# PT-104

# Thermistor Converter

User's Guide

pt104.en-6

pico®
Technology

# Contents

# 1 Introduction

## 1.1 Overview

The PT-104 is a four-channel, high-resolution temperature converter for use with PT100 and PT1000 type sensors. It can be used to measure temperature, resistance and voltage.

In PT100/PT1000/resistance mode, the unit uses a four-wire circuit.

In voltage mode, the input connector can be treated as a differential input with ground, or two single-ended inputs. Both inputs must be 0 V or above, though it does not matter which input has the higher voltage. For the 115 mV range, the accuracy may vary by 2%, and the temperature coefficient will be 100 ppm/°C.

## 1.2 Safety warning

We strongly recommend that you read the general safety information below before using your product for the first time. If the equipment is not used in the manner specified, then the protection provided may be impaired. This could result in damage to your computer and/or injury to yourself or others.

Maximum input range. The PT-104 is designed to measure voltages in the range 0 to +2.5 V. Any voltages in excess of ±30 V may cause permanent damage to the unit.

Mains voltages. Pico products are not designed for use with mains voltages. To measure mains we recommend the use of a differential isolating probe specifically designed for such measurements.

Safety grounding. The ground of every product is connected directly to the ground of your computer via the interconnecting cable provided. This is done in order to minimise interference. If the PC (especially laptop) is not grounded, reading stability cannot be guaranteed and it may be necessary to manually ground the equipment.

As with most oscilloscopes and data loggers, you should take care to avoid connecting the inputs of the product to anything which may be at a hazardous voltage. If in doubt, use a meter to check that there is no hazardous AC or DC voltage. Failure to check may cause damage to the product and/or computer and could cause injury to yourself or others.

Take great care when measuring temperatures near mains equipment. If a sensor is accidentally connected to mains voltages, you risk damage to the converter or your computer and your computer chassis may become live.

You should assume that the product does not have a protective safety earth. Incorrect configuration or use of the device to measure voltages outside the maximum input range can be hazardous.

Repairs. The unit contains no user-serviceable parts. Repair or calibration of the unit requires specialised test equipment and must be performed by Pico Technology or its authorised distributors.

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# 2 Product information

## 2.1 Specifications

| | Temperature | Resistance | Voltage |
|---|---|---|---|
| Sensor | PT100*, PT1000 | N/A | N/A |
| Range | -200 to 800°C | 0 to 375 Ω*;<br>0 to 10 kΩ | 0 to 115 mV;<br>0 to 2.5 V* |
| Linearity | 10 ppm | 10 ppm | 10 ppm |
| Accuracy @25°C | 0.01°C* | 20 ppm* | 0.2%* |
| Temperature coefficient | 3 ppm/°C | 3 ppm/°C | 100 ppm/°C |
| RMS Noise (using filter) | 0.01°C | 10 ppm | 10 ppm |
| Resolution | 0.001°C | 1 mΩ | 0.156 µV |
| Conversion Time Per Channel | 720 ms** | 720 ms** | 180 ms |
| Number of inputs | 4 | | |
| Connectors | 4-pin mini-DIN | | |
| Input impedance | >> 1 MΩ | | |
| Overvoltage protection | ±30 V | | |
| Output | RS-232, DE9 female | | |
| Environmental | 20 to 30°C for stated accuracy; 0 to 70°C overall; 20 to 90% RH | | |
| Dimensions | W 135 mm x L 184 mm x H 36 mm<br>(5.31" x 7.24" x 1.42") | | |
| Software | PicoLog data logging software; Drivers for Windows XP SP2/ Vista; Examples for C/C++, Delphi, Excel, LabVIEW, Visual Basic, Agilent-VEE. | | |
| Quoted accuracy is for options marked * | | | |
| For four-wire temperature and resistance measurement** | | | |

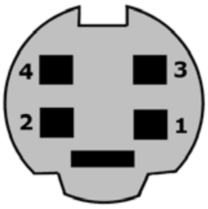
## 2.2 Installing the driver

The driver is installed automatically when you install the PicoLog software. Alternatively, you can download the driver from our website at http://www.picotech.com.

## 2.3 Connection

To use the PT-104, you should connect its D-connector to your computer's serial port using the cable provided. Next, connect a PT100 or PT1000 PRT to one of the input connectors.

Pin Connections to the PT-104 Mini-DIN socket



| Pin | PT100, PT1000<br>4 Wire | PT100, PT1000<br>3 Wire | PT100, PT1000<br>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 |

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. It is not, however, supported by PicoLog.

| 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

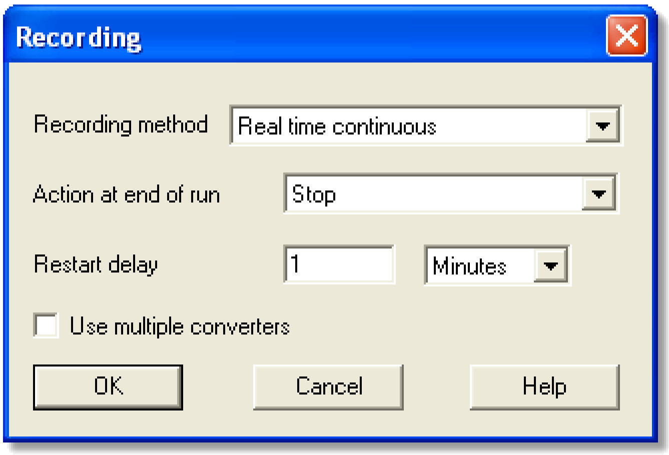
The maximum input voltage range of the PT-104 is 2.5 V. Any voltage in excess of +/- 30 V on any input pin may cause permanent damage to the unit.

