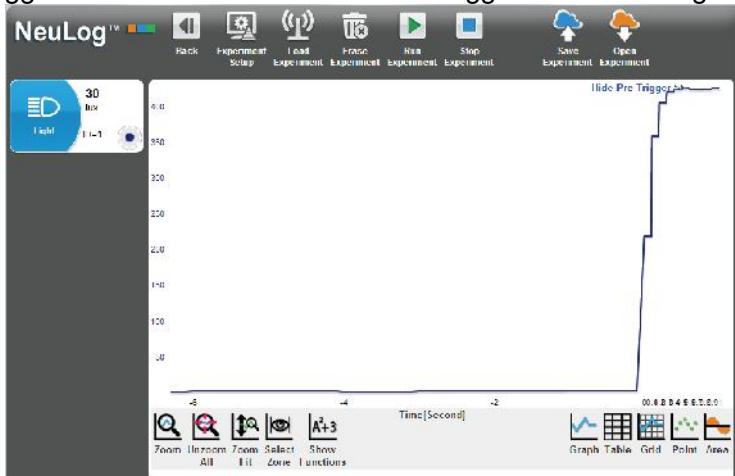
The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.



- Click on the **Zoom-fit icon** to expand the graph in the Y-axis direction and obtain a graph like the one below.



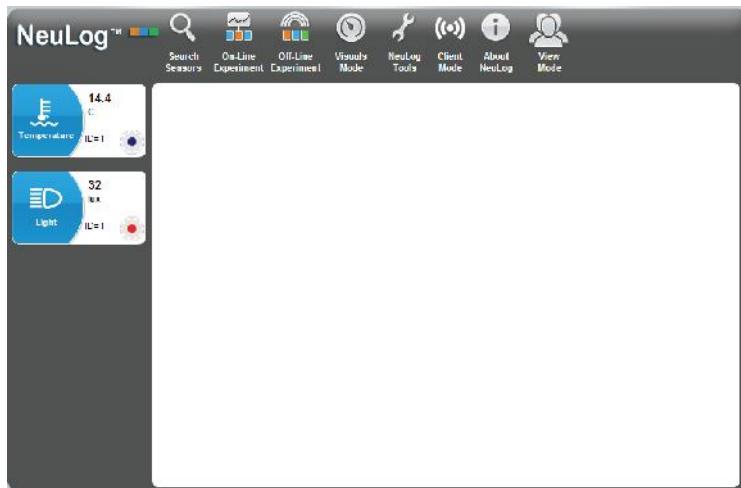
- Click on the **Pre-trigger button** to see how quickly the sensor responded after being triggered. A second click on the Pre-trigger button will slightly extend the time.



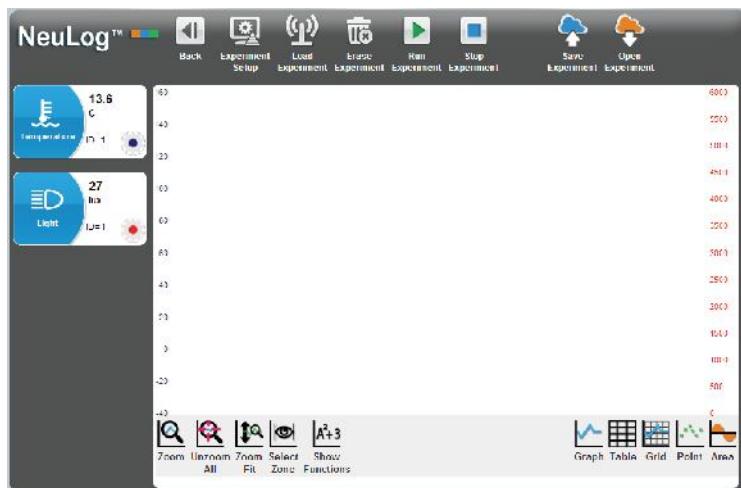
- Click on the **Hide Pre-trigger button** to return the screen to the previous display.

#### 4.2.7 Setting up two sensors with triggers

- Connect a **Temperature sensor**  to the **Light sensor**  or to the **USB Bridge module** .
- Go **Back** to the main screen and click on the **Search Sensors icon**  and Get the following screen.



- Click the **Off-line experiment icon**  in the Main-icon bar to display the window shown below.



- Click the **Module Setup button**  of the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.
- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** and to '2 minutes'.
- Set the **Sampling rate** to '5 per second'.

- Check that you have got the following screen.



- Press Back.
- Click the **Module Setup** button of the Light Sensor Module box to display the Light1 – Options tab window shown below.
- Check that the **Range** button is set to '1000 lx'. Reset if necessary.
- Set the **Experiment duration** and to '1 second'.
- Set the **Sampling rate** to '100 per second'.
- Set the **Trigger** to '5' and **Rise**.
- Check that you have got the following screen.



- Press Back.
- Disconnect the **Temperature sensor** and **Light sensor** from the **USB Bridge module** and connect them to a **Battery module** .

#### 4.2.8 Running two sensors with triggers

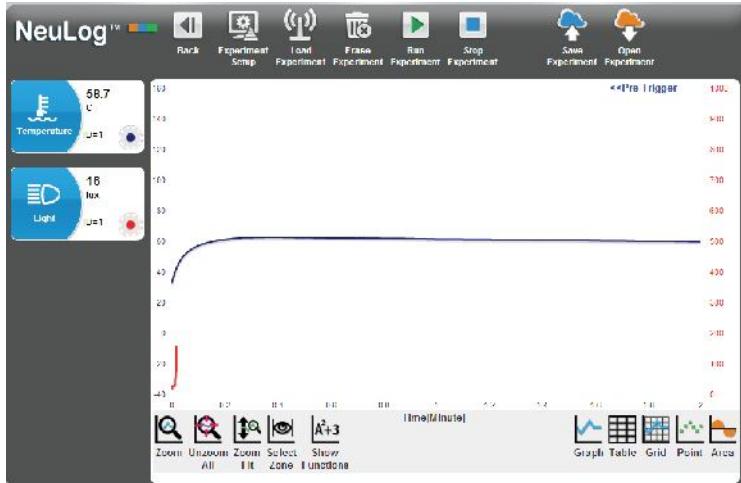
**NOTE: Take care. In this experiment you will be using hot water.**

- If not already available, pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Also pour about 200ml of cold water into another 250ml beaker.
- First place the Temperature sensor's rod into the cold water and press the **Start/stop** button on the Temperature sensor.
- After about 1 minute press the **Start/stop** button on the Light sensor  and move it so that different levels of illumination are sensed.
- When the LED on the Light sensor has gone out move the Temperature sensor's rod into the hot water.
- When both LEDs have gone out, disconnect the sensors from the Battery module  and reconnect them to the USB Bridge module .
- Check that the PC is still in Off-line Experiment mode and click on the **Load Experiment** icon  in the Sub-icon bar and note the following screen:

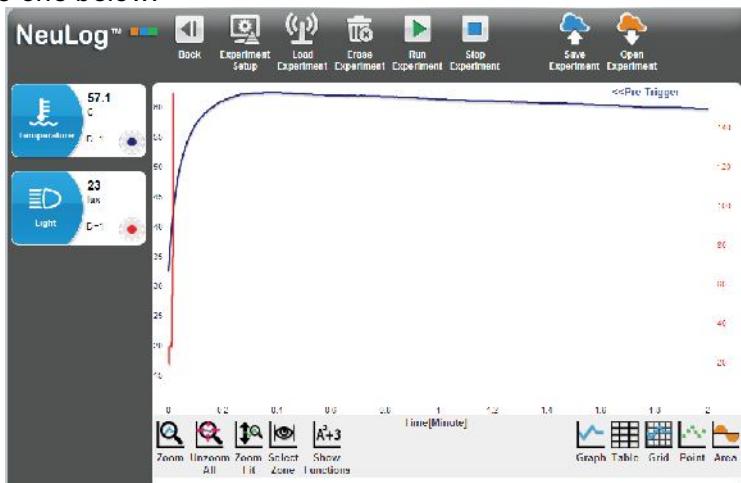


- Click on **Newest**, on the window, to upload the last stored experiment data for both sensors and then click on the **Load Experiment** button.

