

Sensing your
data logging needs



Fourier Sensors

A large variety of external sensors for data collection systems, to conduct almost any experiment in Biology, Physics, Chemistry and Environmental Sciences



User Guide

Put the world of scientific data at the fingertips of your students

The Fourier Sensors Guide

Fourier Systems

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Acceleration

DT138

Type:
Accelerometer

Range:
 $\pm 5g$ ($\pm 49m/s^2$)

Sensor description

The DT138 is a high performance, high accuracy accelerometer. The DT138 measures accelerations from $-49m/s^2$ to $+49m/s^2$. The sensor measures gravitational forces and acceleration-induced forces in the same way. At rest the sensor measures 1g when pointing downward, -1g when pointing upward and zero when positioned horizontally.



How it works

The DT138 uses a mass suspended by two springs lying on the sensor's axis. The mass can move in this axis only. The deflection of the mass is measured with a capacitor that consists of two fixed plates and one central plate attached to the moving mass. Acceleration will unbalance the capacitor, resulting in an output voltage that is proportional to the acceleration.

Calibration

The DT138 ships fully calibrated. No further calibration is needed.

Selecting units:

Multilab displays the data in multiples of g. to change the acceleration units to m/s^2 :

1. Click **Setup Wizard**



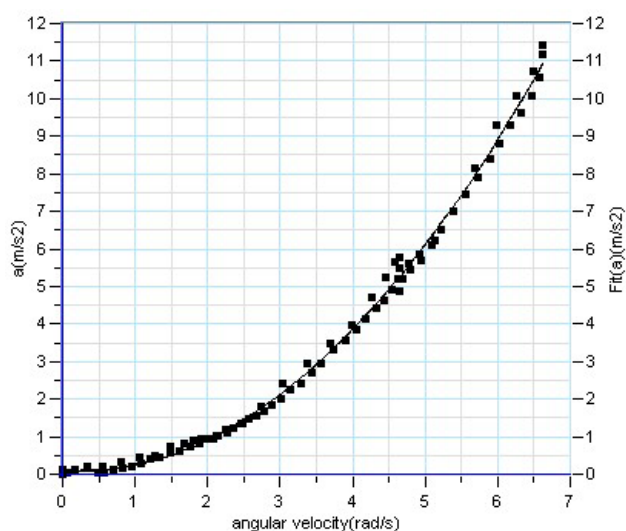
on the main toolbar

2. Click **Properties**



next to the acceleration sensor input

3. Check the checkbox next to the desired unit to select it.
4. Click **OK**



A measurement of radial acceleration vs. angular velocity

What it is used for

The DT138 is used in various experiments in Physics both in the lab and outdoors. In the laboratory, the DT138 is used to measure accelerations of

moving cart, pendulum, falling bodies, etc. Outdoors, the DT138 is used to measure accelerations of cars, amusement park apparatus, bungee jumpers, etc.

Specifications:

- Range: $\pm 5g$ ($\pm 49\text{m/s}^2$)
- 12-bit Resolution (TriLog): $0.0025g$ (0.025 m/s^2)
- 10-bit Resolution (MultiLogPRO, MultiLog): $0.01g$ (0.1 m/s^2)
- Bandwidth: 10kHz

Ammonium selective AC020A

Type: Ion Selective Electrode	Range: 1 M to 5×10^{-6} M (180,000 – 0.1 ppm)
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Sensor description

The AC020A Ion Selective Sensor is used for fast, reliable and accurate measurement of Ammonium concentration in aqueous solutions. The AC020A consists of FastFil Ammonium selective combination electrode (it combines the Ion Selective electrode and the reference electrode in one) and Fourier's ISE amplifier/adaptor.



How it works

The Ion Selective Electrode (ISE) uses an ion selective membrane to allow only NH_4^+ ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the Ammonium ion according with the Nernst equation:

$$E = E_0 + S \cdot \ln(a)$$

Where E is the measured voltage, E_0 the reference potential, S – the slope and a is the Ammonium activity.
The slope is given by:

$$S = \frac{RT}{nF}$$

Where R is the gas constant, T the temperature in Kelvin, n – charge of the ion and F is Faraday constant.
If the ionic strength is high and constant, Nernst equation can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where C is the Ionic concentration

To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.

The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids

in making electrical contact between the reference electrode (which is not in physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

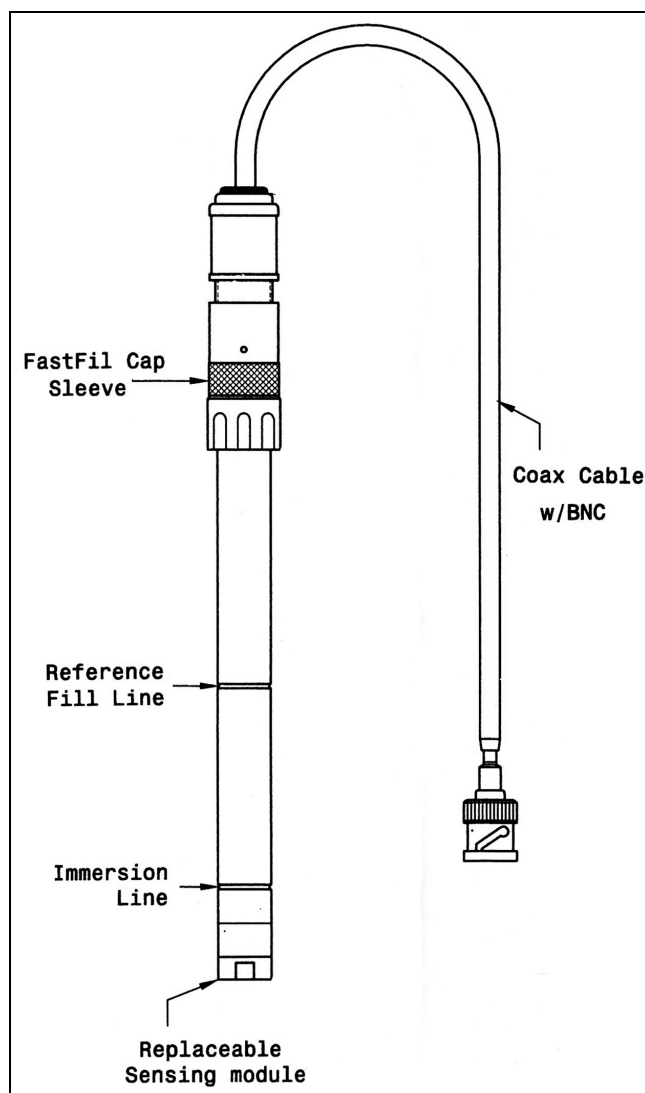


Figure 1: AC020 NH_4^+ Ion Selective Electrode

Items included

- Combination NH_4^+ Electrode housing
- NH_4^+ Sensing Module
- 1 oz. NH_4^+ Reference Filling Solution (RF0012)
- 1 oz. NH_4^+ Ionic Strength Adjuster (ISA) (AJ0015)
- 1 oz. NH_4^+ 10ppm as N Standard (SD2052)
- 1 oz. NH_4^+ 1000ppm as N Standard (SD2002)

Required Equipment

- MultiLogPRO or TriLog
- Wash bottle with distilled or deionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation

1. The AC020 sensing element comes premounted on the end of the electrode with a protective bottle, but can be removed by unscrewing the electrode end. **Caution: Do not touch the PVC membrane with your fingers or over tighten the sensing element** (see Figure 4)
2. The reference chamber must be filled with Reference Fill Solution and remain open during testing and measuring:
 - a. Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 2)
 - b. Fill the reference chamber with the Reference Fill Solution provided above the reference fill line on the electrode (see Figure 1)
3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside
4. Rinse the electrode with DI water, blot dry. **Do not rub dry**
5. Condition the electrode in a 10ppm solution for 30 minutes
6. After the conditioning period, rinse the tip of the electrode with DI water

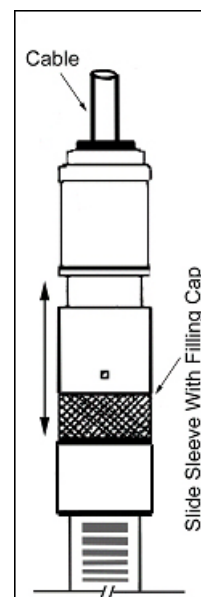


Figure 2: Reference Fill Cap

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

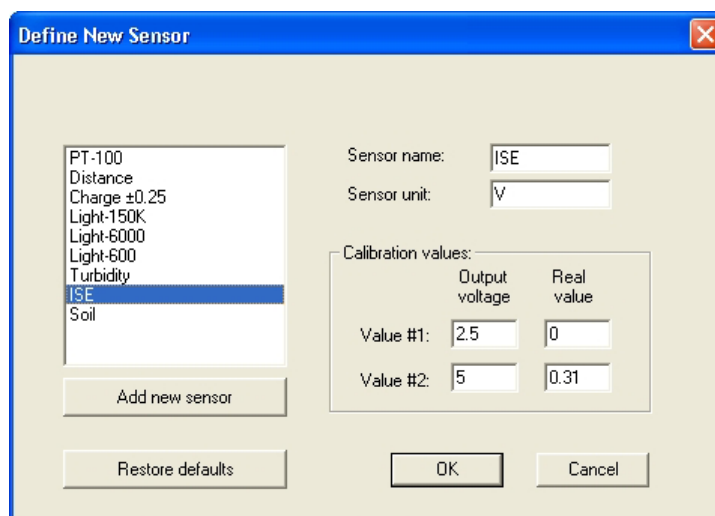


Figure 3: ISE sensor definition

you should see **ISE** on the sensors list (the eighth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **ISE** on the sensor list, click **Restore defaults**. If you still don't see **ISE** go to Fourier's Web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to the MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 3 to define the sensor manually.

Checking Electrode Operation (Slope)

Check the electrode every day when measurements are conducted

1. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly
3. Begin recording
4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2
5. Pipette 1 mL of 1000 ppm Ammonium Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed
6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs
7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope. The normal range for the slope is 56 ± 4 mV at 25°C

Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use
2. Repeat "Checking Electrode Operation" procedure again

Note: All standard solutions should be prepared fresh. Use ISA in all solutions.

Periodically check the Reference Fill Solution level in the reference chamber. The solution level must be above than the reference fill line (see Figure 1)

If the electrode slope is still outside the normal range after this procedure, replace the sensing module

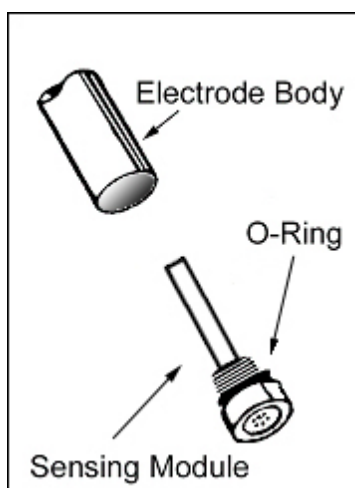


Figure 4: replacing the Sensing Module

Reading a Sample with the Electrode

Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.

ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.

Calibrate once a day before measurements.

The filling hole must remain open during measurements (see Figure 2).

Set up:

1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample

Measurement:

1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir
4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard

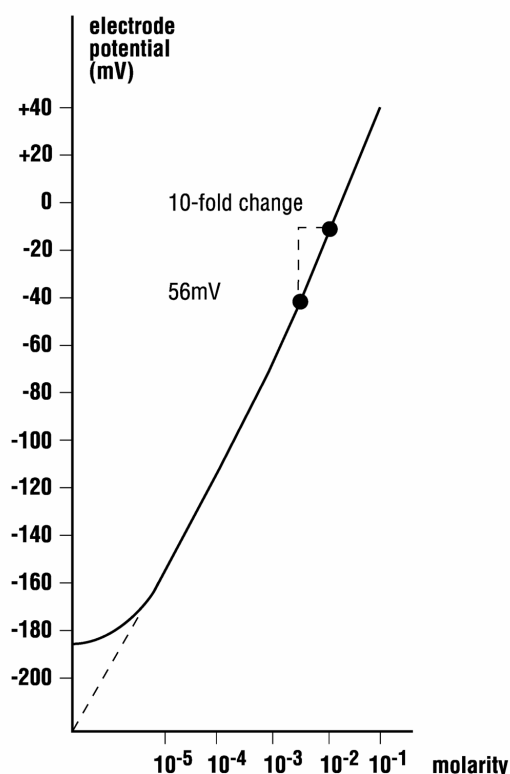


Figure 5: Typical calibration curve

5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 5 for a typical calibration curve
6. Pipette 100 mL of sample into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
7. Rinse electrode with DI water, blot dry and place in the sample beaker. Wait for a stable reading and record the voltage reading
8. Use the calibration curve to determine the sample's concentration

Electrode Storage

Short Term:

Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry.

We recommend a cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:

Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.

Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

What it is used for

Ion-selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which ISEs have been used:

Pollution Monitoring: CN, F, S, Cl, NO₃ etc., in effluents, and natural waters.

Agriculture: NO₃, Cl, NH₄, K, Ca, I, CN in soils, plant material, fertilizers and feedstuffs.

Food Processing: NO₃, NO₂ in meat preservatives.

Salt content of meat, fish, dairy products, fruit juices, brewing solutions

F in drinking water and other drinks

Ca in dairy products and beer

K in fruit juices and wine making

Corrosive effect of NO₃ in canned foods

Detergent Manufacture: Ca, Ba, F for studying effects on water quality.

Paper Manufacture: S and Cl in pulping and recovery-cycle liquors.

Explosives: F, Cl, NO₃ in explosive materials and combustion products.

Electroplating: F and Cl in etching baths; S in anodising baths.

Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat).

F in skeletal and dental studies

Education and Research: Wide range of applications.

Specifications:

- Range: 1 M to 5×10^{-6} M
(18,000 – 0.1 ppm)
- 12-bit Resolution (TriLog): 0.15mV
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.6mV
- pH Range: 4 to 10 pH
- Temperature Range: 0 to 50°C
- Electrode Resistance: 1 to 4MΩ
- Reproducibility: ±4%
- Minimum Sample Size: 3 mL in a 50 mL beaker
- Interfering Ions: K⁺, Na⁺

Solutions

- 1000ppm NH₄⁺ (0.0554 M NH₄⁺):
Dissolve 2.965g NH₄Cl in DI water and dilute
to 1000mL
- ISA 1M NaCl: 58.443g NaCl in 1000mL DI water
- Reference (0.1M NaCl): 29.22g NaCl in 1000mL DI water

Ordering information

ISE amplifier & electrode set	AC020A
ISE amplifier only	AC021
Electrode only	AC020

Anemometer

AC012

Type: Anemometer (Wind speed and wind direction)	Range: Speed: 0 – 240km/h Direction: 0 – 360°
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Sensor description

The AC012 is actually two sensors mounted on one arm. The wind caps are used to measure wind speed and the wind vane measures the wind direction. Only one cable connects the Anemometer to the Data logger.

The Anemometer can work at sampling rates up to one per second.



Connections

To connect the Anemometer to the Data logger, use the splitter cable (DT011). Connect the common end to the wind sensor and the two split ends to the MultiLog inputs. The splitter cable output marked with $\uparrow\downarrow$ carries the wind speed signal and the splitter cable output marked with **S** is the wind direction sensor.

Note: MultiLogPRO cannot automatically identify the Anemometer and must be in 8 sensors mode.

How it works

Wind direction:

The wind vane is mounted on a potentiometer that can revolve indefinitely resulting in an output voltage that corresponds to the vane direction.

Wind speed:

The wind cups spin with the wind. A small magnet is attached to the cups axis and produces a pulse every rotation. The Data logger counts the pulses and calculates the wind velocity.

Calibration

The DT012 ships fully calibrated. No further calibration is needed.

What it is used for

The DT012 is used in various experiments in Climatology and Environmental Studies. The Anemometer enables you to measure wind speed and wind direction.

Specifications:

Wind speed:

- Range: 0 – 240km/h
- Resolution: 1km/h
- Sampling rate: up to 1/s

Wind direction:

- Range: 0 – 360°
- 12-bit Resolution (TriLog): 0.1°
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.4°
- Sampling rate: up to 1/s

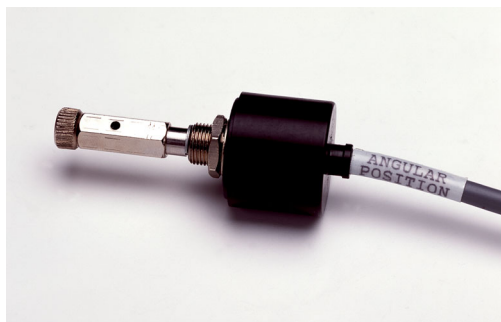
Angular Position

DT031

Type: Angular Position	Range: 0 to 360 Deg.
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Sensor description

The DT031 is a sensor designed to measure changes in angular positions of items connected at its handle. The DT031 consists of a hexagonal handle with a connection screw (for comfortable connection of items), the base of the sensor, and a 20cm connection cable.



How it works

The DT031 is a free-spinning, low friction potentiometer, with an angular range of 0°-360°. When the handle of the sensor turns, the output of the sensor changes from 0 to 5 Volts, a voltage accepted by the analog-digital converter of the Data-Logger. The sensor's output increases, as the handle is turned counter-clockwise.

Defining the sensor:

In the Define new sensor dialog box enter the values shown in the figure below:

Sensor name:	angle	
Sensor unit:	deg	
Calibration values:		
	Output voltage	Real value
Value #1:	0	0
Value #2:	5	360

To learn how to define new sensors please refer to MultiLab user guide or MultiLab help.

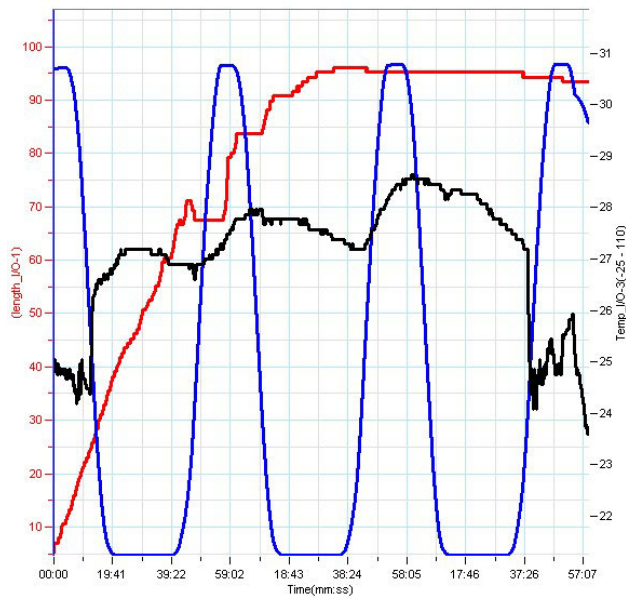
Note: MultiLogPRO cannot automatically identify the Angular position sensor and must first be in 8 sensors mode.
--

Calibration

The DT001 ships fully calibrated. No further calibration is needed.

What it is used for

The DT031 is used in various experiments in Biology and Physics. In Biology, the DT031 is used to measure plant growth and changes in the bending of plants towards light. In Physics, the DT031 is used for measurements such as the motion of a pendulum.



Monitoring plant growth

Specifications:

- Range: 0 - 360 degrees.
- Mechanic rotations: Infinite.
- 12-bit Resolution (IP-eX): 0.08 Degree
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.33 Degree
- Linearity: $\pm 1\%$ over entire range

Breathing

DT037

Type: Spirometer

Range: ± 315 L/min

Sensor description

The DT037 is a breathing sensor. Based on air speed, the DT037 calculates the airflow rate of a user who breathes into it. The results are shown as liters per minute. The DT037 consists of Fourier's egg-shaped sensor case with a unique breath sensor tube.



How it works

The DT037 is based on an extremely sensitive pressure sensor and a unique breath sensor tube. Inside this tube is a small disc, narrowing the middle of the tube. When air travels through the tube, pressure is created on one side of the disc and a vacuum on the other side. The pressure sensor senses this pressure and subsequently the output voltage changes. The analog-digital converter of the logger translates the voltage to the proper results accordingly. Note that when air travels through the tube in the opposite direction, the sensor will measure a negative value.

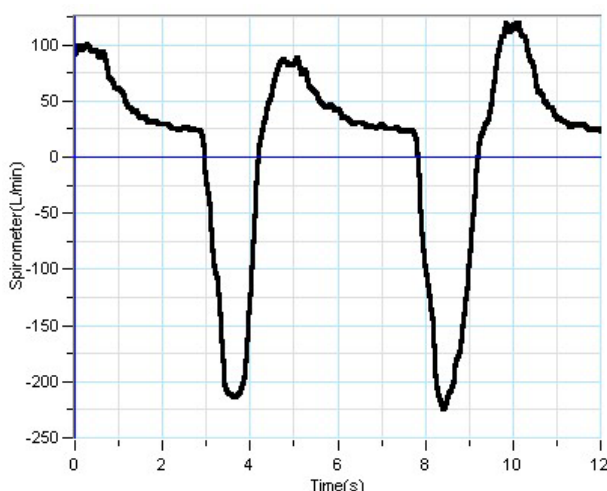
Calibration

The DT037 ships fully calibrated. No further calibration is required.

What is it used for:

The breath sensor is used to measure the volume of air in the lungs. It is used for both academic and professional applications. The following graph is a measurement of breath using the DT037 sensor.

By "Integrating" (one of the **MultiLab** processing functions), one can calculate the user's lung capacity.



A breath measurement using the DT037

Specifications:

- Range: -315 to 315 L/min
- 12-bit Resolution (TriLog): 0.175 L/min
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.7 L/min
- Linearity: 1% FS

Calcium selective

AC019A

Type: Ion selective electrode	Range: 1 M to 5×10^{-7} M (40,000 – 0.02 ppm)
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Sensor description

The AC019A Ion Selective Sensor is used for fast, reliable and accurate measurement of Calcium concentration in aqueous solutions. The AC019A consists of FastFill Calcium selective combination electrode (it combines the Ion Selective electrode and the reference electrode in one) and Fourier's ISE amplifier/adaptor.



How it works

The Ion Selective Electrode (ISE) uses an ion selective membrane to allow only Ca^{++} ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the calcium ion according with the Nernst equation:

$$E = E_0 + S \cdot \ln(a)$$

Where E is the measured voltage, E_0 the reference potential, S – the slope and a is the Calcium activity. The slope is given by:

$$S = \frac{RT}{nF}$$

Where R is the gas constant, T the temperature in Kelvin, n – charge of the ion and F is Faraday constant.

If the ionic strength is high and constant, Nernst equation can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where C is the Ionic concentration

To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.

The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids

in making electrical contact between the reference electrode (which is not in physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

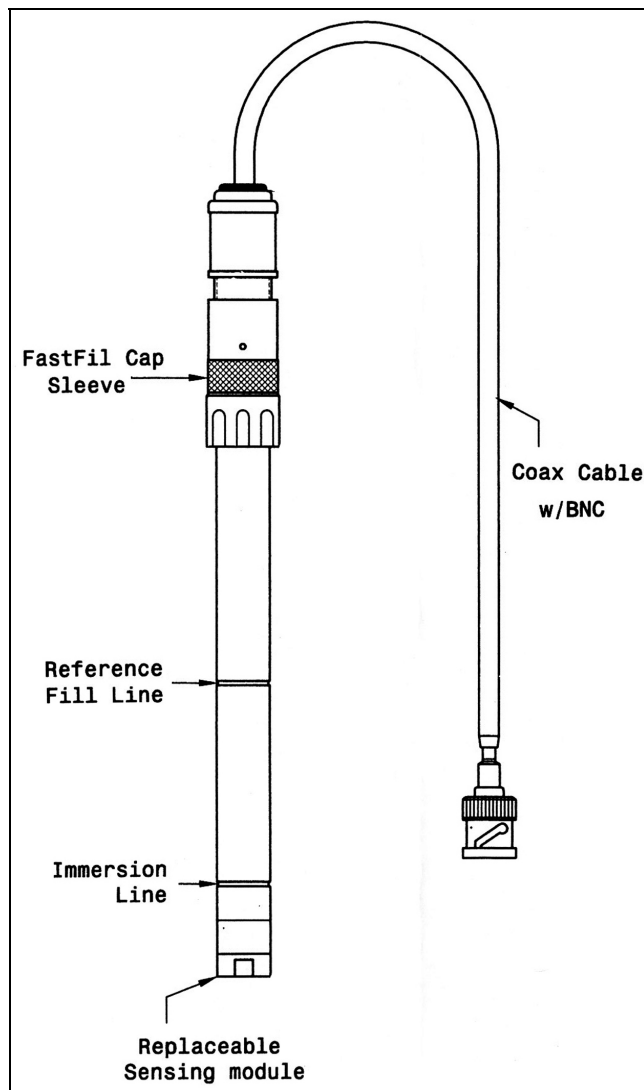


Figure 1: AC019 Ca⁺⁺ Ion Selective Electrode

Items included

- (1) Combination Ca⁺⁺ Electrode
- (1) ISE amplifier
- (1) 1 oz Ca⁺⁺ Reference Filling Solution (RF0005)
- (1) 1 oz Ca⁺⁺ Ionic Strength Adjuster (ISA) (AJ0004)
- (1) 1 oz Ca⁺⁺ 10ppm as Ca Standard (SD2054)
- (1) 1 oz Ca⁺⁺ 1000ppm as Ca Standard (SD2008)

Required Equipment

- MultiLogPRO or TriLog
- Wash bottle with distilled or deionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation

1. The AC019 sensing element comes premounted on the end of the electrode with a protective bottle, but can be removed by unscrewing the electrode end. **Caution: Do not touch the PVC membrane with your fingers or over tighten the sensing element** (see Figure 4)
2. The reference chamber must be filled with Reference Fill Solution and remain open during testing and measuring:
 - a. Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 2)
 - b. Fill the reference chamber with the Reference Fill Solution provided above the reference fill line on the electrode (see Figure 1)
3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside
4. Rinse the electrode with DI water, blot dry. **Do not rub dry**
5. Condition the electrode in a 10ppm solution for 30 minutes
6. After the conditioning period, rinse the tip of the electrode with DI water

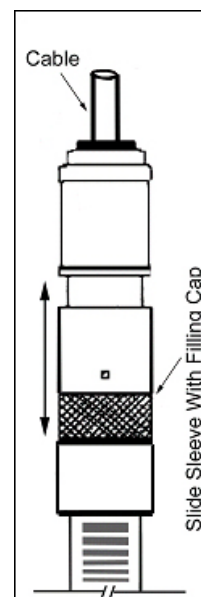


Figure 2: Reference Fill Cap

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

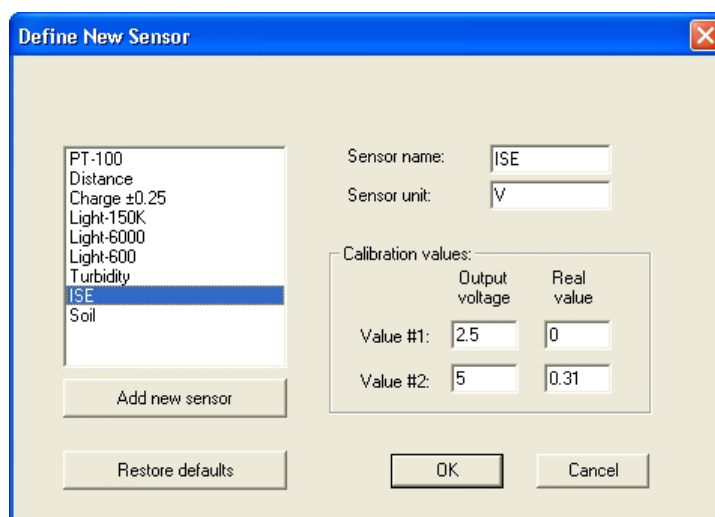


Figure 3: ISE sensor definition

you should see **ISE** on the sensors list (the eighth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **ISE** on the sensor list, click **Restore defaults**. If you still don't see **ISE** go to Fourier's web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 3 to define the sensor manually.

