USB TC-08
Temperature Logger

User guide

USBTC08044-2

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1 Introduction

1.1 Overview

The USB TC-08 is a temperature and voltage logger designed to support multiple thermocouples. With the accompanying PicoLog software, the unit can be used with any laptop or PC running Windows 98SE, ME, 2000, XP or higher. If you are technically-minded and want to tailor the product to a particular application, you can write your own programs with the supplied driver.

The driver provides cold junction compensation for thermocouples. PicoLog supports up to 10 USB TC-08 devices and the driver can support more (as many as 64, if you have a high-specification PC.)

This manual describes the physical and electrical properties of the USB TC-08, and provides an explanation of how to use the software drivers. For information on PicoLog, please consult the PicoLog help file.

1.2 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.

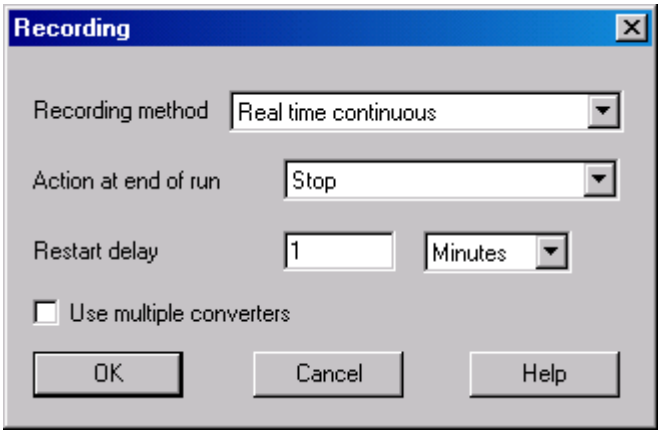
1.3 Connecting the USB TC-08

Please note: do not connect the USB TC-08 until you have installed the software and restarted your PC.

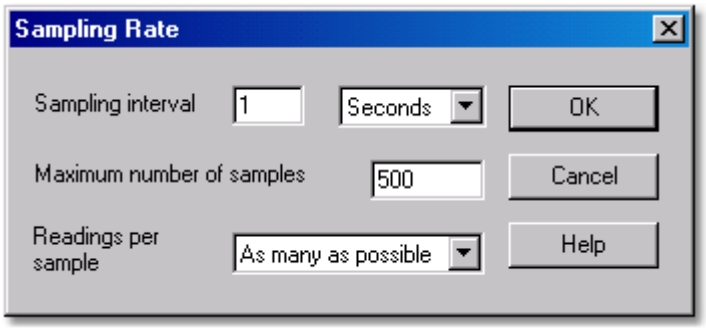
To begin using the USB TC-08, connect it to the USB port on your computer using the cable provided. Next, connect a thermocouple to one of the thermocouple input connectors. To complete the installation, select the USB TC-08 unit and thermocouple type in PicoLog as follows:

1. Start up PicoLog Recorder

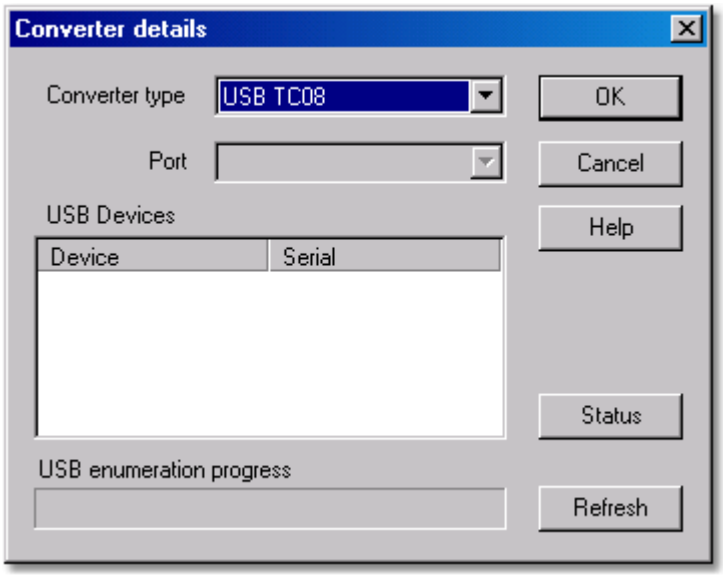
2. Select **New Settings** from the **File** menu.
   The Recording dialog box appears



3. Click the **OK** button.
   The Sampling Rate dialog box appears



4. Click the **OK** button.
   The Converter details dialog box appears

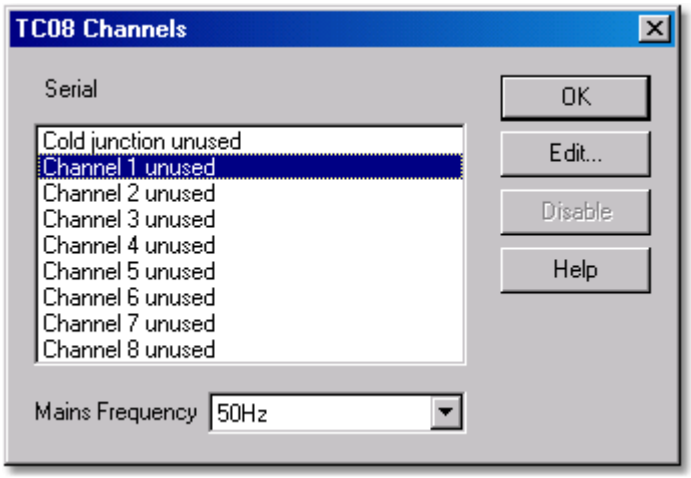


5. Select **USB TC-08** from the drop-down list of converters.
   The device name and serial number should appear in the USB Devices pane and the USB enumeration progress bar gradually expands to 100%. If the progress bar does not start moving, disconnect and reconnect the USB TC-08, then click **Refresh**