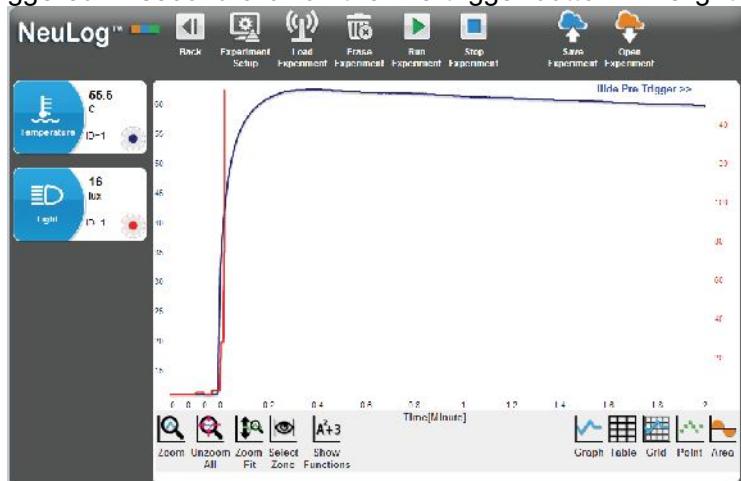
The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.



- Click on the **Zoom-fit icon**  to expand the graph in the Y-axis direction and obtain a graph like the one below.



- Click on the **Pre-trigger button**  to see how quickly the sensor responded after being triggered. A second click on the Pre-trigger button will slightly extend the time.



- Check the following. The triggers of the two sensors were at complete different times, but

- Click on the **Hide Pre-trigger button**  to return the screen to the previous display.
- Click the **Erase Experiment icon**  in the Sub-icon bar.
- Click on the **Zoom-fit icon**  to expand the graph in the Y-axis direction and obtain a graph like the one below.

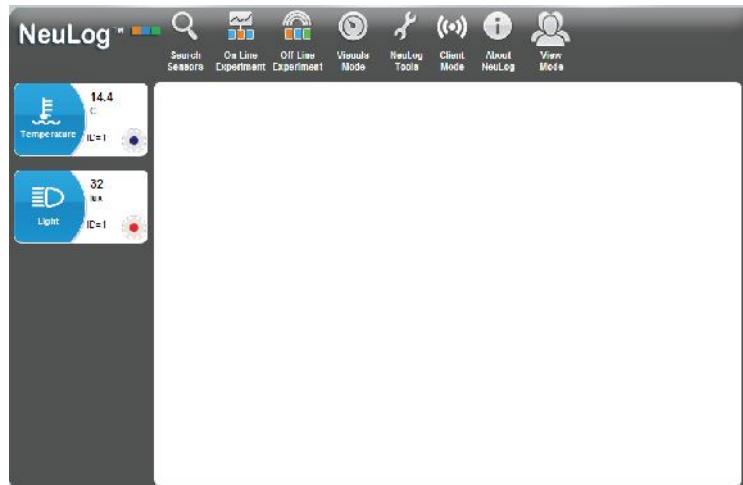
## 4.3 Off-line experiment mode with a PC

We shall repeat the experiment two sensors without triggers with the PC. Instead of pressing the **Start/Stop** button on each sensor, we shall operate the sensor from the PC.

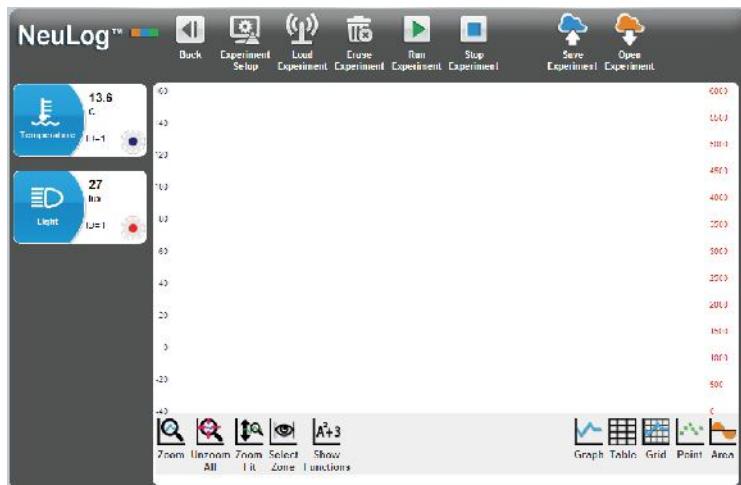
This experiment can be done with any type of MDU.

### 4.3.1 Setting up two sensors without triggers

- Plug the Temperature sensor  and the Light sensor  to the USB Bridge module .
- Go **Back** to the main screen and click on the **Search Sensors icon**  and Get the following screen.



- Click the **Off-line experiment icon**  in the Main-icon bar to display the window shown below.



- Click the **Module Setup button**  of the Temperature Sensor Module box to display the Temperature 1 – Options tab window shown below.



- Check that the **Range** button is set to 'Celsius'. Reset if necessary.
- Set the **Experiment duration** and to '2 minutes'.
- Set the **Sampling rate** to '30 per minute'.
- Set the **Trigger** button to **Grey**.
- Press **Back**.

- Click the **Module Setup button**  of the Light Sensor Module box to display the Light1 – Options tab window shown below.



- Set the **Experiment duration** and to '1 minute'.
- Set the **Sampling rate** to '5 per second'.
- Set the **Trigger** button to **Grey**.
- Press **Back**.

Both the Temperature and Light sensors have now been setup.

**NOTE: Leave both of the sensors connected to the PC via the USB Bridge** .

#### 4.3.4 Running two sensors without triggers

**NOTE: Take care. In this experiment you will be using hot water.**

- If not already available, pour about 200ml of hot water at about 60°C into a 250ml beaker.
- Similarly, if not already available, pour about 200ml of cold water at a temperature below that of the laboratory/room into another 250ml beaker.
- Place the Temperature sensor's rod into the hot water.
- Click the **Run Experiment icon** 

**Note:** This button enables us to run an off-line experiment at the same time.

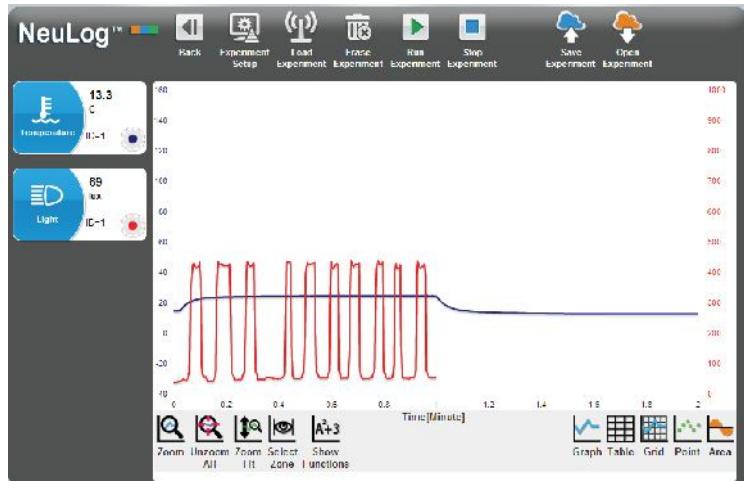
- Direct the light sensor to a light source and the ground alternately.

Pay attention to the two different rates of blinking because of the two different rates of sampling.

- Wait until the temperature sensor stops blinking too.
- Check that the PC is still in Off-line Experiment mode and click on the **Load Experiment icon**  in the Sub-icon bar and note the following screen:



- Click on **Newest**, on the window, to upload the last stored experiment data for both sensors and then click on the **Load Experiment** button.
- The sampled data will be uploaded to the PC and a graph similar to that below will be displayed.



- Click the **Erase Experiment icon**  in the Sub-icon bar.
- Disconnect both the **Light sensor**  and the **Temperature sensor**  from the **USB Bridge module**  and unplug the latter from the PC.

# Chapter 5 – Using the RF Communication Modules

## 5.1 RF with a PC

For wireless communication between a single sensor, or chain of sensors, and a PC, simply plug the sensor(s) **and** RF Communication module into a Battery module. Then, at the PC end, plug another RF Communication module into the USB Bridge module's with the latter plugged into a PC. Communication is then as if the sensor(s) were connected directly.

The PC can be any kind of PC (Windows, MAC, Linux).

The tablets are connected to wirelessly through WiFi to the sensors.

The RF module has also an ID number. Two RF modules that communicate with each other should have the same ID number.

How to setup the RF module ID number is explained in section 7.2.

### Notes:

**Only two RF modules with the same ID number should be used in a classroom.**

The PC does not require any Wi-Fi™ or Bluetooth™ installation.

