Handyscope HS4

User manual

TiePie engineering

ATTENTION!

Measuring directly on the **line voltage** can be very dangerous.
The **outside** of the **BNC connectors** at the Handyscope HS4 are connected with the **ground** of the computer. Use a good isolation transformer or a differential probe when measuring at the **line voltage** or at **grounded power supplies**! A short-circuit current will flow if the **ground** of the Handyscope HS4 is connected to a positive voltage. This short-circuit current can damage both the Handyscope HS4 and the computer.

Revision 2.49, August 2024

Contents

1 Safety

When working with electricity, no instrument can guarantee complete safety. It is the responsibility of the person who works with the instrument to operate it in a safe way. Maximum security is achieved by selecting the proper instruments and following safe working procedures. Safe working tips are given below:

- Always work according (local) regulations.
- Work on installations with voltages higher than 25 V_{AC} or 60 V_{DC} should only be performed by qualified personnel.
- Avoid working alone.
- Observe all indications on the Handyscope HS4 before connecting any wiring
- Check the probes/test leads for damages. Do **not** use them if they are damaged
- Take care when measuring at voltages higher than 25 V_{AC} or 60 V_{DC}.
- Do not operate the equipment in an explosive atmosphere or in the presence of flammable gases or fumes.
- Do not use the equipment if it does not operate properly. Have the equipment inspected by qualified service personal. If necessary, return the equipment to TiePie engineering for service and repair to ensure that safety features are maintained.
- Measuring directly on the **line voltage** can be very dangerous. The **outside** of the **BNC connectors** at the Handyscope HS4 are connected with the **ground** of the computer. Use a good isolation transformer or a differential probe when measuring at the **line voltage** or at **grounded power supplies**! A short-circuit current will flow if the **ground** of the Handyscope HS4 is connected to a positive voltage. This short-circuit current can damage both the Handyscope HS4 and the computer.

2 Declaration of conformity

TiePie engineering
Koperslagersstraat 37
8601 WL Sneek
The Netherlands

EC Declaration of conformity

We declare, on our own responsibility, that the product

Handyscope HS4-5MHz
Handyscope HS4-10MHz
Handyscope HS4-25MHz
Handyscope HS4-50MHz

for which this declaration is valid, is in compliance with

EC directive 2011/65/EU (the RoHS directive)
including up to amendment 2021/1980,

EC regulation 1907/2006 (REACH)
including up to amendment 2021/2045,

and with

EN 55011:2016/A1:2017	IEC 61000-6-1:2019 EN
EN 55022:2011/C1:2011	IEC 61000-6-3:2007/A1:2011/C11:2012 EN

according the conditions of the EMC standard 2004/108/EC,

also with

Canada: ICES-001:2004	Australia/New Zealand: AS/NZS CISPR 11:2011

and

IEC 61010-1:2010/A1:2019	USA: UL 61010-1, Edition 3

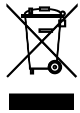
and is categorized as 30 V_{RMS}, 42 V_{pk}, 60 V_{DC}

Sneek, 1-9-2022
ir. A.P.W.M. Poelsma

Environmental considerations

This section provides information about the environmental impact of the Handyscope HS4.

End-of-life handling



Production of the Handyscope HS4 required the extraction and use of natural resources. The equipment may contain substances that could be harmful to the environment or human health if improperly handled at the Handyscope HS4's end of life.

In order to avoid release of such substances into the environment and to reduce the use of natural resources, recycle the Handyscope HS4 in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

The shown symbol indicates that the Handyscope HS4 complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

3 Introduction

Before using the Handyscope HS4 first read chapter 1 about safety.

Many technicians investigate electrical signals. Though the measurement may not be electrical, the physical variable is often converted to an electrical signal, with a special transducer. Common transducers are accelerometers, pressure probes, current clamps and temperature probes. The advantages of converting the physical parameters to electrical signals are large, since many instruments for examining electrical signals are available.

