PicoScope 2000 Series

PC Oscilloscopes

Programmer's Guide

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Contents

1 Introduction

1.1 Overview

The PicoScope 2000 Series PC Oscilloscopes are low-cost , high-performance instruments that are fully USB 2.0-capable and also backwards-compatible with USB 1.1. There is no need for an additional power supply, as power is taken from the USB port.

This manual explains how to develop your own programs for collecting and analyzing data from the PicoScope 2000 Series oscilloscopes. This manual describes the application programming interface (API) for the devices shown below.

- PicoScope 2104
- PicoScope 2105
- PicoScope 2202
- PicoScope 2203
- PicoScope 2204
- PicoScope 2205
- PicoScope 2204A
- PicoScope 2205A

Drivers and example code are available on the *Pico Technology Software and Reference CD-ROM* and on our website at www.picotech.com.

The oscilloscopes are also supplied with the ready-to-use PicoScope oscilloscope software and PicoLog data logging software, which include their own on-line User's Guides.

Please read the important information in this introductory section and then proceed to the Installation instructions.

1.2 Minimum system requirements

To ensure that your PicoScope 2000 Series PC Oscilloscope operates correctly, you must have a computer with at least the minimum system requirements to run one of the supported operating systems, as shown in the following table. The performance of the oscilloscope will be better with a more powerful PC, and will benefit from a multi-core processor.

Please note the PicoScope software is not installed as part of the SDK.

Item	Specification
Operating system	Windows XP (SP3), Windows Vista, Windows 7, Windows 8 (Not Windows RT)
	32 bit and 64 bit versions supported
Processor	As required by Windows
Memory	
Free disk space	
Ports	USB 1.1 compliant port (absolute minimum)* USB 2.0 or USB 3.0 compliant port

* The oscilloscope will run slowly on a USB 1.1 port. This configuration is not recommended.

Using with custom applications

Drivers are available for Windows XP (SP3 or later), Windows Vista, Windows 7 and Windows 8.

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1.6 Company details

You can obtain technical assistance from Pico Technology at the following address:

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Web site:	www.picotech.com

2 Product information

2.1 System requirements

General requirements

See Minimum PC requirements.

USB

The ps2000 driver offers several methods of recording data, all of which support both USB 1.1 and USB 2.0, although the fastest transfer rates are achieved using USB 2.0. The driver is also compatible with USB 3.0, with which it will run at the same speed as USB 2.0.

2.2 Installation instructions

Important

Do not connect the PC Oscilloscope to your PC until you have installed the software.

- Install the software by following the steps in the printed *Installation Guide* supplied with your oscilloscope. You must install the PicoScope 6 PC Oscilloscope software even if you do not intend to use it, as it includes the driver and API DLL that you will need to write your own software.
- Connect the oscilloscope's USB port to the PC using the USB cable supplied. There is no need for an additional power supply, as the oscilloscope obtains its power from the PC.

Checking the installation

Once you have installed the software, ensure that the oscilloscope is connected to the PC and then start the PicoScope software. PicoScope should show a small 50 Hz or 60 Hz mains signal in the oscilloscope window when you touch the probe tip with your finger.

3 Programming the 2000 Series Oscilloscopes

3.1 General procedure

The `ps2000.dll` library in your PicoScope installation directory allows you to program a PicoScope 2000 Series oscilloscope using standard C function calls.

A typical program for capturing data consists of the following steps:

- Open the oscilloscope.
- Set up the input channels with the required voltage ranges and coupling mode.
- Set up triggering.
- Start capturing data. (See Sampling modes, where programming is discussed in more detail.)
- Wait until the oscilloscope is ready.
- Copy data to a buffer.
- Stop capturing data.
- Close the oscilloscope.

Numerous sample programs are included in the SDK. These show how to use the functions of the driver software in each of the modes available.

3.2 Driver

Important
Ensure the PicoScope driver is installed by one of the following methods.

Before plugging the oscilloscope into your computer for the first time, either:

1) Install (or already have installed) the PicoScope software, which includes the driver for the PicoScope PC Oscilloscope.

Note: Once you have installed the PicoScope software, Windows will automatically install the driver when you plug in the oscilloscope for the first time.

Or

2) If you do not want or need an installation of PicoScope, manually run the required `dpinst.exe` which can be found in the `system\amd64` or `system\x86` folder of the SDK.

Note: For an x86 operating system you will also need to copy `picopp.inf` to `SYSTEMROOT\inf` and `picopp.sys` to `SYSTEMROOT\system32\drivers`.

The Windows XP, Windows Vista, Windows 7 and Windows 8 32-bit driver, `picopp.sys`, is installed under the control of an information file, `picopp.inf`.

If you do plug in an oscilloscope before installing the driver, Windows will designate the device as Unknown. You will then need to manually delete the device using the Device Manager before you can install the correct driver.

3.3 Voltage ranges

It is possible to set the gain for each channel with the ps2000_set_channel() function. The input voltage ranges available depend on which type of oscilloscope is connected.

3.4 Triggering

PicoScope 2000 Series PC Oscilloscopes can either start collecting data immediately, or be programmed to wait for a trigger event to occur. In both cases you need to use the ps2000_set_trigger() function or, for scopes that support advanced triggering, the ps2000SetAdvTriggerChannelConditions() function. A trigger event can occur on any of the conditions available in the simple and advanced triggering modes.

Applicability	Available in block mode and fast streaming mode only. Calls to the ps2000_set_trigger() and ps2000SetAdvTriggerChannelConditions() functions have no effect in compatible streaming mode.

3.5 Signal generator

The PicoScope 2203, 2204(A) and 2205(A) PC Oscilloscopes have a built-in signal generator which is set up using ps2000_set_sig_gen_built_in().

Applicability	PicoScope 2203, 2204(A) and 2205(A) oscilloscopes only.

3.6 AC/DC coupling

Using the ps2000_set_channel() function, each channel can be set to either AC or DC coupling. When AC coupling is used, any component of the signal below about 1 Hz is filtered out.

3.7 Oversampling

When the oscilloscope is operating at sampling rates less than the maximum, it is possible to oversample. Oversampling is taking more than one measurement during a time interval and returning an average. If the signal contains a small amount of noise, this technique can increase the effective vertical resolution of the oscilloscope by the amount given by the equation below:

Increase in resolution (bits) = (log oversample) / (log 4)

Applicability	Available in block mode only.

3.8 Scaling

The driver normalises all readings to 16 bits, regardless of the vertical resolution of the oscilloscope. The following table shows the relationship between the reading from the driver and the signal level.

Constant	Reading	Voltage
PS2000_LOST_DATA	-32 768	Indicates a buffer overrun in fast streaming mode.
PS2000_MIN_VALUE	-32 767	Negative full scale
0	0	Zero volts
PS2000_MAX_VALUE	32 767	Positive full scale

4 Sampling modes

PicoScope 2000 Series PC Oscilloscopes can run in various sampling modes.

- Block mode. At the highest sampling rates, the oscilloscope collects data much faster than a PC can read it. In this case, the oscilloscope stores a block of data in an internal memory buffer, delaying transfer to the PC until the required number of data points have been sampled.
- Streaming modes. At all but the highest sampling rates, these modes allow accurately timed data to be transferred back to the PC without gaps. The computer instructs the oscilloscope to start collecting data. The oscilloscope then transfers data back to the PC without storing it in its own memory, so the size of the data set is limited only by the size of the PC's memory. Sampling intervals from less than one microsecond (depending on model) to 60 seconds are possible. There are two streaming modes:
  - Compatible streaming mode
  - Fast streaming mode

4.1 Block mode

In block mode, the computer prompts the oscilloscope to collect a block of data in its internal memory. When the oscilloscope has collected the whole block, it signals that it is ready and then transfers the whole block to the computer's memory through the USB port.

The maximum number of values depends upon the size of the oscilloscope's memory. A PicoScope 2000 Series oscilloscope can sample at a number of different rates that correspond to the maximum sampling rate divided by 1, 2, 4, 8 and so on.

There is a separate memory buffer for each channel. When a channel is unused, its memory can be borrowed by the enabled channels. This feature is handled transparently by the driver.

The driver normally performs a number of setup operations before collecting each block of data. This can take up to 50 milliseconds. If it is necessary to collect data with the minimum time interval between blocks, avoid calling setup functions between calls to ps2000_run_block(), ps2000_ready(), ps2000_stop() and ps2000_get_values().

See Using block mode for programming details.

4.1.1 Using block mode

This is the general procedure for reading and displaying data in block mode:

1. Open the oscilloscope using ps2000_open_unit().
2. Select channel ranges and AC/DC coupling using ps2000_set_channel().
3. Using ps2000_set_trigger(), set the trigger if required.
4. Using ps2000_get_timebase(), select timebases until you locate the required time interval per sample.
5. Start the oscilloscope running using ps2000_run_block().
6. Wait until the oscilloscope says it is ready using ps2000_ready().
7. Transfer the block of data from the oscilloscope using ps2000_get_values() or ps2000_get_times_and_values().
8. Display the data.
9. Repeat steps 5 to 8.
10. Stop the oscilloscope using ps2000_stop().

