pico® Technology Limited

PicoScope 2104 & 2105

PC Oscilloscopes

User guide

PS2100044-1.0

Table of Contents

1 Introduction

1.1 Overview

The PicoScope 2104 and 2105 PC Oscilloscopes are low-cost handheld instruments that are fully USB 2.0-capable and backwards-compatible with USB 1.1. There is no need for an additional power supply, as power is taken from the USB port.

With the PicoScope software, you can use your instrument as a PC Oscilloscope and spectrum analyser; and with the PicoLog software, you can use it as a data logger.

Each product pack contains the following items:

- PicoScope 2104 or 2105 PC Oscilloscope
- Software CD
- Accessories kit
- Quick start guide

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

1.2 Safety symbols

Warning Triangle

This symbol indicates that a safety hazard exists on the indicated connections if correct precautions are not taken. Ensure that you read all safety documentation associated with the product before using it.

1.3 Safety warning

We strongly recommend that you read the general safety information below before using your PicoScope PC Oscilloscope for the first time. Safety protection built in to the equipment may cease to function if the equipment is used incorrectly. This could cause damage to your computer, or lead to injury to yourself and others.

Maximum input range

The PicoScope 2104 and 2105 PC oscilloscopes are designed to measure voltages in the range -20 V to +20 V and are protected against continuous or transient overvoltages of up to ±50 V. Any voltages in excess of ±50 V may cause permanent damage to the oscilloscope or to your computer.

Measurement category

PicoScope 2000 Series PC Oscilloscopes are rated for use in measurement category I (EN61010 CAT I), which covers measurements on circuits not connected to the mains. You must not use your PicoScope PC Oscilloscope to make measurements on any circuit directly connected to the mains, unless you use a purpose-built isolating probe rated for the appropriate voltage and measurement category.

Safety grounding

The PicoScope PC Oscilloscopes connect directly to the ground of a computer through the interconnecting cable provided.

As with most oscilloscopes, avoid connecting the ground input to any source other than ground. If in doubt, use a meter to check that there is no significant AC or DC voltage between the ground input of the oscilloscope and the point to which you intend to connect it. Failure to check may cause damage to your computer, or lead to injury to yourself and others.

You should assume that the product does not have a protective safety earth.

Repairs

PicoScope PC Oscilloscopes contain no user-serviceable parts. Repair or calibration of the unit requires specialised test equipment and must be performed only by Pico Technology. Spare probe tips are available from Pico Technology and its authorised distributors.

1.4 FCC notice

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

For safety and maintenance information see the safety warning.

1.5 CE notice

The PicoScope 2104 and 2105 PC Oscilloscopes meet the intent of the EMC directive 89/336/EEC and have been designed to EN61326-1 (1997) Class A Emissions and Immunity standard.

The devices also meet the intent of the Low Voltage Directive and have been designed to meet the BS EN 61010-1:2001 IEC 61010-1:2001 (safety requirements for electrical equipment, control, and laboratory use) standard.

1.6 Licence conditions

The material contained in this release is licensed, not sold. Pico Technology Limited grants a licence to the person who installs this software, subject to the conditions listed below.

Access

The licensee agrees to allow access to this software only to persons who have been informed of these conditions and agree to abide by them.

Usage

The software in this release is for use only with Pico products or with data collected using Pico products.

Copyright

Pico Technology Limited claims the copyright of, and retains the rights to, all material (software, documents etc.) contained in this release. You may copy and distribute the entire release in its original state, but must not copy individual items within the release other than for backup purposes.

Liability

Pico Technology and its agents shall not be liable for any loss, damage or injury, howsoever caused, related to the use of Pico Technology equipment or software, unless excluded by statute.

Fitness for purpose

Because no two applications are the same, Pico Technology cannot guarantee that its equipment or software is suitable for a given application. It is your responsibility, therefore, to ensure that the product is suitable for your application.

Mission-critical applications

This software is intended for use on a computer that may be running other software products. For this reason, one of the conditions of the licence is that it excludes usage in mission-critical applications; for example, life-support systems.