## 5.2 RF with a PC and groups of sensors

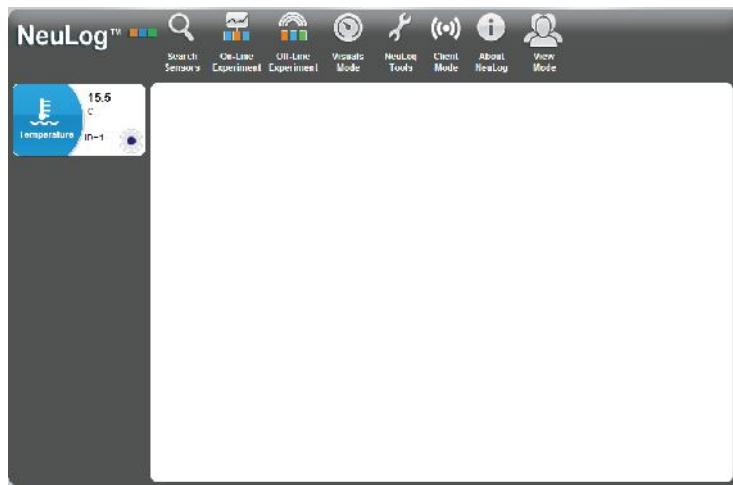
We can use one PC with up to nine groups of sensors operated as described in section 5.1.

Each group of sensors and battery module has a RF module with a different ID number connected to them.

The PC can address each group at a time by setting the ID number of the PC RF module to the required group RF module ID number.

## Chapter 6 – NeuLog™ Tools

- Connect the USB Bridge module  to a USB port on the PC.
- Connect the Temperature sensor  to the USB Bridge module .
- Double-click on the **shortcut icon**  to display the following.



The Logger Sensors software has several tools through which a sensor's ID and software language can be changed.

Another important tool saves an experiment's configuration. For each experiment setup an instruction document can be prepared. When the document is opened (doc, docx, wps, odt, tmd, rtf, pdf etc.) the experiment setup is automatically loaded.

- Pressing on the NeuLog Tools button displays the following keys:



## 6.1 Set Sensor ID Number

- The **Set Sensors' ID** allows us to modify the ID for all of the sensors that are connected to the system according to the key pressed (1 to 9). After pressing 1 to 9, an automatic search will be started.



- Click on the **number 2** button. The sensor will get the instruction to change its ID to '2'.

The **Search** function will run automatically and you will see that the sensor's Module box in the Module window now shows '2'.

- Repeat the above steps and return the sensor's ID number back to '1'.

## 6.2 Set RF Module ID Number

Setting a number in the box alongside the **RF icon** and then clicking on the **RF icon** will change all the connected RF modules IDs to this number. Here you will just deal with one RF module.

- Connect one RF module to the USB module and check that no other RF module is connected to a battery module.
- Click on the **Set RF ID**. The **Set RF ID** key permits modifying the ID of the RF module that is connected to the system according to the key pressed (1 to 9).



- Click on the **number 2** button. The module will get the instruction to change its ID to '2'.

## 6.3 Significant Figures

- The **Significant Figures** key defines the number of digits that the software will display. For example, if the number of significant digits is 4, then the number 5.4321 will be displayed as 5.432 and the number 54.321 will be displayed as 54.32. This scheme allows us to maintain the level of accuracy in the system.



## 6.4 Factory Default and System Notification

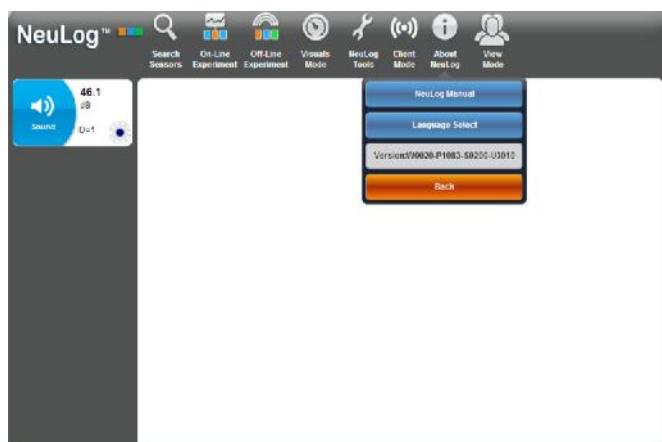
When sensors have been in use in **Off-line** mode they retain whatever settings and data they last had.

The **Factory Default** key sets all the sensor modules that are connected to the system to the standard value set for each sensor module before leaving the factory.

The **System Notification** key allows us to determine if helpful guiding text will be displayed when using the system.

## 6.5 About NeuLog

The **About NeuLog** key displays the version of the software installed in the WiFi module. This information is important when requesting technical support from the factory.



## 6.6 NeuLog Manual and Language Select

The **NeuLog Manual** key displays the user manual for the system.

The **Language Select** key allows changing the language used by the software.



## Chapter 7 – Logger Sensors Modules

This chapter deals with details of the Logger Sensors and associated modules and their special features.

A sensor's **Operating Range** is denoted by the **Y max** and **Y min** values specified.

The **Sampling Rates** of the sensors cover two ranges: (i) from 10,000 samples per second to 1 per hour and (ii) from 100 samples per second to 1 per hour. Not all sensors can be sampled at fast rates as some do not respond quickly. In **On-line Experiment** mode all the modules connected together will automatically run at the same rate, but in **Off-line Experiment** mode they can operate at differing rates.

The **Experiment Duration** should be set by the user; whilst these are most often quite short, they could also be long (many days).

**Sampling Rates** and **Experiment Durations** are interdependent and so, for very fast rates, only short durations are available. The combination of fast rates and long durations is limited by the memory storage capacity of the modules.

### 7.1 Voltage logger sensor NUL-201

Voltages can be measured across various resistive, capacitive and inductive components, as well as those of photovoltaic cells, batteries and power supplies. This sensor can also be used to measure electrode potentials in Redox reactions and to investigate the charging and discharging of capacitors.

When used in conjunction with the Current sensor the dependence of the current flowing on the applied voltage can be studied in various electric circuits.

This sensor can be used to measure low voltage AC and DC circuits. With its 4mm plugs it can easily be connected into electric circuits.

It can also measure, using a step-down transformer, the AC voltage of the Main supply and check its frequency 50/60 Hz (**the input is limited to 60Hz and ±20V maximum**).

**Experiment Duration:** 50 milliseconds to 31 days.

#### Specifications:

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
±20V	12 bit	1%	0.01V	100 Slow 10000 Fast

## 7.2 Current logger sensor NUL-202

This sensor can be used to measure the current in parallel or series low voltage AC and DC circuits.

With its 4mm plugs it can easily be connected into electric circuits.

**Experiment Duration:** 50 milliseconds to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
$\pm 2500\text{mA}$	20 bit	1%	10mA	100 Slow
				10000 Fast

## 7.3 Temperature logger sensor NUL-203

This is one of the most versatile sensors. It can be used in Biology to monitor ecological systems, to study photosynthesis or to study the effect of temperature on enzymes; in Chemistry, to study exothermic or endothermic reactions, and in Physics to study heat/energy transfer.

**Ranges: Celsius, Fahrenheit**

**Experiment Duration:** 1 second to 31 days

The sensitive element is within a 180 mm long, 3.2 mm diameter stainless steel tube. This sensor can be used for temperature measurements in solids, liquids or gases.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
$-35^{\circ}\text{C}$ to $150^{\circ}\text{C}$	12 bit	$\pm 1^{\circ}\text{C}$	0.1 $^{\circ}\text{C}$	100
		$\pm 2^{\circ}\text{F}$	0.1 $^{\circ}\text{F}$	

## 7.4 Light logger sensor NUL-204

This sensor is very versatile with applications in many areas of the natural sciences. In Biology it can be used to study photosynthesis. In Chemistry, to study light-emitting chemical reactions. In Physics it can be used to study the effect of changing voltage on a light-bulb's output.

With three ranges, it can be used in low light environments such as a classroom, or high light environments as in daylight outdoors. It measures Illumination.

With both fast and slow modes, it can be used to measure fast light changes such as those produced by light bulbs connected to an AC supply, as well as the near steady levels outside on a sunny day.

