DrDAQ®

Data Logger

User's Guide

Contents

1   Welcome

Thank you for buying a **DrDAQ** data logger from Pico Technology!

This low-cost measuring device is supplied ready to use - just plug in using the cable supplied and download the free PicoLog and PicoScope software.

Features include:

- Built-in sensors for light, sound (level and waveforms) and temperature
- Measure pH - just plug in our standard pH electrode (available separately)
- Scope input for voltage readings
- Sockets for external sensors
- Use DrDAQ to capture fast signals (for example, sound waveforms)
- Digital output for controlling experiments

Software Development Kit
You can download a free Software Development Kit (SDK) from www.picotech.com/downloads. This enables you to write your own applications to control the DrDAQ. Pico also maintains repositories of example code on GitHub. Refer to the *DrDAQ Data Logger Programmer's Guide* for further information.

⚠ **CAUTION**

For safety information, please read the *Quick Start Guide* supplied with the data logger. For the most recent version of the *Quick Start Guide*, please download it from our website here.

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2 General information

2.1 Software license conditions

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Viruses. This software was continuously monitored for viruses during production. However, the user is responsible for virus checking the software once it is installed.

Support. No software is ever error-free, but if you are dissatisfied with the performance of this software, please contact our technical support staff.

Upgrades. We provide upgrades, free of charge, from www.picotech.com. We reserve the right to charge for updates or replacements sent out on physical media.

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macOS is a trademark of Apple Inc., registered in the U.S. and other countries.

Windows is a registered trademark of Microsoft Corporation in the USA and other countries.

2.3 Conformance

The DrDAQ complies with CE marking regulations and FCC Part 15 Subpart B.

For more information, please refer to your product's EU Declaration of Conformity, available for download from DrDAQ manuals.

3   Product information

3.1   Overview

The DrDAQ features 16 channels, comprising sensors, inputs and outputs. These are covered in more detail in in the data sheet. These connections and sensors cover measurement of sound, light, voltage, resistance, pH levels, and redox potential.

3.2   Connections

Channel	Input Connection
pH / redox	BNC connector
Function generator/AWG	BNC connector
Scope	BNC connector
External sensor 1−3	FCC68 4-pin connector
Resistance input	Screw terminal
Digital input/output 1−4	Screw terminal

Connections and labels
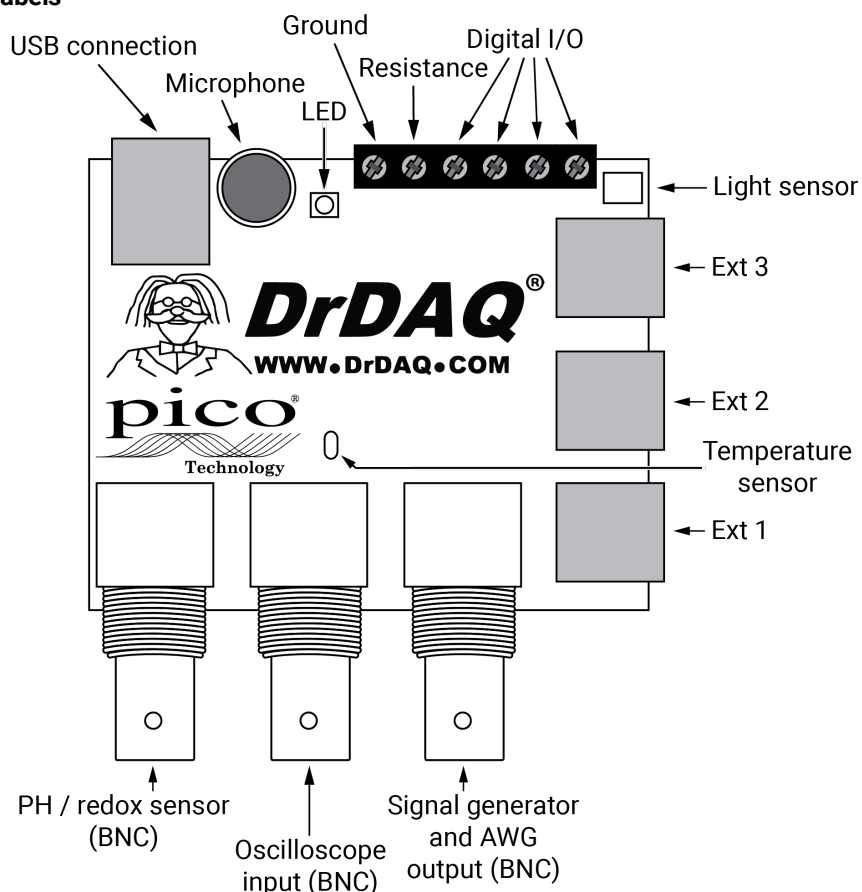
Any connection outside of its range can cause degradation to other signals being recorded. To view the specifications for each channel, please refer to the DrDAQ data sheet.

External Inputs
Each external input socket has four connections:

Pin	Function
1	Input channel with 100k pull-up to 2.5 V
2	Ground
3	Sensor type detect with 100k pull-up to 2.5 V
4	Power up to 100 mA @ 5V (not protected/limited)

Refer to External sensors or Making your own sensors for further information.

When used as basic voltage or resistance inputs, the external connections support sampling rates of up to 1 kS/s.

3.3 Channel scaling

The following table gives details of the scaling for each channel.

Channel number	Input	Min Value	Max Value	Decimal Places	Units
1	Sound waveform	−100	100	1	-
2	Sound level	50	100	2	dB
3	Scope	−10000	10000	0	mV
4	Resistance	0	1000	1	kΩ
5	pH	0	14	2	–
6	Temperature	0	100	1	°C
7	Light	0	100	1	–
8	External 1	Depends on sensor		–	–
9	External 2	Depends on sensor		–	–
10	External 3	Depends on sensor		–	–
11	Digital I/O	Off (Low)	On (High)	–	–
12	Digital I/O	Off (Low)	On (High)	–	–
13	Digital I/O	Off (Low)	On (High)	–	–
14	Digital I/O	Off (Low)	On (High)	–	–

3.4 Minimum system requirements

To ensure that your DrDAQ operates correctly, you must have a computer with at least the minimum system requirements as shown in the following table. The performance of the data logger will be better with a more powerful PC, and will benefit from a multi-core processor.

	Specification
PicoLog 6 and PicoScope	Windows 7, Windows 8, Windows 10. 32-bit and 64-bit versions. Software is also available for Linux (64-bit) and macOS operating systems.
Processor **Memory** **Free disk space**	As required by the operating system
Ports	USB 3.0 or USB 2.0 port(s)

3.5 Using PicoScope and PicoLog

PicoScope turns your PC into an oscilloscope, spectrum analyzer and meter. PicoLog is a powerful, flexible, advanced data logging package for collecting, analyzing and displaying data. The decision on whether to use PicoScope or PicoLog depends on the signals you wish to measure. If you wish to collect fast signals (such as sound waveforms) then use PicoScope, but if you want to collect data over a long period (such as plotting battery discharge) then use PicoLog.

3.6   Installing the software

We have designed the PicoScope and PicoLog software to be as easy as possible to use, even for newcomers to oscilloscopes and data loggers. Once you have followed the simple steps listed below, you will soon be on your way to becoming an expert.

1. Go to www.picotech.com/downloads, then install and run the PicoScope or PicoLog software.

2. Plug in the DrDAQ device. Your PC will recognize it and display and run the **Sound** channel by default in PicoScope and an image of the DrDAQ in the **Devices** menu in PicoLog.

3.7   Making your own sensors

3.7.1   Overview

Making your own sensors for DrDAQ is quite straightforward provided that you follow these guidelines.

Your own sensors should draw no more than 100 mA from the 5 V supply. The DrDAQ is not limited or protected so overcurrents or short circuits could cause damage to the PC USB port.

Designing a DrDAQ sensor overview

Each external sensor socket has two channels. One is an auto-detect to inform the software which type of sensor it is and the other an analog input that represents the sensor reading.

There are four pins on the External inputs. This view is looking into the Ext socket on DrDAQ. The mating connector is an FCC 68 4/4 plug.
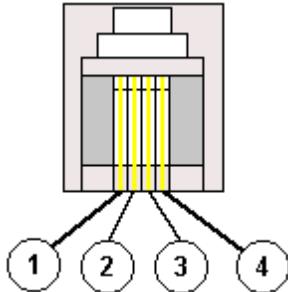

Pin 1 : Signal input

Pin 2 : Ground

Pin 3 : Auto detect

Pin 4 : Supply voltage

The range of the Auto detect and Signal input voltages must be between 0 and 2.5 volts. This is a hardware limitation and any signals outside this range will not be read by the unit. Any voltages greater than ±30 V fed directly into the device are likely to damage the unit, and can cause errors with all other DrDAQ readings.

The Signal Input channel has 100 kΩ pull-up resistors to 2.5 V, so that the input can be either a resistance or a voltage.

Here is a block diagram of a typical DrDAQ sensor:

1 = Signal input

2 = Ground

3 = Auto Detect
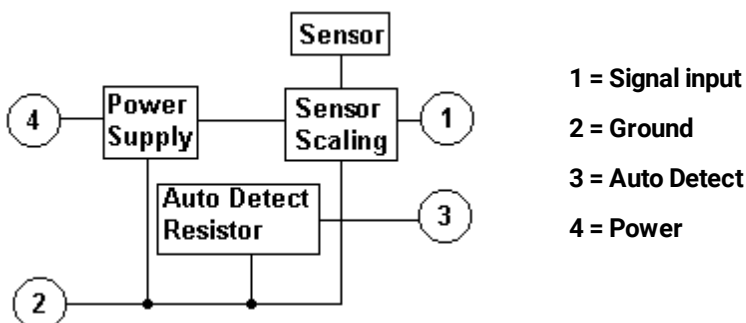
4 = Power

3.7.2 Powering the sensor

A definition of a sensor is:

A device giving a signal for the detection or measurement of a physical property to which it responds.

