PicoScope® 2000 Series (A API)

PC Oscilloscopes and MSOs

Programmer's Guide

ps2000apg.en r10

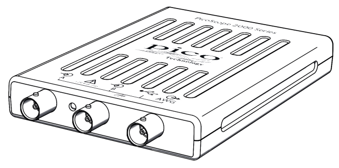
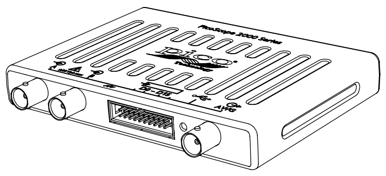
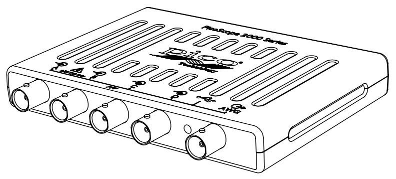
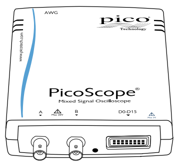
Contents

1 Introduction

1.1 Overview

The **PicoScope 2000 Series PC Oscilloscopes** from Pico Technology are high-speed real-time measuring instruments. They obtain their power from the USB port, so they do not need an additional power supply. With an arbitrary waveform generator these scopes contain everything you need in a convenient, portable unit.

This manual explains how to develop your own programs for collecting and analyzing data from the PicoScope 2000 Series oscilloscopes. It applies to all devices supported by the ps2000a application programming interface (API), as listed below:

2-channel	2-channel MSO	4-channel
		
PicoScope 2206 PicoScope 2206A PicoScope 2206B PicoScope 2207 PicoScope 2207A PicoScope 2207B PicoScope 2208 PicoScope 2208A PicoScope 2208B	PicoScope 2205A MSO PicoScope 2206B MSO PicoScope 2207B MSO PicoScope 2208B MSO	PicoScope 2405A PicoScope 2406B PicoScope 2407B PicoScope 2408B
	 PicoScope 2205 MSO	

The Pico Software Development Kit (SDK) is available free of charge from www.picotech.com/downloads. This download includes support for all PicoScope oscilloscopes including the ps2000a API described in this manual, as well as the original ps2000 API for older oscilloscopes in the PicoScope 2000 Series.

SDK version: 10.6.10

1.2 PC requirements

To ensure that your **PicoScope 2000 Series PC Oscilloscope** operates correctly with the SDK, 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.

Item	Specification
Operating system	Windows XP (SP3) or later (not Windows RT) 32-bit and 64-bit
Processor	As required by Windows
Memory	
Free disk space	
Ports*	USB 2.0 or USB 3.0 port USB 1.1 port (absolute minimum)

* PicoScope oscilloscopes will operate slowly on a USB 1.1 port. Not recommended.
USB 3.0 connections will run at about the same speed as USB 2.0.

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2 Concepts

2.1 Driver

Your application will communicate with a PicoScope 2000 (A API) driver called `ps2000a.dll`, which is supplied in 32-bit and 64-bit versions. The driver exports the `ps2000a` function definitions in standard C format, but this does not limit you to programming in C. You can use the API with any programming language that supports standard C calls.

The API driver depends on another DLL, `picoipp.dll` (which is supplied in 32-bit and 64-bit versions) and a low-level driver called `WinUsb.sys`. These are installed by the SDK and configured when you plug the oscilloscope into each USB port for the first time. Your application does not call these drivers directly.

2.2 System requirements

General requirements
See PC requirements.

USB
The `ps2000a` driver offers four different sampling modes (methods of recording data) all of which support USB 1.1, USB 2.0 and USB 3.0. The fastest transfer rates are achieved using USB 2.0 or USB 3.0.

Note: USB 3.0 connections will run at about the same speed as USB 2.0.

2.3 General procedure

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

1. Open the scope unit.
2. Set up the input channels with the required voltage ranges and coupling type.
3. Set up triggering.
4. Start capturing data. (See Sampling modes, where programming is discussed in more detail.)
5. Wait until the scope unit is ready.
6. Stop capturing data.
7. Copy data to a buffer.
8. Close the scope unit.

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

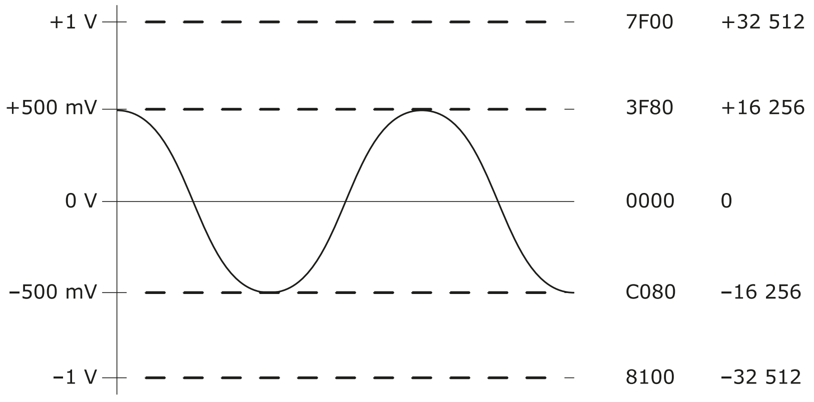
2.4 Voltage ranges

Analog input channels
You can set a device input channel to any voltage range from ±20 mV to ±20 V (subject to the device specification) with ps2000aSetChannel. Each sample is scaled to 16 bits, and the minimum and maximum values returned to your application are given by ps2000aMinimumValue and ps2000aMaximumValue as follows:

Function	Voltage	Value returned	
		decimal	hex
ps2000aMaximumValue	maximum	32 512	7F00
	zero	0	0000
ps2000aMinimumValue	minimum	−32 512	8100

Example

1. Call ps2000aSetChannel with range set to PS2000A_1V.
2. Apply a sine wave input of 500 mV amplitude to the oscilloscope.
3. Capture some data using the desired sampling mode.
4. The data will be encoded as shown opposite.



External trigger input (PicoScope 2206, 2207 and 2208 only)
The external trigger input (marked EXT), where available, is scaled to a 16-bit value as follows:

Voltage	Constant	Digital value
−5 V	PS2000A_EXT_MIN_VALUE	−32 767
0 V		0
+5 V	PS2000A_EXT_MAX_VALUE	+32 767

2.5 MSO digital data

This section applies to mixed-signal oscilloscopes (MSOs) only

A PicoScope MSO has two 8-bit digital ports—PORT0 and PORT1—making a total of 16 digital channels.

The data from each port is returned in a separate buffer that is set up by the ps2000aSetDataBuffer and ps2000aSetDataBuffers functions. For compatibility with the analog channels, each buffer is an array of 16-bit words. The 8-bit port data occupies the lower 8 bits of the word, and the upper 8 bits of the word are undefined.

	PORT1 buffer	PORT0 buffer
Sample$_0$	[XXXXXXXX,D15...D8]$_0$	[XXXXXXXX,D7...D0]$_0$
...	...	...
Sample$_{n-1}$	[XXXXXXXX,D15...D8]$_{n-1}$	[XXXXXXXX,D7...D0]$_{n-1}$

Retrieving stored digital data
The following C code snippet shows how to combine data from the two 8-bit ports into a single 16-bit word and then extract individual bits from the 16-bit word.

```
 // Mask Port 1 values to get lower 8 bits
 portValue = 0x00ff & appDigiBuffers[2][i];

 // Shift by 8 bits to place in upper 8 bits of 16-bit word
 portValue <<= 8;

 // Mask Port 0 values to get lower 8 bits and apply bitwise
 // inclusive OR to combine with Port 1 values
 portValue |= 0x00ff & appDigiBuffers[0][i];

 for (bit = 0; bit < 16; bit++)
 {
  // Shift value (32768 - binary 1000 0000 0000 0000),
  // AND with value to get 1 or 0 for channel.
  // Order will be D15 to D8, then D7 to D0.

  bitValue = (0x8000 >> bit) & portValue? 1 : 0;
}
```

2.6 Triggering

PicoScope oscilloscopes can either start collecting data immediately or be programmed to wait for a trigger event. In both cases you need to use the trigger functions:

- ps2000aSetTriggerChannelConditions
- ps2000aSetTriggerChannelDirections
- ps2000aSetTriggerChannelProperties

Alternatively you can call ps2000aSetSimpleTrigger, which in turn calls all three of the above functions and allows you to set up triggers more quickly in simple cases.

A trigger event can occur when one of the signal or trigger input channels crosses a threshold voltage on either a rising or a falling edge. It is also possible to combine two inputs using the logic trigger function.

To set up pulse width, delay and dropout triggers, you can also call the pulse width qualifier function:

- ps2000aSetPulseWidthQualifier

2.7 Sampling modes

PicoScope 2000 Series oscilloscopes can run in various **sampling modes**.

- **Block mode.** In this mode, the scope stores data in internal buffer memory and then transfers it to the PC. When the data has been collected it is possible to examine the data, with an optional downsampling factor. The data is lost when a new run is started in the same segment, the settings are changed, or the scope is powered down.
- **ETS mode.** In this mode, it is possible to increase the effective sampling rate of the scope when capturing repetitive signals. It is a modified form of block mode.
- **Rapid block mode.** This is a variant of block mode that allows you to capture more than one waveform at a time with a minimum of delay between captures. You can use downsampling in this mode if you wish.
- **Streaming mode.** In this mode, data is passed directly to the PC without being stored in the scope's internal buffer memory. This enables long periods of data collection for chart recorder and data-logging applications. Streaming mode supports downsampling and triggering, while providing fast streaming at typical rates of 1 to 10 MS/s, as specified in the data sheet for your device.

In all sampling modes, the driver returns data asynchronously using a callback. This is a call to one of the functions in your own application. When you request data from the scope, you pass to the driver a pointer to your callback function. When the driver has written the data to your buffer, it makes a callback (calls your function) to signal that the data is ready. The callback function then signals to the application that the data is available.

Because the callback is called asynchronously from the rest of your application, in a separate thread, you must ensure that it does not corrupt any global variables while it runs.

For compatibility with programming environments not supporting C-style callback functions, polling of the driver is available in block mode.

2.7.1 Block mode

In **block mode**, the computer prompts a PicoScope 2000 Series oscilloscope to collect a block of data into 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.

- **Block size.** The maximum number of values depends upon the size of the oscilloscope's memory. The memory buffer is shared between the enabled channels, so if two channels are enabled, each receives half the memory, and if four channels are enabled, each receives a quarter of the memory. These features are handled transparently by the driver. The block size also depends on the number of memory segments in use (see ps2000aMemorySegments).

  * The PicoScope MSO models behave differently. If only the two analog channels or only the two digital ports are enabled, each receives half the memory. If any combination of one or two analog channels and one or two digital ports is enabled, each receives a quarter of the memory.

- **Sampling rate.** A PicoScope 2000 Series oscilloscope can sample at a number of different rates according to the selected timebase and the combination of channels that are enabled. See the Timebases section for the specifications that apply to your scope model.
- **Setup time.** The driver normally performs a number of setup operations, which can take up to 50 milliseconds, before collecting each block of data. If you need to collect data with the minimum time interval between blocks, use rapid block mode and avoid calling setup functions between calls to ps2000aRunBlock, ps2000aStop and ps2000aGetValues.
- **Downsampling.** When the data has been collected, you can set an optional downsampling factor and examine the data. Downsampling is a process that reduces the amount of data by combining adjacent samples. It is useful for zooming in and out of the data without having to repeatedly transfer the entire contents of the scope's buffer to the PC.
- **Memory segmentation.** The scope's internal memory can be divided into segments so that you can capture several waveforms in succession. Configure this using ps2000aMemorySegments.
- **Data retention.** The data is lost when a new run is started in the same segment, the settings are changed, or the scope is powered down.

See Using block mode for programming details.

2.7.1.1 Using block mode

This is the general procedure for reading and displaying data in block mode using a single memory segment:

Note*: Use the * steps when using the digital ports on MSO models.*

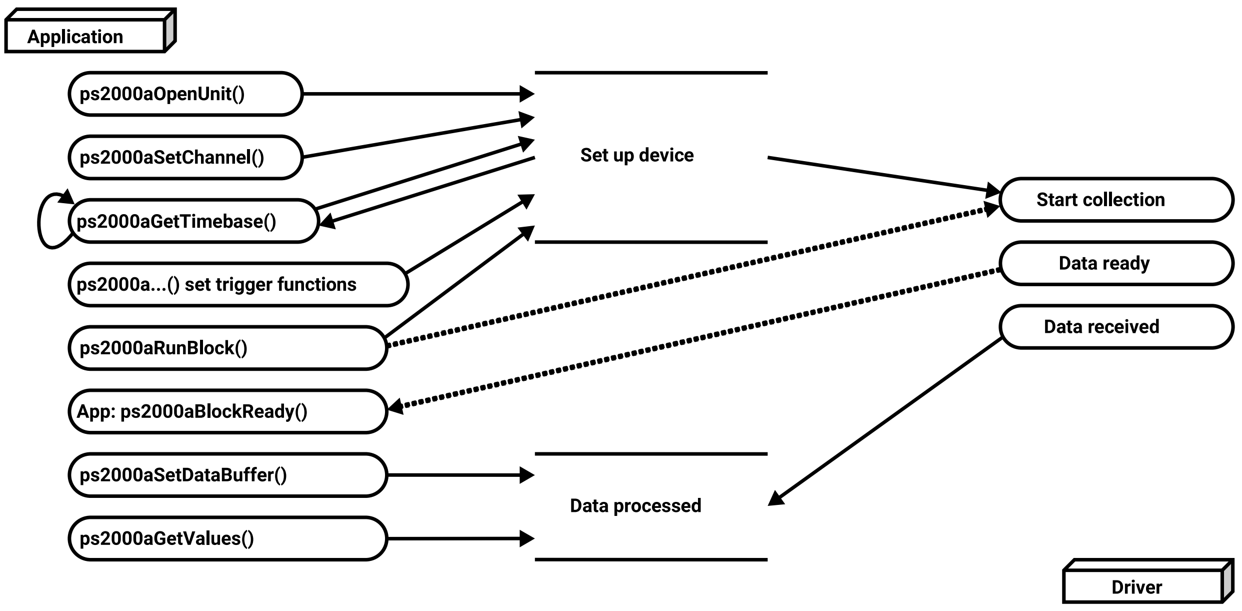
1. Open the oscilloscope using ps2000aOpenUnit.
2. Select channel ranges and AC/DC coupling using ps2000aSetChannel.

2*. Set the digital port using ps2000aSetDigitalPort.

3. Using ps2000aGetTimebase, select timebases until the required nanoseconds per sample is located.
4. Use the trigger setup functions ps2000aSetTriggerChannelConditions, ps2000aSetTriggerChannelDirections and ps2000aSetTriggerChannelProperties to set up the trigger if required.

4*. Use the trigger setup functions ps2000aSetTriggerDigitalPortProperties to set up the digital trigger if required.

5. Start the oscilloscope running using ps2000aRunBlock.
6. Wait until the oscilloscope is ready using the ps2000aBlockReady callback (or poll using ps2000aIsReady).
7. Use ps2000aSetDataBuffer to tell the driver where your memory buffer is. (For greater efficiency when doing multiple captures, you can call this function outside the loop, after step 4.)
8. Transfer the block of data from the oscilloscope using ps2000aGetValues.
9. Display the data.
10. Stop the oscilloscope using ps2000aStop.
11. Repeat steps 5 to 9.
12. Request new views of stored data using different downsampling parameters. See Retrieving stored data.
13. Call ps2000aCloseUnit.



2.7.1.2 Asynchronous calls in block mode

To avoid blocking the calling thread when calling ps2000aGetValues, it is possible to call ps2000aGetValuesAsync instead. This immediately returns control to the calling thread, which then has the option of waiting for the data or calling ps2000aStop to abort the operation.

2.7.2 Rapid block mode

In normal block mode, the PicoScope 2000 Series scopes collect one waveform at a time. You start the the device running, wait until all samples are collected by the device, and then download the data to the PC or start another run. There is a time overhead of tens of milliseconds associated with starting a run, causing a gap between waveforms. When you collect data from the device, there is another minimum time overhead which is most noticeable when using a small number of samples.

Rapid block mode allows you to sample several waveforms at a time with the minimum time between waveforms. It reduces the gap from milliseconds to less than 2 microseconds (on the fastest timebase). Each waveform is stored in a separate buffer segment.

2.7.2.1 Using rapid block mode

You can use rapid block mode with or without aggregation. With aggregation, you need to set up two buffers per channel to receive the minimum and maximum values.

Note*: Use the * steps when using the digital ports on the mixed-signal (MSO) models.*

Without aggregation

1. Open the oscilloscope using ps2000aOpenUnit.
2. Select channel ranges and AC/DC coupling using ps2000aSetChannel.
3. [MSOs only] Set the digital port using ps2000aSetDigitalPort.
4. Set the number of memory segments equal to or greater than the number of captures required using ps2000aMemorySegments. Use ps2000aSetNoOfCaptures before each run to specify the number of waveforms to capture.
5. Using ps2000aGetTimebase, select timebases from zero upwards until the required number of nanoseconds per sample is located.
6. Use the trigger setup functions ps2000aSetTriggerChannelConditions, ps2000aSetTriggerChannelDirections and ps2000aSetTriggerChannelProperties to set up the trigger if required.
7. [MSOs only] Use the trigger setup functions ps2000aSetTriggerDigitalPortProperties to set up the digital trigger if required.
8. Start the oscilloscope running using ps2000aRunBlock.
9. Wait until the oscilloscope is ready using the ps2000aIsReady or wait on the callback function.
10. Use ps2000aSetDataBuffer to tell the driver where your memory buffers are. Call the function once for each channel/segment combination for which you require data. For greater efficiency, these calls can be made outside the loop, between steps 7 and 8.
11. Transfer the blocks of data from the oscilloscope using ps2000aGetValuesBulk.
12. Retrieve the time offset for each data segment using ps2000aGetValuesTriggerTimeOffsetBulk64.
13. Display the data.
14. Repeat steps 8 to 13 if you wish to capture more data.
15. Stop the oscilloscope using ps2000aStop.
16. Call ps2000aCloseUnit.