4.2 Streaming mode

Streaming mode is an alternative to block mode that can capture data without gaps between blocks.

In streaming mode, the computer prompts the oscilloscope to start collecting data. The data is then transferred back to the PC without being stored in the oscilloscope's memory. Data can be sampled with a period between 1 µs or less and 60 s, and the maximum number of samples is limited only by the amount of free space on the PC's hard disk.

There are two varieties of streaming mode:

- Compatible streaming mode
- Fast streaming mode

4.2.1 Compatible streaming mode

Compatible streaming mode is a basic streaming mode that works at speeds from one sample per minute to a thousand samples per second.

The oscilloscope's driver transfers data to a computer program using either normal or windowed mode. In normal mode, any data collected since the last data transfer operation is returned in its entirety. Normal mode is useful if the computer program requires fresh data on every transfer. In windowed mode, a fixed number of samples is returned, where the oldest samples may have already been returned before. Windowed mode is useful when the program requires a constant time period of data.

Once the oscilloscope is collecting data in streaming mode, any setup changes (for example, changing a channel range or AC/DC setting) will cause a restart of the data stream. The driver can buffer up to 32 K samples of data per channel, but the user must ensure that the ps2000_get_values() function is called frequently enough to avoid buffer overrun.

See Using compatible streaming mode for programming details.

Applicability	Not available on PicoScope 2203, 2204, 2204A, 2205 or 2205A. Does not support triggering. The ps2000_get_times_and_values() function always returns FALSE (0) in streaming mode.

4.2.1.1 Using compatible streaming mode

This is the general procedure for reading and displaying data in compatible streaming mode:

1. Open the oscilloscope using ps2000_open_unit().
2. Select channel ranges and AC/DC switches using ps2000_set_channel().
3. Start the oscilloscope running using ps2000_run_streaming().
4. Transfer the block of data from the oscilloscope using ps2000_get_values().
5. Display the data.
6. Repeat steps 4 and 5 as necessary.
7. Stop the oscilloscope using ps2000_stop().

4.2.2 Fast streaming mode

Fast streaming mode is an advanced streaming mode that can transfer data at speeds of a million samples per second or more, depending on the computer's performance. This makes it suitable for high-speed data acquisition, allowing you to capture very long data sets limited only by the computer's memory.

Fast streaming mode also provides data aggregation, which allows your application to zoom in and out of the data with the minimum of effort.

Applicability	PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Works with triggering.

See Using fast streaming mode for programming details.

4.2.2.1 Using fast streaming mode

This is the general procedure for reading and displaying data in fast streaming mode:

1. Open the oscilloscope using ps2000_open_unit().
2. Select channel ranges and AC/DC switches using ps2000_set_channel().
3. Set the trigger using ps2000_set_trigger().
4. Start the oscilloscope running using ps2000_run_streaming_ns().
5. Get a block of data from the oscilloscope using ps2000_get_streaming_last_values().
6. Display or process the data.
7. If required, check for overview buffer overruns by calling ps2000_overview_buffer_status().
8. Repeat steps 5 to 7 as necessary or until auto_stop is TRUE.
9. Stop fast streaming using ps2000_stop().
10. Retrieve any part of the data at any time scale by calling ps2000_get_streaming_values().
11. If you require raw data, retrieve it by calling ps2000_get_streaming_values_no_aggregation().
12. Repeat steps 10 to 11 as necessary.
13. Close the oscilloscope by calling ps2000_close_unit().

4.3 ETS (Equivalent Time Sampling)

ETS is a way of increasing the effective sampling rate when working with repetitive signals. It is controlled by the ps2000_set_trigger() and ps2000_set_ets() functions.

ETS works by capturing many instances of a repetitive waveform, then combining them to produce a composite waveform that has a higher effective sampling rate than the individual instances. The maximum effective sampling rates that can be achieved with this method are listed in the Specifications table for your oscilloscope.

Because of the high sensitivity of ETS mode to small time differences, you must set up the trigger to provide a stable waveform that varies as little as possible from one capture to the next.

Applicability	Block mode only. PicoScope 2104, 2105, 2203, 2204, 2204A, 2205 and 2205A oscilloscopes. As ETS returns random time intervals, the ps2000_get_times_and_values() function must be used. The ps2000_get_values() function will return FALSE (0). Stable, repetitive signals only.

4.3.1 Using ETS mode

This is the general procedure for reading and displaying data in ETS mode:

1. Open the oscilloscope using ps2000_open_unit().
2. Select channel ranges and AC/DC switches using ps2000_set_channel().
3. Using ps2000_set_trigger(), set the trigger if required.
4. Set ETS mode using ps2000_set_ets().
5. Start the oscilloscope running using ps2000_run_block().
6. Wait until the oscilloscope says it is ready using ps2000_ready().
7. Transfer the block of data from the oscilloscope using ps2000_get_times_and_values().
8. Display the data.
9. Repeat steps 6 to 8 as necessary.
10. Stop the oscilloscope using ps2000_stop().

5 Combining several oscilloscopes

The 2000 Series driver can collect data from up to 64 PicoScope 2000 Series PC Oscilloscopes at the same time. Each oscilloscope must be connected to a separate USB port. If a USB hub is used it must be a powered hub.

To begin, call ps2000_open_unit() to obtain a handle for each oscilloscope. All the other functions require this handle for oscilloscope identification. For example, to collect data from two oscilloscopes at the same time:

```
handle1 = ps2000_open_unit()
handle2 = ps2000_open_unit()

ps2000_set_channel(handle1)
... set up unit 1
ps2000_run_block(handle1)

ps2000_set_channel(handle2)
... set up unit 2
ps2000_run_block(handle2)

ready = FALSE
while not ready
   ready = ps2000_ready(handle1)
   ready &= ps2000_ready(handle2)

ps2000_get_values(handle1)
ps2000_get_values(handle2)
```

It is not possible to synchronise the collection of data between multiple 2000 Series oscilloscopes.

6 API Functions

The PicoScope 2000 Series API exports the following functions for you to use in your own applications:

ps2000_close_unit
ps2000_flash_led
ps2000_get_streaming_last_values
ps2000_get_streaming_values
ps2000_get_streaming_values_no_aggregation
ps2000_get_timebase
ps2000_get_times_and_values
ps2000_get_unit_info
ps2000_get_values
ps2000_last_button_press
ps2000_open_unit
ps2000_open_unit_async
ps2000_open_unit_progress
ps2000_overview_buffer_status
ps2000_ready
ps2000_run_block
ps2000_run_streaming
ps2000_run_streaming_ns
ps2000SetAdvTriggerChannelConditions
ps2000SetAdvTriggerChannelDirections
ps2000SetAdvTriggerChannelProperties
ps2000SetAdvTriggerDelay
ps2000_set_channel
ps2000_set_ets
ps2000_set_led
ps2000_set_light
ps2000SetPulseWidthQualifier
ps2000_set_sig_gen_arbitrary
ps2000_set_sig_gen_built_in
ps2000_set_trigger
ps2000_set_trigger2
ps2000_stop

The following user-defined function is also described here:

my_get_overview_buffers

6.1 ps2000_close_unit

```
short ps2000_close_unit (
  short handle
)
```

Shuts down a PicoScope 2000 Series oscilloscope.

Applicability	All modes
Arguments	`handle`: the handle, returned by ps2000_open_unit(), of the oscilloscope being closed.
Returns	non-zero: if a valid handle is passed. 0: if handle is not valid.

6.2 ps2000_flash_led

```
short ps2000_flash_led (
  short handle
)
```

Flashes the LED on the front of the oscilloscope (or in the pushbutton, for the PicoScope 2104 and 2105 oscilloscopes) three times and returns within one second.

Applicability	All modes
Arguments	`handle`: the handle of the PicoScope 2000 Series oscilloscope.
Returns	non-zero: if a valid handle is passed. 0: if handle is invalid.

6.3 ps2000_get_streaming_last_values

```
short ps2000_get_streaming_last_values (
  short                       handle
  GetOverviewBuffersMaxMin lpGetOverviewBuffersMaxMin
)
```

This function is used to collect the next block of values while fast streaming is running. You must call ps2000_run_streaming_ns beforehand to set up fast streaming.

Applicability	Fast streaming mode only. PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Not compatible with ETS triggering. Function has no effect in ETS mode.
Arguments	`handle`: the handle of the required oscilloscope. `lpGetOverviewBuffersMaxMin`: a pointer to the my_get_overview_buffers() callback function in your application that receives data from the streaming driver.
Returns	1: if the callback will be called. 0: if the callback will not be called, either because one of the inputs is out of range or because there are no samples available.