The sensor's properties must be known before work can begin on designing some way of interfacing it to the DrDAQ (sensor scaling).

There are two types of sensor:

Active Sensors: These require power (excitation) from an external source to generate an output signal. Examples of active sensors include:

Property	Sensor	Output
Temperature	Silicon	Voltage / Current
	RTD	Resistance
	Thermistor	Resistance
Force / Pressure	Strain Gauge	Resistance
Acceleration	Accelerometer	Capacitance
Humidity	Capacitor	Resistance
Light	LDR	Resistance
Position	LVDT	AC Voltage

Passive Sensors: These do not require any power to generate an output. Typical examples are:

Property	Sensor	Output
Temperature	Thermocouple	Voltage
Force/pressure	Piezoelectric	Voltage
Position	Variable resistor	Resistance
Light Intensity	Photodiode	Current

When selecting a sensor for an application you should consider the following:

1. Is the input 0-2.5 V?
2. Is the sensor Active or Passive? If Active then can it be powered by the DrDAQ?
3. What is the output of the sensor? Can the sensor be plugged directly into the DrDAQ?
4. Is the sensor already available on the DrDAQ, or are there more suitable sensors out there?

3.7.3 Scaling

Sensor Scaling - software
Scaling is achieved using a look-up table or equation in the channel scaling options in PicoLog.

Sensor Scaling - hardware
With both these types of sensors it is essential that the DrDAQ displays an accurate representation of the property to be measured. There are many factors to take into account when designing scaling circuitry:

Sensitivity
The DrDAQ has 12-bit resolution over the 0 to 2.5 V input range. This means the sensitivity is:
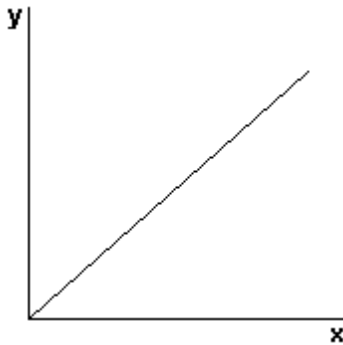
$$2500 \text{ mV} / 2^{12} = 0.611 \text{ mV}$$

To make the most of the resolution, the signal output from the sensor should use as much of the input range of the DrDAQ as possible.
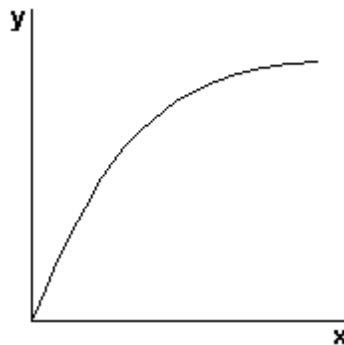
Linearity
As illustrated below, not all sensors have a linear response.
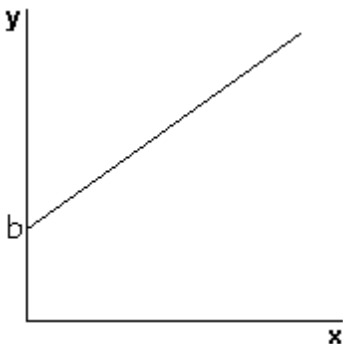
Linear Response   **An Example of Non-Linear Response**

A linear response is one whose output-versus-input graph is a straight line. An example of this type of response is a photodiode.

Note: a non-linear response curve cannot be calculated using a simple $y = ax + b$ formula. An example of this type of response is an LDR.

Offsets

The above linear and non-linear responses could have a voltage, current, resistive or other type of offset that may need taking into account. It is quite usual to see offsets in output signals from sensors.

Sensor output
The DrDAQ requires an input signal in DC volts or resistance. The sensor in question could give an output in other units such as resistance, current or AC volts.

Drift
It is possible that the sensor output drifts over time. This may involve recalibration of the sensor at set time intervals, or some self-calibration.

Hysteresis
The sensor may give a different output value when rising to a voltage than when falling to the same voltage. This is difficult to eliminate and should be taken into account.

Once the sensor has been selected and all of the above has been considered, the design of some scaling circuitry can begin. There are many ICs on the market that can be purchased cheaply that deal with the above potential problems. Look into these before reinventing the wheel and spending expensive development time designing a circuit that can be purchased for a few pounds.

Some simple scaling examples:

Example 1: Interfacing a Resistive sensor
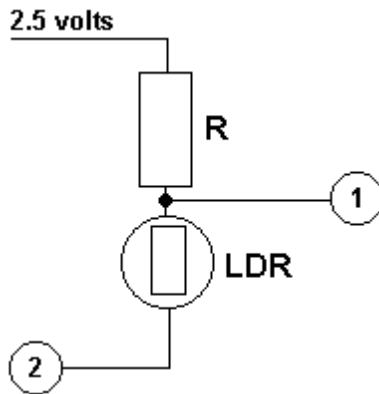
Notes:
Light-dependent resistor (LDR) can be used in conjunction with a fixed resistor to measure light level. A LDR sensor like ORP12 or NORP12 can be used. The 100k resistor (R) is in the DrDAQ.

Example 2: Measuring 4-20 mA Current
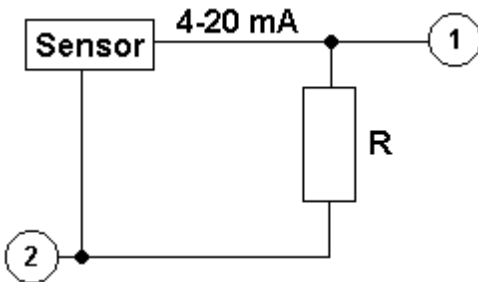
Notes:

4-20 mA output is the industry standard for interfacing between a control center (data logger) and a remote process such as a sensor. For this reason 4-20 mA sensors are very common.

For relatively small currents a simple shunt resistor can be used to convert the current into voltage which the DrDAQ can then measure.

A suitable resistor (R) for the DrDAQ is 120 ohms. This would give (using Ohm's Law):
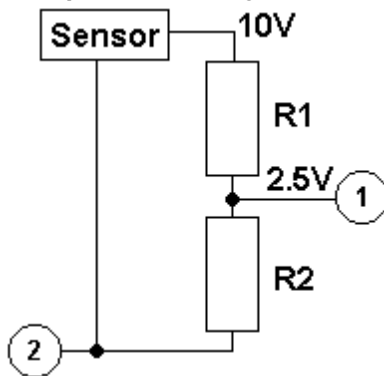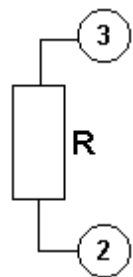
0.48 volts at 4 mA
2.4 volts at 20 mA

P = VI

P = 2.4 V x 20 mA

P = 48 mW

Therefore a >48 mW resistor is required.

Example 3: Measuring 10 volts

Notes:

This is a simple circuit that uses a potential divider to reduce the voltage going into the DrDAQ by a factor of four. R1 = 3k & R2 = 1k The resistors are calculated using Ohm's Law, V=IR.

Auto-Detect

Auto-detect resistor is placed between Ground (Pin 2) and Signal Detect (Pin 3). The value of the resistor should be selected from one of the following common values: 1k0, 2k2, 3k3, 5k6, 7k5, 10k. It is necessary to have an auto-detect resistor so that the software can automatically scale the input signal into the property that it represents.

3.7.4   Examples of digital output use

PicoScope
The following is a short example of how to activate an LED via a digital output on the DrDAQ using the *Mask* and *Alarm* functions of PicoScope. With DrDAQ connected and PicoScope open:

- Connect the LED to the GND connection on the DrDAQ and digital connection *2* (refer to Connections).
  Note: Any digital connection can be used but we are using *2* in this example.
- In PicoScope, activate the *Temp* channel only (refer to Displaying channels).
- Under the **Tools** menu, select **Masks** > **Add Masks**.
- Choose *Mask of Temp* within the **Available Masks** area, or click **Generate** if it doesn't show in the Library list.
- Click **Apply** and select **OK**.
- Right click the oscilloscope window and choose **Masks** > **Edit Mask**.
- Within the mask dialog, adjust the two low values to 28 °C.
- Right click the oscilloscope window and choose **Masks** > **Exit Mask Edit**.
- Under **Tools** menu, choose *Alarms*.
- Under **Event**, choose *Mask(s) Fail* (ensure it is enabled).
- Choose **Add**.
- Under **Action** menu, choose *Digital Output*.
- Set **Channel** to Digital Output 2, and High.
- Choose **OK**.
- Click **Apply** and choose **OK**.
- Start the trace and place the tip of a finger onto the temperature sensor on the DrDAQ. The trace should rise, and upon overlapping the mask, the LED connected to digital connection 2 should illuminate.

PicoLog
The following is a short example of how to activate an LED via a digital output on the DrDAQ using the *Alarm* function of PicoLog. With DrDAQ connected and PicoLog open:

- Connect the LED to the *Gnd* connection on the DrDAQ and digital connection 2 (refer to Connections).
  Note: Any digital connection can be used but we are using number *2* in this example.
- Click on **Alarms** which is a bell symbol and click **Add alarm**.