1.7 Trademarks

- Delphi is a registered trademark of Borland Software Corporation.
- LabView is a registered trademark of National Instruments Corporation.
- Pentium is a registered trademark of Intel Corporation.
- Pico Technology Limited, PicoLog and PicoScope are internationally registered trademarks.
- VEE is a registered trademark of Agilent Technologies.
- Windows, Excel and Visual Basic are registered trademarks of Microsoft Corporation.

1.8 Warranty

Pico Technology warrants upon delivery, and for a period of 24 months unless otherwise stated from the date of delivery, that the Goods will be free from defects in material and workmanship.

Pico Technology shall not be liable for a breach of the warranty if the defect has been caused by fair wear and tear, wilful damage, negligence, abnormal working conditions or failure to follow Pico Technology's spoken or written advice on the storage, installation, commissioning, use or maintenance of the Goods or (if no advice has been given) good trade practice; or if the Customer alters or repairs such Goods without the written consent of Pico Technology.

1.9 Company details

Address:

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Point Roberts, WA
98281

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Fax: 1-877-FAX-IECI

Email:

Technical Support:
Sales: sales@interworldna.com

Web site: www.interworldna.com

2 Product information

2.1 Minimum system requirements

For the PicoScope PC Oscilloscope to operate, a computer with the minimum system requirements to run Windows or the following (whichever is the higher specification) is required:

Processor	Pentium class processor or equivalent, minimum.
Memory	32 MB minimum.
Disk space	10 MB minimum.
Operating system	Microsoft Windows 98SE, ME, 2000 or XP.
Ports	USB 1.1 compliant port minimum. USB 2.0 compliant port recommended. Must be connected direct to the port or a powered USB hub. Will not work on a passive hub.

2.2 Installation instructions

Important

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

- Install the software by following the steps in the installation guide supplied with your oscilloscope.
- Connect the oscilloscope's USB cable to the PC.
- There is no need for an additional power supply as power is drawn from the USB port.

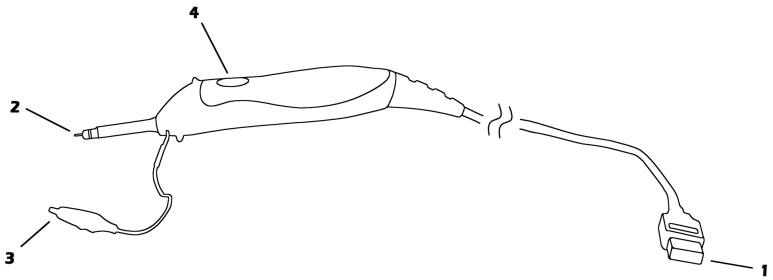
Checking the installation

Once you have installed the software, ensure that the PicoScope PC Oscilloscope is connected to the PC and then start the PicoScope or PicoLog software. PicoScope should show a small 50 Hz or 60 Hz mains signal in the oscilloscope window when you touch the probe tip with your finger. PicoLog, once configured for a PicoScope 2000 Series oscilloscope, should show a small noise voltage.

Input connector

The PicoScope 2104 and 2105 PC Oscilloscopes have a built-in oscilloscope probe. This can be unscrewed if damaged, and replaced with a spare part available from Pico Technology or its authorised distributors.

Connectors and controls



1. USB cable. After installing the Pico software, plug the free end of this cable into your computer's USB port.
2. Probe. Touch this to the signal to be measured. You can fit a probe hook or insulating collar to the end of the probe. All these accessories are supplied with the oscilloscope.
3. Ground clip. You must connect this clip, which is supplied in the accessories pack, to the ground reference point of the circuit or equipment under test. Do not rely on your computer to supply a ground connection through the USB cable.
4. Illuminated button. Press this briefly to start or stop the oscilloscope. Press and hold to activate automatic setup when running PicoScope. The light glows or flashes green when the oscilloscope is running, and glows red when the instrument is stopped.