6.4 ps2000_get_streaming_values

```
unsigned long ps2000_get_streaming_values (
  short         handle,
  double        *start_time,
  short         *pbuffer_a_max,
  short         *pbuffer_a_min,
  short         *pbuffer_b_max,
  short         *pbuffer_b_min,
  short         *pbuffer_c_max,
  short         *pbuffer_c_min,
  short         *pbuffer_d_max,
  short         *pbuffer_d_min,
  short         *overflow,
  unsigned long *triggerAt,
  short         *triggered,
  unsigned long no_of_values,
  unsigned long noOfSamplesPerAggregate
)
```

This function is used after the driver has finished collecting data in fast streaming mode. It allows you to retrieve data with different aggregation ratios, and thus zoom in to and out of any region of the data.

Before calling this function, first capture some data in fast streaming mode, stop fast streaming by calling ps2000_stop(), then allocate sufficient buffer space to receive the requested data. The function will store the data in your buffer with values in the range PS2000_MIN_VALUE to PS2000_MAX_VALUE. The special value PS2000_LOST_DATA is stored in the buffer when data could not be collected because of a buffer overrun. (See Scaling for more on data values.)

Each sample of aggregated data is created by processing a block of raw samples. The aggregated sample is stored as a pair of values: the minimum and the maximum values of the block.

Applicability	Fast streaming mode only. PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Not compatible with ETS triggering - function has no effect in ETS mode.
Arguments	`handle:` the handle of the required oscilloscope. `start_time:` the time in nanoseconds, relative to the trigger point, of the first data sample required. `pbuffer_a_max, pbuffer_a_min:` pointers to two buffers into which the function will write the maximum and minimum aggregated sample values from channel A. `pbuffer_b_max, pbuffer_b_min:` as above but for channel B (two-channel scopes only). `pbuffer_c_max, pbuffer_c_min, pbuffer_d_max, pbuffer_d_min:` not used `overflow:` on exit, the function writes a bit field here indicating whether the voltage on each of the input channels has overflowed: Bit 0: Ch A overflow Bit 1: Ch B overflow `triggerAt:` on exit, the function writes an index value here. This is the offset, from the start of the buffer, of the sample at the trigger reference point. It is valid only when triggered is TRUE. `triggered:` a pointer to a Boolean indicating that a trigger has occurred and `triggerAt` is valid. `no_of_values:` the number of values required. `noOfSamplesPerAggregate:` the number of samples that the driver should combine to form each aggregated value pair. The pair consists of the maximum and minimum values of all the samples that were aggregated. For channel A, the minimum value is stored in the buffer pointed to by `pbuffer_a_min` and the maximum value in the buffer pointed to by `pbuffer_a_max`.
Returns	The number of values written to each buffer, if successful. 0: if a parameter was out of range.

6.5 ps2000_get_streaming_values_no_aggregation

```
unsigned long ps2000_get_streaming_values_no_aggregation (
  short         handle,
  double        *start_time,
  short         *pbuffer_a,
  short         *pbuffer_b,
  short         *pbuffer_c,
  short         *pbuffer_d,
  short         *overflow,
  unsigned long *triggerAt,
  short         *trigger,
  unsigned long no_of_values
)
```

This function retrieves raw streaming data from the driver's data store after fast streaming has stopped.

Before calling the function, capture some data using fast streaming, stop streaming using ps2000_stop(), and then allocate sufficient buffer space to receive the requested data. The function will store the data in your buffer with values in the range `PS2000_MIN_VALUE` to `PS2000_MAX_VALUE`. The special value `PS2000_LOST_DATA` is stored in the buffer when data could not be collected because of a buffer overrun. (See Scaling for more details of data values.)

Applicability	Fast streaming mode only. PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Not compatible with ETS triggering - has no effect in ETS mode.
Arguments	`handle:` the handle of the required oscilloscope. `start_time:` the time in nanoseconds of the first data sample required. `pbuffer_a, pbuffer_b:` pointers to buffers into which the function will write the raw sample values from channels A (all scopes) and B (two-channel scopes only). `pbuffer_c, pbuffer_d:` not used. `overflow:` on exit, the function will write a bit field here indicating whether the voltage on each of the input channels has overflowed. Bit 0 is the LSB. The bit assignments are as follows: Bit 0 - Ch A overflow Bit 1 - Ch B overflow `triggerAt:` on exit, the function writes an index into the buffers here. The index is the number of the the sample at the trigger reference point. It is valid only when trigger is TRUE. `trigger:` on exit, the function writes a Boolean here indicating that a trigger has occurred and `triggerAt` is valid. `no_of_values:` the number of values required.
Returns	The number of values written to each buffer, if successful. 0: if a parameter was out of range.

6.6 ps2000_get_timebase

```
short ps2000_get_timebase (
  short handle,
  short timebase,
  long  no_of_samples,
  long  *time_interval,
  short *time_units,
  short oversample,
  long  *max_samples
)
```

This function discovers which timebases are available on the oscilloscope. You should set up the channels using ps2000_set_channel() and, if required, ETS mode using ps2000_set_ets() first. Then call this function with increasing values of `timebase`, starting from 0, until you find a timebase with a sampling interval and sample count close enough to your requirements.

Applicability	All modes
Arguments	`handle`: the handle of the required oscilloscope. `timebase`: a code between 0 and the maximum timebase (depending on the oscilloscope). Timebase 0 is the fastest timebase. Each successive timebase has twice the sampling interval of the previous one. `no_of_samples`: the number of samples that you require. The function uses this value to calculate the most suitable time unit to use. `time_interval`: on exit, this location will contain the time interval, in nanoseconds, between readings at the selected timebase. If `time_interval` is `NULL`, the function will write nothing. `time_units`: on exit, this location will contain an enumerated type indicating the most suitable unit for expressing sample times. You should pass this value to ps2000_get_times_and_values(). If `time_units` is null, the function will write nothing. `oversample`: the amount of oversample required. For example, an oversample of 4 results in a `time_interval` 4 times larger and a `max_samples` 4 times smaller. At the same time it increases the effective resolution by one bit. See Oversampling for more details. `max_samples`: on exit, this location contains the maximum number of samples available. The number may vary depending on the number of channels enabled, the timebase chosen and the oversample multiplier selected. If `max_samples` is null, the function will write nothing.
Returns	non-zero: if all parameters are in range. 0: on error.

6.7 ps2000_get_times_and_values

```
long ps2000_get_times_and_values (
  short handle
  long  *times,
  short *buffer_a,
  short *buffer_b,
  short *buffer_c,
  short *buffer_d,
  short *overflow,
  short time_units,
  long  no_of_values
)
```

This function is used to get values and times in block mode after calling ps2000_run_block().

Applicability	Block mode only. It will not return any valid times if the oscilloscope is in streaming mode. Essential for ETS operation.
Arguments	`handle`: the handle of the required oscilloscope. `times`: a pointer to a buffer for the sample times in `time_units`. Each time is the interval between the trigger event and the corresponding sample. Times before the trigger event are negative, and times after the trigger event are positive. `buffer_a, buffer_b`: pointers to buffers that receive data from the channels A and B. A pointer will not be used if the oscilloscope is not collecting data from that channel. If a pointer is NULL, nothing will be written to it. `buffer_c, buffer_d`: not used. `overflow`: a bit pattern indicating whether an overflow has occurred and, if so, on which channel. Bit 0 is the LSB. The bit assignments are as follows: Bit 0 - Ch A overflow Bit 1 - Ch B overflow `time_units`: can be one of the following: `PS2000_FS` (0), femtoseconds, `PS2000_PS` (1), picoseconds, `PS2000_NS` (2), nanoseconds [default] `PS2000_US` (3), microseconds, `PS2000_MS` (4), milliseconds, `PS2000_S` (5), seconds `no_of_values`: the number of data points to return. In streaming mode, this is the maximum number of values to return.
Returns	The actual number of data values per channel returned, which may be less than `no_of_values` if streaming. 0: if one or more of the parameters are out of range, or if the times will overflow with the `time_units` requested (use ps2000_get_timebase() to acquire the most suitable `time_units`), or if the oscilloscope is in streaming mode.

6.8 ps2000_get_unit_info

```
short ps2000_get_unit_info (
  short handle,
  char  *string,
  short string_length,
  short line
)
```

This function writes oscilloscope information to a character string. If the oscilloscope failed to open, only `line` types 0 and 6 are available to explain why the last open unit call failed.

Applicability	All modes
Arguments	`handle:` the handle of the oscilloscope from which information is required. If an invalid handle is passed, the error code from the last oscilloscope that failed to open is returned. `string:` a pointer to the character string buffer in the calling function where the function will write the oscilloscope information string selected with `line`. If string is `NULL,` no information will be written. `string_length:` the length of the character string buffer. If the string is not long enough to accept all of the information, only the first `string_length` characters are returned. `line:` a value selected from enumerated type `PS2000_INFO` (see table below) specifying what information is required from the driver.
Returns	The length of the string written to the `string` buffer. 0: if one of the parameters is out of range or string is NULL.