Checking Electrode Operation (Slope)

Check the electrode every day when measurements will be conducted

1. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly
3. Begin recording
4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2
5. Pipette 1 mL of 1000 ppm Calcium Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed
6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs
7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope. The normal range for the slope is 28 ± 2 mV at 25°C

Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use.
2. Repeat "Checking Electrode Operation" procedure again

Note: All standard solutions should be prepared fresh. Use ISA in all solutions.

Periodically check the Reference Fill Solution level in the reference chamber. The solution level must be above than the reference fill line (see Figure 1).

If the electrode slope is still outside the normal range after this procedure, replace the sensing module.

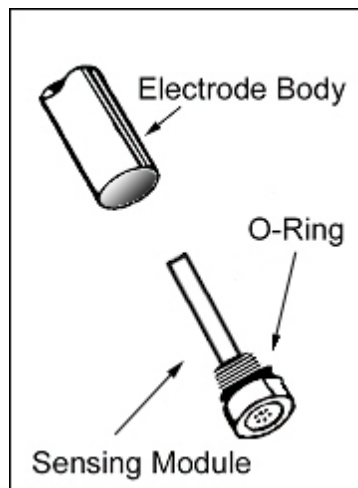


Figure 4: replacing the Sensing Module

Reading a Sample with the Electrode

Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.

ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.

Calibrate once a day before measurements.

The filling hole must remain open during measurements (see Figure 2).

Set up:

1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample

Measurement:

1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir

4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard
5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 5 for a typical calibration curve

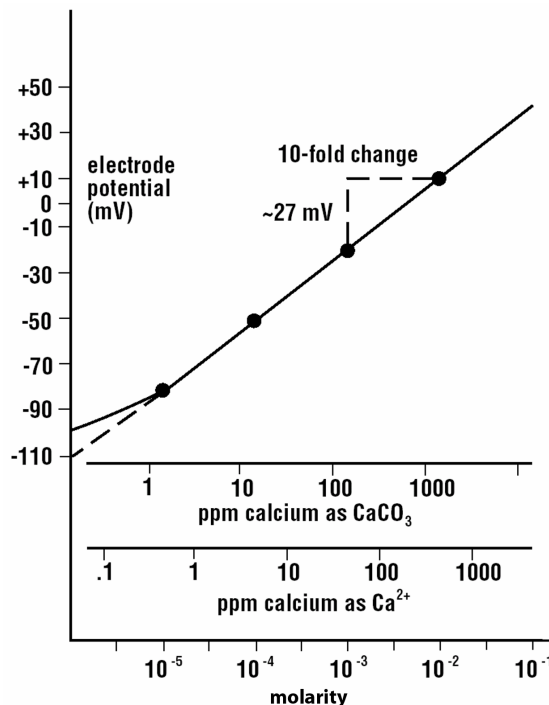


Figure 5: Typical calibration curve

6. Pipette 100 mL of sample into a 150 mL beaker. Add 2 mL of ISA. Stir thoroughly
7. Rinse electrode with DI water, blot dry and place in the sample beaker. Wait for a stable reading and record the voltage reading
8. Use the calibration curve to determine the sample's concentration

Electrode Storage

Short Term:

Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry.

We recommend a cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:

Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.

Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

What it is used for

Ion-selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which ISEs have been used:

Pollution Monitoring: CN, F, S, Cl, NO₃ etc., in effluents, and natural waters.

Agriculture: NO₃, Cl, NH₄, K, Ca, I, CN in soils, plant material, fertilizers and feedstuffs.

Food Processing: NO₃, NO₂ in meat preservatives.

Salt content of meat, fish, dairy products, fruit juices, brewing solutions

F in drinking water and other drinks

Ca in dairy products and beer

K in fruit juices and wine making

Corrosive effect of NO₃ in canned foods

Detergent Manufacture: Ca, Ba, F for studying effects on water quality.

Paper Manufacture: S and Cl in pulping and recovery-cycle liquors.

Explosives: F, Cl, NO₃ in explosive materials and combustion products.

Electroplating: F and Cl in etching baths; S in anodising baths.

Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat).

F in skeletal and dental studies

Education and Research: Wide range of applications.

Specifications:

- Range: 1 M to 5 x 10⁻⁷ M
(40,000 – 0.02 ppm)
- 12-bit Resolution (TriLog): 0.15mV
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.6mV
- pH Range: 2.5 to 11 pH
- Temperature Range: 0 to 40°C
- Electrode Resistance: 1 to 4MΩ
- Reproducibility: ±4%
- Minimum Sample Size: 3 mL in a 50 mL beaker
- Interfering Ions: Pb²⁺, Hg²⁺, Si²⁺, Fe²⁺, Cu²⁺, Ni²⁺, NH₃,
Na⁺, Li⁺, Tris⁺, K⁺, Ba⁺, Zn²⁺, Mg²⁺

Solutions

- 1000ppm Ca (0.249 M Ca): Dissolve 3.668g CaCl₂·2H₂O in DI water
and dilute to 1000mL
- ISA 4M KCl: 300g KCl in 1000mL DI water
- Reference (1M KNO₃): 100g KNO₃ in 1000mL DI water

Ordering information

ISE amplifier & electrode set	AC019A
ISE amplifier only	AC021
Electrode only	AC019

Charge

DT261A

Type: Charge	Dual Range: $\pm 0.25\mu\text{C}$, $\pm 0.025\mu\text{C}$
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Sensor description

The sensor is a dual range, all purpose charge sensor that can be used in many electrostatic experiments. It will replace the traditional electroscope in most cases and has the advantages of performing quantitative measurements and indication of charge polarity. DT261A is equipped with zero button and range switch.

How it works

The charge sensor is a voltage amplifier with very high input resistance ($10^{12}\Omega$). A capacitor is connected to the amplifier input. The applied charge charges the input capacitor, resulting in a voltage drop across it. The voltage is amplified and adjusted to the range of 0-5 volts, which is the range accepted by the Analog-Digital converter. The proper result is then recorded and stored in the data logger's memory. The sensor is equipped with buffer units, protecting the sensor from voltages of up to ± 60 Volts.

Due to the sensor's high sensitivity, it is recommended to use a shielded BNC/alligator cable connecting the sensor to the charge under test.

Before every measurement discharge the input capacitor with the zero button.

What it is used for

The charge sensor is designed for most electrostatic experiments in physics Labs like demonstrating charge by induction and exploring the characteristics of a parallel plate capacitor.

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:



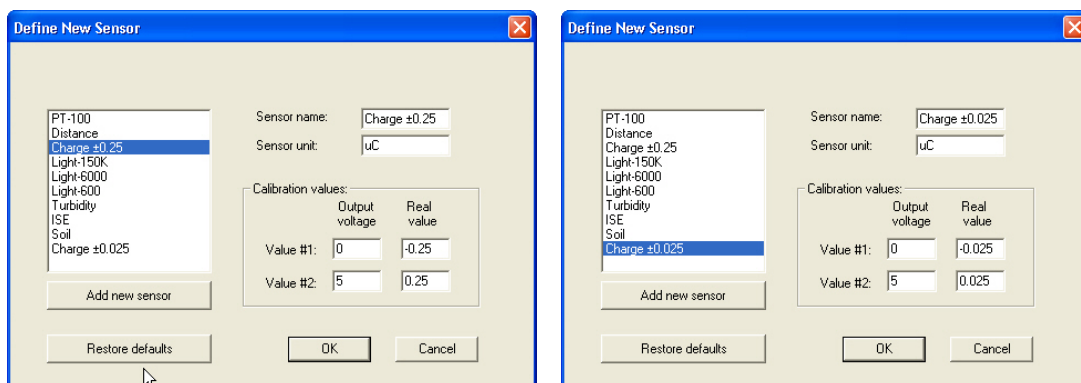


Figure 1: Charge sensor definition

You should see **Charge** on the sensors list (the third and the tenth item on the list)

5. Click **OK**

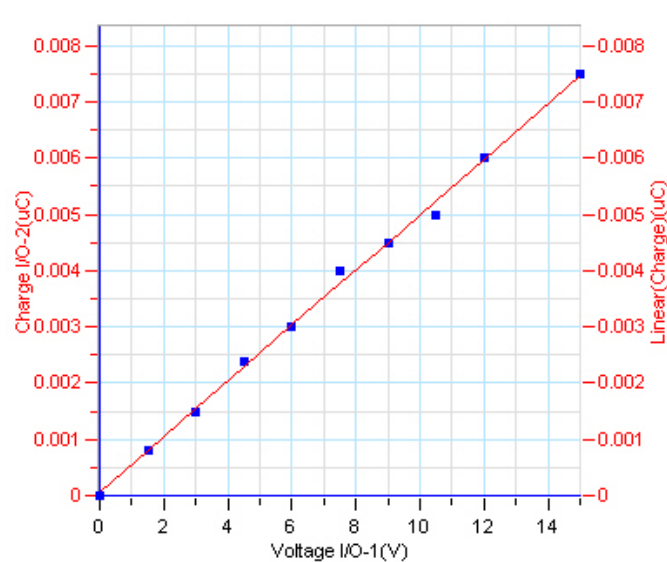
MultiLab will update the defined sensor in your data logger.

If you fail to see **Charge** on the sensor list, click **Restore defaults**. If you still don't see **Charge** go to Fourier's web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 1 to define the sensor manually.

Calibration

The charge sensor requires no calibration.



exploring the relation between the charge and the voltage drop across a parallel plate capacitor

Specifications:

Range: $\pm 0.25 \mu\text{C}$
 12-bit Resolution
 (TriLog): 0.06 nC
 10-bit Resolution
 (MultiLog Pro,
 MultiLog): 0.24 nC
 Range: $\pm 0.025 \mu\text{C}$
 12-bit Resolution
 (TriLog): 6.25 pC
 10-bit Resolution
 (MultiLog Pro,
 MultiLog): 25 pC
 Input capacitance:
 $0.1 \mu\text{F}$
 Input Resistance: $10^{12} \Omega$
 Input over voltage
 protection: $\pm 60 \text{ VDC}$

Ordering information

Charge sensor & cable

DT261A

Charge sensor only

DT261

BNC coaxial cable only

DT229

Chloride selective

AC018A

Type: Ion selective electrode	Range: 1 M to 5×10^{-6} M (35,000 – 1.8 ppm)
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Sensor description

The AC018A Ion Selective Sensor is used for fast, reliable and accurate measurement of Chloride concentration in aqueous solutions. The AC018A consist of FastFil Chloride selective combination electrode (it combines the Ion Selective electrode and the reference electrode in one) and Fourier's ISE amplifier/adaptor.



How it works

The Ion Selective Electrode (ISE) uses ion selective membrane to allow only Cl^- ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the Chloride ion according with the Nernst equation:

$$E = E_0 + S \cdot \ln(a)$$

Wher E is the measured voltage, E_0 the reference potential, S – the slope and a is the Chloride activity.

The slope is given by:

$$S = \frac{RT}{nF}$$

Where R is the gas constant, T the temperature in Kelvin, n – charge of the ion and F is Faraday constant.

If the ionic strength is high and constant, Nernst equatin can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where C is the Ionic concentration

To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.

The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids in making electrical contact between the reference electrode (which is not in

physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

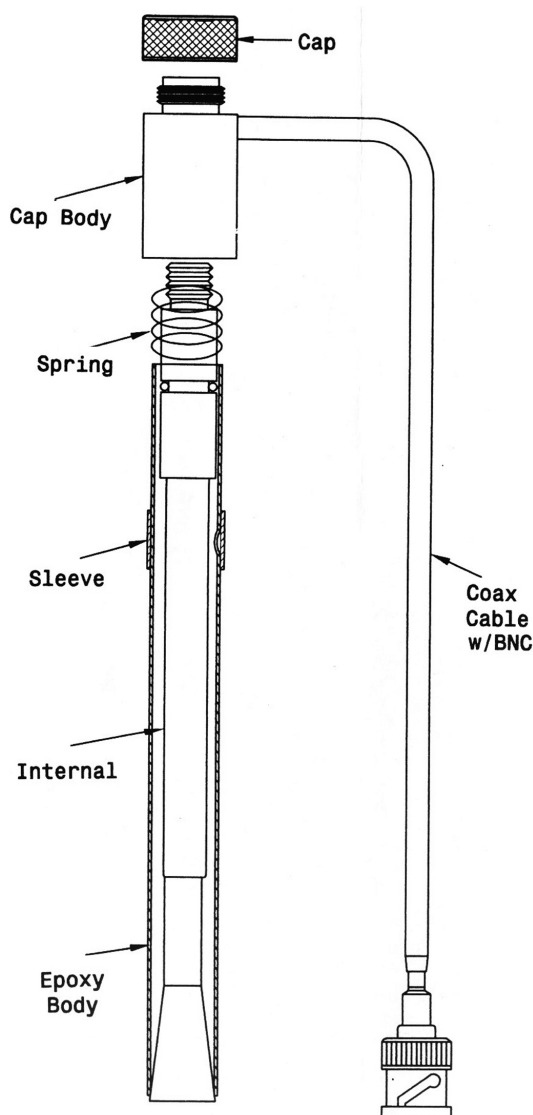


Figure 1: AC018 Cl⁻ Ion Selective Electrode

Items included

- (1) Combination Cl⁻ Electrode
- (1) ISE amplifier
- (1) 1 oz Cl⁻ Reference Filling Solution (RF0007)
- (1) 1 oz Cl⁻ Ionic Strength Adjuster (ISA) (AJ0013)
- (1) 1 oz Cl⁻ 10ppm as Ca Standard (SD2053)
- (1) 1 oz Cl⁻ 1000ppm as Ca Standard (SD2012)

Required Equipment

- MultiLogPRO or TriLog
- Wash bottle with distilled or deionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation

1. The AC018 reference chamber should arrive dry
2. The reference chamber must be filled with Reference Fill Solution and remain open during testing:
 - a. Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 1)
 - b. Fill the reference chamber with the Reference Fill Solution provided level with the fill hole on the electrode (minimum of 3 inches from the sensing element (see Figure 1))
3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside
4. Rinse the electrode with DI water, blot dry. Do not rub dry
5. Condition the electrode in the provided 10ppm solution for 30 minutes
6. After the conditioning period, rinse the tip of the electrode with DI water

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

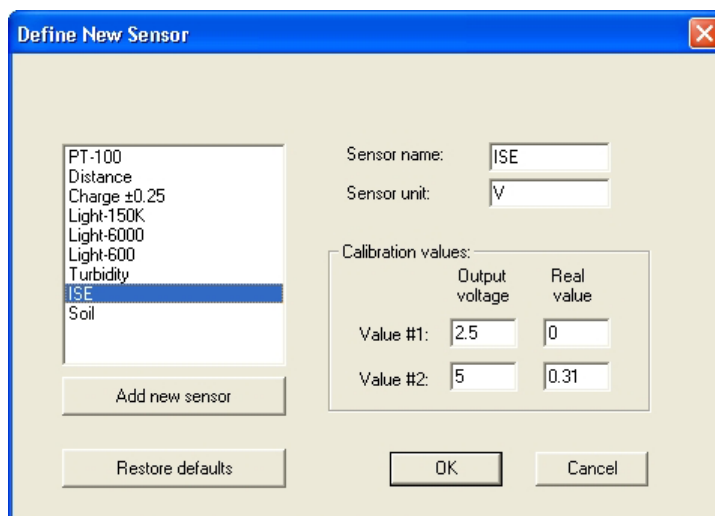


Figure 2: ISE sensor definition

you should see **ISE** on the sensors list (the eighth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **ISE** on the sensor list, click **Restore defaults**. If you still don't see **ISE** go to Fourier's web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 2 to define the sensor manually.

Checking Electrode Operation (Slope)

Check the electrode every day when measurements will be conducted

1. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly
3. Begin recording
4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2
5. Pipette 1 mL of 1000 ppm Chloride Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed
6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs
7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope. The normal range for the slope is 56 ± 4 mV at 25°C

Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use
2. Repeat "Checking Electrode Operation" procedure again

Note: All standard solutions should be prepared fresh. Use ISA in all solutions.

3. If the electrode is still outside of normal range, continue with step 4
4. Press down on the electrode cap and release all of the reference filling solution, unscrew the sensor cap, remove the electrode cap housing, pull the spring up the cable, push gently on the internal sensor and clean all components with DI water (see Figure 1)
5. Polish the end of the sensing element with the polish cloth provided. Gently stoke the sensing element until a glossy finish is produced. Rinse with DI water
6. Reassemble the electrode and fill with fresh reference filling solution
7. Repeat "Checking the Electrode Operation" procedure again

Periodically check the Reference Fill Solution level in the reference chamber. The solution level must be above than the reference fill line (see Figure 1).

If the electrode slope is still outside the normal range after this procedure, replace the sensing module.

Reading a Sample with the Electrode

Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.

ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.

Calibrate once a day before measurements.

The filling hole must remain open during measurements.

Set up:

1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample

Measurement:

1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA. Stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir
4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard
5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 3 for a typical calibration curve

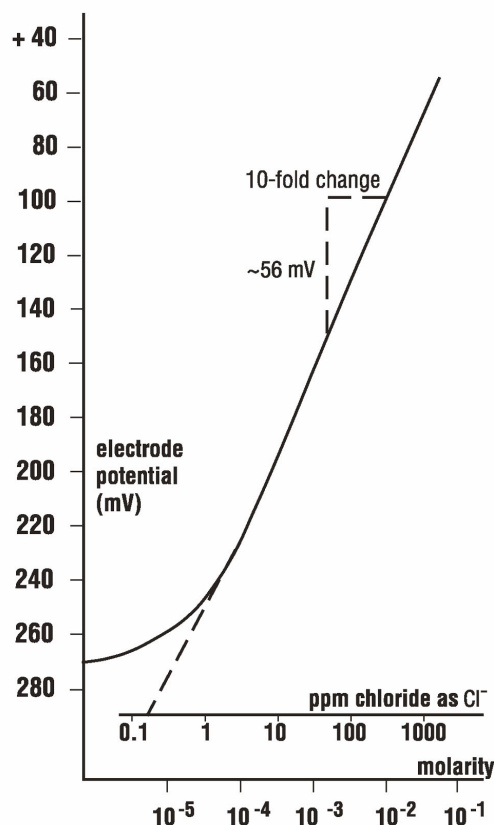


Figure 3: Typical calibration curve

6. Pipette 100 mL of sample into a 150 mL beaker. Add 2 mL of ISA. Stir thoroughly
7. Rinse electrode with DI water, blot dry and place in the sample beaker. Wait for a stable reading and record the voltage reading
8. Use the calibration curve to determine the sample's concentration

Electrode Storage

Short Term:

Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry.

We recommend a cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:

Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.

Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

What it is used for

Ion-selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which ISEs have been used:

Pollution Monitoring: CN, F, S, Cl, NO₃ etc., in effluents, and natural waters.

Agriculture: NO₃, Cl, NH₄, K, Ca, I, CN in soils, plant material, fertilizers and feedstuffs.

Food Processing: NO₃, NO₂ in meat preservatives.

Salt content of meat, fish, dairy products, fruit juices, brewing solutions

F in drinking water and other drinks

Ca in dairy products and beer

K in fruit juices and wine making

Corrosive effect of NO₃ in canned foods

Detergent Manufacture: Ca, Ba, F for studying effects on water quality.

Paper Manufacture: S and Cl in pulping and recovery-cycle liquors.

Explosives: F, Cl, NO₃ in explosive materials and combustion products.

Electroplating: F and Cl in etching baths; S in anodising baths.

Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat).

F in skeletal and dental studies

Education and Research: Wide range of applications.

Specifications:

- Range: 1 M to 5×10^{-6} M
(35,000 – 1.8 ppm)
- 12-bit Resolution (TriLog): 0.15mV
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.6mV
- pH Range: 2.0 to 12 pH
- Temperature Range: 0 to 80°C
- Electrode Resistance: less than 1 megohms
- Reproducibility: $\pm 2\%$
- Minimum Sample Size: 3 mL in a 50 mL beaker
- Interfering Ions: CN⁻, Br⁻, I⁻, OH⁻, S²⁻

Solutions

- 1000ppm Cl (0.0282 M Cl): Dissolve 1.648g NaCl in DI water and dilute to 1000mL
- ISA 5M NaNO₃: 425g NaNO₃ in 1000mL DI water
- Reference (1M KNO₃): 100g KNO₃ in 1000mL DI water

Ordering information

ISE amplifier & electrode set	AC018A
ISE amplifier only	AC021
Electrode only	AC018

CO₂ Gas Sensor

DT039

Type: CO ₂ Gas Sensor	Range: 0-5000 ppm CO ₂
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Sensor description

As CO₂ absorbs infrared light, the CO₂ sensor consists of a tube containing an infrared source at one end and an infrared detector at the other end. The infrared detector detects the infrared light that wasn't absorbed by CO₂ between source and detector. The tube with the infrared sensing element is connected to a box containing the electronics and the connector to the data logger.



How it works

The infrared source consists of a hot metal filament. As infrared radiation causes heating, the infrared detector measures the temperature increase caused by the amount of infrared radiation not being absorbed by CO₂. The higher the concentration of the absorbing CO₂ gas in the tube is, the less radiation is going to reach the detector, i.e. the temperature increases less accordingly. The temperature increase in the infrared sensor produces a voltage to be amplified and read into the data logger. When the sensor is collecting data the IR source blinks on and off - it takes a new reading about once every second. It is recommended to perform line fits as the measurement will record the 'pulsing' of the IR source, thus resulting in a noisy line.

Defining the sensor:

In the Define new sensor dialog box enter the values shown in the figure below:

Sensor name:	<input type="text" value="CO2"/>	
Sensor unit:	<input type="text" value="ppm"/>	
Calibration values:		
	Output voltage	Real value
Value #1:	<input type="text" value="0"/>	<input type="text" value="0"/>
Value #2:	<input type="text" value="2.5"/>	<input type="text" value="5000"/>

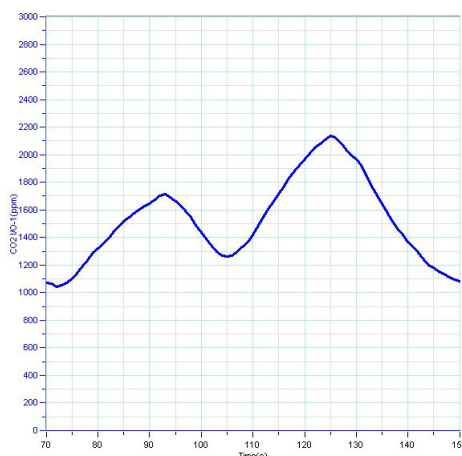
To learn how to define new sensor please refer to MultiLab user guide or MultiLab help.

Note: MultiLogPRO cannot automatically identify the CO ₂ sensor and must be in 8 sensors mode.

Calibration

Although The DT039 ships calibrated, it is recommended to perform a simple calibration before taking measurements:

1. Place the 250 cc bottle together with your sensor outside your building long enough to make sure that its contents are replaced with fresh air. The calibration is based on the fact that the outside air contains 400 ± 40 ppm.
2. Insert the sensor into the gas sampling bottle containing fresh air. Do this by holding the rubber stopper of the sensor and not the bottle.
3. Connect the sensor to your data logger and let it warm up for at least 90 seconds. Follow the reading on the data logger's display or on the software interface to ensure stability prior to the calibration.
4. Push the CAL button on the sensor case with a pencil point. Release the button immediately after the red LED blinks rapidly three times. After about 40 seconds, the reading should stabilize at a value of about 400 ± 40 ppm. If the reading is significantly lower or higher than 400 ppm, press the button again to repeat the process.



Monitoring human respiration

What it is used for

- Increases in carbon dioxide levels from small animals and insects
- Changes in carbon dioxide concentration in a plant terrarium during photorespiration and photosynthesis cycles
- CO₂ levels during cellular respiration of peas and beans
- Changing carbon dioxide levels in a classroom
- The rate at which carbon dioxide is removed from an enclosed atmosphere using sodium hydroxide or potassium hydroxide
- The rate of production of carbon dioxide in a chemical reaction between hydrochloric acid and sodium bicarbonate

- The rate at which carbon dioxide gas diffuses through a gas diffusion tube
- The production of carbon dioxide during fermentation or respiration of sugars

Specifications:

- Range: 0-5000 ppm
- 12-bit Resolution (TriLog): 2.44 ppm CO₂
- 10-bit Resolution (MultiLogPRO, MultiLog): 9.77 ppm CO₂
- Accuracy: (standard pressure, 1 atm):
 - ± 100 ppm in the range 0-1000 ppm;
 - $\pm 10\%$ of reading in the range of 1000-5000 ppm.
- Sampling rate: up to 1/s
- Response time: 95% of full-scale reading in 120 seconds.
- Warm-up time: 90 seconds (maximum).
- Pressure effect: 0.19% of reading/mm of Hg from standard pressure.
- Output signal range: 0-2.5 V
- Output impedance: 1 kW
- Input potential: 5V (± 0.25 V)
- Gas sampling mode: Diffusion
- Normal operating temperature range: 25°C ($\pm 5^\circ\text{C}$)
- Operating humidity range: 5-95%, non-condensing
- Storage temperature range: -40 to 65°C
- Calibration information:
 - Slope (gain): 2000 ppm/V
 - Intercept (offset): 0 ppm
 - Live calibration, performed by push button outside of closed rooms.
- Dimensions:
 - Probe box: 26 ´ 53 ´ 73 mm
 - Sensor tube: 13-mm OD and 75-mm length

Total length of CO₂ Gas sensor: 147 mm.

Colorimeter

DT185

Type: Colorimeter, Solution Concentration	Range: 20-90% Transmission
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Sensor description

The DT185 Colorimeter is designed to determine the concentration of a solution by analyzing its color intensity. Supplied with three color-filter slides.

How it works

White light from an LED light source passes through a color filter and then through a cuvette containing a sample solution as shown in **Figure 1**. Some of the incoming light is absorbed by the solution. The intensity of the light passing through the solution is measured by a photodiode (at the left side of the cuvette in Fig. 1).

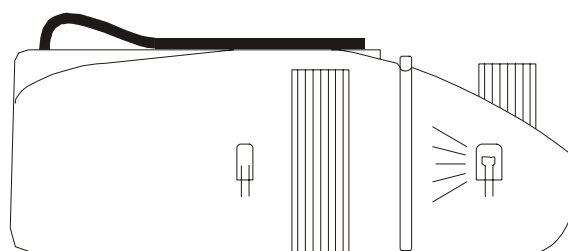


Figure 1

Wavelength Ranges

The colorimeter comes with three color filters: **Blue (480nm)**, **green (500nm)** and **red (650nm)**. There are several ways you can decide which of the three colors to use:

- Look at the color of the solution. Remember that the color of a solution is the color of light that passes through it.
- Another quick method is to place a cuvette containing the solution in question in the Colorimeter and check to see which of the three filters yields the highest absorbance (or lowest transmittance).
- Directions for most colorimetric experiments indicate a recommended wavelength. Use the closest of the three filters. Even if the color is somewhat different, a Beer's law curve can usually be obtained at almost any wavelength in the vicinity of the recommended wavelength.

Calibration

1. To calibrate to 100% transmission, insert one of the three filters and place the blank in the cuvette slot, the blank is a cuvette containing the solvent used in the solution being studied, usually distilled water.

2. Start recording and turn the calibration knob on top of the colorimeter until the reading is 100%.

We strongly recommend that you recalibrate every time you perform a new colorimetric experiment, or when you change the color within an experiment.

Using Cuvettes with the Colorimeter

The colorimeter is designed to use plastic cuvettes. Fifteen of these cuvettes and lids are supplied with the colorimeter. The cuvettes have a volume of approximately 4 ml. The cuvette slot of the colorimeter is designed to give a snug fit to the cuvette and keeps it always in the same position between the LED light source and photodiode. Make sure that the clear sides are facing photodiode and light source. We recommend that you have always the same side facing light source and diode respectively.