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 Ω resistor to mains earth/ground via the serial cable outer braiding and the PC chassis.

## Setting up

To set up the unit, do the following:

1. From the PicoLog Recorder File menu, select New settings. The Recording dialog box appears:



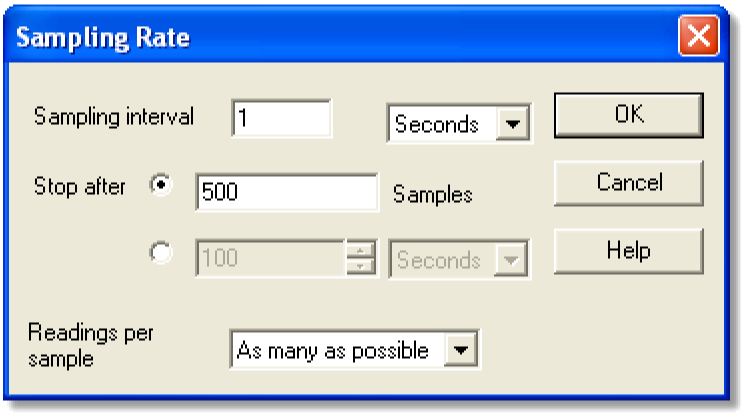
Recording method: Real time continuous

Action at end of run: Stop

Restart delay: 1 Minutes

□ Use multiple converters

2. Click OK. The Sampling Rate dialog box appears:



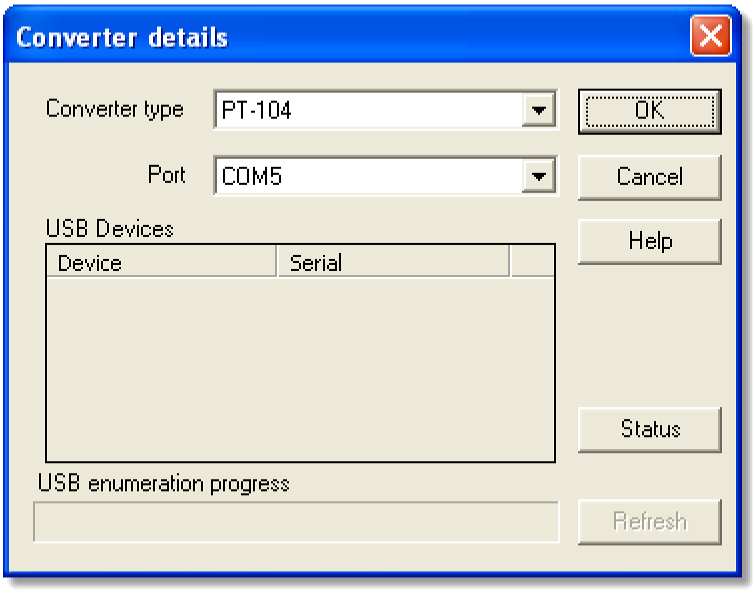
Sampling interval: 1 Seconds

Stop after ● 500 Samples

○ 100 Seconds

Readings per sample: As many as possible

3. Click OK. The Converter details dialog box appears:



Converter type: PT-104

Port: COM5

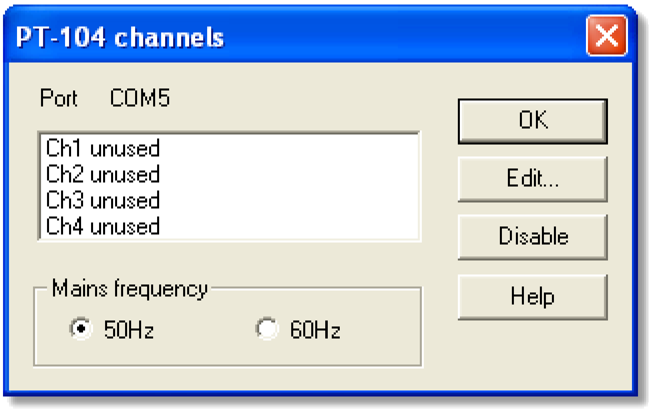
USB Devices

| Device | Serial |
|---|---|

USB enumeration progress

4. From the Converter type drop-down list, select PT-104.

5. From the Port drop-down list, select the port and click OK. After a short while, the PT-104 channels window appears:



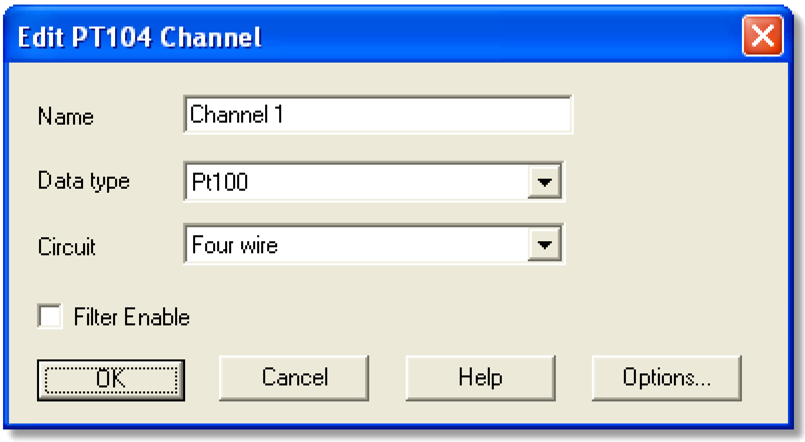
PT-104 channels

Port COM5

Ch1 unused
Ch2 unused
Ch3 unused
Ch4 unused

Mains frequency ● 50Hz ○ 60Hz

6. In the PT-104 channels window, double-click on Ch1 unused. The Edit PT-104 Channel dialog box appears:



Edit PT104 Channel

Name: Channel 1

Data type: Pt100

Circuit: Four wire

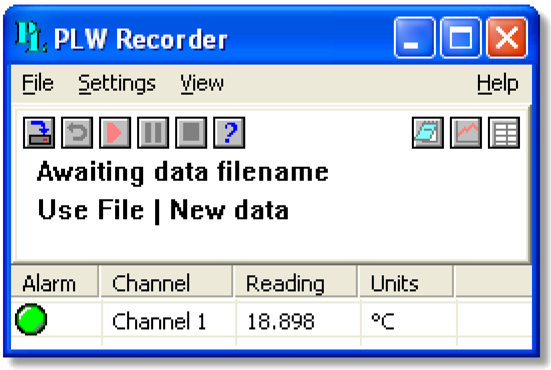
□ Filter Enable

7. Type in a name for the channel, if required

8. Select the data type required i.e temperature, resistance or voltage

9. Select circuit - for PT100 and PT1000

10. Now click OK. Readings from the PT-104 should appear in the monitor window:



PLW Recorder

Awaiting data filename
Use File | New data

| Alarm | Channel | Reading | Units |
|---|---|---|---|
| ● | Channel 1 | 18.898 | °C |

## 2.4 Background on PRTs

PRTs (Platinum Resistance Thermometers) offer excellent accuracy over a wide temperature range (from -200 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 to 100°C range, the error at 50°C is 0.4°C. For precision measurement, it is necessary to linearise 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 linearisation is done automatically with software.

The linearisation equation is:

$$Rt = R0 * (1 + A* t + B*t2 + C*(t-100)* t3)$$

$$A = 3.9083 \text{ E-3}$$

$$B = -5.775 \text{ E-7}$$

$$C = \text{(below } 0°\text{C) } -4.183 \text{ E -12}$$

(Above 0°C) zero