**Ranges:** 1,000 Lx, 6,000 Lx, 150,000 Lx

**Experiment Duration:** 50 milliseconds to 31 days.

The light sensor is located in a plastic box just behind an access hole.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Illumination: 0 to 1,000 lx	12 bit	1 lx	100
Illumination: 0 to 6,000 lx		6 lx	
Illumination: 0 to 150,000 lx		150 lx	
Signal: 0 to 1,000 lx		1 lx	3000
Signal: 0 to 6,000 lx		6 lx	
Signal: 0 to 150,000 lx		150 lx	

## 7.5 Oxygen logger sensor NUL-205

This sensor can be used to make measurements of the level of free-oxygen in air or dissolved oxygen in water.

The free-oxygen in air mode is used to measure changes in oxygen levels during combustion or in reactions that produce oxygen (hydrogen peroxide decomposition). The dissolved-oxygen mode is useful in the study of photosynthesis.

To change mode, click the **Module Setup button**  on the Sensor Module box in NeuLog™ software or use the change range option on the Monitor Display Unit.

**Ranges:** % in air, % in liquid, mg/L

**Experiment Duration:** 1 second to 31 days.

The oxygen sensor is designed for use both in the school laboratory and in the field. It employs easy-to-use polarographic (Clark) technology and replaceable membranes are available for it. The electrode itself is constructed of Delrin® for durability.

With its integral thermistor, it provides dependable temperature-compensated measurements. The thermistor is housed in stainless steel and sealed on the electrode's outer wall providing fast, accurate readings.

The installation and replacement of the membrane is quick and easy. Simply fill the membrane cap assembly with DO electrolyte and screw it into place. Two membrane cap assemblies are included with each sensor. Store in de-ionized water between measurements and overnight. Long-term storage, dissemblent, rinse in de-ionized water and store dry.

### **Sensor Calibration:**

Calibration of the probe is simply achieved in open air, taking this as a standard level of 20.9%<sup>1</sup>. First connect the sensor to a voltage source (the USB Bridge plugged into a PC, Neulog's Monitor Display Unit or Battery Unit) and wait for stabilization of the readings (about 2 minutes). Press the push-button on the sensor's box for about 3 seconds when the readings are stable. The sensor will then be calibrated at 20.9%. Alternatively, the sensor can be connected to a PC running the Logger Sensors software via the USB module. First

click on the **Module setup button**  on the Oxygen sensor's Module box to open its Module setup window. Then click on the **Calibration button**.

### **Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 25% (in air)	10 bit	0.1%	100
0 to 100% (dissolved)		0.1%	
0 to 12.5 mg/L (dissolved)		0.1 mg/L	

### **Specifications for the electrode are as follows:**

<b>Body diameter:</b>	12mm
<b>Overall length:</b>	150mm
<b>Cap:</b>	16mm OD ±30mm Long
<b>Construction:</b>	Polarographic (Clark Type) design with Silver Anode/Gold Cathode, Delrin body and PTFE membrane
<b>Range/Output:</b>	<ul style="list-style-type: none"> <li>▪ 0-20 ppm Dissolved Oxygen (0-200% saturation)</li> <li>▪ Output: 0-40 mA / 0-400 mA</li> </ul>
<b>Response time:</b>	98% of full response in 60 seconds at 25°C

## 7.6 pH logger sensor NUL-206

This sensor can be used to measure the static pH values of common liquids (water, milk, soft drinks, vinegar, etc.) as well as the changing values in titrations or experiments such as those looking at the effect of antacids.

**Experiment Duration:** 1 second to 31 days.

The pH sensor is designed for long life in a variety of general purpose situations. Its sealed reference system and gel fill make it easy to use and maintain. With an epoxy body it is a durable electrode for use both in the laboratory and in the field.

### Sensor Calibration:

This sensor gives a fast response across the full pH range and can be calibrated with any standard buffer solution.

Connect the sensor to a voltage source (the USB Bridge plugged into a PC, NeuLog's™ Monitor Display Unit or Battery Unit). Insert the sensor into a pH = 7 buffer and press the sensor's push button for about 3 seconds. The reading is calibrated to 7. Alternatively the sensor can be connected to a PC running the Logger Sensors software via the USB Bridge.

First click on the **Module setup button**  on the pH sensor's Module box to open its Module setup window. Then click on the **Calibration button**.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 14	16 bit	0.01pH	100

### Specifications for the electrode are as follows:

<b>Body diameter:</b>	12mm
<b>Overall length:</b>	150mm
<b>Cap:</b>	16mm OD ±30mm Long
<b>Construction:</b>	Epoxy Body, Round Bulb ASG VIII pH Glass, Sealed, Gel-filled Single-Junction Reference with fiber frit, Ag/AgCl wire, ATC
<b>Range/Output:</b>	<ul style="list-style-type: none"> <li>▪ 0-14 pH</li> <li>▪ mV output with isopotential point at 0±20mV at pH 7</li> </ul>
<b>Response time:</b>	98% of full response in 30 seconds at 25°C

## 7.7 Relative humidity logger sensor NUL-207

Measuring Relative Humidity, this sensor can find use in recording variations with weather conditions and the biological effect on such organisms as seedlings and insects.

**Experiment Duration:** 1 second to 31 days.

It is located in a plastic box with exposure of the sensor being through a hole in the side.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
0 to 95% RH	16 bit digital	±5% RH	0.1%	100

## 7.8 Heart rate & pulse logger sensor NUL-208

This sensor can be used to monitor and compare pulse rates under various exercise and rest conditions and to compare the "normal" and "after exercise" pulse rates. Additionally, it can show how blood volume/flow rates in the finger or ear lobe vary with time.

**Ranges: BPM, Wave**

**Experiment Duration:** 1 second to 31 days.

To operate, connect the clip to a finger or ear lobe and start measuring either connected via the USB Bridge to a PC, or to the Monitor Display Unit.

On the PC you can choose to see the pulse wave showing changes of blood volume/flow in the finger or earlobe with time (and calculate the pulse) or get the value of the pulse rate directly via the software. The operating mode is changed by clicking on the sensor's **Module**

**Setup button**  on the Sensor Module box to display the Heart and Pulse sensor module setup window, and selecting the mode as required.

For best results, the sensor should be kept away from direct sunlight and high intensity lights.



**Specifications (BPM stands for beats per minute):**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)

**Specifications for the electrode are as follows:**

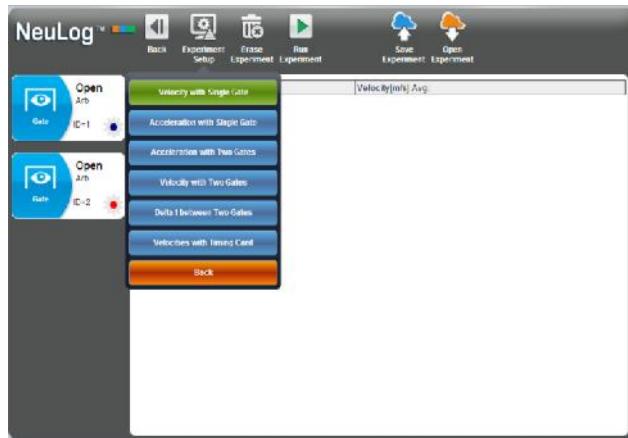
They are both plethysmograph-based and so record changes in blood volume/flow. The sensors consist of an infrared LED transmitter and a matched infrared phototransistor receiver.