2.3 Specifications

Variant	PicoScope 2104	PicoScope 2105
Vertical Resolution	8 bits	
Analog Bandwidth	10 MHz	25 MHz
Maximum Sampling Rate Real-time Repetitive (using ETS)	 50 MS/s 1 GS/s	 100 MS/s 2 GS/s
Timebases	10 ns/div to 50 s/div	5 ns/div to 50 s/div
Buffer Size	8k samples	24k samples
Input	Oscilloscope probe 1 MΩ impedance AC/DC coupling	
Voltage Ranges	±100 mV to ±20 V in 1, 2, 5 steps	
Accuracy	3 % (voltage) 100 ppm (time)	
Linearity	< 1 LSB at 25 °C	
Environmental Limits Operating temperature Operating humidity Storage temperature Storage humidity	 0 °C to 45 °C (20°C to 30°C for quoted accuracy) 5% to 80% RH, non-condensing -20°C to +60°C 5% to 95% RH, non-condensing	
Overload Protection	±50 V (input to ground)	
PC Connection	USB 2.0 Compatible with USB 1.1	
Power Supply	From USB port: 4.6 to 5.25 V @ 300 mA	
Maximum Dimensions	220 mm long (probe only) 3 m long (including cable) 32 mm diameter	
Compliance	CE standard; FCC standard	

3 Technical reference

3.1 Driver

Once you have installed the PicoScope and PicoLog software, Windows will automatically install the driver when the PicoScope PC Oscilloscope is plugged in for the first time.

The Windows 98SE/ME/2000/XP/2003 32-bit driver, `picopp.sys`, is installed in the Windows directory. It is loaded using an `inf` file, `picopp.inf`.

3.2 Driver error codes

This section is aimed at those people who intend to write their own programs for use with the driver. A description of the driver error codes is given below. If the PicoScope or PicoLog software reports an error, refer to the FAQ.

Code	Enumeration	Description
0	PS2000_OK	The PicoScope 2000 Series unit is functioning correctly.
1	PS2000_MAX_UNITS_OPENED	Attempts have been made to open more than PS2000_MAX_UNITS units.
2	PS2000_MEM_FAIL	Not enough memory could be allocated on the host machine.
3	PS2000_NOT_FOUND	No PicoScope 2000 Series unit could be found.
4	PS2000_FW_FAIL	Unable to download firmware.
5	PS2000_NOT_RESPONDING	The PicoScope 2000 Series unit is not responding to commands from the PC.
6	PS2000_CONFIG_FAIL	The configuration information in the oscilloscope has become corrupt or is missing.
7	PS2000_OS_NOT_SUPPORTED	The operating system is not one of the supported products: Windows 98SE, ME, 2000, XP and 2003.

3.3 Functions

3.3.1 ps2000_close_unit

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

This function shuts down a PicoScope 2000 Series PC Oscilloscope.

Arguments	handle, the handle, returned by ps2000_open_unit(), of the unit being closed.
Returns	1 if a valid handle is passed, 0 if not.

3.3.2 ps2000_flash_led

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

This function flashes the red light in the unit's pushbutton three times, and returns within one second.

Arguments	handle, the handle of the PicoScope PC Oscilloscope.
Returns	1 if a valid handle is passed, 0 if not.

3.3.3 ps2000_get_timebase

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

This function discovers which timebases are available on the oscilloscope. This function should be called after channel and ETS options have been set.

Arguments	`handle`, the handle to the required device. `timebase`, a code between 0 and the maximum timebase number (depending on variant). Timebase 0 is the fastest timebase, equal to the maximum sampling frequency (f_{MAX}) given in the Specifications. Each successive timebase is half the frequency of the previous one. f_S, the sampling frequency, is given by: $f_S = f_{MAX} / 2^{timebase}$ `no_of_samples`, the number of samples required. This value is used to calculate the most suitable time unit to use. `time_interval_ns`, a pointer to the time interval, in nanoseconds, between readings at the selected timebase. If a null pointer is passed, nothing will be written here. `time_units`, a pointer to the most suitable time units to return data in, when calling `ps2000_get_times_and_values()`. A list of values for `time_units` is given under `ps2000_get_times_and_values()`. If a null pointer is passed, nothing will be written here. `oversample`, the oversampling factor required, between 1 and 256. See oversampling for an explanation. `max_samples`, a pointer to the maximum number of samples available. The number may vary depending on the number of channels enabled, the timebase chosen and the `oversample` selected. If this pointer is null, nothing will be written here.
Returns	`1` if all parameters are in range, otherwise `0`.