Just like most spectrophotometer sample tubes, individual plastic cuvettes vary slightly in the amount of light they absorb. You may choose to ignore these differences. For most lab exercises, this variation will not have a noticeable effect on experimental results.

For best results, variation in light absorbed by individual cuvettes can be controlled either by using the same cuvette for all experiments of a particular experiment or by *matching* a set of cuvettes.

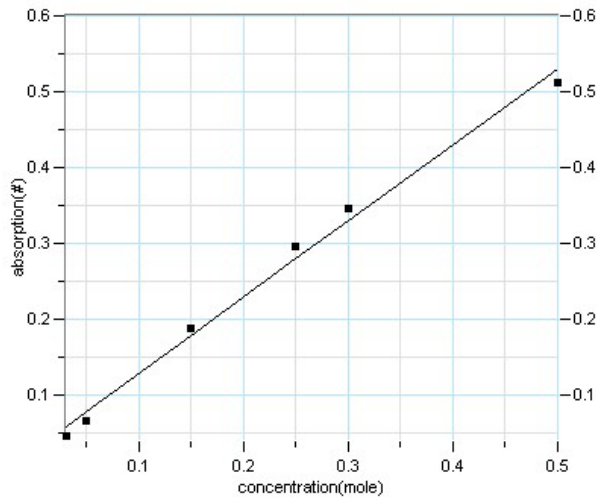
The easiest and most reliable is the first method. If a student is going to use five samples for a Beer's law experiment, the five standard solutions can be transferred to the same cuvette for each measurement. Clean and dry your cuvette after every experiment and always rinse prior to the next experiment with the test solution to be measured. If students have 5 or 6 cuvettes with similar absorbance levels, then each sample can be added to a different cuvette, eliminating the drying or rinsing step described in the previous paragraph. To match a set of cuvettes, first calibrate the colorimeter using the method described in the section on calibration, use a clean, dry cuvette for the 100% calibration, instead of distilled water blank. Put a reference mark on one of the clear sides of the cuvette so it is always oriented the same way in the cuvette slot. Place each cuvette in the batch in the colorimeter and record transmittance values for each. On completion cuvettes should be grouped according to similar %T values. Each group represents a set of matched cuvettes.

Caps are supplied for the original 15 cuvettes. A cuvette may, or may not have a cap on it when placed in the Colorimeter. The purpose of the cap is to prevent evaporation of solvent when an experiment is run over a period of several days. You may find it convenient to store standard solutions in capped cuvettes. If you purchase a replacement set of 100 cuvettes, 20 caps will be included. We felt teachers would probably not need to have one cap per cuvette. The caps can certainly be re-used as cuvettes are replaced.

Fill about 2.2 to 3.5 ml test solution into a cuvette to make sure that the photodiode does not 'see' the upper edge of the solution, which would falsify the results.

What is it used for

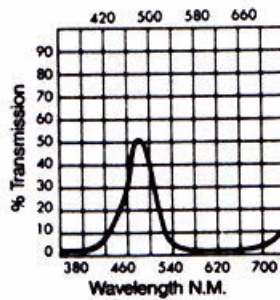
The absorption in three colors can be followed up, enabling you to determine concentrations of diluted solutions. You may furthermore use the colorimeter to characterize chemical reactions, when compounds are formed or decomposed showing absorption at one of these three colors.



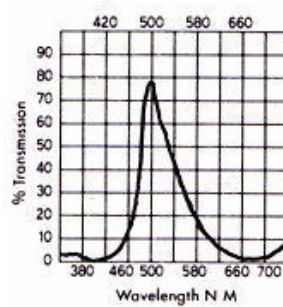
Specifications:

- Absorbance: 0.05 to 0.7
- Transmittance: 20% to 90%
- 12-bit Resolution (TriLog): 0.04%
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.16%
- Cell width: 1cm
- Cell volume: 3.5cc

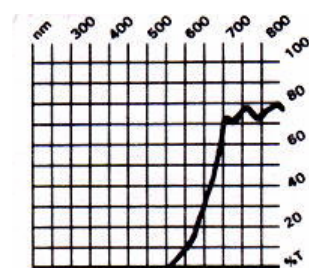
Filters transmission curves



Blue Filter



Green Filter



Red Filter

Conductivity

DT035A

Type: Conductivity Sensor	Range: 0 to 20 mS
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Sensor description

The DT035A is designed to measure conductivity of liquids and solutions. It detects conductivity in the range of 0 to 20 mS (millisimens). The DT035 consists of a conductivity electrode, an egg-shaped adapter and a connecting wire.



How it works

The electrode uses two etched, high grade stainless steel rings. The size of the rings and the distance between them is fixed. When an electric current travels from one ring, with the electrode placed in a liquid of some conductance, the second ring receives some of that current and the solution between the rings acts as resistor. The voltage of that "resistor" is measured and adjusted to a range of 0-5 V accepted by the analog-digital converter of the Data-Logger. The result is then stored into the Logger's memory.

Calibration

An offset calibration screw is located at the back of the sensor case. Place the electrode in a reference sample and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.

Note: If other electrochemical type sensors (Oxygen and pH) are put in the same solution at the same time and connected to the same Data logger, they can interfere with each other's signals. Keep the sensors as far apart as possible - the distance required will depend on the conductivity of the solution. If the problem persists try connecting the sensors to different data loggers, or take readings using one sensor at a time.

Conductivity Measurement

During measurement, avoid particulate matter: allow it to settle. Do not let sediment build up on the sensors. Make sure the two stainless steel sensor bands are immersed in the sample. Do not immerse above the yellow probe guard. Probe guard must be left on during measurement. Avoid air bubble entrapment in the sensor. Rinse with deionised water between the samples.

Probe Care and Maintenance

Keep the conductivity probe clean. Rinse the probe twice, and gently swirl it while you take readings. For best accuracy, soak a dry probe for at least 5 to 10 minutes or longer before calibration. Rinse the probe with deionised water before storing. Never scratch the platinum portions with a hard substance. Do not strike the probe against any hard surface.

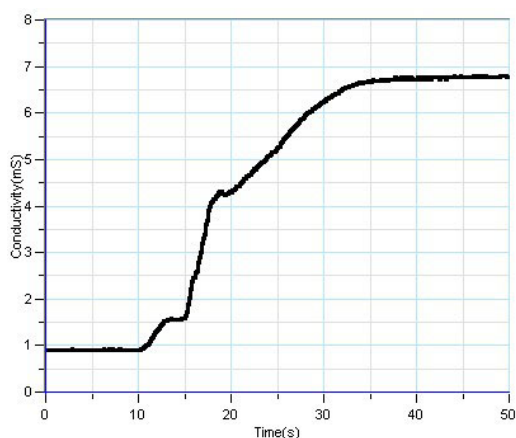
Do not make continuous contact with your solutions. Readings will rise over a period of time while you soak your probe. Do not immerse the probe in oily solutions. Clean the electrode thoroughly by stirring it in a mild detergent bath or isopropyl alcohol. Wipe the probe with a soft tissue paper. Rinse thoroughly in tap water and then in deionised water. Recalibrate the meter after cleaning the probe.

The Conductivity probe features a removable probe guard to make cleaning easy. To remove probe guard:

1. Grip yellow probe guard and twist clockwise. The locking notch will release.
2. Slide probe guard off end of probe.

What it is used for

The DT035A is used for various experiments in Biology and Chemistry. By using the DT035A you can demonstrate changes in conductivity when dissolving salts in water, or monitor bodies of water for pollution.



Changes in conductivity of water when adding salt

Specifications:

- Range: 0 to 20 mS.
- 12-bit Resolution (TriLog): 5 μ S
- 10-bit Resolution (MultiLogPRO, MultiLog): 20 μ S
- Total error: Less than 1.2% over the entire range.
- Typical input resistance: <100 Ω .
- Equipped with an offset calibration screw.

Ordering information

Adaptor & electrode set	DT035A
Adaptor only	DT035
Electrode only	DT050

Control Switch

DT110/111

Type: Control Switch	DT 110 (NC) DT 111 (NO)
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Sensor description

The control switch is connected to the same Data logger input/output as the sensor and opens or closes an electrical circuit when the sensor passes certain predefined values.

The control switch with the black cords and plugs is N.C. (normally closed)

The control switch with the red cords and plugs is N.O. (normally open)



How to set up the Control switch:

1. Connect a splitter cable to the Data logger
2. Connect your sensor to the splitter cable output marked with \updownarrow
3. Connect the egg-shaped sensor case of the control switch to the second splitter cable output, marked with **S**
4. Connect the data logger to the computer and run MultiLab
5. Select your sensor either by using the Data logger keypad or the Setup Wizard in MultiLab
6. click **Triggering** in step 3 of the Setup Wizard to open the triggering dialog
7. Select the triggering sensor in the **Based on sensor** drop list
8. Select the triggering type: select the **Control level** option
9. Select the trigger level in the **Level** drop list
10. Click **OK**

What it is used for

The control switch is used for example to process a heat source (as a simple thermostat), to open or close a light source according to the environmental light intensity. It might furthermore be used to mark the turning point in titration, by opening a lamp upon passing this point.

Specifications:

Maximum switch load:
240V @ 3A

Current ($\pm 2.5A$)

DT005

Type: Current	Range: $\pm 2.5A$
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Sensor description

The DT005 sensor is an Ampere meter, measuring current values between -2.5 and 2.5 Amperes. The DT005 is a differential sensor, capable of measuring both direct and alternate current. The sensor uses the Fourier Systems egg shaped sensor case, and has two durable banana plugs for easy connection. **The DT005 has no "Floating Ground". For proper measurements connect its negative input (black) to the power source negative input (ground).**



How it works

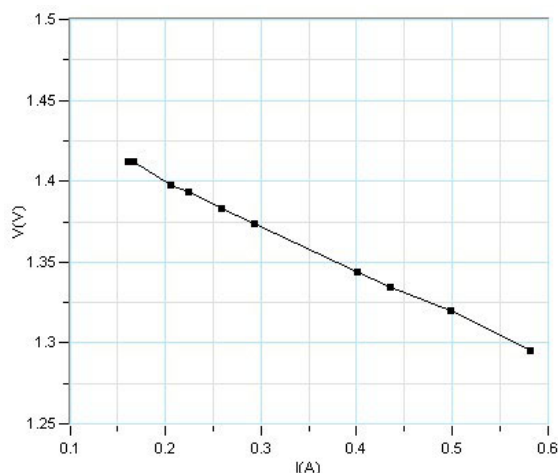
The Current sensor should be connected in serial connection to the measured electronic circuit. Inside the sensor there is a resistor of 0.1Ω . According to Ohm's Law, the voltage measured on that resistor will be $1/10$ of the current in the resistor. The measured voltage then goes through an amplifier unit and is adjusted to the range of $0-5$ volts, which is the range accepted by the Analog-Digital converter. The proper result is then recorded into the Data Logger's memory.

Calibration

The DT005 requires no calibration.

What is it used for:

The DT005 sensor is used in various experiments such as EMF and internal resistance, or the study of current characteristics of a light bulb and a diode. The following graph is a measurement of voltage while discharging a capacitor, performed using the DT005.



A measurement of EMF and internal resistance

Specifications:

- Range: $-2.5A$ to $+2.5A$.
- 12-bit Resolution (TriLog): $1.25mA$
- 10-bit Resolution (MultiLogPRO, MultiLog): $5mA$
- AC or DC input current.
- Accuracy: 3% over entire range.
- Input resistance: 0.1Ω .
- Bandwidth: 5 kHz.
- Maximal input current 5A.

Current ($\pm 250\text{mA}$)

DT006

Type: Current

Range: $\pm 250\text{mA}$

Sensor description

The DT006 sensor is an Ampere meter, measuring current values between -250 and 250 mA . The DT006 is a differential sensor, capable of measuring both direct and alternate current. The sensor uses the Fourier System egg-shaped sensor case, and has two durable banana plugs for easy connection.



How it works

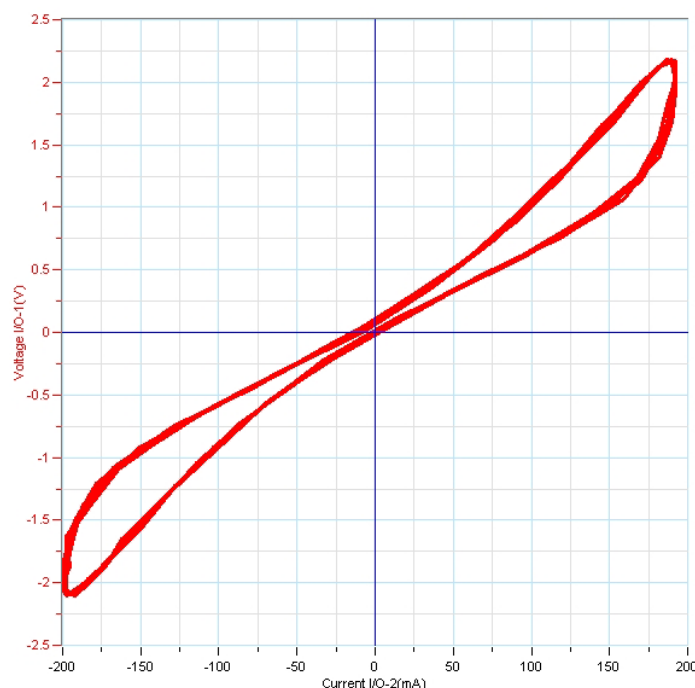
The current sensor should be connected in series to the measured electronic circuit. Inside the sensor is a resistor of 1Ω . According to Ohm's Law, the voltage measured on that resistor will be exactly the current in the resistor. The measured voltage passes an amplifier unit and is adjusted to the range of $0\text{-}5$ volts, which is the range accepted by the Analog-Digital converter. The proper result is then recorded into the Data Logger's memory.

Calibration

The DT006 requires no calibration.

What it is used for

The DT006 sensor is used in various experiments such as EMF and internal resistance or the study of current characteristics of a light bulb and a diode.



measuring bulb characteristics using the DT006

Specifications:

- Range: -250mA to $+250\text{mA}$.
- 12-bit Resolution (TriLog): $125\mu\text{A}$
- 10-bit Resolution (MultiLogPRO, MultiLog): $500\mu\text{A}$
- AC or DC input current
Accuracy: $\pm 5\%$ over entire range.
- Input resistance: 1Ω .
- Bandwidth: 5 kHz .
- Maximal input current 1.7A .

Current (0 to 20mA)

DT007

Type: Current	Range: 0 to 20mA
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Sensor description

The DT007 works as an adapter to industrial sensors with an output of 0 to 20 mA as it is able to record data from any existing industrial sensors in your stock. The DT007 is using Fourier Systems' egg-shaped sensor case and has two durable banana-shaped plugs.



How it works

The DT007 should be connected to the sensor you are going to use. It contains a 250Ω resistor. Measuring the voltage in this resistor will give a result between 1 to 5 Volts according to Ohm's law, which is the range accepted by the Analog-Digital converter. The proper result is then recorded into the Data Logger's memory.

Calibration

The DT007 requires no calibration.

What it is used for

The DT007 is used for enabling industrial sensors to connect to the data logger by using the 0 to 20 mA output.

Specifications:

- Range: 0 to 20mA.
- 12-bit Resolution (TriLog): 4.9μA
- 10-bit Resolution (MultiLogPRO, MultiLog): 19.5μA
- Accuracy: ±0.3% over entire range.
- Input resistance: 250Ω.
- Bandwidth: 5 kHz.

Distance

DT020-1

Type: Distance Sonic Ranger	Dual Range: 0.4 – 10.4m, 0.4 – 2m
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Sensor description

The DT020-1 measures the distance between the sensor and an object in two ranges, one of 0.4 to 10.4m and the other of 0.4 to 2m with better resolution. The range is selected via the MultiLogPRO. The sensor can sample data at up to 50 times per second, making it excellent for motion and movement experiments.

The DT020-1 is supplied with a mounting rod.



As this sensor is current consuming, it is highly recommended to operate while the AC/DC adapter powers the Data logger.

Note: The DT020-1 is using the Data logger Digital output, for triggering the sound pulses, thus cannot be simultaneously operational with other sensors with the Data logger digital input (Smart Pulley, Geiger-Muller).

How it works

The DT020-1 works on the same principle as a sonar system. An ultrasonic loudspeaker and microphone are located inside the sensor's case. A capacitor is connected to the loudspeaker and constantly charges and discharges according to the rate preset by the user. When the capacitor is discharged, the loudspeaker emits an ultrasonic pulse. This pulse travels through the air, hits the closest item (within range) to the sensor, and returns as an echo. When the ultrasonic microphone receives the echo, the processor inside the sensor calculates the distance according to the time difference between the two events and the speed of sound.



Calibration

The DT020-1 ships fully calibrated. No further calibration is needed.

Selecting the range


To select the range, use the **Distance** command from the **Configuration** menu on the MultiLogPRO:

1. In the **MAIN MENU** screen, use the arrow buttons to navigate to

the **System configuration** icon , then press **Enter**  to display the configuration screen



2. Press the **Enter** button  twice to select **Distance**

3. Use the arrow buttons to select the desired range

4. Press the **Escape** button  to return to the main menu
The new setup will be saved until the next time you change it.

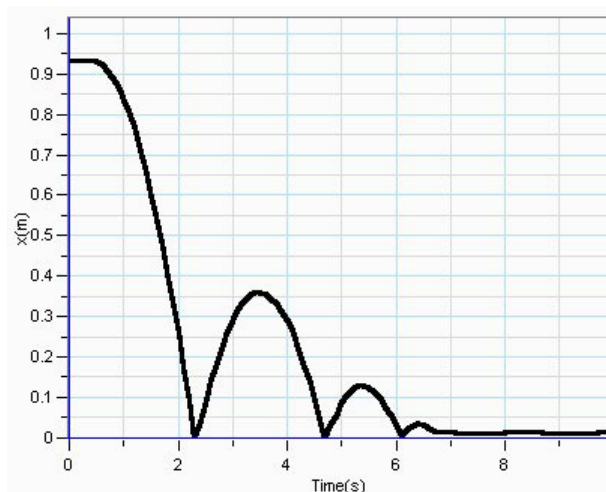
Selecting measurement and positive direction

By default MultiLab displays the position measurement and the positive direction is outgoing (from the sensor). To display other measurements such as velocity or acceleration, or to reverse the positive direction (Incoming) use the sensor properties dialog:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the distance sensor input
3. Check the checkboxes next to the desired measurements to select them.
4. Click **OK**

What it is used for

The DT020-1 is used for various experiments in physics and mechanics. Among the topics explored using the DT020-1 are the harmonic motion of a spring, and free fall acceleration. The following graph shows a sample experiment measuring motion on an inclined plane.



Motion on an inclined plane

Specifications:

- Range: two ranges
0.4 – 10.4m or 0.4 – 2m.
- 12-bit Resolution (TriLog):
1.8mm
- 10-bit Resolution
(MultiLogPRO, MultiLog):
0.4 – 10.4m range: 9.4mm
0.4 – 2m range: 1.8mm
- Accuracy: 1% over entire range
- Receiver viewing angle: $\pm 15^\circ$ to $\pm 20^\circ$.
- Sampling rate: up to 50/s

ECG

DT189

Type: ELECTROCARDIOGRAM	Range: 0 – 5V
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Sensor description

The ECG (Electrocardiogram) measures cardiac electrical potential waveforms (voltages produced during contractions of the heart).

This product is to be used for educational purposes only. It is not appropriate for medical or research applications. Specifically, it may not be used for patient diagnosis.

The sensor comes with a package of one hundred silver/silver chloride electrode patches that can be attached to the skin.

The sensor consists of Fourier's egg-shaped sensor case and three electrode leads. The sensor's circuitry isolates the user from the possibility of electrical shock in two ways:

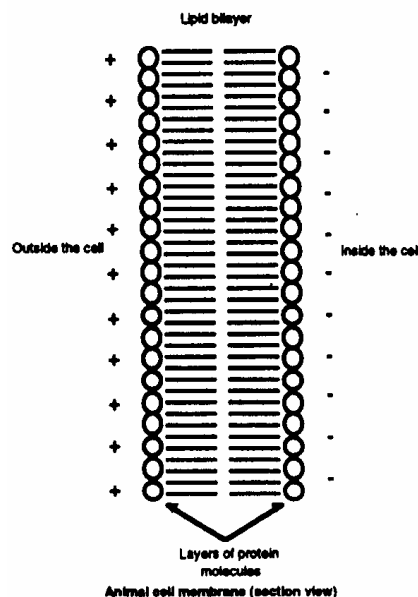
- The sensor signal is transmitted through an opto-isolation circuit.
- Power for the sensor is transferred through a transformer. The circuitry protects against accidental over-voltages of up to 4,000 volts.



Note: As this sensor is current consuming, it is highly recommended to operate it while the AC/DC adapter powers the Data logger.

How it Works

Heart muscle cells are polarized at rest. This means the cells have slightly unequal concentrations of ions across their cell membranes. An excess of positive sodium ions on the outside of the membrane causes the outside of the membrane to have a positive charge relative to the inside of the membrane. The inside of the cell is at a potential of about 90 millivolts (mV) less than the outside of the cell membrane. The 90 mV difference is called the resting potential. The typical cell membrane is relatively impermeable to the entry of sodium. However, stimulation of a muscle cell causes an increase in its permeability to sodium. Sodium ions migrate into the cell through the opening of voltage-gated sodium channels. This causes a change (depolarization) in the

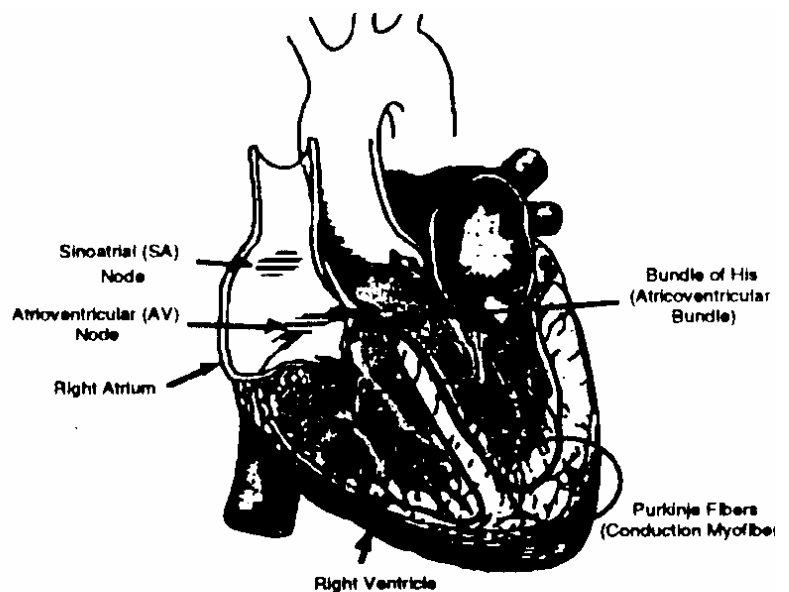


electrical field around the cell. This change in cell potential from negative to positive and back is a voltage pulse called the action potential. In muscle cells, the *action potential* causes a muscle contraction.

Other ions and charged molecules are involved in the depolarization and repolarization of the cardiac muscle. These include potassium, calcium, chlorine, and charged protein molecules. The sum action potential generated during the depolarization and repolarization of the cardiac muscle can be recorded by electrodes at the surface of the skin. A recording of the heart's electrical activity is called an electrocardiogram (ECG). The depolarization of cardiac-muscle cells triggers the contraction.

The cells of the heart's conducting system will depolarize spontaneously. This spontaneous depolarization is most apparent in a cluster of cardiac-muscle cells embedded in the upper wall of the right atrium. This group of cells is called the pacemaker (also known as the *sinoatrial* or *SA node*). Depolarization of the pacemaker generates a current that leads to the depolarization of all other cardiac-muscle cells. The wave of depolarization travels from the right atrium to the left atrium quickly enough so that both atria contract at essentially the same time.

The atria and the ventricles are isolated from each other electrically by connective tissue that acts like the insulation on an electric wire. The depolarization of the atria does not directly affect the ventricles. There is another group of cells in the right atria, called the *atrioventricular* or *AV node*, that will conduct the depolarization of the atria down a special bundle of conducting fibers (called the *Bundle of His*) to the ventricles. In the muscle wall of the ventricles are the *Purkinje Fibers*, which are a special system of muscle fibers that bring depolarization to all parts of the ventricles almost simultaneously. This process causes a small time delay, so there is a short pause after the atria contract and before the ventricles contract.



Because the cells of the heart muscle are interconnected, this wave of depolarization, contraction, and repolarization spreads across all of the connected muscle of the heart.

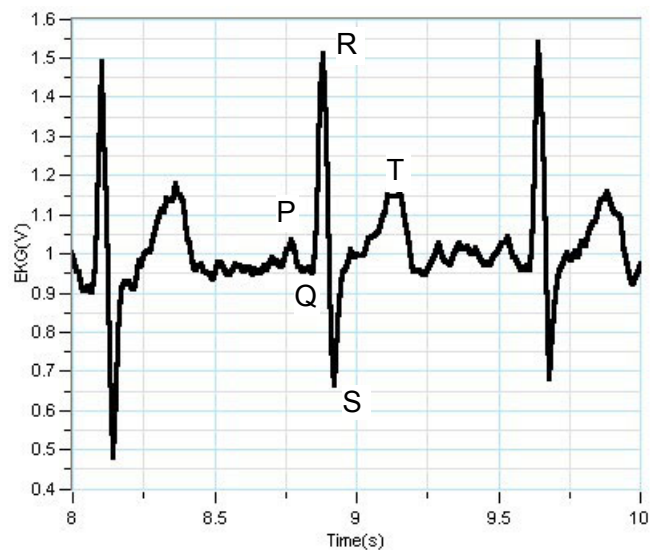
When a portion of the heart is polarized and the adjacent portion is depolarized, an electrical current is created going through the body. This current is greatest when one half of the connected portion of the heart is polarized and the adjacent half is not polarized. The current decreases when the ratio of polarized tissue to non-polarized tissue is less than one to one. The changes in these currents can be measured, amplified, and plotted over time. The ECG represents the summation of all the action potentials from the heart, as detected on the surface of the body. It does not measure the mechanical contractions of the heart directly.

The impulse originating at the SA node causes the atria to contract, forcing blood into the ventricles. Shortly after this contraction, the ventricles contract due to the signal conducted to them from the atria. The blood leaves the ventricles through the aorta and pulmonary artery. The polarity of the cardiac muscle cells returns to normal and the heart cycle starts again.

The Electrocardiogram

The electrocardiogram (ECG) is a graphic tracing of the heart's electrical activity. A typical tracing consists of a series of waveforms occurring in a repetitive order. These waveforms arise from a flat baseline called the isoelectric line. Any deflection from the isoelectric line denotes electrical activity

The letters P, Q, R, S, and T designate the five major deflections on a normal ECG. One heart cycle is represented by a group of waveforms beginning with the P wave, followed by the QRS wave complex, and ending with the T wave. The P wave represents the depolarization of the atria and is associated with their contraction. The QRS wave complex consists of three waves. The first negative deflection is the Q wave and is followed by a positive deflection called the R wave. The complex ends with a negative deflection known as the S wave. The QRS wave complex denotes depolarization of the ventricles and is associated with their contraction. Atrial re-polarization occurs during the depolarization of the ventricles. For this reason, the waveform associated with atrial re-polarization is undetectable on an ECG. The last wave is called the T wave, and is usually represented by a positive deflection. The T wave indicates ventricular re-polarization



Electrical energy is also generated by skeletal muscle, and can be seen as muscle artifacts if your arm is moved while the ECG is attached. The sequence from P wave to T wave represents one heart cycle the number of cycles in a minute is called the heart rate and is typically 70-80 beats per minute at rest. Some typical times for portions of the ECG are:

P-R interval	0.12 to 0.20 seconds
QRS interval	less than 0.1 seconds
Q-T interval	less than 0.38 seconds

If your ECG does not correspond to the above numbers, DO NOT BE ALARMED! These numbers represent typical averages and many healthy hearts have data that fall outside of these parameters. To read an ECG effectively takes considerable training and skill.