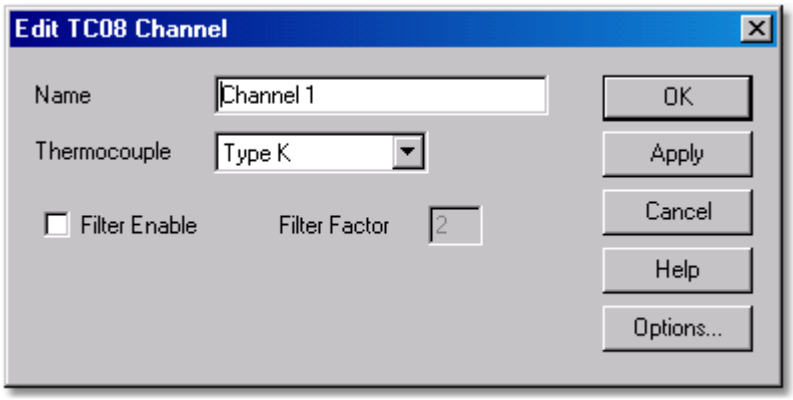
6. In the USB Devices pane, select the **USB TC-08.** If you are using more than one USB TC-08, check the serial number on the bottom of the device so that you know which one to select from the list

7. Click the **OK** button.

   The following dialog box appears

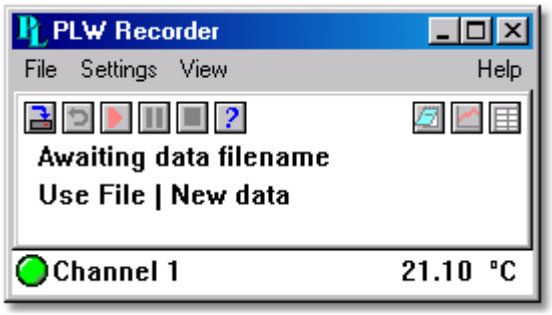


8. In the TC-08 Channels window, double-click on **Channel 1 unused**
   The Edit TC-08 Channel dialog box appears



9. From the **Thermocouple** drop-down list, select the type of thermocouple you are using and click the **OK** button**.**
   The TC-08 Channels dialog box reappears

10. Click the **OK** button.
    Channel 1 should now appear in the monitor window with the current temperature reading.



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1.5 *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 USB TC-08 is designed to measure voltages in the range of ±70 mV. 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.

Safety grounding
The ground of every product is connected directly to the ground of your computer through 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 Limited or their authorised distributors.

1.6 Company details

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2 Product information

2.1 Specifications

Resolution	20 bits (16.25 NFR)
Thermocouple types	B,E,J,K,N,R,S,T
Number of input channels	8
Conversion time - per active channel	100 ms
Conversion time - CJC	100 ms
Uncalibrated accuracy	The sum of ±0.2% and ±0.5°C
Full scale input	±70 mV
Common mode range	±7.5 V
Overvoltage protection	±30 V
Input impedance	2 MΩ
Input connectors	8 x miniature thermocouple
Output connector	USB upstream connector
Power requirements	No power supply required
Environmental conditions	0 to 50°C, 25% to 75% humidity Quoted accuracy over 20 - 30°C NOT water-resistant

Note: The resolution and accuracy depend upon the thermocouple type and the temperature range. Below is a list of the thermocouples and temperature ranges supported by the USB TC-08.

	Actual measurable range	**Theoretical ranges**
CJC	-5°C to 70°C	N/a
Type B	20°C to 1820°C (CJC must be >20°C)	0°C to 1820°C
Type E	-270°C to 910°C	-270°C to 1000°C
Type J	-210°C to 1200°C	-210°C to 1200°C
Type K	-270°C to 1370°C	-270°C to 1370°C
Type N	-270°C to 1300°C	-270°C to 1300°C
Type R	-50°C to 1760°C	-50°C to 1760°C
Type S	-50°C to 1760°C	-50°C to 1760°C
Type T	-270°C to 400°C	-270°C to 400°C

2.2 How a thermocouple works

A discovery by T. J. Seebeck almost 150 years ago opened the way for modern thermoelectric circuitry. In 1831, Seebeck discovered that an electric current flows in a closed circuit of two dissimilar metals when one of the two junctions is heated with respect to the other.

In such a thermocouple circuit the current continues to flow as long as the two junctions are at different temperatures. The magnitude and direction of the current is a function of the temperature difference between the junctions and of the thermal properties of the metals used in the circuit. This phenomenon is known as the Seebeck Effect.

The conductors can be made of any two dissimilar metals, and when the hot junction is heated the current flow can be observed. If the positions of the hot and cold junctions are reversed, current flows in the opposite direction.

In fact, a thermocouple circuit actually generates a measurable, low voltage output that is almost directly proportional to the temperature difference between the hot junction and the cold junction. A change in this temperature difference produces some net change in the voltage.

Note: More information on choosing and using thermocouples can be found at this page on our website.

3 Technical reference

3.1 Introduction

The USB TC-08 is supplied with driver routines that you can build into your own programs. The USB TC-08 driver supports the following versions of the Windows operating system: 98SE, ME, 2000, and XP.

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

The driver is supplied as a Windows DLL. The DLL uses the C `stdcall` calling convention and 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.

3.2 Modes of operation

3.2.1 Introduction

The USB TC-08 is designed for three specific modes of operation to suit a variety of applications. The following modes are supported:

- Streaming mode
- Get Single mode
- Legacy mode

3.2.2 Streaming mode

Streaming mode is an operational mode in which the USB TC-08 unit samples data and returns it to the computer in an unbroken sequence, using the onboard clock to ensure accurate timing.

The unit can buffer up to two sets of readings at once. To avoid loss of readings, make sure that another application on the PC - including the one you are writing - does not prevent the driver from collecting readings for more than three sampling intervals.

To allow the driver to sample continuously, call the Windows `Sleep()` function in any sampling loops (see example below) to make sure that your application does not use too much processor time.

Hint: Try not to use a `Sleep()` call for less than 50-100 milliseconds, e.g., `Sleep(50)` or `Sleep(100)`. If you are programming a Windows GUI application, a good alternative to sampling loops is the `WM_TIMER` message.