The Handyscope HS4 is a portable four channel measuring instrument. The Handyscope HS4 is available in several models with different maximum sampling rates. The native resolution is 12 bits, but user selectable resolutions of 14 and 16 bits are available too, with reduced maximum sampling rate:

resolution	Model 50	Model 25	Model 10	Model 5
12 bit	50 MSa/s	25 MSa/s	10 MSa/s	5 MSa/s
14 bit	3.125 MSa/s	3.125 MSa/s	3.125 MSa/s	3.125 MSa/s
16 bit	195 kSa/s	195 kSa/s	195 kSa/s	195 kSa/s

Table 3.1: Maximum sampling rates

The Handyscope HS4 supports high speed continuous streaming measurements. The maximum streaming rates are:

resolution	Model 50	Model 25	Model 10	Model 5
12 bit	500 kSa/s	250 kSa/s	100 kSa/s	50 kSa/s
14 bit	480 kSa/s	250 kSa/s	99 kSa/s	50 kSa/s
16 bit	195 kSa/s	195 kSa/s	97 kSa/s	48 kSa/s

Table 3.2: Maximum streaming rates

With the accompanying software the Handyscope HS4 can be used as an oscilloscope, a spectrum analyzer, a true RMS voltmeter or a transient recorder. All instruments measure by sampling the input signals, digitizing the values, process them, save them and display them.

3.1 Sampling

When sampling the input signal, samples are taken at fixed intervals. At these intervals, the size of the input signal is converted to a number. The accuracy of this number depends on the resolution of the instrument. The higher the resolution, the smaller the voltage steps in which the input range of the instrument is divided. The acquired numbers can be used for various purposes, e.g. to create a graph.

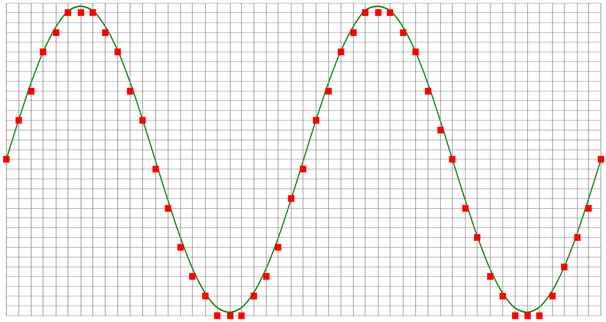


Figure 3.1: Sampling

The sine wave in figure 3.1 is sampled at the dot positions. By connecting the adjacent samples, the original signal can be reconstructed from the samples. You can see the result in figure 3.2.

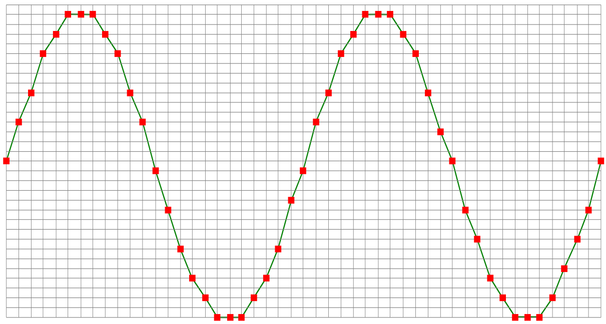


Figure 3.2: "connecting" the samples

3.2 Sampling rate

The rate at which the samples are taken is called the **sampling rate**, the number of samples per second. A higher sampling rate corresponds to a shorter interval between the samples. As is visible in figure 3.3, with a higher sampling rate, the original signal can be reconstructed much better from the measured samples.