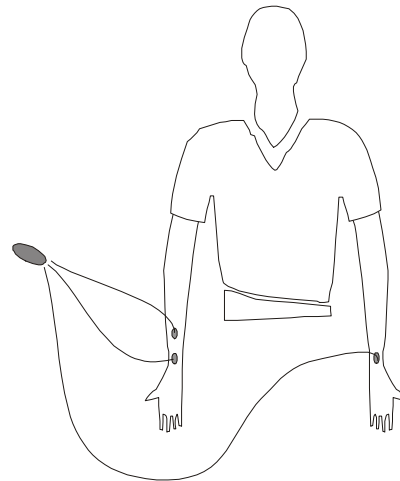
PLEASE BE AWARE: This sensor is NOT intended for medical diagnoses!!!

Connecting the ECG Sensor to a Person

Use three electrode patches per subject. The electrodes can be reused, but since they tend to absorb moisture (they are very hygroscopic), reuse is not

recommended. Note: Once opened, the electrodes should be kept refrigerated in a clean, dry, airtight container for storage. Even with airtight storage, opened electrode packages cannot be stored from one year to the next.

- Because the electrical signal produced by the heart and detected at the body's surface is so small, it is very important that the electrode patch makes good contact with the skin. Scrub the areas of skin where the patches will be attached with a paper towel to remove dead skin and oil.
- Peel three electrode patches from the backing paper. Firmly place the first electrode on the right wrist.
- Place a second electrode a few centimeters above the first one.
- Place a third electrode on the inside of the left wrist.
- Place each electrode so it is on the inside part of the arm (closer to the body) and the tab on the edge of the electrode patch is pointing down. This way, the wire of the sensor can hang freely without twisting the edge of the electrode patch.
- Connect the micro alligator clips of the three sensor's leads to the tabs on the edges of the electrode patches:
- Connect the two leads labeled R.A. (right arm) to the right arm electrode patches.
- Connect the lead labeled L.A. (left arm) to the left arm electrode patch.

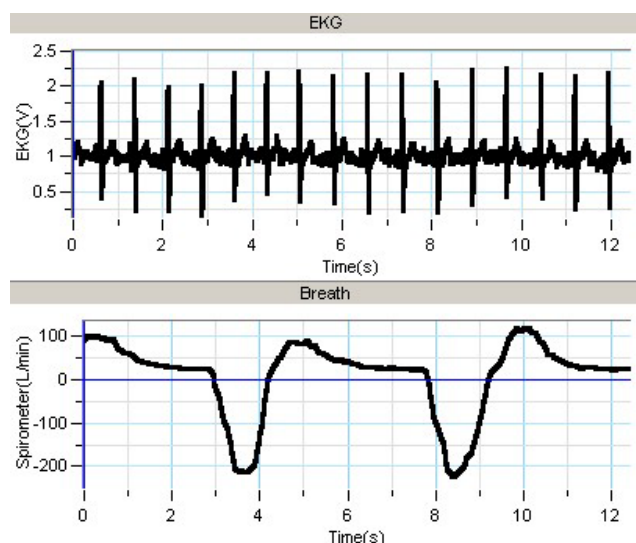


Calibration

The DT048 is shipped fully calibrated and no further calibration is needed.

What is it used for

ECG is usually used for measurements of the heart activity and response in various human body modes like, rest and active, standing up and sitting down, etc...



Simultaneous ECG and respiration graphs

Specifications

- Range: 0 - 5V
- 12-bit Resolution (TriLog): 1.25mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 5mV
- Offset: ~1 V ($\pm 0.3V$)
- Gain: 1000
- Voltage protection: 4kV

Flow rate

DT254A

Type: Propeller with electromagnetic pickup	Range: 0 to 3m/s (0 to 10 ft/s)
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Sensor description

The DT254A is designed to measure the velocity of flowing water. It can be used to measure flow rates of rivers or channels. The DT254A is equipped with telescopic handle and protective housing.

How it works

The DT254A uses a propeller to measure water velocity. When placed in a stream, the water flow rotates the propeller blades. The rotation speed is directly proportional to the water flow. Each blade is equipped with a small magnet. Every half a cycle the magnets trigger a magnetic pickup (reed switch) that sends a pulse to the data logger. The data logger counts the number of pulses in a time interval which is determined by the sampling rate, and converts it to flow rate.

Calibration

The DT254A ships fully calibrated. No further calibration is needed.

What it is used for

The DT254A measures velocity of water in rivers, streams, channels, etc. it is used in exploring flow patterns or calculating the volume discharge of a river.

Specifications:

- Range: 0 to 3m/s (0 to 10ft/s)
- Resolution: 0.006m/s
- Sampling rate: 1/s or less (1 every 10s is recommended)
- Minimum depth: 6 cm (2.4 in)
- Length: 1 to 2 meters (3.6 to 6.5 feet) with telescoping tube
- Materials: PVC housing, handle and fittings, anodized aluminum tube



Force

DT272

Type: Force - strain gage	Dual Range: $\pm 10\text{N}$, $\pm 50\text{N}$
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Sensor description

The DT272 Force Sensor is a popular force sensor. It has two ranges: $\pm 10\text{N}$ or $\pm 50\text{N}$. It can be easily mounted on a ring stand or dynamics cart, or used as a replacement for a hand-held spring scale. It is used to study friction, simple harmonic motion, impact in collisions, or centripetal force.

Note: As this sensor is current consuming, it is highly recommended to operate it while the AC/DC adapter powers the Data logger.

How it works

The DT272 uses strain gage technology to measure force, based on the bending of a beam. Strain gages attached to both sides of the beam change resistance slightly as the beam bends. These resistors are built into a bridge circuit such so changes in resistance result in a small change in voltage. An amplifier circuit inside the sensor steps up this voltage so that it can be measured by the lab interface. Potentiometers are included in the amplifier circuit to allow adjustment of the Resolution and the voltage produced when no force is applied. The DT272 was designed to produce a voltage that varies in a linear way with force.



Calibration

The DT272 is shipped fully calibrated. However, the sensor is equipped with gain and offset calibration screws should you require further calibration:

Offset calibration:

1. Turn on the data logger
2. Fasten the force sensor vertically so that the hook will point downwards
3. Switch to $\pm 10\text{N}$ range
4. Connect the force sensor to MultiLogPRO
5. Begin logging
6. Insert a flat screwdriver to the Offset calibration hole and slowly turn the calibration screw until a zero reading is reached (make sure that no force is applied to the sensor)

Gain calibration:



1. Perform offset calibration as described above
2. Switch to $\pm 50\text{N}$ range

3. Hang a reference weight of about 30N on the sensor's hook
4. Begin logging
5. Insert a flat screwdriver to the Offset calibration hole and slowly turn the calibration screw until the reference reading is reached

Note: you can perform the gain calibration in the $\pm 10\text{N}$ range with a lighter weight.

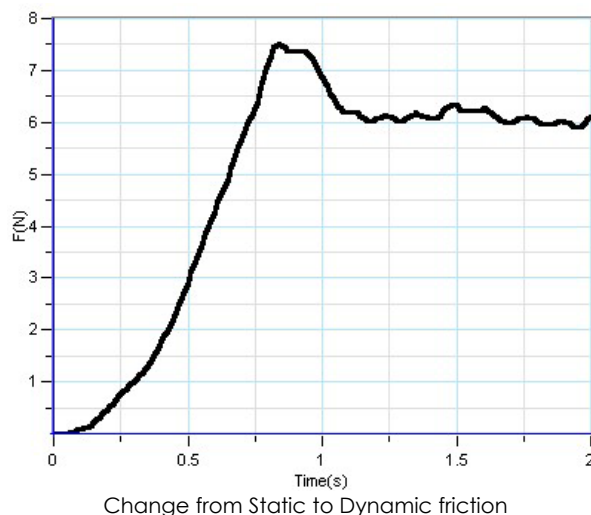
Selecting positive direction

By default MultiLab regards pushing the sensor as positive force. To reverse the positive direction (pull - positive) use the sensor properties dialog:

6. Click **Setup Wizard**  on the main toolbar
7. Click **Properties**  next to the force sensor input
8. Check the checkboxes next to the desired option to select it.
9. Click **OK**

What is it used for

This sensor can be used in experiments where you need to measure collision, harmonic motion and friction forces.



Specifications

- Range : -50 N to +50 N
 - 12-bit Resolution (TriLog): 0.04 N
 - 10-bit Resolution (MultiLogPRO, MultiLog): 0.12 N
- Range : -10 N to +10 N
 - 12-bit Resolution (TriLog): 0.005N
 - 10-bit Resolution (MultiLogPRO, MultiLog): 0.02N

Geiger-Muller Counter DT116

Type: Radioactivity	12-bit Range: 0-4096 Bq 10-bit Range: 0-1024 Bq
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Sensor Description

The DT116 is equipped with built in GM-tube and integral power supply. This will allow direct connection to the input of the MultiLogPRO that will also provide the 5V required operation voltage.

The DT116 is equipped with a power indicator, indicating that an operational voltage is supplied to the unit - a yellow LED. Furthermore, the unit is also equipped with a buzzer emitting an audible signal as each pulse is recorded. The DT116 is sensitive to Alpha, Beta and Gamma radiation.



How it works

The Tube Window is made of a very thin and delicate material, which is easily destroyed. For this very reason, it has been equipped with a protective cap, which may be left on in most cases, except when measuring Alpha radiation. The cap is provided with a venting hole to avoid creating a vacuum when removing the cap, or the reverse, when positioning the cap again.

Note: It is of the utmost importance that the venting hole is uncovered when mounting or removing the cap.

Calibration

The DT116 is shipped fully calibrated. Further calibration is not needed.

What is it used for

- Demonstrating the random nature of radioactive radiation
- Measuring radioactivity vs. distance
- Investigating the affect of different absorbers on the radiation

Specifications

- 12-bit Range (TriLog): 0 to 4096 Bq
- 10-bit Range (MultiLogPRO, MultiLog): 0 to 1024 Bq
- Resolution: 1 Bq
- Operating Voltage:
5V DC
- Current 10mA
- Effect: 50 mW
- Output: 0-5 v (TTL)
- Dimensions:
Radius – 44mm
Length – 112mm
- Weight 160 g

Tube Specifications:

The Tube is sensitive to Alpha, Beta and Gamma radiation

Plateau threshold voltage (V_{b1}) 450 V

Plateau Length ($V_{b2}-V_{b1}$) 150 V

Recommended supply voltage 500 V

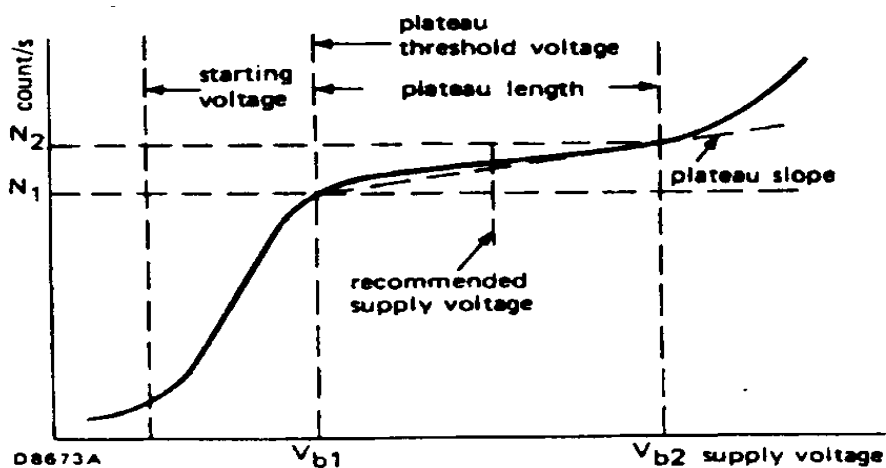
Window Specifications

Thickness 9.14 mm

Material Mica

Gas Filling Neon, Argon and Halogen

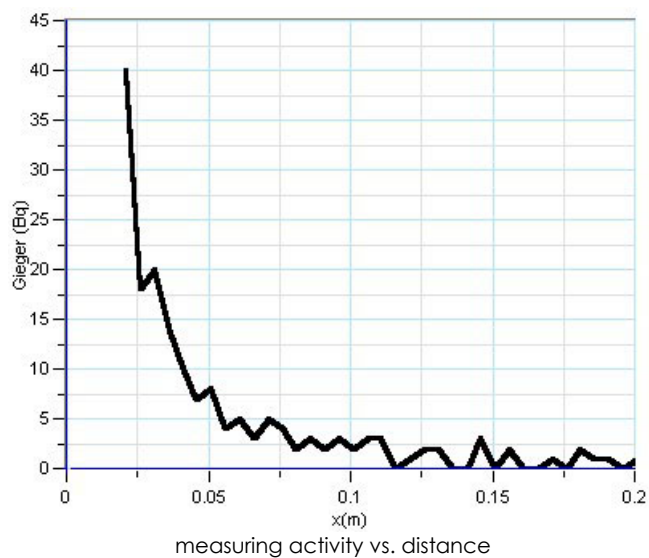
Dead Time (at recommended supply Voltage) 90 μ s



Plateau:

The Plateau is the part of the diagram where the number of counts per second is (almost) independent of the voltage.

The right of the graph expresses the radioactivity magnitude versus the distance between the radioactive source and the Geiger Muller sensor.



Heart Rate

DT155

Type: Heart rate	Double Range: waveform 0 – 5V Pulse rate 0 – 200bpm
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Sensor description

Heart Rate Sensor monitors the light level transmitted through the vascular tissue of the fingertip and the corresponding variations in light intensities that occur as the blood volume changes in the tissue. It has two ranges: waveform and beats per minute.



How it works

Unlike an electrocardiograph (EKG), which monitors the electrical signal of the heart, this sensor monitors the flow of blood through the veins. Best measurements are done at a fingertip. As the heart forces blood through the blood vessels, the amount of blood changes with time. By plotting this signal, the heart rate can be determined, and some details of the pumping action of the heart can be seen on the graph. A sample graph is shown below.

This product is to be used for educational purposes only. It is not appropriate for medical or research applications. Specifically, it may not be used for patient diagnosis

Note: As this sensor is current consuming, it is highly recommended to operate it while the AC/DC adapter powers the Data logger.

What it is used for

The DT155 is mainly used for:

- Comparison of the heart rate of different individuals.
- Comparing of the heart rate of athletes and sedentary people.
- Checking a person's heart rate before and after brief vigorous activity (such as doing jumping jacks). Note that the Heart Rate Monitor cannot be used during the activity. The body's movement would cause shifting of the ear clip and erroneous readings.
- Monitoring the recovery rate (i.e. how fast a person's heart rate returns to its normal performance after exercise).



Calibration

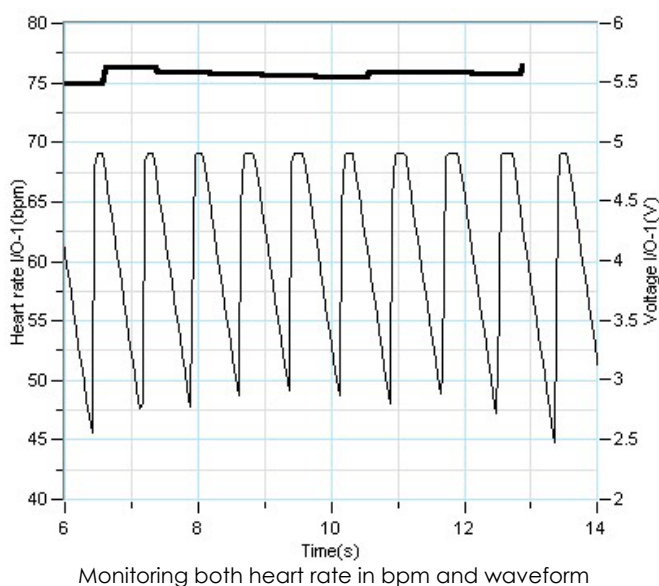
The DT155 requires no calibration.

Resolution adjustment

Sometimes, especially when in very bright light surroundings, the sensor's Resolution should be adjusted. A Resolution screw is located at the back of the sensor case. Start recording, Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the waveform is clear.

Selecting the range:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the Heart rate sensor input
3. Check the checkbox next to the desired range, beats per minute (bpm) or waveform (V), to select it.
4. Click **OK**



Specifications:

- Range:
Waveform 0V to 5V, Pulse rate 0 to 200bpm

Waveform
Resolution:

- 12-bit Resolution (TriLog): 1.25mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 5mV
- Pulse rate
Resolution: 1bpm
- Sampling rate: at least 10/s

Heat flow

DT032

Type: Heat flow	Range: $\pm 2\text{kW/m}^2$
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Sensor description

The DT032 Heat Flow Sensor is designed to measure the flow of heat energy between its upper and lower surfaces giving a bi-directional output in Watts/m. Pupils can observe energy transfer directly rather than indirectly by measuring temperature changes. This makes it particularly useful in demonstrating the distinction between heat energy and temperature.



How it works

Heat Flow is a sensor that has been designed to measure small amounts of thermal energy transfer. The sensing area of the device is a thermopile which consisting of 400 thermocouples potted in resin for protection.

Heat flow through the sensor induces a temperature gradient between its faces.

The sensor uses the thermoelectric effect to convert the small temperature gradient into a voltage. The thermoelectric effect is very small so a large number of thermocouples are connected in series on each surface to increase the output.

The output is bi-directional indicating the direction of heat flow.

The heat flow is then calculated from the temperature gradient.

Calibration

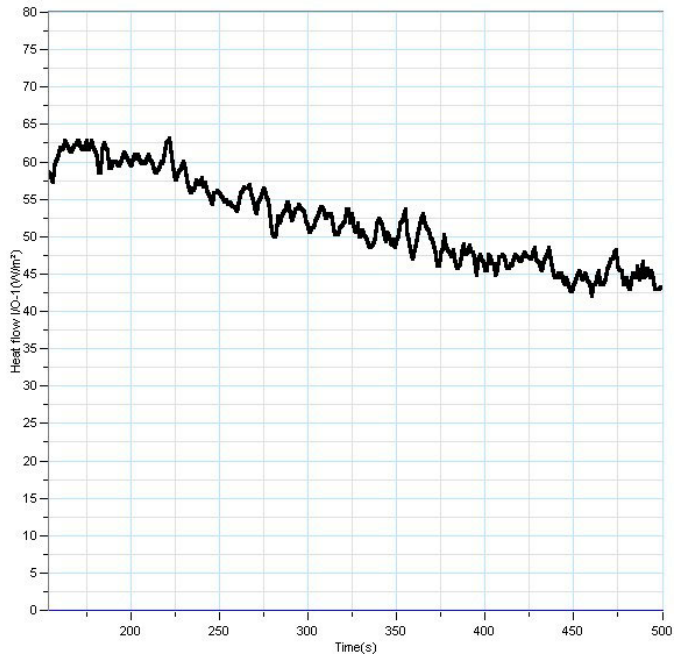
The DT032 requires no calibration.

Tips:

- Place the sensor in position and attach it to the test surface using adhesive tape or an elastic band. Do not hold by hand because heat from your hand will produce false readings.
- Leave the sensor in position for at least 2 minutes to stabilize.
- The sensor can be covered with the same coloring as the test surface to create the same characteristics of absorption.
- If used on low emissive metallic or glass surfaces, attach aluminum foil to the sensor with double sided tape to improve accuracy.
- In order to measure the heat flow accurately, the heat path in which the sensor is placed should have a higher thermal resistance than the sensor. The presence of the sensor will then cause the minimum disturbance to the heat flow. If the material, of which the heat flow is being measured, has a much higher conductivity than the sensor e.g. copper, the heat will tend to flow around the sensor producing a low reading.

What it is used for

The DT032 sensor is used for experiments in Environmental Sciences and Physics. In studying Newton's law of cooling, insulation properties, comparing heat flow or loss in buildings and investigations of heat flow into cold bodies or from hot bodies.



Energy transfer through a polystyrene cup

Specifications:

- Range: $\pm 2 \text{ kW/m}^2$
- 12-bit Resolution (TriLog): 0.98 W/m^2
- 10-bit Resolution (MultiLogPRO, MultiLog): 3.9 W/m^2
- Thermal conductance: $200 \text{ (Watt/m}^2\text{) / }^\circ\text{C}$.
- Operating temperature range: $-25 \text{ to } 85^\circ\text{C}$.
- Resistant to mild solvents and humidity.

Humidity (5% Accuracy) DT014

Type: Relative Humidity	Range: 0% to 100% RH
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Sensor description

The DT014 sensor is a humidity sensor, measuring a range of 0-100% relative humidity. The DT014 uses the Fourier System egg-shaped sensor case, and is equipped with a zero offset calibration screw. The DT014 is mostly used for environmental, biological and meteorological measurements.



The DT014 is sensitive to light and so exposure to sunlight must be avoided.
--

How it works

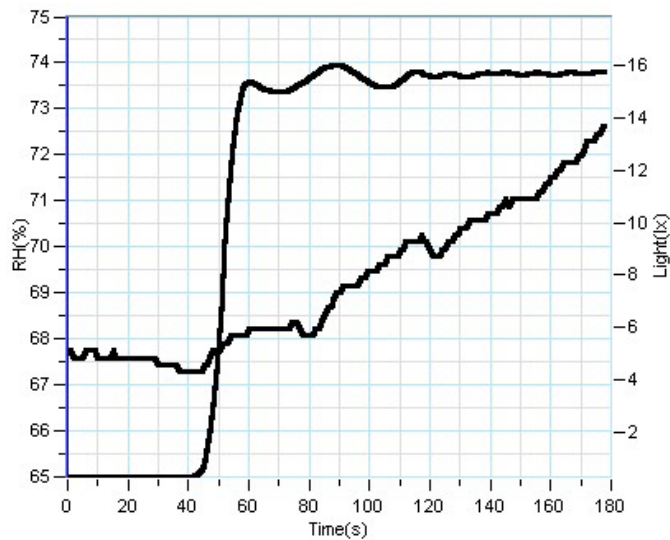
The DT014 is based on a humidity-sensing component. This component is actually a variable capacitor that changes its capacity according to the humidity in the environment. The sensor is part of an electronic oscillator that changes frequency with changing humidity. The oscillator frequency is converted to voltage. This voltage is then adjusted to a range of 0-5 Volts, accepted by the analog-digital converter. The proper result is then recorded and stored in the data logger's memory. The humidity-sensing component is also equipped with a temperature sensor, performing constant temperature compensation, in order to avoid contaminated results caused by changes in room/air temperature.

Calibration

The DT014 ships fully calibrated. For further calibration an offset calibration screw is located at the back of the sensor case. Use a reference humidity meter to measure the humidity and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.

What it is used for

The DT014 is used for biological, environmental and meteorological measurements. Among the experiments using the DT014 are body respiration properties, the exploration of biotic conditions outdoors, and the research of meteorological connections between humidity, temperature and light.



Monitoring leaf respiration

Specifications:

- Range:
0% to 100% RH
- 12-bit Resolution
(TriLog): 0.05% RH
- 10-bit Resolution
(MultiLogPRO,
MultiLog): 0.2% RH
- Total accuracy: $\pm 5\%$
RH @ 25 °C, (with
saturated salt
calibration).
- Bandwidth: 1 Hz.
- Equipped with zero
offset calibration
screw.

Humidity (2% Accuracy) and Temperature

DT041

Type: Relative Humidity and Temperature	Range: 0% to 100% RH and -25°C to +110°C
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Sensor description

The DT041 sensor is a highly accurate humidity sensor. It measures relative humidity ranging from 0 to 100% with an error of not more than $\pm 2\%$ over the entire range. The DT041 includes, in its screw-on cap, a temperature sensing element that measures temperatures ranging from -25°C to 110°C.

How it works

The DT041 is based on a humidity-sensing component. This component is actually a variable capacitor that changes capacitance according to the humidity in the environment. Results are recorded in Volts ranging from 0-1 Volts, which is accepted by the analog-digital converter. The proper result is then recorded and stored in the data logger's memory. The humidity-sensing component is equipped with two temperature sensors, performing constant temperature compensation, in order to avoid contaminated results caused by changes in room/air temperature.

The temperature sensor receives an input voltage of 5V and returns output voltage between 0 to 5 Volts, which is the range accepted by the Data logger analog-digital converter. The data logger then records the value into its memory.

Connections

Because DT041 contains two sensors in one unit, MultiLogPRO cannot automatically identify the sensor and must operate in 8 sensors mode.

To use DT041 as Humidity sensor only: plug in the sensor and select the second Humidity sensor from the sensor list.

To use DT041 as Humidity and temperature sensors: connect the DT041 to the common end of a splitter cable (DT011) via a female to female adaptor (DT129). The splitter cable output marked with \updownarrow carries the Humidity signal and the splitter cable output marked with **S** is the temperature sensor.

Calibration

The DT041 ships fully calibrated. No further calibration is needed.



What it is used for

The DT014 is used for biological, environmental and meteorological measurements. Among the experiments using the DT041 is the recording of the body respiration properties, the exploration of biotic conditions outdoors, and the research of meteorological connections between humidity, temperature and light. The sensor's high precision makes it excellent for academic or professional applications.

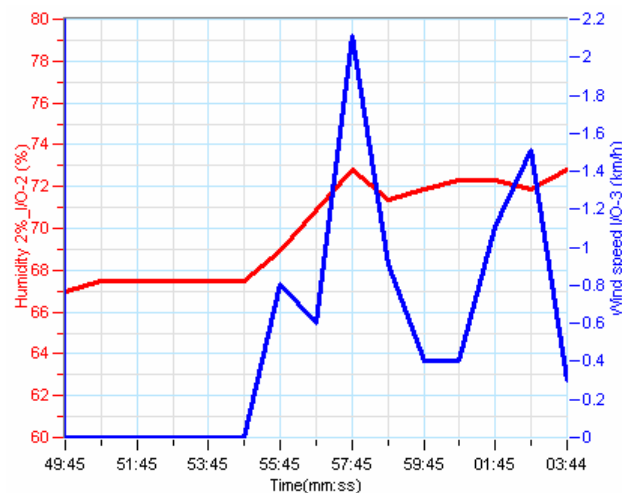
Specifications:

Humidity

- Range: 0% to 100% RH
- 12-bit Resolution (TriLog): 0.13% RH
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.49% RH
- Total accuracy: $\pm 2\%$ RH at 25 °C
- Bandwidth: 1 Hz

Temperature

- Range: -25°C to +110°C.
- 12-bit Resolution (TriLog): 0.09°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.25°C
- Total error: $\pm 1\%$



How winds affects indoor humidity

Light (0 to 130klx)

DT010

Type: Light	Range: 0 to 130klx
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Sensor description

The DT010 is a light sensor designed for measurements of light ranging from 0 to 130klx. The DT010 uses the Fourier System egg-shaped sensor case and is ideal for measurements of outdoor light.



How it works



The DT010 is a high precision photoelectric cell. Inside this photoelectric cell is a small plate made of elements called "pin-diodes". When a reversed fixed voltage is applied to the photoelectric cell, any photon that hits the pin-diodes causes the photoelectric cell to release an electron. As a result, when light level is higher, the current through the photoelectric cell is higher. The current from the cell then passes through a resistor. The voltage is measured on this resistor and adjusted to the range of 0-5 Volts that is accepted by the analog-digital converter of the Data Logger. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT010 requires no calibration.

