

# Handyscope HS5

## User manual



TiePie engineering

## ATTENTION!

Measuring directly on the **line voltage** can be very dangerous.

The **outside** of the **BNC connectors** at the Handyscope HS5 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 HS5 is connected to a positive voltage. This short-circuit current can damage both the Handyscope HS5 and the computer.

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Despite the care taken for the compilation of this user manual, TiePie engineering can not be held responsible for any damage resulting from errors that may appear in this manual.

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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<sub>AC</sub> or 60 V<sub>DC</sub> should only be performed by qualified personnel.
- Avoid working alone.
- Observe all indications on the Handyscope HS5 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<sub>AC</sub> or 60 V<sub>DC</sub>.
- 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 HS5 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 HS5 is connected to a positive voltage. This short-circuit current can damage both the Handyscope HS5 and the computer.



## Declaration of conformity

2



TiePie engineering  
Koperslagersstraat 37  
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The Netherlands

### EC Declaration of conformity

We declare, on our own responsibility, that the product

**Handyscope HS5-540(XM/S/XMS)**  
**Handyscope HS5-530(XM/S/XMS)**  
**Handyscope HS5-220(XM/S/XMS)**  
**Handyscope HS5-110(XM/S/XMS)**  
**Handyscope HS5-055(XM/S/XMS)**

for which this declaration is valid, is in compliance with

EN 55011:2009/A1:2010      IEC 61000-6-1/EN 61000-6-1:2007  
EN 55022:2006/A1:2007      IEC 61000-6-3/EN 61000-6-3:2007

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

also with

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

and

IEC 61010-1:2001/EN      USA: UL61010-1: 2004

and is categorized as CAT I 30 Vrms, 42 Vpk, 60 Vdc

Sneek, 29-5-2012  
ir. A.P.W.M. Poelsma

A handwritten signature in blue ink, appearing to read 'A.P.W.M. Poelsma', written over a horizontal line.

## Environmental considerations

This section provides information about the environmental impact of the Handyscope HS5.

### End-of-life handling

Production of the Handyscope HS5 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 HS5'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 HS5 in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

The symbol shown below indicates that the Handyscope HS5 complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE).



### Restriction of Hazardous Substances

The Handyscope HS5 has been classified as Monitoring and Control equipment, and is outside the scope of the 2002/95/EC RoHS Directive.





Before using the Handyscope HS5 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 HS5 is a portable two channel measuring instrument with Arbitrary Waveform Generator. The Handyscope HS5 is available in several models with different maximum sampling frequencies: 50 MS/s, 100 MS/s, 200 MS/s or 500 MS/s. The native resolutions are 8, 12 and 14 bits and a user selectable resolution of 16 bits is available too, with adjusted maximum sampling frequencies:

| Handyscope HS5 | Channels | Resolution |          |            |
|----------------|----------|------------|----------|------------|
|                |          | 8 / 12 bit | 14 bit   | 16 bit     |
| Model 540      | CH1      | 500 MS/s   | 100 MS/s | 6.25 MS/s  |
|                | CH1+CH2  | 200 MS/s   |          |            |
| Model 530      | CH1      | 500 MS/s   | 100 MS/s | 6.25 MS/s  |
|                | CH1+CH2  | 200 MS/s   |          |            |
| Model 220      | CH1      | 200 MS/s   | 50 MS/s  | 3.125 MS/s |
|                | CH1+CH2  | 100 MS/s   |          |            |
| Model 110      | CH1      | 100 MS/s   | 20 MS/s  | 1.25 MS/s  |
|                | CH1+CH2  | 50 MS/s    |          |            |
| Model 055      | CH1      | 50 MS/s    | 10 MS/s  | 625 kS/s   |
|                | CH1+CH2  | 20 MS/s    |          |            |

Table 3.1: Maximum sampling frequencies

The Handyscope HS5 supports high speed continuous streaming measurements. The maximum streaming rates are:

| Handyscope HS5 | Channels | Resolution |           |            |
|----------------|----------|------------|-----------|------------|
|                |          | 8 bit      | 12/14 bit | 16 bit     |
| Model 540      | CH1      | 40 MS/s    | 20 MS/s   | 6.25 MS/s  |
|                | CH1+CH2  | 20 MS/s    | 10 MS/s   |            |
| Model 530      | CH1      | 40 MS/s    | 20 MS/s   | 6.25 MS/s  |
|                | CH1+CH2  | 20 MS/s    | 10 MS/s   |            |
| Model 220      | CH1      | 20 MS/s    | 10 MS/s   | 3.125 MS/s |
|                | CH1+CH2  | 10 MS/s    | 5 MS/s    |            |
| Model 110      | CH1      | 10 MS/s    | 5 MS/s    | 1.25 MS/s  |
|                | CH1+CH2  | 4 MS/s     | 2 MS/s    |            |
| Model 055      | CH1      | 4 MS/s     | 2 MS/s    | 625 kS/s   |
|                | CH1+CH2  | 2 MS/s     | 1 MS/s    |            |