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 µ A through a 100 Ω resistor will generate 6 µW of heat. If the sensor element is unable to dissipate this heat, it will report 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 will give 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 will produce a large error in the temperature measurement. For example, a 100 µV voltage measurement error will give a 0.4°C error in the temperature reading. Similarly, a 1 µA error in the sense current will give 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 colour 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.

# 3 Driver information

## 3.1 Introduction

The PT-104 is supplied with driver routines that you can build into your own programs.

Once you have installed the software, the `Drivers` directory contains the drivers and a selection of examples of how to use the drivers. It also contains a copy of this manual as a PDF file.

The driver routine is supplied as a Windows DLL.

The Windows DLL can be used with C, C++, Delphi and Visual Basic programs: it can also be used with programs like Microsoft Excel, where the macro language is a form of Visual Basic. More than one application can access the Windows DLL at the same time, as long as the applications do not change the settings for channels that they are not using.

These are the routines in the driver:

| | |
|---|---|
| ● pt104_open_unit | Open the device on a specified serial port. |
| ● pt104_close_unit | Close the port (do this each time you finish using the device!) |
| ● pt104_poll_driver | Poll the driver (not usually necessary). |
| ● pt104_get_cycle | Find out when the driver has taken a new set of readings. |
| ● pt104_set_channel | Specify the sensor type and filtering for a channel. |
| ● pt104_set_mains | Specify the mains setting 50 or 60 Hz. This enables the product to reject mains-frequency interference signals. |
| ● pt104_get_value | Get the most recent data reading from a channel. |
| ● pt104_get_version | Get the version number of this PT-104. |
| ● pt104_get_unit_info | Get the version number, batch number and calibration number and date of this PT-104. |
| ● pt104_get_driver_version | Get the version number of the driver. |
| ● pt104_labview | Easy to use interface for LabVIEW. |

The normal calling sequence for these routines is as follows:

```
1. Open driver
2. Set Channels
3. While you want to read data
4.   Get data
5. End While
6. Close Unit
7. Close Driver
```

## 3.2 pt104_open_unit

```
short pt104_open_unit ( short port );
```

This routine specifies the serial port number with a PT-104 unit. If you wish to use more than one PT-104, you should call the routine once for each PT-104.

| | |
|---|---|
| Arguments: | port - the port must be 1 for COM1, 2 for COM2, and so on |
| Returns: | TRUE - if the driver successfully opens the PT-104 |

## 3.3 pt104_close_unit

```
void pt104_close_unit (
   unsigned short port);
```

This routine disconnects the driver from the specified serial port.