`PS2000_INFO` value	Example
`PS2000_DRIVER_VERSION (0),` the version number of the DLL used by the oscilloscope driver.	`"1, 0, 0, 2"`
`PS2000_USB_VERSION (1),` the type of USB connection that is being used to connect the oscilloscope to the computer.	`"1.1" or "2.0"`
`PS2000_HARDWARE_VERSION (2),` the hardware version of the attached oscilloscope.	`"1"`
`PS2000_VARIANT_INFO (3),` the variant of PicoScope 2000 PC Oscilloscope that is attached to the computer.	`"2203"`
`PS2000_BATCH_AND_SERIAL (4),` the batch and serial number of the oscilloscope.	`"CMY66/052"`
`PS2000_CAL_DATE (5),` the calibration date of the oscilloscope.	`"14Jan08"`
`PS2000_ERROR_CODE (6),` one of the Error codes.	`"4"`
`PS2000_KERNEL_DRIVER_VERSION (7),` the version number of the kernel driver.	`"1,1,2,4"`

6.9 ps2000_get_values

```
long ps2000_get_values (
  short handle
  short *buffer_a,
  short *buffer_b,
  short *buffer_c,
  short *buffer_d,
  short *overflow,
  long  no_of_values
)
```

This function is used to get values in compatible streaming mode after calling ps2000_run_streaming(), or in block mode after calling ps2000_run_block().

Applicability	Compatible streaming mode and block mode only. Does nothing if ETS triggering is enabled. Use ps2000_get_times_and_values() instead. Do not use in fast streaming mode. Use ps2000_get_streaming_last_values() instead.
Arguments	`handle:` the handle of the required oscilloscope. `buffer_a, buffer_b:` pointers to the buffers that receive data from the specified channels (A and B). A pointer is not used if the oscilloscope is not collecting data from that channel. If a pointer is NULL, nothing will be written to it. `buffer_c, buffer_d:` not used. `overflow:` on exit, contains a bit pattern indicating whether an overflow has occurred and, if so, on which channel. Bit 0 is the least significant bit. The bit assignments are as follows: Bit 0 - Ch A overflow Bit 1 - Ch B overflow `no_of_values:` the number of data points to return. In streaming mode, this is the maximum number of values to return.
Returns	The actual number of data values per channel returned, which may be less than `no_of_values` if streaming. 0: if one of the parameters is out of range or the oscilloscope is not in a suitable mode.

6.10 ps2000_last_button_press

```
short ps2000_last_button_press (
    short handle
)
```

This function returns the last registered state of the pushbutton on the PicoScope 2104 or 2105 PC Oscilloscope and then resets the status to zero.

Applicability	PicoScope 2104 and 2105 only
Arguments	`handle`: handle of the oscilloscope
Returns	0: no button press registered 1: short button press registered 2: long button press registered

6.11 ps2000_open_unit

```
short ps2000_open_unit (
  void
)
```

This function opens a PicoScope 2000 Series oscilloscope. The driver can support up to 64 oscilloscopes.

Applicability	All modes
Arguments	None
Returns	-1: if the oscilloscope fails to open. 0: if no oscilloscope is found. >0 (oscilloscope handle): if the oscilloscope opened. Use this as the handle argument for all subsequent API calls for this oscilloscope.

6.12 ps2000_open_unit_async

```
short ps2000_open_unit_async (
  void
)
```

This function opens a PicoScope 2000 Series oscilloscope without waiting for the operation to finish. You can find out when it has finished by periodically calling ps2000_open_unit_progress() until that function returns a non-zero value and a valid oscilloscope handle.

The driver can support up to 64 oscilloscopes.

Applicability	All modes
Arguments	None
Returns	0: if there is a previous open operation in progress. non-zero: if the call has successfully initiated an open operation.

6.13 ps2000_open_unit_progress

```
short ps2000_open_unit_progress (
  short *handle,
  short *progress_percent
)
```

This function checks on the progress of ps2000_open_unit_async().

Applicability	All modes. Use only with ps2000_open_unit_async().
Arguments	`handle:` a pointer to where the function should store the handle of the opened oscilloscope. `0` if no oscilloscope is found or the oscilloscope fails to open, handle of oscilloscope (valid only if function returns `1`) `progress_percent:` a pointer to an estimate of the progress towards opening the oscilloscope. The function will write a value from 0 to 100, where 100 implies that the operation is complete.
Returns	>0: if the driver successfully opens the oscilloscope 0: if opening still in progress -1: if the oscilloscope failed to open or was not found

6.14 ps2000_overview_buffer_status

```
short ps2000_overview_buffer_status (
  short handle,
  short *previous_buffer_overrun
)
```

This function indicates whether or not the overview buffers used by ps2000_run_streaming_ns() have overrun. If an overrun occurs, you can choose to increase the `overview_buffer_size` argument that you pass in the next call to ps2000_run_streaming_ns().

Applicability	Fast streaming mode only. PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Not compatible with ETS triggering - function has no effect in ETS mode.
Arguments	`handle:` the handle of the required oscilloscope. `previous_buffer_overrun:` a pointer to a Boolean indicating whether the overview buffers have overrun. The function will write a non-zero value to indicate a buffer overrun.
Returns	0: if the function was successful. 1: if the function failed due to an invalid handle.

6.15 ps2000_ready

```
short ps2000_ready (
  short handle
)
```

This function checks to see if the oscilloscope has finished the last data collection operation.

Applicability	Block mode only. Does nothing if the oscilloscope is in streaming mode.
Arguments	`handle`: the handle of the required oscilloscope.
Returns	>0: if ready. The oscilloscope has collected a complete block of data or the auto trigger timeout has been reached. 0: if not ready. An invalid handle was passed, or the oscilloscope is in streaming mode, or the oscilloscope is still collecting data in block mode. -1: if the oscilloscope is not attached. The USB transfer failed, indicating that the oscilloscope may well have been unplugged.

6.16 ps2000_run_block

```
short ps2000_run_block (
  short handle,
  long  no_of_samples,
  short timebase,
  short oversample,
  long  *time_indisposed_ms
)
```

This function tells the oscilloscope to start collecting data in block mode.

Applicability	Block mode only.
Arguments	`handle:` the oscilloscope of the required oscilloscope. `no_of_samples:` the number of samples to return. `timebase:` a code between 0 and the maximum timebase available (consult the driver header file). Timebase 0 gives the maximum sample rate available, timebase 1 selects a sample rate half as fast, timebase 2 is half as fast again and so on. For the maximum sample rate, see the specifications for your oscilloscope. The number of channels enabled may affect the availability of the fastest timebases. `oversample:` the oversampling factor, a number between 1 and 256. See Oversampling for details. `time_indisposed_ms:` a pointer to the approximate time, in milliseconds, that the ADC will take to collect data. If a trigger is set, it is the amount of time the ADC takes to collect a block of data after a trigger event, calculated as (sample interval) x (number of points required). The actual time may differ from computer to computer, depending on how quickly the computer can respond to I/O requests.
Returns	0: if one of the parameters is out of range. non-zero: if successful.

6.17 ps2000_run_streaming

```
short ps2000_run_streaming (
  short handle,
  short sample_interval_ms,
  long  max_samples,
  short windowed
)
```

This function tells the oscilloscope to start collecting data in compatible streaming mode. If this function is called when a trigger has been enabled, the trigger settings will be ignored.

For streaming with the PicoScope 2203, 2204, 2204A, 2205 and 2205A variants, use ps2000_run_streaming_ns() instead.

Applicability	PicoScope 2202, 2104 and 2105 only.
Arguments	`handle`: the handle of the required oscilloscope. `sample_interval_ms`: the time interval, in milliseconds, between data points. This can be no shorter than 1 ms. `max_samples`: the maximum number of samples that the driver is to store. This can be no greater than 60 000. It is the application's responsibility to retrieve data before the oldest values are overwritten. `windowed`: if this is `0`, only the values taken since the last call to ps2000_get_values() are returned. If this is `1`, the number of values requested by ps2000_get_values() are returned, even if they have already been read by ps2000_get_values().
Returns	non-zero: if streaming has been enabled correctly. `0`: if a problem occurred or a value was out of range.

6.18 ps2000_run_streaming_ns

```
short ps2000_run_streaming_ns (
  short                handle,
  unsigned long        sample_interval,
  PS2000_TIME_UNITS    time_units,
  unsigned long        max_samples,
  short                auto_stop,
  unsigned long        noOfSamplesPerAggregate,
  unsigned long        overview_buffer_size
)
```

This function tells the oscilloscope to start collecting data in fast streaming mode. It returns immediately without waiting for data to be captured. After calling it, you should next call ps2000_get_streaming_last_values() to copy the data to your application's buffer.