Table 3.2: Maximum streaming rates

The Handyscope HS5 is available with two memory configurations, these are:

| Memory         | Model 540 | Model 530 | Model 220 | Model 110 | Model 055 |
|----------------|-----------|-----------|-----------|-----------|-----------|
| Standard model | 128 KiS   | 128 KiS   | 128 KiS   | 128 KiS   | 128 KiS   |
| Option XM      | 32 MiS    | 32 MiS    | 32 MiS    | 32 MiS    | 32 MiS    |

Table 3.3: Maximum record lengths per channel

Optionally available for the Handyscope HS5 are **SureConnect** connection test and resistance measurement. **SureConnect** connection test tells you immediately whether your test probe or clip actually makes electrical contact or not. No more doubt whether your probe doesn't make contact or there really is no signal. This is useful when surfaces are oxidized and your probe cannot get a good electrical contact. Simply activate the **SureConnect** and you know whether there is contact or not. Also when back probing connectors in confined places, **SureConnect** immediately shows whether the probes make contact or not.

Models of the Handyscope HS5 with **SureConnect** come with resistance measurement on all channels. Resistances up to 2 MOhm can be measured directly. Resistance can be shown in meter displays and can also be plotted versus time in a graph, creating an Ohm scope.

With the accompanying software the Handyscope HS5 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.

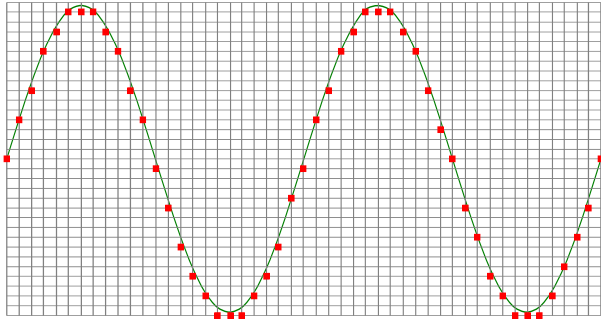


Figure 3.1: Sampling

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.

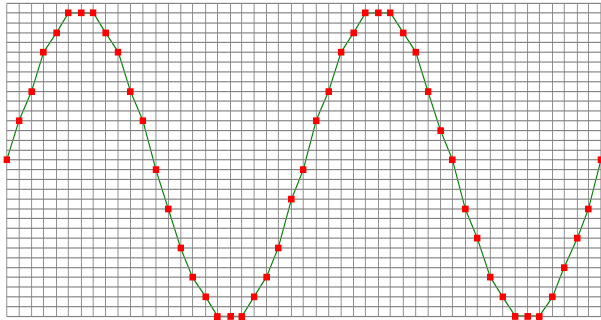


Figure 3.2: "connecting" the samples

## 3.2 Sample frequency

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

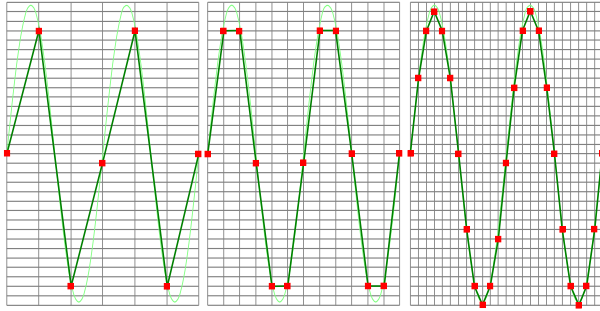


Figure 3.3: The effect of the sampling frequency

The sampling frequency 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 frequency, signals appear in the output with frequencies equal to the sum and difference of the signal frequency and multiples of the sampling frequency. For example, when the sampling frequency is 1000 Hz and the signal frequency is 1250 Hz, the following signal frequencies will be present in the output data:

| Multiple of sampling frequency | 1250 Hz signal                | -1250 Hz signal        |
|--------------------------------|-------------------------------|------------------------|
| ...                            |                               |                        |
| -1000                          | $-1000 + 1250 = \mathbf{250}$ | $-1000 - 1250 = -2250$ |
| 0                              | $0 + 1250 = 1250$             | $0 - 1250 = -1250$     |
| 1000                           | $1000 + 1250 = 2250$          | $1000 - 1250 = -250$   |
| 2000                           | $2000 + 1250 = 3250$          | $2000 - 1250 = 750$    |
| ...                            |                               |                        |