- Choose **Threshold** (trigger when a channel leaves a specified range).
- Select an **Upper threshold** and **Lower threshold** and a measurement **Channel** to monitor.
- Tick **Digital output** and select Digital 2.
- Chose a Holdoff time and alarm Color if required and choose if you wish to run an application when the alarm thresholds are crossed.
- Click **Save**.
- Place a finger tip on the *Temp* sensor and an alarm will trigger once the temperature goes above the upper threshold entered earlier. When this happens the LED will illuminate, along with the red alarm icon in PicoLog. When you remove your finger, the LED will extinguish (once the temperature drops back below the upper threshold value).

You can also trigger a digital output on the DrDAQ when an alarm condition is met on an additional connected data logger, like the TC-08, which does not have its own digital outputs:

- Connect the LED to the *Gnd* connection on the DrDAQ and digital connection 2 (refer to Connections). Note: Any digital connection can be used but we are using number *2* in this example.
- Connect an additional data logger like the TC-08 to your PC and plug in a suitable thermocouple
- Configure a channel on the TC-08
- Click on **Alarms** which is a bell symbol and click **Add alarm**.
- Choose **Threshold** (trigger when a channel leaves a specified range).
- Select an **Upper threshold** and **Lower threshold** and a measurement **Channel** to monitor.
- Tick **Digital output** and select **Digital 2** from the list. This will identify the DrDAQ digital outputs even though you are setting an alarm for a channel on the TC-08.
- Chose a **Holdoff** time and alarm **Color** if required and choose if you wish to run an application when the alarm thresholds are crossed.
- Click **Save**.
- Place a finger tip on the thermocouple and an alarm will trigger once the temperature goes above the upper threshold entered earlier. When this happens the LED connected to the DrDAQ digital output will illuminate, along with the red alarm icon in PicoLog. When you remove your finger, the LED will extinguish (once the temperature drops back below the upper threshold value).

3.7.5   Calibration

All input channels of a DrDAQ are calibrated during manufacture.

Calibration involves measuring a known value (such as the temperature of boiling water, or the resistance of a known resistor, or the values shown by a calibrated sensor) then converting these values into the units you need.

Linear
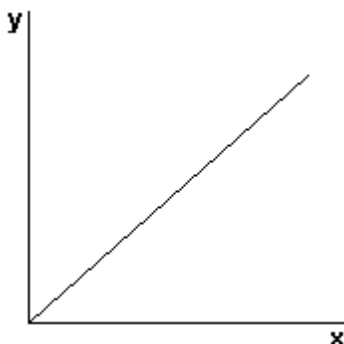
Single-Point Calibration
When calibrating a sensor with a linear response curve it may only be necessary to perform a **Single-Point Calibration**. This only occurs in one circumstance:

One pair of values is known - for example on the DrDAQ oxygen sensor. The sensor is known to output 0 mV at 0% oxygen content. Therefore we only need to find one other pair of values. All we are doing here is changing the gradient of the response curve. See the oxygen sensor description for a full example.

Two-Point Calibration

A two-point calibration should always be carried out if possible, since it is the most accurate calibration method for a sensor with a linear response curve.

It is important that the readings are taken for both extremes of the sensor's **operating input range** to ensure accuracy. For example:

A temperature sensor has an input range of −200 °C to +200 °C but we only want to use it between −5 °C and 110 °C. Therefore, this will be its **operating input range**. The first calibration point should be close to −5 °C, so the sensor will be placed in melting ice, which is known to be 0 °C. The second calibration point should be close to 110 °C, so the sensor will be placed in boiling water, which is known to be 100 °C.

It is rare that such a convenient range is available, but the principle of two-point calibration stays the same.

It is important to distinguish between the operating range and the full input range of the sensor, since it would be far more difficult to calibrate the sensor between −200 °C and +200 °C and would yield no accuracy benefit for the user between −5 °C and 110 °C.

Non-Linear
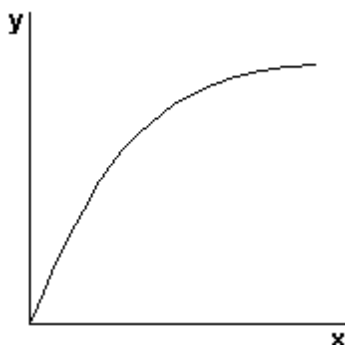
Multi-point Calibration

You will need more than two points to describe a non-linear response curve, and therefore you will need to create a look-up table experimentally. Since you will be measuring a series of readings at unconfirmed intervals, the only way to know the calibrated value is to perform the same measurement with both the sensor you are calibrating and a sensor which you know has already been calibrated. Create a table of raw and scaled values similar to below.

x (raw) new sensor	y (scaled) calibrated sensor
0	0
5	8
10	12
15	14
20	15

Both PicoLog and PicoScope have the facility to manually enter look-up tables (see the respective help files).

3.8   External sensors

3.8.1   Overview

As well as the built in sensors, DrDAQ has sockets for optional external sensors. When a sensor is plugged in to the external sensor sockets, the software detects it and automatically scales readings. For example, if a temperature sensor is plugged in, readings are displayed in °C, or if a humidity sensor is plugged in, readings are displayed in %RH.

External sensors are optional extras and can be purchased at any time. For an up-to-date list of the available external sensors, consult the DrDAQ section of our web site.

- DD100 temperature sensor
- DD011 pH electrode
- PP066 reed switch
- DD101 humidity sensor
- DD103 oxygen sensor
- TA137 redox sensor

3.8.2   DD100 temperature sensor

A high-accuracy general-purpose temperature sensor with a 2 meter lead. Suitable for air, surface or liquid measurements.

Range	−10 °C to +105 °C
Resolution (at 25 °C)	0.1 °C
Accuracy (at 25 °C)	0.3 °C

3.8.3   DD011 pH electrode

Before using your electrode, remove the storage bottle.

Size	12 x 120 mm
Operating temperature	0 to 60 °C
Resolution	0.02 pH

Using DrDAQ with pH electrodes
The pH input on DrDAQ is a very high-impedance input that is suitable for use with any standard pH electrode. For most applications no calibration is required: just plug in an electrode and measure. If, however, you require very accurate pH measurements, then you should calibrate the probe before use (see below).

If you are using a pH probe and not getting the results you expect then the most probable cause is a defective pH electrode. If cared for properly, pH electrodes will last for a number of years (see the instructions supplied with the electrode). If they are not stored properly, they will be destroyed in a few weeks. Trying to calibrate out errors from a defective probe will not work and may further increase errors.

pH measurement and temperature calibration
The output from a pH electrode is proportional to absolute temperature (kelvin). A temperature difference of 10 °C will cause the probe output to change by approximately 4%. This is a major source of error with most pH meters and data loggers. To minimize these errors, a temperature sensor can be connected to Ext 1 and the DrDAQ will compensate for temperature changes.

Testing pH electrodes
The best way to test a pH electrode is to use pH buffers (pH 4, pH 7 and pH 10 buffers are widely available). If you do not have any pH buffers, then distilled deionized water will have a pH near 7 (some still mineral water bottles have the typical pH printed on the label). Most fizzy (carbonated) cola drinks have a pH in a 2.5 to 3 range.

With the pH electrode connected to DrDAQ, display the pH channel using PicoLog. Measure the pH of each buffer in turn. Allow 30 seconds for the reading to stabilize and be sure to wash the electrode in clean water before swapping solutions. If the pH measured is within 1 pH of the expected value, you can be fairly sure the electrode is working correctly. If the readings are wrong, the electrode is probably defective. Replacement electrodes are available from Pico Technology.

If you suspect that the pH input on DrDAQ may be defective, short out the BNC connector using a terminator plug. The reading on the screen should be pH 7. If it is not, the most likely reason is that someone has calibrated the probe incorrectly. In PicoLog, select the trash can at the top of the screen and choose **Delete configuration** to delete the user calibration and return to the default calibration. If the reading is still wrong, contact technical support at Pico Technology.

Calibrating for accurate pH measurements
As described above, calibration is only required when accurate (better than 0.5 pH) measurements are required. Calibration should be performed just before the measurements are made. User calibration information is stored separately in PicoScope and PicoLog, so if you wish to measure pH accurately with both programs, two calibrations will be required.

To calibrate a pH electrode you will require at least 2 pH buffers (pH 4, pH 7 and pH 10 buffers are widely available). Calibration should be performed with the ambient temperature close to 25 °C. A container of clean water is also required to wash the electrode between buffers.

1. Connect the pH electrode to DrDAQ and display the pH using either PicoScope or PicoLog (depending on which program you are calibrating for).
2. Place the electrode in the first solution and wait for at least 30 seconds for the readings to stabilize (gently stirring helps).
3. Make a note of the reading and repeat the procedure for each of the buffer solutions. Don't forget to wash the probe between buffers.
4. You should now have a table of readings similar to the one below:

pH Buffer value at 25 °C	Measured value from DrDAQ
4.01	4.06
7.00	7.07
10.01	9.92

pH calibration with PicoLog
As already mentioned you will need to note down the measured pH value and compare it with the actual value to create a lookup table. Then follow these steps:

1. Select the channel on the DrDAQ which is connected to the pH electrode
2. Click **Advanced options** to show the **Probe or scaling** options.
3. Enter the real measured pH value below **input** and the actual value below **output:**
4. Click **Save** to verify the calibrated pH readings.

