

NEULOG ELECTROCARDIOGRAM LOGGER SENSOR GUIDE



NeuLog electrocardiogram logger sensor NUL-218

The NeuLog electrocardiogram sensor can be used for any science experiment that utilizes heartbeat data such as in the fields of: Biology, Physiology, Human medicine, Psychology, etc.

An electrocardiogram is a very commonly used medical device which measures and graphs the heart's electrical activity. Every single heartbeat is a very complex event which involves many anatomical locations undergoing changes in their electrical charges. A depolarizing cascade event originates in the Sinoatrial (SA) Node, often referred to as the natural pacemaker, and travels throughout the rest of the heart.

The sensor comes pre-calibrated so you can start experimentation right out of the box using this guide.

Among hundreds of possible experimental subjects that can be studied with the NUL-218 sensor are: electrical impulses, heart rate monitoring, human physiology, muscle physiology, heart rate changes to stimuli, and many more.

The ECG sensor's measurement unit is:

- Arbitrary analog unit (Arb): An arbitrary unit to demonstrate waves, frequencies, and periods. What you see on the Y-axis is signal intensity, while the X-axis shows time.

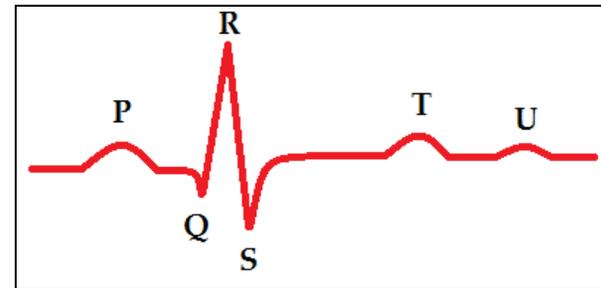
Electrocardiograms:

The heart undergoes a very complex process of electrical activity; this is the basis for how electrocardiograms work. As the heart's muscles contract, the cells are electrically depolarized causing a cascade of depolarization to flow across the heart – contracting the heart's muscle fibers.

During a heartbeat a complex series of events happen which begin with the cells resting potential at roughly -90 mV (millivolts). The heart's Sinoatrial Node begins the cascade by depolarizing – creating an electrical voltage. The electrical signal travels to the right atrium and almost immediately to the left atrium. Because the atria and the ventricles are insulated from each other by a special type of cell which acts as an

electrical insulator, the signal is picked up in another cluster of cells called the Atrioventricular (AV) Node located in the right atria. The signal is carried by a special type of fibers - the Bundle of His into the ventricles. Purkinje fibers rapidly spread the electrical depolarization cascade throughout the ventricles. The entire event takes some time to complete. The graph is a visual demonstration of the heart's relative charge at any given point during heartbeats.

The electrical voltage is measured on the skin using conducting leads and it is converted into a graph that is very standard and reproducible.



- P:** Contraction of atria
- Q:** Initial depolarization of the interventricular septum
- R:** Early depolarization of the ventricles
- S:** Late depolarization of the ventricles
- T:** Repolarization of the ventricles
- U:** Often hidden by the T wave – this wave has an unknown origin

The graph above represents one complete heart beat from depolarization of the Sinoatrial Node to repolarization of the ventricles.

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The following graph is from a NeuLog ECG experiment.



Connecting to the ECG sensor:

The NeuLog electrocardiogram sensor uses three reusable clip leads for easy connection to the arms and legs. The heart's electrical fluctuations can be measured as a voltage signal appears between the left and the right arms.

This is a noisy signal and very difficult to measure. Instead, it is much better to use a reference electrode (usually connected to the left leg) and to measure the voltages of the left arm and the right arm in reference to this electrode and to amplify the difference between them. This is how it is done in NUL-218.

Leads:

- Black: Reference
- Red: Left
- Yellow: Right

The NUL-218 is completely isolated from electrical power and signal in order to prevent the effect of these on the test subject.

How to connect:

1. Connect the NeuLog ECG sensor to a smart device using one of the following guides (PC or Mac/Tablet/Viewer).
2. Wet the red clip and place it on the subject's left wrist with the metal connector on the underside (palm side) of the arm.
3. Wet the yellow clip and place it on the subject's right wrist with the metal connector on the underside (palm side) of the arm.
4. Wet the black clip and place it on the subject's left leg or forearm or elbow.
5. Connect the three alligator clips (red, yellow, black) directly to their corresponding arm clip's (red, yellow, black) metal piece that forms a loop.
6. You are now connected.

Note: There are other configurations possible, this is just one. If the R wave shows a downward slope instead of upward, your connection's polarization is reversed though the absolute results are still the same.