3.3.4 ps2000_get_times_and_values

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

This function is used to get values and times. It will not return any valid times if the unit is in streaming mode. It is essential for ETS operation.

Arguments	handle, the handle to the required device. times, a pointer to the buffer for the times. Each time is the interval between the trigger event and the corresponding sample. Times before the trigger event are negative, and times after the trigger event are positive. buffer_a, pointer to the buffer that receives data from the oscilloscope. If the pointer is NULL, nothing will be written to it. See Scaling for details of data format. buffer_b, buffer_c, buffer_d, not used overflow. Bit 0 indicates whether an overflow has occurred. time_units, which can be one of the following: PS2000_FS (0) = femtoseconds, PS2000_PS (1) = picoseconds, PS2000_NS (2) = nanoseconds (default), PS2000_US (3) = microseconds, PS2000_MS (4) = milliseconds, or PS3000_S (5) = seconds. no_of_values, the number of data points to return. In streaming mode, this is the maximum number of values to return.
Returns	The actual number of data values returned, which may be less than the no_of_values if streaming. 0 is returned if one or more of the parameters are out of range or if the times will overflow with the time_units requested. Use ps2000_get_timebase() in order to acquire the most suitable time_units.

3.3.5 ps2000_get_unit_info

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

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

Arguments	`handle`, the handle to the device from which `info` is required. If an invalid handle is passed, the error code from the last unit that failed to open is returned. `* string`, a pointer to the character string buffer in the calling function where the unit information string (selected with `info`) will be stored. If a null pointer is passed, no information will be written. `string_length`, the length of the character string buffer. If the string is not long enough to accept all of the information, only the first `string_length` characters are returned. `info`, an enumerated type specifying what information is required from the driver.
Returns	The length of the string written to the character string buffer, `string`, by the function. If one of the parameters is out of range, or a null pointer is passed for `string`, zero will be returned.

info	Information returned	Example
PS2000_DRIVER_VERSION (0)	Version number of the DLL used by the PicoScope 2000 Series driver.	"1, 3, 0, 0"
PS2000_USB_VERSION (1)	Type of USB connection that is being used to connect the oscilloscope to the computer.	"2.0"
PS2000_HARDWARE_VERSION (2)	Hardware version of the attached oscilloscope.	"4"
PS2000_VARIANT_INFO (3)	Model of PicoScope 2000 Series unit that is attached to the computer.	"2105"
PS2000_BATCH_AND_SERIAL (4)	Batch and serial number of the oscilloscope.	"INR73/6"
PS2000_CAL_DATE (5)	Calibration date of the oscilloscope.	"17Jan06"
PS2000_ERROR_CODE (6)	One of the Error codes.	"0"

3.3.6 ps2000_get_values

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

This function is used to get values. It does nothing if ETS triggering is enabled.

Arguments	handle, the handle to the required device. buffer_a, pointer to the buffer that receives data from the oscilloscope. If the pointer is NULL, nothing will be written to it. See Scaling for details of data values. buffer_b, buffer_c, buffer_d, unused pointers overflow. The least-significant bit indicates whether an overflow has occurred. no_of_values. The number of data points to return. In streaming mode, this is the maximum number of values to return.
Returns	The actual number of data values returned, which may be less than no_of_values if streaming. FALSE is returned if one of the parameters is out of range.

3.3.7 ps2000_last_button_press

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

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

Arguments	handle - handle of the device
Returns	0 – No button press registered 1 – Short button press registered 2 – Long button press registered

3.3.8 ps2000_open_unit

```
short ps2000_open_unit ( void )
```

This function opens a PicoScope 2000 Series PC Oscilloscope. The API driver can support up to four units.

Arguments	None
Returns	-1 if the unit fails to open, 0 if no unit found, >0 (handle) if the unit opened

3.3.9 ps2000_ready

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

This function checks to see if the oscilloscope has finished the last data collection operation. It does nothing if the unit is in streaming mode.

Arguments	handle, the handle to the required device.
Returns	1 (meaning 'ready') is returned when the unit has collected a complete block of data or the auto trigger timeout has been reached. If an invalid handle is passed, or the unit is in streaming mode, it returns 0 (meaning 'not ready'). -1 (meaning 'device not attached') is returned if the endpoint transfer fails, indicating that the unit may well have been unplugged.