Table 3.4: Aliasing

As stated before, when sampling a signal, only frequencies lower than half the sampling frequency can be reconstructed. In this case the sampling frequency is 1000 Hz, so we can 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 frequency is lower than twice the frequency of the input signal, **aliasing** will occur. The following illustration shows what happens.

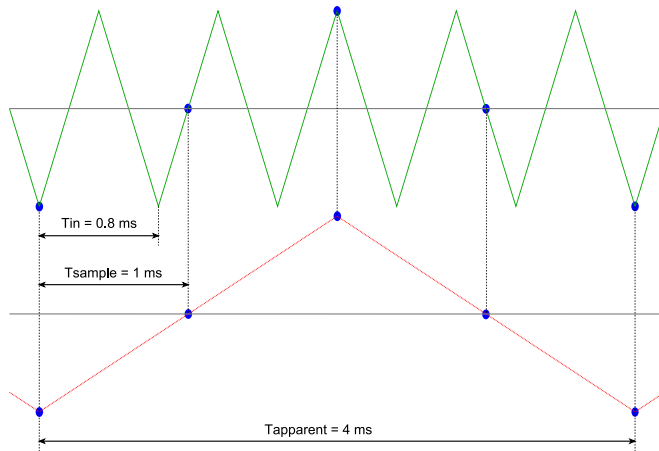


Figure 3.4: Aliasing

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 frequency of 1 kHz. The corresponding sampling interval is  $1/1000\text{Hz} = 1\text{ms}$ . 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 ( $1.25 \text{ kHz} - 1 \text{ kHz}$ ).



To avoid aliasing, always start measuring at the highest sampling frequency and lower the sampling frequency 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).

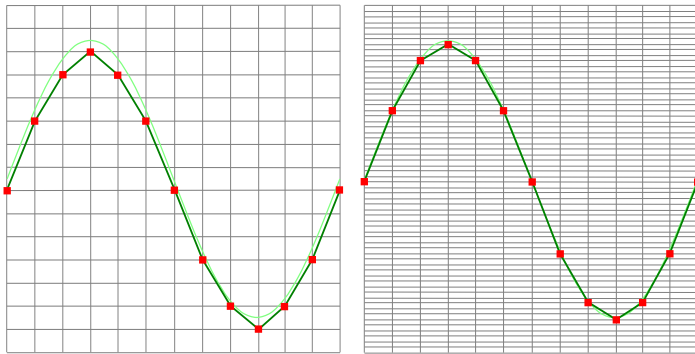


Figure 3.5: The effect of the resolution

The Handscope HS5 measures at e.g. 14 bit resolution ( $2^{14}=16384$  levels). The smallest detectable voltage step depends on the input range. This voltage can be calculated as:

$$\text{VoltageStep} = \text{FullInputRange} / \text{LevelCount}$$

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  $0.400 \text{ V} / 16384 = 24.41 \mu\text{V}$ .

### 3.4 Signal coupling

The Handscope HS5 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.




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

---

### 3.5 Probe compensation

The Handscope HS5 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 equipped 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.

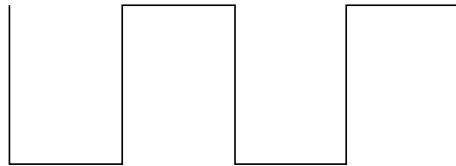


Figure 3.6: correct

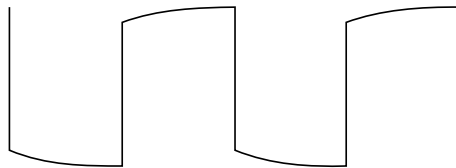


Figure 3.7: under compensated

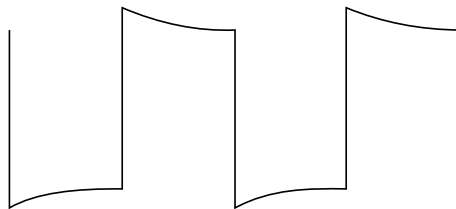


Figure 3.8: over compensated







Before connecting the Handyscope HS5 to the computer, the drivers need to be installed.