With aggregation
To use rapid block mode with aggregation, follow steps 1 to 9 above and then:

10a. Call ps2000aSetDataBuffer or (ps2000aSetDataBuffers) to set up one pair of buffers for every waveform segment required.
11a. Call ps2000aGetValuesBulk for each pair of buffers.
12a. Retrieve the time offset for each data segment using ps2000aGetValuesTriggerTimeOffsetBulk64.

Continue from step 13.

2.7.2.2 Rapid block mode example 1: no aggregation

```
#define MAX_SAMPLES 1000
```

Set up the device up as usual.

- Open the device
- Channels
- Trigger
- Number of memory segments (this should be equal or more than the no of captures required)

```
// set the number of waveforms to 32
ps2000aSetNoOfCaptures (handle, 32);

pParameter = false;
ps2000aRunBlock
(
    handle,
    0,              // noOfPreTriggerSamples
    MAX_SAMPLES,  // noOfPostTriggerSamples
    1,              // timebase to be used
    1,
    &timeIndisposedMs,
    0,              // segment index
    lpReady,
    &pParameter
);
```

Comment: these variables have been set as an example and can be any valid value. pParameter will be set true by your callback function lpReady.

```
while (!pParameter) Sleep (0);

for (int i = 0; i < 10; i++)
{
    for (int c = PS2000A_CHANNEL_A; c <= PS2000A_CHANNEL_B; c++)
    {
        ps2000aSetDataBuffer
        (
            handle,
            c,
            &buffer[c][i],
            MAX_SAMPLES,
            i,
        PS2000A_RATIO_MODE_NONE
        );
    }
}
```

Comments: buffer has been created as a two-dimensional array of pointers to int16_t, which will contain 1000 samples as defined by MAX_SAMPLES. There are only 10 buffers set, but it is possible to set up to the number of captures you have requested.

```
ps2000aGetValuesBulk
(
    handle,
    &noOfSamples,          // set to MAX_SAMPLES on entering the function
    10,                    // fromSegmentIndex
    19,                    // toSegmentIndex
    1,                     // downsampling ratio
    PS2000A_RATIO_MODE_NONE, // downsampling ratio mode
    overflow               // an array of size 10 int16_t
)
```

Comments: See the earlier snippets for code to set up the segment buffers.

The number of samples could be up to noOfPreTriggerSamples + noOfPostTriggerSamples, the values set in ps2000aRunBlock. The samples are always returned from the first sample taken, unlike the ps2000aGetValues function which allows the sample index to be set. The above segments start at 10 and finish at 19 inclusive. It is possible for the fromSegmentIndex to wrap around to the toSegmentIndex, by setting the fromSegmentIndex to 28 and the toSegmentIndex to 7.

```
ps2000aGetValuesTriggerTimeOffsetBulk64
(
    handle,
    times,
    timeUnits,
    10,
    19
)
```

Comments: the above segments start at 10 and finish at 19 inclusive. It is possible for the fromSegmentIndex to wrap around to the toSegmentIndex, if the fromSegmentIndex is set to 28 and the toSegmentIndex to 7.

2.7.2.3 Rapid block mode example 2: using aggregation

```
#define MAX_SAMPLES 1000
```

Set up the device up as usual.

- Open the device
- Channels
- Trigger
- Number of memory segments (this should be equal or more than the number of captures required)

```
// set the number of waveforms to 32
ps2000aSetNoOfCaptures(handle, 32);

pParameter = false;
ps2000aRunBlock
(
    handle,
    0,              // noOfPreTriggerSamples,
    MAX_SAMPLES,    // noOfPostTriggerSamples,
    1,              // timebase to be used,
    1,
    &timeIndisposedMs,
    1,              // SegmentIndex
    lpReady,
    &pParameter
);
```

Comments: the set-up for running the device is exactly the same whether or not aggregation will be used when you retrieve the samples.

```
for (int segment = 10; segment < 20; segment++)
{
  for (int c = PS2000A_CHANNEL_A; c <= PS2000A_CHANNEL_D; c++)
  {
    ps2000aSetDataBuffers
      (
        handle,
        c,
        &bufferMax[c],
        &bufferMin[c]
        MAX_SAMPLES
        segment,
        PS2000A_RATIO_MODE_AGGREGATE
      );
  }
}
```

Comments: since only one waveform will be retrieved at a time, you only need to set up one pair of buffers; one for the maximum samples and one for the minimum samples. Again, the buffer sizes are 1000 (MAX_SAMPLES) samples.

```
ps2000aGetValues
```

```
(
  handle,
  0,
  &noOfSamples,        // set to MAX_SAMPLES on entering
  10,
  &downSampleRatioMode, //set to RATIO_MODE_AGGREGATE
  index,
  overflow
);

ps2000aGetTriggerTimeOffset64
(
  handle,
  &time,
  &timeUnits,
  index
)
```

Comments: each waveform is retrieved one at a time from the driver with an aggregation of 10.

2.7.3 ETS (Equivalent Time Sampling)

ETS is a way of increasing the effective sampling rate of the scope when capturing repetitive signals. It is a modified form of block mode, and is controlled by the ps2000a set of trigger functions and the ps2000aSetEts function.

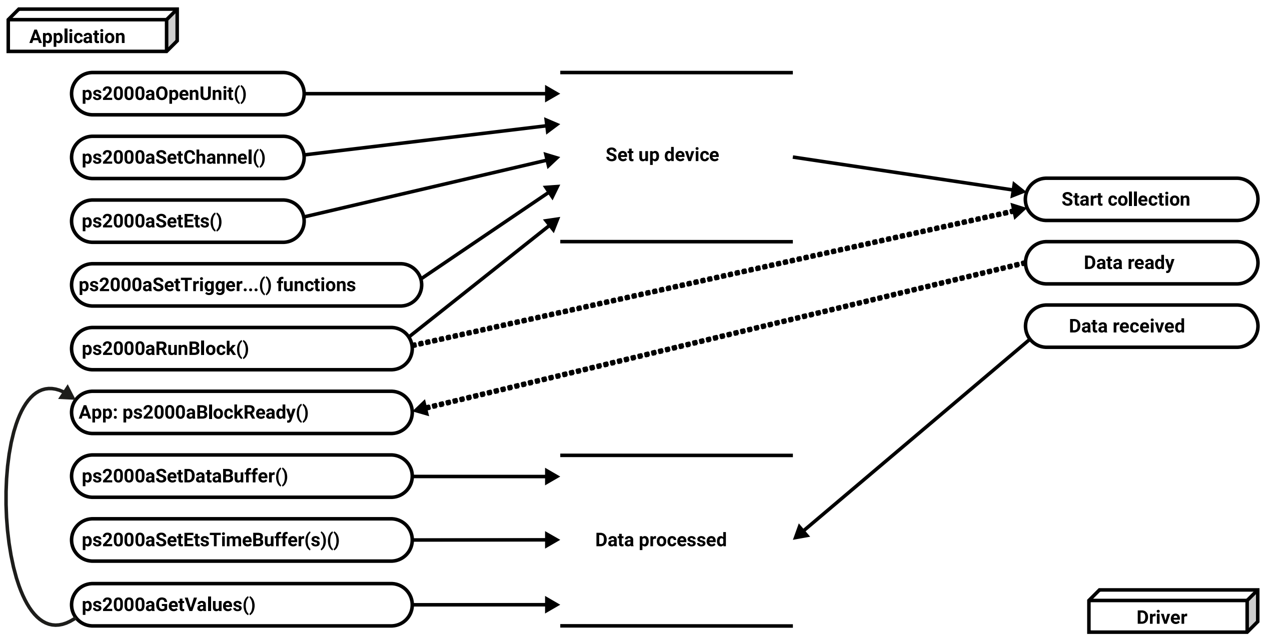
- **Overview.** ETS works by capturing several cycles of a repetitive waveform, then combining them to produce a composite waveform that has a higher effective sampling rate than the individual captures. The scope hardware accurately measures the delay, which is a small fraction of a single sampling interval, between each trigger event and the subsequent sample. The driver then shifts each capture slightly in time and overlays them so that the trigger points are exactly lined up. The result is a larger set of samples spaced by a small fraction of the original sampling interval. The maximum effective sampling rates that can be achieved with this method are listed in the User's Guide for the scope device. Other scopes do not contain special ETS hardware, so the composite waveform is created by software.
- **Trigger stability.** Because of the high sensitivity of ETS mode to small time differences, the trigger must be set up to provide a stable waveform that varies as little as possible from one capture to the next.
- **Callback.** ETS mode calls the ps2000aBlockReady callback function when a new waveform is ready for collection. The ps2000aGetValues function needs to be called for the waveform to be retrieved.

Applicability	Available in block mode only. Not suitable for one-shot (non-repetitive) signals. Aggregation is not supported. Edge-triggering only. Auto trigger delay (autoTriggerMilliseconds) is ignored. Cannot be used when MSO digital ports are enabled.

2.7.3.1 Using ETS mode

This is the general procedure for reading and displaying data in ETS mode using a single memory segment:

1. Open the oscilloscope using ps2000aOpenUnit.
2. Select channel ranges and AC/DC coupling using ps2000aSetChannel.
3. Use ps2000aSetEts to enable ETS and set the parameters.
4. Use the trigger setup functions ps2000aSetTriggerChannelConditions, ps2000aSetTriggerChannelDirections and ps2000aSetTriggerChannelProperties to set up the trigger if required.
5. Start the oscilloscope running using ps2000aRunBlock.
6. Wait until the oscilloscope is ready using the ps2000aBlockReady callback (or poll using ps2000aIsReady).
7. Use ps2000aSetDataBuffer to tell the driver where to store sampled data.
8. Use ps2000sSetEtsTimeBuffer or ps2000sSetEtsTimeBuffers to tell the driver where to store sample times.
9. Transfer the block of data from the oscilloscope using ps2000aGetValues.
10. Display the data.
11. While you want to collect updated captures, repeat steps 7 to 10.
12. Stop the oscilloscope using ps2000aStop.
13. Repeat steps 5 to 12.
14. Call ps2000aCloseUnit.



2.7.4 Streaming mode

Streaming mode, unlike block mode, can capture data without gaps between blocks. Streaming mode supports downsampling and triggering, while providing fast streaming. This makes it suitable for **high-speed data acquisition**, allowing you to capture long data sets limited only by the computer's memory.

- **Aggregation.** The driver returns aggregated readings while the device is streaming. If aggregation is set to 1, only one buffer is used per channel. When aggregation is set above 1, two buffers (maximum and minimum) per channel are used.

- **Memory segmentation.** The memory can be divided into segments to reduce the latency of data transfers to the PC. However, this increases the risk of losing data if the PC cannot keep up with the device's sampling rate.

See Using streaming mode for programming details.

2.7.4.1 Using streaming mode

This is the general procedure for reading and displaying data in streaming mode using a single memory segment:

***Note**: Please use the * steps when using the digital ports on the mixed-signal (MSO) models.*

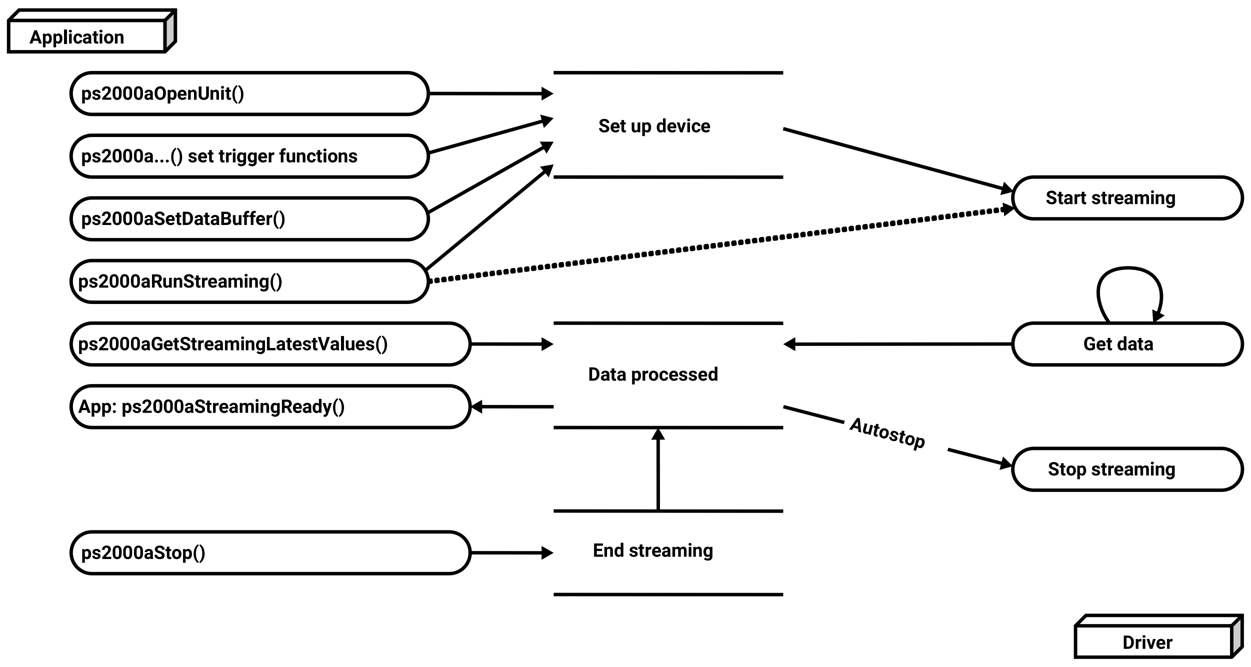
1. Open the oscilloscope using ps2000aOpenUnit.
2. Select channels, ranges and AC/DC coupling using ps2000aSetChannel.

*2. Set the digital port using ps2000aSetDigitalPort.

3. Use the trigger setup functions ps2000aSetTriggerChannelConditions, ps2000aSetTriggerChannelDirections and ps2000aSetTriggerChannelProperties to set up the trigger if required.

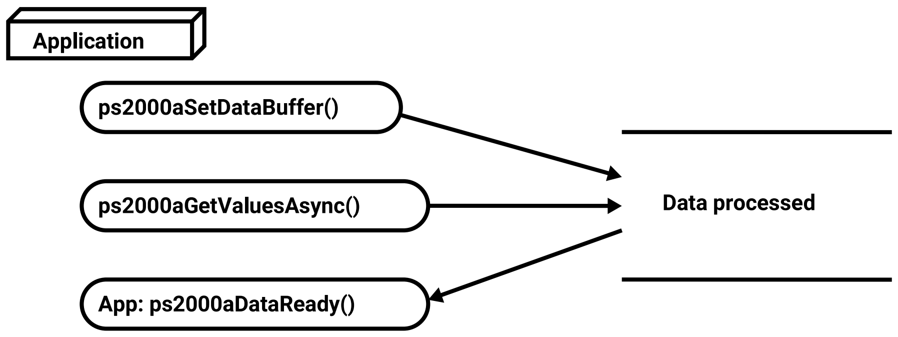
*3. Use the trigger setup functions ps2000aSetTriggerDigitalPortProperties to set up the digital trigger if required.

4. Call ps2000aSetDataBuffer (or ps2000aSetDataBuffers if you will be using aggregation) to tell the driver where your data buffer is.
5. Start the oscilloscope running using ps2000aRunStreaming.
6. Call ps2000aGetStreamingLatestValues to get data.
7. Process data returned to your application's function. This example is using autoStop, so after the driver has received all the data points requested by the application, it stops the device streaming.
8. Call ps2000aStop, even if autoStop is enabled.
9. Request new views of stored data using different downsampling parameters: see Retrieving stored data.
10. Call ps2000aCloseUnit.



2.7.5 Retrieving stored data

You can collect data from the ps2000a driver with a different downsampling factor when ps2000aRunBlock or ps2000aRunStreaming has already been called and has successfully captured all the data. Use ps2000aGetValuesAsync.



2.8 Timebases

The ps2000a API allows you to select any of 2^{32} different timebases based on the maximum sampling rate[†] of your oscilloscope. The timebases allow slow enough sampling in block mode to overlap the streaming sample intervals, so that you can make a smooth transition between block mode and streaming mode. Calculate the timebase using the ps2000aGetTimebase call.

500 MS/s maximum sampling rate models:

timebase (n)	sample interval formula	sample interval examples
0	2^n / 500,000,000	2 ns*
1		4 ns
2		8 ns
3 to $2^{32}-1$	(n – 2) / 62,500,000	3 => 16 ns ... $2^{32}-1$ => ~ 69 s

1 GS/s maximum sampling rate models:

timebase (n)	sample interval formula	sample interval examples
0	2^n / 1,000,000,000	1 ns*
1		2 ns
2		4 ns
3 to $2^{32}-1$	(n – 2) / 125,000,000	3 => 8 ns ... $2^{32}-1$ => ~ 34 s

PicoScope 2205 MSO:

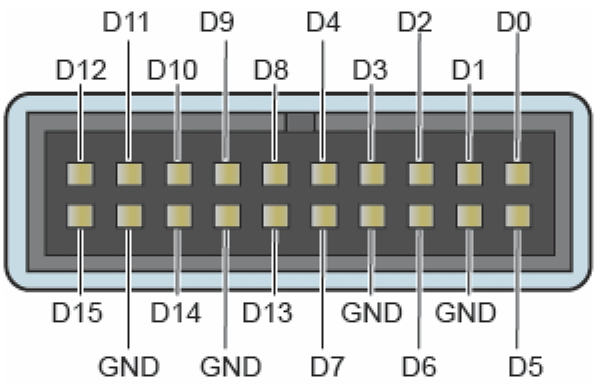
timebase (n)	sample interval formula	sample interval examples
0	2^n / 200,000,000	0 => 5 ns**
1	n / 100,000,000	10 ns
2		20 ns
3 to $2^{32}-1$		3 => 30 ns ... $2^{32}-1$ => ~ 43 s

† The fastest available sampling rate may depend on which channels are enabled, and on the sampling mode. Refer to the oscilloscope data sheet for sampling rate specifications. In streaming mode the sampling rate may additionally be limited by the speed of the USB port.
* Available only in single-channel mode.
** Not available when channel B active, nor when channel A and both digital ports active.

ETS mode
In ETS mode the sample time is not set according to the above tables but is instead calculated and returned by ps2000aSetEts.

2.9 MSO digital connector diagram

The MSO models have a digital input connector. The layout of the 20-pin header plug is detailed below. The diagram is drawn as you look at the front panel of the device.