3.3.10 ps2000_run_block

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

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

Arguments	`handle`, the handle to the required device. `no_of_samples`, the number of samples to return. `timebase`, a code between 0 and the maximum timebase (depending on variant). Timebase 0 is the fastest timebase, equal to the maximum sampling frequency (f_{MAX}) given in the specifications. Each successive timebase is half the frequency of the previous one. f_S, the sampling frequency, is given by: $f_S = f_{MAX} / 2^{timebase}$ `oversample`, the oversample factor, a number between 1 and 256. See oversampling for more information. `time_indisposed_ms`, a pointer to the `time_indisposed_ms`. This is the approximate time, in milliseconds, that the ADC will take to collect data. If a trigger is set, it is measured from the trigger event. It is calculated as: (sample interval) x (number of samples required) Note: The actual time may differ from computer to computer, depending on how fast the computer can respond to I/O requests.
Returns	`0` if one of the parameters is out of range, otherwise `1`.

3.3.11 ps2000_run_streaming

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

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

Arguments	`handle`, the handle to the required device. `time_interval_ms`, the time interval, in milliseconds, between samples. This can be no shorter than 1 ms. `max_samples`, the maximum number of samples that the driver is to store. This can be no greater than 60 000. It is the caller's responsibility to retrieve data before the oldest values are overwritten. `windowed`. If this is `0`, only the values taken since the last call to get values are returned. If it is 1, the number of values requested by `ps2000_get_values()` are returned, even if they have already been read by `ps2000_get_values()`. See streaming mode for details.
Returns	`1` if streaming has been enabled correctly, `0` if a problem occurred or a value was out of range.

3.3.12 ps2000_set_channel

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

Specifies whether a channel is to be enabled, the position of the AC/DC switch and the input range.

Arguments	`handle`, the handle to the required device. `channel`, an enumerated type, must be `PS2000_CHANNEL_A` or `0`. `enabled`, specifies whether the channel is active: `TRUE` = active, `FALSE` = inactive. `dc`, specifies the position of the AC/DC switch: `TRUE` = DC, `FALSE` = AC. `range`, a code between 3 and 10. See the table below.
Returns	`0` if unsuccessful, or if one or more of the arguments are out of range. `1` if successful.

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

3.3.13 ps2000_set_ets

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

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

Arguments	`handle`, the handle to the required device. `mode`: - `PS2000_ETS_OFF` (`0`) - disables ETS, - `PS2000_ETS_FAST`(`1`) - enables ETS and provides `ets_cycles` of data, which may contain data from previously returned cycles, - `PS2000_ETS_SLOW` (`2`) - enables ETS and provides fresh data every `ets_cycles` cycles. This takes longer to provide each data set, but the data sets are more stable and are unique. `ets_cycles`, specifies the number of cycles to store: the computer can then select `ets_interleave` cycles to give the most uniform spread of samples. `ets_cycles` should be between two and five times the value of `ets_interleave`. `ets_interleave`, specifies the number of ETS interleaves to use. If the sample time is 20 ns and the interleave 10, the approximate time per sample will be 2 ns.
Returns	If ETS is enabled, the effective sample time will be returned. `0` if ETS is disabled or one of the parameters is out of range.

3.3.14 ps2000_set_trigger

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

This function is used to enable or disable triggering and its parameters. Triggering is not available in streaming mode.

Arguments	`handle`, the handle to the required device. `source`, specifies where to look for a trigger. Use `PS2000_CHANNEL_A` (`0`) or `PS2000_NONE` (`5`). `threshold`, the threshold for the trigger event. This is scaled in 16-bit ADC counts at the currently selected range. `direction`. Specifies the edge on which to trigger. Use `PS2000_RISING` (`0`) or `PS2000_FALLING` (`1`). `delay`, specifies the delay, as a percentage of the requested number of samples, between the trigger event and the start of the block. It should be in the range -100% to +100%. Thus, 0% means that the the trigger event is at the first data value in the block, and -50% means that it is in the middle of the block. `auto_trigger_ms`, the delay in milliseconds after which the unit will collect samples if no trigger event occurs. If this is set to zero, the unit will wait for a trigger indefinitely.
Returns	`0` if one of the parameters is out of range, otherwise `1`.