If you successfully open any serial ports, you MUST call pt104_close_unit for each port before you exit from your program. If you do not, your computer may misbehave until you next reboot it.

| | |
|---|---|
| Arguments: | port - the port number. The port must be 1 for COM1, 2 for COM2, and so on |
| Returns: | none |

## 3.4 pt104_poll_driver

```
void pt104_poll_driver (void);
```

It is not normally necessary to call this routine, as the driver uses the timer to poll the PT-104. Some programs, like Excel, appear to block the timer, so it is necessary to poll the driver periodically whilst waiting for data.

| | |
|---|---|
| Arguments: | none |
| Returns: | none |

## 3.5 pt104_get_cycle

```
unsigned short pt104_get_cycle(
  unsigned long far * cycle,
  unsigned short      port);
```

This routine returns the number of complete cycles of readings taken from a specified PT-104.

When you call pt104_get_value, it returns immediately with the most recent reading for the specified channel. If you call it repeatedly, it will return the same reading repeatedly, until the driver takes the next reading from that channel.

If you wish to record values only when the driver has taken a new reading, you can use this routine to find out how many complete cycles of readings the driver has taken, then you can call pt104_get_value only when a cycle has completed.

Note: Each PT-104 is polled independently, so the cycle numbers for multiple PT-104s may not keep in step.

| | |
|---|---|
| Arguments: | cycle - a pointer to an array where the cycle numbers are stored |
| | port - the port number. The port must be 1 for COM1, 2 for COM2, and so on |
| Returns: | a value representing the number of complete cycles of readings taken from a particular PT-104 |

## 3.6 pt104_set_channel

```
short pt104_set_channel (
  unsigned short port,
  unsigned short channel,
  unsigned short data_type
  unsigned short no_of_wires);
```

You should call this routine once for each channel that you would like to take readings from. You can do this any time after calling pt104_open_unit.

The fewer channels are selected, the more frequently these channels will be updated. It takes about 1 second per active channel.

If a call to pt104_set_channel has a data_type of single ended, then the channel specified's 'sister' channel is also enabled. For example, enabling 3 also enables 7.

| | |
|---|---|
| Arguments: | channel - which channel you want to set the details for. It should be between 1 and 4 if using single ended inputs in voltage mode.<br>data_type - the type of reading you require:<br>0: disable channel<br>1: PT100<br>2: PT1000<br>3: resistance 0 to 500 Ω<br>4: resistance 0 to 10 kΩ<br>5: differential voltage 0 to 100 mV<br>6: differential voltage 0 to 2.5 V<br>7: single-ended voltage 0 to 100 mV<br>8: single-ended voltage 0 to 2.5 V<br>no_of_wires - how many wires the PT100 or PT1000 has (set to 2, 3 or 4) |
| Returns: | TRUE - if the channel was successfully set |

## 3.7 pt104_set_mains

```
void pt104_set_mains (
  unsigned short sixty_hertz);
```

This routine is used to select the mains frequency of 50 or 60 Hz.

Choosing the wrong frequency may increase susceptibility to electrical noise.

| | |
|---|---|
| Arguments: | sixty_hertz - for 50 Hz set to 0; for 60 Hz set to 1 |
| Returns: | none |

## 3.8 pt104_get_value

```
short pt104_get_value (
  long far        * data,
  unsigned short    port,
  unsigned short    channel,
  unsigned short    filtered);
```

Once you open the driver and define some channels, the driver begins to take continuous readings from the PT-104. When you call this routine, it immediately sets data to the most recent reading for the specified channel.

Temperatures are returned in thousandths of a degree Celsius, voltages in the 2.5 V range are returned in tens of nanovolts (2.5 V returned as 250 000 000 * 10 nV), voltages in the 115 mV range are returned in nanovolts and resistances in milliohms.

When measuring single-ended voltages:

connector 1 pin 2 is channel 1
connector 2 pin 2 is channel 2
...
connector 1 pin 3 is channel 5
connector 2 pin 3 is channel 6

| | |
|---|---|
| Arguments: | data - a pointer to an array where the sample values will be stored<br>port - the port number. The port must be 1 for COM1, 2 for COM2, and so on<br>channel -<br>1 - returns a reading from Channel 1<br>2 - returns a reading from Channel 2<br>3 - returns a reading from Channel 3<br>4 - returns a reading from Channel 4<br>filtered - if set to TRUE, the driver returns a low-pass filtered value of the temperature. The time constant of the filter depends on the value of filter_factor for this channel, and on how many channels are active |
| Returns: | TRUE - if a reading is available<br>FALSE - if any of the inputs are out of range. It will normally return FALSE for a few seconds after you open the driver, until the driver has taken a reading from the specified channel |

## 3.9 pt104_get_version

```
unsigned short pt104_get_version (
  unsigned short far * version,
  unsigned short       port);
```

This routine sets version to version number of the specified PT-104.

| | |
|---|---|
| Arguments: | version - driver version. The upper byte of the version is always 104 for a PT-104; the lower byte is the two hex digits of the version and release. It provides a useful check that the link to the PT-104 is working correctly.<br>port - the port number. The port must be 1 for COM1, 2 for COM2, and so on. |
| Returns: | TRUE - if the parameters are in range |

