

TH03 Manual v1.0

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PicoLog Manual
(DataLogging software)



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Introduction

The PICO TH-03 is a complete temperature measuring device for use with IBM compatible computers. Upto 3 channels can be measured per TH-03 using precision thermistor sensors from Pico Technology.

It can be used with the supplied PicoLog data logging program: alternatively, you can use the TH-03 driver software to develop your own programs to collect and analyse data from the unit.

The TH-03 software provides all of the calculations necessary for thermistor curve normalisation. The TH-03 is highly accurate, and gives results to a resolution of hundredths of a degree, to an accuracy typically better than 0.1°C.

Picolog and the drivers support up to four TH-03 units under DOS, and nine TH-03 units under Windows.

This manual describes the physical and electrical properties of the TH-03, and explains how to use the software drivers. For information about other facilities in PicoLog, please consult the appropriate manual.

Connecting the TH-03

To use the TH-03, you should connect the D-connector on the RH-02 to the serial port on your computer using the cable provided. If you have a 25-way serial port, use the 9 to 25 way adaptor supplied. Next connect a EL015 or EL039 temperature sensor to CH1.

To check that the unit is working:

1. start up PicoLog for Windows
2. Select **File**
3. Select **New Settings**
4. At the Recording dialog, press **OK**
5. At the Sampling dialog, press **OK**
6. Set the converter type to **TH03**
7. Select the COM port that you have connected the TH03 to
8. Press **OK**
9. At the TH03 channels dialog, double-click on **CH1 Unused**
10. At the Edit TH03 channel dialog select EL015 (or EL039) as TH type
11. At the Edit TH03 channel dialog, press **OK**
12. Back to the TH03 channels dialog, press **OK**
13. The recorder view should now display the temperature.

Safety Warning

The sensor ground input of the TH-03 is connected directly to the ground of your computer, in order to minimise electrical interference.

Do not connect the sensor input to anything other than the sensors supplied by Pico Technology Limited.

Take particular care when measuring temperatures near mains equipment. If a sensor input is accidentally connected to mains, you may risk damage to the TH-03 and your computer, and your computer chassis may become live.

Specifications

Number of channels	3
Temperature range	-30°C to +70°C (Using Pico EL015 or EL039 sensors)
Resolution	0.003°C
Accuracy	±0.3°C (-30°C to 30°C)
Conversion Time	800ms per active channel + 1600ms per reference conversion
Input connectors	3xFCC68 4/4
Output connector	9 way D-type to computer serial port
Power connector	No external power supply required
Environmental conditions	0 to 50°C 0 to 95% humidity NOT water resistant

Principles of operation

Thermistors

The TH-03 uses thermistors to measure temperatures. Up to three thermistors can be attached to each TH-03.

A thermistor is a small bead of material whose resistance changes very markedly with temperature. Standard thermistors are in a stainless steel tube about 50mm long and 8mm in diameter: other packages are available.

The resistance normally changes exponentially with temperature. This exponential response is very difficult to deal with in a simple electronic circuit, but it is very easy to use a computer to convert a thermistor resistance into an accurate temperature measurement.

Reference resistors

The TH-03 measures the resistance of each thermistor, and also of two internal reference resistors. It uses the readings from the reference resistors to adjust the reading from the thermistor to allow for small errors within the converter.

The software continuously takes readings from the selected thermistor channels and from the reference resistors. As the readings from the reference resistors change very little, it is possible to read the reference resistors less frequently than the so that the thermistors are read more often. One consequence is that thermistor readings are not at equal short intervals unless reference resistor update is either turned off or set to update every thermistor reading cycle.

Filtering

The TH-03 software includes a filter which eliminates errors caused by electrical noise. You can use either the measured or the filtered value: the filtered value is much less prone to electrical noise, but it tends to lag behind if the measured value changes quickly.

The filter time constant is controlled by the filter factor. The filter factor can be adjusted between 1 (no filter) and 100 (very slow filter).

Note that the filter time constant is also affected by the number of channels that are in use. The more channels selected, the slower the filter.

Technical Information

Serial port settings	(Interrupts etc)
Serial port connections	(Pin connections on the serial port)
Protocol	(Directly driving the unit)
Sensor connection	
Modem operation	(Remote use with radio / telephone modems)

Driver summary

The TH-03 is supplied with driver routines that you can build into your own programs. Drivers are supplied for use with the following operating systems:

DOS
Windows 3.1
Windows 95/98
Windows NT/2000
Linux

Once you have installed the software, the DRIVERS directory contains the drivers and a selection of examples of how to use the drivers.