## 4.1 Introduction

To operate a Handyscope HS5, 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 HS5 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.

## 4.2 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 and on the CD-ROM that came with the instrument. 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.

## 4.3 Executing the installation utility

To start the driver installation, execute the downloaded driver setup program, or the one on the CD-ROM that came with the instrument. 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.

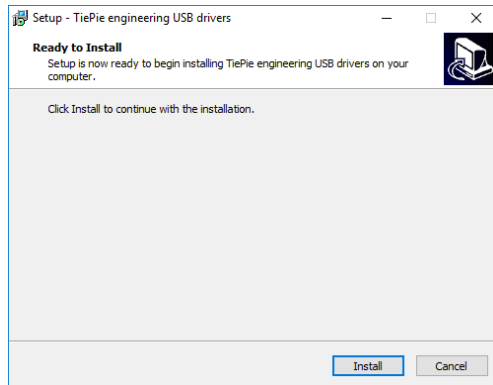


Figure 4.1: Driver install: step 1

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 Handscope HS5 is disconnected from the computer prior to starting the driver install utility. When the Handscope HS5 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.

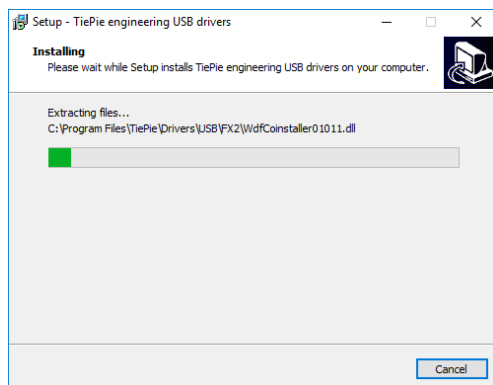


Figure 4.2: Driver install: Copying files

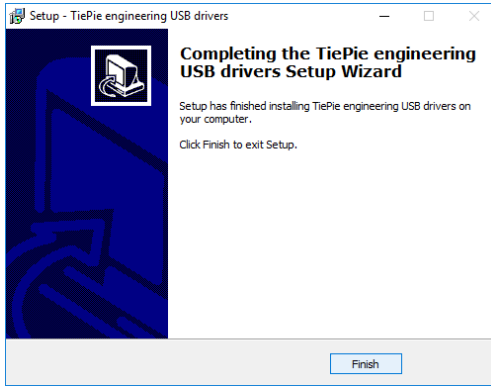


Figure 4.3: Driver install: Finished





Drivers have to be installed before the Handyscope HS5 is connected to the computer for the first time. See chapter 4 for more information.

### 5.1 Power the instrument

The Handyscope HS5 is powered by the USB, no external power supply is required. Only connect the Handyscope HS5 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 HS5 cannot get enough power from the USB port. When a Handyscope HS5 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 HS5 will be lost.

Most USB ports can supply enough current for the Handyscope HS5 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 HS5 functions properly on one computer, but does not on another.

The Handyscope HS5 comes with a universal power supply, that can be connected to a power outlet using the appropriate adapter. The 3.5 mm connector attached to the power supply must be plugged into the power connector at the rear of the Handyscope HS5. Refer to paragraph 8.1 for specifications of the external power input.

When the Arbitrary Waveform Generator is used, the power that the Handyscope HS5 requires may strongly increase. It is recommended to use the external power supply when the Handyscope HS5 Arbitrary Waveform Generator is used.

### 5.2 Connect the instrument to the computer

After the new driver has been pre-installed (see chapter 4), the Handyscope HS5 can be connected to the computer. When the Handyscope HS5 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 HS5 can be used.

### 5.3 Plug into a different USB port

When the Handyscope HS5 is plugged into a different USB port, some Windows versions will treat the Handyscope HS5 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.

### 5.4 Operating conditions

The Handyscope HS5 is ready for use as soon as the software is started. However, to achieve rated accuracy, allow the instrument to settle for 20 minutes. If the instrument has been subjected to extreme temperatures, allow additional time for internal temperatures to stabilize. Because of temperature compensated calibration, the Handyscope HS5 will settle within specified accuracy regardless of the surrounding temperature.

When more channels are required than one instrument can offer, multiple instruments can be combined into a larger combined instrument. To combine two or more instruments, the instruments need to be connected to each other using special cables.