## 3.10 pt104_get_unit_info

```
short  pt104_get_unit_info (
  char             * str,
  unsigned short    line,
  unsigned short    port)
```

Call this routine to obtain information on the unit. str is set to the information specified by line.

| | |
|---|---|
| Arguments: | str - a pointer to a char array that is to receive the information<br>line - 0 for version number, 1 for calibration number, 2 for calibration date, 3 for batch number<br>port - the port number. The port must be 1 for COM1, 2 for COM2, and so on. |
| Returns: | the number of bytes written to str |

## 3.11 pt104_get_driver_version

```
short pt104_get_driver_version (void)
```

| | |
|---|---|
| Arguments: | none |
| Returns: | the version number of the current driver |

## 3.12 pt104_labview

```
short pt104_labview (
  float            * result,
  unsigned short     port,
  unsigned short     channel,
  unsigned short     data_type,
  unsigned short     filtered
  unsigned short     no_of_wires)
```

This is an easy-to-use interface for LabVIEW. To gain a thorough understanding of the capabilities of this routine, see the example program supplied with the software.

| | |
|---|---|
| Arguments: | result - a pointer to a float that is to receive the result<br>port - the port number. The port must be 1 for COM1, 2 for COM2, and so on<br>channel - 1 for Channel 1, 2 for Channel 2, 3 for Channel 3, and so on<br>data_type - set to the type of reading you require (1 for PT100, 2 for PT1000, 3 for resistance 0 to 500 R, 4 for resistance 0 to 10 k, 5 for differential voltage 0 to 100 mV, 6 for differential voltage 0 to 2.5 V, 7 for single ended voltage 0 to 100 mV and 8 for single ended voltage 0 to 2.5 V<br>filtered - if set to TRUE, the driver returns a low-pass filtered value of the temperature. The time constant of the filter depends on the value of filter_factor for this channel, and on how many channels are active<br>no_of_wires - specifies how many wires the PT100 or PT1000 has (set to 2, 3 or 4) |
| Returns: | 1 - if successful<br>0 - if unsuccessful |

## 3.13 Windows

The 32-bit Windows driver is the file pt10432.dll, which is installed in the PicoLog installation directory.  If an application is unable to find the DLL, try moving the DLL to c:\windows\system.

# 4 Writing your own programs

## 4.1 C / C++

### C

You should find the following files in the SDK:

pt104tes.c - demonstration file
pt10432.dll - Windows 32-bit driver
pt104.h - header file

### Producing a library file (.lib)

For Borland and Watcom C, Microsoft Visual C version 1.5 or lower, use the implib program that comes supplied with these compilers.

The command is:

```
Implib pt10432.lib pt10432.dll
```

This command is typed in at the command prompt - make sure you are in the correct directory or the pt10432.dll file will not be found. This will create a file called pt10432.lib.

The following steps are then required to use the drivers in your program:

1. Include the pt10432.lib in your program
2. Include the file pt104.h in the source file(s) of your program.

The pt104tes.c file can be used to demonstrate using the PT-104 driver program within a Windows application. You will also need to include the resource file pt104tes.rc.

For Microsoft Visual C versions 2, 4 and 5, Microsoft no longer supply implib. Furthermore, the names used in these versions of C are decorated - there is a prefix which indicates how many bytes are transferred to the routine as parameters. As a result, the C names do not match the names in the DLL. The Microsoft tools to alias decorated to undecorated names do not appear to work, so it is therefore necessary to use ordinal linking- linking by number, rather than name. The file pt104ms.lib (supplied with examples) contains all the necessary routines. To use this file:

1. Include the pt104ms.lib in your project
2. Include the file pt104.h in the C source file(s) of your program.

### C++

C++ programs can access all versions of the driver. If pt104.h is included in a C++ program, the PREF1 macro expands to extern "C": this disables name-decoration and enables C++ routines to make calls to the driver routines using C headers.

## 4.2 Delphi

The SDK contains a simple program, pt104.dpr, which opens the drivers and reads temperatures from two channels. You will need the following files to build a complete program:

| | |
|---|---|
| pt104.dpr | - Project file |
| pt104fm.dfm | - Delphi form file |
| pt104fm.pas | - Delphi Pascal unit |
| pt104.inc | - Procedure prototypes for driver routines |

The file pt104.inc contains procedure prototypes for the driver routines: you can include this file in your application.

This example has been tested with Delphi version 2.

## 4.3 Excel

The easiest way to transfer data into Excel is to use PicoLog.

If, however, you need to do something that is not possible using PicoLog, you can write an Excel macro which calls pt104xx.dll to read in a set of data values. The Excel Macro language is similar to Visual Basic.

Excel 7

The example pt10432.xls reads in 20 values from the unit on channel 1 at one per second, and assigns them to cells A4 to A24.

## 4.4 LabVIEW

The routines described here were tested using LabVIEW under Windows 98 version 4.0.

Although it is possible to access all of the driver routines described earlier, it is easier to use the special LabVIEW access routine. The pt104.llb library in the SDK shows how to access this routine.