The driver routine is supplied as object files for DOS and protected mode, and as a Dynamic Link Library for Windows.

The object files use Pascal linkage conventions and do not require any compiler run-time routines: they can therefore be used with most real-mode and some protected-mode C and Pascal compilers.

The Windows DLL can be used with 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.

The following table specifies the function of each of the routines in the driver:

Routine	Function
th03_open_unit	Open the driver to use a specified serial port(s)
th03_close_unit	Close the port (ALWAYS DO THIS!)
th03_poll_driver	Poll the driver (not usually necessary)
th03_get_cycle	Find out when the driver has taken a new set of readings
th03_set_channel	Specify the thermistor type and filtering for a channel
th03_get_temp	Get the most recent temperature reading from a channel
th03_set_ref_update	Set the frequency of update for the reference resistors
th03_get_version	get the version number of this TH-03

The normal calling sequence for these routines is as follows:

```
Open driver
Set Channels
While you want to measure temperatures,
    Get temperature
End While
Close Driver
```

th03_open_unit

DOS version:

```
short int th03_open_unit (
    short int  port,
    short int  base,
    short int  irq);
```

Windows version:

```
short int th03_open_unit (
    short int  port);
```

This routine specifies the serial port number with an TH-03 unit. If you wish to use more than one TH-03, you should call the routine once for each TH-03.

The `port` must be 1 for COM1, 2 for COM2, etc.

Under DOS, this routine has extra parameters to specify the base address and short interrupt number for the COM port. These can be set to zero for the default base address and IRQ. See [Serial port settings](#) for more information

Under Windows, the base address and IRQ information is defined within Windows, so it is not necessary to specify a value.

This routine returns TRUE if the driver successfully opens the TH-03.

th03_close_unit

```
void th03_close_unit (unsigned short int port);
```

This routine disconnects the driver from the specified serial port.

If you successfully open any serial ports, you **MUST** call `th03_close_unit` for each port before you exit from your program. If you do not, your computer may misbehave until you next reboot it.

th03_poll_driver

```
void th03_poll_driver (void);
```

It is not normally necessary to call this routine, as the driver uses the timer to poll the TH-03. Some programs, like Excel, appear to block the timer and so it is necessary to poll the driver periodically whilst waiting for data.

th03_get_cycle

```
short int th03_get_cycle
        (long *      cycle,
         short int   port);
```

This routine returns the number of complete cycles of readings taken from a particular TH-03.

When you call `th03_get_temp`, 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 `th03_get_temp` only when a cycle has completed.

Note: each TH-03 is polled independently, so the cycle numbers for multiple TH-03s may not keep in step.

th03_set_channel

```
void th03_set_channel (
        unsigned short int    port,
        unsigned short int    channel,
        unsigned short int    th_type,
        unsigned short int    filter_factor);
```

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 `th03_open_unit`.

The fewer channels are selected, the more frequently these channels will be updated: it takes about 2 seconds for reference resistors and 1 second per active channel.

`channel` specifies which channel you want to set the details for: it should be between 1 and 3

`th_type` specifies what type of thermistor is connected to this channel. Set `th_type` to

- 0 for Off
- 1 for EL015 temperature sensor
- 4 for EL031 light sensor
- 5 for EL029 door switch
- 7 for EL039 temperature sensor

See `th03.h` for an up to date list of sensor types

The `filter_factor` controls the time constant of the filter. Each time the driver takes a reading from this channel, it updates the filtered value by adding a proportion of the difference between the measured and filtered values. The `filter_factor` sets the proportion that is added. A `filter_factor` of 1 means add all of the difference (effectively no filtering) and 100 means add 1/100 of the difference (very slow filtering). A factor of 10 gives a time constant of about a minute when all channels are selected.

th03_get_temp

```
short int th03_get_temp (
    long *      temp,
    short int    port,
    short int    channel,
    short int    filtered);
```

Once you open the driver and define some channels, the driver constantly takes readings from the TH-03. When you call this routine, it immediately sets `temp` to the most recent reading for the specified channel, in hundredths of a degree Celsius.

If a reading is available, it returns `TRUE`, otherwise it returns `FALSE`. 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.

`channel` should be 1 for channel 1, 2 for channel 2 et cetera.

If you set `filtered` 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.

th03_set_ref_update

```
short int th03_set_ref_update (
    short int    port,
    short int    update_interval);
```

This routine specifies how frequently the computer should take readings from the reference resistors for the specified TH-03. Normally, it is not necessary to call this routine.