Applicability	PicoScope 2203, 2204, 2204A, 2205 and 2205A only.
Arguments	`handle`: the handle of the required oscilloscope. `sample_interval`: the time interval, in `time_units`, between data points. `time_units`: the units in which `sample_interval` is measured. `max_samples`: the maximum number of samples that the driver should store from each channel. Your computer must have enough physical memory for this many samples, multiplied by the number of channels in use, multiplied by the number of bytes per sample. `auto_stop`: a Boolean to indicate whether streaming should stop automatically when `max_samples` is reached. Set to any non-zero value for `TRUE`. `noOfSamplesPerAggregate`: the number of incoming samples that the driver will merge together (or aggregate: see aggregation) to create each value pair passed to the application. The value must be between 1 and `max_samples`. `overview_buffer_size`: the size of the overview buffers, temporary buffers used by the driver to store data before passing it to your application. You can check for overview buffer overruns using the ps2000_overview_buffer_status() function and adjust the overview buffer size if necessary. We recommend using an initial value of 15,000 samples.
Returns	non-zero: if streaming has been enabled correctly. 0: if a problem occurred or a value was out of range.

6.19 ps2000SetAdvTriggerChannelConditions

```
short ps2000SetAdvTriggerChannelConditions(
  short                      handle,
  PS2000_TRIGGER_CONDITIONS *conditions,
  short                      nConditions
)
```

This function sets up trigger conditions on the scope's inputs. The trigger is defined by a PS2000_TRIGGER_CONDITIONS structure.

Applicability	PicoScope 2202, 2204, 2204A, 2205 and 2205A only
Arguments	`handle:` the handle of the required oscilloscope. `conditions:` a pointer to a PS2000_TRIGGER_CONDITIONS structure specifying the conditions that should be applied to the current trigger channel. If NULL, triggering is switched off. `nConditions:` should be set to 1 if `conditions` is non-null, otherwise 0.
Returns	0: if unsuccessful, or if one or more of the arguments are out of range. non-zero: if successful.

6.19.1 PS2000_TRIGGER_CONDITIONS structure

A structure of this type is passed to ps2000SetAdvTriggerChannelConditions() in the `conditions` argument to specify the trigger conditions, and is defined as follows: -

```
typedef struct tPS2000TriggerConditions
{
  PS2000_TRIGGER_STATE channelA;
  PS2000_TRIGGER_STATE channelB;
  PS2000_TRIGGER_STATE channelC;
  PS2000_TRIGGER_STATE channelD;
  PS2000_TRIGGER_STATE external;
  PS2000_TRIGGER_STATE pulseWidthQualifier;
} PS2000_TRIGGER_CONDITIONS;
```

Applicability	See ps2000SetAdvTriggerChannelConditions().

Members	`channelA, channelB:` the type of condition that should be applied to each channel. Use these constants: -
	`CONDITION_DONT_CARE (0)`
	`CONDITION_TRUE (1)`
	`CONDITION_FALSE (2)`
	
	`channelC, channelD:` not used
	
	`external:` not used
	
	`pulseWidthQualifier:` the type of condition to apply to the pulse width qualifier. Choose from the same list of constants given under `channelA, channelB.`

Remarks

The channels that are set to `CONDITION_TRUE` or `CONDITION_FALSE` must all meet their conditions simultaneously to produce a trigger. Channels set to `CONDITION_DONT_CARE` are ignored.

The oscilloscope can use only a single input channel (either channel A or channel B) for the trigger source. Therefore you may define `CONDITION_TRUE` or `CONDITION_FALSE` for only one of these channels at a time. You can, optionally, set up the pulse width qualifier in combination with one of the input channels.

6.20 ps2000SetAdvTriggerChannelDirections

```
short ps2000SetAdvTriggerChannelDirections(
  short handle,
  PS2000_THRESHOLD_DIRECTION channelA,
  PS2000_THRESHOLD_DIRECTION channelB,
  PS2000_THRESHOLD_DIRECTION channelC,
  PS2000_THRESHOLD_DIRECTION channelD,
  PS2000_THRESHOLD_DIRECTION ext
)
```

This function sets the direction of the trigger for each channel.

Applicability	PicoScope 2202, 2204, 2204A, 2205 and 2205A only
Arguments	`handle:` the handle of the required oscilloscope `channelA, channelB:` specify the direction in which the signal must pass through the threshold to activate the trigger. The allowable values for a `PS2000_THRESHOLD_DIRECTION` variable are listed in the table below. `channelC, channelD:` not used `ext:` not used
Returns	0: if unsuccessful, or if one or more of the arguments are out of range. non-zero: if successful.

PS2000_THRESHOLD_DIRECTION constants

`ABOVE`	for gated triggers: above a threshold
`BELOW`	for gated triggers: below a threshold
`RISING`	for threshold triggers: rising edge
`FALLING`	for threshold triggers: falling edge
`RISING_OR_FALLING`	for threshold triggers: either edge
`INSIDE`	for window-qualified triggers: inside window
`OUTSIDE`	for window-qualified triggers: outside window
`ENTER`	for window triggers: entering the window
`EXIT`	for window triggers: leaving the window
`ENTER_OR_EXIT`	for window triggers: either entering or leaving the window
`NONE`	no trigger

6.21 ps2000SetAdvTriggerChannelProperties

```
short ps2000SetAdvTriggerChannelProperties(
  short                              handle,
  PS2000_TRIGGER_CHANNEL_PROPERTIES *channelProperties,
  short                              nChannelProperties,
  long                               autoTriggerMilliseconds
)
```

This function is used to enable or disable triggering and set its parameters.

Applicability	PicoScope 2202, 2204, 2204A, 2205 and 2205A only
Arguments	`handle:` the handle of the required oscilloscope. `channelProperties:` a pointer to a `PS2000_TRIGGER_CHANNEL_PROPERTIES` structure describing the requested properties. If NULL, triggering is switched off. `nChannelProperties:` should be set to 1 if `channelProperties` is non-null, otherwise 0. `autoTriggerMilliseconds:` the time in milliseconds for which the oscilloscope will wait before collecting data if no trigger event occurs. If this is set to zero, the oscilloscope will wait indefinitely for a trigger.
Returns	0: if unsuccessful, or if one or more of the arguments are out of range. non-zero: if successful.

6.21.1 PS2000_TRIGGER_CHANNEL_PROPERTIES structure

A structure of this type is passed to ps2000SetAdvTriggerChannelProperties() in the channelProperties argument to specify the trigger mechanism, and is defined as follows: -

```
typedef struct tPS2000TriggerChannelProperties
{
  short                 thresholdMajor;
  short                 thresholdMinor;
  unsigned short        hysteresis;
  short                 channel;
  PS2000_THRESHOLD_MODE thresholdMode;
} PS2000_TRIGGER_CHANNEL_PROPERTIES
```

Applicability	See ps2000SetAdvTriggerChannelProperties()

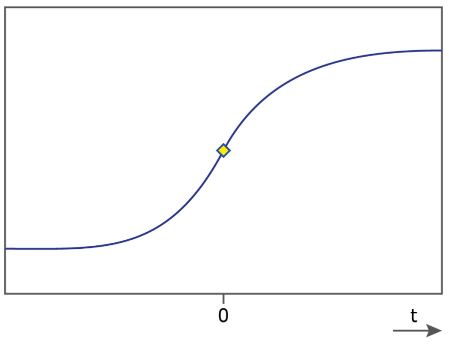
Members	`thresholdMajor`: the upper threshold at which the trigger event is to take place. This is scaled in 16-bit ADC counts at the currently selected range for that channel.
	
	`thresholdMinor`: the lower threshold at which the trigger event is to take place. This is scaled in 16-bit ADC counts at the currently selected range for that channel.
	
	`hysteresis`: the hysteresis that the trigger has to exceed before it will fire. It is scaled in 16-bit counts.
	
	`channel`: the channel to which the properties apply.
	
	`thresholdMode`: either a level or window trigger. Use one of these constants:
	`LEVEL (0)`
	`WINDOW (1)`

6.22 ps2000SetAdvTriggerDelay

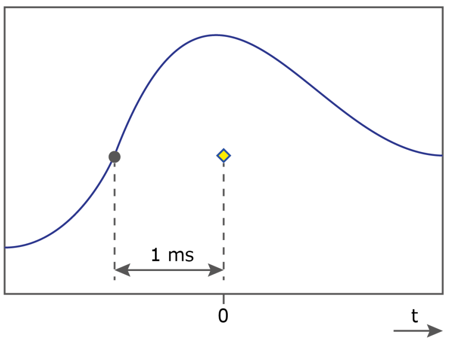
```
short ps2000SetAdvTriggerDelay(
  short         handle,
  unsigned long delay,
  float         preTriggerDelay
)
```

This function sets the pre-trigger and post-trigger delays. The default action, when both these delays are zero, is to start capturing data beginning with the trigger event and to stop a specified time later. The start of capture can be delayed by using a non-zero value of `delay`. Alternatively, the start of capture can be advanced to a time before the trigger event by using a negative value of `preTriggerDelay`. If both arguments are non-zero then their effects are added together.