Example

The following code is a fragment of a C application demonstrating how to use Streaming mode with the USB TC-08 driver:

```
//================================================
// Setting up and running the unit in Streaming mode
//================================================

usb_tc08_set_mains(handle, 0); // use 50Hz mains noise rejection

for (channel = 0; channel < 9; channel++)
 {
 // set each channel up as a type K thermocouple
 // channel 0 is the cold junction and will be enabled
 // by setting the third argument to anything other than ' '
 usb_tc08_set_channel(handle, channel, 'K');
 }

// find out how fast the unit can sample in its current setup state
minimum_interval = usb_tc08_get_minimum_interval_ms(handle);

usb_tc08_run(handle, minimum_interval); // sample as fast as possible

// not required (just illustrates that the application
// can be idle while the driver collects the readings)
Sleep(10000);

// use a two dimensional array with an array of readings for each
channel
// In a real application, this would be a nested loop to regularly poll
// the unit for readings
for (channel = 0; channel < 9; channel++)
 {
 no_of_readings = usb_tc08_get_temp( handle,
                   &reading_buffer[channel],
                   &times_buffer[channel],
                   buffer_length,
                   &overflows[channel],
                   channel,
                   0,  // degrees Celsius units
                   0); // do not fill missing readings
 }

// finished polling, now do something with the readings
// if overflows[channel] is high, then one of the readings
// in reading_buffer[channel] has exceeded the input range
// of the USB TC-08

// only stop the unit when we've completely finished streaming
usb_tc08_stop(handle);
```

Note: You should close down all other applications while you are performing any timing-critical data logging tasks. Check that the Windows scheduler does not have any activities planned during the logging session.

3.2.3 *Get Single mode*

Get Single mode is an operational mode in which readings are produced on demand, using the usb_tc08_get_single function. Since the function relies entirely on the timing of the calling application, it is ideal for time intervals greater than 1 minute. If high-speed sampling is required, use Streaming mode.

Note: The function call overhead can be significant, since it takes approximately 360 ms to convert all 9 channels, equating to 40 ms per channel. To reduce this overhead, disable channels that are not required.

Example

The following code is a fragment of a C application demonstrating how to use Get Single mode with the USB TC-08 driver:

```
//=========================================================
// Setting up and converting readings with Get Single mode
//=========================================================

usb_tc08_set_mains (handle, 0); // use 50Hz mains noise rejection

for (channel = 0; channel < 9; channel++)
 {
 // set each channel up as a type K thermocouple
 // channel 0 is the cold junction and will be enabled
 // by setting the third argument to anything other than ' '
 usb_tc08_set_channel (handle, channel, 'K');
 }

// find out the approximate conversion time
// for a call to usb_tc08_get_single
minimum_interval = usb_tc08_get_minimum_interval_ms (handle);
printf("Conversion time: %d\n", minimum_interval);

// Collect 10 readings over approximately 9 minutes
last_time = GetTickCount();
for (i = 0, i < 10, i++)
 {
 // do the conversion for all channels
 usb_tc08_get_single( handle,
                      value_array,     // short value_array[9]
                      &overflow_flags,
                      0);              // degrees Celsius units

 // print out the values
 printf("\n\nTime: %d minute(s)", i);
 for (c = 0; c < 9; c++)
  {
  // check for overflows on each channel
  // with a bitwise & comparator
  // shift the comparison bit to match the channel
  if (overflow_flags & (1 << c))
   {
   printf("\nChannel %d overflowed", c);
   }
  else // no overflow
   {
   printf("\nChannel %d: %f", c, value_array[c]);
   }
  }

 if (i < 9)
  {
  while (60000 > (GetTickCount() - last_time)) // 60000ms = 1 minute
   {
   Sleep(100); // let other applications run
   }
  last_time = GetTickCount();
  }
 }
```

3.2.4 Legacy mode

Legacy mode is designed to aid developers who have already written code for the serial version of the TC-08 and are not yet ready to rewrite their code for the Streaming or Get Single modes available with the USB version. The legacy support is going to be phased out and will eventually be removed from the driver altogether. If you want full support in the future, use the Streaming or Get Single modes.

To allow code to be easily developed for both the serial version and the USB version of the TC-08, all the function names have been changed. The usb_tc08_legacy_set_channel function no longer supports offset and gain - this is now stored only as calibration information in the unit itself. The legacy routines will be familiar if you previously used the serial TC-08, but the following changes should be made to convert legacy applications:

- Reference the new Header file
- Reference the new Library file
- Place the new DLL in the directory of the application
- Set the mains frequency
- Run and stop the unit
- Store a handle returned from usb_tc08_open_unit instead of using the serial port number

Example

The following code is a fragment of a C application demonstrating how to use legacy mode with the USB TC-08 driver:

```
//=========================================================
// Setting up and running the unit in Legacy mode
// This is designed to make it easier to adapt code written
// for the Serial TC08 for use with the USB TC08
//=========================================================

usb_tc08_set_mains(handle, 0); // use 50Hz mains noise rejection

for (channel = 1; channel < 9; channel++)
 {
 // set each channel up as a type K thermocouple
 // switch off filtering for all channels
 usb_tc08_legacy_set_channel(handle, channel, 'K', 0);
 }

usb_tc08_legacy_run(handle);

last_cycle_no = 0;
no_of_readings = 0;
while (no_of_readings < 50) // collect 50 readings
 {
 usb_tc08_legacy_get_cycle(handle, &this_cycle_no);

 if (last_cycle_no != this_cycle_no)
  {
  last_cycle_no = this_cycle_no;
  no_of_readings++;

  for (channel = 1; channel < 9; channel++)
   {
   usb_tc08_legacy_get_temp( &reading[channel],
                             handle,
                             channel,
                             0);
   }
  // now do something with the readings
  // check that they have not overflowed
  // by comparing each reading with 2147483647L
  // or LONG_MAX (include limits.h)

  usb_tc08_legacy_get_cold_junction(handle, &cold_junction);
  // now do something with the cold junction temperature
  }
 }

usb_tc08_stop(handle);
```

3.3 Driver routines

3.3.1 Introduction

The following table explains each of the USB TC-08 routines:

Routine	Description
New USB and serial mode	
usb_tc08_open_unit	Opens the USB TC-08 unit and gets a valid USB handle.
usb_tc08_open_unit_async	Opens the unit asynchronously.
usb_tc08_open_unit_progress	Polls the unit's enumeration progress during asynchronous operation.
usb_tc08_close_unit	Closes the handle.
usb_tc08_stop	Stops the unit streaming.
usb_tc08_set_mains	Sets the mains interference rejection filter to either 50 Hz or 60 Hz.
usb_tc08_get_minimum_interval_ms	Returns the minimum sampling interval for the current setup.
usb_tc08_get_unit_info	Retrieves information on a particular unit and presents it as a structure.
usb_tc08_get_formatted_info	Retrieves information on a particular unit and presents it in string form.
usb_tc08_get_last_error	Returns the last error for a specified unit or for a call to open a unit.
New USB mode only	
usb_tc08_set_channel	Sets up a USB TC-08 channel.
usb_tc08_run	Starts the USB TC-08 unit streaming.
usb_tc08_get_single	Converts readings from currently set up channels on demand.
usb_tc08_get_temp	In streaming mode, retrieves temperature readings from a specified channel.
usb_tc08_get_temp_deskew	In streaming mode, retrieves temperature readings from a specified channel with time deskewed.
Legacy mode only	
usb_tc08_legacy_run	Starts the USB TC-08 unit running in legacy mode.
usb_tc08_legacy_set_channel	Sets up a USB TC-08 channel.
usb_tc08_legacy_get_temp	Retrieves temperature readings from a specified channel.
usb_tc08_legacy_get_cold_junction	Retrieves a temperature reading for the cold junction.
usb_tc08_legacy_get_driver_version	Returns the driver version.
usb_tc08_legacy_get_version	Returns the hardware version of the USB TC-08 unit.
usb_tc08_legacy_get_cycle	Returns the number of readings taken so far.