To use this routine, copy pt104.llb and pt10432.dll to your LabVIEW user.lib directory.

You will then use the PT-104 sub-vi, and an example sub-vi which demonstrates how to use them. You can use one of these sub-vis for each of the channels that you wish to measure. The sub-vi accepts the port (1 for COM1), the channel (1 to 4) the PRT type (1 for PT100, 2 for PT1000). The sub-vi returns a temperature for the PRT.

## 4.5 Visual Basic

The SDK contains the following files:

`pt10432.vbp` - Visual basic project file
`pt10432.bas` - Contains procedure prototypes for driver routines
`pt10432.frm` - Visual basic form

## 4.6 Agilent VEE

The routine described here was tested using Agilent-VEE version 5 under Windows 98.

The SDK contains the following files:

`pt10432.dll` - 32-bit driver file
`pt104.vee` - Agilent-VEE file
`pt104.vh` - Procedure prototypes for driver

To use the example, open the file `pt104.vee` in Agilent-VEE and edit the import library icon so:

File Name path is set to the location of `pt10432.dll`
Definition File path is set to the location of `pt104.vh`

The example program collects 1000 readings from the PT-104 and displays them on an XY trace.

# 5 Technical reference

## 5.1 Serial port settings

2400 baud, 8 data, 1 stop, no parity.

The following table shows the standard serial port settings for COM ports.

| Port | Base address | Interrupt | Standard? |
|---|---|---|---|
| COM1 | 3F8 | 4 | Yes |
| COM2 | 2F8 | 3 | Yes |
| COM3 | 3E8 | 4 | De facto |
| COM4 | 2E8 | 3 | De facto |
| COM5... | | No | No |

Note: on most computers, it is not possible to use the same interrupt for two serial ports at the same time. If, for example, you wish to use COM1 and COM3 at the same time, it is necessary to use a serial port card which can be set to an interrupt other than 4. These can be obtained either from Pico Technology or your computer supplier.

## 5.2 Serial port connections

The information presented here is necessary only if you wish to connect the PT-104 to the PC in some unusual way (for example, via a radio modem).

The PT-104 uses the following RS232 data lines (pin connections as on PT-104).

| Pin | Name | Usage |
|---|---|---|
| 3 | TX | Data from the PC to the PT-104 |
| 2 | RX | Data from the PT-104 to the PC |
| 7 | RTS | Held at a positive voltage (>7V) to power the PT-104 |
| 5 | GND | 0 V line |
| 4 | DTR | Held at a negative voltage (<-7V) to power the PT-104 |

The driver powers up the PT-104 by enabling RTS and disabling DTR to provide the correct polarity power supply. If these are set incorrectly no damage will occur to either PC or PT-104.

When the PT-104 is first powered up, it sends a version response (see Protocol information).

## 5.3 Protocol information

### Requests

The computer can send the following request to the PT-104.

| Command | Data bytes | Function |
|---|---|---|
| 0x00 | - | Get Version |
| 0x01 | - | Read EEPROM |
| 0x02 | one byte, bit 0 is LSB | Start Converting |
| | bit 0: enable channel 1 | 0 = off, 1 = on |
| | bit 1: enable channel 2 | ditto |
| | bit 2: enable channel 3 | ditto |
| | bit 3: enable channel 4 | ditto |
| | bit 4: channel 1 gain | 0 = x1, 1 = x21 |
| | bit 5: channel 2 gain | ditto |
| | bit 6: channel 3 gain | ditto |
| | bit 7: channel 4 gain | ditto |
| 0x03 | bit 0: select 50/60 Hz mains | 0 = 50 Hz, 1 = 60 Hz |

### Responses

At start-up, and on receipt of a version request, the PT-104 sends a version response.

| Byte | Value | |
|---|---|---|
| 1 | xFF | |
| 2 | x55 | |
| 3 | xAA | |
| 4 | x68 | Product type |
| 5 | x11 | Version |

On receipt of a Start Converting request, the PT-104 starts sending conversion responses - approx one every 180 milliseconds. There are four measurement points for each channel, and the PT-104 automatically cycles through each of the measurements for each of the active channels.  Each response is as follows:

| Byte | Value |
|---|---|
| 1 | bits 0-1: measurement no. (0 to 3) |
| | bits 2-3: channel no. (0 to 3) |
| | bits 4-7: always zero |
| 2-5 | reading data: byte 2 is MSB |
| | 0x20000000 = scaled minimum |
| | 0xE0000000 = scaled maximum |
| | The result will always be in the range 0x20000000 to 0xE0000000 inclusive |

On receipt of a Read EEPROM request, the unit returns 64 bytes of EEPROM data. This data contains the following:

| Byte | Size |
|---|---|
| 1 | Checksum (always 0x55AB) |
| 3 | Calibration version (1 = current) |
| 4 | Spare |
| 5 | Calibration date (ddmmyy followed by NULL char) |
| 13 | Batch number |
| 19 | Calibration for channel 1 (resistance x 1E6) |
| 23 | Calibration for channel 2 |
| 27 | Calibration for channel 3 |
| 31 | Calibration for channel 4 |

Examples

```
GAIN = 21
MAXINPUT = 2500000
FSD = 0x10000000
SCALED_MIN = 0x20000000
```

To obtain a single ended voltage reading 0 - 115 mV
0x0A in byte 1 is measurement no 2 on channel 2.