2.10 Combining several oscilloscopes

It is possible to collect data using up to 64 PicoScope 2000 Series oscilloscopes at the same time, subject to the capabilities of the PC. Each oscilloscope must be connected to a separate USB port. The ps2000aOpenUnit function returns a handle to an oscilloscope. All the other functions require this handle for oscilloscope identification. For example, to collect data from two oscilloscopes at the same time:

```
CALLBACK ps2000aBlockReady(...)
// define callback function specific to application

handle1 = ps2000aOpenUnit()
handle2 = ps2000aOpenUnit()

ps2000aSetChannel(handle1)
// set up unit 1
ps2000aSetDigitalPort // only when using MSO
ps2000aRunBlock(handle1)

ps2000aSetChannel(handle2)
// set up unit 2
ps2000aSetDigitalPort // only when using MSO
ps2000aRunBlock(handle2)

// data will be stored in buffers
// and application will be notified using callback

ready = FALSE
while not ready
    ready = handle1_ready
    ready &= handle2_ready
```

3 API functions

The ps2000a API exports a number of functions for you to use in your own applications. All functions are C functions using the standard call naming convention (__stdcall). They are all exported with both decorated and undecorated names.

3.1 ps2000aBlockReady() - find out if block-mode data ready

```
typedef void (CALLBACK *ps2000aBlockReady)
(
    int16_t                         handle,
    PICO_STATUS                     status,
    void                            * pParameter
)
```

This callback function is part of your application. You register it with the ps2000a driver using ps2000aRunBlock, and the driver calls it back when block-mode data is ready. You can then download the data using the ps2000aGetValues function.

Applicability	Block mode only
Arguments	handle, device identifier returned by ps2000aOpenUnit status, indicates whether an error occurred during collection of the data * pParameter, a void pointer passed from ps2000aRunBlock. Your callback function can write to this location to send any data, such as a status flag, back to your application.
Returns	nothing

3.2 ps2000aCloseUnit() - close a scope device

```
PICO_STATUS ps2000aCloseUnit
(
    int16_t                        handle
)
```

This function shuts down an oscilloscope.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit
Returns	PICO_OK PICO_HANDLE_INVALID PICO_USER_CALLBACK PICO_DRIVER_FUNCTION

3.3 ps2000aDataReady() - find out if post-collection data ready

```
typedef void (__stdcall *ps2000aDataReady)
(
    int16_t               handle,
    PICO_STATUS           status,
    uint32_t              noOfSamples,
    int16_t               overflow,
    void                  * pParameter
)
```

This is a callback function that you write to collect data from the driver. You supply a pointer to the function when you call ps2000aGetValuesAsync, and the driver calls your function back when the data is ready.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit status, a PICO_STATUS code returned by the driver noOfSamples, the number of samples collected overflow, a set of flags that indicates whether an overvoltage has occurred and on which channels. It is a bit field with bit 0 representing Channel A. * pParameter, a void pointer passed from ps2000aGetValuesAsync. The callback function can write to this location to send any data, such as a status flag, back to the application. The data type is defined by the application programmer.
Returns	nothing

3.4 ps2000aEnumerateUnits() - find all connected oscilloscopesfind all connected oscilloscopes

```
PICO_STATUS ps2000aEnumerateUnits
(
    int16_t                  * count,
    int8_t                   * serials,
    int16_t                  * serialLth
)
```

This function counts the number of unopened PicoScope 2000 Series (A API) units connected to the computer and returns a list of serial numbers as a string. It does not detect units that are already open and have a handle assigned to them by the driver.

Applicability	All modes
Arguments	* count, on exit, the number of ps2000a units found * serials, on exit, a list of serial numbers separated by commas and terminated by a final null Example: AQ005/139,VDR61/356,ZOR14/107 Can be NULL on entry if serial numbers are not required * serialLth, on entry, the length of the char buffer pointed to by serials; on exit, the length of the string written to serials
Returns	PICO_OK PICO_BUSY PICO_NULL_PARAMETER PICO_FW_FAIL PICO_CONFIG_FAIL PICO_MEMORY_FAIL PICO_CONFIG_FAIL_AWG PICO_INITIALISE_FPGA

3.5 ps2000aFlashLed() - flash the front-panel LED

```
PICO_STATUS ps2000aFlashLed
(
    int16_t                     handle,
    int16_t                     start
)
```

This function flashes the LED on the front of the scope without blocking the calling thread. Calls to ps2000aRunStreaming and ps2000aRunBlock cancel any flashing started by this function. It is not possible to set the LED to be constantly illuminated, as this state is used to indicate that the scope has not been initialized.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit start, the action required: < 0 : flash the LED indefinitely 0 : stop the LED flashing > 0 : flash the LED start times. If the LED is already flashing on entry to this function, the flash count will be reset to start.
Returns	PICO_OK PICO_HANDLE_INVALID PICO_BUSY PICO_DRIVER_FUNCTION PICO_NOT_RESPONDING

3.6 ps2000aGetAnalogueOffset() - get allowable offset range

```
PICO_STATUS ps2000aGetAnalogueOffset
(
    int16_t                    handle,
    PS2000A_RANGE              range,
    PS2000A_COUPLING           coupling
    float                      * maximumVoltage,
    float                      * minimumVoltage
)
```

This function is used to get the maximum and minimum allowable analog offset for a specific voltage range.

Applicability	All ps2000a units except the PicoScope 2205 MSO
Arguments	handle, device identifier returned by ps2000aOpenUnit range, the voltage range to be used when gathering the min and max information coupling, the type of AC/DC coupling used * maximumVoltage, output: maximum voltage allowed for the range. Pointer will be ignored if NULL. If device does not support analog offset, zero will be returned. * minimumVoltage, output: minimum voltage allowed for the range. Pointer will be ignored if NULL. If device does not support analog offset, zero will be returned. If both maximumVoltage and minimumVoltage are NULL, the driver will return PICO_NULL_PARAMETER.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_INVALID_VOLTAGE_RANGE PICO_NULL_PARAMETER

3.7 ps2000aGetChannelInformation() - get list of available ranges

```
PICO_STATUS ps2000aGetChannelInformation
(
    int16_t                    handle,
    PS2000A_CHANNEL_INFO       info
    int32_t                    probe
    int32_t                    * ranges
    int32_t                    * length
    int32_t                    channels
)
```

This function queries which ranges are available on a scope device.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit info, the type of information required. The following value is currently supported: PS2000A_CI_RANGES probe, not used, must be set to 0 * ranges, an array that will be populated with available PS2000A_RANGE values for the given info. If NULL, length is set to the number of ranges available. * length, input: length of ranges array; output: number of elements written to ranges array channels, the channel for which the information is required
Returns	PICO_OK PICO_HANDLE_INVALID PICO_BUSY PICO_DRIVER_FUNCTION PICO_NOT_RESPONDING PICO_NULL_PARAMETER PICO_INVALID_CHANNEL PICO_INVALID_INFO

3.8 ps2000aGetMaxDownSampleRatio() - get aggregation ratio for data

```
PICO_STATUS ps2000aGetMaxDownSampleRatio
(
    int16_t                     handle,
    uint32_t                    noOfUnaggregatedSamples,
    uint32_t                    * maxDownSampleRatio,
    PS2000A_RATIO_MODE          downSampleRatioMode,
    uint32_t                    segmentIndex
)
```

This function returns the maximum downsampling ratio that can be used for a given number of samples in a given downsampling mode.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit noOfUnaggregatedSamples, the number of unprocessed samples to be downsampled * maxDownSampleRatio, the maximum possible downsampling ratio output downSampleRatioMode, the downsampling mode. See ps2000aGetValues. segmentIndex, the memory segment where the data is stored
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NO_SAMPLES_AVAILABLE PICO_NULL_PARAMETER PICO_INVALID_PARAMETER PICO_SEGMENT_OUT_OF_RANGE PICO_TOO_MANY_SAMPLES

3.9 ps2000aGetMaxSegments() - find out how many segments allowed

```
PICO_STATUS ps2000aGetMaxSegments
(
    int16_t                      handle,
    uint32_t                     * maxsegments
)
```

This function returns the maximum number of segments allowed for the opened variant. Refer to ps2000aMemorySegments for specific figures.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * maxsegments, output: maximum number of segments allowed
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_NULL_PARAMETER

3.10 ps2000aGetNoOfCaptures() - get number of captures available

```
PICO_STATUS ps2000aGetNoOfCaptures
(
    int16_t                    handle,
    uint32_t                   * nCaptures
)
```

This function finds out how many captures are available in rapid block mode after ps2000aRunBlock has been called. It can be called during data capture, or after the normal end of collection, or after data collection was terminated by ps2000aStop. The returned value (* nCaptures) can then be used to iterate through the number of segments using ps2000aGetValues, or in a single call to ps2000aGetValuesBulk where it is used to calculate the toSegmentIndex parameter.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * nCaptures, output: the number of available captures that has been collected from calling ps2000aRunBlock
Returns	PICO_OK PICO_DRIVER_FUNCTION PICO_INVALID_HANDLE PICO_NOT_RESPONDING PICO_NO_SAMPLES_AVAILABLE PICO_NULL_PARAMETER PICO_INVALID_PARAMETER PICO_SEGMENT_OUT_OF_RANGE PICO_TOO_MANY_SAMPLES

3.11 ps2000aGetNoOfProcessedCaptures() - get number of captures processed

```
PICO_STATUS ps2000aGetNoOfProcessedCaptures
(
    int16_t                    handle,
    uint32_t                   * nCaptures
)
```

This function finds out how many captures in rapid block mode have been processed after ps2000aRunBlock has been called and the collection is either still in progress, completed, or interrupted by a call to ps2000aStop.

It is mainly intended for use while capture is still in progress and you are collecting data using ps2000aGetValuesOverlappedBulk. The returned value (* nCaptures) indicates how many captures have been completed and therefore how many buffer segments have been filled.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * nCaptures, output: the number of available captures resulting from the call to ps2000aRunBlock
Returns	PICO_OK PICO_DRIVER_FUNCTION PICO_INVALID_HANDLE PICO_NO_SAMPLES_AVAILABLE PICO_NULL_PARAMETER PICO_INVALID_PARAMETER PICO_SEGMENT_OUT_OF_RANGE PICO_TOO_MANY_SAMPLES

3.12 ps2000aGetStreamingLatestValues() - get streaming data while scope is running

```
PICO_STATUS ps2000aGetStreamingLatestValues
(
    int16_t                    handle,
    ps2000aStreamingReady      lpPs2000AReady,
    void                       * pParameter
)
```

This function instructs the driver to return the next block of values to your ps2000aStreamingReady callback function. You must have previously called ps2000aRunStreaming beforehand to set up streaming.

Applicability	Streaming mode only
Arguments	handle, device identifier returned by ps2000aOpenUnit lpPs2000AReady, a pointer to your ps2000aStreamingReady callback function * pParameter, a void pointer that will be passed to the ps2000aStreamingReady callback function. The callback function may optionally use this pointer to return information to the application.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NO_SAMPLES_AVAILABLE PICO_INVALID_CALL PICO_BUSY PICO_NOT_RESPONDING PICO_DRIVER_FUNCTION

3.13 ps2000aGetTimebase() - find out what timebases are available

```
PICO_STATUS ps2000aGetTimebase
(
    int16_t                   handle,
    uint32_t                  timebase,
    int32_t                   noSamples,
    int32_t                   * timeIntervalNanoseconds,
    int16_t                   oversample,
    int32_t                   * maxSamples
    uint32_t                  segmentIndex
)
```

This function calculates the sampling rate and maximum number of samples for a given timebase under the specified conditions. The result will depend on the number of channels enabled by the last call to ps2000aSetChannel.

This function is provided for use with programming languages that do not support the float data type. The value returned in the timeIntervalNanoseconds argument is restricted to integers. If your programming language supports the float type, we recommend that you use ps2000aGetTimebase2 instead.

To use ps2000aGetTimebase or ps2000aGetTimebase2, first estimate the timebase number that you require using the information in the timebase guide. Next, call one of these functions with the timebase that you have just chosen and verify that the timeIntervalNanoseconds argument that the function returns is the value that you require. You may need to iterate this process until you obtain the time interval that you need.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit timebase, see timebase guide noSamples, the number of samples required * timeIntervalNanoseconds, on exit, the time interval between readings at the selected timebase. Use NULL if not required. In ETS mode this argument is not valid; use the sample time returned by ps2000aSetEts instead. oversample, not used * maxSamples, on exit, the maximum number of samples available. The scope allocates a certain amount of memory for internal overheads and this may vary depending on the number of segments, number of channels enabled, and the timebase chosen. Use NULL if not required. segmentIndex, the index of the memory segment to use
Returns	PICO_OK PICO_INVALID_HANDLE PICO_TOO_MANY_SAMPLES PICO_INVALID_CHANNEL PICO_INVALID_TIMEBASE PICO_INVALID_PARAMETER PICO_SEGMENT_OUT_OF_RANGE PICO_DRIVER_FUNCTION

3.14 ps2000aGetTimebase2() - find out what timebases are available

```
PICO_STATUS ps2000aGetTimebase2
(
    int16_t                 handle,
    uint32_t                timebase,
    int32_t                 noSamples,
    float                   * timeIntervalNanoseconds,
    int16_t                 oversample,
    int32_t                 * maxSamples
    uint32_t                segmentIndex
)
```

This function is an upgraded version of ps2000aGetTimebase, and returns the time interval as a float rather than a long. This allows it to return sub-nanosecond time intervals. See ps2000aGetTimebase for a full description.

Applicability	All modes
Arguments	* timeIntervalNanoseconds, a pointer to the time interval between readings at the selected timebase. If a null pointer is passed, nothing will be written here. All other arguments: see ps2000aGetTimebase
Returns	See ps2000aGetTimebase

3.15 ps2000aGetTriggerTimeOffset() - find out when trigger occurred (32-bit)

```
PICO_STATUS ps2000aGetTriggerTimeOffset
(
    int16_t                     handle
    uint32_t                    * timeUpper
    uint32_t                    * timeLower
    PS2000A_TIME_UNITS          * timeUnits
    uint32_t                    segmentIndex
)
```

This function gets the time, as two 4-byte values, at which the trigger occurred. Call it after block-mode data has been captured or when data has been retrieved from a previous block-mode capture. A 64-bit version of this function, ps2000aGetTriggerTimeOffset64, is also available.

Applicability	Block mode, rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * timeUpper, on exit, the upper 32 bits of the time at which the trigger point occurred * timeLower, on exit, the lower 32 bits of the time at which the trigger point occurred * timeUnits, returns the time units in which timeUpper and timeLower are measured. The allowable values are: PS2000A_FS PS2000A_PS PS2000A_NS PS2000A_US PS2000A_MS PS2000A_S segmentIndex, the number of the memory segment for which the information is required
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DEVICE_SAMPLING PICO_SEGMENT_OUT_OF_RANGE PICO_NOT_USED_IN_THIS_CAPTURE_MODE PICO_NOT_RESPONDING PICO_NULL_PARAMETER PICO_NO_SAMPLES_AVAILABLE PICO_DRIVER_FUNCTION

3.16 ps2000aGetTriggerTimeOffset64() - find out when trigger occurred (64-bit)

```
PICO_STATUS ps2000aGetTriggerTimeOffset64
(
    int16_t                 handle,
    int64_t                 * time,
    PS2000A_TIME_UNITS      * timeUnits,
    uint32_t                segmentIndex
)
```

This function gets the time, as a single 64-bit value, at which the trigger occurred. Call it after block-mode data has been captured or when data has been retrieved from a previous block-mode capture. A 32-bit version of this function, ps2000aGetTriggerTimeOffset, is also available.

Applicability	Block mode, rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * time, on exit, the time at which the trigger point occurred * timeUnits, on exit, the time units in which time is measured. The possible values are: PS2000A_FS PS2000A_PS PS2000A_NS PS2000A_US PS2000A_MS PS2000A_S segmentIndex, the number of the memory segment for which the information is required
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DEVICE_SAMPLING PICO_SEGMENT_OUT_OF_RANGE PICO_NOT_USED_IN_THIS_CAPTURE_MODE PICO_NOT_RESPONDING PICO_NULL_PARAMETER PICO_NO_SAMPLES_AVAILABLE PICO_DRIVER_FUNCTION

3.17 ps2000aGetUnitInfo() - get information about scope device

```
PICO_STATUS ps2000aGetUnitInfo
(
    int16_t          handle,
    int8_t           * string,
    int16_t          stringLength,
    int16_t          * requiredSize
    PICO_INFO        info
)
```

This function retrieves information about the specified oscilloscope. If the device fails to open, or no device is opened only the driver version is available.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit. If an invalid handle is passed, only the driver versions can be read. * string, on exit, the unit information string selected specified by the info argument. If string is NULL, only requiredSize is returned. stringLength, the maximum number of chars that may be written to string * requiredSize, on exit, the required length of the string array info, a number specifying what information is required. The possible values are listed in the table below.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NULL_PARAMETER PICO_INVALID_INFO PICO_INFO_UNAVAILABLE PICO_DRIVER_FUNCTION

info		Example
0	PICO_DRIVER_VERSION Version number of PicoScope 2000A DLL	1,0,0,1
1	PICO_USB_VERSION Type of USB connection to device: 1.1 or 2.0	2.0
2	PICO_HARDWARE_VERSION Hardware version of device	1
3	PICO_VARIANT_INFO Variant number of device	2206
4	PICO_BATCH_AND_SERIAL Batch and serial number of device	KJL87/6
5	PICO_CAL_DATE Calibration date of device	30Sep09
6	PICO_KERNEL_VERSION Version of kernel driver	1,1,2,4
7	PICO_DIGITAL_HARDWARE_VERSION Hardware version of the digital section	1
8	PICO_ANALOGUE_HARDWARE_VERSION Hardware version of the analog section	1
9	PICO_FIRMWARE_VERSION_1	1.0.0.0
10	PICO_FIRMWARE_VERSION_2	1.0.0.0

3.18 ps2000aGetValues() - get block-mode data with callback

```
PICO_STATUS ps2000aGetValues
(
    int16_t                  handle,
    uint32_t                 startIndex,
    uint32_t                 * noOfSamples,
    uint32_t                 downSampleRatio,
    PS2000A_RATIO_MODE       downSampleRatioMode,
    uint32_t                 segmentIndex,
    int16_t                  * overflow
)
```

This function returns block-mode data, with or without downsampling, starting at the specified sample number. It is used to get the stored data from the driver after data collection has stopped.