Storing pH electrodes
If KCl solution is not available then any pH 4 buffer solution will be suitable for storing electrodes. KCl is recommended because it is the substance inside the bulb of the electrode. Tap water would be acceptable but is not ideal. Do not under any circumstances use deionized or distilled water!

3.8.4   PP066 reed switch

A reed switch sensor can be used to detect the presence of a magnetic field such as that from a bar magnet or an electromagnet. Alternatively, a simple single-pole switch can be connected to terminals inside the unit.

Size	72 x 45 x 28 mm
Operating range	0 to 99%
Maximum response time	2 ms

The unit's reed switch may be connected to either Ext 1, Ext 2 or Ext 3 on DrDAQ.

To determine the optimum position for the magnet:
Hold the sensor with its connecting socket towards you and the screw that fixes the lid facing up.

The best position for the magnet is about half way along (towards the bottom) of the right hand side of the case. The label on the bottom of the unit indicates this position.

When a magnet is in place next to the unit the reed switch inside closes. This is shown in PicoScope and PicoLog by a change from 99% (switch open) to 0% (switch closed). This percentage is an indication of the proportion of the sampling period that the switch is in the open state for.

You may use the unit to connect a simple, single-pole switch (such as a microswitch) to DrDAQ. You will need to obtain a switch and some insulated connecting wire. Remember to keep magnets or magnetic fields away from the unit when you use it with an external switch. Magnetic fields will still make the internal reed switch operate, overriding the open setting of the external switch.

To connect the switch follow these steps:

1. Make sure that the leads from the external switch have about 5 mm of bare wire to form the connections.
2. Remove the lid.
3. Find the small terminal block, with two screws in its top, towards the back of the circuit board.
4. Loosen the screws in the terminal block. Do not remove them altogether.
5. Thread the two wires from the external switch through one of the holes in the bottom of the unit.
6. If you do not wish to use either of the two holes in the bottom of the case, make a hole in the side of the case just big enough for the leads to pass through. Take care not to damage the electrical components.
7. Leaving enough free wire to make the connection, secure the leads by looping them around the central boss of the case. Alternatively, put a cable tie around the leads inside the case and near the hole. Make sure that the leads are securely held inside the unit.
8. Push the bare ends of the leads into the holes in the back of the terminal block. There should be one lead in each hole.
9. Tighten the screws in the terminal block and check that the leads are held firmly in place. Do not overtighten the screws.
10. Put the lid back on to the unit. Make sure it is on the right way round.
11. Tighten the fixing screw. Be careful not to overtighten it.
12. Check the operation of the external switch. Connect up the unit and make sure that PicoScope or PicoLog shows near to 100% when your external switch is open and 0% when it is closed.

3.8.5   DD101 humidity sensor

The DD101 humidity sensor measures humidity using a 'non-condensing' technique. It has a short response time and plugs into the external sensor connections of DrDAQ. The DD101 is supplied in a kit (order number PP163) which also includes an EL032 sensor extension cable (3 m) to connect the sensor to your DrDAQ.

Size	72 x 45 x 28 mm
Operating range	20% to 90% Relative Humidity
Overall accuracy	Reading ±10%
Operating temperature	0 to 60 °C
Resolution	0.2% Relative Humidity
Minimum response time	60 seconds with vigorous air movement
Maximum response time	60 minutes in still air

Caution: Do not allow the DD101 sensor to become wet. It is a non-condensing sensor and liquid (including condensation) inside the case may damage it.

The DD101 may be connected to either Ext 1, Ext 2 or Ext 3 on DrDAQ.

Tips for use of DD101 humidity sensors
The sensor responds to humidity changes more slowly in still air. If you need to increase the response time, then increase the air flow around the sensor. For example, swing the sensor gently on its lead or create a constant draft using a fan. Do not blow into the sensor, as your breath is very humid and will produce incorrect results. Never allow the sensor to get wet; for example, do not take a cold sensor into a warm humid environment where condensation may form inside the sensor's case.

Making accurate measurements
The DD101 will give good readings of humidity and show trends well. However, if you need to make more accurate measurements, you will have to calibrate the sensor. The calibrated sensor could have an accuracy as good as ±5% though this depends on how well the calibration procedure is carried out.

The output of the sensor may vary over time. For this reason you should calibrate the sensor regularly (at least once a year).

Basis of the calibration method
Calibration relies on the general physical properties of saturated solutions. The humidity above such solutions in closed containers is known quite accurately and is used to calibrate the sensors. Chemical salts used for this purpose include potassium chloride, magnesium chloride and magnesium nitrate.

Note: The humidity that exists above all such solutions varies with temperature.

The standard solutions may be harmful in contact with skin or eyes or if swallowed. Take all necessary precautions to avoid contact when preparing and using the standard solutions.

Note: For the highest accuracy you should compare the readings from you DD101 with the readings from your calibrated 'laboratory standard' reference humidity gauge.

Calibration of the sensor involves:

- Preparation of the calibration equipment.
- Measurement of the standard saturated solutions.
- Creation of calibration data for the DrDAQ software.
- A check that the calibrated sensor is accurate.

Note: You must measure at least two different standard solutions to provide two or more fixed points for calibration.

Equipment you will need:

- DrDAQ with DD101 sensor
- Pico DD100 Temperature Sensor
- At least two Standard Solutions
- A label for the DD101
- A test container
- An insulated box
- A stand for the DD101
- [Optional] high-accuracy, calibrated reference 'laboratory standard' humidity gauge

Stand
It is very important that the standard solution does not enter the case of the DD101. The solution may damage the electrical components of the sensor. Therefore the DD101 needs to be suspended in the test container clear of the standard solution. A small stand is the best way to hold the sensor above the solution. The stand may be any object (open framework) that is impervious to the standard solution. Make sure that the material that your stand is made from is compatible with the test solutions you intend to use.

Test container
Your test container should be only just big enough to hold the DD101 and DD100 sensors, the stand, and a small quantity of standard solution (the solution should fill approximately 5% of the volume of your container). It will also have to be watertight with a seal that allows you to pass the leads for the sensors into the container.

Note: The smaller your container, the more quickly the humidity will stabilize. You can reduce the time taken for the system to stabilize by forcing the air in the container to circulate. This will require a fan that does not introduce heat into the container (it must be driven by a shaft or magnetic coupling so that the motor is outside the container).

If you are going to compare the values measured with the DD101 and a calibrated reference, your container will have to be large enough for the reference sensor too.

Make sure that the material that your container is made of is compatible with the chemicals you are going to use. If the chemicals react in any way with the container, the humidity reference will not be correct.

Standard Solutions

The standard solutions may be harmful in contact with skin or eyes or if swallowed. Take all necessary precautions to avoid contact when preparing and using the standard solutions.

There are several chemicals that have been measured under laboratory conditions to find out what humidity they provide. Whichever chemicals you choose, make sure that the humidity they give is within the operating range of the DD101 sensor (that is, greater than 20% and less than 90% relative humidity). You should use at least two standard solutions to give two fixed points for your calibration. Standard reference books such as Kaye & Laby "Tables of Physical and Chemical Constants" (Longman) give tables with the humidity of standard solutions. For example:

Compound	Humidity at 20 °C
Potassium chloride	85%
Magnesium nitrate	54%
Magnesium chloride	33%

Note: The humidity produced by the standard solution depends on the temperature. If the temperature changes from 20 to 21 °C this could give a change in relative humidity of as much as 3% for a nominal 50% value. This change would be worse for higher values of relative humidity.

Insulated box

Because the humidity produced by the standard solution depends on temperature, you should use your test container inside an insulated box. A domestic cool box (without the cold blocks) is suitable.

Preparation

The standard solutions may be harmful in contact with skin or eyes or if swallowed. Take all necessary precautions to avoid contact when preparing and using the standard solutions.

Prepare your standard solutions before you start the calibration procedure. Follow the instructions given by the manufacturers of the solutions you are using. A slurry of undissolved chemical in your solution should improve the stability. Make sure that all the containers you use for preparation are thoroughly clean before use as contamination of the solution will alter the humidity. Do not use tap water to make up the solution as this is insufficiently pure: use distilled and deionized water. Allow time for the solution to reach room temperature before use. Always use fresh solutions to ensure that the chemicals have not become contaminated or degraded.

Allow the standard solutions and other equipment to reach the same temperature (ideally 20 °C) before you start.

Measure humidity

1. Set up the equipment.
2. Clean the equipment. Make especially sure that the test container is clean; rinse it out with distilled water.
3. Put the test container into your insulated box.

The standard solutions may be harmful in contact with skin or eyes or if swallowed. Take all necessary precautions to avoid contact when preparing and using the standard solutions.

Caution: It is very important that the standard solution does not enter the case of the DD101. The solution may damage the electrical components of the sensor.

1. Put some of the standard solution into the test container. The solution should occupy about 5% of the volume of your container.
2. Put the stand into the test container. The stand should give you a clear platform above the level of the liquid. Do not allow any standard solution to spill on to the top of your stand.
3. Put the DD101 and DD100 sensors onto the stand. (If you are using a calibrated reference put this in too).
4. Connect the DD101 and DD100 sensors to DrDAQ.
5. Take your measurements
6. Start the PicoLog software and click **Start recording**. Make sure DrDAQ is receiving readings from the sensors on Ext 1 or Ext 2.
7. Seal the test container and close the insulated box. If you are using a fan, start the fan.
8. Record the temperature and humidity inside the test container for at least one hour. You must wait for the temperature to stabilize and the DD101 to provide correct readings. This may take up to eight hours if you have used a large container.
9. Check that the DrDAQ plots for temperature and humidity have been constant over the last few minutes of your measurements. (If you are using a calibrated reference, take a reading now. Take care to minimize changes in the setup so that the reading does not change significantly).
10. Save your results.
11. Dispose of the solution as recommended by the supplier of the chemical. Remember to take adequate precautions to protect your skin and eyes when disposing of chemicals.
12. Do the measurements again for the other standard solutions. You should end up with a set of recorded measurements for each standard solution. Remember that you must provide at least two fixed points for calibration of the sensor.