Quick start procedure:

PC or Mac Computer

Materials needed:

- NUL-218 ECG Sensor
- 3 NeuLog Reusable Clamp Leads
- USB-200 USB Module
- USB to mini USB cable (included with the USB-200 module)

Your ECG sensor needs to be connected to a USB-200 module. The USB-200 module then connects to a computer via a USB to mini-USB cable. Please note that you cannot plug the ECG sensor directly into the computer.

The browser based application can be downloaded for free at www.NeuLog.com as well as a full application user guide. Choose "Downloads" on the main menu and then choose "Software and Application".

Procedure:

1. Install the NeuLog application.
2. Connect the USB-200 module to the PC or Mac.
3. Connect the ECG sensor to the USB-200 module (they directly plug together). Please note that no calibration is required for this sensor.

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4. Open the NeuLog application by clicking on the shortcut on the screen.
5. Once an ECG sensor module box appears on the left side of the screen the probe has been automatically identified and you can begin experimentation.
6. If the ECG sensor is not automatically identified then click the "Search for sensors" icon to find the sensor.
7. Select the "On-line experiment" icon; this will open a graph below.
8. Click on the "Module setup" button located in the ECG sensor icon in the module window to change the sensor's settings if need be.
9. Click on the "Experiment setup" icon to change the experiment settings if need be (experiment duration for example).
10. The ECG sensor will give a live reading in the module box to the left of the screen while plugged in.
11. To run an experiment and collect data click the "Run experiment" icon.
12. To end data collection early, click the "Stop experiment" icon.

Tablet, smart phone device

Materials needed:

- NUL-218 ECG Sensor
- 3 NeuLog Reusable Clamp Leads
- WIFI-201 WIFI Module
- BAT-200 Battery Module

Your ECG sensor needs to be connected to a WIFI-201 module. The WIFI-201 module will create a closed NeuLog WiFi network which will stream the NeuLog data to a device of your choosing. Once your device is wirelessly connected to the NeuLog network, you can run experiments and collect data through a browser of your choosing.

Procedure:

1. Connect the ECG sensor directly to the left side of a WIFI-201 module (no wires required).
2. Connect a BAT-200 module to the right side of the WIFI-201 module.
3. Although not required, we recommend plugging the BAT-200 to an outlet using a USB to mini USB charger (such as a typical cell phone charger). The WIFI-201 module will run for 60-90 minutes (depending on the sensor) without being plugged in.
4. The WIFI-201 can be powered directly using a mini to USB cord and plugging it into your computer or a wall charger. Please note this function is only available on WIFI-201 modules with the USB icon on the cover.

5. For further WIFI-201 instructions or the WIFI-201 quick start guide please visit: www.NeuLog.com; Choose "Products" on the main menu, then choose "WiFi Communication module".
6. The WIFI-201 indicator lights will flash; take no action until the LED to the far left turns blue; this can take up to one minute.
7. Take your tablet or smart phone, go to the WiFi settings and select the NeuLog network (NeuLog0184 for example) which matches the ID found on the back of the WIFI-201 module (0184 for example).
8. Give your device about 20 seconds to connect to the WIFI-201.
9. Once the device is connected, go to your browser and type the website **wifi201.com** into the URL bar, then wait for 30-60 seconds.
10. You will see a "Control mode" icon in the application, click on it.
11. The application will then load a new screen and begin to auto detect the sensor(s); this can take a minute. (You can stop the search when the sensor is found.)
12. If the application does not auto detect the sensor(s), select "Search for sensors".
13. Once the sensor is found you will see a module box on the left side of the screen for the ECG sensor. In this box, real time data will be displayed.
14. Click on the "Module setup" button located in the ECG sensor module box to change the ECG probe settings if need be.
15. Click on the "Experiment setup" icon to change the experiment settings if need be (Experiment duration for example).
16. To run an experiment and collect data, click the "On-Line experiment" icon, then click the "Run experiment" icon.
17. If you have a newer generation WIFI-201 module (with the USB icon on the cover) this can be used as a USB-200, meaning you can tether the probes directly to the computer using the WIFI-201. To engage operation in this fashion, press 3 times on the panel button. Repeating this operation will return the module to WiFi mode.

Operation with NeuLog Graphic Display Module (viewer)

Materials needed:

- NUL-218 ECG Sensor
- 3 NeuLog Reusable Clamp Leads
- VIEW-101 Graphic Display Module
- BAT-200 Battery Module

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Procedure:

1. Connect the ECG sensor to the left side of the viewer.
2. Connect the BAT-200 module to the right side of the viewer.
3. The VIEW-101 will auto detect the sensor and you will see it appear on the left side of the screen.
4. Once the sensor appears it will be monitoring data in real time.
5. To run an experiment and collect data press the run icon (little green person).