Reading data in bytes 2-5 gives a value of 0x50000000.

Then:

result = ((0x50000000 - SCALED_MIN ) * MAXINPUT) / (GAIN * FSD)

= 357142.857142857142857142857142857

where

MAXINPUT = 2,500,000 is the maximum input voltage in microvolts,
GAIN is a fixed gain factor,
FSD = 0x10000000 for a 28-bit ADC

To convert the result to mV divide by 10,000.0:

= 35.7142

To obtain a single ended voltage reading 0 - 2.5 V
using the same reading.

0x0A in byte 1 is measurement no 2 on channel 2.

Reading data in bytes 2-5 giving a value of 0x50000000.

To convert to voltage:

result = (0x50000000 - SCALED_MIN ) * MAXINPUT) / FSD

where MAXINPUT is the maximum input voltage in microvolts.

To convert result to V divide result by 10,000,000.0

To obtain a differential reading 0 - 2.5V

Take two measurements on a channel, e.g. measurement 3 and 2 on channel 2.

Then:

((measurement 3 - measurement 2) * MAXINPUT) / FSD

To convert result to V divide answer by 10,000,000.0

To calculate a resistance

Read the EEPROM to obtain the calibration information for the channels.

Take measurement 0, 1, 2 and 3 on a channel.

Then:

result = (channel calibration * (measurement 3 - measurement 2)) / (measurement 1 - measurement 0)

To convert to a resistance divide result by 1,000,000.0

To calculate a temperature

Carry out resistance measurement

Use a lookup table to convert the resistance to a temperature.

## 5.4 Modem operation

The PT-104 is normally connected directly to the computer, but it is also possible to access the PT-104 via a modem using the Windows driver.

It is necessary to provide power to the PT-104, either by instructing the modem to provide power or by connecting a power supply directly to the PT-104. See Serial port connections for information.

Warning: In order to comply with current legislation, use only radio modems which comply with the RTTE directive.

## 5.5 Lookup table

| Temp (°C) | Resistance (Ω) |
|---|---|
| -50 | 80.306282 |
| -49 | 80.703340 |
| -48 | 81.100257 |
| -47 | 81.497036 |
| -46 | 81.893677 |
| -45 | 82.290179 |
| -44 | 82.686545 |
| -43 | 83.082774 |
| -42 | 83.478868 |
| -41 | 83.874827 |
| -40 | 84.270652 |
| -39 | 84.666343 |
| -38 | 85.061901 |
| -37 | 85.457327 |
| -36 | 85.852622 |

| | |
|---|---|
| -35 | 86.247785 |
| -34 | 86.642818 |
| -33 | 87.037721 |
| -32 | 87.432495 |
| -31 | 87.827140 |
| -30 | 88.221657 |
| -29 | 88.616046 |
| -28 | 89.010309 |
| -27 | 89.404445 |
| -26 | 89.798455 |
| -25 | 90.192339 |
| -24 | 90.586099 |
| -23 | 90.979734 |
| -22 | 91.373246 |
| -21 | 91.766634 |
| -20 | 92.159898 |
| -19 | 92.553041 |
| -18 | 92.946061 |
| -17 | 93.338960 |
| -16 | 93.731737 |
| -15 | 94.124394 |
| -14 | 94.516930 |
| -13 | 94.909346 |
| -12 | 95.301643 |
| -11 | 95.693820 |
| -10 | 96.085879 |
| -9 | 96.477819 |
| -8 | 96.869641 |
| -7 | 97.261345 |
| -6 | 97.652931 |
| -5 | 98.044401 |
| -4 | 98.435753 |
| -3 | 98.826989 |
| -2 | 99.218109 |
| -1 | 99.609112 |
| 0 | 100.000000 |
| 1 | 100.390772 |
| 2 | 100.781429 |
| 3 | 101.171970 |
| 4 | 101.562396 |
| 5 | 101.952706 |
| 6 | 102.342901 |
| 7 | 102.732980 |
| 8 | 103.122944 |
| 9 | 103.512792 |
| 10 | 103.902525 |
| 11 | 104.292142 |
| 12 | 104.681644 |
| 13 | 105.071030 |
| 14 | 105.460301 |
| 15 | 105.849456 |
| 16 | 106.238496 |
| 17 | 106.627420 |
| 18 | 107.016229 |
| 19 | 107.404922 |
| 20 | 107.793500 |
| 21 | 108.181962 |
| 22 | 108.570309 |

