PT-104®

PRT temperature data logger

User's Guide

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1　　Welcome

Thank you for buying a PT-104 from Pico Technology!

The PT-104 is a four-channel high-resolution temperature data logger for use with PT100 and PT1000 type platinum resistance thermometers (PRTs). It can be used to measure temperature, resistance and voltage.

In PT100, PT1000 and resistance modes, the unit can use a two, three or four-wire circuit. Four-wire measurement gives the greatest accuracy.

In voltage mode, the input connector can be treated as a differential input with ground. In the SDK only, the input connector can be treated as two single-ended inputs.

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 PT-104. Pico also maintains repositories of example code on GitHub. Refer to the *PT-104 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   Conformance

The PT-104 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 PT-104 manuals.

2.2   Software licence conditions

Grant of license. The material contained in this release is licensed, not sold. Pico Technology Limited ('Pico') grants a license to the person who installs this software, subject to the conditions listed below.

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Mission-critical applications. Because the software runs on a computer that may be running other software products, and may be subject to interference from these other products, this license specifically excludes usage in 'mission-critical' applications, for example life-support systems.

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.

2.3   Pack contents

Please check that your PT-104 pack (order code PP682) contains the following items:

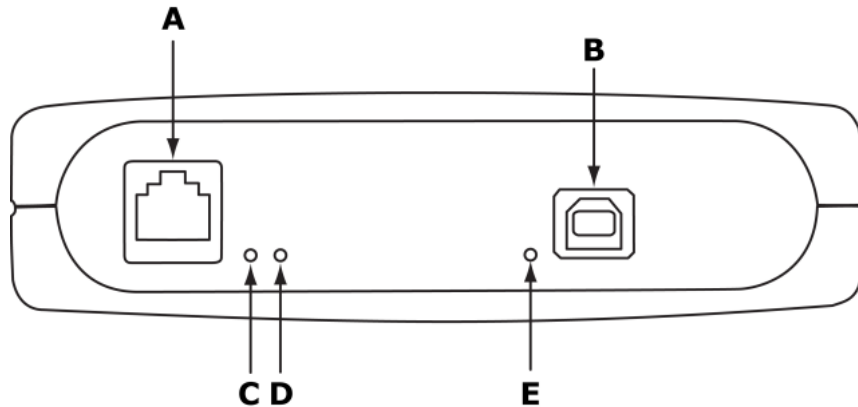| Quantity	Reorder code	Description
1	PP682	PT-104 Data Logger
1	DO112	USB Installation Guide
1	MI106	USB lead
1	TA076	Ethernet patch cable

2.4   Minimum system requirements

To ensure that your PT-104 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
Operating system	All supported Windows operating systems. Software is also available for Linux (64-bit) and macOS operating systems. Compatible with Raspbian Buster or newer using Raspberry Pi model 4B Click here for the latest software release notes and OS support.
Processor	As required by the operating system
Memory	
Free disk space	
Ports	USB 3.0 or USB 2.0 port(s)

3   Getting started

3.1   The back panel

A. Ethernet port

B. USB port

C. Ethernet Data indicator - Flashes to indicate Ethernet data transfer.

D. Ethernet Link indicator - On when Ethernet port connected to an active device.

E. Power/Status indicator - On when power is applied. Flashes to indicate conversion in progress.

3.2   Checking the installation

Before you connect the PT-104 to your computer for the first time, you must download and install the PicoLog software which is available free from www.picotech.com/downloads.

1. When you have connected the data logger to a USB port on your PC, click the PicoLog icon on your PC desktop to start the software:

PicoLog icon

2. The PT-104 will appear in the Devices tab:
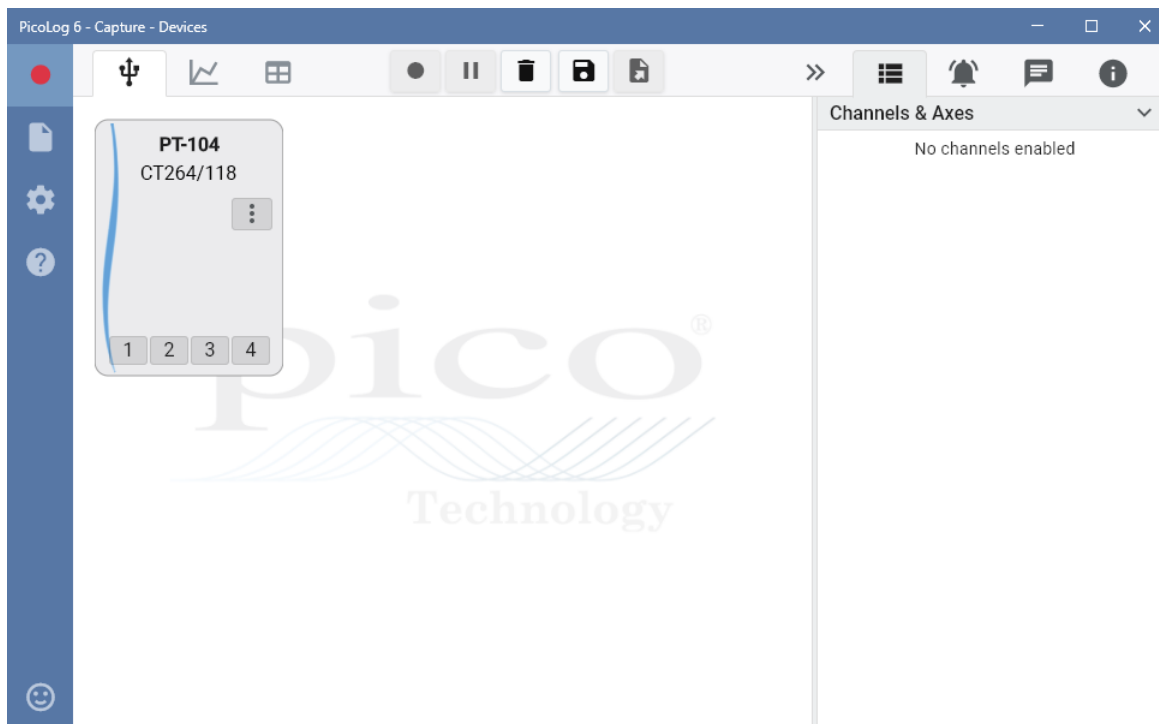
3. Connect a temperature sensor (you will not see a temperature reading unless a sensor is connected because the input is open circuit) and configure its channel by selecting it in the graphic. This will display a channel setup dialog box. You can type in a channel **Label** and choose a channel **Color**, **Sample interval** and **Input type** (sensor or other measurement). You also have an advanced option to set **Custom scaling**:


4. Click Add channel. The selected channel (in this case, channel 1) on the PT-104 will be highlighted in a color corresponding to the plot line Color chosen.

To make the configuration of multiple channels easier you can 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.