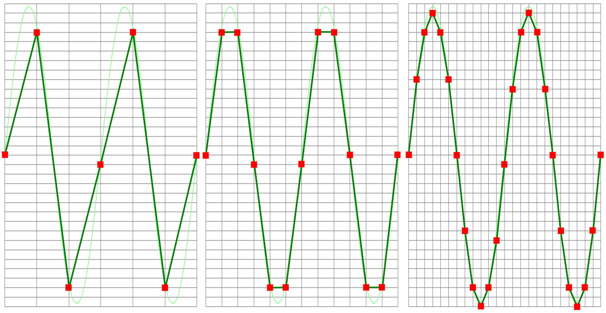


Figure 3.3: The effect of the sampling rate

The sampling rate must be higher than 2 times the highest frequency in the input signal. This is called the **Nyquist frequency**. Theoretically it is possible to reconstruct the input signal with more than 2 samples per period. In practice, 10 to 20 samples per period are recommended to be able to examine the signal thoroughly.

3.2.1 Aliasing

When sampling an analog signal with a certain sampling rate, signals appear in the output with frequencies equal to the sum and difference of the signal frequency and multiples of the sampling rate. For example, when the sampling rate is 1000 Sa/s and the signal frequency is 1250 Hz, the following signal frequencies will be present in the output data:

Multiple of sampling rate	1250 Hz signal	-1250 Hz signal
...		
-1000	-1000 + 1250 = **250**	-1000 - 1250 = -2250
0	0 + 1250 = 1250	0 - 1250 = -1250
1000	1000 + 1250 = 2250	1000 - 1250 = -250
2000	2000 + 1250 = 3250	2000 - 1250 = 750
...		

Table 3.3: Aliasing

As stated before, when sampling a signal, only frequencies lower than half the sampling rate can be reconstructed. In this case the sampling rate is 1000 Sa/s, so we can we only observe signals with a frequency ranging from 0 to 500 Hz. This means that from the resulting frequencies in the table, we can only see the 250 Hz signal in the sampled data. This signal is called an **alias** of the original signal.

If the sampling rate is lower than twice the frequency of the input signal, **aliasing** will occur. The following illustration shows what happens.

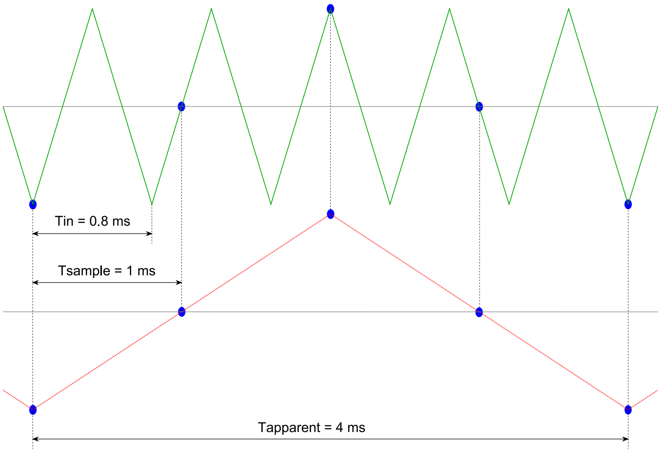


Figure 3.4: Aliasing

In figure 3.4, the green input signal (top) is a triangular signal with a frequency of 1.25 kHz. The signal is sampled with a rate of 1 kSa/s. The corresponding sampling interval is 1/1000Hz = 1ms. The positions at which the signal is sampled are depicted with the blue dots. The red dotted signal (bottom) is the result of the reconstruction. The period time of this triangular signal appears to be 4 ms, which corresponds to an apparent frequency (alias) of 250 Hz (1.25 kHz - 1 kHz).

To avoid aliasing, always start measuring at the highest sampling rate and lower the sampling rate if required.

3.3 Digitizing

When digitizing the samples, the voltage at each sample time is converted to a number. This is done by comparing the voltage with a number of levels. The resulting number is the number corresponding to the level that is closest to the voltage. The number of levels is determined by the resolution, according to the following relation: $LevelCount = 2^{Resolution}$.

The higher the **resolution**, the more levels are available and the more accurate the input signal can be reconstructed. In figure 3.5, the same signal is digitized, using two different amounts of levels: 16 (4-bit) and 64 (6-bit).