Applicability	Block mode, rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit startIndex, a zero-based index that indicates the start point for data collection. It is measured in sample intervals from the start of the buffer. * noOfSamples, on entry, the number of samples required. On exit, the actual number retrieved. The number of samples retrieved will not be more than the number requested, and the data retrieved starts at startIndex. downSampleRatio, the downsampling factor that will be applied to the raw data downSampleRatioMode, which downsampling mode to use. The available values are: PS2000A_RATIO_MODE_NONE (downSampleRatio is ignored) PS2000A_RATIO_MODE_AGGREGATE PS2000A_RATIO_MODE_AVERAGE PS2000A_RATIO_MODE_DECIMATE AGGREGATE, AVERAGE, DECIMATE are single-bit constants that can be ORed to apply multiple downsampling modes to the same data. segmentIndex, the zero-based number of the memory segment where the data is stored * overflow, on exit, a set of flags that indicate whether an overvoltage has occurred on any of the channels. It is a bit field with bit 0 denoting Channel A.

Returns	PICO_OK PICO_INVALID_HANDLE PICO_NO_SAMPLES_AVAILABLE PICO_DEVICE_SAMPLING PICO_NULL_PARAMETER PICO_SEGMENT_OUT_OF_RANGE PICO_STARTINDEX_INVALID PICO_ETS_NOT_RUNNING PICO_BUFFERS_NOT_SET PICO_INVALID_PARAMETER PICO_TOO_MANY_SAMPLES PICO_DATA_NOT_AVAILABLE PICO_STARTINDEX_INVALID PICO_INVALID_SAMPLERATIO PICO_INVALID_CALL PICO_NOT_RESPONDING PICO_MEMORY PICO_RATIO_MODE_NOT_SUPPORTED PICO_DRIVER_FUNCTION

3.18.1 Downsampling modes

Various methods of data reduction, or **downsampling**, are possible with the PicoScope 2000 Series oscilloscopes. The downsampling is done at high speed by dedicated hardware inside the scope, making your application faster and more responsive than if you had to do all the data processing in software.

You specify the downsampling mode when you call one of the data collection functions such as ps2000aGetValues. The following modes are available:

PS2000A_RATIO_MODE_AGGREGATE	Reduces every block of *n* values to just two values: a minimum and a maximum. The minimum and maximum values are returned in two separate buffers.
PS2000A_RATIO_MODE_AVERAGE	Reduces every block of *n* values to a single value representing the average (arithmetic mean) of all the values. Equivalent to the 'oversampling' function on older scopes.
PS2000A_RATIO_MODE_DECIMATE	Reduces every block of *n* values to just the first value in the block, discarding all the other values.

3.19 ps2000aGetValuesAsync() - get streaming data with callback

```
PICO_STATUS ps2000aGetValuesAsync
(
    int16_t                 handle,
    uint32_t                startIndex,
    uint32_t                noOfSamples,
    uint32_t                downSampleRatio,
    PS2000A_RATIO_MODE      downSampleRatioMode,
    uint32_t                segmentIndex,
    void                    * lpDataReady,
    void                    * pParameter
)
```

This function returns data either with or without downsampling, starting at the specified sample number. It is used to get the stored data from the scope after data collection has stopped. It returns the data using a callback.

Applicability	Streaming mode and block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit startIndex, see ps2000aGetValues noOfSamples, see ps2000aGetValues downSampleRatio, see ps2000aGetValues downSampleRatioMode, see ps2000aGetValues segmentIndex, see ps2000aGetValues * lpDataReady, a pointer to the user-supplied function that will be called when the data is ready. This will be a ps2000aDataReady function for block-mode data or a ps2000aStreamingReady function for streaming-mode data. * pParameter, a void pointer that will be passed to the callback function. The data type is determined by the application.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NO_SAMPLES_AVAILABLE PICO_DEVICE_SAMPLING PICO_NULL_PARAMETER PICO_STARTINDEX_INVALID PICO_SEGMENT_OUT_OF_RANGE PICO_INVALID_PARAMETER PICO_DATA_NOT_AVAILABLE PICO_INVALID_SAMPLERATIO PICO_INVALID_CALL PICO_DRIVER_FUNCTION

3.20 ps2000aGetValuesBulk() - get data in rapid block mode

```
PICO_STATUS ps2000aGetValuesBulk
(
    int16_t                 handle,
    uint32_t                * noOfSamples,
    uint32_t                fromSegmentIndex,
    uint32_t                toSegmentIndex,
    uint32_t                downSampleRatio,
    PS2000A_RATIO_MODE      downSampleRatioMode,
    int16_t                 * overflow
)
```

This function retrieves waveforms captured using rapid block mode. The waveforms must have been collected sequentially and in the same run.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * noOfSamples, on entry, the number of samples required; on exit, the actual number retrieved. The number of samples retrieved will not be more than the number requested. The data retrieved always starts with the first sample captured. fromSegmentIndex, the first segment from which the waveform should be retrieved toSegmentIndex, the last segment from which the waveform should be retrieved downSampleRatio, see ps2000aGetValues downSampleRatioMode, see ps2000aGetValues * overflow, an array of integers equal to or larger than the number of waveforms to be retrieved. Each segment index has a corresponding entry in the overflow array, with overflow[0] containing the flags for the segment numbered fromSegmentIndex and the last element in the array containing the flags for the segment numbered toSegmentIndex. Each element in the array is a bit field as described under ps2000aGetValues.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_PARAMETER PICO_INVALID_SAMPLERATIO PICO_ETS_NOT_RUNNING PICO_BUFFERS_NOT_SET PICO_TOO_MANY_SAMPLES PICO_SEGMENT_OUT_OF_RANGE PICO_NO_SAMPLES_AVAILABLE PICO_NOT_RESPONDING PICO_DRIVER_FUNCTION

3.21 ps2000aGetValuesOverlapped() - set up data collection ahead of capture

```
PICO_STATUS ps2000aGetValuesOverlapped
(
    int16_t                 handle,
    uint32_t                startIndex,
    uint32_t                * noOfSamples,
    uint32_t                downSampleRatio,
    PS2000A_RATIO_MODE      downSampleRatioMode,
    uint32_t                segmentIndex,
    int16_t                 * overflow
)
```

This function allows you to make a deferred data-collection request in block mode. The request will be executed, and the arguments validated, when you call ps2000aRunBlock. The advantage of this function is that the driver makes contact with the scope only once, when you call ps2000aRunBlock, compared with the two contacts that occur when you use the conventional ps2000aRunBlock, ps2000aGetValues calling sequence. This slightly reduces the dead time between successive captures in block mode.

After calling ps2000aRunBlock, you can optionally use ps2000aGetValues to request further copies of the data. This might be required if you wish to display the data with different data reduction settings.

Applicability	Block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit startIndex, see ps2000aGetValues * noOfSamples, on entry, the number of raw samples to be collected before any downsampling is applied. On exit, the actual number stored in the buffer. The number of samples retrieved will not be more than the number requested, and the data retrieved starts at startIndex. downSampleRatio, see ps2000aGetValues downSampleRatioMode, see ps2000aGetValues segmentIndex, see ps2000aGetValues * overflow, see ps2000aGetValuesBulk
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_PARAMETER PICO_DRIVER_FUNCTION

3.21.1 Using the GetValuesOverlapped functions

1. Open the oscilloscope using ps2000aOpenUnit.

2. Select channel ranges and AC/DC coupling using ps2000aSetChannel.

3. Using ps2000aGetTimebase, select timebases until the required nanoseconds per sample is located.

4. Use the trigger setup functions ps2000aSetTriggerChannelDirections and ps2000aSetTriggerChannelProperties to set up the trigger if required.

5. Wait until the oscilloscope is ready using the ps2000aBlockReady callback (or poll using ps2000aIsReady).

6. Use ps2000aSetDataBuffer to tell the driver where your memory buffer is.

7. Set up the transfer of the block of data from the oscilloscope using ps2000aGetValuesOverlapped.

8. Start the oscilloscope running using ps2000aRunBlock.

9. Display the data.

10. Stop the oscilloscope.

11. Repeat steps 8 and 9 if needed.

A similar procedure can be used with rapid block mode using the ps2000aGetValuesOverlappedBulk function.

3.22 ps2000aGetValuesOverlappedBulk() - set up data collection in rapid block mode

```
PICO_STATUS ps2000aGetValuesOverlappedBulk
(
    int16_t                 handle,
    uint32_t                startIndex,
    uint32_t                * noOfSamples,
    uint32_t                downSampleRatio,
    PS2000A_RATIO_MODE      downSampleRatioMode,
    uint32_t                fromSegmentIndex,
    uint32_t                toSegmentIndex,
    int16_t                 * overflow
)
```

This function allows you to make a deferred data-collection request, which will later be executed, and the arguments validated, when you call ps2000aRunBlock in rapid block mode. The advantage of this method is that the driver makes contact with the scope only once, when you call ps2000aRunBlock, compared with the two contacts that occur when you use the conventional ps2000aRunBlock, ps2000aGetValuesBulk calling sequence. This slightly reduces the dead time between successive captures in rapid block mode.

After calling ps2000aRunBlock, you can optionally use ps2000aGetValues to request further copies of the data. This might be required if you wish to display the data with different data reduction settings.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit startIndex, see ps2000aGetValues * noOfSamples, see ps2000aGetValuesOverlapped downSampleRatio, see ps2000aGetValues downSampleRatioMode, see ps2000aGetValues fromSegmentIndex, see ps2000aGetValuesBulk toSegmentIndex, see ps2000aGetValuesBulk * overflow, see ps2000aGetValuesBulk
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_PARAMETER PICO_DRIVER_FUNCTION

3.23 ps2000aGetValuesTriggerTimeOffsetBulk() - get rapid-block waveform times (32-bit)

```
PICO_STATUS ps2000aGetValuesTriggerTimeOffsetBulk
(
    int16_t                   handle,
    uint32_t                  * timesUpper,
    uint32_t                  * timesLower,
    PS2000A_TIME_UNITS        * timeUnits,
    uint32_t                  fromSegmentIndex,
    uint32_t                  toSegmentIndex
)
```

This function retrieves the time offsets, as lower and upper 32-bit values, for waveforms obtained in rapid block mode. The time offset of a waveform is the delay from the trigger sampling instant to the time at which the driver estimates the waveform to have crossed the trigger threshold. You can add this offset to the time of each sample in the waveform to reduce trigger jitter. Without using the time offset, trigger jitter can be up to 1 sample period; adding the time offset reduces jitter to a small fraction of a sample period.

This function is provided for use in programming environments that do not support 64-bit integers. If your programming environment supports this data type, it is easier to use ps2000aGetValuesTriggerTimeOffsetBulk64.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * timesUpper, an array of integers. On exit, the most significant 32 bits of the time offset for each requested segment index. times[0] will hold the fromSegmentIndex time offset and the last times index will hold the toSegmentIndex time offset. The array must be long enough to hold the number of requested times. * timesLower, an array of integers. On exit, the least significant 32 bits of the time offset for each requested segment index. times[0] will hold the fromSegmentIndex time offset and the last times index will hold the toSegmentIndex time offset. The array size must be long enough to hold the number of requested times. * timeUnits, an array of integers. The array must be long enough to hold the number of requested times. On exit, timeUnits[0] will contain the time unit for fromSegmentIndex and the last element will contain the time unit for toSegmentIndex. Refer to ps2000aGetTriggerTimeOffset for allowable values. fromSegmentIndex, the first segment for which the time offset is required. toSegmentIndex, the last segment for which the time offset is required. If toSegmentIndex is less than fromSegmentIndex then the driver will wrap around from the last segment to the first.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NOT_USED_IN_THIS_CAPTURE_MODE PICO_NOT_RESPONDING PICO_NULL_PARAMETER PICO_DEVICE_SAMPLING PICO_SEGMENT_OUT_OF_RANGE PICO_NO_SAMPLES_AVAILABLE PICO_DRIVER_FUNCTION

3.24 ps2000aGetValuesTriggerTimeOffsetBulk64() – get rapid-block waveform times (64-bit)

```
PICO_STATUS ps2000aGetValuesTriggerTimeOffsetBulk64
(
    int16_t                 handle,
    int64_t                 * times,
    PS2000A_TIME_UNITS      * timeUnits,
    uint32_t                fromSegmentIndex,
    uint32_t                toSegmentIndex
)
```

This function retrieves the 64-bit time offsets for waveforms captured in rapid block mode.

A 32-bit version of this function, ps2000aGetValuesTriggerTimeOffsetBulk, is available for use with programming languages that do not support 64-bit integers.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * times, an array of integers. On exit, this will hold the time offset for each requested segment index. times[0] will hold the time offset for fromSegmentIndex, and the last times index will hold the time offset for toSegmentIndex. The array must be long enough to hold the number of times requested. * timeUnits, an array of integers long enough to hold the number of requested times. timeUnits[0] will contain the time unit for fromSegmentIndex, and the last element will contain the toSegmentIndex. Refer to ps2000aGetTriggerTimeOffset64 for specific figures. fromSegmentIndex, the first segment for which the time offset is required. The results for this segment will be placed in times[0] and timeUnits[0]. toSegmentIndex, the last segment for which the time offset is required. The results for this segment will be placed in the last elements of the times and timeUnits arrays. If toSegmentIndex is less than fromSegmentIndex then the driver will wrap around from the last segment to the first.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NOT_USED_IN_THIS_CAPTURE_MODE PICO_NOT_RESPONDING PICO_NULL_PARAMETER PICO_DEVICE_SAMPLING PICO_SEGMENT_OUT_OF_RANGE PICO_NO_SAMPLES_AVAILABLE PICO_DRIVER_FUNCTION

3.25 ps2000aHoldOff() – not supported

```
PICO_STATUS ps2000aHoldOff
(
    int16_t                 handle,
    uint64_t                holdoff,
    PS2000A_HOLDOFF_TYPE    type
)
```

This function has no effect and is reserved for future use.

Applicability	Not supported. Reserved for future use.
Arguments	handle, device identifier returned by ps2000aOpenUnit holdoff, reserved for future use type, reserved for future use
Returns	PICO_OK PICO_INVALID_HANDLE

3.26 ps2000aIsReady() – poll driver in block mode

```
PICO_STATUS ps2000aIsReady
(
    int16_t                     handle,
    int16_t                     * ready
)
```

This function may be used instead of a callback function to receive data from ps2000aRunBlock. To use this method, pass a NULL pointer as the lpReady argument to ps2000aRunBlock. You must then poll the driver to see if it has finished collecting the requested samples.

Applicability	Block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * ready, output: indicates the state of the collection. If zero, the device is still collecting. If non-zero, the device has finished collecting and ps2000aGetValues can be used to retrieve the data.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_NULL_PARAMETER PICO_NO_SAMPLES_AVAILABLE PICO_CANCELLED PICO_NOT_RESPONDING

3.27 ps2000aIsTriggerOrPulseWidthQualifierEnabled() – get trigger status

```
PICO_STATUS ps2000aIsTriggerOrPulseWidthQualifierEnabled
(
    int16_t                handle,
    int16_t                * triggerEnabled,
    int16_t                * pulseWidthQualifierEnabled
)
```

This function discovers whether a trigger, or pulse width triggering, is enabled.

Applicability	Call after setting up the trigger, and just before calling either ps2000aRunBlock or ps2000aRunStreaming.
Arguments	handle, device identifier returned by ps2000aOpenUnit * triggerEnabled, on exit, indicates whether the trigger will successfully be set when ps2000aRunBlock or ps2000aRunStreaming is called. A non-zero value indicates that the trigger is set, zero that the trigger is not set. * pulseWidthQualifierEnabled, on exit, indicates whether the pulse width qualifier will successfully be set when ps2000aRunBlock or ps2000aRunStreaming is called. A non-zero value indicates that the pulse width qualifier is set, zero that the pulse width qualifier is not set.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NULL_PARAMETER PICO_DRIVER_FUNCTION

3.28 ps2000aMaximumValue() – get maximum ADC count in get-values calls

```
PICO_STATUS ps2000aMaximumValue
(
    int16_t                    handle
    int16_t                    * value
)
```

This function returns the maximum ADC count returned by calls to the "GetValues" functions.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * value, output: the maximum ADC value
Returns	PICO_OK PICO_USER_CALLBACK PICO_INVALID_HANDLE PICO_TOO_MANY_SEGMENTS PICO_MEMORY PICO_DRIVER_FUNCTION

3.29 ps2000aMemorySegments() – divide scope memory into segments

```
PICO_STATUS ps2000aMemorySegments
(
    int16_t                     handle
    uint32_t                    nSegments,
    int32_t                     * nMaxSamples
)
```

This function sets the number of memory segments that the scope will use.

When the scope is opened, the number of segments defaults to 1, meaning that each capture fills the scope's available memory. This function allows you to divide the memory into a number of segments so that the scope can store several waveforms sequentially.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit nSegments, the number of segments required, from 1 to 32 * nMaxSamples, on exit, the number of samples available in each segment. This is the total number over all channels, so if more than one channel is in use then the number of samples available to each channel is nMaxSamples divided by the number of channels.
Returns	PICO_OK PICO_USER_CALLBACK PICO_INVALID_HANDLE PICO_TOO_MANY_SEGMENTS PICO_MEMORY PICO_DRIVER_FUNCTION

3.30 ps2000aMinimumValue() – get minimum ADC count in get-values calls

```
PICO_STATUS ps2000aMinimumValue
(
    int16_t                         handle
    int16_t                         * value
)
```

This function returns the minimum ADC count returned by calls to the GetValues functions.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * value, output: the minimum ADC value
Returns	PICO_OK PICO_USER_CALLBACK PICO_INVALID_HANDLE PICO_TOO_MANY_SEGMENTS PICO_MEMORY PICO_DRIVER_FUNCTION

3.31 ps2000aNoOfStreamingValues() – get number of samples in streaming mode

```
PICO_STATUS ps2000aNoOfStreamingValues
(
    int16_t                     handle,
    uint32_t                    * noOfValues
)
```

This function returns the number of samples available after data collection in streaming mode. Call it after calling ps2000aStop.