5. The Maths channel configurator will appear in the Devices tab as a small calculator. The sensor channel will be displayed in the Channels & axes column on the right of the screen and also the Start recording, Pause, Delete, Save and Export buttons will be available:
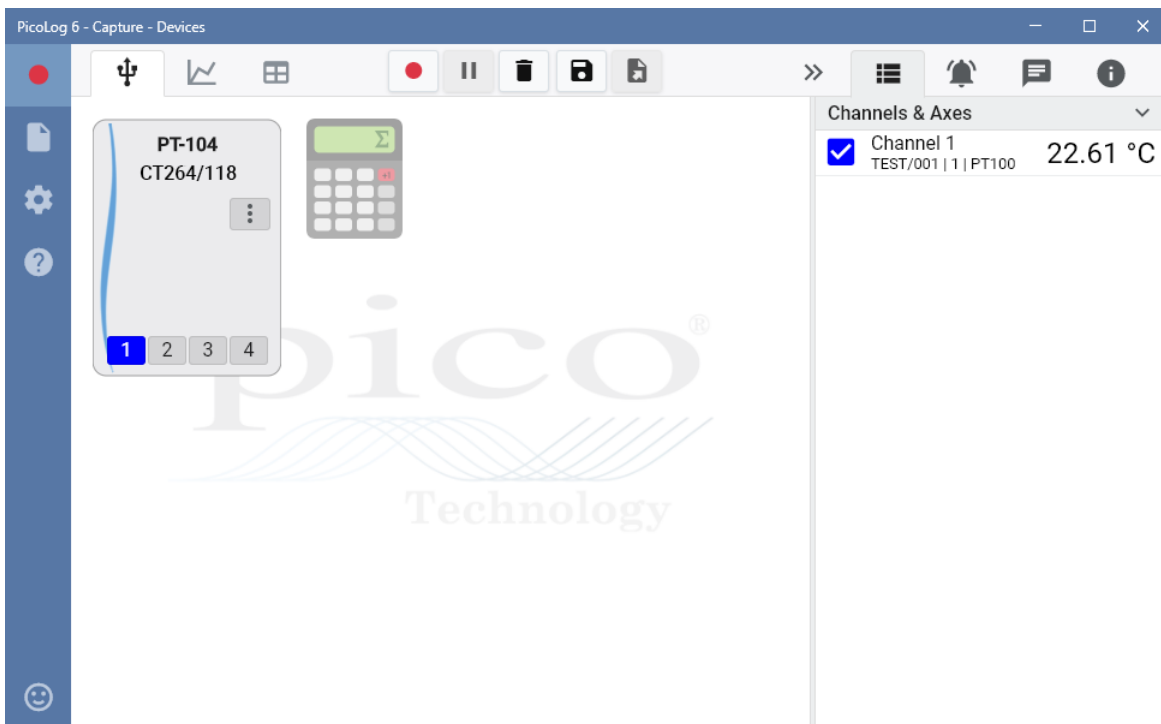
6. To start recording, click the red **Start recording** button and then choose a capture setting of either **Unlimited** or **Fixed** length from the pop up dialog box. Don't forget to ensure there is sufficient PC storage capacity:
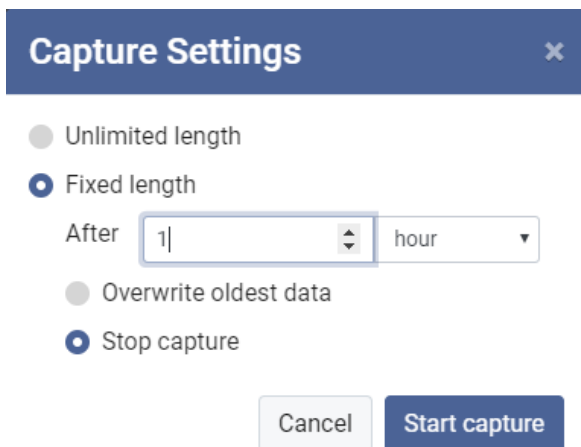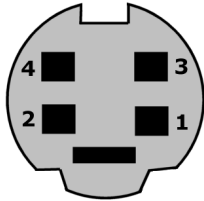
3.3   Connection: PRT inputs

The PT-104 is compatible with PT100 and PT1000 type platinum resistance thermometers (PRTs). Connect each one of these devices to the unit as follows.

Pin Connections to the PT-104 Mini-DIN socket

Pin	PT100, PT1000 or Resistance 4-Wire	PT100, PT1000 or Resistance 3-Wire	PT100, PT1000 or Resistance 2-Wire	Differential voltage
1	White	Connect to pin 3	Connect to pin 3	Do not connect
2	Red	Red	Red	V −
3	White	White	White	V +
4	Red	Red	Connect to pin 2	Gnd

In voltage mode, the input connector can be treated as a differential input with ground. In the SDK only, the input connector can be treated as two single-ended inputs.

Single-ended voltage connection
Single-ended mode allows you to double the number of channels from 4 to 8. It is supported by the driver, so you can use it in your own applications written using the PicoSDK. It is not, however, supported by the PicoLog software.
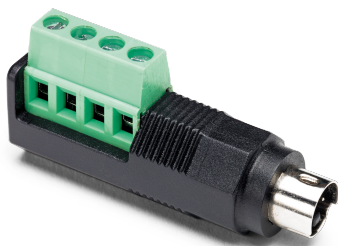
Connector	Channel	Pin
1	1	3
	5	2
2	2	3
	6	2
3	3	3
	7	2
4	4	3
	8	2

Note on differential voltage mode
The maximum input voltage range of the PT-104 is 2.5 V. Any voltage in excess of ±30 V (with respect to USB ground) on any input pin may cause permanent damage to the unit.