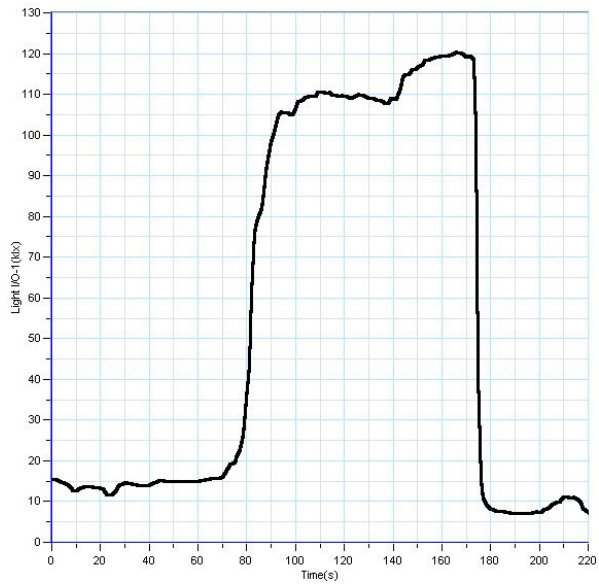
Selecting units:

MultiLab displays the data in lx. to change the acceleration units to W/m²:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the light sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What it is used for

The DT010 is used for experiments in Biology, Chemistry, and Environmental sciences. Due to its high range, it is most useful for outside measurements, like measuring abiotic conditions above and under a rock.



Outdoor and indoor light levels measured with DT010

Specifications:

- Range: 0 to 130klx.
- 12-bit Resolution (TriLog): 40 lx
- 10-bit Resolution (MultiLogPRO, MultiLog): 120 lx
- Spectral range: Visible light.

Light (0 to 6.6lx)

DT009

Type: Light	Range: 0 to 6.6lx
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Sensor description

The DT009 is a high precision, quick response light sensor, designed for measurements of light ranging from 0 to 6.6lx. The DT009 uses the Fourier System egg-shaped sensor case and is ideal for light interference and light diffraction measurements.



How it works



The DT009 is a high precision photoelectric cell. Inside this photoelectric cell there is a small plate made of elements called "pin-diodes". When a reversed fixed voltage is applied to the photoelectric cell, any photon that hits the pin-diodes causes the photoelectric cell to release an electron. The result is that when light level is higher, the current through the photoelectric cell is higher. The current from the cell then passes through a resistor. The voltage is measured on this resistor and adjusted to the range of 0-5 Volts that is accepted by the analog-digital converter of the Data Logger. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT009 requires no calibration.

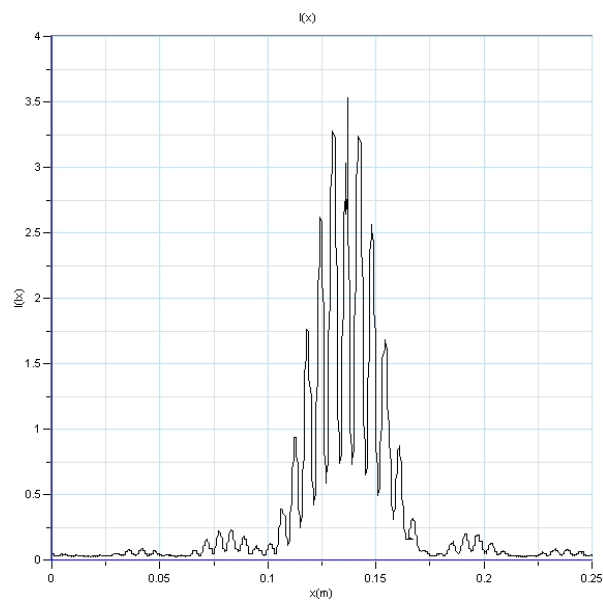
Selecting units:

MultiLab displays the data in lx. to change the acceleration units to W/m²:

5. Click **Setup Wizard**  on the main toolbar
6. Click **Properties**  next to the light sensor input
7. Check the checkbox next to the desired unit to select it.
8. Click **OK**

What it is used for

The DT009 is used as a high resolution light sensor in experiments such as diffraction and interference of light. The following graph displays laser interference through two slits.



A light interference measurement using the DT009

Specifications:

- Range: 0 to 6.6 lx
- 12-bit Resolution (TriLog): 0.00175lx
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.007lx
- Spectral range: Visible light.
- Bandwidth: 3000 Hz.

Light (0 to 300lx)

DT009-1

Type: Light	Range: 0 to 300lx
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Sensor description

The DT009-1 is a high precision, quick response light sensor, designed for measurements in the range of 0 to 300lx. This light sensor is ideal for indoor light measurements.

How it works

The DT009-1 is a high precision Photoelectric cell. Inside this photoelectric cell there is a small plate made of elements called "pin-diodes".

When a reversed fixed voltage is applied to the photoelectric cell, any photon that hits the pin-diodes causes the photoelectric cell to release an electron. The result is that when light levels are higher, the current through the photoelectric cell is higher. The current from the cell then passes through a resistor. The voltage is measured on this resistor and adjusted to the range of 0-5 Volts that is accepted by the analog-digital converter of the Data Logger. The proper result is then recorded and stored in the data logger's memory.





Calibration

The DT009-1 requires no calibration.

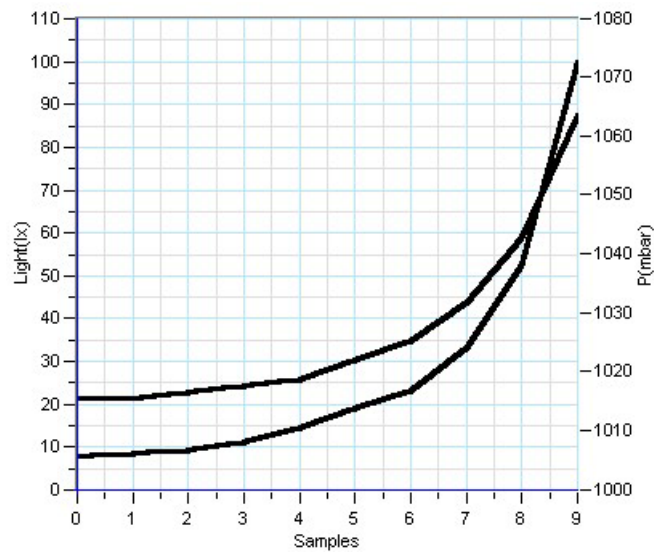
Selecting units:

MultiLab displays the data in lx. to change the acceleration units to W/m²:

9. Click **Setup Wizard**  on the main toolbar
10. Click **Properties**  next to the light sensor input
11. Check the checkbox next to the desired unit to select it.
12. Click **OK**

What is it used for:

The DT009-1 is a very sensitive light sensor, which is usually used in room light environments. It is used in experiments like light interference, bulb intensities, light absorbance, photosynthesis and more.



Measurement of photosynthesis

Specifications:

- Range: 0 to 300 lx
- 12-bit Resolution (TriLog): 0.075 lx
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.3 lx
- Error: 20% over entire range (before calibration)
- Spectral Response: Visible light

Light (triple range)

DT009-4

Type: Light	Triple Range: 0 – 600lx 0 – 6klx 0 – 150klx
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Sensor description

The DT009-4 is an all purpose, high precision, quick response light sensor, designed for measurements of three ranges, 0 to 600lx, 0 to 6klx and 0 to 150klx making it an ideal sensor for both indoor and outdoor light measurements.

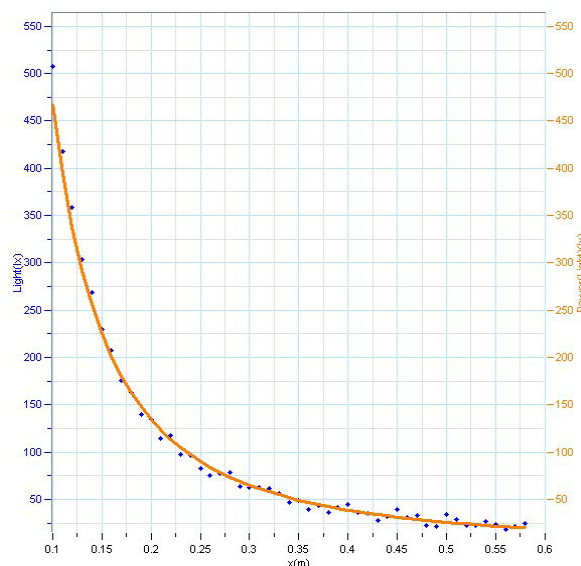
How it works

The DT009-4 is a high precision photoelectric cell, inside the cell there is a small plate made of elements called "pin-diodes". When a reversed fixed voltage is applied to the photoelectric cell, any photon that hits the pin-diodes causes the photoelectric cell to release an electron. The result is that when light levels are higher, the current through the photoelectric cell is higher. The current from the cell then passes through a resistor. The voltage is measured and amplified adjusted to the range of 0-5 Volts that is accepted by the analog-digital converter of the Data Logger. The proper result is then recorded and stored in the data logger's memory.



Calibration

The DT009-4 requires no calibration.



Light intensity vs. distance

What is it used for:

The DT009-4 is a very sensitive light sensor, which can be used both in indoor and outdoor environments. In room light environments it is used in experiments

like bulb intensities, light absorbance, photosynthesis and more as well as in outdoor experiments measuring solar radiation.

Specifications:

- Ranges:
 - 0 – 600lx
 - 0 – 6klx
 - 0 – 150klx
- 12-bit Resolution (TriLog):

0 – 600lx	0.2lx
0 – 6klx	1.5lx
0 – 150klx	37lx
- 10-bit Resolution (MultiLogPRO, MultiLog):

0 – 600lx	0.6lx
0 – 6klx	6lx
0 – 150klx	147lx
- Spectral Response: Visible light

Magnetic Field

DT156

Type: Magnetic Field Sensor	Dual Range: ± 10 mT ± 0.2 mT
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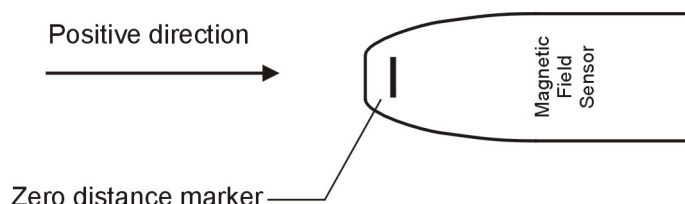
Sensor description

The Magnetic Field sensor has two ranges. Low resolution range to explore the nature and strengths of magnetic fields of solenoids and permanent magnets and high resolution range to explore the Earth's magnetic field

How it works

The sensor uses a Hall Effect transducer, which produces a voltage, which is proportional to the magnetic field. The sensor measures the axial component of the magnetic field (parallel to the sensor tube).

The line mark at the front of the sensor indicates the exact location of the hall element. The magnetic field sensor measures positive values when the magnetic field points towards the sensor (see figure below).





Selecting the range

Flick the sensitivity switch on the top of the sensor tube to the desired range: High (± 0.2 mT) or Low (± 10 mT)

Selecting units:

The default unit is Tesla. To change the units to Gauss:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the magnetic field sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

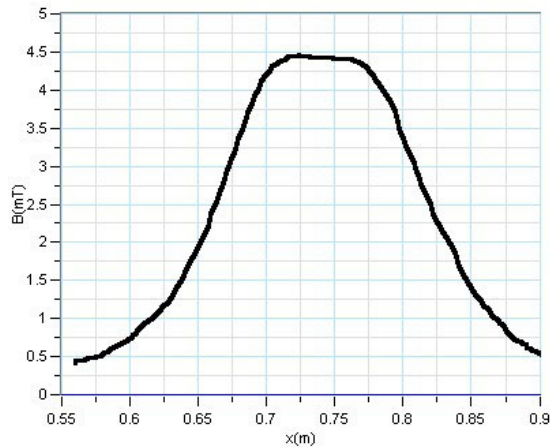
Calibration

The DT156 ships fully calibrated. For further calibration an offset calibration screw is located at the top of the sensor tube. Place the sensor in a known

magnetic field and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.

What it is used for

The Magnetic Field sensor can be used for a variety of interesting experiments like measurement of the earth's magnetic field or studying the magnetic field near a permanent magnet, near a current-carrying wire or inside a solenoid.



Magnetic field produced by a pair of Helmholtz coils

Specifications:

- Two Ranges:
High sensitivity ± 0.2 mT
Low sensitivity ± 10 mT
- 12-bit Resolution (TriLog):
0.0001 mT (high sensitivity)
0.005 mT (low sensitivity)
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.0004 mT (high sensitivity)
0.02 mT (low sensitivity)

Microphone

DT008

Type : Microphone	Range: ± 2.5 V
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Sensor description

The DT008 is a sound sensor (microphone) giving an output of ± 2.5 Volts. The DT008 is not a noise level sensor, but designed to study the properties of sound waves. The DT008 uses the Fourier System egg-shaped sensor case. The frequency range of the DT008 is 35Hz to 10000Hz.



How it works

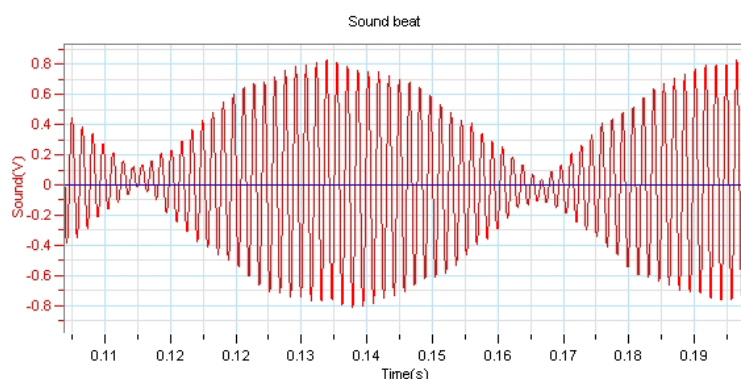
The microphone component inside the DT008 is composed of a variable capacitor. One of the capacitor's plates is actually a sound-sensitive membrane, moving back and forth as sound waves resonant through it. This capacitor is connected serial to a resistor. When the capacitor is charged, and sound waves change the dielectric parameter of the capacitor, the voltage measured on the resistor changes. This voltage is then adjusted to a range of 0-5 Volts, accepted by the analog-digital converter of the Data-Logger, and transformed to a value between -2.5 to 2.5 Volts. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT008 requires no calibration.

What it is used for

The DT008 is used for the study of sound properties. Sound speed through air and other materials, Sound Beats and harmonic properties of sound are among the experiments using the DT008. The following graph is a measurement of two interfering sound waves, creating a "sound beat".



A sound measurement of two interfering waves using the DT008

Specifications:

- Range: -2.5 V to $+2.5$ V.
- 12-bit Resolution (TriLog): 1.22 mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 5 mV
- Frequency response: 35 Hz to 10000 Hz.

Nitrate selective

AC017A

Type: Ion selective electrode	Range: 1 M to 5×10^{-7} M (40,000 – 0.02 ppm)
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Sensor description

The AC017A Ion Selective Sensor is used for fast, reliable and accurate measurement of Nitrate concentration in aqueous solutions. The AC017A consist of FastFill Nitrate selective combination electrode (it combines the Ion Selective electrode and the reference electrode in one) and Fourier's ISE amplifier/adaptor.



How it works

The Ion Selective Electrode (ISE) uses ion selective membrane to allow only NO_3^- ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the Nitrate ion according with the Nernst equation:

$$E = E_0 + S \cdot \ln(a)$$

Where E is the measured voltage, E_0 the reference potential, S – the slope and a is the Nitrate activity. The slope is given by:

$$S = \frac{RT}{nF}$$

Where R is the gas constant, T the temperature in Kelvin, n – charge of the ion and F is Faraday constant.

If the ionic strength is high and constant, Nernst equation can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where C is the Ionic concentration

To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.

The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids

in making electrical contact between the reference electrode (which is not in physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

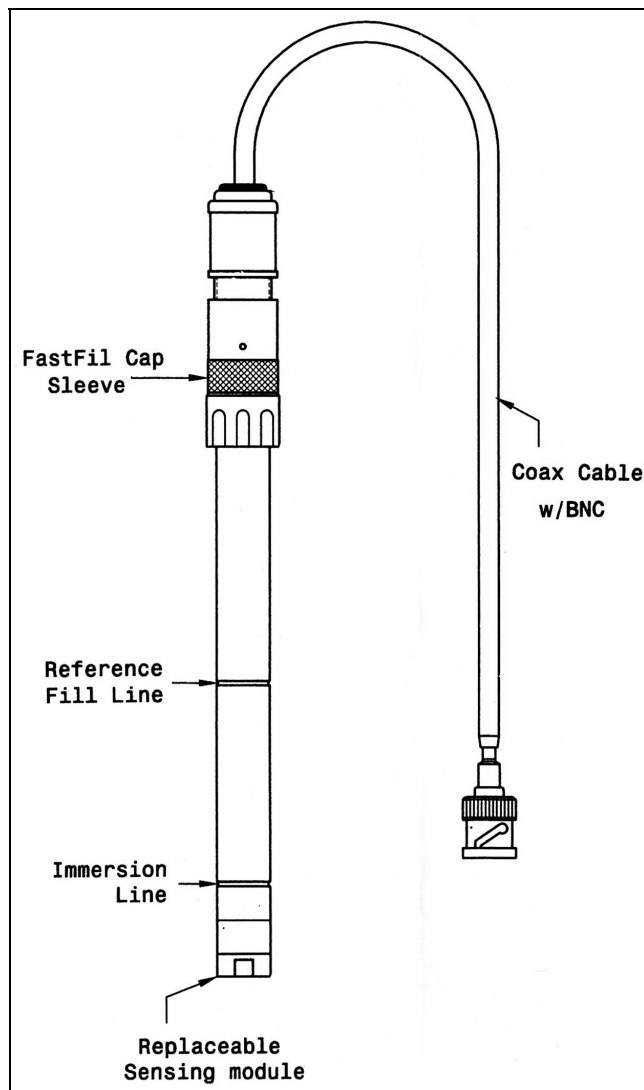


Figure 1: AC017 NO₃⁻ Ion Selective Electrode

Items included

- (1) Combination NO₃⁻ Electrode
- (1) ISE amplifier
- (1) 1 oz NO₃⁻ Reference Filling Solution (RF0011)
- (1) 1 oz NO₃⁻ Ionic Strength Adjuster (ISA) (AJ0011)
- (1) 1 oz NO₃⁻ 10ppm as N Standard (SD2051)
- (1) 1 oz NO₃⁻ 1000ppm as N Standard (SD2030)

Required Equipment

- MultiLogPRO or TriLog
- Wash bottle with distilled or deionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation

1. The AC017 sensing element comes premounted on the end of the electrode with a protective bottle, but can be removed by unscrewing the electrode end. **Caution: Do not touch the PVC membrane with your fingers or over tighten the sensing element** (see Figure 4)
2. The reference chamber must be filled with Reference Fill Solution and remain open during testing and measuring:
 - a) Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 2)
 - b) Fill the reference chamber with the Reference Fill Solution provided above the reference fill line on the electrode (see Figure 1)
3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside
4. Rinse the electrode with DI water, blot dry. **Do not rub dry**
5. Condition the electrode in a 10ppm solution for 30 minutes
6. After the conditioning period, rinse the tip of the electrode with DI water

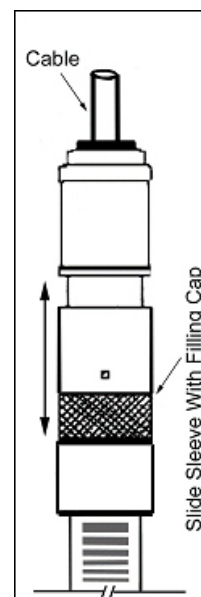


Figure 2:Reference Fill Cap

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

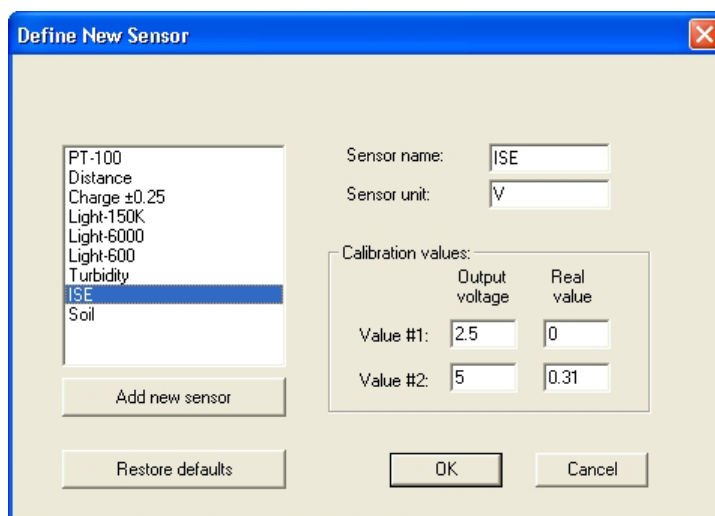


Figure 3: ISE sensor definition

you should see **ISE** on the sensors list (the eighth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **ISE** on the sensor list, click **Restore defaults**. If you still don't see **ISE** go to Fourier's web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 3 to define the sensor manually.

Checking Electrode Operation (Slope)

Check the electrode every day when measurements will be conducted

1. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly
3. Begin recording
4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2
5. Pipette 1 mL of 1000 ppm Nitrate Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed
6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs
7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope. The normal range for the slope is 28 ± 2 mV at 25°C

Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use
2. Repeat "Checking Electrode Operation" procedure again

Note: All standard solutions should be prepared fresh. Use ISA in all solutions.

Periodically check the Reference Fill Solution level in the reference chamber. The solution level must be above than the reference fill line (see Figure 1).

If the electrode slope is still outside the normal range after this procedure, replace the sensing module.

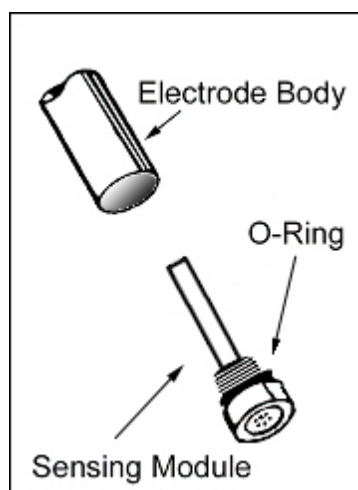


Figure 4: replacing the Sensing Module

Reading a Sample with the Electrode

Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.

ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.

Calibrate once a day before measurements.

The filling hole must remain open during measurements (see Figure 2).

Set up:

1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample

Measurement:

1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA. Stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir
4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard
5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 5 for a typical calibration curve

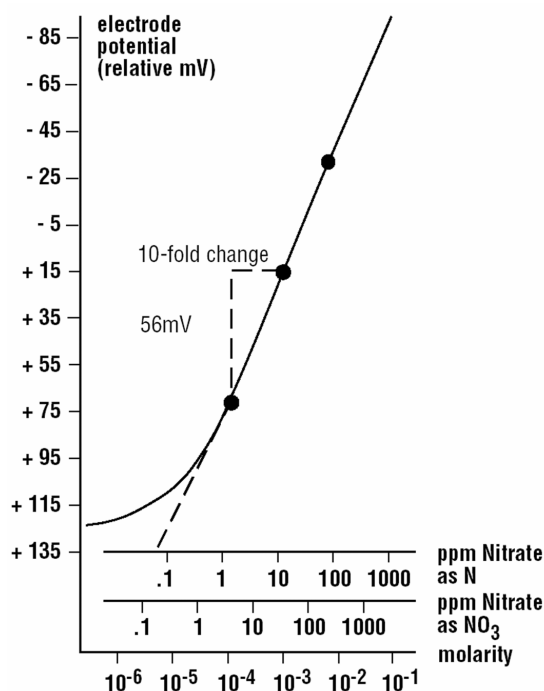


Figure 5: Typical calibration curve

6. Pipette 100 mL of sample into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
7. Rinse electrode with DI water, blot dry and place in the sample beaker. Wait for a stable reading and record the voltage reading
8. Use the calibration curve to determine the sample's concentration

Electrode Storage

Short Term:

Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry.

We recommend cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:

Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.

Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

What it is used for

Ion-selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which ISEs have been used:

Pollution Monitoring: CN, F, S, Cl, NO₃ etc., in effluents, and natural waters.

Agriculture: NO₃, Cl, NH₄, K, Ca, I, CN in soils, plant material, fertilizers and feedstuffs.

Food Processing: NO₃, NO₂ in meat preservatives.
 Salt content of meat, fish, dairy products, fruit juices, brewing solutions
 F in drinking water and other drinks
 Ca in dairy products and beer
 K in fruit juices and wine making
 Corrosive effect of NO₃ in canned foods
 Detergent Manufacture: Ca, Ba, F for studying effects on water quality.
 Paper Manufacture: S and Cl in pulping and recovery-cycle liquors.
 Explosives: F, Cl, NO₃ in explosive materials and combustion products.
 Electroplating: F and Cl in etching baths; S in anodising baths.
 Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat).
 F in skeletal and dental studies
 Education and Research: Wide range of applications.

Specifications:

- Range: 1 M to 5 x 10⁻⁷ M
(40,000 – 0.02 ppm)
- 12-bit Resolution (TriLog): 0.15mV
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.6mV
- pH Range: 2.5 to 11 pH
- Temperature Range: 0 to 40°C
- Electrode Resistance: 1 to 4MΩ
- Reproducibility: ±4%
- Minimum Sample Size: 3 mL in a 50 mL beaker
- Interfering Ions: Pb²⁺, Hg²⁺, Si²⁺, Fe²⁺, Cu²⁺, Ni²⁺, NH₃,
Na⁺, Li⁺, Tris⁺, K⁺, Ba⁺, Zn²⁺, Mg²⁺

Solutions

- 1000ppm Ca (0.249 M Ca): Dissolve 3.668g CaCl₂·2H₂O in DI water
and dilute to 1000mL
- ISA 4M KCl: 300g KCl in 1000mL DI water
- Reference (1M KNO₃): 100g KNO₃ in 1000mL DI water

Ordering information

ISE amplifier & electrode set	AC017A
ISE amplifier only	AC021
Electrode only	AC017

Oxygen

DT222A

Type: Oxygen electrode and adaptor	Dual Range: 0 – 12.5mg/L DO ₂ 0 – 25% O ₂
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Sensor description

The Oxygen sensor consists of an oxygen sensitive electrode with a processing unit (oxygen adaptor, equipped with a calibration knob).

The sensor can measure % O₂ in air and O₂ concentration in aqueous solutions. Select the range directly from the Data logger or via MultiLab. Calibrate the sensor before every measurement.

The sensor is supplied with five spare membranes, 30ml electrolyte solution, a syringe and a soaking bottle.



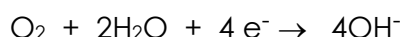
How it works

The probe is a galvanic measuring element that produces a mill-volt output directly proportional to the oxygen present in the medium in which it is placed. It consists of an upper part comprising cathode, anode and cable, and the lower part comprising of membrane cap, membrane and electrolyte.

Oxygen diffuses through the membrane onto the cathode, where it is consumed. This process produces an electrical current that flows through the cable to the meter. The electric current produced is proportional to the oxygen that passes through the membrane and the layer of electrolyte. This makes it possible to measure the partial pressure of oxygen in the sample at a given temperature.

Since the cathode consumes the DO in the sample, it is essential that a new sample must flow past the membrane of the probe to prevent the occurrence of false readings. The probe uses very little oxygen for its measurement. This enables it to function correctly with liquid movement as low as 2.5 cm/sec

DO probes respond to the partial pressure of oxygen in liquid or gas being measured – they measure the “pressure” of oxygen rather than concentration. All of the oxygen entering the probe is consumed at the cathode where it is electrochemically reduced to hydroxyl ions producing an electrical current within the probe:



Since all oxygen entering the probe is chemically consumed, the partial pressure of oxygen in the electrolyte is zero. Therefore, a partial pressure gradient exists across the membrane and the rate at which oxygen enters the probe is a function of the partial pressure of oxygen in the gas or in liquid being measured.