The CMI (Combine Multiple Instruments) interface that is available by default on the Handyscope HS5 provides an easy way to couple multiple oscilloscopes to one combined oscilloscope. The CMI interface supports automatic recognition of the instrument. The high speed trigger bus is automatically terminated with the correct impedance and the high speed sampling bus is automatically configured and terminated at the beginning and end of the bus. The high speed sampling bus takes care that each Handyscope is fully synchronized to ensure that even at the highest sampling rate the instruments operate at the same sample clock (0 ppm clock error!). The connection order when combining multiple instruments is not important. The CMI interface has built-in intelligence to detect the connections and terminate all buses properly at both ends of the bus. So instruments can be connected to each other in random order. Placing terminators and determining the proper connection order is not required!

Advantages of the CMI (Combine Multiple Instruments) interface are:

- automatic instrument recognition,
- automatic creation and termination of the high speed trigger bus,
- automatic creation and termination of the high speed sampling bus,
- automatic master/slave setting of the sampling clock bus.

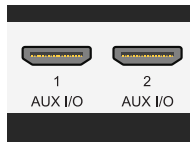


Figure 6.1: Auxiliary I/O or CMI connectors

Connecting is done by daisy chaining the CMI connectors of the instruments prior to starting the software, using special coupling cables (order number TP-C50H). The software will detect how the instruments are connected to each other and will automatically terminate the connection bus. The software will combine the connected instruments to one large instrument. The combined instruments will sample using the same clock, with a deviation of 0 ppm.



Figure 6.2: 3 Handyscope HS5s combined

A six channel instrument is easily made by connecting three Handyscope HS5s to each other.

When combining one or more Handyscope HS5s with Handyscope HS6 DIFFs, the daisy chained CMI bus must begin or end with a Handyscope HS6 DIFF. Additionally, the maximum sampling rate is limited to 100 MS/s at 14 bit resolution.



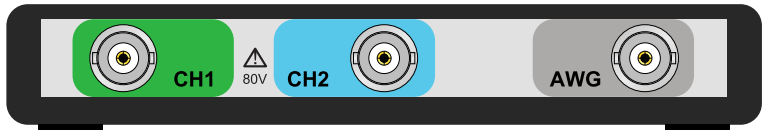


Figure 7.1: Front panel

## 7.1 CH1 and CH2 input connectors

The CH1 and CH2 BNC connectors are the main inputs of the acquisition system. The outside of the BNC connectors is connected to the ground of the Handyscope HS5. 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 HS5 and the computer.

## 7.2 AWG output connector

The AWG BNC connector is the output of the internal Arbitrary Waveform Generator. The outside of this BNC connector is connected to the ground of the Handyscope HS5.

## 7.3 Power indicator

A power indicator is situated at the top cover of the instrument. It is lit when the Handyscope HS5 is powered.



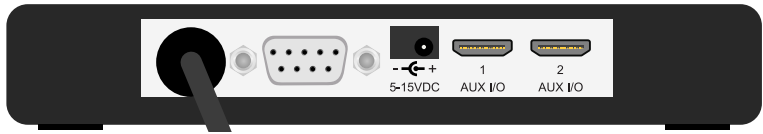


Figure 8.1: Rear panel

## 8.1 Power

The Handyscope HS5 is powered through the USB. If the USB cannot supply enough power, it is possible to power the instrument externally. The Handyscope HS5 has two external power inputs located at the rear of the instrument: the dedicated power connector and a pin of the 9 pin D-sub extension connector. The specifications of the dedicated power connector are:



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

Figure 8.2: Power connector

To power the instrument through the extension connector, the power has to be applied to pin 7 of the extension connector. Pin 6 can be used as ground. The following minimum and maximum voltages apply to the power inputs:

|         |                                |
|---------|--------------------------------|
| Minimum | 4.5 V <sub>DC</sub> / 2 A max. |
| Maximum | 15 V <sub>DC</sub> / 1 A max.  |

Table 8.1: Maximum voltages

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

### 8.1.1 Power adapter

The Handyscope HS5 comes with an external power adapter that can be connected to any mains power net that supplies 100 – 240 V<sub>AC</sub>, 50 – 60 Hz. The external power adapter can be connected to the dedicated power connector.



Figure 8.3: Power adapter

### 8.1.2 USB power cable

A special USB external power cable is supplied with the Handyscope HS5 that can be used instead of a power adapter. One end of this cable can be connected to a second USB port on the computer, the other end can be plugged in the dedicated power connector at the rear of the instrument. The power for the instrument will then be taken from two USB ports.



Figure 8.4: USB power cable

## 8.2 USB

The Handyscope HS5 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.