Off-line experiments

(Off-line experiments are when you do not have a sensor connected directly to a computer, tablet, smartphone, or NeuLog viewer).

Materials needed:

- NUL-218 ECG Sensor
- 3 NeuLog Reusable Clamp Leads
- BAT-200 Battery Module

Materials needed to configure your offline experiment:

- USB-200 Module, WIFI-201 module or VIEW-101 Module
- USB to mini USB cable (included with the USB-200 module).

Procedure:

1. To determine the experiment settings, first connect to your chosen device (PC, Mac, tablet, smart device) and click on the "Off-line experiment" icon after the sensor search has ended. (For more information on how to change the experiment settings, view the quick start procedure section for your chosen device in this document.)
2. Connect the ECG sensor directly to the left side of a charged BAT-200 module.
3. When ready to collect data press the "Start/Stop" button on the ECG sensor, a red light will turn on for the duration of the experiment.
4. After the experiment has concluded (the "Start/Stop" button is pressed again or the data collection period ends) connect the sensor to your chosen device (you can find full instructions in each device's quick start procedure section).
5. Open the NeuLog application.
6. Click the "Off-line experiment" icon.

7. Click the "Load data from sensors" icon.
8. Select which experimental data to upload (5 experimental runs can be stored at one time on the NUL-218 ECG sensor).

Restoring sensor's factory default settings:

Procedure:

1. Connect the USB-200 to a PC, Mac, tablet, or smart device.
2. Connect the ECG sensor to a USB-200 module (they directly plug together).
3. Open the NeuLog application.
4. Click the "Tools" icon.
5. Click the "Restore sensor's factory defaults" on the menu.

Included with the sensor:

- NeuLog NUL-218 ECG Sensor Guide (this document)
- NeuLog ECG probe with three alligator clips for easy connection to clamp leads
- Three ECG clamp leads (red, yellow, black)

Sensor's specifications	
Range and operation modes	0 to 4092 Arbitrary units
ADC resolution	12 bit
Resolution	1
Max sample rate (S/sec)	100

Experiment Duration: 1 seconds to 31 days.

Sensor's features:

- Fully digital data
 - Rugged plastic ergonomic case
 - Push button switch for Start/Stop experiments in off line mode
 - LED indicator of experiment status (blinks while collecting data)
 - ECG probe attached to the sensor's body by a durable rubber-coated wire with three alligator clip ends
 - Pre-calibrated sensing equipment
- Note:** NeuLog products are intended for educational use.

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Videos and experiment examples:

- Videos, literature and other probes can be found at www.NeuLog.com.
- In order to access the electrocardiogram sensor's page, choose "Products" on the main menu and then "Electrocardiogram logger sensor".
- In order to find the science experiments, choose "Experiments" on the main menu of the NeuLog website, then choose "Physics", "Chemistry", "Biology" or "Environmental Science".
- Biology Experiment:
 - Electrocardiogram Measurement (B-40)

Technical background:

The philosophy behind NeuLog's plug and play technology is based on each sensor's ability to store its own data due to an internal flash memory chip and micro-controller in each plastic NeuLog body. This technology allows the sensor to collect and then store the digital data in the correct scientific units ($^{\circ}\text{C}$, $^{\circ}\text{F}$, Lux, %, ppm, for example).

The sensor is pre-calibrated at the factory. The built-in software in the logger can be upgraded for free at any time using the provided firmware update.

The ECG sensor detects minor changes in electrical voltage which originate in the heart and spread out across the body over a very short period of time. Cells have a resting potential of about 0.9 mV. A heart beat originates from an electrical impulse in the Sinoatrial Node, often called the natural pacemaker. The electrical potential cascade spreads across the heart. Using three leads (left, right and reference) the heart's electrical voltages (which originate in the heart) are measured.

Although the NeuLog ECG sensor is not aimed for medical measurements, it is built as an ECG real device.

One important feature is complete electrical isolation from the USB and the computer to which it is connected.

The power supply is isolated and transferred by transformers.

The signals are converted and transmitted by optical couplers.

Maintenance and storage:

- Never submerge the NeuLog plastic body in any liquid.
- Do not allow liquid into the ECG sensor's body.
- After use, gently wipe away any foreign material from the ECG sensor.
- Store in a box at room temperature out of direct sunlight.

Warranty:

We promise to deliver our sensor free of defects in materials and workmanship. The warranty is for a period of 3 years from the date of purchase and does not cover damage of the product caused by improper use, abuse, or incorrect storage. Sensors with a shelf life such as ion selective probes have a warranty of 1 year. Should you need to act upon the warranty, please contact your distributor. Your sensor will be repaired or replaced.

Thank you for using NeuLog!



Flexible, simple, fast, forward thinking.

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