Note: If other electrochemical type sensors (pH and Conductivity) are put in the same solution at the same time and connected to the same Data logger, they can interfere with each other's signals. Keep the sensors as far apart as possible –the distance required will depend on the conductivity of the solution. If the problem persists, try connecting the sensors to different Data loggers, or take readings using one sensor at a time.

Temperature Compensation

When a probe is placed in air-saturated water, the current it produces will not be affected by the temperature or salinity of the water. The DO concentration in the water, however, will vary with temperature and salinity. Because it is convenient to report DO concentration in mg/l, it is necessary to adjust for temperature and salinity of the water to get correct readings in these units.

If DO were to be reported in terms of % Saturation, then temperature and/or salinity compensation for oxygen solubility would not be necessary.

To allow for temperature compensation, plug a temperature sensor to the Data logger's 1st input and the oxygen sensor to the 2nd input. Insert both sensors to the sampled solution. MultiLogPRO will automatically compensate for temperature changes.

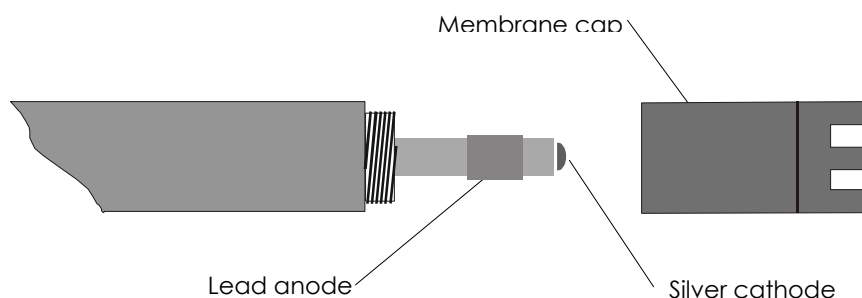
If no temperature sensor is employed MultiLogPRO assumes that the temperature is 25°C.

Preparing the Oxygen electrode

1. Remove the membrane cap by unscrewing it
2. Gently clean the silver cathode with a dry cloth
3. Place the membrane cap, with the membrane downward, on a clean surface
4. Use the syringe to half fill the cap with the electrolyte supplied. Tap the cap gently to remove any air bubbles from the electrolyte

Note: It is important to remove trapped air bubbles because they will feed oxygen to the cathode and hence cause extra signal current to flow regardless of the oxygen concentration in the sample

5. Hold the electrode body vertically (with the cable uppermost) and screw on the membrane cap. One side of the thread is flat which will allow any surplus electrolyte to escape



6. Plug the Oxygen electrode into the BNC socket on the adaptor

7. Connect the Oxygen sensor to the Data logger. Turn the Data logger on and leave the adaptor and electrode connected to the Data logger for **15 minutes** in order to stabilize before use

Selecting the range

The default range in auto ID mode is DO₂ (0 – 14mg/L). To set the Data logger to O₂ (0 – 25%) range switch the MultiLogPRO to 8 sensors mode and select the required range from the sensor list.

Calibration

Note: When the electrode reading is too low and can not be adjusted with the adaptor gain knob - gently clean the silver cathode with a dry cloth.



To calibrate for use in Gas or Air:

Leave the electrode in the air, start recording and turn the knob on the Oxygen adaptor until a value of **20.9%** is shown.

To calibrate for use in aqueous solutions (0 – 14mg/L DO₂) and to compensate your DO₂ sensor for the right salinity and/or altitude parameters:

Use the **Do2 Calibration** command from the **Configuration** menu on the MultiLogPRO:

1. In the **MAIN MENU** screen, use the arrow buttons to navigate to

the **System configuration** icon , then press **Enter**  to display the configuration screen.

2. Press the **Enter** button  three times to select **Do2 Calibration**

3. Press the **Forward** arrow button  to enter the DO₂ calibration screen

4. Use the **arrow** buttons to select salinity between 0, 5, 10, 15, 20, 25, 30 and 35 ppt and press the **Enter** button to confirm and move to "calibrate altitude".

5. Use the arrow buttons to select altitude between 0, 500, 1000, 1500, 2000, 2500, 3000 and 3500 ft and press the **Enter** button to confirm.

MultiLogPRO will display the saturation level at 25°C and will exit the DO₂ calibration screen. Write down the saturation level.

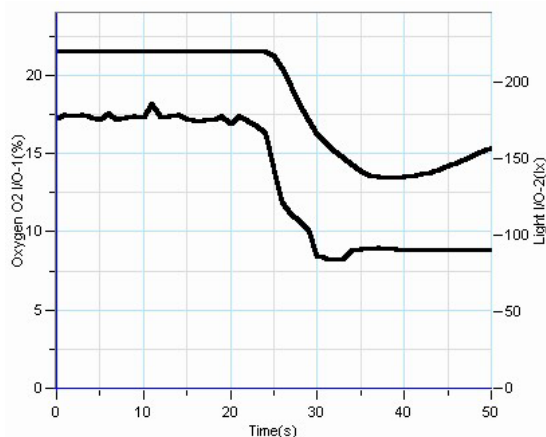
The new calibration parameters will be saved until the next time you change them.

6. Press the **Escape** button  twice to return to the main menu

7. Stir a cup of distilled water over a magnetic stirrer for two hours. Insert the Oxygen electrode to the water. Start recording and turn the knob on the Oxygen adaptor until the saturation level is shown.

Salinity and altitude (pressure) compensation

See **Calibration** for use in aqueous solutions (0 – 14mg/L DO₂) above.



oxygen level drops as CO₂ sinks in the "Dog's cave"

Troubleshooting

When experiencing difficulties with the equipment, keep in mind the following:

Check for the obvious, such as the physical condition of the probe, any signs of damage to the cable, power or signal connections etc.

Determine whether it is the probe, meter or the surrounding environment that is causing the problem.

The following troubleshooting table identifies most of the problems likely to occur:

Problem	Probable Causes	Solution
1. Fluctuating readings when probe is shaken or bumped lightly or when membrane is touched.	Probe has lost electrolyte – a sloshing noise will be heard when the probe is shaken. Torn or damaged membrane. Wet connections in the wiring or within probe. See Problem 2.	Determine whether the probe problem is physical or electronic. Unscrew the membrane cap, discard the electrolyte, membrane and O-ring. Dry the internals of the probe, especially the cathode with a soft cloth. Switch the meter ON and observe the display. If the display reads zero, the probe and cable circuitry are working. Service probe and change membrane. If the display does not read zero, but some other value, then there is probably moisture somewhere. See Problem 2.
2. With membrane cap removed and probe internals thoroughly dry, the reading from the probe is not zero and/or is erratic.	Moisture has entered the system – either into the probe itself or at junctions or points in the cable. This moisture creates a secondary galvanic action in addition to that produced by the probe and results in non-zero or erratic readings.	Locate the source of moisture by a process of elimination. If moisture has entered a junction box or a cable joint, thoroughly dry out the area and take measures to prevent reoccurrence.
3. It is not possible to calibrate the probe in air – the display will not read high enough after fully adjusting the offset.	Probe has dried out – no electrolyte inside. Probe is overdue for servicing – excessive build-up of anode oxide. A deposit has built-up on the silver cathode, which is inhibiting the reduction of oxygen at its surface.	Service probe and change membrane. Use a stiff nylon brush to remove the oxide built-up from the anode. Do not use a wire brush. It is only necessary to remove the loose oxide layer. If it is suspected that the anode is badly corroded, replace with a new DO probe. Remember to tighten the nut under the anode before fitting a new anode. If it is suspected that a deposit is coating the silver cathode, clean the cathode with 400 grit wet/dry emery paper or with some scouring powder. The deposit is sometimes visible as a brownish stain on the surface of the cathode.

Problem	Probable Causes	Solution
4. Display values are erratic when membrane is lightly touched. Membrane has bulged outwards.	<p>The membrane has been damaged.</p> <p>The breather hole has become plugged. This prevents release of internal pressure due to expansion of electrolyte caused by the probe being warmed up in the sun, for example.</p>	<p>If the membrane has been damaged then change it and service the probe.</p> <p>If the breather hole is blocked, clear hole with a pin or fine gauge wire. Change the membrane and service the probe.</p>

NOTE: The cathode must not be polished – the surface must remain dull (do not use a wire brush).

Storage

After measurement is complete, rinse the probe with distilled water and store the electrode.

The dissolved oxygen electrode is best stored dry. As such, it's should be left in the open.

Zero oxygen solution

Dissolve a few grains of the zero oxygen powder in distilled water.

Cleaning and maintenance

The probe is virtually maintenance free, requiring only its membrane to be kept reasonably clean. The membrane material has been specially chosen to ensure a negligible influence of deposits on the surface. In any biological active systems, deposits will be found on any surface, including the oxygen probe. Since deposits act as a barrier to the oxygen diffusing through the membrane, the membrane must be cleaned at regular intervals. The frequency depends on factors such as the biological loading of the system, the oxygen consumption of the probe and the accuracy needed.

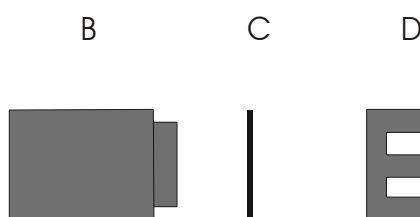
It is recommended to clean the membrane regularly to ensure maximum reliability. Although the membrane is very robust and can be simply wiped clean with cloth or paper, care must still be taken.

NOTE: The probe should not be taken apart unless it needs renovation. It is also important to handle the probe with care.

Membrane Replacement

A new membrane can be fitted easily according to the following steps:

1. Remove guard cup
2. Remove and discard the old membrane (C). Clean top of cover cap (B)



3. Place a new membrane over top of cover cap and press guard cap tightly into position. Trim excessive membrane

4. Fill the cover cap with fresh refilling electrolyte solution using the syringe provided. Screw cover cap back to the probe and wipe it dry

Electrolyte Replacement

There is no need to exchange the electrolyte on a regular basis.

Refilling is needed under the following circumstances:

1. When the probe is used for an extended period of time
2. When the internal electrolyte has dried up
3. When there is a fluctuating reading
4. When it is not possible to calibrate

To replace the electrolyte, remove the cover cap from the probe. Discard the used solution, rinse thoroughly with distilled water and fill the cover cap with new refilling electrolyte solution using a syringe. Screw cover cap back to the probe and wipe it dry

Probe Renovation

You may need to rejuvenate only if the following symptoms occur:

1. If it is not possible to calibrate to 100% due to loss of slope (output);
2. If the reading is unstable. This may be due to a perforated membrane;
3. If a white ring or white dots can be seen around the anode, e.g. due to heavy build-up of oxide.

This procedure is only recommended if the above procedure fails to stabilize reading or a constant difficulty in calibration:

1. Rinse the probe thoroughly in distilled water and wipe it clean
2. Follow the steps 1 to 3 as per membrane replacement
3. Clean the anode with a non-metallic brush, alternatively wet or dry emery paper grade 600 gently
4. Fill the cover cap with fresh refilling electrolyte solution using a syringe provided. Screw cover cap back to the probe and wipe it dry

*Note: After renovation, calibration has to be done. **AVOID UNNECESSARY RENOVATION!***

What is it used for:

- Monitoring human respiration
- Changes in oxygen during photosynthesis and respiration of plants
- Monitoring dissolved oxygen concentration resulting from photosynthesis and respiration in an aquarium containing plants and/or fish.
- Demonstrating how oxygen is removed from the air by re-breathing the sample of air in a paper bag using different patterns of breathing

- Monitoring the pattern between light and dissolved oxygen levels, in an aquarium with pondweed
- On-site testing in streams & ponds - lake survey to evaluate the capability of the water to support different types of plant and animal life
- Respiration of animals, insects, germinating seeds
- Consumption of oxygen by yeast during respiration of sugars
- The effect of temperature change on the solubility of oxygen
- Fermentation of yoghurt
- Oxidation of metals
- Discovering the change in oxygen level during combustion – using a candle burning in a bell jar

SPECIFICATION

- Range:

DO ₂	0 – 125% ¹
DO ₂	0 – 12.5mg/L
O ₂	0 – 25%
- 12-bit Resolution (TriLog):

0 – 125%	0.09%
0 – 14mg/L	0.007 mg/L
0 – 25%	0.013%
- 10-bit Resolution (MultiLogPRO, MultiLog):

0 – 125%	0.25%
0 – 14mg/L	0.028 mg/L
0 – 25%	0.052%

Electrode specifications:

- Galvanic dissolved oxygen probe
- Diameter: 12 mm
- Output span: 30-50 mV
- Offset: 0-5 mV
- Anode: Lead (Pb)
- Cathode: Silver (Ag)
- Cable: 1-meter termination in BNC connector

Ordering information

Adaptor & electrode set	DT222A
Adaptor only	DT222
Electrode only	DT118

¹ MultiLab Software will cut everything above 125%, while the MultiLog will still show more because the adapter is inaccurate above 125% DO₂

pH

DT016

Type: pH	Range: 0 to 14
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Sensor description

The DT016 is a pH sensor measuring the entire range of 0 to 14pH. The DT016 consists of the Fourier Systems egg-shaped adaptor and a pH electrode. The sensor is equipped with an automatic temperature compensation system. In order to use temperature compensation a temperature sensor should be connected to the Data logger along with the pH sensor (the temperature sensor must be plugged into input 1).



How it works

The pH electrode contains two half-cells. One contains a reference element of known H^+ -concentration. The other, at the bottom of the electrode, is an H^+ -sensitive glass membrane. The adaptor measures and amplifies the potential difference between the two half-cells. The pH level ($pH = -\log(H^+)$) is calculated from the potential difference.

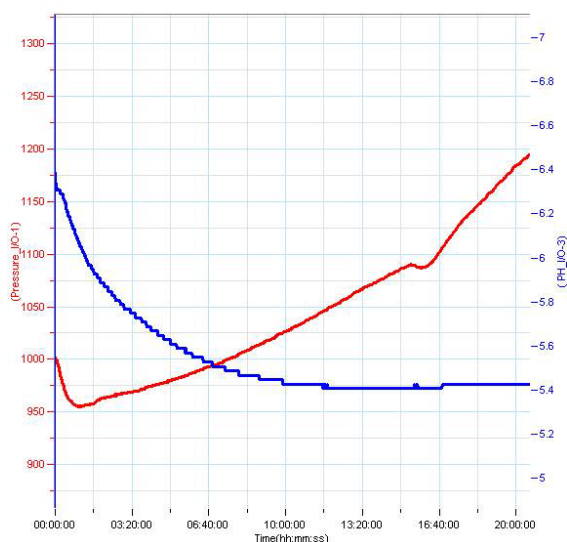
Calibration

The DT016 is shipped fully calibrated. For experiments that require very accurate calibration, however, the DT016 is equipped with an offset calibration screw. The screw is located at the back of the sensor case. Place the electrode in a reference solution (buffer of pH 7) and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.

Note: If other electrochemical type sensors (Oxygen and Conductivity) are put in the same solution at the same time and connected to the same Data logger, they can interfere with each other's signals. Keep the sensors as far apart as possible -the distance required will depend on the conductivity of the solution. If there is still a problem, try connecting the sensors to different Data loggers or take readings using one sensor at a time.

What is it used for:

The DT016 is used for various experiments in Biology, Chemistry and Environmental Science. For measuring the pH of bodies of water over long periods of time, experiments such as diffusion of liquids, acidification of milk, or acid-base titration.



Monitoring corn germination with pH sensor

Specifications:

- Range: 0 - 14 pH.
- 12-bit Resolution (TriLog): 0.005 pH
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.02 pH
- Operating temperature: 0 - 100 °C
- Total accuracy: $\pm 2\%$ over full range (after temperature compensation).
- Response time for 95% of reading: 10 Sec.
- Equipped with calibration screw
- temperature compensation

Ordering information

Adaptor & electrode set

DT016

Adaptor only

DT017

Electrode only

DT018

Photo Gate

DT137

Type: Photo Gate	Range: 0-5V
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Sensor description

A general-purpose photo gate that measures the time it takes for an object to pass between its arms. It is used for a wide variety of experiments in physics and physical science classes.

Note: As this sensor is current consuming, it is highly recommended to operate it while the AC/DC adapter powers the Data logger.



How It Works

The Photo gate has a narrow, infrared beam and fast response time, which provide very accurate signals for timing. When the infrared beam between the source and detector is blocked, the output of the photo gate is "high" (High Voltage, 5V, on the graph) when the beam is not blocked; the output is "low" (Low Voltage, 0V, on the graph).

When working with the Data logger and MultiLab software, it should be referred to as a 0-5V sensor.

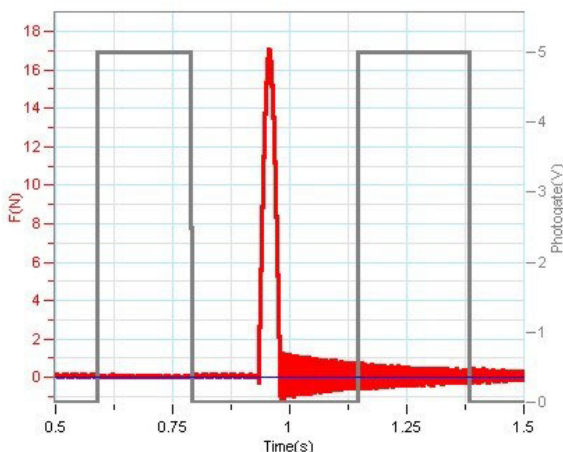
Calibration

The DT137 requires no calibration.

Note: If the surroundings is flooded with strong light, it may disturb the operation of the photo gate.

What is it used for:

- Measuring the acceleration due to gravity
- Studying the swing of a pendulum
- Measuring the speed of a rolling object
- Measuring the speed of objects undergoing collisions



Using the photo gate to measure velocities in a collision

Specifications

- Detector rise time: 180ns.
- Detector fall time: 180ns.
- Parallax error: For an object passing within 1 cm of the detector, with a velocity less than 10 m/s, the difference between the true and effective length is less than 1 mm.
- Infrared source: Peak at 800 nm.
- Signal output: MiniDin.

Potassium selective

AC008A

Type: Ion selective electrode	Range: 1 M to 7×10^{-6} M (39,000 – 90.04 ppm)
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Sensor description

The AC008A Ion Selective Sensor is used for fast, reliable and accurate measurement of Potassium concentration in aqueous solutions. The AC008A consists of FastFil Potassium selective combination electrode (it combines the Ion Selective electrode and the reference electrode in one) and Fourier's ISE amplifier/adaptor.



How it works

The Ion Selective Electrode (ISE) uses ion selective membrane to allow only K^+ ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the Potassium ion according with the Nernst equation:

$$E = E_0 + S \cdot \ln(a)$$

Where E is the measured voltage, E_0 the reference potential, S – the slope and a is the Potassium activity.
The slope is given by:

$$S = \frac{RT}{nF}$$

Where R is the gas constant, T the temperature in Kelvin, n – charge of the ion and F is Faraday constant.

If the ionic strength is high and constant, Nernst equation can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where C is the Ionic concentration

To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.

The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids

in making electrical contact between the reference electrode (which is not in physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

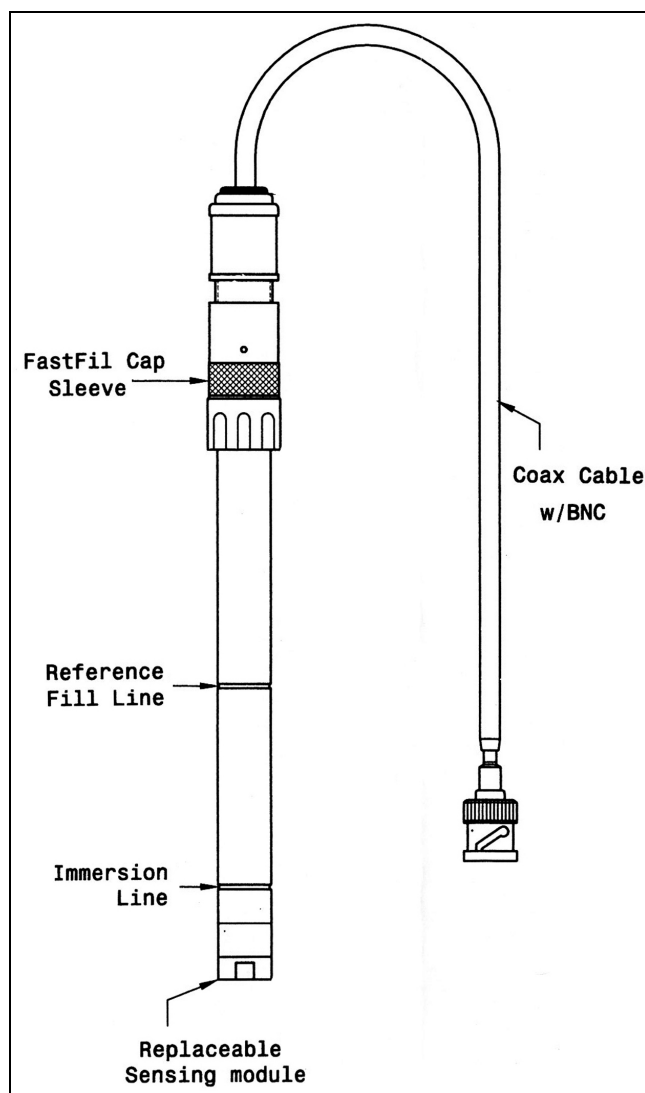


Figure 1: AC008 K⁺ Ion Selective Electrode

Items included

- (1) Combination K⁺ Electrode
- (1) ISE amplifier
- (1) 1 oz K⁺ Reference Filling Solution (RF0012)
- (1) 1 oz K⁺ Ionic Strength Adjuster (ISA) (AJ0015)
- (1) 1 oz K⁺ 10ppm as K Standard (SD2055)
- (1) 1 oz K⁺ 1000ppm as K Standard (SD2038)

Required Equipment

- MultiLogPRO or TriLog
- Wash bottle with distilled or deionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation

1. The AC008 sensing element comes premounted on the end of the electrode with a protective bottle, but can be removed by unscrewing the electrode end. **Caution: Do not touch the PVC membrane with your fingers or over tighten the sensing element** (see Figure 4)
2. The reference chamber must be filled with Reference Fill Solution and remain open during testing and measuring:
 - a. Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 2)
 - b. Fill the reference chamber with the Reference Fill Solution provided above the reference fill line on the electrode (see Figure 1)
3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside
4. Rinse the electrode with DI water, blot dry. **Do not rub dry**
5. Condition the electrode in a 10ppm solution for 30 minutes
6. After the conditioning period, rinse the tip of the electrode with DI water

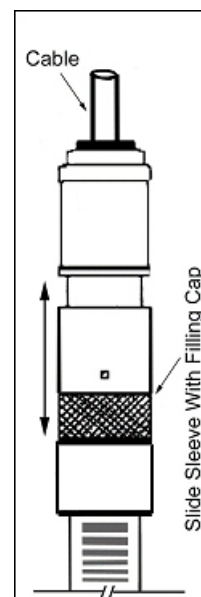


Figure 2:Reference Fill Cap

Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

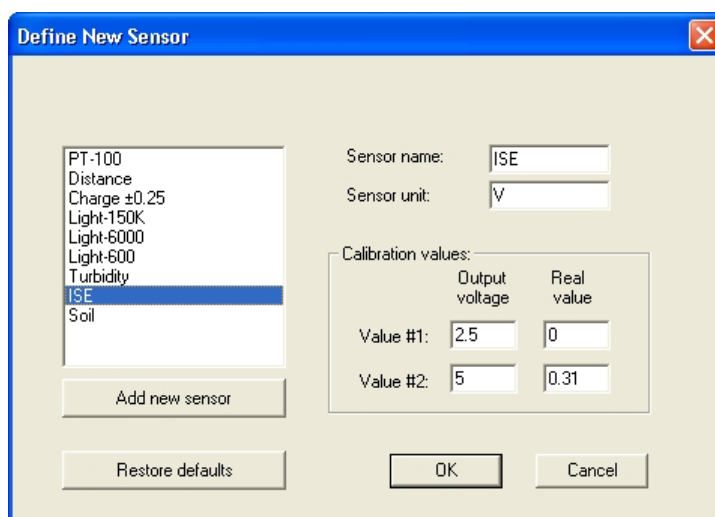


Figure 3: ISE sensor definition

you should see **ISE** on the sensors list (the eighth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **ISE** on the sensor list, click **Restore defaults**. If you still don't see **ISE** go to Fourier's web site www.fourier-sys.com and download the latest update of *Defined Sensors* file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 3 to define the sensor manually.

Checking Electrode Operation (Slope)

Check the electrode every day when measurements will be conducted

1. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly
3. Begin recording
4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2
5. Pipette 1 mL of 1000 ppm Potassium Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed
6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs
7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope. The normal range for the slope is 56 ± 4 mV at 25°C

Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use.
2. Repeat "Checking Electrode Operation" procedure again.

Note: All standard solutions should be prepared fresh. Use ISA in all solutions.

Periodically check the Reference Fill Solution level in the reference chamber. The solution level must be above than the reference fill line (see Figure 1).

If the electrode slope is still outside the normal range after this procedure, replace the sensing module.

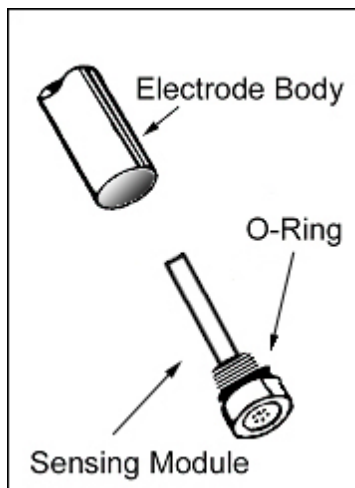


Figure 4: replacing the Sensing Module

Reading a Sample with the Electrode

Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.

ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.

Calibrate once a day before measurements.

The filling hole must remain open during measurements (see Figure 2).

Set up:

1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample

Measurement:

1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir

4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard
5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 5 for a typical calibration curve

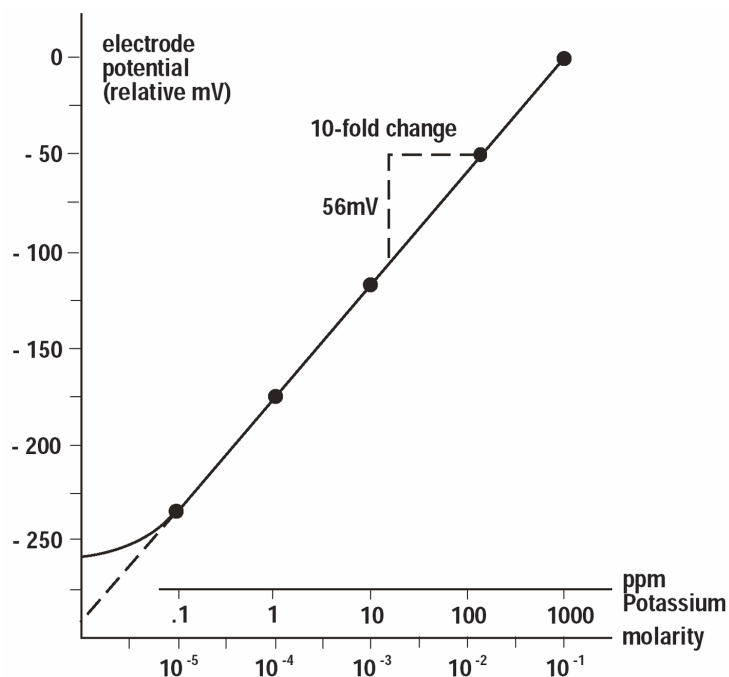


Figure 5: Typical calibration curve

6. Pipette 100 mL of sample into a 150 mL beaker. Add 2 mL of ISA and stir thoroughly
7. Rinse electrode with DI water, blot dry and place in the sample beaker. Wait for a stable reading and record the voltage reading
8. Use the calibration curve to determine the sample's concentration

Electrode Storage

Short Term:

Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry.