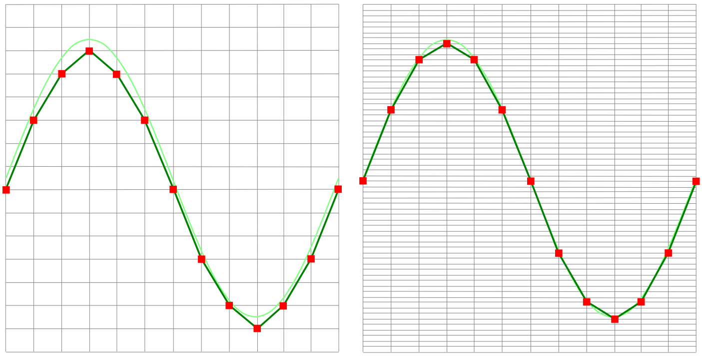


Figure 3.5: The effect of the resolution

The Handyscope HS4 measures at e.g. 12 bit resolution (2^{12}=4096 levels). The smallest detectable voltage step depends on the input range. This voltage can be calculated as:

$$VoltageStep = FullInputRange/LevelCount$$

For example, the 200 mV range ranges from -200 mV to +200 mV, therefore the full range is 400 mV. This results in a smallest detectable voltage step of 0.400 V / 4096 = 97.65 μV.

3.4 Signal coupling

The Handyscope HS4 has two different settings for the signal coupling: AC and DC. In the setting DC, the signal is directly coupled to the input circuit. All signal components available in the input signal will arrive at the input circuit and will be measured.

In the setting AC, a capacitor will be placed between the input connector and the input circuit. This capacitor will block all DC components of the input signal and let all AC components pass through. This can be used to remove a large DC component of the input signal, to be able to measure a small AC component at high resolution.

When measuring DC signals, make sure to set the signal coupling of the input to DC.

3.5 Probe compensation

The Handyscope HS4 is shipped with a probe for each input channel. These are 1x/10x selectable passive probes. This means that the input signal is passed through directly or 10 times attenuated.

When using an oscilloscope probe in 1:1 the setting, the bandwidth of the probe is only 6 MHz. The full bandwidth of the probe is only obtained in the 1:10 setting

The x10 attenuation is achieved by means of an attenuation network. This attenuation network has to be adjusted to the oscilloscope input circuitry, to guarantee frequency independency. This is called the low frequency compensation. Each time a probe is used on an other channel or an other oscilloscope, the probe must be adjusted.

Therefore the probe is equiped with a setscrew, with which the parallel capacity of the attenuation network can be altered. To adjust the probe, switch the probe to the x10 and attach the probe to a 1 kHz square wave signal. Then adjust the probe for a square front corner on the square wave displayed. See also the following illustrations.

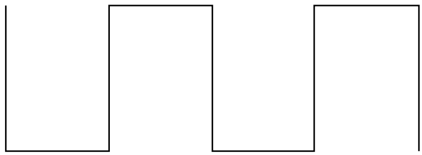


Figure 3.6: correct

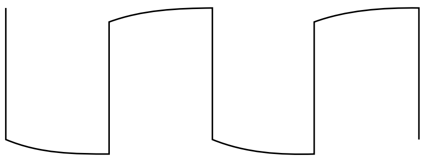


Figure 3.7: under compensated

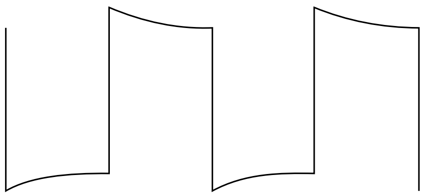


Figure 3.8: over compensated

4 Driver installation

Before connecting the Handyscope HS4 to the computer, the drivers need to be installed.

4.1 Introduction

To operate a Handyscope HS4, a driver is required to interface between the measurement software and the instrument. This driver takes care of the low level communication between the computer and the instrument, through USB. When the driver is not installed, or an old, no longer compatible version of the driver is installed, the software will not be able to operate the Handyscope HS4 properly or even detect it at all.