3.3.2 New USB mode and legacy mode

3.3.2.1 usb_tc08_open_unit

```
short usb_tc08_open_unit (void)
```

This routine returns a valid handle to the USB TC-08 if the driver successfully opens it. If the routine fais, see the error code explanations in the usb_tc08_get_last_error section. If you wish to use more than one USB TC-08, call this routine once for each unit connected to the PC. The function will return 0 if there are no more units found. The driver is thread-safe and will not allow access to a single unit from more than one application. If, therefore, `usb_tc08_open_unit` does not find a unit, check that other applications are not using the USB TC-08. This includes applications on other user accounts on the same computer, where fast user switching is supported.

Note: The `usb_tc08_open_unit` function provides a simple way to open USB TC-08 units. However, the function call locks up the calling thread until the attached USB TC-08 unit has been fully enumerated. If a single-threaded application needs to perform concurrent processing, such as displaying a progress bar, use usb_tc08_open_unit_async.

Arguments:		
	None	

Returns:	
Positive short	- The handle to a unit.
0	- No more units were found.
-1	- Unit failed to open. Call usb_tc08_get_last_error with a handle of 0 to obtain the error code.

Example

The following code is a fragment of a C application which demonstrates how to open multiple units with the USB TC-08 driver. The handles to the open units are stored in an array for later use:

```
//=======================================================
// Opening multiple units
//=======================================================

for (i = 0; (new_handle = usb_tc08_open_unit()) > 0; i++)
 {
// store the handle in an array
 handle_array[i] = new_handle;
 }
no_of_units = i;

// deal with the error if there is one,
// if new_handle was zero, then there was no error
// and we reached the last available unit
if (new_handle == -1)
 {
 error_code = usb_tc08_get_last_error(0);
 printf("Unit failed to open\nThe error code is %d", error_code);
 // could terminate the application here
 }

//
```

```
// Start using the open units
//
```

3.3.2.2 usb_tc08_open_unit_async

```
short usb_tc08_open_unit_async (void)
```

This routine begins enumerating USB TC-08 units in the background and provides a return immediately, so the calling thread can continue executing other code.

Note: The driver is thread safe and will not allow access to a single unit from more than one application. If, therefore, `usb_tc08_open_unit_async` does not find a unit, check that other applications are not using the same USB TC-08. This includes applications on other user accounts on the same computer, where fast user switching is supported.

Arguments		
	None	

Returns:	
1	- The call was successful.
0	- No more units were found.
-1	- An error occurred, call usb_tc08_get_last_error with a handle of 0 to obtain the error code.

Example

The following code is a fragment of a C application which demonstrates how to open a single unit with the asynchronous open unit functions:

```
//=====================================================
// Opening a unit asynchronously
//=====================================================

// Tell the driver to start enumerating the unit in the background
// (usb_tc08_open_unit_async returns immediately)
result = usb_tc08_open_unit_async();
// handle any error conditions
if (result == -1)
 {
 error_code = usb_tc08_get_last_error(0);
 printf("Unit failed to open\nThe error code is %d", error_code);

 // could terminate the application here
 }
else if (result == 0)
 {
 printf("No USB TC08 units found");

 // could terminate the application here
 }

// No errors, so start polling usb_tc08_open_unit_progress
// continuously for its enumeration state
do
 {
 result = usb_tc08_open_unit_progress(&handle, &progress);

 switch (result)
  {
```

```
    case USBTC08_PROGRESS_FAIL:   // enum equates to: -1
     error_code = usb_tc08_get_last_error(0);
     printf("Unit failed to open\nThe error code is %d", error_code);

     // could terminate the application here
     break;

    case USBTC08_PROGRESS_PENDING: // enum equates to: 0
     printf("\nThe unit is %d percent enumerated", progress);
     Sleep(500); // wait for approx. half a second
     break;

    case USBTC08_PROGRESS_COMPLETE: // enum equates to: 1
     printf("\n\nThe unit with handle '%d', opened successfully",
handle);
     break;
   }
  }
while (result == USBTC08_PROGRESS_PENDING);

//
// Start using the open unit
//
```

3.3.2.3 usb_tc08_open_unit_progress

```
short usb_tc08_open_unit_progress( short * handle,
                                   short * progress)
```

Call this function after `usb_tc08_open_unit_async`. Repeatedly call it to determine the state of the background enumeration process. For an example of usage, see usb_tc08_open_unit_async.

Arguments:		
	`handle`	(Out) A handle (positive short) to the unit if the enumeration is completed. Handle will always be 0 if the enumeration is incomplete.
	`progress`	(Out) (Optional - can pass NULL) returns a number from 0 to 100 representing the percentage completion of the enumeration of one unit.

Returns:		
	`-1 (USBTC08_PROGRESS_FAIL)`	An error occurred, call usb_tc08_get_last_error with a handle of 0 to obtain the error code.
	`0 (USBTC08_PROGRESS_PENDING)`	Enumeration has not completed (keep calling `usb_tc08_open_unit_progress`).
	`1 (USBTC08_PROGRESS_COMPLETE)`	Enumeration has completed and the handle is now valid.

3.3.2.4 usb_tc08_close_unit

```
short tc08_close_unit(short handle)
```

This routine closes the unit for a specified USB handle.

Arguments:		
	handle	- Specifies the USB TC-08 unit.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Unit closed successfully.

Note: If you successfully open any USB TC-08 units, call usb_tc08_close_unit for each handle before you exit from your program. If you do not, there is a chance that the unit will not reopen until it has been disconnected and reconnected.