The following values are useful:

- 0 turns off update - make sure that you leave enough time for at least one reference reading before turning off update
- 1 takes one reference reading for every cycle of thermistor readings, so each cycle takes the same amount of time
- 10 is the default value: the computer reads the reference resistors every tenth cycle.

th03_get_version

```
short int th03_get_version (
    short int * version,
    short int    port);
```

This routine sets `version` to version number of the specified TH-03.

The upper byte of the version is always 8 for a TH-03; the lower byte is the two hex digits of the version and release. It provides a useful check that the link to the TH-03 is working correctly.

DOS Driver

The DOS driver is supplied in two object files, `th03drv.obj` and `commdrv.obj`. It can be used in both C and Pascal programs.

Windows 16-bit Driver

The windows 16-bit driver is the file `TH0316.DLL`: it is installed in the `drivers\win` directory. If an application is unable to find the DLL, try moving the DLL to `\windows\system`.

It has been tested under Windows 3.11 and under Windows 95 with the following 16-bit applications:

- Borland C 4.5
- Delphi 1
- Visual Basic 3
- Excel 5

Windows 95/98

Windows 95 and 98 can run both 16-bit and 32-bit applications. For 16-bit applications, see Windows 3.1.

The windows 32-bit driver is the file `TH0332.DLL`: it is installed in the `drivers\win32` directory. If an application is unable to find the DLL, try moving the DLL to `\windows\system`.

Windows NT/2000

Most applications running under Windows NT are 32-bit applications. The windows 32-bit driver is the file `TH0332.DLL`: it is installed in the `drivers\win32` directory. If an application is unable to find the DLL, try moving the DLL to `\windows\system`.

Linux

A Linux driver is under development: please check the drivers section of the Pico Technology web site (<http://www.picotech.com/driver>) for availability.

C (DOS)

To link the driver into you program, you should take the following steps:

add `#define DOS` to your program

`#include` the header file `th03.h` into your program

If you are using an IDE, include the file `th03drv.obj` and `commdrv.obj` in you project.

If you are using a command-line compiler, include the file `th03drv.obj` and `commdrv.obj` in you linkfile.

C/C++

C

The C example program is a generic windows application- ie it does not use Borland AppExpert or Microsoft AppWizard. To compile the program, create a new project for an Application containing the following files:

```
th03tes.c
th03tes.rc
either th0316.lib (All 16-bit applications)
or th0332.lib (Borland 32-bit applications)
or th03ms.lib (Microsoft Visual C 32-bit applications)
```

The following files must be in the same directory:

```
th03tes.rch
th03w.h
either th0316.dll (All 16-bit applications)
or th0332.dll (All 32-bit applicaitons)
```

C++

C++ programs can access all versions of the driver. If adc11.h or adc11w.h are included in a C++ program, the PREF1 macro expands to **extern "C"**: this disables name-mangling (or decoration, as Microsoft call it), and enables C++ routines to make calls to the driver routines using C headers.

Pascal

The program th03pas.pas can be compiled either as a stand-alone program `{ $DEFINE MAIN }` or as a unit which can be linked short into other programs `{ $UNDEF MAIN }`.

th03pas.pas includes the driver using the `{ $L th03drv.obj }` and `{ $L commdrv.obj }` commands: it also provides pascal prototypes for each of the routine in the driver.

This program has been tested with Borland Turbo Pascal V6.0.

Delphi

The WIN sub-directory contains a simple program th03.dpr which opens the drivers and reads temperatures from the three channels. You will need the following files to build a complete program.

- th03fm.dfm
- th03fm.pas
- th03.inc

The file TH03.inc contains procedure prototypes for the driver routines: you can include this file in your application.

This example has been tested with Delphi versions 1, 2 and 3.

Excel

The easiest way to get data into Excel is to use PicoLog for Windows.

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

Excel 5

The example TH0316.XLS reads in 20 values of the channel 1 temperature, one per second, and assigns them to cells A1..A20.

Excel 7

The example TH0332.XLS reads in 20 values of the channel 1 temperature, one per second, and assigns them to cells A1..A20.

Visual Basic

Version 3 (16 bits)

The DRIVERS\WIN16 sub-directory contains a simple Visual Basic program, th0316.mak.

```
th0316.MAK  
th0316.FRM
```

Note that it is usually necessary to copy the .DLL file to your \windows\system directory.

Version 4 and 5 (32 bits)

The DRIVERS\WIN32 sub-directory contains the following files:

```
th0332.VBP  
th0332.BAS  
th0332.FRM
```

Labview

The routines described here were tested using Labview for Windows 95 version 4.0.

While it is possible to access all of the driver routines described earlier, it is easier to use the special Labview access routine. The th03.llb library in the DRIVERS\WIN32 sub-directory shows how to access this routine.