| | |
|---|---|
| 23 | 108.958540 |
| 24 | 109.346656 |
| 25 | 109.734656 |
| 26 | 110.122541 |
| 27 | 110.510310 |
| 28 | 110.897964 |
| 29 | 111.285502 |
| 30 | 111.672925 |
| 31 | 112.060232 |
| 32 | 112.447424 |
| 33 | 112.834500 |
| 34 | 113.221461 |
| 35 | 113.608306 |
| 36 | 113.995036 |
| 37 | 114.381650 |
| 38 | 114.768149 |
| 39 | 115.154532 |
| 40 | 115.540800 |
| 41 | 115.926952 |
| 42 | 116.312989 |
| 43 | 116.698910 |
| 44 | 117.084716 |
| 45 | 117.470406 |
| 46 | 117.855981 |
| 47 | 118.241440 |
| 48 | 118.626784 |
| 49 | 119.012012 |
| 50 | 119.397125 |
| 51 | 119.782122 |
| 52 | 120.167004 |
| 53 | 120.551770 |
| 54 | 120.936421 |
| 55 | 121.320956 |
| 56 | 121.705376 |
| 57 | 122.089680 |
| 58 | 122.473869 |
| 59 | 122.857942 |
| 60 | 123.241900 |
| 61 | 123.625742 |
| 62 | 124.009469 |
| 63 | 124.393080 |
| 64 | 124.776576 |
| 65 | 125.159956 |
| 66 | 125.543221 |
| 67 | 125.926370 |
| 68 | 126.309404 |
| 69 | 126.692322 |
| 70 | 127.075125 |
| 71 | 127.457812 |
| 72 | 127.840384 |
| 73 | 128.222840 |
| 74 | 128.605181 |
| 75 | 128.987406 |
| 76 | 129.369516 |
| 77 | 129.751510 |
| 78 | 130.133389 |
| 79 | 130.515152 |
| 80 | 130.896800 |

| | |
|---|---|
| 81 | 131.278332 |
| 82 | 131.659749 |
| 83 | 132.041050 |
| 84 | 132.422236 |
| 85 | 132.803306 |
| 86 | 133.184261 |
| 87 | 133.565100 |
| 88 | 133.945824 |
| 89 | 134.326432 |
| 90 | 134.706925 |
| 91 | 135.087302 |
| 92 | 135.467564 |
| 93 | 135.847710 |
| 94 | 136.227741 |
| 95 | 136.607656 |
| 96 | 136.987456 |
| 97 | 137.367140 |
| 98 | 137.746709 |
| 99 | 138.126162 |
| 100 | 138.505500 |
| 101 | 138.884722 |
| 102 | 139.263829 |
| 103 | 139.642820 |
| 104 | 140.021696 |
| 105 | 140.400456 |
| 106 | 140.779101 |
| 107 | 141.157630 |
| 108 | 141.536044 |
| 109 | 141.914342 |
| 110 | 142.292525 |
| 111 | 142.670592 |
| 112 | 143.048544 |
| 113 | 143.426380 |
| 114 | 143.804101 |
| 115 | 144.181706 |
| 116 | 144.559196 |
| 117 | 144.936570 |
| 118 | 145.313829 |
| 119 | 145.690972 |
| 120 | 146.068000 |
| 121 | 146.444912 |
| 122 | 146.821709 |
| 123 | 147.198390 |
| 124 | 147.574956 |
| 125 | 147.951406 |
| 126 | 148.327741 |
| 127 | 148.703960 |
| 128 | 149.080064 |
| 129 | 149.456052 |
| 130 | 149.831925 |
| 131 | 150.207682 |
| 132 | 150.583324 |
| 133 | 150.958850 |
| 134 | 151.334261 |
| 135 | 151.709556 |
| 136 | 152.084736 |
| 137 | 152.459800 |
| 138 | 152.834749 |

| | |
|---|---|
| 139 | 153.209582 |
| 140 | 153.584300 |
| 141 | 153.958902 |
| 142 | 154.333389 |
| 143 | 154.707760 |
| 144 | 155.082016 |
| 145 | 155.456156 |
| 146 | 155.830181 |
| 147 | 156.204090 |
| 148 | 156.577884 |
| 149 | 156.951562 |
| 150 | 157.325125 |
| 151 | 157.698572 |
| 152 | 158.071904 |
| 153 | 158.445120 |
| 154 | 158.818221 |
| 155 | 159.191206 |
| 156 | 159.564076 |
| 157 | 159.936830 |
| 158 | 160.309469 |
| 159 | 160.681992 |
| 160 | 161.054400 |
| 161 | 161.426692 |
| 162 | 161.798869 |
| 163 | 162.170930 |
| 164 | 162.542876 |
| 165 | 162.914706 |
| 166 | 163.286421 |
| 167 | 163.658020 |
| 168 | 164.029504 |
| 169 | 164.400872 |
| 170 | 164.772125 |
| 171 | 165.143262 |
| 172 | 165.514284 |
| 173 | 165.885190 |
| 174 | 166.255981 |
| 175 | 166.626656 |
| 176 | 166.997216 |
| 177 | 167.367660 |
| 178 | 167.737989 |
| 179 | 168.108202 |
| 180 | 168.478300 |
| 181 | 168.848282 |
| 182 | 169.218149 |
| 183 | 169.587900 |
| 184 | 169.957536 |
| 185 | 170.327056 |
| 186 | 170.696461 |
| 187 | 171.065750 |
| 188 | 171.434924 |
| 189 | 171.803982 |
| 190 | 172.172925 |
| 191 | 172.541752 |
| 192 | 172.910464 |
| 193 | 173.279060 |
| 194 | 173.647541 |
| 195 | 174.015906 |
| 196 | 174.384156 |

| | |
|---|---|
| 197 | 174.752290 |
| 198 | 175.120309 |
| 199 | 175.488212 |
| 200 | 175.856000 |

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