## 8.3 Extension Connector



Figure 8.5: Extension connector

A 9 pin female D-sub connector is available at the back of the Handyscope HS5 containing the following signals:

| Pin | Description          | Pin | Description                 |
|-----|----------------------|-----|-----------------------------|
| 1   | EXT 1 (LVTTTL)       | 6   | GND                         |
| 2   | EXT 2 (LVTTTL)       | 7   | Power IN                    |
| 3   | EXT 3 (LVTTTL)       | 8   | Power OUT (see description) |
| 4   | I <sup>2</sup> C SDA | 9   | reserved                    |
| 5   | I <sup>2</sup> C SCL |     |                             |

Table 8.2: Pin description Extension connector

Pins EXT 1, EXT 2 and EXT 3 are equipped with internal 1 kOhm pull-up resistors to 2.5 V. These pins can simultaneously be used as inputs and outputs. Each pin can be configured as external digital trigger input for the acquisition system and/or the generator of the Handyscope HS5. Also, each pin can be configured to output one of the following function generator outputs:

- Generator start
- Generator stop
- Generator new period

The I<sup>2</sup>C pins are equipped with internal 2.2 kOhm pull-up resistors connected to 3 V.

Pin 8, Power OUT, has the same potential as the Handyscope HS5 power supply. When the Handyscope HS5 is USB powered, it is at USB power level. When the Handyscope HS5 is externally powered, it is at the same level as the external power input.

## 8.4 AUX I/O

The Handyscope HS5 has two Auxiliary I/O connectors at the rear of the instrument, connected to the CMI bus. These can be used to combine multiple instruments to a single combined instrument to perform synchronized measurements.



Figure 8.6: Auxiliary I/O connector

| Pin | Description       | Pin | Description             |
|-----|-------------------|-----|-------------------------|
| 1   | GND               | 11  | Data OK P EXT (LVDS)    |
| 2   | EXT CLK P (LVDS)  | 12  | Data OK N EXT (LVDS)    |
| 3   | EXT CLK N (LVDS)  | 13  | reserved                |
| 4   | GND               | 14  | Generator Trigger (I/O) |
| 5   | Data OK (I/O)     | 15  | reserved                |
| 6   | reserved          | 16  | reserved                |
| 7   | GND               | 17  | GND                     |
| 8   | Ext Trigger (I/O) | 18  | reserved                |
| 9   | reserved          | 19  | GND                     |
| 10  | GND               |     |                         |

Table 8.3: Pin description Auxiliary I/O connector

The I/O signals (pins 5, 8 and 14) can be used as input and output. They are digital signals switching between 0 V and 2.5 V. The LVDS external clock (pins 2 and 3) must be 10 MHz,  $\pm 1\%$ .



The Auxiliary I/O connectors use HDMI type C sockets, but are not HDMI compliant. They can not be used to connect an HDMI device to the Handyscope HS5.

To achieve rated accuracy, allow the instrument to settle for 20 minutes. When subjected to extreme temperatures, allow extra time for internal temperatures to stabilize. Because of temperature compensated calibration, the Handyscope HS5 will settle within specified accuracy regardless of the surrounding temperature.