Applicability	All modes. PicoScope 2202, 2204, 2204A, 2205 and 2205A only
Arguments	`handle`: the handle of the required oscilloscope. `delay`: the post-trigger delay, measured in sample periods. This is the time between the trigger event and the sample at time *t* = 0. For example, at a timebase of 50 MS/s, or 20 ns per sample, and with `delay = 100`, the post-trigger delay would be 100 × 20 ns = 2 µs. Range: [0, 2^{32}–1] `preTriggerDelay`: the location of the sample at time *t* = 0 within the data block, as a percentage of the data block length. 0% places *t* = 0 at the start of the block, –50% places it in the middle, and –100% places it at the end. Positive values can also be used to place *t* = 0 before the beginning of the data block, but the `delay` argument is more convenient for this purpose as it has a wider range. Range: [–100%, +100%]
Returns	0: if unsuccessful, or if one or more of the arguments are out of range. non-zero: if successful.



Example 1:
`delay` = 0,
`preTriggerDelay` = –50%



Example 2:
`delay` = 1 ms,
`preTriggerDelay` = –50%

6.23 ps2000_set_channel

```
short ps2000_set_channel (
  short handle,
  short channel,
  short enabled,
  short dc,
  short range
)
```

Specifies if a channel is to be enabled, the AC/DC coupling mode and the input range.

Note: The channels are not configured until capturing starts.

Applicability	All modes
Arguments	`handle`: the handle of the required oscilloscope. `channel`: an enumerated type specifying the channel. Use `PS2000_CHANNEL_A (0)` or `PS2000_CHANNEL_B (1)`. `enabled`: specifies if the channel is active: `TRUE` = active `FALSE` = inactive `dc`: specifies the AC/DC coupling mode: `TRUE`: DC coupling `FALSE`: AC coupling `range`: a code between 1 and 10. See the table below, but note that each oscilloscope variant supports only a subset of these ranges.
Returns	0: if unsuccessful, or if one or more of the arguments are out of range non-zero: if successful

Code	Enumeration	Range
1	`PS2000_20MV`	±20 mV
2	`PS2000_50MV`	±50 mV
3	`PS2000_100MV`	±100 mV
4	`PS2000_200MV`	±200 mV
5	`PS2000_500MV`	±500 mV
6	`PS2000_1V`	±1 V
7	`PS2000_2V`	±2 V
8	`PS2000_5V`	±5 V
9	`PS2000_10V`	±10 V
10	`PS2000_20V`	±20 V

6.24 ps2000_set_ets

```
long ps2000_set_ets (
  short handle,
  short mode,
  short ets_cycles,
  short ets_interleave

)
```

This function is used to enable or disable ETS (equivalent time sampling) and to set the ETS parameters.

Applicability	Not PicoScope 2202.
Arguments	`handle:` the handle of the required oscilloscope. `mode:` `PS2000_ETS_OFF (0)` - disables ETS `PS2000_ETS_FAST (1)` - enables ETS and provides `ets_cycles` cycles of data, which may contain data from previously returned cycles `PS2000_ETS_SLOW (2)` - enables ETS and provides fresh data every `ets_cycles` cycles. `PS2000_ETS_SLOW` takes longer to provide each data set, but the data sets are more stable and unique `ets_cycles:` the number of cycles to store. The computer can then select `ets_interleave` cycles to give the most uniform spread of samples. `ets_cycles` should be between two and five times the value of `ets_interleave`. `ets_interleave:` the number of ETS interleaves to use. If the sample time is 20 ns and the interleave 10, the approximate time per sample will be 2 ns.
Returns	The effective sample time in picoseconds, if ETS is enabled. 0: if ETS is disabled or one of the parameters is out of range.

6.25 ps2000_set_light

```
short ps2000_set_light (
    short handle,
    short state
)
```

This function controls the white light that illuminates the probe tip on a handheld oscilloscope.

Applicability	PicoScope 2104 and 2105 handheld oscilloscopes only.
Arguments	`handle:` handle of the oscilloscope `state:` `0`: light off 1: light on
Returns	0: the function failed, for example if a PicoScope 2000 Series oscilloscope was not found. non-zero: success.

6.26 ps2000_set_led

```
short ps2000_set_led (
    short handle,
    short state
)
```

This function turns the LED on the oscilloscope on and off, and controls its colour.

Applicability	PicoScope 2104 and 2105 handheld oscilloscopes only.
Arguments	`handle:` handle of the oscilloscope `state:` 3: off 1: red 2: green
Returns	0: the function failed, for example if a PicoScope 2000 Series oscilloscope was not found. non-zero: success.

6.27 ps2000SetPulseWidthQualifier

```
short ps2000SetPulseWidthQualifier(
  short                        handle,
  PS2000_PWQ_CONDITIONS        *conditions,
  short                        nConditions,
  PS2000_THRESHOLD_DIRECTION direction,
  unsigned long                lower,
  unsigned long                upper,
  PS2000_PULSE_WIDTH_TYPE      type
)
```

This function sets up pulse width qualification, which can be used on its own for pulse width triggering or combined with other triggering to produce more complex triggers. The pulse width qualifier is set by defining a `conditions` structure.

Applicability	All modes PicoScope 2202, 2204, 2204A, 2205 and 2205A only
Arguments	`handle`: the handle of the required oscilloscope. `conditions`: a pointer to a `PS2000_PWQ_CONDITIONS` structure specifying the conditions that should be applied to the trigger channel. If `conditions` is NULL then the pulse width qualifier is not used. `nConditions`: should be set to 1 if `conditions` is non-null, otherwise 0. `direction`: the direction of the signal required to trigger the pulse. `lower`: the lower limit of the pulse width counter. `upper`: the upper limit of the pulse width counter. This parameter is used only when the `type` is set to `PW_TYPE_IN_RANGE` or `PW_TYPE_OUT_OF_RANGE`. `type`: the pulse width type, one of these constants: `PW_TYPE_NONE` do not use the pulse width qualifier `PW_TYPE_LESS_THAN` pulse width less than lower `PW_TYPE_GREATER_THAN` pulse width greater than lower `PW_TYPE_IN_RANGE` pulse width between lower and upper `PW_TYPE_OUT_OF_RANGE` pulse width not between lower and upper
Returns	0: if unsuccessful, or if one or more of the arguments are out of range. non-zero: if successful.

6.27.1 PS2000_PWQ_CONDITIONS structure

A structure of this type is passed to ps2000SetPulseWidthQualifier() in the `conditions` argument to specify the pulse-width qualifier conditions, and is defined as follows: -

```
typedef struct tPS2000PwqConditions
{
  PS2000_TRIGGER_STATE channelA;
  PS2000_TRIGGER_STATE channelB;
  PS2000_TRIGGER_STATE channelC;
  PS2000_TRIGGER_STATE channelD;
  PS2000_TRIGGER_STATE external;
} PS2000_PWQ_CONDITIONS
```

Applicability	Pulse-width-qualified triggering

Members	`channelA, channelB:` the type of condition that should be applied to each channel. Choose from these constants:
	`CONDITION_DONT_CARE (0)`
	`CONDITION_TRUE (1)`
	`CONDITION_FALSE (2)`
	
	`channelC, channelD, external:` not used

6.28 ps2000_set_sig_gen_arbitrary

```
short ps2000_set_sig_gen_arbitrary (
  short              handle,
  long               offsetVoltage,
  unsigned long      pkToPk,
  unsigned long      startDeltaPhase,
  unsigned long      stopDeltaPhase,
  unsigned long      deltaPhaseIncrement,
  unsigned long      dwellCount,
  unsigned char      *arbitraryWaveform,
  long               arbitraryWaveformSize,
  PS2000_SWEEP_TYPE  sweepType,
  unsigned long      sweeps
)
```

This function programs the signal generator to produce an arbitrary waveform.

The arbitrary waveform generator uses direct digital synthesis (DDS). It maintains a 32-bit phase accumulator that indicates the present location in the waveform. The top bits of the phase accumulator are used as an index into a buffer containing the arbitrary waveform. The remaining bits act as the fractional part of the index, enabling high-resolution control of output frequency and allowing the generation of lower frequencies.