The installation of the USB driver is done in a few steps. Firstly, the driver has to be pre-installed by the driver setup program. This makes sure that all required files are located where Windows can find them. When the instrument is plugged in, Windows will detect new hardware and install the required drivers.

4.1.1 Where to find the driver setup

The driver setup program and measurement software can be found in the download section on TiePie engineering's website. It is recommended to install the latest version of the software and USB driver from the website. This will guarantee the latest features are included.

4.1.2 Executing the installation utility

To start the driver installation, execute the downloaded driver setup program. The driver install utility can be used for a first time installation of a driver on a system and also to update an existing driver.

The screen shots in this description may differ from the ones displayed on your computer, depending on the Windows version.

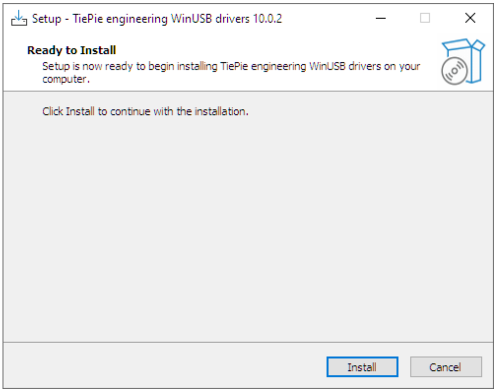


Figure 4.1: Driver install: step 1

When drivers were already installed, the install utility will remove them before installing the new driver. To remove the old driver successfully, **it is essential** that the Handyscope HS4 is disconnected from the computer prior to starting the driver install utility. When the Handyscope HS4 is used with an external power supply, this must be disconnected too.

Clicking *"**Install**"* will remove existing drivers and install the new driver. A *remove entry* for the new driver is added to the software applet in the Windows control panel.

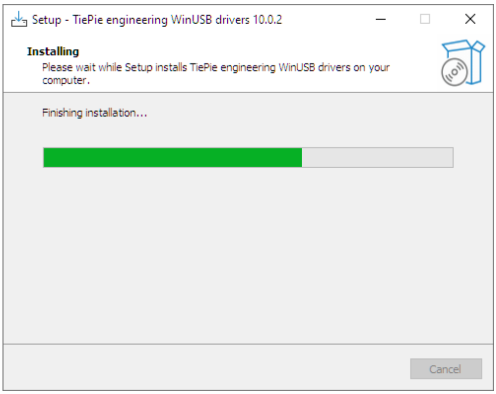


Figure 4.2: Driver install: Copying files

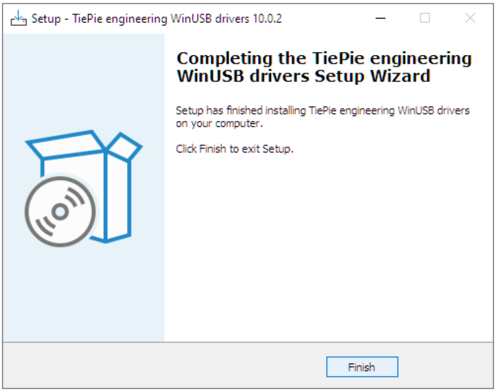


Figure 4.3: Driver install: Finished

5 Hardware installation

Drivers have to be installed before the Handyscope HS4 is connected to the computer for the first time. See chapter 4 for more information.

5.1 Power the instrument

The Handyscope HS4 is powered by the USB, no external power supply is required. Only connect the Handyscope HS4 to a bus powered USB port, otherwise it may not get enough power to operate properly.

5.1.1 External power

In certain cases, the Handyscope HS4 cannot get enough power from the USB port. When a Handyscope HS4 is connected to a USB port, powering the hardware will result in an inrush current higher than the nominal current. After the inrush current, the current will stabilize at the nominal current.

USB ports have a maximum limit for both the inrush current peak and the nominal current. When either of them is exceeded, the USB port will be switched off. As a result, the connection to the Handyscope HS4 will be lost.