To use this routine, copy th03.llb and th0332.dll to your labview user.lib directory.

You will then the th03 sub-vi, and an example sub-vi which demonstrate 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 3) the thermistor type (1 for standard). The sub-vi returns a temperature

HP-Vee

The sample program th03.vee is in the drivers\win32 sub-directory. It was tested using Windows 95 and HP-Vee version 5.0.

The example demonstrates how to read continuously from the TH-03.

Serial port settings

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

Note that, 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.

Connections

The information presented here is necessary only if you wish to connect the TH03 to the PC in some unusual way (for example, via a radio modem).

The TH-03 uses the following RS232 data lines (pin connections as on TH-03)

Pin	Name	Usage
3	TX	Data from the PC to the TH-03
2	RX	Data from the TH-03 to the PC
7	RTS	Held at a positive voltage ($>7V$) to power the TH-03
5	GND	0V line
4	DTR	Held at a negative voltage ($<-7V$) to power the TH-03

The driver powers up the TH-03 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 TH-03.

Protocol

The TH-03 operates at 2400 baud with 1 stop bit and no parity.

The driver controls the TH-03 using the following sequence

1. Switch RTS on and DTR off to provide power.
2. Wait for more than 1 second for the TH03 to settle
3. Send an single control byte to the TH03
4. Wait for the 3 byte response from the TH03

Steps 3 and 4 are repeated for each measurement.

The TH03 signals the end of conversion by sending two bytes, most significant byte first. No data should be sent to the TH03 during the conversion, as it may be lost or corrupted.

The commands are:

- 0x01 - get version
- 0x02 - get low reference
- 0x03 - get high reference
- 0x04 - channel 1
- 0x08 - channel 2
- 0x0C - channel 3

The two references should be 20082 and 43773 respectively: the actual values may differ by up to 500. The theoretical and actual reference values are used to apply a correction to the measured value:

$$\text{corrected} = 20082 + (\text{measured} - \text{low_ref}) * (43773 - 20082) / (\text{high_ref} - \text{low_ref})$$

The corrected value is then converted to a temperature using a lookup table. The following lookup table is for an EL015 temperature sensor: is one entry in the table for each degree celsius.

```
/* 0000 */ 29219U,  
/* 0001 */ 28840U,  
/* 0002 */ 28467U,  
/* 0003 */ 28099U,  
/* 0004 */ 27738U,  
/* 0005 */ 27380U,  
/* 0006 */ 27031U,  
/* 0007 */ 26690U,  
/* 0008 */ 26355U,  
/* 0009 */ 26027U,  
/* 0010 */ 25705U,  
/* 0011 */ 25392U,  
/* 0012 */ 25087U,  
/* 0013 */ 24789U,  
/* 0014 */ 24498U,  
/* 0015 */ 24214U,  
/* 0016 */ 23939U,  
/* 0017 */ 23671U,  
/* 0018 */ 23411U,  
/* 0019 */ 23158U,
```

```
/* 0020 */ 22911U,  
/* 0021 */ 22673U,  
/* 0022 */ 22442U,  
/* 0023 */ 22218U,  
/* 0024 */ 22002U,  
/* 0025 */ 21790U,  
/* 0026 */ 21587U,  
/* 0027 */ 21390U,  
/* 0028 */ 21200U,  
/* 0029 */ 21016U,  
/* 0030 */ 20837U,  
/* 0031 */ 20665U,  
/* 0032 */ 20499U,  
/* 0033 */ 20339U,  
/* 0034 */ 20184U,  
/* 0035 */ 20034U,  
/* 0036 */ 19889U,  
/* 0037 */ 19750U,  
/* 0038 */ 19616U,  
/* 0039 */ 19486U,  
/* 0040 */ 19360U,
```

Sensor connector

The TH03 sensor input is fitted with an FCC68 type 4/4 connector. Only two pins are used: when facing the socket, these are the left-hand pins.

Thermistor sensor cables can be extended by up to 100 metres: at normal operating temperatures, this will have a minimal ($\ll 0.1^{\circ}\text{C}$) effect on the temperature reading.

Modem operation

The TH-03 is normally connected directly to the computer, but it is also possible to access the TH-03 via a modem using the Windows driver.

It is necessary to provide power to the TH-03, either by instructing the modem to provide power or by connecting a power supply directly to the TH03. See serial port connections for information.

For some radio modems, there is a delay between sending text to the modem and its arrival at the other end, and a similar delay for the response from the TH03. If, for example, the maximum possible delay is 150ms each way, 300ms total, the following text should be added to Win.INI so that the driver waits longer for each response.

[TH03]

Turnround=300