The generator steps through the waveform by adding a *deltaPhase* value between 1 and *phaseAccumulatorSize-1* to the phase accumulator every *ddsPeriod* (*1 / ddsFrequency*). If the *deltaPhase* is constant, the generator produces a waveform at a constant frequency that can be calculated as follows:

$$outputFrequency = ddsFrequency \times \left(\frac{deltaPhase}{phaseAccumulatorSize}\right) \times \left(\frac{awgBufferSize}{arbitraryWaveformSize}\right)$$

where:

outputFrequency	= repetition rate of the complete arbitrary waveform
ddsFrequency	= clock rate of phase accumulator (not the same as the DAC update rate)
deltaPhase	= user-specified delta phase value
phaseAccumulatorSize	= 2^{32} for all models
awgBufferSize	= AWG buffer size
arbitraryWaveformSize	= length in samples of the user-defined waveform

Parameter	Value
phaseAccumulatorSize	2^{32}
awgBufferSize	4096
ddsFrequency	48 MHz
ddsPeriod (= 1/*ddsFrequency*)	20.833 ns (= 1/48 MHz)

It is also possible to sweep the frequency by continually modifying the *deltaPhase.* This is done by setting up a `deltaPhaseIncrement` that the oscilloscope adds to the *deltaPhase* at intervals specified by `dwellCount`.

Applicability	All modes. PicoScope 2203, 2204, 2204A, 2205 and 2205A only.
Arguments	

`handle:` the handle of the required oscilloscope
 	
`offsetVoltage:` the voltage offset, in microvolts, to be applied to the waveform
 	
`pkToPk:` the peak-to-peak voltage, in microvolts, of the waveform signal
 	
`startDeltaPhase:` the initial value added to the phase counter as the generator begins to step through the waveform buffer
 	
`stopDeltaPhase:` the final value added to the phase counter before the generator restarts or reverses the sweep
 	
`deltaPhaseIncrement:` the amount added to the delta phase value every time the `dwellCount` period expires. This determines the amount by which the generator sweeps the output frequency in each dwell period.
 	
`dwellCount:` the time, in multiples of *ddsPeriod*, between successive additions of `deltaPhaseIncrement` to the delta phase counter. This determines the rate at which the generator sweeps the output frequency.
 	
`arbitraryWaveform:` a pointer to a buffer that holds the waveform pattern as a set of samples equally spaced in time.
 	
`arbitraryWaveformSize:` the size of the arbitrary waveform buffer.
 	
`sweepType:` determines whether the `startDeltaPhase` is swept up to the `stopDeltaPhase,` or down to it, or repeatedly swept up and down. Use one of the following values:
`UP`
`DOWN`
`UPDOWN`
`DOWNUP`
 	
`sweeps:` the number of times to sweep the frequency after a trigger event, according to `sweepType`.	

Returns	0: if one of the parameters is out of range. non-zero: if successful.

6.29 ps2000_set_sig_gen_built_in

```
short ps2000_set_sig_gen_built_in (
  short              handle,
  long               offsetVoltage,
  unsigned long      pkToPk,
  PS2000_WAVE_TYPE   waveType,
  float              startFrequency,
  float              stopFrequency,
  float              increment,
  float              dwellTime,
  PS2000_SWEEP_TYPE  sweepType,
  unsigned long      sweeps
)
```

This function sets up the signal generator to produce a signal from a list of built-in waveforms. If different start and stop frequencies are specified, the oscilloscope will sweep either up, down or up and down.

Applicability	PicoScope 2203, 2204, 2204A, 2205 and 2205A only.
Arguments	

`handle:` the handle of the required oscilloscope
 	
`offsetVoltage:` the voltage offset, in microvolts, to be applied to the waveform
 	
`pkToPk:` the peak-to-peak voltage, in microvolts, of the waveform signal
 	
`waveType:` the type of waveform to be generated by the oscilloscope. See the table below.
 	
`startFrequency:` the frequency at which the signal generator should begin. For allowable values see `ps2000.h`.
 	
`stopFrequency:` the frequency at which the sweep should reverse direction or return to the start frequency
 	
`increment:` the amount by which the frequency rises or falls every `dwellTime` seconds in sweep mode
 	
`dwellTime:` the time in seconds between frequency changes in sweep mode
 	
`sweepType:` specifies whether the frequency should sweep from `startFrequency` to `stopFrequency,` or in the opposite direction, or repeatedly reverse direction. Use one of these values of the enumerated type `enPS2000SweepType:`
`PS2000_UP`
`PS2000_DOWN`
`PS2000_UPDOWN`
`PS2000_DOWNUP`
 	
`sweeps:` the number of times to sweep the frequency	

Returns	0: if one of the parameters is out of range. non-zero: if successful.

`waveType` values

`PS2000_SINE`	sine wave
`PS2000_SQUARE`	square wave
`PS2000_TRIANGLE`	triangle wave
`PS2000_RAMP_UP`	rising sawtooth
`PS2000_RAMP_DOWN`	falling sawtooth
`PS2000_DC_VOLTAGE`	DC voltage

6.30 ps2000_set_trigger

```
short ps2000_set_trigger (
  short handle,
  short source,
  short threshold,
  short direction,
  short delay,
  short auto_trigger_ms
)
```

This function is used to enable or disable basic triggering and its parameters.

For oscilloscopes that support advanced triggering, see ps2000SetAdvTriggerChannelConditions(), ps2000SetAdvTriggerDelay() and related functions.

Applicability	Triggering is available in block mode and fast streaming mode.
Arguments	`handle`, the handle of the required oscilloscope. `source`, where to look for a trigger. Use `PS2000_CHANNEL_A (0)`, `PS2000_CHANNEL_B (1)` or `PS2000_NONE(5)`. The number of channels available depends on the oscilloscope. `threshold`, the threshold for the trigger event. This is scaled in 16-bit ADC counts at the currently selected range. `direction`, use `PS2000_RISING (0)` or `PS2000_FALLING (1)`. `delay`, the delay, as a percentage of the requested number of data points, between the trigger event and the start of the block. It should be in the range -100% to +100%. Thus, 0% means that the trigger event is at the first data value in the block, and -50% means that it is in the middle of the block. If you wish to specify the delay as a floating-point value, use ps2000_set_trigger2() instead. `auto_trigger_ms`, the delay in milliseconds after which the oscilloscope will collect samples if no trigger event occurs. If this is set to zero the oscilloscope will wait for a trigger indefinitely.
Returns	0: if one of the parameters is out of range. non-zero: if successful.

6.31 ps2000_set_trigger2

```
short ps2000_set_trigger2 (
  short handle,
  short source,
  short threshold,
  short direction,
  float delay,
  short auto_trigger_ms
)
```

This function is used to enable or disable triggering and its parameters. It has the same behaviour as ps2000_set_trigger(), except that the `delay` parameter is a floating-point value.

For oscilloscopes that support advanced triggering, see ps2000SetAdvTriggerChannelConditions() and related functions.

Applicability	Triggering is available in block mode and fast streaming mode only.
Arguments	`handle`, the handle of the required oscilloscope. `source`, specifies where to look for a trigger. Use `PS2000_CHANNEL_A (0)`, `PS2000_CHANNEL_B (1)` or `PS2000_NONE (5)`. `threshold`, the threshold for the trigger event. This is scaled in 16-bit ADC counts at the currently selected range. `direction`, use `PS2000_RISING (0)` or `PS2000_FALLING (1)`. `delay`, specifies the delay, as a percentage of the requested number of data points, between the trigger event and the start of the block. It should be in the range -100% to +100%. Thus, 0% means that the trigger event is at the first data value in the block, and -50% means that it is in the middle of the block. If you wish to specify the delay as an integer, use ps2000_set_trigger() instead. `auto_trigger_ms`, the delay in milliseconds after which the oscilloscope will collect samples if no trigger event occurs. If this is set to zero the oscilloscope will wait for a trigger indefinitely.
Returns	0: if one of the parameters is out of range. non-zero: if successful.

6.32 ps2000_stop

```
short ps2000_stop (
  short handle
)
```

Call this function to stop the oscilloscope sampling data. If this function is called before a trigger event occurs, the oscilloscope may not contain valid data.

Applicability	All modes.
Arguments	`handle,` the handle of the required oscilloscope.
Returns	0: if an invalid handle is passed. non-zero: if successful.

6.33 my_get_overview_buffers

```
void my_get_overview_buffers (
  short         **overviewBuffers,
  short         overflow,
  unsigned long triggeredAt,
  short         triggered,
  short         auto_stop,
  unsigned long nValues
)
```

This is the callback function in your application that receives data from the driver in fast streaming mode. You pass a pointer to this function to ps2000_get_streaming_last_values(), which then calls it back when the data is ready. Your callback function should do nothing more than copy the data to another buffer within your application. To maintain the best application performance, the function should return as quickly as possible without attempting to process or display the data.

The function name `my_get_overview_buffers()` is arbitrary. When you write this function, you can give it any name you wish. The PicoScope driver does not need to know your function's name, as it refers to it only by the pointer that you pass to ps2000_get_streaming_last_values().

For an example of a suitable callback function, see the C sample code included in the PicoScope 2000 Series SDK.