Applicability	Streaming mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * noOfValues, on exit, the number of samples
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NULL_PARAMETER PICO_NO_SAMPLES_AVAILABLE PICO_NOT_USED PICO_BUSY PICO_DRIVER_FUNCTION

3.32 ps2000aOpenUnit() – open a scope device

```
PICO_STATUS ps2000aOpenUnit
(
    int16_t                  * handle,
    int8_t                   * serial
)
```

This function opens a PicoScope 2000 Series (A API) scope attached to the computer. The maximum number of units that can be opened depends on the operating system, the kernel driver and the computer.

Applicability	All modes
Arguments	* handle, on exit, the result of the attempt to open a scope: -1 : if the scope fails to open 0 : if no scope is found > 0 : a number that uniquely identifies the scope If a valid handle is returned, it must be used in all subsequent calls to API functions to identify this scope. * serial, on entry, a null-terminated string containing the serial number of the scope to be opened. If serial is NULL then the function opens the first scope found; otherwise, it tries to open the scope that matches the string.
Returns	PICO_OK PICO_OS_NOT_SUPPORTED PICO_OPEN_OPERATION_IN_PROGRESS PICO_EEPROM_CORRUPT PICO_KERNEL_DRIVER_TOO_OLD PICO_FPGA_FAIL PICO_MEMORY_CLOCK_FREQUENCY PICO_FW_FAIL PICO_MAX_UNITS_OPENED PICO_NOT_FOUND (if the specified unit was not found) PICO_NOT_RESPONDING PICO_MEMORY_FAIL PICO_ANALOG_BOARD PICO_CONFIG_FAIL_AWG PICO_INITIALISE_FPGA

3.33 ps2000aOpenUnitAsync() – open a scope device without blocking

```
PICO_STATUS ps2000aOpenUnitAsync
(
    int16_t                         * status
    int8_t                          * serial
)
```

This function opens a scope without blocking the calling thread. You can find out when it has finished by periodically calling ps2000aOpenUnitProgress until that function returns a non-zero value.

Applicability	All modes
Arguments	* status, a status code: 0 if the open operation was disallowed because another open operation is in progress 1 if the open operation was successfully started * serial, see ps2000aOpenUnit
Returns	PICO_OK PICO_OPEN_OPERATION_IN_PROGRESS PICO_OPERATION_FAILED

3.34 ps2000aOpenUnitProgress() – check progress of OpenUnit call

```
PICO_STATUS ps2000aOpenUnitProgress
(
    int16_t                     * handle,
    int16_t                     * progressPercent,
    int16_t                     * complete
)
```

This function checks on the progress of a request made to ps2000aOpenUnitAsync to open a scope.

Applicability	Use after ps2000aOpenUnitAsync
Arguments	* handle, see ps2000aOpenUnit. This handle is valid only if the function returns PICO_OK. * progressPercent, on exit, the percentage progress towards opening the scope. 100% implies that the open operation is complete. * complete, set to 1 when the open operation has finished
Returns	PICO_OK PICO_NULL_PARAMETER PICO_OPERATION_FAILED

3.35 ps2000aPingUnit() – check communication with opened device

```
PICO_STATUS ps2000aPingUnit
(
    int16_t                    handle
)
```

This function can be used to check that the already opened device is still connected to the USB port and communication is successful.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_BUSY PICO_NOT_RESPONDING

3.36 ps2000aQueryOutputEdgeDetect() – find out if state trigger edge-detection is enabled

```
PICO_STATUS ps2000aQueryOutputEdgeDetect
(
    int16_t                      handle,
    int16_t                      * state
)
```

This function obtains the state of the edge-detect flag, which is described in ps2000aSetOutputEdgeDetect.

Applicability	Level and window trigger types
Arguments	handle, device identifier returned by ps2000aOpenUnit state, on exit, the value of the edge-detect flag: 0 : do not wait for a signal transition <> 0 : wait for a signal transition (default)
Returns	PICO_OK

3.37 ps2000aRunBlock() – capture in block mode

```
PICO_STATUS ps2000aRunBlock
(
    int16_t                 handle,
    int32_t                 noOfPreTriggerSamples,
    int32_t                 noOfPostTriggerSamples,
    uint32_t                timebase,
    int16_t                 oversample,
    int32_t                 * timeIndisposedMs,
    uint32_t                segmentIndex,
    ps2000aBlockReady       lpReady,
    void                    * pParameter
)
```

This function starts collecting data in block mode. For a step-by-step guide to this process, see Using block mode.

The number of samples is determined by noOfPreTriggerSamples and noOfPostTriggerSamples (see below for details). The total number of samples must not be more than the size of the segment referred to by segmentIndex.

Applicability	Block mode, rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit noOfPreTriggerSamples, the number of samples to store before the trigger event noOfPostTriggerSamples, the number of samples to store after the trigger event Note: the maximum number of samples returned is always noOfPreTriggerSamples + noOfPostTriggerSamples. This is true even if no trigger event has been set. timebase, a number in the range 0 to 2^{32}–1. See the guide to calculating timebase values. This argument is ignored in ETS mode, when ps2000aSetEts selects the timebase instead. oversample, not used * timeIndisposedMs, on exit, the time, in milliseconds, that the scope will spend collecting samples. This does not include any auto trigger timeout. It is not valid in ETS capture mode. The pointer can be set to null if a value is not required. segmentIndex, zero-based, which memory segment to use lpReady, a pointer to the ps2000aBlockReady callback function that the driver will call when the data has been collected. To use the ps2000aIsReady polling method instead of a callback function, set this pointer to NULL. * pParameter, a void pointer that is passed to the ps2000aBlockReady callback function. The callback can use this pointer to return arbitrary data to the application.
Returns	PICO_OK PICO_BUFFERS_NOT_SET (in Overlapped mode) PICO_INVALID_HANDLE PICO_USER_CALLBACK

	PICO_SEGMENT_OUT_OF_RANGE PICO_INVALID_CHANNEL PICO_INVALID_TRIGGER_CHANNEL PICO_INVALID_CONDITION_CHANNEL PICO_TOO_MANY_SAMPLES PICO_INVALID_TIMEBASE PICO_NOT_RESPONDING PICO_CONFIG_FAIL PICO_INVALID_PARAMETER PICO_NOT_RESPONDING PICO_TRIGGER_ERROR PICO_DRIVER_FUNCTION PICO_FW_FAIL PICO_NOT_ENOUGH_SEGMENTS (in Bulk mode) PICO_PULSE_WIDTH_QUALIFIER PICO_SEGMENT_OUT_OF_RANGE (in Overlapped mode) PICO_STARTINDEX_INVALID (in Overlapped mode) PICO_INVALID_SAMPLERATIO (in Overlapped mode) PICO_CONFIG_FAIL

3.38 ps2000aRunStreaming() – capture in streaming mode

```
PICO_STATUS ps2000aRunStreaming
(
    int16_t                 handle,
    uint32_t                * sampleInterval,
    PS2000A_TIME_UNITS      sampleIntervalTimeUnits
    uint32_t                maxPreTriggerSamples,
    uint32_t                maxPostTriggerSamples,
    int16_t                 autoStop,
    uint32_t                downSampleRatio,
    PS2000A_RATIO_MODE      downSampleRatioMode,
    uint32_t                overviewBufferSize
)
```

This function tells the oscilloscope to start collecting data in streaming mode. When data has been collected from the device it is downsampled if necessary and then delivered to the application. Call ps2000aGetStreamingLatestValues to retrieve the data. See Using streaming mode for a step-by-step guide to this process.

When a trigger is set, the total number of samples stored in the driver is the sum of maxPreTriggerSamples and maxPostTriggerSamples. If autoStop is false, this will become the maximum number of samples without downsampling.

Applicability	Streaming mode
Arguments	handle, device identifier returned by ps2000aOpenUnit * sampleInterval, on entry, the requested time interval between samples; on exit, the actual time interval used sampleIntervalTimeUnits, the unit of time used for sampleInterval. Use one of these values: PS2000A_FS PS2000A_PS PS2000A_NS PS2000A_US PS2000A_MS PS2000A_S maxPreTriggerSamples, the maximum number of raw samples before a trigger event for each enabled channel. If no trigger condition is set this argument is ignored. maxPostTriggerSamples, the maximum number of raw samples after a trigger event for each enabled channel. If no trigger condition is set, this argument states the maximum number of samples to be stored. autoStop, a flag that specifies if the streaming should stop when all of maxSamples have been captured downSampleRatio, see ps2000aGetValues downSampleRatioMode, see ps2000aGetValues

	overviewBufferSize, the size of the overview buffers. These are temporary buffers used for storing the data before returning it to the application. The size is the same as the bufferLth value passed to ps2000aSetDataBuffer.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_ETS_MODE_SET PICO_USER_CALLBACK PICO_NULL_PARAMETER PICO_INVALID_PARAMETER PICO_STREAMING_FAILED PICO_NOT_RESPONDING PICO_TRIGGER_ERROR PICO_INVALID_SAMPLE_INTERVAL PICO_INVALID_BUFFER PICO_DRIVER_FUNCTION PICO_FW_FAIL PICO_MEMORY

3.39 ps2000aSetChannel() – set up input channel

```
PICO_STATUS ps2000aSetChannel
(
    int16_t                 handle,
    PS2000A_CHANNEL         channel,
    int16_t                 enabled,
    PS2000A_COUPLING        type,
    PS2000A_RANGE           range,
    float                   analogOffset
)
```

This function specifies whether an input channel is to be enabled, its input coupling type, voltage range, analog offset.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit channel, the channel to be configured. The values are: PS2000A_CHANNEL_A: Channel A input PS2000A_CHANNEL_B: Channel B input PS2000A_CHANNEL_C: Channel C input PS2000A_CHANNEL_D: Channel D input enabled, whether or not to enable the channel. The values are: TRUE: enable FALSE: do not enable type, the impedance and coupling type. The values are: PS2000A_AC: 1 megohm impedance, AC coupling. The channel accepts input frequencies from about 1 hertz up to its maximum analog bandwidth. PS2000A_DC: 1 megohm impedance, DC coupling. The channel accepts all input frequencies from zero (DC) up to its maximum analog bandwidth. range, the input voltage range: PS2000A_20MV: ±20 mV, PS2000A_1V: ±1 V PS2000A_50MV: ±50 mV, PS2000A_2V: ±2 V PS2000A_100MV: ±100 mV, PS2000A_5V: ±5 V PS2000A_200MV: ±200 mV, PS2000A_10V: ±10 V PS2000A_500MV: ±500 mV, PS2000A_20V: ±20 V analogOffset, a voltage to add to the input channel before digitization. The allowable range of offsets can be obtained from ps2000aGetAnalogueOffset and depends on the input range selected for the channel. This argument is ignored if the device is a PicoScope 2205 MSO.
Returns	PICO_OK PICO_USER_CALLBACK PICO_INVALID_HANDLE PICO_INVALID_CHANNEL PICO_INVALID_VOLTAGE_RANGE PICO_INVALID_COUPLING

	PICO_INVALID_ANALOGUE_OFFSET PICO_DRIVER_FUNCTION

3.40 ps2000aSetDataBuffer() – register data buffer with driver

```
PICO_STATUS ps2000aSetDataBuffer
(
    int16_t                 handle,
    int32_t                 channel,
    int16_t                 * buffer,
    int32_t                 bufferLth,
    uint32_t                segmentIndex,
    PS2000A_RATIO_MODE      mode
)
```

This function tells the driver where to store the data, either unprocessed or downsampled, that will be returned after the next call to one of the GetValues functions. The function allows you to specify only a single buffer, so for aggregation mode, which requires two buffers, you need to call ps2000aSetDataBuffers instead.

You must allocate memory for the buffer before calling this function.

Applicability	Block, rapid block and streaming modes. All downsampling modes except aggregation.
Arguments	handle, device identifier returned by ps2000aOpenUnit channel, the channel you want to use with the buffer. Use one of these values for analog channels: PS2000A_CHANNEL_A PS2000A_CHANNEL_B PS2000A_CHANNEL_C PS2000A_CHANNEL_D To set the buffer for a digital port (MSO models only), use one of these values: PS2000A_DIGITAL_PORT0 = 0x80 PS2000A_DIGITAL_PORT1 = 0x81 * buffer, the location of the buffer bufferLth, the size of the buffer array segmentIndex, the number of the memory segment to be used mode, the downsampling mode. See ps2000aGetValues for the available modes, but note that a single call to ps2000aSetDataBuffer can only associate one buffer with one downsampling mode. If you intend to call ps2000aGetValues with more than one downsampling mode activated, then you must call ps2000aSetDataBuffer several times to associate a separate buffer with each downsampling mode.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_CHANNEL PICO_RATIO_MODE_NOT_SUPPORTED PICO_SEGMENT_OUT_OF_RANGE PICO_DRIVER_FUNCTION PICO_INVALID_PARAMETER

3.41 ps2000aSetDataBuffers() – register aggregated data buffers with driver

```
PICO_STATUS ps2000aSetDataBuffers
(
    int16_t                 handle,
    int32_t                 channel,
    int16_t                 * bufferMax,
    int16_t                 * bufferMin,
    int32_t                 bufferLth,
    uint32_t                segmentIndex,
    PS2000A_RATIO_MODE  mode
)
```

This function tells the driver the location of one or two buffers for receiving data. You need to allocate memory for the buffers before calling this function. If you do not need two buffers, because you are not using aggregate mode, you can optionally use ps2000aSetDataBuffer instead.

Applicability	Block and streaming modes with aggregation.
Arguments	handle, device identifier returned by ps2000aOpenUnit channel, the channel for which you want to set the buffers. Use one of these constants: PS2000A_CHANNEL_A PS2000A_CHANNEL_B PS2000A_CHANNEL_C PS2000A_CHANNEL_D To set the buffer for a digital port (MSO models only), use one of these values: PS2000A_DIGITAL_PORT0 = 0x80 PS2000A_DIGITAL_PORT1 = 0x81 * bufferMax, a buffer to receive the maximum data values in aggregation mode, or the non-aggregated values otherwise * bufferMin, a buffer to receive the minimum aggregated data values. Not used in other downsampling modes bufferLth, the size of the bufferMax and bufferMin arrays segmentIndex, the number of the memory segment to be used mode, see ps2000aGetValues.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_CHANNEL PICO_RATIO_MODE_NOT_SUPPORTED PICO_SEGMENT_OUT_OF_RANGE PICO_DRIVER_FUNCTION PICO_INVALID_PARAMETER

3.42 ps2000aSetDigitalAnalogTriggerOperand() – set up combined analog/digital trigger

```
PICO_STATUS ps2000aSetDigitalAnalogTriggerOperand
(
    int16_t                        handle,
    PS2000A_TRIGGER_OPERAND        operand
)
```

Mixed-signal (MSO) models in this series have two independent triggers, one for the analog input channels and another for the digital inputs. This function defines how the two triggers are combined.

Applicability	MSO models only
Arguments	handle, device identifier returned by ps2000aOpenUnit operand, one of the following constants: PS2000A_OPERAND_NONE, ignore the trigger settings PS2000A_OPERAND_OR, fire when either trigger is activated PS2000A_OPERAND_AND, fire when both triggers are activated PS2000A_OPERAND_THEN, fire when one trigger is activated followed by the other
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_NOT_USED PICO_INVALID_PARAMETER

3.43 ps2000aSetDigitalPort() – set up digital input

```
PICO_STATUS ps2000aSetDigitalPort
(
    int16_t                  handle,
    PS2000A_DIGITAL_PORT     port,
    int16_t                  enabled,
    int16_t                  logiclevel
)
```

This function is used to enable the digital ports of an MSO and set the logic level (the voltage point at which the state transitions from 0 to 1).

Applicability	MSO devices only. Block and streaming modes with aggregation. Not compatible with ETS mode.
Arguments	handle, device identifier returned by ps2000aOpenUnit port, the digital port to be configured: PS2000A_DIGITAL_PORT0 = 0x80 (D0 to D7) PS2000A_DIGITAL_PORT1 = 0x81 (D8 to D15) enabled, whether or not to enable the channel. The values are: TRUE: enable FALSE: do not enable logiclevel, the logic threshold voltage Range: –32767 (–5 V) to 32767 (5 V).
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_CHANNEL PICO_RATIO_MODE_NOT_SUPPORTED PICO_SEGMENT_OUT_OF_RANGE PICO_DRIVER_FUNCTION PICO_INVALID_PARAMETER

3.44 ps2000aSetEts() – set up equivalent-time sampling

```
PICO_STATUS ps2000aSetEts
(
    int16_t                  handle,
    PS2000A_ETS_MODE         mode,
    int16_t                  etsCycles,
    int16_t                  etsInterleave,
    int32_t                  * sampleTimePicoseconds
)
```

This function is used to enable or disable ETS (equivalent-time sampling) and to set the ETS parameters. See ETS overview for an explanation of ETS mode.

Applicability	Block mode only. On MSOs, ETS mode not available when digital port(s) enabled.
Arguments	handle, device identifier returned by ps2000aOpenUnit mode, the ETS mode. Use one of these values: PS2000A_ETS_OFF: disables ETS PS2000A_ETS_FAST: enables ETS and provides etsCycles of data, which may contain data from previously returned cycles PS2000A_ETS_SLOW: enables ETS and provides fresh data every etsCycles. This mode takes longer to provide each data set, but the data sets are more stable and are guaranteed to contain only new data. etsCycles, the number of cycles to store: the computer can then select etsInterleave cycles to give the most uniform spread of samples. Range: between two and five times the value of etsInterleave, and not more than the appropriate MAX_ETS_CYCLES constant: 500 for the PicoScope 2206B, 2206B MSO, 2207B, 2207B MSO, 2208B, 2208B MSO, 2405A, 2406B, 2407B, 2408B PS2206_MAX_ETS_CYCLES for the PicoScope 2206, 2206A PS2207_MAX_ETS_CYCLES for the PicoScope 2207, 2207A PS2208_MAX_ETS_CYCLES for the PicoScope 2208, 2208A etsInterleave, the number of waveforms to combine into a single ETS capture. Maximum value is: 40 for the PicoScope 2206B, 2206B MSO, 2207B, 2207B MSO, 2208B, 2208B MSO, 2405A, 2406B, 2407B, 2408B PS2206_MAX_INTERLEAVE for the PicoScope 2206, 2206A PS2207_MAX_INTERLEAVE for the PicoScope 2207, 2207A PS2208_MAX_INTERLEAVE for the PicoScope 2208, 2208A * sampleTimePicoseconds, on exit, the effective sampling interval of the ETS data. For example, if the captured sample time is 4 ns and etsInterleave is 10, then the effective sample time in ETS mode is 400 ps.
Returns	PICO_OK PICO_USER_CALLBACK PICO_INVALID_HANDLE PICO_INVALID_PARAMETER PICO_DRIVER_FUNCTION

3.45 ps2000aSetEtsTimeBuffer() – set up 64-bit buffer for ETS timings

```
PICO_STATUS ps2000aSetEtsTimeBuffer
(
    int16_t                 handle,
    int64_t                 * buffer,
    int32_t                 bufferLth
)
```

This function tells the driver where to find your application's ETS time buffers. These buffers contain the 64-bit timing information for each ETS sample after you run a block-mode ETS capture.