In differential voltage mode, the input connector should be treated as a differential input with reference to ground. Both inputs (V+ and V−) must be zero volts or above (it does not matter which input has the higher voltage) and must remain within the input range. A ground reference connection is also required for correct operation. The ground connection of each mini-DIN socket consists of a 100 ohm resistor to mains earth/ground through the USB cable outer braiding and the PC chassis.

Single-channel screw terminal adaptor

You can interface third-party sensors not fitted with the 4-pin mini-DIN connector and you can measure voltage or resistance using the PP660 screw terminal adaptor. This adaptor has 4 breakout terminals and occupies a single channel of the PT-104.

3.4   Connection: Ethernet port

Setup
Ethernet connection is only available with Windows operating systems.

Before connecting to the PT-104's Ethernet port, you must first configure the Ethernet settings. Proceed as follows:

1. Connect the unit to your computer using the USB port.

2. In the **Devices** tab view, click the three dots on the PT-104:

3. Select **Device information** to view the dialog:
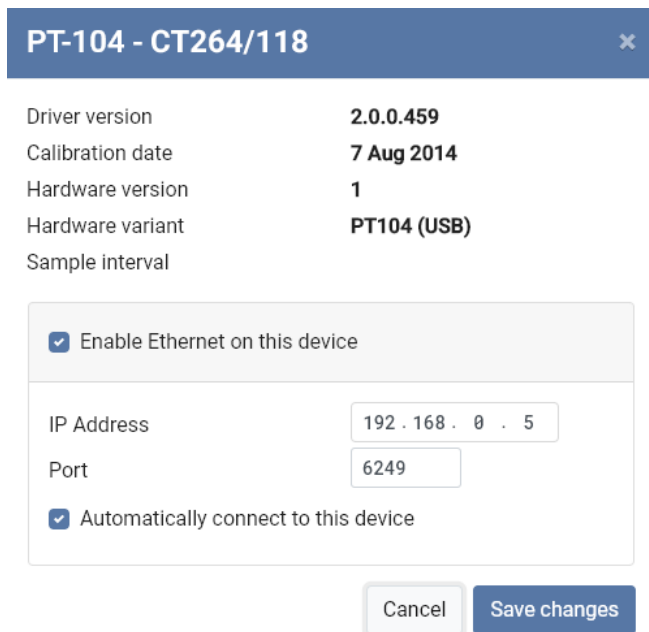
4. Ensure **Enable Ethernet on this device** is checked to show the Ethernet settings (**IP Address** and **Port**)

5. Enter the IP address and port that you wish to give the device. You may need to ask your network manager for an IP address that does not conflict with existing devices on the network.

6. Click **Save changes**.

7. You can now either continue to use the PT-104 as a USB device, or unplug the USB cable and reconnect the device using its Ethernet port.

Power-saving tip

If you wish to stop using the PT-104 in Ethernet mode, you can use the *Ethernet Settings* utility to disable its Ethernet port. This reduces the power consumption of the device when used in USB mode.

Ethernet and USB

Do not use the PT-104 in USB mode when it is being powered by Power-over-Ethernet (PoE). This could cause the unit to radiate electromagnetic energy outside the limits permitted by FCC and EU regulations, and could also cause it to produce spurious measurements. It will not, however, cause permanent damage to the unit.

LAN connection

To use the PT-104 on a local-area network (LAN), connect it to your network switch or network router using the Ethernet cable provided.

Direct connection

You can also connect the PT-104 directly to the network port on your computer. Most Ethernet ports on PCs and switches support Auto MDI-X (automatic cross-over). If your Ethernet ports do not, you may need to use an Ethernet cross-over cable (not supplied).

Power over Ethernet (PoE)

The PT-104 can obtain its power from the Ethernet port as a Powered Device (PD) according to the PoE standard. To use this feature, you must connect the unit to Power Sourcing Equipment (PSE) such as a network switch, router or power injector that also supports the PoE standard. Any standard Ethernet cable up to 100 m (about 328 ft) in length can be used.