3.3.15 ps2000_stop

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

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

Arguments	`handle`, the handle to the required device.
Returns	`0` if an invalid handle is passed, otherwise `1`.

3.4 Advanced features

3.4.1 Sampling modes

A PicoScope PC Oscilloscope can run in various sampling modes. At high sampling rates, the oscilloscope collects data much faster than a PC can read it. To compensate for this, the oscilloscope stores a block of data in an internal memory buffer, delaying transfer to the PC until a preset number of data points has been sampled. This is called block mode. At very low sampling rates, you may want to switch to streaming mode. This allows accurately timed data to be transferred back to the PC, without gaps. Real-time continuous mode is also provided for use at low sampling rates, and allows capture of data from multiple converters.

Sampling mode support in Pico software

	Block	Streaming	Real-time continuous
PicoScope	Yes * †	Yes * †	No
PicoLog	Yes *	Yes *	Yes

* Only with a single converter
† PicoScope automatically selects block or streaming mode

3.4.2 More on block mode

In block mode, the computer prompts a unit to collect a block of data into its internal memory. When the oscilloscope has collected the whole block, it will signal it is ready, and transfer the whole block into computer memory via the USB port.

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

The PicoScope 2000 Series driver normally performs a number of setup operations before collecting each block of data. This can take up to 50 milliseconds. If it is necessary to collect data with the minimum time interval between blocks, avoid calling setup functions between calls to `ps2000_run_block()`, `ps2000_ready()`, `ps2000_stop()` (not normally used) and `ps2000_get_values()`.

3.4.3 More on streaming mode

In streaming mode, the computer prompts the unit to start collecting data. The data are then transferred back to the PC without being stored in oscilloscope memory. Data can be sampled with a period between 1 millisecond and 60 seconds.

Data can be transferred by the PicoScope 2000 Series driver to a computer program in either normal or windowed mode.

Normal mode

In normal mode, any data collected since the last data transfer operation are returned in their entirety. This mode is useful if the computer program requires only fresh data on every transfer.

Windowed mode

In windowed mode, a fixed number of samples is returned, even if the oldest samples have been returned before. Windowed mode is useful when the program requires data from a constant time interval.

Notes

Once the unit is collecting data in streaming mode, any setup changes (for example, changing a channel range or AC/DC setting in the PicoScope software application) will cause a restart of the data stream.

The driver can buffer up to 32K samples of data per channel, but the user must ensure that the `ps2000_get_values()` function is called frequently enough to avoid buffer overrun.

The `ps2000_get_times_and_values()` function will always return `FALSE (0)` in streaming mode.

3.4.4 Triggering

The unit can either start collecting data immediately, or it can be programmed to wait for a trigger event to occur. In either case, you need to use the `ps2000_set_trigger()` function. A trigger occurs when the input crosses a threshold voltage on either a rising or a falling edge.

3.4.5 ETS (Equivalent Time Sampling)

ETS is a way of increasing the effective sample rate when working with repetitive signals. It is not possible to use ETS with one-shot signals. ETS is controlled by the `ps2000_set_trigger()` and `ps2000_set_ets()` functions, and is available in block mode only. Calls to the `ps2000_set_trigger()` function have no effect in streaming mode. As ETS will return random time intervals, the `ps2000_get_times_and_values()` function must be used. The `ps2000_get_values()` function will return `FALSE (0)`.

3.4.6 Voltage ranges

It is possible to set the gain for each channel with the `ps2000_set_channel()` function. This allows you to set an input voltage range between ±100 mV and ±20 V.

3.4.7 AC/DC operation

Using the ps2000_set_channel() function, the input can be set to either AC or DC coupling. When AC coupling is used, any DC component of the signal is filtered out.

3.4.8 Oversampling

When the unit is operating in block mode at speeds less than the maximum, it is possible to oversample, which means taking more than one measurement during a time interval and returning an average. This reduces the effects of noise, and increases the effective vertical resolution of the oscilloscope.