Create calibration data

When the measurements are completed you need to make a written calibration table.

1. From your recorded results find the place near the end of the measurement time where the readings are most stable.
2. Write down these temperature and humidity readings for the standard solution in a table.
3. Look up the humidity that the standard solution should give for the temperature that you have recorded. Write this value in your table next to the value measured by the DD101 (the manufacturer of the standard solution should have provided you with a table for humidities for different temperatures).
4. Fill in entries for all the standard solutions you have measured.

You should end up with a table something like this:

Chemical	Measured humidity	Standard humidity	Temperature
Potassium chloride	81%	85%	20 °C
Magnesium nitrate	50%	54%	21 °C
Magnesium chloride	30%	33%	20 °C

Keep this table for further reference. It will be useful if you have to re-enter the data into the **Custom scaling** table in PicoLog.

At this stage compare the measured and standard values. If you find that the measured values differ from the standard values by more than 10%, then there is something wrong. You may have had an unsaturated solution, some contamination in the solution, inadequate sealing of your test container, or possibly a damaged sensor. Check your calibration routine. If you still get large errors contact Pico for assistance.

If you are using a calibrated reference this should give values very close to those quoted for your standard solutions. If these values disagree by more than a few percent there may be an error in your calibration procedure. When the two are in agreement use the values given by the calibrated reference as the correct figures for your data table.

Once you have your calibration data you must enter it into the PicoLog software to calibrate the sensor:

1. Start the PicoLog software.
2. Select the channel associated with the humidity sensor. This will open the channel configuration dialog box
3. Click on **Advanced options**.
4. Next to **Probe or scaling**, click the box to open the **Probes and custom scaling** selector
5. Choose **Table**
6. Type in the values that you measured with the DD101 under **input**. Type a space then enter the standard value under **output**.
7. Enter all the pairs of measured and standard values that you have to build your table. You should end up with two columns of values. Note - your table must have at least two pairs of values.
8. Select any return units and then click **Save**.

This completes the entry of the calibration data.

Note: You can remove the calibration data by following the process above and deleting the values from the table.

Check the calibration
To be sure that the calibration has been successful, you must repeat the measurement stage of the procedure. When the check measurements have been completed there should be very close agreement between the measured and standard values (that is, within 5% of the value). If this is not the case, check that you have entered the calibration data correctly and repeat the process.

Once you have successfully calibrated your DD101, write the calibration date on a label and stick the label on the sensor (do not block the holes in the sensor with the label).

Testing Sensors
You can check whether a sensor is working properly or not by running through the calibration procedure. If you find that the sensor values differ from the standard values by more than 10% you may have a damaged sensor. In this case contact Pico for assistance.

3.8.6   DD103 oxygen sensor

The DD103 oxygen sensor is used to measure the percentage of oxygen in a gas. The sensor plugs into the external sensor sockets of DrDAQ using the supplied cable.

Specification

Sensor Type	Galvanic Cell (lead-oxygen with weak acid electrolyte)
Input Range	0 to 100% oxygen
Accuracy (Calibrated)	±3.0% over operating conditions range
Response Times	< 15 seconds for 90% response < 25 seconds for 97% response
Max Humidity	0 to 95% Non-condensing
Operating Temperature	5 °C to 40 °C
Storage Temperature	−15 °C to 50 °C

Setting up the oxygen sensor
Since the oxygen sensor has an output of 0 mV at 0% oxygen, a single-point calibration can be carried out. The procedure below guides you through setting up the oxygen sensor to work with PicoLog and calibrating it using the oxygen in the atmosphere as a reference point (calibration is necessary to use the sensor with ±3% accuracy).

Connect the sensor to the DrDAQ and set up a channel:

1. Connect the oxygen sensor to the socket labeled **Ext 1** on the DrDAQ unit.
2. In the PicoLog **Devices** tab, click **Ext 1** to open the channel set up dialog.
3. Click **Save changes**

DrDAQ should be receiving information from the oxygen sensor. The sensor should be calibrated using the procedure below:

Calibrating the oxygen sensor
Both PicoLog and PicoScope provide the facility to enter scaling look-up tables. These instructions will concentrate on doing so in PicoLog (for instructions on custom ranges in PicoScope, see the PicoScope help file).

This is the information we have so far:

Raw Values after built in Scaling File (%)	Calibrated Values known to be true (%)
0	0
19.9	20.9 (known oxygen in air at sea level)

Only one more value is needed to complete the look-up table. If you are measuring the normal atmosphere then this reading is currently displayed on the PicoLog **Channels & axes** view. Complete the table above with this value (replace 19.9 with your reading) and follow the instructions below:

1. In the **Devices** view, select the relevant channel on the DrDAQ which will open the channel settings dialog box.

CU985/190 - External 2

Label	External 2
Color	
Sample interval	1	second
Sample mode	Latest sample
Probe or scaling	None
Sensor	Oxygen (Percentage)

Cancel Save changes

2. Click on **Probe or scaling**:

Probes and Custom Scaling

No scaling	Equation	Table
1:1	Σ	⊞

Cancel Save

3. Then select **Table**.
4. From the look-up table you completed above, enter these values in the following format (replace 19.9 with whichever value you read from the Channels & axes view):
   0 0
   19.9 20.9
   (Separate the values above with spaces):

Table Scaling

input % vs. output %

```
0 0
19.9 20.9
```

Return units

Same as input | %

Cancel Save

5. Click **Save**.

PicoLog's **Channels & axes** view should now display 20.9% (or very close) for the oxygen content in air. If so, you've successfully calibrated your DrDAQ oxygen sensor.

Storing the oxygen sensor
Ensure that the storage temperature and humidity ranges in the specification are not exceeded. The sensor is not designed for use in liquids and using it in this way will damage the sensor.

The sensor has a lifetime of 900 000 O_2 % hrs. In air at sea level the sensor will operate effectively for over 4 years (this will decrease if the sensor is exposed to high oxygen concentrations for prolonged periods).

The lifetime of the sensor can be affected by exceeding the storage / operating ranges and exposure to some gaseous chemicals in high concentrations. Please avoid the following: sodium hydroxide, acetone, MEK.

3.8.7   TA137 redox sensor

The DrDAQ TA137 redox sensor (also known as an oxidation reduction potential or ORP sensor) can measure redox potential in the range of −1500 mV to +1500 mV. The voltage measured is proportional to the tendency of a solution to gain or lose electrons. Positive readings indicate an increase in oxidation state (loss of electrons), while negative readings indicate a reduction in the oxidation state (gain of electrons).

Specification

Model	99Pt-B
Measuring range	±1500 mV
Junction	Ceramic
Reference cell	Ag/AgCl, KCl gel
Sensitive component	Dia. 6 x 2.5 mm platinum ring
Size	Diameter: 12 mm Length: 160 mm
Plug	BNC with 1 meter cable

4 Getting started with PicoScope

4.1 Using PicoScope for the first time

1. After installing the software, click the new PicoScope icon on your Windows desktop, macOS Launchpad or Linux application launcher.

2. PicoScope will detect your device and prepare to display a waveform. The green **Start** button will be highlighted to show that PicoScope is ready. Adjacent to this is the red **Stop** button.

3. Try clicking your fingers over the microphone, and the trace on the screen should react. DrDAQ is now successfully installed and working.
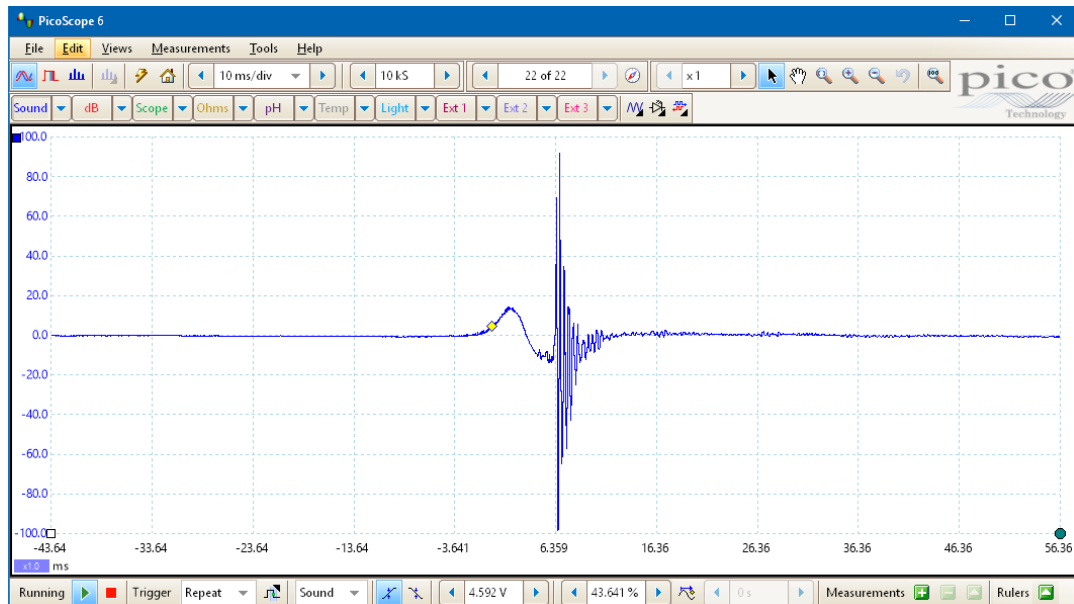
A typical 'finger click' trace

Problems?