3.3.2.5 usb_tc08_stop

```
short usb_tc08_stop (short handle)
```

This routine stops the unit from running.

Arguments:		
	handle	- Specifies the USB TC-08 unit.

Returns:		
	0	- Invalid parameter.
	1	- Unit stopped streaming successfully.

3.3.2.6 usb_tc08_set_mains

```
short usb_tc08_set_mains( short handle,
                          short sixty_hertz)
```

This routine sets the USB TC-08 to reject either 50 or 60 Hz.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	sixty_hertz	- Specifies whether to reject 50Hz or 60Hz. If set to 1, the unit will reject 60Hz, if set to 0, the unit will reject 50Hz.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Mains rejection set correctly.

Note: If the rejection is not set correctly the unit will be more susceptible to mains interference.

3.3.2.7 usb_tc08_get_minimum_interval_ms

```
long usb_tc08_get_minimum_interval_ms (short handle)
```

This routine returns the minimum sampling interval (or fastest millisecond interval) that the unit can achieve in its current configuration. The configuration is defined by calling usb_tc08_set_channel().

Arguments:		
	handle	- Specifies the USB TC-08 unit.

Returns:		
	0	- Use usb_tc08_get_last_error.
	Minimum Interval	- Minimum sampling interval for current setup (in milliseconds).

Note: The USB TC-08 can sample, from a single channel, at a rate of 10 samples per second. The absolute minimum sampling interval, with all 8 channels and the cold junction enabled, is 900 ms. You must set up all the channels that you wish to use before calling this routine.

3.3.2.8 usb_tc08_get_unit_info

```
short usb_tc08_get_unit_info( short handle,
                              USBTC08_INFO * info)
```

This routine gets the unit information and copies it to the USBTC08_INFO structure, declared in the usbtc08.h header file. If you pass zero to the function as the handle, only the driver version member will be valid, but the function will return 1 (success.)

Arguments:		
	handle	- Specifies the TC-08 unit.
	info	- A pointer to a structure containing unit information.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Routine was successful.

You must assign the correct value to the `size` field of your USBTC08_INFO structure before calling this routine. For example, in C, if `devinfo` is your structure, use this code:

```
devinfo.size = sizeof(USBTC08_INFO);
usb_tc08_get_unit_info(hTC08, &devinfo);
```

3.3.2.9 usb_tc08_get_formatted_info

```
short usb_get_formatted_info ( short handle,
                               char * unit_info,
                               short string_length)
```

This function is similar to the usb_get_unit_info routine, but the unit information is returned in the form of a formatted character string. The string is separated into the following elements, each appearing on a different line: driver version; hardware version; variant info; serial number; calibration date.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	unit_info	- A string where the unit info is to be placed.
	string_length	- Length of the string to be copied. Should be at least 256 (USBTC08_MAX_INFO_CHARS) characters long.

Returns:		
	0	- Too many bytes to copy, will copy as many full lines as possible.
	1	- Routine was successful.

3.3.2.10 usb_tc08_get_last_error

```
short usb_tc08_get_last_error (short handle)
```

This routine returns the last error for the unit specified by handle. If zero is passed instead of a handle, the function returns the error associated with the last call to usb_tc08_open_unit or usb_tc08_open_unit_async.

Note: If an invalid handle is passed to a function, the function will fail. The error code, however, cannot be associated with a unit so `usb_tc08_get_last_error` will not retain an error code in this instance. `usb_tc08_get_last_error` will also fail if the invalid handle is passed to it.

The error codes, also found in the C header file, are as follows:

User/Developer error codes:

Error code	Error	Further information
0	USBTC08_ERROR_OK	No error occurred.
1	USBTC08_ERROR_OS_NOT_SUPPORTED	Need to use Windows 98 SE (or later) or Windows 2000 (or later.)
2	USBTC08_ERROR_NO_CHANNELS_SET	A call to usb_tc08_set_channel is required.
3	USBTC08_ERROR_INVALID_PARAMETER	One or more of the function arguments were invalid.
4	USBTC08_ERROR_VARIANT_NOT_SUPPORTED	The hardware version is not supported. Download the latest driver.
5	USBTC08_ERROR_INCORRECT_MODE	An incompatible mix of legacy and non-legacy functions was called (or usb_tc08_get_single was called while in streaming mode.)
6	USBTC08_ERROR_ENUMERATION_INCOMPLETE	usb_tc08_open_unit_async was called again while a background enumeration was already in progress.

Note: For more details on error codes, see troubleshooting.

Reserved Pico error codes

Error code	Error	Further information
7	USBTC08_ERROR_NOT_RESPONDING	Cannot get a reply back from a USB TC-08 unit.
8	USBTC08_ERROR_FW_FAIL	Unable to download firmware.
9	USBTC08_ERROR_CONFIG_FAIL	Missing or corrupted EEPROM.
10	USBTC08_ERROR_NOT_FOUND	Cannot find enumerated device.
11	USBTC08_ERROR_THREAD_FAIL	A threading function failed.
12	USBTC08_ERROR_PIPE_INFO_FAIL	Can not get USB pipe information.
13	USBTC08_ERROR_NOT_CALIBRATED	No calibration date was found.
14	USBTC08_ERROR_PICOPP_TOO_OLD	An old picopp.sys driver was found on the system.

Note: These reserved error code values are only meaningful to Pico technical support staff, but they are supplied to allow developers to display warnings in their applications. For more details on error codes, see troubleshooting.

Arguments:		
	handle	- Specifies the USB TC-08 unit.

Returns:		
	-1	- Invalid handle.
	Error code	- See the error code information above for further explanation.

3.3.3 New USB mode only

3.3.3.1 usb_tc08_set_channel

```
short usb_tc08_set_channel ( short handle,
                             short channel,
                             char tc_type)
```

Call this routine once for each channel that you want to use. You can do this any time after calling usb_tc08_open_unit. By default, all channels are disabled.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	channel	- Specifies which channel you want to set the details for: this should be between 0 - 8 (0 denotes the cold junction.)
	tc_type	- Specifies what type of thermocouple is connected to this channel. Set to one of the following characters: 'B', 'E', 'J', 'K', 'N', 'R', 'S', 'T.' Use a space in quotes to disable the channel. Voltage readings can be obtained by passing 'X' as the character.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Routine was successful.

Note: The CJC is always enabled automatically if a thermocouple is being used. When no channels are active as thermocouples, the CJC can be optionally enabled or disabled.