Setting an oversampling factor of *n* increases the time interval by a factor of *n* and reduces the maximum number of samples by the same factor. At the same time it increases the effective resolution by the amount given by the equation:

increase in resolution (bits) = (log oversample) / (2 log 2)

For example, an oversampling factor of four increases the resolution by one bit.

The ps2000_run_block() function controls oversampling.

3.4.9 Scaling

PicoScope 2000 Series PC Oscilloscopes have a resolution of 8 bits, but the oscilloscope driver normalises all readings to 16 bits. This enables it to take advantage of noise reduction from oversampling, when this is enabled. The following table shows the relationship between the reading from the driver and the voltage of the signal.

Reading	Voltage
-32 767	Negative full scale
0	Zero volts
32 767	Positive full scale

3.4.10 Combining oscilloscopes

With PicoLog or your own program, it is possible to collect data using up to four PicoScope 2000 Series PC Oscilloscopes at the same time. Each unit must be connected to a separate USB port, or, if a USB hub is used, it must be a powered hub. The ps2000_open_unit() function returns a handle to a unit, and all of the other functions require this handle for unit identification. For example, to collect data from two units at the same time:

```
handle1 = ps2000_open()
handle2 = ps2000_open()

ps2000_set_channel(handle1)
... set up unit 1
ps2000_run(handle1)

ps2000_set_channel(handle2)
... set up unit 2
ps2000_run(handle2)

ready1 = FALSE
ready2 = FALSE

while not ready1
    ready1 = ps2000_ready(handle1)
while not ready2
    ready2 = ps2000_ready(handle2)

ps2000_get_values(handle1)
ps2000_get_values(handle2)
```

Note: It is not possible to synchronise the collection of data between PicoScope PC Oscilloscopes that are being used in combination.

3.5 Using different modes

3.5.1 Introduction

The previous section on advanced features supplied the programmer with extended information on PicoScope 2000 Series PC Oscilloscopes. The C sample program, ps2000con.c, demonstrates how to use the functions of the driver software, and includes examples showing how to use each of the modes available.

3.5.2 Using block mode

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

1. Open the unit using ps2000_open_unit()
2. Select channel range and AC/DC switch using ps2000_set_channel()
3. Using ps2000_set_trigger(), set the trigger if required
4. Using ps2000_get_timebase(), select timebases until the required time per sample in nanoseconds is located
5. Start the unit running using ps2000_run_block()
6. Wait until the unit says it is ready using ps2000_ready()
7. Transfer the block of data from the unit using ps2000_get_values() or ps2000_get_times_and_values()
8. Display the data
9. Repeat steps 5 to 8 as many times as necessary
10. Stop the unit using ps2000_stop().

3.5.3 Using streaming mode

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

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

3.5.4 Using ETS mode

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

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

3.6 Programming

3.6.1 C

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

GUI example

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

```
ps2000.c
ps2000.rc
```

and

```
ps2000bc.lib     (Borland 32-bit applications); or
ps2000.lib       (Microsoft Visual C 32-bit applications)
```

The following files must be in the compilation directory:

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

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

```
ps2000.dll
```

Console example

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

```
ps2000con.c
```

and

```
ps2000bc.lib     (Borland 32-bit applications); or
ps2000.lib       (Microsoft Visual C 32-bit applications).
```

The following files must be in the compilation directory:

```
ps2000.h
```

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

```
ps2000.dll
```


3.6.2 Visual Basic

The Win32\ subdirectory contains the following files:

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

Note: The functions that return a TRUE/FALSE value return 0 for FALSE and 1 for TRUE, whereas Visual Basic expects 65 535 for TRUE. To avoid this problem, check for > 0 rather than = TRUE.

3.6.3 Delphi

The program ps2000.dpr demonstrates how to operate PicoScope 2000 Series PC Oscilloscopes. The file ps2000.inc contains procedure prototypes that you can include in your own programs. Other required files include ps2000.res, ps2000fm.dfm and ps2000fm.pas. This has been tested with Delphi version 3.