Most USB ports can supply enough current for the Handyscope HS4 to work without an external power supply, but this is not always the case. Some (battery operated) portable computers or (bus powered) USB hubs do not supply enough current. The exact value at which the power is switched off, varies per USB controller, so it is possible that the Handyscope HS4 functions properly on one computer, but does not on another.

In order to power the Handyscope HS4 externally, an external power input is provided for. It is located at the rear of the Handyscope HS4. Refer to paragraph 7.1 for specifications of the external power intput.

5.2 Connect the instrument to the computer

After the new driver has been pre-installed (see chapter 4), the Handyscope HS4 can be connected to the computer. When the Handyscope HS4 is connected to a USB port of the computer, Windows will detect new hardware.

Depending on the Windows version, a notification can be shown that new hardware is found and that drivers will be installed. Once ready, Windows will report that the driver is installed.

When the driver is installed, the measurement software can be installed and the Handyscope HS4 can be used.

5.3 Plug into a different USB port

When the Handyscope HS4 is plugged into a different USB port, some Windows versions will treat the Handyscope HS4 as different hardware and will install the drivers again for that port. This is controlled by Microsoft Windows and is not caused by TiePie engineering.

6 Front panel

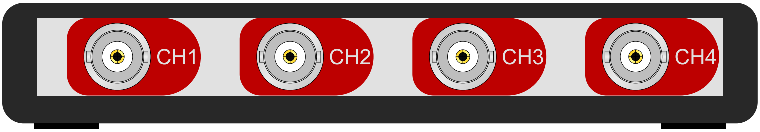


Figure 6.1: Front panel

6.1 Channel input connectors

The CH1 – CH4 BNC connectors are the main inputs of the acquisition system. The outside of all four BNC connectors is connected to the ground of the Handyscope HS4. Connecting the outside of the BNC connector to a potential other than ground will result in a short circuit that may damage the device under test, the Handyscope HS4 and the computer.

6.2 Power indicator

A power indicator is situated at the top cover of the instrument. It is lit when the Handyscope HS4 is powered.

7 Rear panel

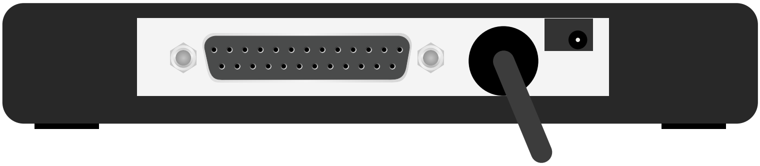
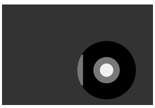


Figure 7.1: Rear panel

7.1 Power

The Handyscope HS4 is powered through the USB. If the USB cannot deliver enough power, it is possible to power the instrument externally. The Handyscope HS4 has two external power inputs located at the rear of the instrument: the dedicated power input and a pin of the extension connector.

The specifications of the dedicated power connector are:



Pin	Dimension	Description
Center pin	Ø1.3 mm	ground
Outside bushing	Ø3.5 mm	positive

Figure 7.2: Power connector

Besides the external power input, it is also possible to power the instrument through the extension connector, the 25 pin D-sub connector at the rear of the instrument. The power has to be applied to pin 3 of the extension connector. Pin 4 can be used as ground.

The following minimum and maximum voltages apply to both power inputs:

Minimum	Maximum
4.5 V_{DC}	14 V_{DC}

Table 7.1: Maximum voltages

Note that the externally applied voltage should be higher than the USB voltage to relieve the USB port.

7.1.1 USB power cable

The Handyscope HS4 is delivered with a special USB external power cable.

Figure 7.3: USB power cable

One end of this cable can be connected to a second USB port on the computer, the other end can be plugged in the external power input at the rear of the instrument. The power for the instrument will be taken from two USB ports of the computer.

The outside of the external power connector is connected to +5 V. In order to avoid shortage, first connect the cable to the Handyscope HS4 and then to the USB port.