4   Background information

4.1   Platinum resistance thermometers (PRTs)

PRTs (Platinum Resistance Thermometers) offer excellent accuracy over a wide temperature range
(from −200 °C to 850 °C). Sensors are interchangeable between different manufacturers, and are available in
various accuracy ratings in packages to suit most applications. Unlike thermocouples, it is not necessary to use
special cables to connect to the sensor.

The principle of operation is to measure the resistance of a platinum element. The most common type (PT100)
has a resistance of 100 Ω at 0 °C and 138.4 Ω at 100 °C.

The relationship between temperature and resistance is approximately linear over a small temperature range. For
example, if you assume that it is linear over the 0 °C to 100 °C range, the error at 50 °C is 0.4 °C.

For precision measurement, it is necessary to linearize the resistance to give an accurate temperature. The most
recent definition of the relationship between resistance and temperature is International Temperature Standard
90 (ITS-90). This linearization is done automatically with software.

The linearization equation is:

$$R_t = R_0 (1 + At + Bt^2 + C(t-100)t^3)$$

$$A = 3.9083 \times 10^{-3}$$

$$B = -5.775 \times 10^{-7}$$

$$C = \quad \text{(below 0 °C)} \; -4.183 \times 10^{-12}$$

$$\text{(above 0 °C)} \; 0$$

For a PT100 sensor, a 1 °C temperature change will cause a 0.384 Ω change in resistance, so even a small error in
measurement of the resistance (for example, the resistance of the wires leading to the sensor) can cause a large
error in the measurement of the temperature. For precision work, sensors have four wires - two to carry the sense
current, and two to measure the voltage across the sensor element. It is also possible to obtain three-wire
sensors, although these operate on the (not necessarily valid) assumption that the resistance of each of the
three wires is the same.

The current through the sensor will cause some heating. For example, a sense current of 245 μA through a 100 Ω
resistor generates 6 μW of heat. If the sensor element is unable to dissipate this heat, it reports an artificially high
temperature. This effect can be reduced by either using a large sensor element, or by making sure that it is in
good thermal contact with its environment.

Using a 1 mA sense current gives a signal of only 100 mV. Because the change in resistance for a degree Celsius
is very small, even a small error in the measurement of the voltage across the sensor produces a large error in the
temperature measurement. For example, a 100 μV voltage measurement error would give a 0.4 °C error in the
temperature reading. Similarly, a 1 μA error in the sense current would give a 0.4 °C temperature error.

Because of the low signal levels, it is important to keep any cables away from electric cables, motors, switchgear
and other devices that may emit electrical noise. Using screened cable, with the screen grounded at one end, may
help to reduce interference. When using long cables, it is necessary to check that the measuring equipment is
capable of handling the resistance of the cables. Most equipment can cope with up to 100 Ω per core.

The type of probe and cable should be chosen carefully to suit the application. The main issues are the
temperature range and exposure to fluids (corrosive or conductive) or metals. Clearly, normal solder junctions on
cables should not be used at temperatures above about 170 °C.

Sensor manufacturers offer a wide range of sensors that comply with BS1904 class B (DIN 43760). These sensors offer an accuracy of ±0.3 °C at 0 °C. For increased accuracy, you can use BS1904 class A (±0.15 °C) or tenth-DIN sensors (±0.03 °C). Companies like Isotech can provide standards with 0.001 °C accuracy. Please note that these accuracy specifications relate to the SENSOR ONLY. It is necessary to add on any error in the measuring system as well.

Related standards are IEC751 and JISC1604-1989. IEC751 also defines the color coding for PRT sensor cables: the one or two wires attached to one end of the sensor are red, and the one or two wires at the other end are white.

5   Glossary

Ethernet. The most widely installed local area network (LAN) technology. **Ethernet** is a link layer protocol in the TCP/IP stack, describing how networked devices can format data for transmission to other network devices on the same network segment, and how to put that data out on the network connection.

Local area network (LAN). A network that connects computers and other devices in a relatively small area.

Thermocouple. A device consisting of two dissimilar metals joined together. The thermoelectric voltage developed between the two junctions is proportional to the temperature difference between the junctions.

USB. Universal Serial Bus. This is an industry standard enabling peripherals to connect to hosts such as personal computers, for example. The PT-104 is compatible with any USB port from USB 1.1 upwards.

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