Help is at hand! The technical support staff at our UK, US or Chinese offices are always ready to answer your telephone call during their own office hours (9 am to 5 pm, Monday to Friday). At other times, you can leave a message on our support forum or send us an email.

4.2   Displaying channels

To display channels in the oscilloscope window, click on a sensor Channel button which will recede slightly to indicate that it is active:

Channel buttons →
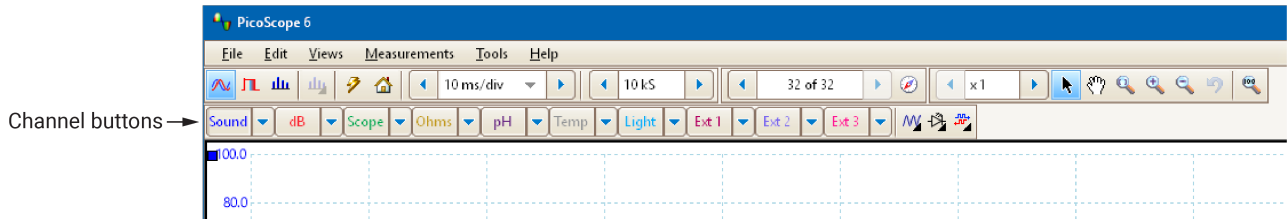
You can add other channels to the oscilloscope screen by clicking on the sensor that you wish to view. In this example, we have added **Temp** (temperature). While the trace is running, put your finger on the temperature sensor and notice the corresponding rise on the screen:
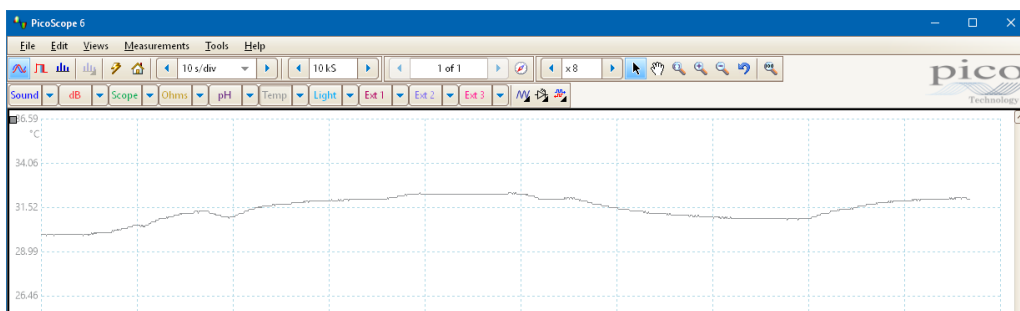
4.3 Changing the oscilloscope timebase

The timebase can be adjusted by selecting the drop-down menu shown below. Adjust the timebase from 1 ms/div to 50 ms/div to change the display as follows:
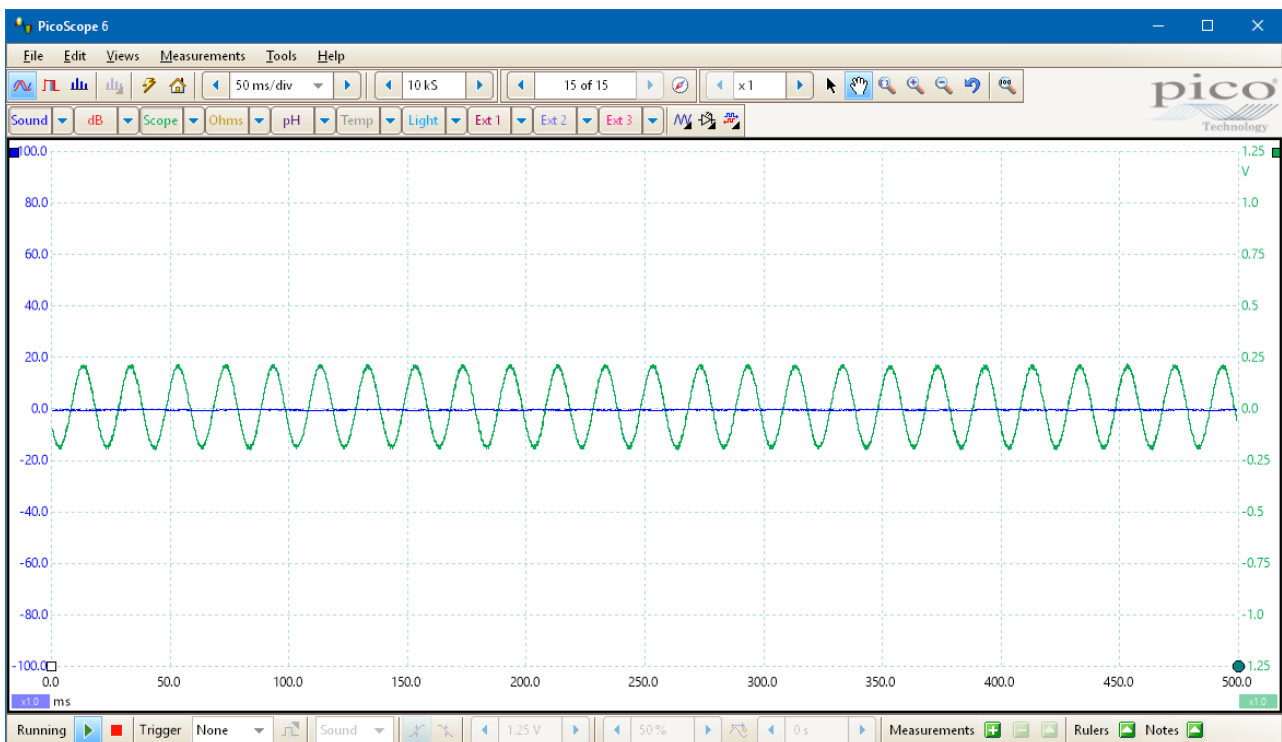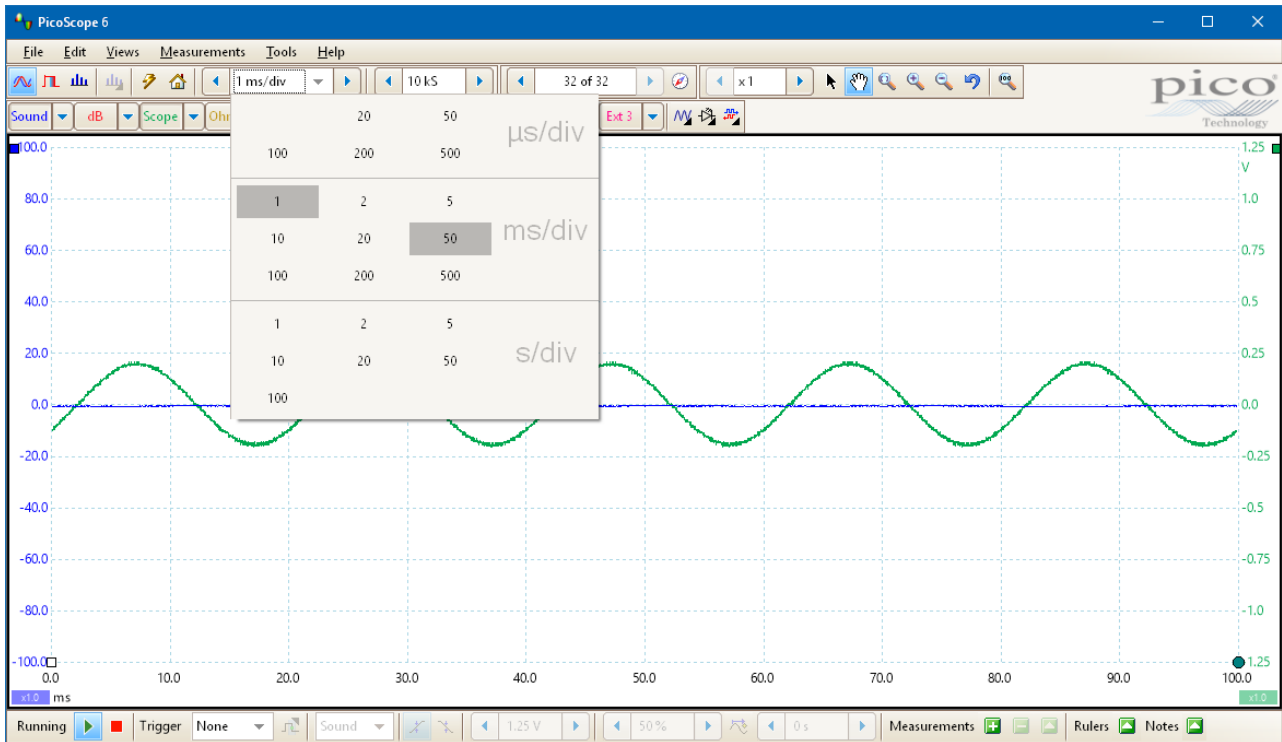
4.4 Using the trigger

The PicoScope trigger can be used to capture infrequent or one-off events. As an example, click your fingers over the microphone; a waveform is displayed but vanishes as soon as the display updates. The correct way to capture such a signal is to use a trigger.