7.1.2 Power adapter

In case a second USB port is not available, or the computer still can't provide enough power for the instrument, an external power adapter can be used. When using an external power adapter, make sure that:

- the polarity is set correctly
- the voltage is set to a valid value for the instrument and higher than the USB voltage
- the adapter can supply enough current (preferably >1 A)
- the plug has the correct dimensions for the external power input of the instrument

7.2 USB

The Handyscope HS4 is equipped with a USB 2.0 High speed (480 Mbit/s) interface with a fixed cable with type A plug. It will also work on a computer with a USB 1.1 interface, but will then operate at 12 Mbit/s.

7.3 Extension Connector

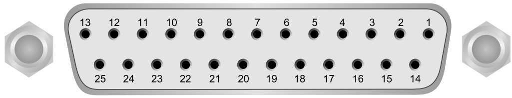


Figure 7.4: Extension connector

To connect to the Handyscope HS4 a 25 pin female D-sub connector is available, containing the following signals:

Pin	Description	Pin	Description
1	Ground	14	Ground
2	Reserved	15	Ground
3	External Power in DC	16	Reserved
4	Ground	17	Ground
5	+5V out, 10 mA max.	18	Reserved
6	Ext. sampling clock in (TTL)	19	Reserved
7	Ground	20	Reserved
8	Ext. trigger in (TTL)	21	Reserved
9	Data OK out (TTL)	22	Ground
10	Ground	23	I^2C SDA
11	Trigger out (TTL)	24	I^2C SCL
12	Reserved	25	Ground
13	Ext. sampling clock out (TTL)		

Table 7.2: Pin description Extension connector

All TTL signals are 3.3 V TTL signals which are 5 V tolerant, so they can be connected to 5 V TTL systems.

Pins 9, 11, 12, 13 are open collector outputs. Connect a pull-up resistor of 1 kOhm to pin 5 when using one of these signals.

8 Specifications

The accuracy of a channel is defined as a percentage of the Full Scale range. The Full Scale range runs from *-range* to *range* and is effectively *2 * range*. When the input range is set to 4 V, the Full Scale range is -4 V to 4 V = 8 V. Additionally a number of Least Significant Bits is incorporated. The acuracy is determined in the highest resolution.

When the accuracy is specified as ±0.2% of the Full Scale range ± 1 LSB, and the input range is 4 V, the maximum deviation the measured value can have is ±0.2% of 8 V = ±16 mV. ±1 LSB equals 8 V / 65536 (= number of LSB at 16 bit) = ± 122 μV. Therefore the measured value will be between 16.122 mV lower and 16.122 mV higher than the actual value. When e.g. applying a 3.75 V signal and measuring it in the 4 V range, the measured value will be between 3.766122 V and 3.733878 V.

8.1 Acquisition system

Number of input channels	4 analog			
CH1, CH2, CH3, CH4	BNC, female			
Type	Single ended			
Resolution	12, 14, 16 bit user selectable			
Accuracy	0.2% of full scale ± 1 LSB			
Ranges (full scale)	±200 mV ±2 V ±20 V	±400 mV ±4 V ±40 V	±800 mV ±8 V ±80 V	
Coupling	AC/DC			
Impedance	1 MΩ / 30 pF			
Noise	150 μV_{RMS} (200 mV range, 12 bit, 50 MSa/s) 45 μV_{RMS} (200 mV range, 16 bit, 195 kSa/s)			
Maximum voltage	200 V (DC + AC peak <10 kHz)			
Bandwidth (-3dB)	50 MHz			
AC coupling cut off frequency (-3dB)	±1.5 Hz			
Maximum sampling rate	HS4-50	HS4-25	HS4-10	HS4-5
12 bit	50 MSa/s	25 MSa/s	10 MSa/s	5 MSa/s
14 bit	3.125 MSa/s	3.125 MSa/s	3.125 MSa/s	3.125 MSa/s
16 bit	195 kSa/s	195 kSa/s	195 kSa/s	195 kSa/s
Maximum streaming rate	HS4-50	HS4-25	HS4-10	HS4-5
12 bit	500 kSa/s	250 kSa/s	100 kSa/s	50 kSa/s
14 bit	480 kSa/s	250 kSa/s	99 kSa/s	50 kSa/s
16 bit	195 kSa/s	195 kSa/s	97 kSa/s	48 kSa/s
Sampling source	internal quartz, external			
Internal	Quartz			
Accuracy	±0.01%			
Stability	±100 ppm over -40°C to +85°C			
External	On extension connector			
Voltage	3.3 V TTL, 5 V TTL tolerant			
Frequency range	95 MHz to 105 MHz			
Memory	128 kSamples per channel			