3.6.4 Excel

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

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

3.6.5 Agilent VEE

The example function ps2000.vee is in the drivers\ subdirectory. It uses procedures that are defined in ps2000.vh. It was tested using Agilent VEE version 5.

3.6.6 LabVIEW

The ps2000.vi example in the Drivers\Win32\ subdirectory shows how to access the driver functions using LabVIEW. It was tested using version 6.1 of LabVIEW for Windows. To use the example, copy these files to your LabVIEW directory:

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

You will also need

- ps2000.dll

from the Drivers\ subdirectory.

4 Troubleshooting

4.1 Software error codes

Consult this section if you are a PicoScope or PicoLog user. If you are writing your own program, refer to the driver error codes section.

PicoLog reports error code 1.
This error is reported when you try to open more than 4 PicoScope PC Oscilloscopes on one machine. It is not possible to use more than 4 units with PicoLog.

PicoScope or PicoLog reports error code 2.
This error is reported when the driver cannot allocate enough of the computer's memory to operate the unit. Consult the system requirements section for more information.

PicoScope or PicoLog reports error code 3.
This error indicates that a PicoScope 2000 Series PC Oscilloscope could not be found on your machine. Make sure the software is installed before the unit is plugged into the USB socket, and restart your computer.

Ensure that the Windows Device Manager mentions the PicoScope 2000 Series unit. If the unit is not mentioned there, contact Pico Technical Support for further advice.

PicoScope or PicoLog reports error code 4, 5 or 6.
These errors are reported when there is a problem with the unit itself. They could arise from configuration settings being corrupted, or a firmware or hardware error.

Unplug the unit, wait a few seconds, and reconnect it to the USB port. If the error is still reported, consult Pico Technical Support for further advice.

PicoScope or PicoLog reports error code 7.
This error is reported if the operating system is not recent enough to support the PicoScope 2000 Series PC Oscilloscope. Consult the system requirements section for more information.

5 Glossary

AC/DC switch
To switch between measuring alternating current and direct current, select AC or DC from the control on the oscilloscope toolbar of the PicoScope software application. Choose the setting to suit the characteristics of the input signal.

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

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

Buffer size
The size of the PicoScope PC Oscilloscope buffer memory. The unit uses this to store data temporarily, so that it can sample data independently of the speed at which it can transfer data to the computer.

Driver
A software application that controls a piece of hardware. The driver for the PicoScope 2000 Series PC Oscilloscopes is supplied in the form of a 32-bit Windows DLL. This is used by the PicoScope and PicoLog software to control the units.

ETS
Equivalent time sampling. The PicoScope 2104 and 2105 can collect data over a number of cycles of a repetitive waveform to give a higher effective sampling rate than is possible for a single cycle. Equivalent time sampling allows the oscilloscope to use faster timebases than those available in real-time mode.

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

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

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

PicoLog software
This is a software product that accompanies all our oscilloscopes. It turns your PC into a data logger and chart recorder.

PicoScope 2000 Series
A range of low-cost PC Oscilloscopes that includes the PicoScope 2202 entry-level unit and 2104 and 2105 variants.

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

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

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

Timebase
The timebase controls the time interval represented across the width of the oscilloscope screen. If you select "Scope timebase is time per division" in the Scope Advanced Options dialog box in the PicoScope application (Settings | Options, Advanced), it works like a traditional bench-top oscilloscope. There are ten divisions across the screen, so the total time interval is ten times the timebase.

USB 1.1
Universal Serial Bus (Full Speed). This is a standard port that enables you to connect external devices to PCs. A typical USB 1.1 port supports a data transfer rate of 12 megabits per second, and is much faster than an RS-232 or COM port.

USB 2.0
Universal Serial Bus (High Speed). This is a standard port that enables you to connect external devices to PCs. A typical USB 2.0 port supports a data transfer rate 40 times faster than USB 1.1. USB 2.0 is backwards-compatible with USB 1.1.

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

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

Windows Device Manager
Windows Device Manager is a component of Microsoft Windows that displays the current hardware configuration of your computer. On Windows 98 or Windows ME, right click on My Computer, select Properties and click the Device Manager tab. On Windows 2000 or Windows XP, right-click My Computer, choose Properties, click the Hardware tab and then the Device Manager button.

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