Stop PicoScope (click the **Stop** icon at the bottom left hand corner of the window, or press the space bar) and select a **Single** trigger using the trigger options at the bottom of the screen. Press the space bar to start PicoScope and click your fingers over the microphone. The single trigger option means that PicoScope stops running when it has captured a signal.
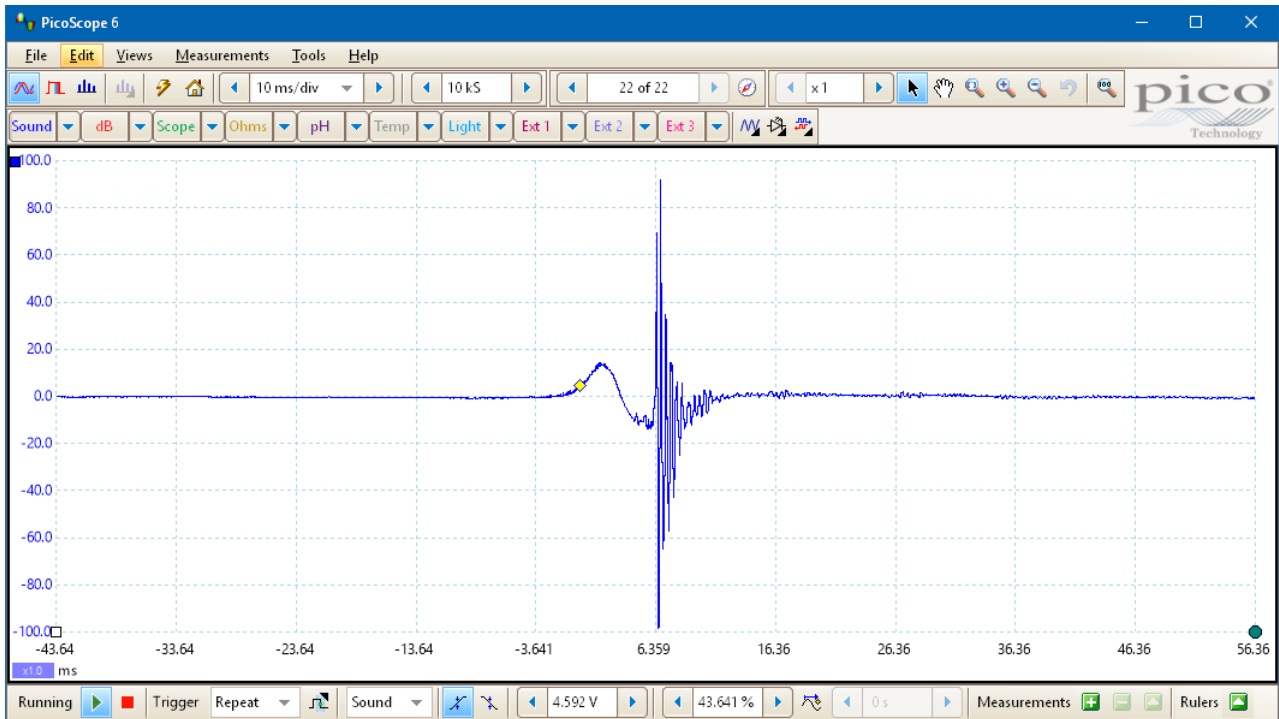
4.5 Adding spectrum views

So far we have looked at the oscilloscope functions. PicoScope allows DrDAQ to be used as a spectrum analyzer as well. The buttons on the top left-hand side control the oscilloscope and spectrum views.

- Oscilloscope view (view signals against time)

- Spectrum analyzer view (view amplitude against frequency)

4.6 Adjusting the RGB LED

The DrDAQ units include an RGB LED. The color of this LED can be changed by clicking the LED icon above the oscilloscope window. The following drop down will appear:
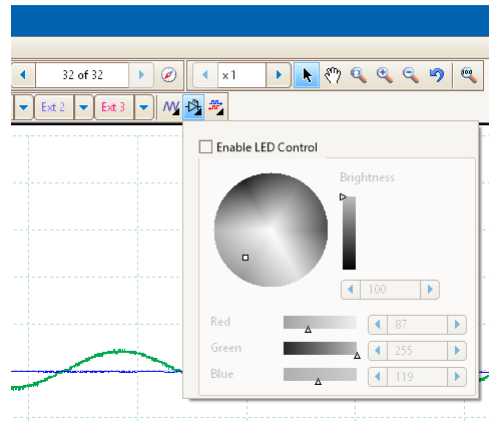
Clicking **Enable LED Control** will show the numerical values intended to make the LED glow RED:

Note: When *Enable LED Control* is active, the LED will not flash when sampling.
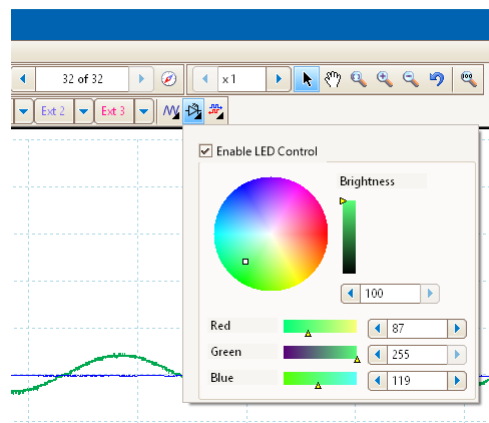
The color of the LED is adjusted by dragging the individual color and brightness sliders, entering specific RGB values, or clicking within the color disk:
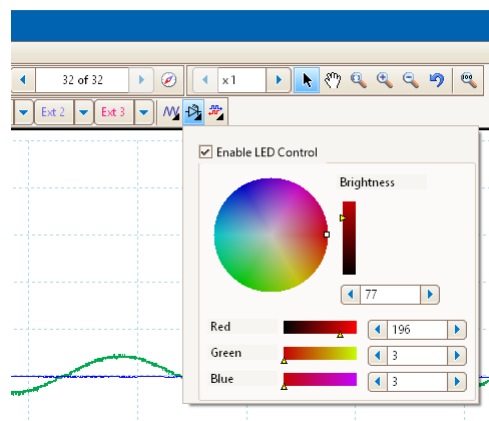
4.7   Controlling the digital outputs

The DrDAQ device includes several digital connections. To activate the digital outputs, ensure your accessory is connected both to the *GND* of the DrDAQ and the digital connection you wish to control. To operate the connections click the **Digital outputs** button (🔧) above the oscilloscope window. The following drop-down will appear:
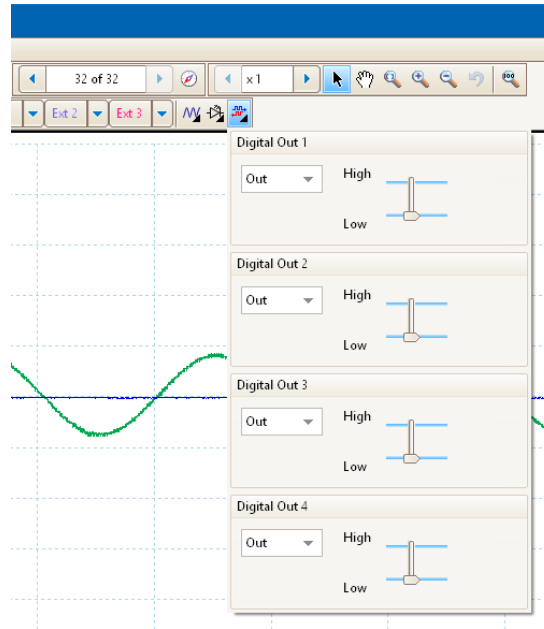
Moving any of the 4 sliders to **High** will activate that digital output. Only outputs 1 and 2 are able to output a PWM (Pulse Width Modulation) signal. To do this choose **PWM** in the drop-down for either digital output 1 or 2. This allows adjustment of the PWM *Period* and *Duty Cycle* values:
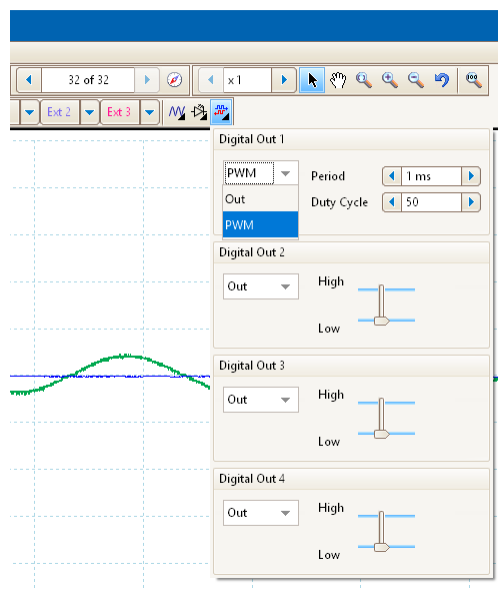
Refer to Examples of digital in/out use for an example of PicoScope and the digital connections of DrDAQ.