We recommend cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:

Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.

Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

What it is used for

Ion-selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which ISEs have been used:

Pollution Monitoring: CN, F, S, Cl, NO₃ etc., in effluents, and natural waters.

Agriculture: NO₃, Cl, NH₄, K, Ca, I, CN in soils, plant material, fertilizers and feedstuffs.

Food Processing: NO₃, NO₂ in meat preservatives.

Salt content of meat, fish, dairy products, fruit juices, brewing solutions

F in drinking water and other drinks

Ca in dairy products and beer

K in fruit juices and wine making

Corrosive effect of NO₃ in canned foods

Detergent Manufacture: Ca, Ba, F for studying effects on water quality.

Paper Manufacture: S and Cl in pulping and recovery-cycle liquors.

Explosives: F, Cl, NO₃ in explosive materials and combustion products.

Electroplating: F and Cl in etching baths; S in anodising baths.

Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat).

F in skeletal and dental studies

Education and Research: Wide range of applications.

Specifications:

- Range: 1 M to 7×10^{-6} M
(39,000 – 90.04 ppm)
- 12-bit Resolution (TriLog): 0.15mV
- 10-bit Resolution (MultiLogPRO, MultiLog):
0.6mV
- pH Range: 2.0 to 12 pH
- Temperature Range: 0 to 40°C
- Electrode Resistance: 10 to 20MΩ
- Reproducibility: ±2%
- Minimum Sample Size: 3 mL in a 50 mL beaker
- Interfering Ions: Cs⁺, Nh⁴⁺, Ti⁺, H⁺, Ag⁺, Tris⁺, Li⁺, Na⁺

Solutions

- 1000ppm K (0.0256 M K): Dissolve 1.910g KCl in DI water
- and dilute to 1000mL
- ISA 1M NaCl: 58.443g NaCl in 1000mL DI water
- Reference (0.1M NaCl): 29.22g NaCl in 1000mL DI water

Ordering information

ISE amplifier & electrode set	AC008A
ISE amplifier only	AC021
Electrode only	AC008

Pressure (0 to 10kPa)

DT015-2

Type: Gas Pressure	Range: 0 to 10kPa
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Sensor description

The DT015-2 pressure sensor measures low gas pressure between 0 to 10kPa. It is a gauge pressure sensor which measures the difference between applied pressure and the atmospheric pressure.



How it works



The main sensing unit inside the DT015-2 is composed of a pressure sensitive membrane, and a flexible resistor attached to it. This flexible resistor changes its resistance when it bends. When the pressure alters, the resistance changes, and according to Ohm's law so does the voltage drop across it. This voltage is then amplified to a range of 0-5 Volts, accepted by the analog-digital converter of the Data-Logger. The pressure is then calculated and stored in the data logger's memory.

Calibration

The DT015-2 ships fully calibrated. For further calibration an offset calibration screw is located at the back of the sensor case. Apply a known reference pressure to the sensor and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.



Selecting units

MultiLab displays the data in kPa. to change to other pressure units:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the pressure sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

Measuring water level and water volume

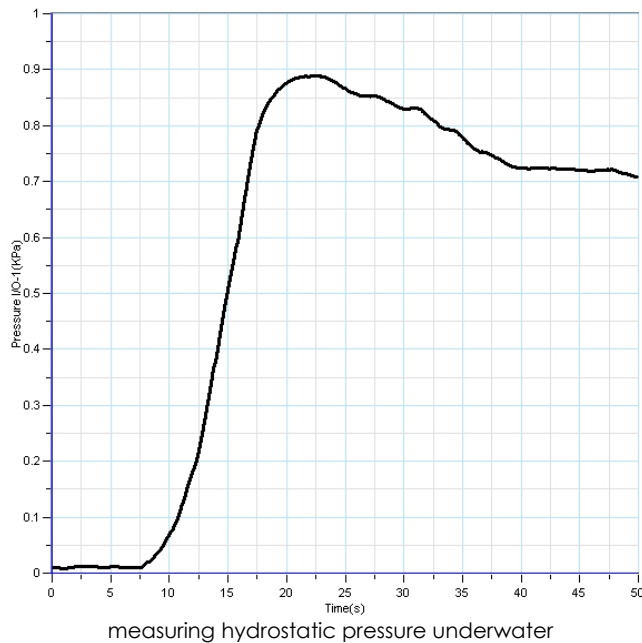
The DT015-2 can also be used to measure water level and water volume. Due to its high Resolution the sensor can detect few millimeters change in water level.

1. Place the sensor plastic tube under water (the sensor case must remain dry) and start measuring.
2. Click **Setup Wizard**  on the main toolbar
3. Click **Properties**  next to the pressure sensor input
4. To measure water level check the checkbox next to the **Pressure cm H2O** option

5. To measure water volume check the checkbox next to the **Volume** option, click the **Calibration** tab and enter the diameter of the vessel in which you are taking measurements, in cm, in the **Diameter** box
6. Click **OK**

What it is used for

The DT015-2 is used in Biology to measure water levels, as in plant water consumption experiments, by taking the water level out of the pressure. In Physics the sensor is used to measure hydrostatic pressure.



Specifications:

- Range:
0-10 kPa
- 12-bit Resolution
(TriLog): 2.5 Pa
- 10-bit Resolution
(MultiLogPRO,
MultiLog): 10 Pa
- Equipped with
offset calibration
screws.

Pressure (0 to 700kPa) DT015-1

Type: Gas Pressure	Range: 0 to 700kPa
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Sensor description

The DT015-1 is an absolute gas pressure sensor. It measures applied external pressure relative to zero pressure reference sealed inside the sensor.

How it works

The main sensing unit inside the DT015-1 is composed of a pressure sensitive membrane, and a flexible resistor attached to it. This flexible resistor changes its resistance when it bends.

When the pressure alters, the resistance changes, and according to Ohm's law so does the voltage drop across it. This voltage is then amplified to a range of 0-5 Volts, accepted by the analog-digital converter of the Data-Logger. The pressure is then calculated and recorded in the Logger's memory.





Calibration

The DT015-1 ships fully calibrated. For further calibration an offset calibration screw is located at the back of the sensor case. Apply a known reference pressure to the sensor and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached.

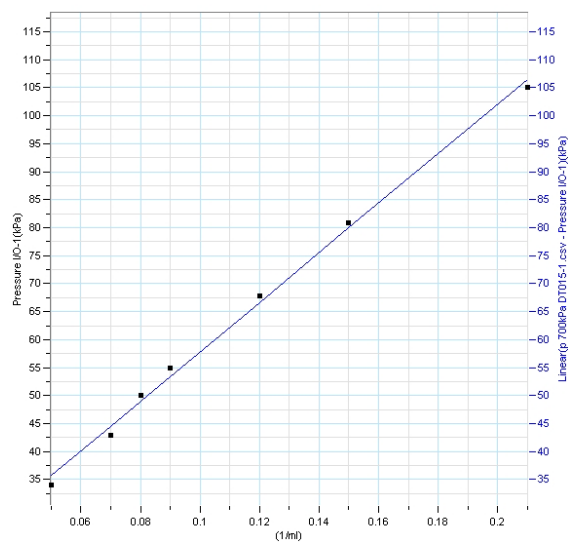
Selecting units

MultiLab displays the data in kPa. to change to other pressure units:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the pressure sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What it is used for

The DT015-1 is mostly used as a pressure sensor for experiments in Biology and Chemistry for topics like gas laws.



Verifying the ideal gas law using DT015-1

Specifications:

- Range: 0-700 kPa (0 – 7 atm)
- 12-bit Resolution (TriLog): 0.125 kPa
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.5 kPa
- Total accuracy: $\pm 0.05\%$ FS
- Operating temperature: 0-85°C
- Response time: 1ms
- Equipped with offset calibration screws

Pressure (150 to 1150mbar) DT015

Type: Gas Pressure	Range: 150 to 1150mbar
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Sensor description

The DT015 is an absolute gas pressure sensor. It measures applied external pressure relative to zero pressure reference sealed inside the sensor.

How it works

The main sensing unit inside the DT015 is composed of a pressure sensitive membrane with a flexible resistor attached to it. This flexible resistor alters its resistance when bent. When the pressure alters, the resistance changes, and according to Ohm's law so does the voltage drop across it. This voltage is then amplified to a range of 0-5 Volts, accepted by the analog-digital converter of the Data-Logger. The pressure is then calculated and recorded in the data logger's memory.





Calibration

The DT015 requires no calibration.

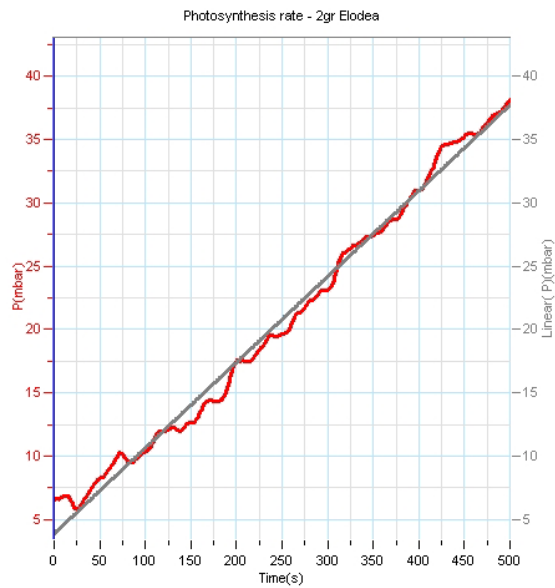
Selecting units

MultiLab displays the data in mbar. to change to other pressure units:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the pressure sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What it is used for

The DT015 has several uses. It is used mostly as a pressure sensor for experiments in Biology and Chemistry. It is furthermore used as an altimeter (measures the height you are at) and as a barometer for various meteorological measurements. The following graph shows the example for a photosynthesis experiment where the increase of pressure caused by formed oxygen is followed in comparison to the ambient pressure.



A Photosynthesis experiment performed using the DT015

Specifications:

- Range: 150 to 1150 mbar.
- 12-bit Resolution (TriLog): 0.25 mbar
- 10-bit Resolution (MultiLogPRO, MultiLog): 1 mbar
- Total accuracy: ± 15 mbar
- Operating temperature: 0-85 °C .
- Response time: 1 ms.

Pressure Mat

DT033

Type: Pressure Mat	Range: 0 to 5 V
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Sensor description

The DT033 is a 55×20 cm cushion, designed to sense animal or human steps. The DT033 is a switch, meaning that it has only two positions: open and closed. The DT033 is equipped with a six foot wire for comfortable use.



How it works

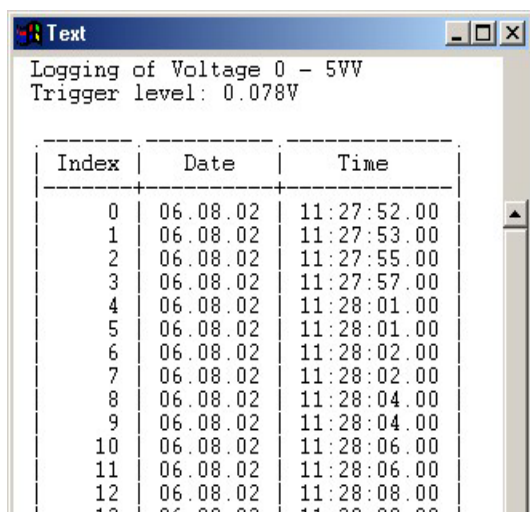
Inside the DT033 are two separate layers of a conductive material. Between the two layers there is a layer of isolation sponge, with holes in it. When pressure is applied onto the cushion, the two conductive layers connect through the holes and close an electric circuit. The logger receives then a 0 Volts output.

Calibration

The DT033 does not require any calibration.

What is it used for:

There are two logging types for which you can use the DT033: The first is regular logging, where you will receive a graph of the on/off position of the cushion as a function of time. The second (recommended) is to use a trigger function called "Event Recording". In this type of logging you will receive a list of all the times the cushion was switched (both on and off). Using this type of logging will allow you to study wildlife, or to count the number of people entering a building.



Index	Date	Time
0	06.08.02	11:27:52.00
1	06.08.02	11:27:53.00
2	06.08.02	11:27:55.00
3	06.08.02	11:27:57.00
4	06.08.02	11:28:01.00
5	06.08.02	11:28:01.00
6	06.08.02	11:28:02.00
7	06.08.02	11:28:02.00
8	06.08.02	11:28:04.00
9	06.08.02	11:28:04.00
10	06.08.02	11:28:06.00
11	06.08.02	11:28:06.00
12	06.08.02	11:28:08.00
13	06.08.02	11:28:08.00

A Sample of an event recording output list using the DT033

Specifications:

- A digital switch for sensing applied pressure.
- No calibration required.

Rain Collector

AC013

Type: Rain Collector	12-bit Range: 0 to 204mm 10-bit Range: 0 to 820mm
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Sensor description

The AC013 is a Rain Collector designed to meet the guidelines of the World Meteorological Organization. The Rain Collector consists of a collection cone and two tipping buckets.

How it works

Rain enters the collector cone, passes through a debris-filtering screen, and collects in one chamber of the tipping bucket. The bucket tips when it has collected an amount of water equal to the increment in which the collector measures (0.2 mm). As the bucket tips, it causes a switch closure and brings the second tipping bucket chamber into position. The rainwater drains out through the screened drains in the base of the collector. Every switch closure produces a pulse. The Data logger counts the pulses and calculates the rainfall.



Calibration

The DT012 ships fully calibrated. No further calibration is needed.

What it is used for

The DT012 is used in various experiments in Climatology and Environmental Studies to measure the rainfall.

Specifications:

- 12-bit Range (TriLog):
0 – 820mm
- 10-bit Range
(MultiLogPRO,
MultiLog):
0 – 204mm
- Resolution: 0.2mm.

Rotary Motion

DT148

Type: Rotary Motion	Range: $\pm \infty^\circ$ 0 to 1023 turns Resolution: ± 0.25 degree
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Sensor description

The DT148 measures angular position in very high resolution and counts the sensor pulley turns. The rotary motion can also be used for linear motion measurements with a resolution of 0.1mm. This is done by rolling the pulley along a plane, or by hanging a string over the pulley.

Supplied with a 3-step pulley and mounting rod.

Additional accessory: a pendulum that consists of a long light aluminum rod and two brass masses which can be attached at any point on the thin rod.



How it works



The DT148 consists of an optic encoder connected to the sensor main axis. The encoder produces 1440 pulses for every full turn of the sensor pulley. A microprocessor inside the DT148 counts those pulses and produces a voltage output between 0 to 5V, corresponding to the number of pulses. The encoder also provides an indication as to the direction of the pulley, while the microprocessor provides a pulse for every turn, enabling the Data logger to count the number of pulley turns. The pulley axis has very low friction, this does not have a practical affect on experiment setups like: Harmonic motion, pendulum and more.

Calibration

The DT148 requires no calibration.

Selecting measurement and units

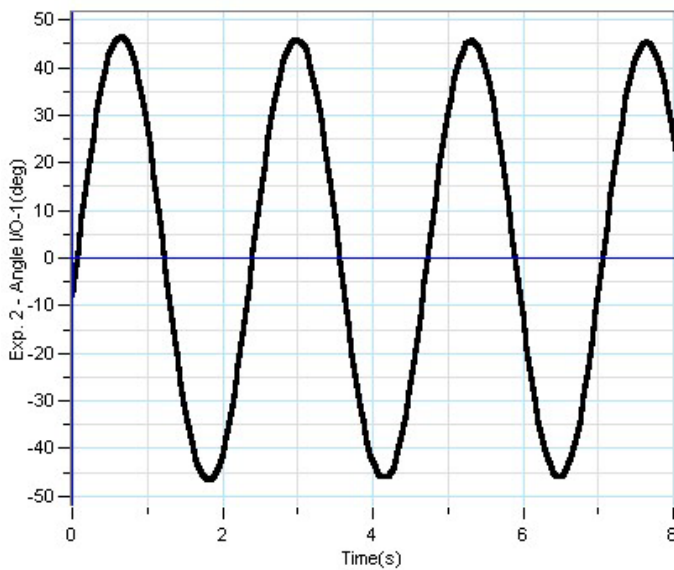
By default MultiLab displays the angular position measurement in degrees. To display other measurements such as velocity or acceleration, or other units use the sensor properties dialog:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the rotary motion sensor input
3. Check the checkboxes next to the desired measurements and units to select them.
4. If you have selected linear motion measurements, click the **calibration** tab and select or enter the pulley's radius.
5. Click **OK**

To count the number of rotations, switch the MultiLogPRO to 8 sensors mode and select **Counter** from the input sensor list.

What is it used for:

The DT148 is a very sensitive, accurate angular and linear position sensor. It can be used in experiments like: acceleration, pendulum (see graph below), harmonic motion, torque, moments of inertia and for very accurate linear position in 2 slits laser interference.



A pendulum motion measurement

Specifications:

- Range: $\pm \infty^\circ$, 0 to 1023 turns
- Resolution: 0.25° , 1 turn
- Indicates direction of motion

Smart Pulley

DT122

Type: Photo Gate	12 bit Range: 0 to 99 m/s 12 bit Range: 0 to 6.7 m/s
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Sensor description

This Smart Pulley comprises a pulley and photo gate. It is used to measure the speed of a string suspended over the pulley by measuring the tangent velocity of the pulley.

Note: MultiLogPRO cannot automatically identify the smart pulley and must be in 8 sensors mode.



Mounting the photo gate

The rod included with the photo gate can be threaded into the hole in the photo gate and provides a convenient method to mount the photo gate. The rod can be mounted to a ring stand using standard laboratory clamps. The rod can also be attached to the photo gate by running the thread of the rod through the larger hole in the photo gate and threading a quarter inch nut.

Clamp the photo gate to a support rod or mounting bracket. Position the photo gate so the object to be timed will pass through the photo gate, blocking the beam. Plug the RJ12 phone plug from the cable assembly into the modular phone jack on the photo gate housing. Plug the MiniDin plug at the other end of the cable assembly into the Data logger. Test the operation of the photo gate by watching the LED when the beam is blocked. The LED should go on when the photo gate is blocked.

The Super Pulley accessory connects to the photo gate by using the metal rod. Place the rod through the hole in the photo gate and move the pulley into position so that the rod can be threaded into it. Tighten up the rod so that the pulley is held firmly against the photo gate. When properly positioned, the spokes of the pulley, will block the infrared beam of the photo gate, each time the spokes pass by.

How it works

The photo gate has a narrow, infrared beam and fast response time, which provide very accurate signals for timing. When the pulley blocks the infrared beam between the source and detector, the output of the photo gate is low, and the light-emitting diode (LED) on the photo gate lights up. When the beam is not blocked, the output is high, and the LED is OFF.

The Data logger measures the time between successive blockings of the infrared beam and calculates the velocity.

Note: Please notice that as the DT-122 is a digital sensor, it cannot operate simultaneously with "Digital Output" nature sensors (Sonic Ranger, Control Out).



Note: As this sensor is current consuming, it is highly recommended to operate it while the AC/DC adapter powers the Data logger.

Calibration

The DT122 is fully calibrated and no further calibration is needed

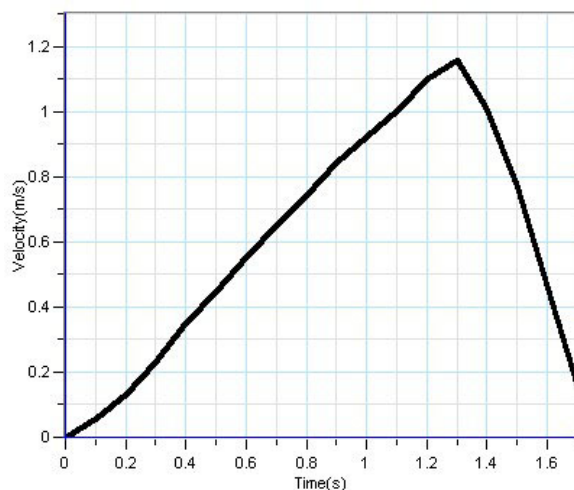
Selecting measurement

By default MultiLab displays the velocity measurement. To display other measurements such as position or acceleration use the sensor properties dialog:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the smart pulley sensor input
3. Check the checkboxes next to the desired measurements to select them.
4. Click **OK**

What it used for

The DT122 sensor is mainly used in Physics mechanics experiments, to measure velocity and acceleration of moving objects and learn Newton's laws of dynamics.



Velocity of a motion on an inclined plane

Specifications

- 12 bit Range (TriLog): 0 to 99 m/s
- 10 bit Range (MultiLogPRO, MultiLog): 0 to 6.7 m/s
- Resolution: 0.0065 m/s
- Accuracy: ± 0.05 m/s
- Parallax error (special error): For an object passing within 1 cm of the detector, with a velocity less than 10 m/s, the difference between the true and effective length is less than 1 mm.
- Power requirements: 5VDC at 45 mA.
- Timing interval: $< 5\mu\text{s}$
- Infrared source: Peak at 880 nm.

Soil moisture

DT171A

Type:
Electrical resistance

Range: 0 to 200kPa
(0 to 200 centibars)

Sensor description

The DT171A is a high performance and accurate soil moisture sensor. It measures soil moisture from 0 to 2bar. The DT171A includes WATERMARK soil moisture sensor, Fourier's egg shaped adaptor and BNC/alligator cable.

How it works

The DT171A measures the soil moisture's electric resistance and converts it to calibrated readings of soil water suction.

The WATERMARK sensor consists of two concentric electrodes embedded in reference granular matrix material. The matrix material is surrounded by protective synthetic membrane and held in a stainless case.

This device is buried in intimate contact with soil, and reaches equilibrium with the soil moisture. The adaptor excites the electrodes with 5V ac current and measures the electrical resistance which decreases with increasing soil moisture. The data logger then converts the resistance to soil moisture units.



Defining the sensor with MultiLab

1. Turn on the data logger
2. Connect the data logger to the computer
3. Open MultiLab program
4. Click **Logger** on the menu bar, then click **Define new sensors** to open a dialog:

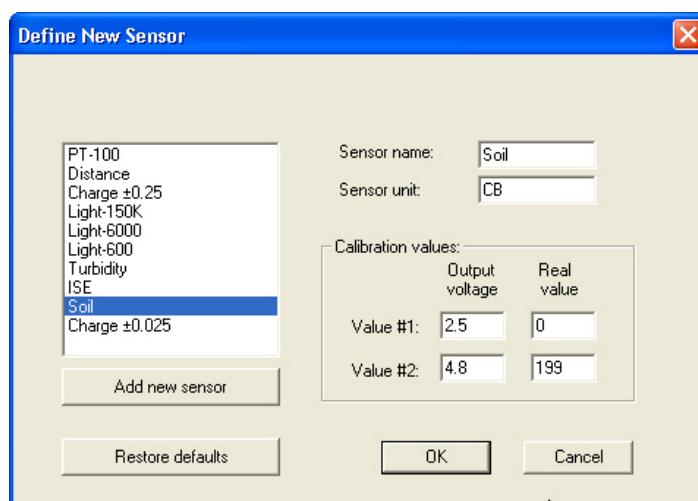


Figure 1: Soil sensor definition

You should see **Soil** on the sensors list (the ninth item on the list)

5. Click **OK**

MultiLab will update the defined sensor in your data logger.

If you fail to see **Soil** on the sensor list, click **Restore defaults**. If you still don't see **Soil** go to Fourier's web site www.fourier-sys.com and download the latest update of **Defined Sensors** file, copy it to MultiLab folder on your computer, then proceed as above.

You can also use the definition parameters in Figure 1 to define the sensor manually.

Calibration

The DT138 ships fully calibrated. No further calibration is needed.

Installation:

1. Soak the soil moisture sensors overnight in water
 - Always "plant" a wet soil moisture sensor
 - If time permits, wet the soil moisture sensor for 30 minutes in the morning and let dry until evening, then wet for 30 minutes and let dry over-night, wet again for 30 minutes the next morning and let dry again until evening. Soak over the next night and install wet. This will improve sensor response during the first few irrigations
2. Make sensor access holes to the depth required with a 7/8" (22.5 mm) diameter rod
 - For very coarse or gravelly soils, an oversize hole of 1" to 1 1/4" may be needed to prevent abrasion damage to the soil moisture sensor membrane. In this case, mix soil and water to a creamy consistency and place one or two tablespoons into the installation hole
3. Always install sensors in the active root system of the crop with a snug fit in the soil

CAUTION: In gravelly soils and with deeper sensors, carefully install the sensor to prevent damaging the membrane.

- Lack of a snug fit is the biggest problem in obtaining good soil moisture sensor readings
 - The ideal method of making the access hole is to have a stepped tool. This makes an oversize hole for the upper portion and an exact sized hole at the bottom where the sensor is located
4. Fill the hole with water and push the sensor down into the hole so it bottoms out
 - A length of 1/2" Class 315 PVC tubing fits snugly over the sensor collar and can be used to push the sensor. A good snug fit in the soil is important
 5. Carefully refill the access hole with soil and tamp it down to eliminate any air pockets

Note: You can solvent weld the 1/2" Class 315 PVC tubing to the sensor collar for easier installation and removal. Use a PVC/ABS cement (IPS Weld-on #794 or equivalent). Seal the upper end of the tube with a piece of tape to prevent water dripping down to the sensor

- After you have installed the soil moisture sensors, the sensors will need one or two irrigation cycles to “break-in” and acclimate to the soil conditions and provide better accuracy

Wiring

Connect the Soil moisture electrode to the SOIL Adaptor, and then connect the adaptor to the data logger.

Maintenance

No maintenance is required.

Removing the Sensors

- Remove the sensor when the soil is moist
- Do not pull the sensor out by the wires. You may have to dig out, at least partially, any sensors more than 12" deep or any sensors in dry soil. Careful removal prevents sensor and sensor membrane damage
- When sensors are removed for storage, clean the sensors, dry them, and place them in a clean, dry location

What it is used for

The DT171A is used as a tool to optimize irrigation and to warn of plant stress at the dry or wet ends of the scale. The table below shows typical interpretation of soil moisture readings:

Soil moisture (kPa)	Soil condition
0-10	Saturated Soil. Occurs for a day or two after irrigation
10-20	Soil is adequately wet (except coarse sands which are drying out at this range)
30-60	Usual range to irrigate or water (except heavy clay soils).Irrigate at the upper end of this range in cool humid climates and with higher water-holding capacity soils
60-100	Usual range to irrigate heavy clay soils
100-200	Soil is becoming dangerously dry for maximum production. Proceed with caution

Specifications:

- Range: 0 to 200centibars (0 to 200kPa)
- 12-bit Resolution (TriLog): 0.1cbar
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.4cbar
- Operating temperature range: 0 to 40°C (32 to 105°F)

Ordering information

Soil moisture sensor, adaptor & cable	DT171A
Soil moisture sensor only	DT171
Soil moisture adaptor only	DT281
BNC/Alligator cable only	11550

Temperature (-200 to 400°C)

DT027

Type: Temperature PT-100 Adapter	Range: -200°C to 400°C
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Sensor description

The DT027 is a high-precision PT-100 adaptor (to be used with a PT-100 probe).

How it works

The DT027 adapter outputs a steady electric current of 1.7 mA to the PT-100 electrode. The PT-100 is based on a high precision temperature dependent resistor. The DT027 adapter amplifies the output voltage to a range of 0-5 volts, accepted by the Data logger analog-digital converter. The temperature is then calculated and recorded in the Data-Logger's memory.