Applicability	ETS mode only. If your programming language does not support 64-bit data, use the 32-bit version ps2000aSetEtsTimeBuffers instead.
Arguments	handle, device identifier returned by ps2000aOpenUnit * buffer, an array of 64-bit words, each representing the time in femtoseconds (10^{-15} s) at which the sample was captured bufferLth, the size of the buffer array
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NULL_PARAMETER PICO_DRIVER_FUNCTION

3.46 ps2000aSetEtsTimeBuffers() – set up 32-bit buffers for ETS timings

```
PICO_STATUS ps2000aSetEtsTimeBuffers
(
    int16_t                     handle,
    uint32_t                    * timeUpper,
    uint32_t                    * timeLower,
    int32_t                     bufferLth
)
```

This function tells the driver where to find your application's ETS time buffers. These buffers contain the timing information for each ETS sample after you run a block-mode ETS capture. There are two buffers containing the upper and lower 32-bit parts of the timing information, to allow programming languages that do not support 64-bit data to retrieve the timings.

Applicability	ETS mode only. If your programming language supports 64-bit data then you can use ps2000aSetEtsTimeBuffer instead.
Arguments	handle, device identifier returned by ps2000aOpenUnit * timeUpper, an array of 32-bit words, each representing the upper 32 bits of the time in femtoseconds (10^{-15} s) at which the sample was captured * timeLower, an array of 32-bit words, each representing the lower 32 bits of the time in femtoseconds (10^{-15} s) at which the sample was captured bufferLth, the size of the timeUpper and timeLower arrays
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NULL_PARAMETER PICO_DRIVER_FUNCTION

3.47 ps2000aSetNoOfCaptures() – set number of captures to collect in one run

```
PICO_STATUS ps2000aSetNoOfCaptures
(
    int16_t   handle,
    uint32_t nCaptures
)
```

This function sets the number of captures to be collected in one run of rapid block mode. If you do not call this function before a run, the driver will capture only one waveform. Once a value has been set, the value remains constant unless changed.

Applicability	Rapid block mode
Arguments	handle, device identifier returned by ps2000aOpenUnit nCaptures, the number of waveforms to capture in one run
Returns	PICO_OK PICO_INVALID_HANDLE PICO_INVALID_PARAMETER PICO_DRIVER_FUNCTION

3.48 ps2000aSetOutputEdgeDetect() – enable or disable state trigger edge-detection

```
PICO_STATUS ps2000aSetOutputEdgeDetect
(
    int16_t                 handle,
    int16_t                 state
)
```

This function tells the device whether or not to wait for an edge on the trigger input when one of the 'level' or 'window' trigger types is in use. By default the device waits for an edge on the trigger input before firing the trigger. If you switch off edge detect mode, the device will trigger continually for as long as the trigger input remains in the specified state.

You can query the state of this flag by calling ps2000aQueryOutputEdgeDetect.

Applicability	Level and window trigger types
Arguments	handle, device identifier returned by ps2000aOpenUnit state, a flag that specifies the trigger behavior: 0 : do not wait for a signal transition <> 0 : wait for a signal transition (default)
Returns	PICO_OK

3.49 ps2000aSetPulseWidthDigitalPortProperties() – set pulse-width triggering on digital inputs

```
PICO_STATUS ps2000aSetPulseWidthDigitalPortProperties
(
    int16_t                                 handle,
    PS2000A_DIGITAL_CHANNEL_DIRECTIONS      * directions
    int16_t                                 nDirections
)
```

This function will set the individual digital channels' pulse-width trigger directions. Each trigger direction consists of a channel name and a direction. If the channel is not included in the array of PS2000A_DIGITAL_CHANNEL_DIRECTIONS the driver assumes the digital channel's pulse-width trigger direction is PS2000A_DIGITAL_DONT_CARE.

Applicability	All modes. MSO models only.
Arguments	handle, device identifier returned by ps2000aOpenUnit * directions, a pointer to an array of PS2000A_DIGITAL_CHANNEL_DIRECTIONS structures describing the requested properties. The array can contain a single element describing the properties of one channel, or a number of elements describing several digital channels. If directions is NULL, digital pulse-width triggering is switched off. A digital channel that is not included in the array will be set to PS2000A_DIGITAL_DONT_CARE. nDirections, the number of digital channel directions being passed to the driver
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_INVALID_DIGITAL_CHANNEL PICO_INVALID_DIGITAL_TRIGGER_DIRECTION

3.50 ps2000aSetPulseWidthQualifier() – set up pulse width triggering

```
PICO_STATUS ps2000aSetPulseWidthQualifier
(
    int16_t                         handle,
    PS2000A_PWQ_CONDITIONS          * conditions,
    int16_t                         nConditions,
    PS2000A_THRESHOLD_DIRECTION     direction,
    uint32_t                        lower,
    uint32_t                        upper,
    PS2000A_PULSE_WIDTH_TYPE        type
)
```

This function sets up the conditions for pulse width qualification, which is used with either threshold triggering, level triggering or window triggering to produce time-qualified triggers.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * conditions, an array of PS2000A_PWQ_CONDITIONS structures specifying the conditions that should be applied to each channel. In the simplest case, the array consists of a single element. When there are several elements, the overall trigger condition is the logical OR of all the elements. Since each element can combine a number of input conditions using AND logic, this AND-OR logic enables you to create a qualifier based on any possible Boolean function of the inputs. If conditions is NULL then the pulse-width qualifier is not used. nConditions, the number of elements in the conditions array. If nConditions is zero then the pulse-width qualifier is not used. Range: 0 to PS2000A_MAX_PULSE_WIDTH_QUALIFIER_COUNT. direction, the direction of the signal required for the pulse width trigger to fire. See PS2000A_THRESHOLD_DIRECTION constants for the list of possible values. Each channel of the oscilloscope (except the EXT input) has two thresholds for each direction —for example, PS2000A_RISING and PS2000A_RISING_LOWER — so that one can be used for the pulse-width qualifier and the other for the level trigger. The driver will not let you use the same threshold for both triggers; so, for example, you cannot use PS2000A_RISING as the direction argument for both ps2000aSetTriggerConditions and ps2000aSetPulseWidthQualifier at the same time. There is no such restriction when using window triggers. lower, the lower limit of the pulse-width counter, measured in sample periods upper, the upper limit of the pulse-width counter, measured in sample periods. This parameter is used only when the type is set to PS2000A_PW_TYPE_IN_RANGE or PS2000A_PW_TYPE_OUT_OF_RANGE. type, the pulse-width type, one of these constants: PS2000A_PW_TYPE_NONE: do not use the pulse width qualifier PS2000A_PW_TYPE_LESS_THAN: pulse width less than lower PS2000A_PW_TYPE_GREATER_THAN: pulse width greater than lower PS2000A_PW_TYPE_IN_RANGE: pulse width between lower and upper PS2000A_PW_TYPE_OUT_OF_RANGE: pulse width not between lower and upper

Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_CONDITIONS PICO_PULSE_WIDTH_QUALIFIER PICO_DRIVER_FUNCTION

3.50.1 PS2000A_PWQ_CONDITIONS structure

A structure of this type is passed to ps2000aSetPulseWidthQualifier in the conditions argument to specify a set of trigger conditions. It is defined as follows:

```
typedef struct tPS2000APwqConditions
{
    PS2000A_TRIGGER_STATE    channelA;
    PS2000A_TRIGGER_STATE    channelB;
    PS2000A_TRIGGER_STATE    channelC;
    PS2000A_TRIGGER_STATE    channelD;
    PS2000A_TRIGGER_STATE    external;
    PS2000A_TRIGGER_STATE    aux;
    PS2000A_TRIGGER_STATE    digital;
} PS2000A_PWQ_CONDITIONS
```

The resulting trigger condition is the logical AND of the conditions applied to all the inputs. An array of these structures can be passed to ps2000aSetPulseWidthQualifier, which ORs them to produce the final pulse width qualifier. This method can generate any possible Boolean function of the scope's input conditions.

The structure is byte-aligned. In C++, for example, you should specify this using the #pragma pack() instruction.

Elements	channelA, channelB, channelC, channelD, external: the type of condition that should be applied to each channel. Use these constants: PS2000A_CONDITION_DONT_CARE PS2000A_CONDITION_TRUE PS2000A_CONDITION_FALSE The channels that are set to PS2000A_CONDITION_TRUE or PS2000A_CONDITION_FALSE must all meet their conditions simultaneously to produce a trigger. Channels set to PS2000A_CONDITION_DONT_CARE are ignored. aux, digital: not used

3.51 ps2000aSetSigGenArbitrary() - – set up arbitrary waveform generator

```
PICO_STATUS ps2000aSetSigGenArbitrary
(
    int16_t                          handle,
    int32_t                          offsetVoltage,
    uint32_t                         pkToPk
    uint32_t                         startDeltaPhase,
    uint32_t                         stopDeltaPhase,
    uint32_t                         deltaPhaseIncrement,
    uint32_t                         dwellCount,
    int16_t                          * arbitraryWaveform,
    int32_t                          arbitraryWaveformSize,
    PS2000A_SWEEP_TYPE               sweepType,
    PS2000A_EXTRA_OPERATIONS         operation,
    PS2000A_INDEX_MODE               indexMode,
    uint32_t                         shots,
    uint32_t                         sweeps,
    PS2000A_SIGGEN_TRIG_TYPE         triggerType,
    PS2000A_SIGGEN_TRIG_SOURCE       triggerSource,
    int16_t                          extInThreshold
)
```

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 phase accumulator initially increments by startDeltaPhase. If the AWG is set to sweep mode, the phase increment is increased at specified intervals until it reaches stopDeltaPhase. The easiest way to obtain the values of startDeltaPhase and stopDeltaPhase necessary to generate the desired frequency is to call ps2000aSigGenFrequencyToPhase. Alternatively, see Calculating deltaPhase below for more information on how to calculate these values.

Applicability	All modes
Arguments	
handle, device identifier returned by ps2000aOpenUnit 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 accumulator as the generator begins to step through the waveform buffer. Calculate this value from the information above, or use ps2000aSigGenFrequencyToPhase. stopDeltaPhase, the final value added to the phase accumulator before the generator restarts or reverses the sweep. When frequency sweeping is not required, set equal to startDeltaPhase.	

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. When frequency sweeping is not required, set to zero.

dwellCount, the time, in multiples of *ddsPeriod*, between successive additions of deltaPhaseIncrement to the delta phase accumulator. This determines the rate at which the generator sweeps the output frequency.
Minimum value: PS2000A_MIN_DWELL_COUNT

* arbitraryWaveform, a buffer that holds the waveform pattern as a set of samples equally spaced in time. Each sample is scaled to an output voltage as follows:

$$v_{OUT} = 1\ \mu V \times (\text{pkToPk} / 2) \times (\textit{sample\_value} / 32767) + \text{offsetVoltage}$$

and clipped to the overall ±2 V range of the AWG.

arbitraryWaveformSize, the size of the arbitrary waveform buffer, in samples, in the range:
[minArbitraryWaveformSize, maxArbitraryWaveformSize]
where minArbitraryWaveformSize and maxArbitraryWaveformSize are the values returned by ps2000aSigGenArbitraryMinMaxValues.

sweepType, determines whether the startDeltaPhase is swept up to the stopDeltaPhase, or down to it, or repeatedly swept up and down. Use one of these values:
PS2000A_UP
PS2000A_DOWN
PS2000A_UPDOWN
PS2000A_DOWNUP

operation, the type of waveform to be produced, specified by one of the following enumerated types:
PS2000A_ES_OFF, normal AWG operation using the waveform buffer.
PS2000A_WHITENOISE, the signal generator produces white noise and ignores all settings except offsetVoltage and pkToPk.
PS2000A_PRBS, produces a random bitstream with a bit rate specified by the phase accumulator.

indexMode, specifies how the signal will be formed from the arbitrary waveform data. Single and dual index modes are possible. Use one of these constants:
PS2000A_SINGLE
PS2000A_DUAL

shots,
0: sweep the frequency as specified by sweeps
1...PS2000A_MAX_SWEEPS_SHOTS: the number of cycles of the waveform to be produced after a trigger event. sweeps must be zero.
PS2000A_SHOT_SWEEP_TRIGGER_CONTINUOUS_RUN: start and run continuously after trigger occurs (not PicoScope 2205 MSO)

sweeps,
0: produce number of cycles specified by shots
1..PS2000A_MAX_SWEEPS_SHOTS: the number of times to sweep the frequency after a trigger event, according to sweepType. shots must be zero.
PS2000A_SHOT_SWEEP_TRIGGER_CONTINUOUS_RUN: start a sweep and continue after trigger occurs (not PicoScope 2205 MSO)

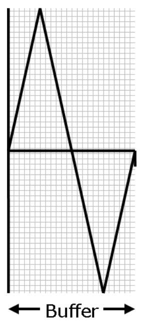
triggerType, the type of trigger that will be applied to the signal generator:

	PS2000A_SIGGEN_RISING trigger on rising edge PS2000A_SIGGEN_FALLING trigger on falling edge PS2000A_SIGGEN_GATE_HIGH run while trigger is high PS2000A_SIGGEN_GATE_LOW run while trigger is low triggerSource, the source that will trigger the signal generator: PS2000A_SIGGEN_NONE run without waiting for trigger PS2000A_SIGGEN_SCOPE_TRIG use scope trigger PS2000A_SIGGEN_EXT_IN use EXT input (if available) PS2000A_SIGGEN_SOFT_TRIG wait for software trigger provided by ps2000aSigGenSoftwareControl PS2000A_SIGGEN_TRIGGER_RAW reserved If a trigger source other than P2000A_SIGGEN_NONE is specified, then either shots or sweeps, but not both, must be non-zero. extInThreshold, trigger level, in ADC counts, for external trigger
Returns	PICO_OK PICO_AWG_NOT_SUPPORTED PICO_BUSY PICO_INVALID_HANDLE PICO_SIG_GEN_PARAM PICO_SHOTS_SWEEPS_WARNING PICO_NOT_RESPONDING PICO_WARNING_EXT_THRESHOLD_CONFLICT PICO_NO_SIGNAL_GENERATOR PICO_SIGGEN_OFFSET_VOLTAGE PICO_SIGGEN_PK_TO_PK PICO_SIGGEN_OUTPUT_OVER_VOLTAGE PICO_DRIVER_FUNCTION PICO_SIGGEN_WAVEFORM_SETUP_FAILED

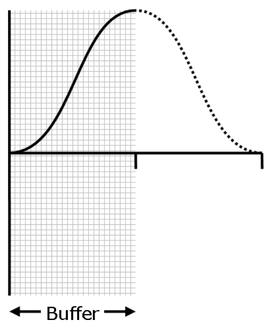
3.51.1 AWG index modes

The arbitrary waveform generator supports **single** and **dual** index modes to help you make the best use of the waveform buffer.

Single mode. The generator outputs the raw contents of the buffer repeatedly. This mode is the only one that can generate asymmetrical waveforms. You can also use this mode for symmetrical waveforms, but the dual and quad modes make more efficient use of the buffer memory.



Dual mode. The generator outputs the contents of the buffer from beginning to end, and then does a second pass in the reverse direction through the buffer. This allows you to specify only the first half of a waveform with twofold symmetry, such as a Gaussian function, and let the generator fill in the other half.



3.51.2 Calculating deltaPhase

The arbitrary waveform generator (AWG) steps through the waveform buffer 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	= update rate of DDS counter for each model
deltaPhase	= calculated from `startDeltaPhase` and `deltaPhaseIncrement` (we recommend that you use ps2000aSigGenFrequencyToPhase to calculate *deltaPhase*)
phaseAccumulatorSize	= 2^{32} for all models
awgBufferSize	= AWG buffer size for each model
arbitraryWaveformSize	= length in samples of the user-defined waveform

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`.

Parameter	**PicoScope 2205 MSO**	**PicoScope 2205A MSO 2206/2206A 2207/2207A 2208/2208A 2405A**	**PicoScope 2206B/2206B MSO 2207B/2207B MSO 2208B/2208B MSO 2406B 2407B 2408B**
phaseAccumulatorSize	2^{32}	2^{32}	2^{32}
ddsFrequency	48 MHz	20 MHz	20 MHz
awgBufferSize	8192 samples	8192 samples	32 768 samples
ddsPeriod (= 1/*ddsFrequency*)	20.83 ns	50 ns	50 ns

3.52 ps2000aSetSigGenBuiltIn() – set up standard signal generator

```
PICO_STATUS ps2000aSetSigGenBuiltIn
(
    int16_t                       handle,
    int32_t                       offsetVoltage,
    uint32_t                      pkToPk
    int16_t                       waveType
    float                         startFrequency,
    float                         stopFrequency,
    float                         increment,
    float                         dwellTime,
    PS2000A_SWEEP_TYPE            sweepType,
    PS2000A_EXTRA_OPERATIONS      operation,
    uint32_t                      shots,
    uint32_t                      sweeps,
    PS2000A_SIGGEN_TRIG_TYPE      triggerType,
    PS2000A_SIGGEN_TRIG_SOURCE    triggerSource,
    int16_t                       extInThreshold
)
```

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 device will sweep either up, down, or up and down.