5 Getting started with PicoLog

5.1 Using PicoLog for the first time

After installing the software, connect the DrDAQ to the computer and then click the new PicoLog icon on your Windows desktop or macOS Launchpad. When PicoLog is first run, the following screen will appear:
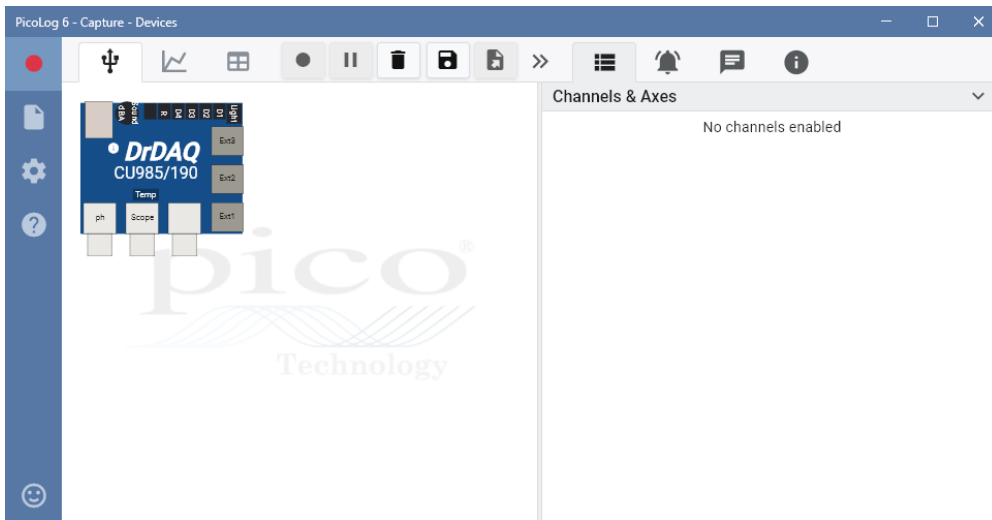

1. Click on the DrDAQ graphic to enlarge it and select a channel on the device to show the channel setup dialog which allows you to configure the channel. You can type in a channel **Label** and choose a channel **Color and Sample interval.** You also have an advanced option to set **Probe** or **Custom scaling** in the advanced options. Then click **Save changes**:
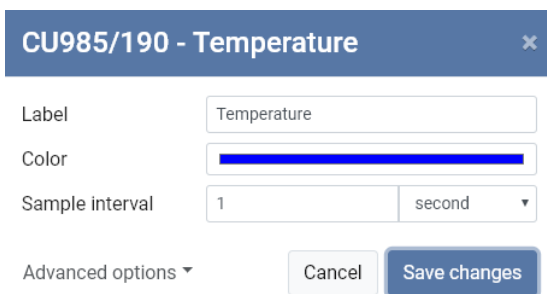
To make the configuration of multiple channels easier, hold Ctrl (Windows and Linux) or cmd (macOS) and click on the channels to be configured. Then release Ctrl (or cmd) and click one of the channels or press Enter to display the channel setup dialog box.

2. Once a channel has been assigned, data will appear in the **Channels & Axes** column:
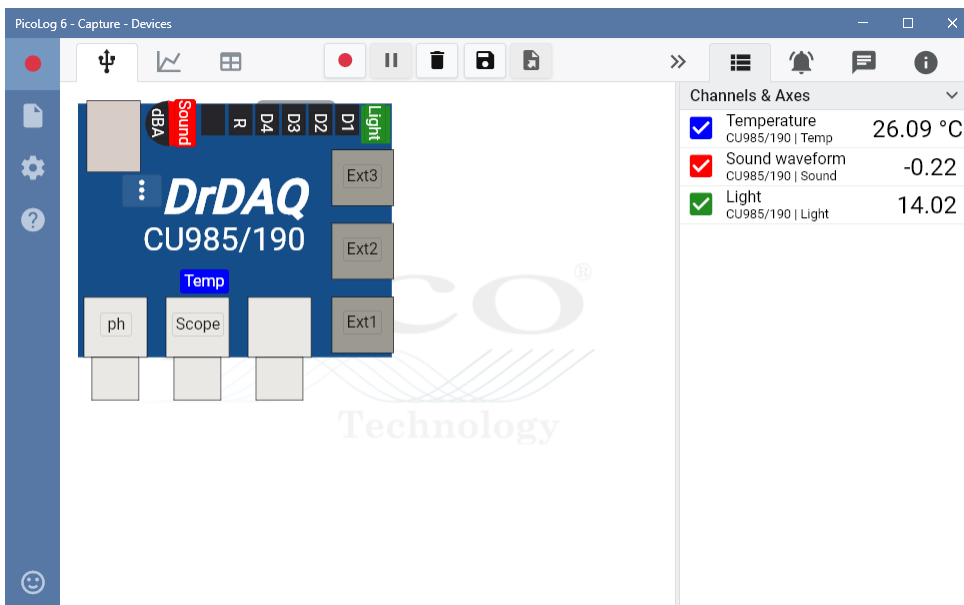
3. Click the red Start recording button and choose a Capture setting of either Unlimited or Fixed length. Don't forget to ensure there is sufficient PC storage capacity. Then click Start capture:
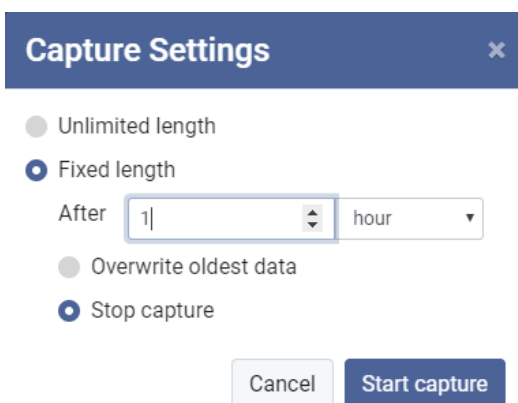

Refer to Examples of digital in/out use for an example of PicoLog and the digital connections of DrDAQ.

6 Software updates

Our software is regularly updated with new features. To check what version of the software you are running in PicoScope, select **Help** from the top drop-down menu and then **About PicoScope 6**. In PicoLog select the question mark icon in the side bar to display the **Help & support** dialog where you will be able to check the version.
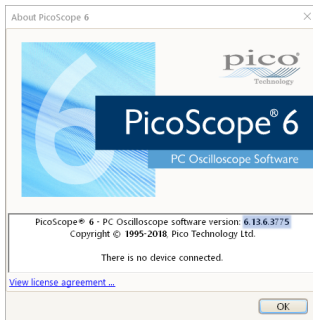
PicoScope
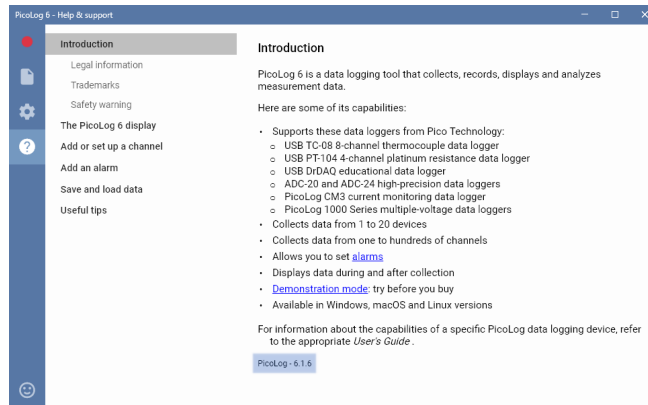
PicoLog

PicoScope and PicoLog can check for updates automatically and will advise you if an update is available. The latest version of all our software can be downloaded free of charge from the Pico Technology web site at:

https://www.picotech.com/downloads

To be kept up to date with news of new software releases, click here to join our e-mail mailing list.

7   Glossary

Analog bandwidth. The range of input frequencies within which the measured signal amplitude is reduced by no more than 3 decibels from its known value.

Buffer size. The size of the oscilloscope buffer memory, measured in samples. The buffer allows the oscilloscope to sample data faster than it can transfer it to the computer.

Driver. A program that controls a piece of hardware. The driver for the oscilloscopes is supplied in the form of 32-bit and 64-bit versions of a Windows DLL. Drivers for other operating systems are also available. These are used by the PicoScope and PicoLog software, and by user-designed applications, to control the unit.

Maximum sampling rate. A figure indicating the maximum number of samples the oscilloscope can acquire per second. The higher the sampling rate of the oscilloscope, the more accurate the representation of the high-frequency details in a fast signal.

PC Oscilloscope. A virtual instrument formed by connecting a PicoScope oscilloscope to a computer running the PicoScope software.

PicoLog software. This powerful data acquisition software allows you to collect, manipulate, analyze, display and export data.

PicoScope software. A software product that accompanies all PicoScope oscilloscopes. It turns your PC into an oscilloscope, spectrum analyzer and measuring instrument.

Redox potential. A measure in volts of the affinity of a substance for electrons.

Timebase. The timebase controls the time interval that each horizontal division of an oscilloscope view represents. There are ten divisions across the oscilloscope view, so the total time across the view is ten times the timebase per division.

USB. Universal Serial Bus. This is an industry standard enabling peripherals to connect to hosts, for example, personal computers. The DrDAQ is compatible with any USB port from USB 1.1 upwards.

Vertical resolution. A value, in bits, indicating the number of unique values that the oscilloscope can generate when converting input voltages to digital values. In PicoScope, resolution enhancement can improve the effective vertical resolution.

Voltage range. The range of input voltages that the data logger can measure. For example, a voltage range of ±1.25 V means that the oscilloscope can measure voltages between −1.25V and +1.25V. Input voltages outside this range will not damage the instrument as long as they remain within the protection limits stated in the data sheet.

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