## 7.9 Photo gate logger sensor NUL-209

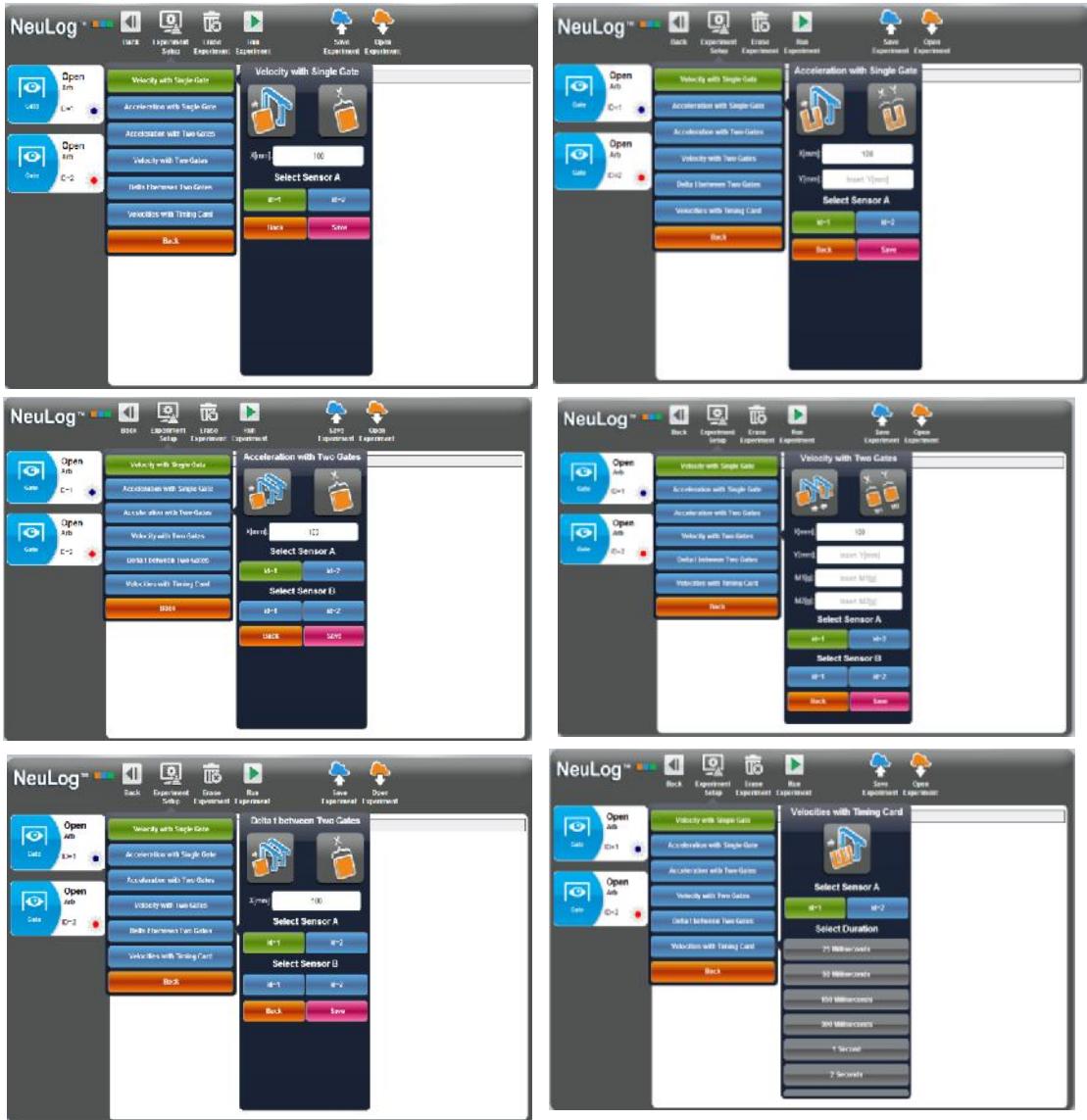
This sensor can be used to study various kinds of motion. With six modes of operation, time, velocity or acceleration can be measured with one or two photo gates and associated timing cards, as well as showing pictorially the status (digital 1 or 0) of the voltage output of the photo gate as timing cards pass through it.

The modes of operation are selected by clicking on the relevant picture.

The photo gate sensor will work only On-Line and in a manner different from all the other sensors. When this sensor is connected, the system will relate only to other photo sensors that are connected and disregards all other sensors. The photo gate sensor has six operating modes that are described in the following screen:



Upon selecting one of the modes of operation, one of the following windows that relate to the specific operating mode will be displayed.



After entering the parameters and press the "Run Experiment" button, every movement of a body that is detected by one or two sensors (according to the operating mode) will display the measured data in a table. There is no graphic display for these modes of operation.

Time[sec]	Avg@0.0501	Velocity[m/s]	Avg@3.062
0.0056		1.160	
0.0134		7.463	
0.0153		1.980	
0.0502		3.311	
0.0711		1.407	

The photo gate is contained in a strong plastic frame with an infrared light emitting diode (LED) on one side and an infrared-sensitive phototransistor on the other side.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
Single timing card with one photo gate	16 bit digital	100 µS	100 µS	10,000
Double timing card with one photo gate				
Single timing card with two photo gates				
Digital status one photo gate				

## 7.10 Pressure logger sensor NUL-210

This sensor can be used to monitor chemical reactions that involve gases and to investigate both Boyle's Law and the Pressure Law for ideal gases. It can also prove useful in studies of weather phenomena.

**Ranges: kPa, Psi, Bar, Atm**

**Experiment Duration:** 1 second to 31 days.

The pressure sensor is located in a plastic box. The sensing part is connected to a small stainless steel tube for connection to pressure sources such as a syringe via an adapter.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
0 to 7 atm	12 bit	$\pm 1\%$ 20°C-30°C	0.01 atm	100
0 to 100 p.s.i.			0.1 p.s.i.	
0 to 700 kPa			0.1 kPa	
0 to 7 bar			0.01 bar	

## 7.11 Force logger sensor NUL-211

This sensor can measure the mass to weight relationship and study how different pulley systems affect the effort needed to lift weights. It can also be used to measure push/pull forces and impacts.

**Ranges: 10N, 50N**

**Experiment Duration:** 50ms to 31 days.

The force sensor is contained in a metal box. There is a hook at the bottom of the box that can be connected to various pulling loads. A simple bumper (for push/impact measurements) could be made and attached using a bolt which is placed through a length of plastic tubing.

The sensor can be hung from a universal laboratory stand via a rod through the hole in its box.

This sensor can be operated either facing upwards, downwards and any intermediate (including horizontal) position.

### Sensor zeroing

Connect the sensor to a voltage source (NeuLog's Bridge, Monitor Display Unit or Battery Unit). To zero the reading, just press the sensor's push-button for about 3 seconds. Alternatively the sensor can be connected to a PC running the Logger Sensors software via the USB module. First click on the **Module setup button**  on the Force sensor's Module box to open its Module setup window. Then click on the **Calibration button**.

### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
±10 N	12 bit	0.01 N	3000
±50 N			

## 7.12 Sound logger sensor NUL-212

This sensor has two modes of operation. In slow mode it can be used to measure Sound-pressure level in decibels. In fast mode it can be used to compare different sources of sound, and their waveforms can also be displayed. The frequencies of tuning forks and wind-chimes could be determined and simple electronic signal generators calibrated using it. With two sound sensors the velocity of propagation of sound in various media could be determined by timing a pulse traveling between them.

**Ranges: dB, Wave**

**Experiment Duration:** 25 milliseconds to 31 days.

The sound sensor is located in a plastic box accessible to the atmosphere via a hole in its side.

**Specifications:**

Range and operation modes	ADC resolution	Accuracy	Resolution	Max Sample Rate (S/sec)
Level: 40 to 110 dB	12 bit	±2 dB	0.1 dB	100
Signal: 0-1024		1	1	10,000

## 7.13 Motion logger sensor NUL-213

This sensor uses an ultrasonic transducer to transmit an ultrasonic wave and measure the time of the echo return. In this way, the sensor measures the distance to an article located against it.

Using the module software, it is able to calculate also the item velocity and acceleration.

The sensor has three modes of operation.

**Ranges: m, m/s, m/s<sup>2</sup>**

**Experiment Duration:** 1 second to 31 days.

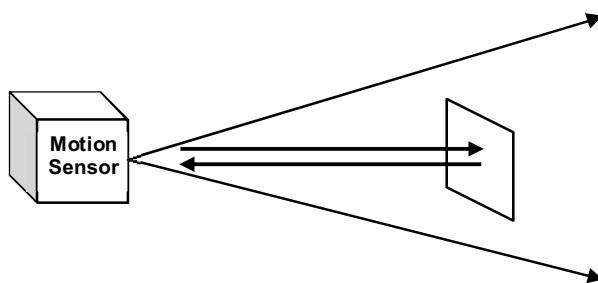
### Specifications:

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Distance: 0.15-10m	12 bit	1mm	
Velocity: $\pm 10$ m/s		m/s	
Acceleration: $\pm 100$ m/s <sup>2</sup>		0.01 m/s <sup>2</sup>	

### Note:

The measurement is based on ultrasonic waves, a sound wave humans cannot hear. The wave is not narrow. Echo can be received from bodies near the line between the motion sensor and the measured article.

The size of the measured article must be at least 10 x 10 cm.



## 7.14 Magnetic logger sensor NUL-214

This is a very sensitive magnetic fields sensor. It can measure a very low level of magnetic fields such as the magnetic field of Earth.

The logger sensor has only one range and measures the magnetic fields in milliTesla (mT).