3.3.3.2 usb_tc08_run

```
long usb_tc08_run( short handle,
                   long interval)
```

This routine starts the unit running with a sampling interval, specified in milliseconds. This routine should be called after usb_tc08_set_channel has been called.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	interval	- Specifies the requested sampling period. You can use usb_tc08_get_minimum_interval_ms to obtain the smallest sampling period permitted with the current setup.

Returns:		
	0	- Use usb_tc08_get_last_error.
	Interval	- Actual interval allowed by the driver.

3.3.3.3 usb_tc08_get_single

```
short usb_tc08_get_single( short   handle,
                           float * temp,
                           short * overflow_flags,
                           short   units)
```

You must set up the channels before calling this function. You must **not** have put the unit into Streaming mode with usb_tc08_run, as this will cause `usb_tc08_get_single` to fail. The function will convert all readings on demand. For more details and an example see the Get Single mode section.

Arguments:		
	`handle`	- Specifies the USB TC-08 unit.
	`temp`	- Pointer to an array of length [9]. There are 9 channels on the USB TC-08 (8 + cold junction) and the readings are always placed in the array subscript corresponding to the channel number. Channels which are not enabled are filled with QNaN values.
	`overflow_flags`	- Pointer to a variable containing a set of bit flags that are set high when an overflow occurs on a particular channel. An overflow occurs when the input signal is higher than the measuring range of the USB TC-08. The lowest significant bit (bit 0) represents channel 0 (the cold juction channel) and bit 8 represents channel 8 (the last thermocouple channel). Bitwise comparisons should be performed to determine the overflow state of each channel.
	`units`	- Specifies the temperature units for returned data: 0: USBTC08_UNITS_CENTIGRADE 1: USBTC08_UNITS_FAHRENHEIT 2: USBTC08_UNITS_KELVIN 3: USBTC08_UNITS_RANKINE

Returns:		
	`0`	- An error occurred, use usb_tc08_get_last_error to get the code.
	`1`	- The function succeeded.

3.3.3.4 usb_tc08_get_temp

```
long usb_tc08_get_temp( short   handle,
                        float * temp_buffer,
                        long  * times_ms_buffer,
                        long    buffer_length,
                        short * overflow,
                        short   channel,
                        short   units,
                        short   fill_missing)
```

Once you open the driver and set up some channels, you can call the usb_tc08_run routine. The driver will then begin to continually take readings from the USB TC-08. Use the `usb_tc08_get_temp` routine to retrieve readings from the driver's buffer periodically. You must call the function at least once per minute to avoid losing data (the driver's buffer is circular, so the oldest readings will be overwritten first).

Streaming mode relies on the driver to buffer readings without interruption. If the driver does not get enough share of the PC's processor time (the most frequent cause of which is too many applications running at the same time), readings will be dropped and the sample buffer will be padded with QNaN floating integers.

Warning: The padding of the buffer is also dependent on the performance of the PC and under very heavy processor loading, padding may not always be accurate.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	temp_buffer	- Pointer to a location where the readings are to be placed.
	times_ms_buffer	- Returns the time that the first channel was converted (optional.)
	buffer_length	- Length of data buffers.
	overflow	- Pointer to a variable that will be assigned a value of 1 if an overflow occured on any of the readings copied into temp_buffer, or 0 if an overflow did not occur. An overflow occurs when the input signal is higher than the measuring range of the USB TC-08.
	channel	- Specifies the channel to read the temperature from.
	units	- Specifies the temperature units for returned data: 0: USBTC08_UNITS_CENTIGRADE 1: USBTC08_UNITS_FAHRENHEIT 2: USBTC08_UNITS_KELVIN 3: USBTC08_UNITS_RANKINE Voltages are always returned in millivolts
	fill_missing	- Choose whether or not to replace QNaN values with the last known value: 0 - Use QNaNs to represent missing readings 1 - Fill missing readings with previous good reading.

Returns:		
	-1	- An error occurred, use usb_tc08_get_last_error to get the code.
	0	- Currently no readings to collect.
	> 0	- Number of readings copied into array (there may still be more readings in the driver's internal buffer.)

3.3.3.5 usb_tc08_get_temp_deskew

```
long usb_tc08_get_temp_deskew ( short   handle,
                                float * temp,
                                long  * times,
                                long    buffer_length,
                                short * overflow,
                                short   channel,
                                short   units,
                                short   fill_missing)
```

Same as usb_tc08_get_temp but the times take account of small differences caused by the order in which channels are converted. Note: Unless there is a specific reason to use the `usb_tc08_get_temp_deskewed` routine, use `usb_tc08_get_temp` instead.

Arguments:		
	`handle`	- Specifies the USB TC-08 unit.
	`temp`	- Pointer to a location where the temperature is to be placed.
	`times_ms_buffer`	- Returns the exact time that this channel was converted (optional.)
	`buffer_length`	- Specifies the length of the sample buffer.
	`overflow`	- Pointer to a variable that will be assigned a value of 1 if an overflow occured on any of the readings copied into `temp_buffer`, or 0 if an overflow did not occur. An overflow occurs when the input signal is higher than the measuring range of the USB TC-08.
	`channel`	- Specifies the channel to read the temperature from.
	`units`	- Specifies the temperature units in which the data are returned: 0: USBTC08_UNITS_CENTIGRADE 1: USBTC08_UNITS_FAHRENHEIT 2: USBTC08_UNITS_KELVIN 3: USBTC08_UNITS_RANKINE Voltages are always returned in millivolts.
	`fill_missing`	- Choose whether or not to replace QNaN values (missing readings) with the last known value: 0 - Use QNaNs to represent missing readings. 1 - Fill missing readings (no QNaNs.)

Returns:		
	-1	- An error occurred, use usb_tc08_get_last_error to get the code.
	0	- Currently no readings to collect.
	> 0	- Number of readings copied into array (there may still be more readings in the driver's internal buffer.)

3.3.4 Legacy mode only

3.3.4.1 usb_tc08_legacy_run

```
short usb_tc08_legacy_run(short handle)
```

This routine starts the sampling thread and forces the specified unit to run in legacy mode.

Arguments:		
	handle	- Specifies the USB TC-08 unit.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Legacy run successful.

3.3.4.2 usb_tc08_legacy_set_channel

```
short usb_tc08_legacy_set_channel (short handle,
                                   short channel,
                                   char tc_type,
                                   short filter_factor,
                                   short offset,
                                   short slope)
```

Call this routine once for each channel that you would like to take readings from. You can do this any time after calling usb_tc08_open_unit.