Calibration

An offset calibration screw is located at the back of the Adaptor. Place the electrode in a reference sample (e.g. ice and water in 0°C) and start recording. Insert a flat screwdriver to the calibration hole and slowly turn the calibration screw until the reference value is reached

Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What is it used for:

The DT027 sensor is mostly used for industrial applications, where the high precision of the PT-100 is required. In scientific fields the PT-100 is used mostly for the research of extremely low temperatures. Due to its low temperature measurement response and high accuracy, this is a very powerful sensor for monitoring liquid gases and other materials.

Specifications:

- Range:
-200°C to +400°C.
- 12-bit Resolution (TriLog): 0.15°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.6°C
- Maximum error over entire range: 0.5%
- Equipped with offset and gain calibration screws.

Temperature (- 10 to 50°C) DT012

Type: Temperature	Range: - 10°C to 50°C
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Sensor description

The DT012 is a high accuracy temperature sensor for measurements between -10°C and 50°C. The sensor consists of the Fourier System egg-shaped sensor case, and a temperature probe with a 30cm cord. For higher accuracy the DT012 is equipped with a zero offset calibration screw.



How it works



The temperature probe on the DT012 receives a 9V input. It outputs current of 0.1μA for every K. The output current from the probe passes through a resistor, and the voltage measured on that resistor is then adjusted by an amplifier to a range of 0 - 5V. this is the range accepted by the analog-digital converter in the data logger. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT012 ships fully calibrated. If further calibration is needed use the offset calibration screw at the back of the sensor case. Place the probe in a reference sample (e.g. ice and water in 0°C) and start recording. Insert a flat screwdriver to the calibration hole and turn the calibration screw until the reference value is reached.

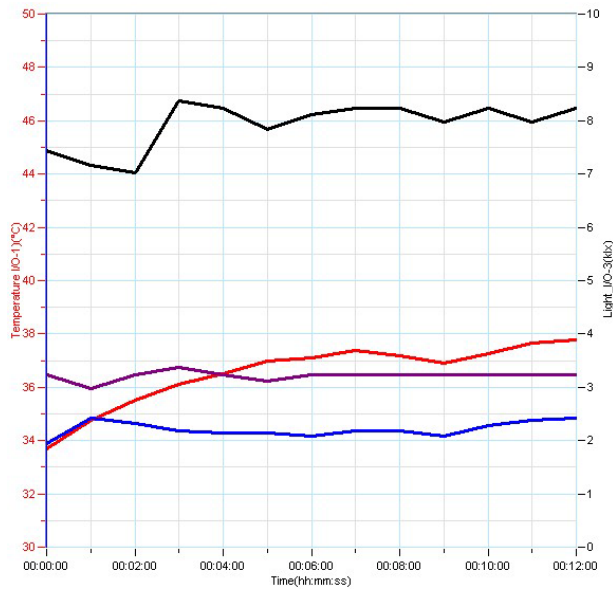
Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What it is used for

The DT012 is used for precise temperature measurements in Chemistry experiments such as acid-base titration, endothermic-exothermic reactions or the Ideal Gas Law, and in Biology experiments such as loss of heat through sweat production, or measurements of abiotic conditions under a rock.



Monitoring temperature and light above and under a leaf

Specifications:

- Range: from -10°C to +50°C.
- 12-bit Resolution (TriLog): 0.015°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.06°C
- Temperature error over entire range: $\pm 0.7^{\circ}\text{C}$ (after calibration).
- Bandwidth: 10Hz.
- Equipped with zero offset calibration screw.
- Suitable for water temperature measurements

Temperature (-25 to 110°C) DT029

Type: Temperature	Range: -25°C to 110°C
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Sensor description

The DT029 is a simple, durable, temperature sensor. It connects directly to the data logger using a standard mini-din cable. The temperature probe is covered with isolating material ensuring protection. The DT029 measures temperature between -25°C and 110°C, and has an accuracy of $\pm 1^\circ\text{C}$. It is mostly suitable for water and other chemical solution temperature measurements.



How it works



The DT029 connects directly to the Data Logger. The temperature sensing element receives an input voltage of 5V and returns output voltage between 0 to 5 Volts, which is the range accepted by the Data logger analog-digital converter. The data logger then records the value into its memory.

Calibration

The DT029 ships fully calibrated. No further calibration is needed.

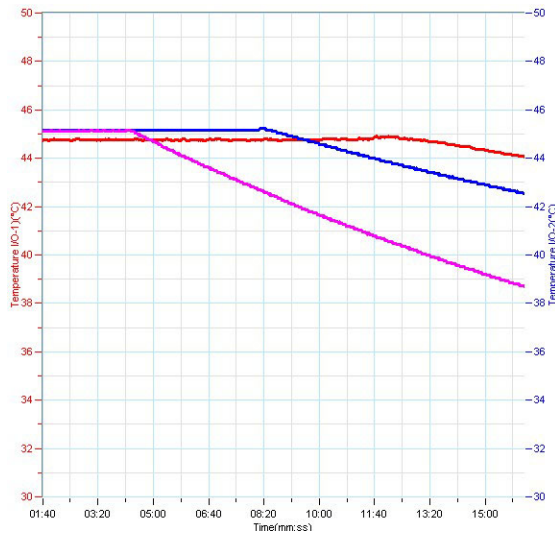
Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What is it used for:

The DT029 sensor can be used in various experiments such as endothermic reactions or the combined gas law. The DT029 is furthermore recommended for long-term measurements on bodies, in water or outdoor temperature due to its durability.



Cooling rates of different clay jars

Specifications:

- Range: -25°C to +110°C.
- 12-bit Resolution (TriLog): 0.09°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 0.25°C
- Total error: $\pm 1\%$.
- resistant to mild chemical solutions

Temperature (0 to 750°C) DT026

Type: Temperature Thermocouple type J adapter	Range: 0°C to 750°C
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Sensor description

The DT026 sensor is a thermocouple type J temperature sensor with a sensing range of 0 to 750°C. The sensor is extremely accurate, and has a maximum error of 2% over the entire range. The DT026 consists of a Fourier System egg-shaped sensor case and a 20-cm thermocouple wire.



How it works



A thermocouple consists of two long wires made of different metals connected at one end and at the other end close but without contact. When the connected end of the thermocouple is placed in a higher temperature than the temperature acting on the other end, a voltage builds up between the wires at the other end. This is the principle, which the DT026 works by. The DT026 is equipped with an additional internal temperature sensor designed to compensate for room temperature. Finally, the voltage received after correcting this offset is amplified and adjusted to a range of 0-5 Volts, accepted by the analog-digital converter. The proper result is then recorded into the logger's memory.

Calibration

The DT026 ships fully calibrated. However, there might be deterioration in accuracy over time. If further calibration is needed use the offset calibration screw at the back of the sensor case. Place the probe in a reference sample and start recording. Insert a flat screwdriver to the calibration hole and turn the calibration screw until the reference value is reached.

Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What is it used for:

The DT026 sensor is mainly used for measurements of high temperatures, monitoring chemical processes occurring at high temperatures, or simply monitoring ovens. Because of its fast response and high accuracy the DT026 can be used in Climatology measurements.

Specifications:

- Range: 0°C to 750°C
- 12-bit Resolution (TriLog): 0.25°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 1°C
- Maximum error over entire range: 2%
- Bandwidth: 1 Hz
- Equipped with a gain calibration screw
- Suitable for liquid measurements

Temperature (0 to 1250°C) DT025

Type: Temperature Thermocouple type K adapter	Range: 0°C to 1250°C.
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Sensor description

The DT025 sensor is a thermocouple type K temperature sensor with a range of 0 to 1250 °C. The sensor is extremely accurate, and has a maximum error of 0.5% over the entire range. The DT025 is composed of the Fourier System egg-shaped sensor case and a 20-cm thermocouple wire.



How it works



A thermocouple consists of two long wires made of different metals connected at one end and at the other end close but without contact. When the connected end of the thermocouple is placed in a higher temperature than the other end, voltage is produced between the wires at the other end. The DT025 is equipped with another temperature sensor, designed to correct the bias that is caused by the room temperature. Finally, the voltage received after correcting this offset is amplified and adjusted to a range of 0-5 Volts, accepted by the Data logger. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT025 ships fully calibrated. However, there might be deterioration in accuracy over the time. If further calibration is needed use the offset calibration screw at the back of the sensor case. Place the probe in a reference sample and start recording. Insert a flat screwdriver to the calibration hole and turn the calibration screw until the reference value is reached.

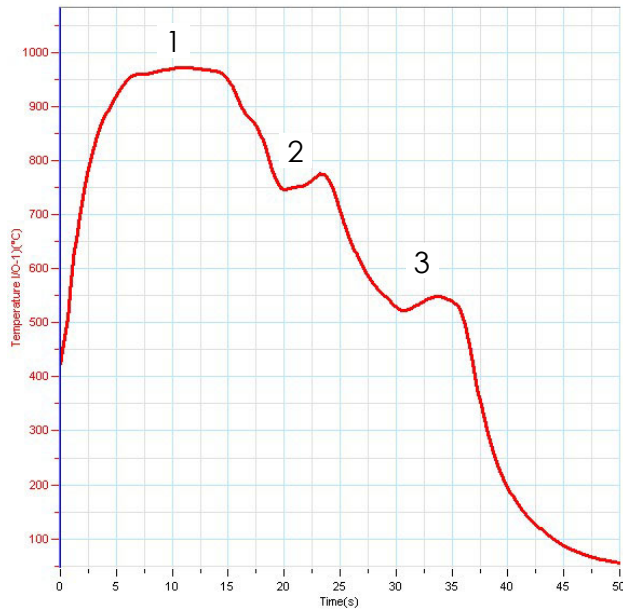
Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What it is used for

The DT025 sensor is mainly used for high temperature measurements, monitoring chemical processes that occur in high temperatures, or simply monitoring ovens. The high accuracy and reliability of the DT025 make it an excellent tool for industry as well as educational requirements like measuring the different temperatures in a flame.



The temperature in three different zones of candle flame

Specifications:

- Range: 0°C to 1250°C.
- 12-bit Resolution (TriLog): 0.38°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 1.5°C
- Maximum error over entire range: 0.5%
- Bandwidth: 1 Hz.
- Equipped with a gain calibration screw.
- Resistant to mild chemicals solutions

Temperature (-200 to 1000°C)

DT025-1

Type: Temperature Thermocouple type K	Range: -200°C to 1000°C
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Sensor description

The DT025-1 sensor is a thermocouple type K temperature sensor with a range of -200 to 1000 °C. It is extremely accurate, and has a maximum error of 0.5% over entire range. The DT025-1 is composed of the Fourier System egg-shaped sensor case and a 20-cm thermocouple wire.



How it works



A thermocouple consists of two long wires made of different metals connected at one end and at the other end close but without contact. When the connected end of the thermocouple is placed in a higher temperature than the other end, voltage is produced between the wires at the other end. The DT025-1 is equipped with another temperature sensor, designed to correct the bias that is caused by the room temperature. Finally, the voltage received after correcting this offset is amplified and adjusted to a range of 0-5 Volts, accepted by the Data logger. The proper result is then recorded and stored in the data logger's memory.

Calibration

The DT025-1 ships fully calibrated. However, there might be deterioration in the accuracy over the time. If further calibration is needed use the offset calibration screw at the back of the sensor case. Place the probe in a reference sample and start recording. Insert a flat screwdriver to the calibration hole and turn the calibration screw until the reference value is reached.

Selecting units

MultiLab displays the data in °C. to change the display to °F:

1. Click **Setup Wizard**  on the main toolbar
2. Click **Properties**  next to the temperature sensor input
3. Check the checkbox next to the desired unit to select it.
4. Click **OK**

What is it used for:

The DT025-1 sensor is mainly used for high temperature measurements, monitoring chemical processes that occur in high temperatures, or simply monitoring ovens. The high accuracy and reliability of the DT025-1 make it an excellent tool for industry as well as educational needs.

Specifications:

- Range:
-200°C to 1000°C.
- 12-bit Resolution (TriLog): 0.38°C
- 10-bit Resolution (MultiLogPRO, MultiLog): 1.5°C
- Maximum error over entire range: 0.5%
- Bandwidth: 1 Hz.
- Equipped with a gain calibration screw.
- Resistant to mild chemicals solutions

Turbidity

DT095

Type: Scattering Turbidity	Range: 0 to 200 NTU
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Sensor description

Turbidity is a measure of the cloudiness of water - the cloudier the water, the greater the turbidity. Turbidity in water is caused by suspended matter such as clay, silt, and organic matter as well as by plankton and other microscopic organisms that interfere with the passage of light through water. Turbidity is closely related to total suspended solids, but also includes plankton and other organisms.



These solids will deflect (or scatter) light as it passes through the sample. Turbidity is a measurement of the scattered light as compared to the amount of light scattered by a standard. The more light that is deflected, the higher the turbidity of the sample. The measuring device is called a nephelometric meter. This type of meter does not measure all of the deflected light, only that which is deflected at a right angle (90°) from the sample and light source. Turbidity is read as nephelometric turbidity units (NTU).

The sensor is supplied with 15 empty cuvettes and a bottle of 100 NTU Formazin Standard.

How it works


Light from an infrared source passes through the sample fluid in the cuvette and scatters in all directions. A photodiode detector is placed at a 90° angle to the direction of the incident light beam. The photodiode measures the amount of scattered light. The measured voltage passes an amplifier unit and is adjusted to the range of 0-5 volts, which is the range accepted by the Analog-Digital converter. The result is then converted to NTU units, recorded and stored in the data logger's memory.

Preparing the sample water for taking measurements

1. Gently invert the sample water to mix in any particles that may have settled to the bottom.
NOTE: Do not shake the sample as this will introduce tiny air bubbles that will affect turbidity
2. Rinse the cuvette with sample water, then fill it to the line mark with sample water
3. Close the cuvette with the cup. Gently wipe the outside with a soft, lint-free cloth or tissue
4. Holding the cuvette by the cup, place it in the Turbidity Sensor
5. Close the lid

Calibration

The DT095 ships calibrated. For more accurate measurements however, we recommend that you recalibrate every time you perform a new turbidity experiment.

1. Connect the Turbidity sensor to input 1 on the MultiLogPRO
2. Switch the MultiLogPRO to the 8 sensors mode (please refer to the User Guide)
3. Click **Setup Wizard**  on the main toolbar and select **Voltage 0-5V** in **Input 1** box

First calibrating point:

1. Prepare a blank by rinsing the empty cuvette with distilled water, then filling it to the mark line with distilled water
2. Close the cuvette with the cap. Gently wipe the outside with a soft, lint-free cloth or tissue
3. Holding the cuvette by the cap, place it into the slot of the Turbidity Sensor and close the lid.
4. Start recording and measure the output voltage. This value corresponds to zero NTU

Second calibrating point:

1. Obtain the cuvette containing the Turbidity Standard (100 NTU) and gently invert it four times in order to mix in any particles that may have settled to the bottom.
NOTE: Do not shake the standard as this will introduce tiny air bubbles that will affect turbidity readings
2. Gently wipe the outside of the cuvette with a soft, lint-free cloth or tissue
3. Holding the cuvette by the cap, place it into the slot of the Turbidity Sensor and close the lid.
4. Start recording and measure the output voltage. This value corresponds to 100 NTU

Entering the calibration values:

1. Click **Logger** on the menu bar and then click **Define new sensors**
2. Select the Turbidity sensor¹. Enter "0" and "100" in the **real value** boxes and the measured output voltages in the **output voltage** boxes
3. Click **OK**

The Turbidity sensor is now calibrated and you can switch back to Auto ID mode and begin recording.

What it is used for

Turbidity affects water quality. Listed below are some approximate acceptable values for some uses:

Designated Use	Acceptable Ranges
Recreation	5 NTU
Aquatic Life	< 50 NTU instantaneously or

¹ If Turbidity is not on the list, click **Add new sensor**, enter Turbidity in the **Sensor name** box and NTU in the **Sensor unit** box, and then proceed as above

< 25 NTU for a 10-day average

Human Consumption 1 to 5 NTU

Effects on human and aquatic life

Health Effects: Turbidity may be composed of organic and/or inorganic constituents. Organic particulates may harbor microorganisms. Thus, turbid conditions may increase the possibility for waterborne disease.

Inorganic constituents have no notable health effects.

Industrial Effects: Turbid water may not be suitable for use in industrial processes. The abundance of suspended solids may clog or scour pipes and machinery.

Recreational Effects: Highly turbid waters may be hazardous to the welfare of swimmers and boaters. Turbidity may obscure potentially dangerous obstructions such as boulders and logs. The organic constituents of turbid waters may harbor high concentrations of bacteria, viruses, and protozoan.

Environmental Effects: The series of turbidity-induced changes that can occur in a water body may change the composition of an aquatic community (Wilber, 1983). First, turbidity due to a large volume of suspended sediment will reduce light penetration, thereby suppressing photosynthetic activity of phytoplankton, algae, and macrophytes, especially those further from the surface. If turbidity is largely due to algae, light will not penetrate very far into the water, and primary production will be limited to the uppermost layers of the water. Cyan bacteria (blue-green algae) are favored in this situation because they possess flotation mechanisms. Overall, excess turbidity leads to fewer photosynthetic organisms available to serve as food sources for many invertebrates. As a result, overall invertebrate numbers may also decline, which may then lead to a fish population decline.

If turbidity is largely due to organic particles, dissolved oxygen depletion may occur in the water body. The excess nutrients available will encourage microbial breakdown, a process that requires dissolved oxygen. In addition, excess nutrients may result in algal growth. Although photosynthetic by day, algae respire at night, using valuable dissolved oxygen. Fish deaths often result from extensive oxygen depletion

Specifications:

- Range: 0 to 200 NTU
- 12-bit Resolution (TriLog): 0.25 NTU
- 10-bit Resolution (MultiLogPRO, MultiLog): 1 NTU
- Accuracy:
 - ±2 NTU for readings under 25 NTU
 - ±5% for readings above 25 NTU
- LED wavelength: 875nm
- Standard: Formazin 100 NTU

Voltage ($\pm 50\text{mV}$)

DT004**Type:** Voltage**Range:** $\pm 50\text{mV}$ **Sensor description**

The DT004 sensor is a regular voltage sensor, measuring voltage values between -50 and 50 mV . Working as a differential sensor, the sensor is capable of measuring both direct and alternate current. The sensor uses the Fourier System egg-shaped sensor case. The DT004 has floating inputs, i.e. you can connect any number of voltage sensors to a circuit without shortening them.

**How it works**

The voltage sensor should be connected in parallel to the measured electronic circuit. The measured voltage passes an amplifier unit and is adjusted to the range of $0-5$ volts, which is the range accepted by the Analog-Digital converter. The proper result is then recorded and stored in the data logger's memory.

The DT004 is equipped with buffer units, protecting the sensor from voltages of up to ± 60 Volts.

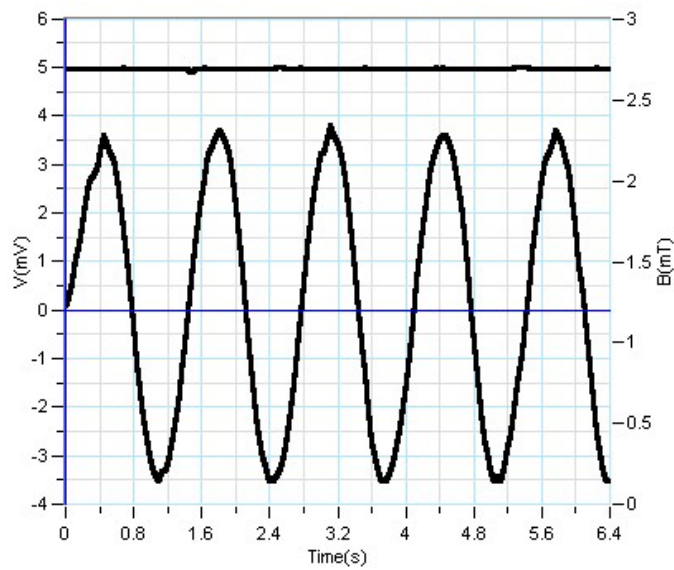
Calibration

The DT004 requires no calibration.

What it is used for

The DT004 sensor is specially designed for accurately measuring very low voltages (like in magnetic induction add Lenz's law experiments).

Due to the sensor' high Resolution, it is recommended to use a shielded BNC cable connecting the sensor to the circuit under test.



Magnetic induction in rotating coil in uniform magnetic field

Specifications:

- Range: -50 to +50 mV
- 12-bit Resolution (TriLog): 12.5 μ V
- 10-bit Resolution (MultiLogPRO, MultiLog): 50 μ V
- Differential and Floating sensor inputs
- AC or DC input voltage
- Accuracy: $\pm 3\%$ over entire range
- Input Resistance > 1 M Ω
- Input over voltage protection: ± 60 V
- Bandwidth: 5 kHz

Voltage (0 to 5V)

DT003

Type: Voltage

Range: 0 to 5V

Sensor description

The DT003 sensor is a regular voltage sensor, measuring voltage between 0 and 5 Volts. The sensor uses the Fourier System egg-shaped sensor case, and has two durable banana plugs for easy connection. The sensor has floating inputs, which mean that any number of voltage sensors can be connected to a circuit without shortening them.



How it works

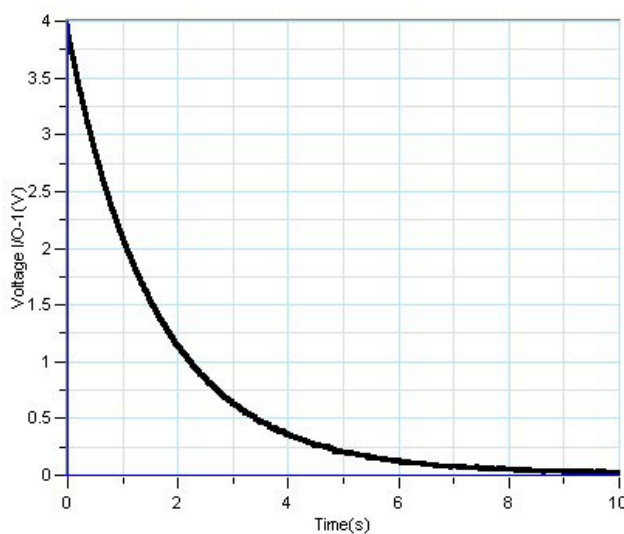
The voltage sensor should be connected in parallel to the measured electronic circuit. The measured voltage passes a differential amplifier which isolates the input from the analog-digital converter. The proper result is then recorded into the data logger's memory. The DT003 is equipped with buffer units, protecting the sensor from voltages of up to ± 60 Volts.

Calibration

The DT003 requires no calibration.

What is it used for:

The DT003 sensor is used in various experiments such as capacitor charging and discharging, the study of voltage characteristics of light bulb and diode, measurements of internal resistance and EMF. The following graph is a measurement of voltage while discharging a capacitor.



A Voltage Measurement of a discharging capacitor using the DT003

Specifications:

- Range: 0 to +5 Volts
- 12-bit Resolution (TriLog): 1.25 mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 5mV
- Accuracy: $\pm 3\%$ over entire range
- Input Resistance $> 1\text{M}\Omega$
- Input over voltage & reverse voltage protection: $\pm 60\text{V}$
- Bandwidth: 5 kHz

Voltage ($\pm 2.5V$)

DT002

Type: Voltage	Range: $\pm 2.5V$
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Sensor description

The DT002 sensor is a regular voltage sensor, measuring between -2.5 and 2.5 Volts. The DT002 is a differential sensor, capable of measuring both direct and alternate current. The sensor uses the Fourier egg-shaped sensor case, and has two durable banana plugs for easy connection. The DT002 has floating inputs, meaning you can connect any number of voltage sensors to a circuit without shortening them.



How it works

The Voltage sensor should be connected in parallel to the measured electronic circuit. The measured voltage passes an amplifier unit and is adjusted to the range of 0-5 Volts, which is the range accepted by the analog-digital converter. The proper result is then recorded and stored in the data logger's memory.

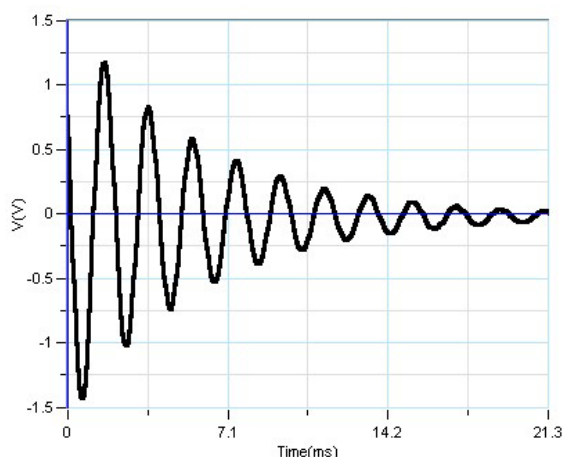
The DT002 is equipped with buffer units, protecting the sensor from voltages of up to ± 60 Volts.

Calibration

The DT002 requires no calibration.

What it is used for

The DT002 sensor is used in various experiments such as capacitor charging and discharging, the study of voltage characteristics of a light bulb and a diode, EMF and damped oscillations. The following graph is a measurement of damped electric oscillations.



Measuring electric oscillations using the DT002

Specifications:

- Range: -2.5 to +2.5 Volts
- 12-bit Resolution (TriLog): 1.25 mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 5 mV
- Accuracy: $\pm 3\%$ over entire range
- Differential and Floating sensor inputs
- AC or DC input voltage
- Input Resistance $> 1M\Omega$
- Input over voltage protection: $\pm 60V$
- Bandwidth: 5 kHz

Voltage ($\pm 25V$)

DT001

Type: Voltage

Range: $\pm 25V$

Sensor description

The DT001 sensor is a regular voltage sensor, measuring between -25 and 25 volts. The DT001 is a differential sensor, capable of measuring both direct and alternate current. The sensor uses the Fourier egg-shaped sensor case, and has two durable banana plugs for easy connection. The DT001 has floating inputs, meaning you can connect any number of voltage sensors to a circuit without shortening them.



How it works

The Voltage sensor should be connected in parallel to the measured electronic circuit. The measured voltage passes an amplifier unit and is adjusted to the range of 0-5 Volts, which is the range accepted by the analog-digital converter. The proper result is then recorded and stored in the data logger's memory.

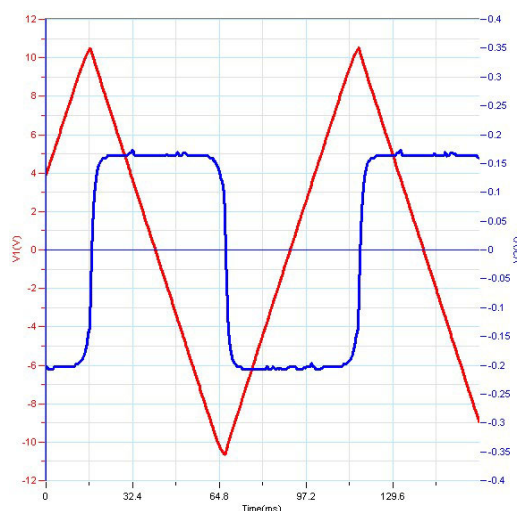
The DT001 is equipped with buffer units, protecting the sensor from voltages of up to ± 60 Volts.

Calibration

The DT001 requires no calibration.

What it is used for

The DT001 sensor is used in various experiments such as capacitor charging and discharging, the study of voltage characteristics of a light bulb and a diode, measurements of magnetic induction, EMF and damped oscillations.



Magnetic induction in a transformer. The primary coil is fed with a triangular signal.

Specifications:

- Range: -25 to +25 Volts
- 12-bit Resolution (TriLog): 12.5 mV
- 10-bit Resolution (MultiLogPRO, MultiLog): 50 mV
- Differential and Floating sensor inputs
- AC or DC input voltage
- Accuracy: $\pm 3\%$ over entire range
- Input Resistance $> 1M\Omega$
- Input over voltage protection: $\pm 60V$
- Bandwidth: 5 kHz

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