**Experiment Duration:** 25 milliseconds to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
±10 mT	12 bit	0.001mT	3000

## 7.15 Conductivity logger sensor NUL-215

This logger sensor is based on a probe with two flat electrodes with known surface area and distance between them. A signal is supplied to the electrodes and by testing the signal behavior, the conductivity of the solution is calculated.

The logger sensor has three ranges for displaying the solution conductivity:

**Ranges:**  $\mu\text{s}/\text{cm}$  – micro Siemens per centimeter  
 $\text{mg/L}$  – milli gram per Liter  
 $\text{ppm}$  – part per million

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-20000 $\mu\text{s}/\text{cm}$	12 bit	0-2000 $\mu\text{s}/\text{cm}$ - 0.1 $\mu\text{s}/\text{cm}$ Over 2000 - 1 $\mu\text{s}/\text{cm}$	100
0-18000 mg/L		0-1000 mg/L - 0.1 mg/L Over 1000 - 1 mg/L	
0-18000 ppm		0-1000 ppm - 0.1 ppm Over 1000 - 1 ppm	

## 7.16 Spirometer logger sensor NUL-216

The spirometer enables measuring the volume of our lungs. The sensor includes a tube and it measures the air flow that passes through it. The volume (in liters) is calculated by the software area calculation function.

The tube has a narrow part in its center and it measures the flow rate by measuring the pressure difference between the two ports of the tube.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
±10 L/s	12 bit	0.05 L/s	100

**Note:**

Disposable laminated papers are included with the sensor.

A paper must be rolled and put in the tube before using it and exhaling through it.

## 7.17 GSR logger sensor NUL-217

The Galvanic Skin Response (GSR) logger sensor measures the conductivity of our skin, especially between our hand fingers.

The conductivity of our skin changes according to unconscious emotion effects such as sudden noise, smell, touch, pain or view.

This sensor has two ranges: conductivity in micro Siemens and arbitrary numbers.

**Ranges: Signal, uS**

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-65279 Arbitrary units	12 bit	10nS	100
0-10 µS			

**Note:**

The skin response time from the sudden effect is between 0.1 to 0.5 seconds. The level of the response changes dramatically from one person to another.

## 7.18 Electrocardiogram logger sensor NUL-218

In a very simple way, this sensor enables to measure the electrocardiogram. It does not use disposable electrodes.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
200 to 4,000 $\mu$ V			

## 7.19 Colorimeter logger sensor NUL-219

The colorimeter measures the levels of color components (red, green and blue) of a solution.

Another option is to measure the solution absorbance of each color component.

The colorimeter logger sensor has an opening for a special square solution tube. The colorimeter turns on 3 different lights (RGB) in known values and measures the received light that passes through the solution.

This sensor has two modes of operation.

**Ranges: Red, Green, Blue, % Transparency, Absorbance**

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
R.G.B. 0-4 absorbance	12 bit	0.01 % 0.01 abs	100

**Note:**

The tube must be put in a certain way inside the colorimeter. The tube has one rough side. This side should not be in the line of the light.

## 7.20 CO<sub>2</sub> logger sensor NUL-220

This logger sensor is based on an electromechanical reaction between CO<sub>2</sub> gas and the sensor.

The result of the electromechanical reaction is voltage, measured by the logger sensor.

The measure units are ppm (parts of CO<sub>2</sub> per million of air).

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
350-10,000 ppm	12 bit	1 ppm	100

**Note:**

The sensor must be calibrated before every use according to the following simple procedure:

Connect the sensor to the PC through a USB module or to a battery module.

Wait for two minutes to warm the sensor and press the pushbutton switch on the CO<sub>2</sub> logger sensor for 3 seconds.

## 7.21 Barometer logger sensor NUL-221

This sensor measures atmospheric barometric pressure using a barometer pressure sensor in it.

This sensor has four common ranges for displaying atmospheric pressure:

**Ranges:** KPa – Kilo Pascal  
Atm – Atmospheres  
in/hg – Mercury in inches  
m – Altitude

The highest barometric pressure is on the sea level – when we go up, the pressure goes down.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
80-106 KPa	12 bit	0.1 KPa	100
0.80-1.00 Atm		0.01 Atm	
23.60-31.30 in/hg		0.01 in/hg	

## 7.22 Blood pressure logger sensor NUL-222

The sensor measures the pressure in the air pillow wrapped on the tested person's arm.

Heartbeats affect the blood pressure. That is the reason for the difference between the systolic and diastolic pressure of the tested person.

**Ranges:** mmHg      - The average pressure in the air pillow in mm/Hg  
 Arb                  - The pressure beats with no units  
 Arb+mmHg          - The sum of the two above signals.

The two parameters of the blood pressure are the average pressure where the pressure beats are 10% of their maximum value.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-250 mm/Hg	12 bit	0.30 mm/Hg	
0-250 Arb		0.30 mm/Hg	
0-250 mm/Hg + Arb		0.30 mm/Hg	

## 7.23 Drop Counter logger sensor NUL-223

This sensor is perfect for titrations. Combined with the pH sensor it gives a very nice titration curve.

**Ranges:** Counts, mL

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0 to 6,500 drops			
0 to 6,500 X drop vol. In ml			

## 7.24 Flow logger sensor NUL-224

This sensor measures water flow. It includes a rotation wheel that rotates when water flows through it. The sensor has inlet and outlet pipes.

The wheel is floating on a bearing and is not connected mechanically to anything else. Its speed is measured by magnetic field changes.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-4.7 m/s	12 bit	0.0001m/s	100

## 7.25 Force plate logger sensor NUL-225

This sensor measures heavy weight or forces. We can stand or jump on it.

Handles can be connected to its plates for measuring pulling forces.

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-800-(+3500) N	12 bit	0.3N	100

## 7.26 Rotary motion logger sensor NUL-226

This sensor measures angles, rotation speed or rotation acceleration.

The sensor has a pulley connected to its shaft and the pulley rotation is measured.

This sensor has four modes of operation.

**Ranges:** Angle, Rad/s, Rad/s<sup>2</sup>, Rev/s

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0°-360° ±345 Rad/s +32 222 Rad/s <sup>2</sup>	10 bit	0.08° 0.6 Rad/s 11 Rad/s <sup>2</sup>	100

## 7.27 Acceleration logger sensor NUL-227

This logger sensor includes a 3D (three dimensions) acceleration sensor, but only one dimension acceleration can be displayed at a time.

**Ranges:** X-axis, Y-axis, Z-axis

**Experiment Duration:** 25 milliseconds to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
Acc-x -80 to 80 m/s <sup>2</sup>	10 bit	0.15 m/s <sup>2</sup>	3000
Acc-y -80 to 80 m/s <sup>2</sup>			
Acc-z -80 to 80 m/s <sup>2</sup>			

**Note:**

The logger sensor measures all the three accelerations at the same time and stores it.

We can run an experiment on-line, upload one dimension acceleration, freeze it and upload another, using the off-line method.

## 7.28 Salinity logger sensor NUL-228

This sensor enables measurements of the salt content in a solution.

**Ranges:** %, mg/L, ppm

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0.0000 to 6.4000%			
0 to 64,000 ppm			
0 to 64,000 mg/L			

## 7.29 Soil moisture logger sensor NUL-229

This logger sensor is based on measuring the vacuum pressure in a tensiometer.

A tensiometer is a closed tube with a special ceramic part in its end.

The tensiometer is filled with water and put in the soil. If the soil is dry, water goes out by diffusion through the ceramic holes and vacuum pressure is created in the tensiometer.

When we wet the soil, the vacuum in the tensiometer pulls water into the tensiometer and the vacuum decreases.

This is why soil moisture is measured in pressure level.

**Ranges:** cBar, kPa

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-50 cBar 0-50 KPascal	12 bit	0.02 cBar 0.02 KPascal	100

## 7.30 UVB logger sensor NUL-230

There are different wave lengths of ultra violet light.

The UVB wave length range is 280-320 nm, which is 2% of the total UV radiation.

The UVB radiation affects the vitamin generation in the human body, the immune suppression, skin cancer and cataract.

The intensity of this light is measured in mW/m<sup>2</sup> (milli Watt per square meter).

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-1500 mW/m <sup>2</sup>	12 bit	0.8 mW/m <sup>2</sup>	100

## 7.31 Turbidity logger sensor NUL-231

This sensor measures the reflected light that enters into a tube containing a solution. As solution turbidity is higher, more light is reflected and measured by the light sensor, located perpendicular to the tube.

The turbidity measurement units are Nephelometric Turbidity Unit (NTU).