8.2 Trigger system

System	digital, 2 levels
Source	CH1, CH2, CH3, CH4, digital external, AND, OR
Trigger modes	rising slope, falling slope, inside window, outside window
Level adjustment	0 to 100% of full scale
Hysteresis adjustment	0 to 100% of full scale
Resolution	0.024 % (12 bits)
Pre trigger	0 to 128 ksamples (0 to 100%, one sample resolution)
Post trigger	0 to 128 ksamples (0 to 100%, one sample resolution)
Trigger hold-off	0 to 1 MSamples, 1 sample resolution
Digital external trigger	
Input	extension connector
Range	0 to 5 V (TTL)
Coupling	DC

8.3 Interface

Interface	USB 2.0 High Speed (480 Mbit/s) (USB 1.1 Full Speed (12 Mbit/s) and USB 3.0 compatible)

8.4 Power

Input	from USB or external input
Consumption	500 mA max

8.5 Physical

Instrument height	25 mm / 1.0"
Instrument length	170 mm / 6.7"
Instrument width	140 mm / 5.2"
Weight	480 gram / 17 ounce
USB cord length	1.8 m / 70"

8.6 I/O connectors

CH1 .. CH4	BNC, female
Power	3.5 mm power socket
Extension connector	D-sub 25 pins female
USB	Fixed cable with type A plug

8.7 System requirements

PC I/O connection	USB 2.0 High Speed (480 Mbit/s) (USB 1.1 Full Speed (12 Mbit/s) and USB 3.0 compatible)
Operating System	Windows 10 / 11, 64 bits

8.8 Environmental conditions

Operating	
Ambient temperature	0°C to 55°C
Relative humidity	10 to 90% non condensing
Storage	
Ambient temperature	-20°C to 70°C
Relative humidity	5 to 95% non condensing

8.9 Certifications and Compliances

CE mark compliance	Yes
RoHS	Yes
REACH	Yes
EN 55011:2016/A1:2017	Yes
EN 55022:2011/C1:2011	Yes
IEC 61000-6-1:2019 EN	Yes
IEC 61000-6-3:2007/A1:2011/C11:2012	Yes
ICES-001:2004	Yes
AS/NZS CISPR 11:2011	Yes
IEC 61010-1:2010/A1:2019	Yes
UL 61010-1, Edition 3	Yes

8.10 Probes

Model	HP-3250I	
	X1	X10
Bandwidth	6 MHz	250 MHz
Rise time	58 ns	1.4 ns
Input impedance	1 MΩ oscilloscope impedance	10 MΩ incl. 1 MΩ oscilloscope impedance
Input capacitance	56 pF + oscilloscope capacitance	13 pF
Compensation range	-	10 to 30 pF
Working voltage (DC + AC peak)	300 V 150 V CAT II	600 V 300 V CAT II

8.11 Package contents

Instrument	Handyscope HS4
Probes	4 x HP-3250I X1 / X10 switchable
Accessories	USB power cable
Software	Windows 10 / 11, 64 bits, via website
Drivers	Windows 10 / 11, 64 bits, via website
Software Development Kit	Windows 10 / 11 (64 bits) and Linux, via website
Manual	Instrument manual and software manual

If you have any suggestions and/or remarks regarding this manual, please contact:

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