## 9.1 Acquisition system

|   |   |   |   |           |          |
|---|---|---|---|-----------|----------|
| Number of input channels  | 2 analog                                |   |   |           |          |
| CH1, CH2  | BNC                                     |   |   |           |          |
| Type  | Single ended                            |   |   |           |          |
| Resolution  | 8, 12, 14, 16 bit user selectable       |   |   |           |          |
| Accuracy  | 0.25% of full scale $\pm$ 1 LSB         |   |   |           |          |
| Ranges (full scale)   | $\pm$ 200 mV<br>$\pm$ 2 V<br>$\pm$ 20 V | $\pm$ 400 mV<br>$\pm$ 4 V<br>$\pm$ 40 V | $\pm$ 800 mV<br>$\pm$ 8 V<br>$\pm$ 80 V |           |          |
| Coupling  | AC/DC                                   |   |   |           |          |
| Impedance   | 1 M $\Omega$ / 25 pF                    |   |   |           |          |
| Maximum voltage   | 200 V (DC + AC peak <10 kHz)            |   |   |           |          |
| Bandwidth (-3dB)  | Ch1                                     | Ch2                                     |   |           |          |
| at 75% of full scale input  | 250 MHz                                 | 100 MHz                                 |   |           |          |
| AC coupling cut off freq. (-3dB)  | $\pm$ 1.5 Hz                            |   |   |           |          |
| SureConnect   | Optionally available (option S)         |   |   |           |          |
| Maximum voltage on connection   | 200 V (DC + AC peak <10 kHz)            |   |   |           |          |
| Resistance measurement  | Optionally available (option S)         |   |   |           |          |
| Ranges  | 100 Ohm to 2 MOhm full scale            |   |   |           |          |
| Accuracy  | 1%                                      |   |   |           |          |
| Response time (to 95%)  | <10 $\mu$ s                             |   |   |           |          |
| Maximum sampling rate   | HS5-540                                 | HS5-530                                 | HS5-220                                 | HS5-110   | HS5-055  |
| 8 bit, 12 bit   |   |   |   |           |          |
| Measuring 1 channel   | 500 MS/s                                | 500 MS/s                                | 200 MS/s                                | 100 MS/s  | 50 MS/s  |
| Measuring 2 channels  | 200 MS/s                                | 200 MS/s                                | 100 MS/s                                | 50 MS/s   | 20 MS/s  |
| 14 bit  | 100 MS/s                                | 100 MS/s                                | 50 MS/s                                 | 20 MS/s   | 10 MS/s  |
| 16 bit  | 6.25 MS/s                               | 6.25 MS/s                               | 3.125 MS/s                              | 1.25 MS/s | 625 kS/s |
| Maximum streaming rate <sup>1</sup>   | HS5-540                                 | HS5-530                                 | HS5-220                                 | HS5-110   | HS5-055  |
| 8 bit   |   |   |   |           |          |
| Measuring 1 channel   | 40 MS/s                                 | 40 MS/s                                 | 20 MS/s                                 | 10 MS/s   | 4 MS/s   |
| Measuring 2 channels  | 20 MS/s                                 | 20 MS/s                                 | 10 MS/s                                 | 4 MS/s    | 2 MS/s   |
| 12 bit, 14 bit  |   |   |   |           |          |
| Measuring 1 channel   | 20 MS/s                                 | 20 MS/s                                 | 10 MS/s                                 | 5 MS/s    | 2 MS/s   |
| Measuring 2 channels  | 10 MS/s                                 | 10 MS/s                                 | 5 MS/s                                  | 2 MS/s    | 1 MS/s   |
| 16 bit  | 6.25 MS/s                               | 6.25 MS/s                               | 3.125 MS/s                              | 1.25 MS/s | 625 kS/s |
| <sup>1</sup> On some computers, the highest streaming rates may not be available, due to computer restrictions. |   |   |   |           |          |
| Memory per channel  | Standard model                          |   | XM Option                               |           |          |
| Measuring 1 channel   | 128 KiSamples                           |   | 64 MSamples                             |           |          |
| Measuring 2 channels  | 128 KiSamples                           |   | 32 MSamples                             |           |          |

## 9.2 Acquisition system - continued

|                 |   |
|-----------------|---|
| Sampling source |   |
| Internal        | TCXO  |
| Accuracy        | $\pm 0.0001\%$  |
| Stability       | $\pm 1$ ppm over $0\text{ }^{\circ}\text{C}$ to $+55\text{ }^{\circ}\text{C}$ |
| Time base aging | $\pm 1$ ppm per year time base aging  |
| External        | LVDS, on auxiliary connectors   |
| Input range     | 10 MHz  |

## 9.3 Trigger system

|                                  |  |
|----------------------------------|--|
| System                           | Digital, 2 levels  |
| Source                           | CH1, CH2, digital external, OR, generator start, generator new period, generator stop                      |
| Trigger modes                    | Rising edge, falling edge, any edge, inside window, outside window, enter window, exit window, pulse width |
| Level adjustment                 | 0 to 100% of full scale  |
| Hysteresis adjustment            | 0 to 100% of full scale  |
| Resolution                       | 0.024 % (12 bits)/0.006 % (14/16 bits)   |
| Pre trigger                      | 0 to 64 MSamples measuring 1 channel, 0 to 32 MSamples measuring 2 channels, 1 sample resolution           |
| Post trigger                     | 0 to 64 MSamples measuring 1 channel, 0 to 32 MSamples measuring 2 channels, 1 sample resolution           |
| Trigger hold-off                 | 0 to 64 MSamples, 1 sample resolution  |
| Trigger delay                    | 0 to 16 GSamples, 1 sample resolution  |
| Segmented trigger                | Available via <a href="#">LibTiePie SDK</a>  |
| Maximum number of segments       | 1024   |
| Minimum segment length           | 1 sample   |
| Maximum segment length           | 64 M / number of segments measuring 1 channel<br>32 M / number of segments measuring 2 channels            |
| Trigger rearm time               | Sample frequency dependent, < 700 ns on highest sample frequency   |
| Digital external trigger         |  |
| Input                            | Extension connector pins 1, 2 and 3  |
| Range                            | 0 to 2.5 V (TTL)   |
| Coupling                         | DC   |
| Jitter                           |  |
| Source = channel                 | Depending on source and sample frequency<br>$\leq 1$ sample  |
| Source = external or generator   |  |
| Sample frequency = 500 MS/s      | $\leq 8$ samples   |
| Sample frequency < 500 MS/s      | $\leq 4$ samples   |
| Sample frequency $\leq 100$ MS/s | $\leq 1$ sample  |