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-200 NTU	12 bit	0.08NTU	100

## 7.32 UVA logger sensor NUL-232

There are different wave lengths of ultra violet light.

The UVA wave length range is 320-370 nm, which is 98% of the total UV radiation.

The UVA radiation affects the photo aging and photo chemical smog.

The intensity of this light is measured in mW/m<sup>2</sup> (milli Watt per square meter).

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
0-50,000 mW/m <sup>2</sup>	12 bit	74 mW/m <sup>2</sup>	100

## 7.33 Surface temperature logger sensor NUL-233

This logger sensor is very similar to the temperature sensor NUL-203, without the stainless steel tube.

The sensor can be put on any surface and even in water.

This sensor has two modes of operation.

**Ranges: Celsius, Fahrenheit**

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-35°C to 150°C -31°F to 238°F	12 bit	0.1°C 0.1°F	100

## 7.34 High temperature logger sensor NUL-234

This sensor is based on a thermocouple sensor that enables measuring very high temperature levels, even the temperature of a flame, as well as very low temperature levels.

**Ranges: Celsius, Fahrenheit**

**Experiment Duration:** 1 second to 31 days.

**Specifications:**

Range and operation modes	ADC resolution	Resolution	Max Sample Rate (S/sec)
-200°C to 1200°C -328°F to 2200°F	12 bit	0.1°C 0.1°F	100

## 7.35 USB bridge module USB-200

This NeuLog™ module enables a fast connection of the sensors to any type of PC with USB port.

The USB module is the first in a chain of sensors connected to a USB port of the PC. It provides both power from the PC to the sensors and communication between the PC and the sensors.

The connecting to the PC is done by using a standard USB – mini USB connecting cable (camera cable). Such a cable comes with the USB module.

## 7.36 Battery module Bat-200

The Battery module supplies power to a sensor, or chain of sensors, operating in the Off-Line mode, and to sensors connected to an RF Communication module.

This module can be checked for the 'goodness' of its internal battery by pressing its pushbutton. This will turn **ON** its light emitting diode (LED) when the battery is OK

### **Specifications:**

Internal Rechargeable Battery

Battery test button

The Battery module  is a rechargeable battery module that can be recharged by connecting it to the PC's USB socket via the USB module  USB cable. Check that.

The Battery module  has a LED and a pushbutton switch. The LED indicates whether the battery is charged enough or not when pressing the pushbutton. Check that.

## 7.37 RF Communication module RF-200

The RF Communication module allows remote operation of a single sensor or a chain of sensors. The remote single sensor or chain is connected to an RF Communication module and to a Battery Module which powers them all. Another RF Communication module should be connected directly to the Monitor Display Unit, or to the PC via the USB Bridge module. More than two units can be used to cater for more chains of sensors or more independent sensors.

The PC does not need to have either Bluetooth™ or Wi-Fi™ incorporated. Everything required is built into the RF Communication Module.

### Specifications:

Frequency: 2.4GHz DSSS (Direct-sequence spread spectrum).

Bit Rate: 1Mbps.

Maximum distance of use in open space: 30m.



## 7.38 Digital display module VIEW-200

The VIEW-200 is a small display module that can be connected to any chain of logger sensors working off-line with a Battery Module.

The VIEW-200 automatically searches for the connected sensors and displays one of them digitally. Scrolling for displaying the reading of another sensor is done by pressing the pushbutton switch on the module.



## 7.39 Graphic display module VIEW-101

The Graphic Display Unit (GDU) is used to run experiments without a PC. The GDU displays the sensor's measurements in digital and graphical forms. It can also be used to program the sensor's experiment setup as well as viewing the input from up to five sensors at a time.

This unit has a user-friendly design with a color graphic display and touch screen.

The Graphic Display Unit is used when a PC is not available for each group. It can work with up to 5 sensors in parallel.

Some of the unit's features are:

- Automatic recognition of sensors.
- Uses preset experiment parameters for easy initiation.
- Communicates with all the sensors or one at a time.
- Controls each sensor's range and measurement units.
- Internal charging circuit is incorporated.
- Mode to view sensor values in real time – up to five at a time.
- Automatic Power-Off for longer battery life.

The VIEW-101 can be connected to a chain of sensors ending with the battery module connected to the last sensor of the chain.

When the GDU VIEW-101 receives power, it starts scanning and identifies the connected sensors. The located sensors are displayed on the left side of the screen.

The viewer uses the same icons as the NeuLog™ software:



- Search for connected sensors.



- Run experiment while displaying the results. The data is also saved in the modules' internal memory and can be uploaded to the viewer at any time.



- Stop experiment run.



- Upload experiment data from the sensors. This function acts also as zoom out.



- Zoom fit.



- Erase screen.



- Experiment setup.



- Tools: Set sensor ID, set RF ID, set screen shut down, turn the viewer off. The last two functions are aimed for saving battery.

# Appendix A – NeuLog™ Modules

## A.1 Accessory modules

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
BAT-200	Battery Module			Powers logger sensors when not connected to PC or Monitor Display Unit
RF-200	RF Communication Module			Enables wireless connection of logger sensors to PC and Monitor Display Unit
USB-200	USB Bridge Module			Connects logger sensors to PC

## A.2 Logger sensors modules

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-201	Voltage logger sensor			Measures voltage in DC and AC circuits
NUL-202	Current logger sensor			Measures current in DC and AC circuits
NUL-203	Temperature logger sensor			Measures temperature
NUL-204	Light logger sensor			Measures level of illumination
NUL-205	Oxygen logger sensor			Measures % oxygen in air and dissolved in water
NUL-206	pH logger sensor			Measures relative pH
NUL-207	Relative Humidity logger sensor			Measures humidity
NUL-208	Heart Rate & Pulse logger sensor			Measures pulse rate and blood flow
NUL-209	Photo/Light gate logger sensor			Measures time and, indirectly, speed/velocity and

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-210	Pressure logger sensor			Measures gas or air pressure
NUL-211	Force logger sensor			Measures forces, both push and pull
NUL-212	Sound logger sensor			Measures sound level and displays waveforms
NUL-213	Motion logger sensor			Measures distance, velocity and acceleration
NUL-214	Magnetic logger sensor			Measures magnetic field intensity
NUL-215	Conductivity logger sensor			Measures solution conductivity
NUL-216	Spirometer logger sensor			Measures lung air flow and volume
NUL-217	GSR logger sensor			Measures Galvanic Skin Response
NUL-218	Electrocardiogram logger sensor			Measures electrocardiogram
NUL-219	Colorimeter logger sensor			Measures solution RGB color transfer and absorbance

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-220	CO <sub>2</sub> logger sensor			Measures CO <sub>2</sub> in air
NUL-221	Barometer logger sensor			Measures air pressure and altitude
NUL-222	Blood pressure logger sensor			Measures blood pressure
NUL-223	Drop Counter logger sensor			Counts falling drops
NUL-224	Flow logger sensor			Measures water flow
NUL-225	Force plate logger sensor			Measures high weight
NUL-226	Rotary motion logger sensor			Measures rotary speed, acceleration and rounds
NUL-227	Acceleration logger sensor			Measures 3D acceleration
NUL-228	Salinity logger sensor			Measures salt content in a solution

Catalog No.	Module	Module Symbol	Photographic Image	Purpose
NUL-229	Soil moisture logger sensor			Measures soil moisture
NUL-230	UVB logger sensor			Measures UVB radiation
NUL-231	Turbidity logger sensor			Measures solution turbidity
NUL-232	UVA logger sensor			Measures UVA radiation
NUL-233	Surface temperature logger sensor			Measures temperature of a surface
NUL-234	Wide range temperature logger sensor			Measures a wide range of temperature levels

Comprehensive details of each of these modules is provided in Chapter 7.

## Appendix B – NeuLog™ Through WiFi

Around the world, there is now widespread use of tablets and various types of computers and various operating systems. The only predominant commonality among them is wireless surfing on the Internet and the use of browsers, which for the most part operate in a similar manner.

The innovative solution to this subject offered by NeuLog is to replace the USB module with WiFi communications, thereby connecting the sensors to the browser via wireless communications.