Arguments:		
	handle	- Specifies the USB TC-08 unit.
	channel	- Specifies which channel you want to set the details for: This should be between 0 and 8.
	tc_type	- Specifies what type of thermocouple is connected to this channel. Set to one of the following characters 'B', 'E', 'J', 'K', 'N', 'R', 'S', 'T.' Use a space in quotes to disable the channel.
	filter_factor	- Specifies the size of the median filter. Each time the driver takes a reading from this channel, it updates the filtered value by adding a reading to a median filter. The filter factor can be set to any value between 0 - 255 (0 or 1 turns filtering off).
	filter_factor	- These parameters are provided for backward compatibility with the serial TC-08 and have no effect when used with the USB TC-08.

Returns:		
	0	- Use usb_tc08_get_last_error.
	1	- Legacy set channel successful.

Note: Do not call this function unless you are operating the USB TC-08 in legacy mode, having called usb_tc08_legacy_run.

3.3.4.3 usb_tc08_legacy_get_temp

```
short usb_tc08_legacy_get_temp (long * temp,
                                short handle,
                                short channel,
                                short filtered)
```

Once you open the driver and define some channels, you can call the usb_tc08_legacy_run routine. The driver will then constantly take readings from the USB TC-08. Temperatures are returned in hundredths of a degree Celsius and voltages are returned in microvolts.

Arguments:		
	`channel`	- Specifies from which channel to read temperature. Should be 0 for CJC, 1 for Channel 1, 2 for Channel 2 and so on.
	`temp`	- Pointer to a location where readings are to be placed. Each reading should be compared with 2147483647L or LONG_MAX (include limits.h) to check for overflows. An overflow occurs when the input signal is higher than the measuring range of the USB TC-08.
	`filtered`	- Specifies whether or not to filter the data. The readings are median filtered if set to 1. 0 causes the unfiltered temperature to be stored in `temp`. The filter has a depth defined by the filter factor, set during a usb_legacy_set_channel call.

Returns:		
	`0`	- Use usb_tc08_get_last_error.
	`1`	- Temperature retrieval successful.

Note: Do not call this function unless you are operating the USB TC-08 in legacy mode, having called usb_tc08_legacy_run.

3.3.4.4 usb_tc08_legacy_get_cold_junction

```
short usb_tc08_legacy_get_cold_junction (long * temp,
                                         short handle)
```

This routine retrieves a cold junction temperature reading. This can also be achieved by passing `channel = 0` to usb_tc08_get_temp. Temperatures are returned in hundredths of a degree Celsius. Normally, you do not need to worry about the cold junction temperature, as the driver automatically uses it to compensate thermocouples. You can, however, use it as an indication of ambient temperature.

Arguments:		
	`handle`	- Specifies USB TC-08 unit.
	`temp`	- Pointer to a location where the temperature reading is to be stored.

Returns:		
	`0`	- Use usb_tc08_get_last_error.
	`1`	- Retrieval of cold junction temperature reading successful.

3.3.4.5 usb_tc08_legacy_get_driver_version

```
short usb_tc08_legacy_get_driver_version (void)
```

This routine returns the driver version. This is useful when you need to find out if the latest driver is being used.

Arguments:		
	`none`	

Returns:		
	`Driver version number`	

3.3.4.6 usb_tc08_legacy_get_version

```
short usb_tc08_legacy_get_version (short * version,
                                   short  handle)
```

This routine sets the 'version' variable to match the version of the USB TC-08 currently being used.

Arguments:		
	`handle`	- Specifies the USB TC-08 unit.
	`version`	- Pointer to a location where the version number is to be stored.

Returns:		
	`0`	- Invalid handle.
	`1`	- Retrieval of version number successful.

3.3.4.7 usb_tc08_legacy_get_cycle

```
short usb_tc08_legacy_get_cycle (long * cycle,
                                 short handle)
```

This routine gives the number of complete cycles of readings taken from a particular USB TC-08. Calling usb_tc08_legacy_get_temp causes the most recent reading for the specified channel to be returned immediately. 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 usb_tc08_legacy_get_temp, but only when the cycle has been incremented.

Arguments:		
	`handle`	- Specifies a USB TC-08 unit.
	`cycle`	- Pointer to a location where the cycle number is to be stored.

Returns:		
	`0`	- Use usb_tc08_get_last_error.
	`1`	- Legacy get cycle successful.

Tip: Do not test for an exact cycle number; instead, test for a different cycle number as your application may have missed readings. See the Legacy mode section for an example.

Note: Do not call this function unless you are operating the USB TC-08 in legacy mode, having called usb_tc08_legacy_run.

3.4 Programming

3.4.1 Introduction

We supply examples for the following programming languages:

- C and C++
- Delphi
- Excel
- LabVIEW
- Visual Basic
- HP-Vee

3.4.2 C and C++

C

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

```
            usb_tc08tes.c
            usb_tc08tes.rc
either      usbtc08bc.lib (Borland 32-bit applications)
or          usbtc08.lib (Microsoft Visual C 32-bit applications)
```

The following files must be in the same directory:

```
            usb_tc08tes.rch
            usbtc08.h
            usb_tc0832.dll (All 32-bit applications)
```

C++

C++ programs can access all versions of the driver. If `usbtc08.h` is included in a C++ program, the PREF1 macro expands to extern "C": this disables name-mangling (or name-decoration), and enables C++ routines to make calls to the driver routines using C headers.

3.4.3 Delphi

The WIN sub-directory contains a simple program `usbtc08.dpr` which opens the drivers and reads temperatures from the three channels. You will need the following files to build a complete program.

```
usbtc08fm.dfm
usbtc08fm.pas
usbtc08.inc
```

The file `USBTC08.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.

3.4.4 Excel

The easiest way to transfer data to Excel is to use the PicoLog software application.

If, however, you need to do something that is not possible using PicoLog, you can write an Excel macro which calls `usbtc08.dll` to read in a set of data values. The Excel Macro language is similar to Visual Basic.

The example `USBTC0832.XLS` reads in 20 values of the cold junction temperature and channel 1 temperature, one per second, and assigns them to cells A1..B20.

3.4.5 LabVIEW

While it is possible to access all of the driver routines described earlier, it is easier to use the special LabVIEW access routine.