Applicability	Fast streaming mode only. PicoScope 2203, 2204, 2204A, 2205 and 2205A only. Not compatible with ETS triggering - has no effect in ETS mode.
Arguments	`overviewBuffers`, a pointer to a location where ps2000_get_streaming_last_values() will store a pointer to its overview buffers that contain the sampled data. The driver creates the overview buffers when you call ps2000_run_streaming_ns() to start fast streaming. `overviewBuffers` is a two dimensional array containing an array of length `nValues` for each channel (`overviewBuffers[4][nValues]`). Disabled channels return a null pointer resulting in four overview pointers whether all channels are enabled or not. `overviewBuffer [0]` ch_a_max `overviewBuffer [1]` ch_a_min `overviewBuffer [2]` ch_b_max `overviewBuffer [3]` ch_b_min `overflow`, a bit field that indicates whether there has been a voltage overflow and, if so, on which channel. The bit assignments are as follows: Bit 0 - Ch A overflow Bit 1 - Ch B overflow `triggeredAt`, an index into the overview buffers, indicating the sample at the trigger event. Valid only when triggered is `TRUE`. `triggered`, a Boolean indicating whether a trigger event has occurred and `triggeredAt` is valid. Any non-zero value signifies `TRUE`. `auto_stop`, a Boolean indicating whether streaming data capture has automatically stopped. Any non-zero value signifies `TRUE`. `nValues`, the number of values in each overview buffer.
Returns	nothing

7 Programming examples

7.1 C

There are two C example programs: a simple GUI application, and a more comprehensive console mode program that demonstrates all of the facilities of the driver.

GUI example

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

```
ps2000.c
resource.h
```

and

`ps2000.lib` (Microsoft Visual C 32-bit applications)

The following files must be in the compilation directory:

```
ps2000.rch
ps2000.h
```

and the following file must be in the same directory as the executable.

```
ps2000.dll
```

Console example

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

```
ps2000con.c
```

and

`ps2000.lib` (Microsoft Visual C 32-bit applications).

The following files must be in the compilation directory:

```
ps2000.h
```

and the following file must be in the same directory as the executable.

```
ps2000.dll
```

7.2 Visual Basic

The `Examples` subdirectory contains the following files:

`ps2000.vbp` - project file
`ps2000.bas` - procedure prototypes
`ps2000.frm` - form and program

The project was created using Microsoft Visual Basic 6.0.

Return values

The functions that return a TRUE/FALSE value return 0 for FALSE and 1 for TRUE, whereas Visual Basic expects 65535 for TRUE. To avoid this problem, check for `> 0` rather than `= TRUE`.

7.3 Delphi

The program `ps2000.dpr` demonstrates how to operate PicoScope 2000 Series PC Oscilloscopes. The file `ps2000.inc` contains procedure prototypes that you can include in your own programs. Other required files include:

```
ps2000.res
ps2000fm.dfm
ps2000fm.pas
```

This has been tested with Delphi version 3.

7.4 Excel

1. Load the spreadsheet `ps2000.xls`
2. Select Tools | Macro
3. Select GetData
4. Select Run

Note: the Excel Macro language is similar to Visual Basic. The functions which return a TRUE/FALSE value, return 0 for FALSE and 1 for TRUE, whereas Visual Basic expects 65 535 for TRUE. Check for `> 0` rather than `= TRUE`.

7.5 LabVIEW

The `ps2000.vi` example in the `Examples` subdirectory shows how to access the driver functions using LabVIEW. It was tested using version 6.1 of LabVIEW for Windows. To use the example, copy these files to your LabVIEW directory:

- `ps2000.vi`
- `open_unit.vi`
- `set_channel.vi`
- `setup_data_collection.vi`

You will also need

- `ps2000.dll`

from the installation directory.

8 Driver error codes

Code	Name	Description
0	PS2000_OK	The oscilloscope is functioning correctly.
1	PS2000_MAX_UNITS_OPENED	Attempts have been made to open more than PS2000_MAX_UNITS oscilloscopes.
2	PS2000_MEM_FAIL	Not enough memory could be allocated on the host machine.
3	PS2000_NOT_FOUND	An oscilloscope could not be found.
4	PS2000_FW_FAIL	Unable to download firmware.
5	PS2000_NOT_RESPONDING	The oscilloscope is not responding to commands from the PC.
6	PS2000_CONFIG_FAIL	The configuration information in the oscilloscope has become corrupt or is missing.
7	PS2000_OS_NOT_SUPPORTED	The operating system is not supported by this driver.

9 Glossary

Aggregation. In fast streaming mode, the PicoScope 2000 driver can use a method called aggregation to reduce the amount of data your application needs to process. This means that for every block of consecutive samples, it stores only the minimum and maximum values. You can set the number of samples in each block, called the aggregation parameter, when you call ps2000_run_streaming_ns() for real-time capture, and when you call ps2000_get_streaming_values() to obtain post-processed data.

Analog bandwidth. The input frequency at which the signal amplitude has fallen by 3 dB, or by half the power, from its nominal value.

Block mode. A sampling mode in which the computer prompts the oscilloscope to collect a block of data into its internal memory before stopping the oscilloscope and transferring the whole block into computer memory. This is the best mode to use when the input signal being sampled contains high frequencies. To avoid aliasing effects, the sampling rate must be greater than twice the maximum frequency in the input signal.

Buffer size. The size of the oscilloscope's buffer memory. The oscilloscope uses this to store data temporarily so that it can sample data independently of the speed at which it can transfer data to the computer.

Coupling mode. This mode selects either AC or DC coupling in the oscilloscope's input path. Use AC mode for small signals that may be superimposed on a DC level. Use DC mode for measuring absolute voltage levels. Set the coupling mode using ps2000_set_channel().

Driver. A piece of software that controls a hardware device. The driver for the PicoScope 2000 Series PC Oscilloscopes is supplied in the form of a 32-bit Windows DLL, which contains functions that you can call from your application.

ETS. Equivalent time sampling. Some PicoScope 2000 Series oscilloscopes can collect data over a number of cycles of a repetitive waveform to give a higher effective sampling rate than is possible for a single cycle. Equivalent time sampling allows the oscilloscope to use faster timebases than those available in real-time mode.

Maximum sampling rate. A figure indicating the maximum number of samples the oscilloscope is capable of acquiring per second. Maximum sample rates are usually given in MS/s (megasamples per second) or GS/s (gigasamples per second). The higher the sampling speed of the oscilloscope, the more accurate the representation of the high-frequency details in a fast signal.

Oversampling. A method of increasing the effective resolution of a measurement by sampling faster than the required sampling rate, then averaging the extra samples. An oversampling factor of four increases the effective resolution by one bit, but this increased resolution comes at the expense of reducing the maximum sampling rate by the same factor.

Overview buffer. A buffer in the PC's memory in which the PicoScope 2000 Series driver temporarily stores data on its way from the oscilloscope to the application's buffer.

PC Oscilloscope. A virtual instrument consisting of a PicoScope PC Oscilloscope and a software application.

PicoScope 2000 Series. A range of low-cost PC Oscilloscopes that includes the PicoScope 2202, 2203, 2204 and 2205 two-channel oscilloscopes and the PicoScope 2104 and 2105 handheld oscilloscopes.

PicoScope software. This is an application that accompanies all our PC Oscilloscopes. Although you do not need it if you are writing your own application, you should install it anyway, because it includes the drivers that you will need to control the oscilloscope.

Real-time continuous mode. A sampling mode in which the software repeatedly requests single samples from the oscilloscope. This mode is suitable for low sampling rates when you require the latest sample to be displayed as soon as it is captured.

Streaming mode. A sampling mode in which the oscilloscope samples data and returns it to the computer in an unbroken stream. This mode of operation is suitable when the input signal being sampled contains only low frequencies.

Timebase. A number that is supplied to the driver to specify a sampling rate for the oscilloscope. Each oscilloscope model has a different range of possible sampling frequencies, as specified in the User's Guide for that model.

USB 1.1—An early version of the Universal Serial Bus standard found on older PCs. Although your PicoScope will work with a USB 1.1 port, it will operate much more slowly than with a USB 2.0 or 3.0 port.

USB 2.0—Universal Serial Bus (High Speed). A standard port used to connect external devices to PCs. The high-speed data connection provided by a USB 2.0 port enables your PicoScope to achieve its maximum performance.

USB 3.0—A faster version of the Universal Serial Bus standard. Your PicoScope is fully compatible with USB 3.0 ports and will operate with the same performance as on a USB 2.0 port.

Vertical resolution. A value, in bits, that indicates the number of input voltage levels that the oscilloscope can distinguish. Calculation techniques can improve the effective resolution.

Voltage range. The range of input voltages that the oscilloscope will measure in a given mode.

Windows Device Manager. Windows Device Manager is a component of Microsoft Windows that displays the current hardware configuration of your computer. On Windows XP or Vista, right-click My Computer, choose Properties, click the Hardware tab and then the Device Manager button.

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