Applicability	All modes
Arguments	

handle, device identifier returned by ps2000aOpenUnit
offsetVoltage, the voltage offset, in microvolts, to be applied to the waveform

pkToPk, the peak-to-peak voltage, in microvolts, of the waveform signal

Note: if the signal voltages described by the combination of offsetVoltage and pkToPk extend outside the voltage range of the signal generator, the output waveform will be clipped.

waveType, the type of waveform to be generated:

PS2000A_SINE	sine wave
PS2000A_SQUARE	square wave
PS2000A_TRIANGLE	triangle wave
PS2000A_DC_VOLTAGE	DC voltage
PS2000A_RAMP_UP	rising sawtooth
PS2000A_RAMP_DOWN	falling sawtooth
PS2000A_SINC	sin(x)/x
PS2000A_GAUSSIAN	Gaussian
PS2000A_HALF_SINE	half (full-wave rectified) sine

startFrequency, the frequency that the signal generator will initially produce. Allowable values are between one of these constants:

PS2000A_MIN_FREQUENCY
PS2000A_PRBS_MIN_FREQUENCY

and one of these constants:

PS2000A_SINE_MAX_FREQUENCY
PS2000A_SQUARE_MAX_FREQUENCY
PS2000A_TRIANGLE_MAX_FREQUENCY
PS2000A_SINC_MAX_FREQUENCY
PS2000A_RAMP_MAX_FREQUENCY
PS2000A_HALF_SINE_MAX_FREQUENCY
PS2000A_GAUSSIAN_MAX_FREQUENCY
PS2000A_PRBS_MAX_FREQUENCY

depending on the signal type.

stopFrequency, the frequency at which the sweep reverses direction or returns to the initial frequency

increment, the amount of frequency increase or decrease in sweep mode

dwellTime, the time for which the sweep stays at each frequency, in seconds

sweepType, whether the frequency will sweep from startFrequency to stopFrequency, or in the opposite direction, or repeatedly reverse direction. Use one of these constants:
PS2000A_UP
PS2000A_DOWN
PS2000A_UPDOWN
PS2000A_DOWNUP

operation, the type of waveform to be produced, specified by one of the following enumerated types:
PS2000A_ES_OFF, normal signal generator operation specified by waveType.
PS2000A_WHITENOISE, the signal generator produces white noise and ignores all settings except pkToPk and offsetVoltage.
PS2000A_PRBS, produces a random bitstream with a bit rate specified by the start and stop frequency *(not available on PicoScope 2205 MSO)*.

shots, see ps2000aSigGenArbitrary
sweeps, see ps2000aSigGenArbitrary
triggerType, see ps2000aSigGenArbitrary
triggerSource, see ps2000aSigGenArbitrary
extInThreshold, see ps2000aSigGenArbitrary

Returns	PICO_OK PICO_BUSY PICO_INVALID_HANDLE PICO_SIG_GEN_PARAM PICO_SHOTS_SWEEPS_WARNING PICO_NOT_RESPONDING PICO_WARNING_AUX_OUTPUT_CONFLICT PICO_WARNING_EXT_THRESHOLD_CONFLICT PICO_NO_SIGNAL_GENERATOR PICO_SIGGEN_OFFSET_VOLTAGE PICO_SIGGEN_PK_TO_PK PICO_SIGGEN_OUTPUT_OVER_VOLTAGE PICO_DRIVER_FUNCTION PICO_SIGGEN_WAVEFORM_SETUP_FAILED PICO_NOT_RESPONDING

3.53 ps2000SetSigGenBuiltInV2() – double precision sig. gen. setup

```
PICO_STATUS ps2000aSetSigGenBuiltInV2
(
    int16_t                        handle,
    int32_t                        offsetVoltage,
    uint32_t                       pkToPk
    int16_t                        waveType
    double                         startFrequency,
    double                         stopFrequency,
    double                         increment,
    double                         dwellTime,
    PS2000_SWEEP_TYPE              sweepType,
    PS2000_EXTRA_OPERATIONS        operation,
    uint32_t                       shots,
    uint32_t                       sweeps,
    PS2000_SIGGEN_TRIG_TYPE        triggerType,
    PS2000_SIGGEN_TRIG_SOURCE      triggerSource,
    int16_t                        extInThreshold
)
```

This function sets up the signal generator. It differs from ps2000SetSigGenBuiltIn in having double-precision arguments instead of floats, giving greater resolution when setting the output frequency.

Applicability	All modes
Arguments	See ps2000SetSigGenBuiltIn
Returns	See ps2000SetSigGenBuiltIn

3.54 ps2000aSetSigGenPropertiesArbitrary() – change AWG properties

```
PICO_STATUS ps2000aSetSigGenPropertiesArbitrary
(
    int16_t                       handle,
    uint32_t                      startDeltaPhase,
    uint32_t                      stopDeltaPhase,
    uint32_t                      deltaPhaseIncrement,
    uint32_t                      dwellCount,
    PS2000A_SWEEP_TYPE            sweepType,
    uint32_t                      shots,
    uint32_t                      sweeps,
    PS2000A_SIGGEN_TRIG_TYPE      triggerType,
    PS2000A_SIGGEN_TRIG_SOURCE    triggerSource,
    int16_t                       extInThreshold
)
```

This function reprograms the arbitrary waveform generator. All values can be reprogrammed while the signal generator is waiting for a trigger.

Applicability	All modes
Arguments	See ps2000SetSigGenArbitrary
Returns	PICO_OK if successful PICO_INVALID_HANDLE PICO_NO_SIGNAL_GENERATOR PICO_DRIVER_FUNCTION PICO_AWG_NOT_SUPPORTED PICO_SIGGEN_OFFSET_VOLTAGE PICO_SIGGEN_PK_TO_PK PICO_SIGGEN_OUTPUT_OVER_VOLTAGE PICO_SIG_GEN_PARAM PICO_SHOTS_SWEEPS_WARNING PICO_WARNING_EXT_THRESHOLD_CONFLICT PICO_BUSY PICO_SIGGEN_WAVEFORM_SETUP_FAILED PICO_NOT_RESPONDING

3.55 ps2000aSetSigGenPropertiesBuiltIn() – change standard signal generator properties

```
PICO_STATUS ps2000aSetSigGenPropertiesBuiltIn
(
    int16_t                       handle,
    double                        startFrequency,
    double                        stopFrequency,
    double                        increment,
    double                        dwellTime,
    PS2000A_SWEEP_TYPE            sweepType,
    uint32_t                      shots,
    uint32_t                      sweeps,
    PS2000A_SIGGEN_TRIG_TYPE      triggerType,
    PS2000A_SIGGEN_TRIG_SOURCE    triggerSource,
    int16_t                       extInThreshold
)
```

This function reprograms the signal generator. Values can be changed while the signal generator is waiting for a trigger.

Applicability	All modes
Arguments	See ps2000SetSigGenBuiltIn
Returns	PICO_OK if successful PICO_INVALID_HANDLE PICO_NO_SIGNAL_GENERATOR PICO_DRIVER_FUNCTION PICO_WARNING_EXT_THRESHOLD_CONFLICT PICO_SIGGEN_OFFSET_VOLTAGE PICO_SIGGEN_PK_TO_PK PICO_SIGGEN_OUTPUT_OVER_VOLTAGE PICO_SIG_GEN_PARAM PICO_SHOTS_SWEEPS_WARNING PICO_WARNING_EXT_THRESHOLD_CONFLICT PICO_BUSY PICO_SIGGEN_WAVEFORM_SETUP_FAILED PICO_NOT_RESPONDING

3.56 ps2000aSetSimpleTrigger() – set up level triggers

```
PICO_STATUS ps2000aSetSimpleTrigger
(
    int16_t                       handle,
    int16_t                       enable,
    PS2000A_CHANNEL               source,
    int16_t                       threshold,
    PS2000A_THRESHOLD_DIRECTION   direction,
    uint32_t                      delay,
    int16_t                       autoTrigger_ms
)
```

This function simplifies arming the trigger. It supports only the LEVEL trigger types and does not allow more than one channel to have a trigger applied to it. Any previous pulse width qualifier is canceled.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit enable, zero to disable the trigger; any non-zero value to set the trigger source, the channel on which to trigger threshold, the ADC count at which the trigger will fire direction, the direction in which the signal must move to cause a trigger. The following directions are supported: ABOVE, BELOW, RISING, FALLING and RISING_OR_FALLING. delay, the time between the trigger occurring and the first sample being taken. For example, if delay=100 then the scope would wait 100 sample periods before sampling. autoTrigger_ms, the number of milliseconds the device will wait if no trigger occurs. If this is set to zero, the scope device will wait indefinitely for a trigger.
Returns	PICO_OK PICO_INVALID_CHANNEL PICO_INVALID_PARAMETER PICO_MEMORY PICO_CONDITIONS PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_DRIVER_FUNCTION

3.57 ps2000aSetTriggerChannelConditions() – specify which channels to trigger on

```
PICO_STATUS ps2000aSetTriggerChannelConditions
(
    int16_t                          handle,
    PS2000A_TRIGGER_CONDITIONS       * conditions,
    int16_t                          nConditions
)
```

This function sets up trigger conditions on the scope's inputs. The trigger is defined by one or more PS2000A_TRIGGER_CONDITIONS structures that are then ORed together. Each structure is itself the AND of the states of one or more of the inputs. This AND-OR logic allows you to create any possible Boolean function of the scope's inputs.

If complex triggering is not required, use ps2000aSetSimpleTrigger.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * conditions, an array of PS2000A_TRIGGER_CONDITIONS structures specifying the conditions that should be applied to each channel. In the simplest case, the array consists of a single element. When there is more than one element, the overall trigger condition is the logical OR of all the elements. nConditions, the number of elements in the conditions array. If nConditions is zero then triggering is switched off.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_CONDITIONS PICO_MEMORY PICO_DRIVER_FUNCTION

3.57.1 PS2000A_TRIGGER_CONDITIONS structure

A structure of this type is passed to ps2000aSetTriggerChannelConditions in the conditions argument to specify the trigger conditions, and is defined as follows:

```
typedef struct tPS2000ATriggerConditions
{
    PS2000A_TRIGGER_STATE    channelA;
    PS2000A_TRIGGER_STATE    channelB;
    PS2000A_TRIGGER_STATE    channelC;
    PS2000A_TRIGGER_STATE    channelD;
    PS2000A_TRIGGER_STATE    external;
    PS2000A_TRIGGER_STATE    aux;
    PS2000A_TRIGGER_STATE    pulseWidthQualifier;
    PS2000A_TRIGGER_STATE    digital;
} PS2000A_TRIGGER_CONDITIONS
```

Each structure is the logical AND of the states of the scope's inputs. The ps2000aSetTriggerChannelConditions function can OR together a number of these structures to produce the final trigger condition, which can be any possible Boolean function of the scope's inputs.

The structure is byte-aligned. In C++, for example, you should specify this using the #pragma pack() instruction.

Elements	channelA, channelB, channelC, channelD, external, pulseWidthQualifier: the type of condition that should be applied to each channel. Use these constants: PS2000A_CONDITION_DONT_CARE PS2000A_CONDITION_TRUE PS2000A_CONDITION_FALSE The channels that are set to PS2000A_CONDITION_TRUE or PS2000A_CONDITION_FALSE must all meet their conditions simultaneously to produce a trigger. Channels set to PS2000A_CONDITION_DONT_CARE are ignored. aux, digital: not used

3.58 ps2000aSetTriggerChannelDirections() – set up signal polarities for triggering

```
PICO_STATUS ps2000aSetTriggerChannelDirections
(
    int16_t                          handle,
    PS2000A_THRESHOLD_DIRECTION      channelA,
    PS2000A_THRESHOLD_DIRECTION      channelB,
    PS2000A_THRESHOLD_DIRECTION      channelC,
    PS2000A_THRESHOLD_DIRECTION      channelD,
    PS2000A_THRESHOLD_DIRECTION      ext,
    PS2000A_THRESHOLD_DIRECTION      aux
)
```

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

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit channelA, channelB, channelC, channelD, ext, the direction in which the signal must pass through the threshold to activate the trigger. See the table below for allowable values. If using a level trigger in conjunction with a pulse-width trigger, see the description of the direction argument to ps2000aSetPulseWidthQualifier for more information. aux: not used
Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_INVALID_PARAMETER

PS2000A_THRESHOLD_DIRECTION **constants**

Constant	Trigger type	Direction
PS2000A_ABOVE	gated	above the upper threshold
PS2000A_ABOVE_LOWER	gated	above the lower threshold
PS2000A_BELOW	gated	below the upper threshold
PS2000A_BELOW_LOWER	gated	below the lower threshold
PS2000A_RISING	threshold	rising edge, using upper threshold
PS2000A_RISING_LOWER	threshold	rising edge, using lower threshold
PS2000A_FALLING	threshold	falling edge, using upper threshold
PS2000A_FALLING_LOWER	threshold	falling edge, using lower threshold
PS2000A_RISING_OR_FALLING	threshold	either edge
PS2000A_INSIDE	window-qualified	inside window
PS2000A_OUTSIDE	window-qualified	outside window
PS2000A_ENTER	window	entering the window
PS2000A_EXIT	window	leaving the window
PS2000A_ENTER_OR_EXIT	window	entering or leaving the window
PS2000A_NONE	none	none

3.59 ps2000aSetTriggerChannelProperties() – set up trigger thresholds

```
PICO_STATUS ps2000aSetTriggerChannelProperties
(
    int16_t                             handle,
    PS2000A_TRIGGER_CHANNEL_PROPERTIES  * channelProperties,
    int16_t                             nChannelProperties,
    int16_t                             auxOutputEnable,
    int32_t                             autoTriggerMilliseconds
)
```

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

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * channelProperties, a pointer to an array of PS2000A_TRIGGER_CHANNEL_PROPERTIES structures describing the requested properties. The array can contain a single element describing the properties of one channel, or a number of elements describing several channels. If NULL is passed, triggering is switched off. nChannelProperties, the size of the channelProperties array. If zero, triggering is switched off. auxOutputEnable, not used autoTriggerMilliseconds, the time in milliseconds for which the scope device will wait before collecting data if no trigger event occurs. If this is set to zero, the scope device will wait indefinitely for a trigger.
Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_TRIGGER_ERROR PICO_MEMORY PICO_INVALID_TRIGGER_PROPERTY PICO_DRIVER_FUNCTION PICO_INVALID_PARAMETER

3.59.1 PS2000A_TRIGGER_CHANNEL_PROPERTIES structure

A structure of this type is passed to ps2000aSetTriggerChannelProperties in the channelProperties argument to specify the trigger mechanism, and is defined as follows:

```
typedef struct tPS2000ATriggerChannelProperties
{
    int16_t                     thresholdUpper;
    uint16_t                    thresholdUpperHysteresis;
    int16_t                     thresholdLower;
    uint16_t                    thresholdLowerHysteresis;
    PS2000A_CHANNEL             channel;
    PS2000A_THRESHOLD_MODE      thresholdMode;
} PS2000A_TRIGGER_CHANNEL_PROPERTIES
```

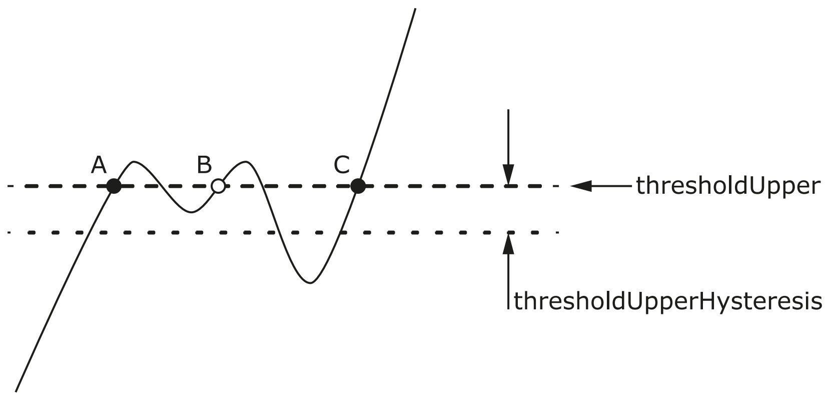
The structure is byte-aligned. In C++, for example, you should specify this using the #pragma pack() instruction.

Upper and lower thresholds
The digital triggering hardware in your PicoScope has two independent trigger thresholds called *upper* and *lower*. For some trigger types you can freely choose which threshold to use. The table in ps2000aSetTriggerChannelDirections shows which thresholds are available for use with which trigger types. Dual thresholds are used for pulse-width triggering, when one threshold applies to the level trigger and the other to the pulse-width qualifier; and for window triggering, when the two thresholds define the upper and lower limits of the window.

Each threshold has its own trigger and hysteresis settings.

Hysteresis
Each trigger threshold (*upper* and *lower*) has an accompanying parameter called *hysteresis*. This defines a second threshold at a small offset from the main threshold. The trigger fires when the signal crosses the trigger threshold, but will not fire again until the signal has crossed the hysteresis threshold and then returned to cross the trigger threshold. The double-threshold mechanism prevents noise on the signal from causing unwanted trigger events.

For a rising-edge trigger the hysteresis threshold is below the trigger threshold. After one trigger event, the signal must fall below the hysteresis threshold before the trigger is enabled for the next event. Conversely, for a falling-edge trigger, the hysteresis threshold is always above the trigger threshold. After a trigger event, the signal must rise above the hysteresis threshold before the trigger is enabled for the next event.



Hysteresis – The trigger fires at **A** as the signal rises past the trigger threshold. It does not fire at **B** because the signal has not yet dipped below the hysteresis threshold. The trigger fires again at **C** after the signal has dipped below the hysteresis threshold and risen again past the trigger threshold.

Elements	thresholdUpper, the upper threshold at which the trigger fires. This is scaled in 16-bit ADC counts at the currently selected range for that channel. thresholdUpperHysteresis, the distance between the upper trigger threshold and the upper hysteresis threshold, scaled in 16-bit counts. thresholdLower, thresholdLowerHysteresis, the settings for the lower threshold: see thresholdUpper and thresholdUpperHysteresis. channel, the channel to which the properties apply. This can be one of the four input channels listed under ps2000aSetChannel, or PS2000A_TRIGGER_EXT for the Ext input fitted to some models. thresholdMode, either a level or window trigger. Use one of these constants: PS2000A_LEVEL PS2000A_WINDOW

3.60 ps2000aSetTriggerDelay() – set up post-trigger delay

```
PICO_STATUS ps2000aSetTriggerDelay
(
    int16_t                    handle,
    uint32_t                   delay
)
```

This function sets the post-trigger delay, which causes capture to start a defined time after the trigger event.