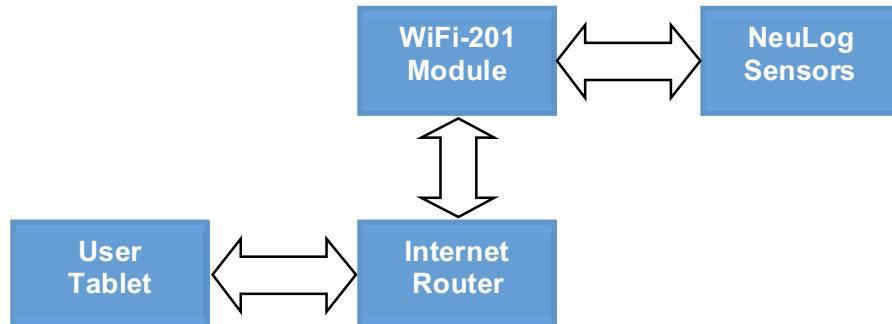
Such a module contains the entire user interface and eliminates the need for special installation programs that need to be adapted for each type of the end user's computer and operating system.

The WiFi module has two operating modes:

1. Use **Access Point (AP)** when there is no wireless Internet communication.



2. Use **Client Mode** in places that have wireless Internet communications. The Tablet will communicate with the WiFi module as if it is a remote Internet website. In this manner, the user can browse in parallel to use the system with access to other sites on the web.



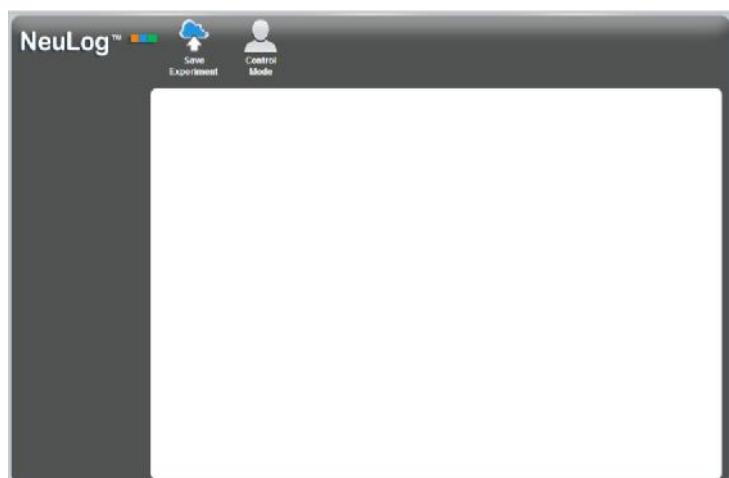
## NeuLog Software through WiFi

- Each WiFi module contains a unique identification name (SSID), which can be accessed by any Wi-Fi supported device. The address is denoted as a name of a wireless Internet network. The name of the network is printed on a tag that is glued to the bottom of the module.
  - When the module is connected to its supply voltage, its three indicator lights flash. The flashing sequence occurs during the initialization stage. At the end of this sequence, the blue light is constantly lit. This designates that the module Wi-Fi network is ready to be accessed by any device.
  - In order to browse to the module, you must locate the Internet network identification (SSID) and connect to it. Use your tablet **Setting** program. Among the internet networks that will be displayed, you will find a network with the name **NeuLog** ended with the module ID number. You can find this number on the back of your WiFi module. For example: **NeuLog1097**.
- Every WiFi module has its unique ID number.

**Important Note:**

You can't browse through wifi to the **WiFi-201** module when you are also connected by wire to network.

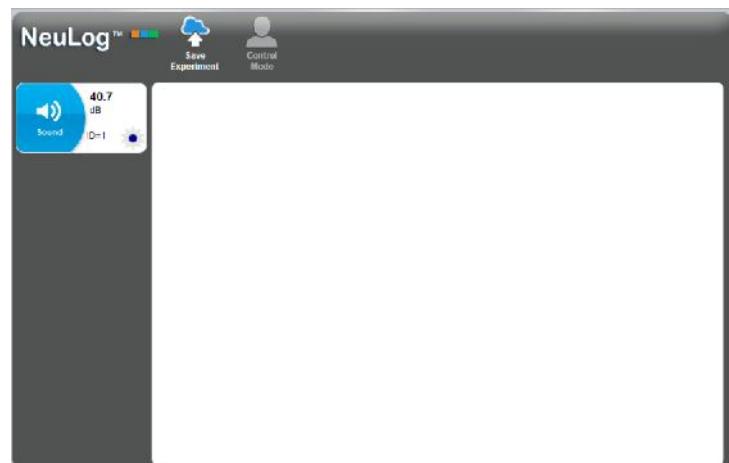
- After connecting to the Internet network, you should browse to the **wifi201.com site**.
- Upon surfing to the module, the 'Viewer' screen is displayed. The student can passively observe experiments.



- The 'Viewer' screen is shown with the 'Control Mode' push button enabled. Selecting Control Mode brings it to the **Control Mode** as shown in the following screen. The student is now able to actively perform experiments.



- When entering the **Control Mode**, an automatic search starts to identify which sensors are connected. This search can also be initiated by pressing on the Search Sensors button.
- During the search, a 'stop' button appears at the end of the search bar. This button can be used in order to stop the search when all the connected sensors are identified.
- The software strives to achieve maximum intuition; only the buttons that are relevant to each stage is shown. The **Back** button brings you back to the previous step.
- Once one of the passive viewers select the **Control Mode** button, this button is blocked on other viewers' screens.
- When a "controller" exits the Control mode by pressing the View Mode button, the **Control Mode** button is displayed on all the other users' screens until one of them presses the **Control Mode** button.
- The view screen is shown below:

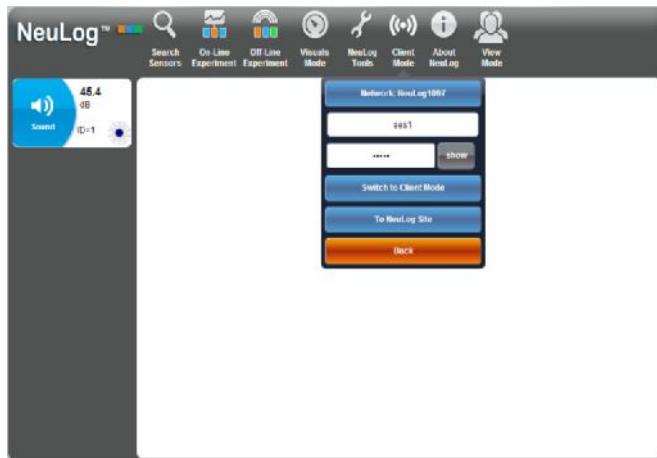


### Client Mode

- When first connecting to the WiFi module, the system operates in the **Access Point Mode**. In this mode, surfing accesses the WiFi module directly. Since the system is not connected to the Internet, it is not possible to access other sites. The **Client Mode** button causes the system to operate in the client mode, which allows access to the system via the local Internet. After pressing on the **Switch to Client Mode** button, a window is displayed; you need to enter the local Internet name and password.



- After pressing of the **Switch to Client Mode** key, the WiFi module attempts to connect to the local Internet and transmits its local IP address to the NeuLog website. While this is taking place, the green light on the WiFi module flashes. In the even that the NeuLog site could not be accessed, the blue light will light continuously once again. The window will also display the “**To NeuLog Site**” key. Remain in this window and do not press any key.



- If the connection to the NeuLog site is successful, the system disconnects from the computer or tablet; therefore, you need to connect the computer or tablet to the local communication network. Once the computer or tablet is connected to the local communication network, press on the “**To NeuLog Site**” key. The software will access the NeuLog site, obtain the local IP address of the module, test if the computer or tablet appears on the same network and access the WiFi module.

- The next time the WiFi module is activated, it will attempt to connect to the local communication network in the **Client Mode** so that it will be possible to access it through this network. Should this succeed, the green light will be lit. However, if it does not succeed, it will return to the **Access Point Mode** and the blue light will be lit.
- If it succeeds, surfing is done through the local network to the **wifi201.com** site, which looks like the following:



- In the **wifi201** field, enter the number that is located on the bottom of the WiFi module and press on the **Connect** button.
- All software functions, which were previously described, behave in the same manner for the two modes of operation except for one thing. In the **Client Mode**, you can send experiment results through the Internet to any email account.
- To return the WiFi module to the **Access Point Mode**, press on the push button located on the WiFi module panel.

### **Important comment**

To exit the software properly, enter the **View Mode** before closing the software. In the event that any user used the WiFi module as a controller and forgot to disconnect from it, the WiFi module will not allow any other user to connect to the WiFi module as a controller.

In order to allow another controller to access the WiFi module, press on the push button on the WiFi module panel continuously for about 3 seconds until all 3 lights are lit and then release the push button.