To use this routine, copy `usb_tc0832.vi` from the `DRIVERS` subdirectory to your LabVIEW `user.lib` directory. You will then need `usb_tc08` 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 returns a temperature for thermocouple types.

3.4.6 Visual Basic

The `DRIVERS` directory contains the following files, created in Visual Basic 6:

```
USBTC0832.VBP
USBTC0832.BAS
USBTC0832.FRM
USBTC0832.VBW
```

3.4.7 HP-Vee

The example program `usb_tc08.vee` shows how to collect a block of data from the `usb_tc08`. There are prototypes in `USB_TC08.vh`.

3.5 Troubleshooting

The following table lists each of the error codes described in the usb_tc08_get_last_error section, and divides them into categories, so that you know what to do in the event of a particular error occurring.

Error code	Description	Category
1	USBTC08_ERROR_OS_NOT_SUPPORTED	**P***
2	USBTC08_ERROR_NO_CHANNELS_SET	**P**
3	USBTC08_ERROR_INVALID_PARAMETER	**P**
4	USBTC08_ERROR_VARIANT_NOT_SUPPORTED	**P***
5	USBTC08_ERROR_INCORRECT_MODE	**P**
6	USBTC08_ERROR_ENUMERATION_INCOMPLETE	**S**
7	USBTC08_ERROR_NOT_RESPONDING	**S**
8	USBTC08_ERROR_FW_FAIL	**S**
9	USBTC08_ERROR_CONFIG_FAIL	**S**
10	USBTC08_ERROR_NOT_FOUND	**S**
11	USBTC08_ERROR_THREAD_FAIL	**S**
12	USBTC08_ERROR_PIPE_INFO_FAIL	**S**
13	USBTC08_ERROR_NOT_CALIBRATED	**S**
14	USBTC08_ERROR_PICOPP_TOO_OLD	**S**

Key	
S	- Errors in this category indicate that a fault has occurred with the USB TC-08 unit or your PC. Try disconnecting the USB TC-08, then reconnecting it. If this does not work, restart your PC. If this does not work, do the following: 1. Uninstall the software and restart the PC 2. Reinstall the software and restart the PC 3. If this does not work, download the latest version of the software from http://www.picotech.com/download.html and install this, then restart the PC 4. If this does not work, contact support@picotech.com
P	- Errors in this category are handled internally within software applications, and only developers need to be aware of their meanings. Find a routine which fails with one of these error codes.
P*	- Errors in this category are user-dependent and developers should make sure that their application provides suitable error messages for users to read in the event of an error occurring.

3.6 Glossary

CJC

A method of compensating for ambient temperature variations in thermocouple circuits.

Cold junction compensation

See **CJC**.

Common mode range

The voltage range, relative to the ground of the data logger, within which both inputs of a differential measurement must lie in order to achieve an accurate measurement.

DLL

Dynamic Link Library. Files with this file extension contain a collection of Windows functions designed to perform a specific class of operations.

Input impedance

The resistance measured between the input terminals of a circuit.

NFR

Noise-Free Resolution. The effective number of bits of resolution that can be considered noise-free.

Overvoltage protection

The maximum input voltage that can be applied without damaging the unit.

QNaN

Quiet Not a Number. In the context of the USB TC-08, QNaNs are numbers created artificially to fill in gaps in sampling. These gaps are interruptions caused by lack of available PC or laptop processor time, normally caused by too many applications being open simultaneously. QNaNs are defined in the **IEEE 754-1985** ISO standard and are indeterminate, meaning no two QNaNs have the same value.

In C/C++, the **int _isnan(double)** function in the **<float.h>** header can be used to identify QNaN float representations, cast to a **double** first. QNaNs will not cause an error if arithmetic operations are performed on them - however, the results will remain indeterminate.

Resolution

A value in bits, related to the number of increments of an analog input signal that can be detected by a digital measurement system. A high-resolution measurement system detects smaller signal increments than a low-resolution measurement system.

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.

Type B thermocouple

Type B thermocouples are made from platinum and rhodium and are suitable for high temperature measurements of up to 1820°C. Unusually, due to the shape of their temperature / voltage curve, type B thermocouples give the same output at 0°C as at 42°C.

Type E thermocouple

Type E thermocouples are made from chromel and constantan. They have a high output (68 uV/°C), making them well suited to low-temperature (cryogenic) use. They are non-magnetic.

Type J thermocouple

Type J thermocouples are made from iron and constantan. They measure temperatures in the range -210 to +1200°C. The main application is with old equipment that can not accept the more modern thermocouple. J types should not be used above 760°C, as an abrupt magnetic transformation will cause permanent decalibration.

Type K thermocouple

Type K thermocouples are low-cost, general-purpose thermocouples, made from chromel and alumel, operating in the -270°C to +1370°C temperature range. Sensitivity is approx 41 uV/°C.

Type N thermocouple

Type N thermocouples are made from nicrosil and nisil. The high stability and resistance to high-temperature oxidation of these thermocouples make them suitable for measuring high temperatures. They are less expensive than platinum types B,R, and S and were designed to be an improved type K.

Type R thermocouple

Type R thermocouples are made from platinum and rhodium, and are suitable for high-temperature measurements of up to 1760°C. Low sensitivity (10 uV/°C) and high cost make them unsuitable for general purpose use.

Type S thermocouple

Type S thermocouples are made from platinum and rhodium, and are suitable for high-temperature measurements of up to 1760°C. Low sensitivity (10 uV/vC) and high cost make these thermocouples unsuitable for general purpose use. Due to their high stability, type S thermocouples are used as the standard of calibration for the melting point of gold.

Type T thermocouple

Type T thermocouples are made from copper and constantan, are highly accurate, and operate in the -270°C to +400°C temperature range.

USB

Universal Serial Bus. This is a standard port that enables you to connect external devices to PCs. A typical USB 1.1 port supports a data transfer rate of 12 Mbps (12 megabits per second), and is much faster than a COM port.

USBTC08_INFO

```
typedef struct tUSBTC08Info
{
short size;
short DriverVersion;
short PicoppVersion;
short HardwareVersion;
short Variant;
char szSerial[USBTC08_MAX_SERIAL_CHARS];
char szCalDate[USBTC08_MAX_DATE_CHARS];
} USBTC08_INFO, *LPUSBTC08_INFO;
```

This structure is used to receive information from the usb_tc08_get_unit_info function and is defined in the `usbtc08.h` header file. Note: If the programming language you are using does not support structures, use the usb_tc08_get_formatted_info function.

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