Applicability	All modes (but delay is ignored in streaming mode)
Arguments	handle, device identifier returned by ps2000aOpenUnit delay, the time between the trigger occurring and the first sample. For example, if delay=100 then the scope would wait 100 sample periods before sampling. At a timebase of 1 GS/s, or 1 ns per sample, the total delay would then be 100 x 1 ns = 100 ns. Range: 0 to MAX_DELAY_COUNT
Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_DRIVER_FUNCTION

3.61 ps2000aSetTriggerDigitalPortProperties() - – set up digital channel trigger directions

```
PICO_STATUS ps2000aSetTriggerDigitalPortProperties
(
    int16_t                                 handle,
    PS2000A_DIGITAL_CHANNEL_DIRECTIONS      * directions,
    int16_t                                 nDirections
)
```

This function will set the individual Digital channels trigger directions. Each trigger direction consists of a channel name and a direction. If the channel is not included in the array of PS2000A_DIGITAL_CHANNEL_DIRECTIONS the driver assumes the digital channel's trigger direction is PS2000A_DIGITAL_DONT_CARE.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit * directions, a pointer to an array of PS2000A_DIGITAL_CHANNEL_DIRECTIONS structures describing the requested properties. The array can contain a single element describing the properties of one channel, or a number of elements describing several digital channels. If directions is NULL, digital triggering is switched off. A digital channel that is not included in the array will be set to PS2000A_DIGITAL_DONT_CARE. nDirections, the number of digital channel directions being passed to the driver
Returns	PICO_OK PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION PICO_INVALID_DIGITAL_CHANNEL PICO_INVALID_DIGITAL_TRIGGER_DIRECTION

3.61.1 PS2000A_DIGITAL_CHANNEL_DIRECTIONS structure

A structure of this type is passed to ps2000aSetTriggerDigitalPortProperties in the directions argument to specify the trigger mechanism, and is defined as follows:

```
pragma pack(1)
typedef struct tPS2000ADigitalChannelDirections
{
    PS2000A_DIGITAL_CHANNEL   channel;
    PS2000A_DIGITAL_DIRECTION direction;
} PS2000A_DIGITAL_CHANNEL_DIRECTIONS;
#pragma pack()

typedef enum enPS2000ADigitalChannel
{
    PS2000A_DIGITAL_CHANNEL_0,
    PS2000A_DIGITAL_CHANNEL_1,
    PS2000A_DIGITAL_CHANNEL_2,
    PS2000A_DIGITAL_CHANNEL_3,
    PS2000A_DIGITAL_CHANNEL_4,
    PS2000A_DIGITAL_CHANNEL_5,
    PS2000A_DIGITAL_CHANNEL_6,
    PS2000A_DIGITAL_CHANNEL_7,
    PS2000A_DIGITAL_CHANNEL_8,
    PS2000A_DIGITAL_CHANNEL_9,
    PS2000A_DIGITAL_CHANNEL_10,
    PS2000A_DIGITAL_CHANNEL_11,
    PS2000A_DIGITAL_CHANNEL_12,
    PS2000A_DIGITAL_CHANNEL_13,
    PS2000A_DIGITAL_CHANNEL_14,
    PS2000A_DIGITAL_CHANNEL_15,
    PS2000A_DIGITAL_CHANNEL_16,
    PS2000A_DIGITAL_CHANNEL_17,
    PS2000A_DIGITAL_CHANNEL_18,
    PS2000A_DIGITAL_CHANNEL_19,
    PS2000A_DIGITAL_CHANNEL_20,
    PS2000A_DIGITAL_CHANNEL_21,
    PS2000A_DIGITAL_CHANNEL_22,
    PS2000A_DIGITAL_CHANNEL_23,
    PS2000A_DIGITAL_CHANNEL_24,
    PS2000A_DIGITAL_CHANNEL_25,
    PS2000A_DIGITAL_CHANNEL_26,
    PS2000A_DIGITAL_CHANNEL_27,
    PS2000A_DIGITAL_CHANNEL_28,
    PS2000A_DIGITAL_CHANNEL_29,
    PS2000A_DIGITAL_CHANNEL_30,
    PS2000A_DIGITAL_CHANNEL_31,
    PS2000A_MAX_DIGITAL_CHANNELS
} PS2000A_DIGITAL_CHANNEL;

typedef enum enPS2000ADigitalDirection
{
    PS2000A_DIGITAL_DONT_CARE,
        PS2000A_DIGITAL_DIRECTION_LOW,
        PS2000A_DIGITAL_DIRECTION_HIGH,
        PS2000A_DIGITAL_DIRECTION_RISING,
        PS2000A_DIGITAL_DIRECTION_FALLING,
        PS2000A_DIGITAL_DIRECTION_RISING_OR_FALLING,
        PS2000A_DIGITAL_MAX_DIRECTION
    } PS2000A_DIGITAL_DIRECTION;
```

The structure is byte-aligned. In C++, for example, you should specify this using the #pragma pack() instruction.

3.62 ps2000aSigGenArbitraryMinMaxValues() – query AWG parameter limits

```
PICO_STATUS ps2000aSigGenArbitraryMinMaxValues
(
    int16_t                     handle,
    int16_t                     * minArbitraryWaveformValue,
    int16_t                     * maxArbitraryWaveformValue,
    uint32_t                    * minArbitraryWaveformSize,
    uint32_t                    * maxArbitraryWaveformSize
)
```

This function returns the range of possible sample values and waveform buffer sizes that can be supplied to ps2000aSetSigGenArbitrary for setting up the arbitrary waveform generator (AWG). These values may vary between models.

Applicability	All models with AWG
Arguments	handle, device identifier returned by ps2000aOpenUnit minArbitraryWaveformValue, on exit, the lowest sample value allowed in the arbitraryWaveform buffer supplied to ps2000aSetSigGenArbitrary maxArbitraryWaveformValue, on exit, the highest sample value allowed in the arbitraryWaveform buffer supplied to ps2000aSetSigGenArbitrary minArbitraryWaveformSize, on exit, the minimum value allowed for the arbitraryWaveformSize argument supplied to ps2000aSetSigGenArbitrary maxArbitraryWaveformSize, on exit, the maximum value allowed for the arbitraryWaveformSize argument supplied to ps2000aSetSigGenArbitrary
Returns	PICO_OK PICO_NOT_SUPPORTED_BY_THIS_DEVICE, if the device does not have an arbitrary waveform generator PICO_NULL_PARAMETER, if all the parameter pointers are NULL PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION

3.63 ps2000aSigGenFrequencyToPhase() – calculate AWG phase from frequency

```
PICO_STATUS ps2000aSigGenFrequencyToPhase
(
    int16_t                     handle,
    double                      frequency,
    PS2000A_INDEX_MODE          indexMode,
    uint32_t                    bufferLength,
    uint32_t                    * phase
)
```

This function converts a frequency to a phase count for use with the arbitrary waveform generator setup functions ps2000aSetSigGenArbitrary and ps2000aSetSigGenPropertiesArbitrary. The value returned depends on the length of the buffer, the index mode passed and the device model.

Applicability	All models with AWG
Arguments	handle, device identifier returned by ps2000aOpenUnit frequency, the required AWG output frequency indexMode, see ps2000aSetSigGenArbitrary bufferLength, the number of samples in the AWG buffer phase, on exit, the deltaPhase argument to be sent to the AWG setup function
Returns	PICO_OK PICO_NOT_SUPPORTED_BY_THIS_DEVICE, if the device does not have an AWG PICO_SIGGEN_FREQUENCY_OUT_OF_RANGE, if the frequency is out of range PICO_NULL_PARAMETER, if phase is a NULL pointer PICO_SIG_GEN_PARAM, if indexMode or bufferLength is out of range PICO_INVALID_HANDLE PICO_DRIVER_FUNCTION

3.64 ps2000aSigGenSoftwareControl() – trigger the signal generator

```
PICO_STATUS ps2000aSigGenSoftwareControl
(
    int16_t                   handle,
    int16_t                   state
)
```

This function causes a trigger event, or starts and stops gating. Use it as follows:

1. Call ps2000aSetSigGenBuiltIn or ps2000aSetSigGenArbitrary to set up the signal generator, setting the triggerSource argument to SIGGEN_SOFT_TRIG.
2. (a) If you set the signal generator triggerType to edge triggering (PS2000A_SIGGEN_RISING or PS2000A_SIGGEN_FALLING), call ps2000aSigGenSoftwareControl once to trigger a capture.
(b) If you set the signal generator triggerType to gated triggering (PS2000A_SIGGEN_GATE_HIGH or PS2000A_SIGGEN_GATE_LOW), call ps2000aSigGenSoftwareControl with state set to 0 to start capture, and then again with state set to 1 to stop capture.

Applicability	Use with ps2000aSetSigGenBuiltIn or ps2000aSetSigGenArbitrary.
Arguments	handle, device identifier returned by ps2000aOpenUnit state, specifies whether to start or stop capture. Effective only when the signal generator triggerType is set to SIGGEN_GATE_HIGH or SIGGEN_GATE_LOW. Ignored for other trigger types. 0: to start capture <> 0: to stop capture
Returns	PICO_OK PICO_INVALID_HANDLE PICO_NO_SIGNAL_GENERATOR PICO_SIGGEN_TRIGGER_SOURCE PICO_DRIVER_FUNCTION PICO_NOT_RESPONDING

3.65 ps2000aStop() – stop data capture

```
PICO_STATUS ps2000aStop
(
    int16_t                     handle
)
```

This function stops the scope device while it is waiting for a trigger or capturing data.

- In block mode, you can optionally call ps2000aStop to terminate the current capture. Any data in the buffer will be invalid.
- In rapid block mode, you can optionally call ps2000aStop to terminate the sequence of captures. Any completed captures will contain valid data but no further captures will be made.
- In streaming mode, calling ps2000aStop is the usual way to terminate data capture. If this function is called before a trigger event occurs, the oscilloscope may not contain valid data. If capture has already started, the buffer will contain valid data.

Applicability	All modes
Arguments	handle, device identifier returned by ps2000aOpenUnit
Returns	PICO_OK PICO_INVALID_HANDLE PICO_USER_CALLBACK PICO_DRIVER_FUNCTION

3.66 ps2000aStreamingReady() – find out if streaming-mode data ready

```
typedef void (CALLBACK *ps2000aStreamingReady)
(
    int16_t                 handle,
    int32_t                 noOfSamples,
    uint32_t                startIndex,
    int16_t                 overflow,
    uint32_t                triggerAt,
    int16_t                 triggered,
    int16_t                 autoStop,
    void                    * pParameter
)
```

This callback function is part of your application. You register it with the driver using ps2000aGetStreamingLatestValues, and the driver calls it back when streaming-mode data is ready. You can then download the data using the ps2000aGetValuesAsync function.

The 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.

Applicability	Streaming mode only
Arguments	handle, device identifier returned by ps2000aOpenUnit noOfSamples, the number of samples to collect startIndex, an index to the first valid sample in the buffer. This is the buffer that was previously passed to ps2000aSetDataBuffer. overflow, returns a set of flags that indicate whether an overvoltage has occurred on any of the channels. It is a bit pattern with bit 0 denoting Channel A. triggerAt, an index to the buffer indicating the location of the trigger point relative to startIndex. The trigger point is therefore at StartIndex + triggerAt. This parameter is valid only when triggered is non-zero. triggered, a flag indicating whether a trigger occurred. If non-zero, a trigger occurred at the location indicated by triggerAt. autoStop, the flag that was set in the call to ps2000aRunStreaming * pParameter, a void pointer passed from ps2000aGetStreamingLatestValues. The callback function can write to this location to send any data, such as a status flag, back to the application.
Returns	nothing

3.67 Wrapper functions

The Software Development Kits (SDKs) for PicoScope devices contain wrapper dynamic link library (DLL) files in the lib subdirectory of your SDK installation for 32-bit and 64-bit systems. The wrapper functions provided by the wrapper DLLs are for use with programming languages such as MathWorks MATLAB, National Instruments LabVIEW and Microsoft Excel VBA that do not support features of the C programming language such as callback functions.

The source code contained in the Wrapper projects contains a description of the functions and the input and output parameters.

Below we explain the sequence of calls required to capture data in streaming mode using the wrapper API functions.

The ps2000aWrap.dll wrapper DLL has a callback function for streaming data collection that copies data from the driver buffer specified to a temporary application buffer of the same size. To do this it must be registered with the wrapper and the channel must be specified as being enabled. You should process the data in the temporary application buffer accordingly, for example by copying the data into a large array.

Procedure:
1. Open the oscilloscope using ps2000aOpenUnit.

1a. Inform the wrapper of the number of channels on the device by calling setChannelCount.

2. Select channels, ranges and AC/DC coupling using ps2000aSetChannel.

2a. Inform the wrapper which channels have been enabled by calling setEnabledChannels.

3. [MSOs only] Set the digital port using ps2000aSetDigitalPort.

3a. [MSOs only] Inform the wrapper which digital ports have been enabled by calling setEnabledDigitalPorts.

4. Use the appropriate trigger setup functions. For programming languages that do not support structures, use the wrapper's advanced trigger setup functions.

5. [MSOs only] Use the trigger setup function ps2000aSetTriggerDigitalPortProperties to set up the digital trigger if required.

6. Call ps2000aSetDataBuffer (or for aggregated data collection ps2000aSetDataBuffers) to tell the driver where your data buffer(s) is(are).

6a. Register the data buffer(s) with the wrapper and set the application buffer(s) into which the data will be copied.

For analog channels: Call setAppAndDriverBuffers (or setMaxMinAppAndDriverBuffers for aggregated data collection).

[MSOs Only] For digital ports: Call setAppAndDriverDigiBuffers (or setMaxMinAppAndDriverDigiBuffers for aggregated data collection).

7. Start the oscilloscope running using ps2000aRunStreaming.

8. Loop and call GetStreamingLatestValues and IsReady to get data and flag when the wrapper is ready for data to be retrieved.

8a. Call the wrapper’s AvailableData function to obtain information on the number of samples collected and the start index in the buffer.

8b. Call the wrapper’s IsTriggerReady function for information on whether a trigger has occurred and the trigger index relative to the start index in the buffer.

9. Process data returned to your application data buffers.

10. Call AutoStopped if the autoStop parameter has been set to TRUE in the call to ps2000aRunStreaming.

11. Repeat steps 8 to 10 until AutoStopped returns true or you wish to stop data collection.

12. Call ps2000aStop, even if the autoStop parameter was set to TRUE.

13. To disconnect a device, call ps2000aCloseUnit.

4 Further information

4.1 Programming examples

Your SDK installation includes programming examples in a selection of languages and development environments. Please refer to the SDK for details.

4.2 Driver status codes

Every function in the ps2000a driver returns a **driver status code** from the list of PICO_STATUS values in PicoStatus.h, which is included in the inc folder of the Pico Technology SDK.

4.3 Enumerated types and constants

Enumerated types and constants are defined in ps2000aApi.h, which is included in the SDK under the inc folder. We recommend that you refer to these constants by name unless your programming language allows only numerical values.

4.4 Numeric data types

Here is a list of the numeric data types used in the PicoScope 2000 Series A API:

Type	Bits	Signed or unsigned?
int8_t	8	signed
int16_t	16	signed
uint16_t	16	unsigned
enum	32	enumerated
int32_t	32	signed
uint32_t	32	unsigned
float	32	signed (IEEE 754 binary32)
double	64	signed (IEEE 754 binary64)
int64_t	64	signed
uint64_t	64	unsigned

5 Glossary

AC/DC control. Each channel can be set to either AC coupling or DC coupling. With DC coupling, the voltage displayed on the screen is equal to the true voltage of the signal. With AC coupling, any DC component of the signal is filtered out, leaving only the variations in the signal (the AC component).

Aggregation. This is the data-reduction method used by the PicoScope 2000 Series (A API) scopes. For each block of consecutive samples, the scope transmits only the minimum and maximum samples over the USB port to the PC. You can set the number of samples in each block, called the aggregation parameter, when you call ps2000aRunStreaming for real-time capture, and when you call ps2000aGetStreamingLatestValues to obtain post-processed data.

Aliasing. An effect that can cause digital oscilloscopes to display fast-moving waveforms incorrectly, by showing spurious low-frequency signals ("aliases") that do not exist in the input. To avoid this problem, choose a sampling rate that is at least twice the highest frequency in the input signal.

Analog bandwidth. All oscilloscopes have an upper limit to the range of frequencies at which they can measure accurately. The analog bandwidth of an oscilloscope is defined as the frequency at which a displayed sine wave has half the power of the input sine wave (or, equivalently, about 71% of the amplitude).

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 mode of operation is effective when the input signal being sampled contains high frequencies. Note: To avoid aliasing effects, the maximum input frequency must be less than half the sampling rate.

Buffer size. The size, in samples, of the oscilloscope buffer memory. The buffer memory is used by the oscilloscope to temporarily store data before transferring it to the PC.

ETS. Equivalent Time Sampling. ETS constructs a picture of a repetitive signal by accumulating information over many similar wave cycles. This means the oscilloscope can capture fast-repeating signals that have a higher frequency than the maximum sampling rate. Note: ETS cannot be used for one-shot or non-repetitive signals.

External trigger. This is the BNC socket marked **EXT** on the oscilloscope. It can be used to start a data collection run but cannot be used to record data.

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

MSO (mixed-signal oscilloscope). An oscilloscope that has both analog and digital inputs.

Overvoltage. Any input voltage to the oscilloscope must not exceed the overvoltage limit, measured with respect to ground, otherwise the oscilloscope may be permanently damaged.

PC Oscilloscope. A measuring instrument consisting of a Pico Technology scope device and the PicoScope software. It provides all the functions of a bench-top oscilloscope without the cost of a display, hard disk, network adapter and other components that your PC already has.

PicoScope software. This is a software product that accompanies all our oscilloscopes. It turns your PC into an oscilloscope, spectrum analyzer.

Signal generator. This is a feature of some oscilloscopes which allows a signal to be generated without an external input device being present. The signal generator output is the BNC socket marked **Awg** or **Gen** on the oscilloscope. If you connect a BNC cable between this and one of the channel inputs, you can send a signal into one of the channels. It can generate a sine, square, triangle or arbitrary wave of fixed or swept frequency.

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 effective when the input signal being sampled contains only low frequencies.

Timebase. The timebase controls the time interval across the scope display. There are ten divisions across the screen and the timebase is specified in units of time per division, so the total time interval is ten times the timebase.

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, indicating the degree of precision with which the oscilloscope can turn input voltages into digital values. Calculation techniques can improve the effective resolution.

Voltage range. The voltage range is the difference between the maximum and minimum voltages that can be accurately captured by the oscilloscope.

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