## 9.4 Arbitrary Waveform Generator

|                       |  |          |          |          |         |
|-----------------------|--|----------|----------|----------|---------|
| Output channel        | 1 analog, BNC  |          |          |          |         |
| DAC resolution        | 14 bit @ 240 MS/s  |          |          |          |         |
| Output range          | -12 to +12 V (open circuit), frequency $\leq$ 10 MHz<br>-11 to +11 V (open circuit), frequency $\leq$ 20 MHz<br>-9 to +9 V (open circuit), frequency $\leq$ 30 MHz<br>-7.5 to +7.5 V (open circuit), frequency $\leq$ 40 MHz |          |          |          |         |
| Amplitude             |  |          |          |          |         |
| Range                 | 0.12 V, 1.2 V, 12 V (open circuit)   |          |          |          |         |
| Resolution            | 12 bit   |          |          |          |         |
| Accuracy              | 0.4% of range  |          |          |          |         |
| DC offset             |  |          |          |          |         |
| Range                 | -12 V to +12 V (open circuit)  |          |          |          |         |
| Resolution            | 12 bit   |          |          |          |         |
| Accuracy              | 0.4% of range  |          |          |          |         |
| Noise level           |  |          |          |          |         |
| 0.12 V                | 900 $\mu$ V <sub>RMS</sub>   |          |          |          |         |
| 1.2 V                 | 1.3 mV <sub>RMS</sub>  |          |          |          |         |
| 12 V                  | 1.5 mV <sub>RMS</sub>  |          |          |          |         |
| Coupling              | DC   |          |          |          |         |
| Impedance             | 50 $\Omega$  |          |          |          |         |
| Overload protection   | Output turns off when overload is applied. Instrument will tolerate a short circuit to ground indefinitely.  |          |          |          |         |
| System                | Constant Data Size   |          |          |          |         |
| Memory                |  |          |          |          |         |
| Standard model        | 256 KiSamples  |          |          |          |         |
| XM option             | 64 MiSamples   |          |          |          |         |
| Operating modes       | Continuous, triggered, gated   |          |          |          |         |
| Maximum sampling rate | H55-540  | H55-530  | H55-220  | H55-110  | H55-055 |
|                       | 240 MS/s   | 240 MS/s | 200 MS/s | 100 MS/s | 50 MS/s |
| Sampling source       | Internal TCXO  |          |          |          |         |
| Accuracy              | 0.0001 %   |          |          |          |         |
| Stability             | $\pm$ 1 ppm over 0 °C to +55 °C  |          |          |          |         |
| Time base aging       | $\pm$ 1 ppm per year   |          |          |          |         |
| Waveforms             |  |          |          |          |         |
| Standard              | Sine, square, triangle, pulse, noise, DC   |          |          |          |         |
| Burst                 |  |          |          |          |         |
| Waveforms             | Sine, square, triangle, noise, arbitrary   |          |          |          |         |
| Count                 | 1 to 65535   |          |          |          |         |
| Trigger               | Software, external   |          |          |          |         |
| Sweep                 | Available only on models with extended memory option XM  |          |          |          |         |
| Waveforms             | Sine, square, triangle, noise, arbitrary   |          |          |          |         |
| Type                  | Linear, logarithmic  |          |          |          |         |
| Count                 | Up, down   |          |          |          |         |
| Trigger               | Software, external   |          |          |          |         |

## Arbitrary Waveform Generator - continued

| Signal characteristics                  |   |          |          |          |         |
|---|---|----------|----------|----------|---------|
| Sine                                    | H55-540   | H55-530  | H55-220  | H55-110  | H55-055 |
| Frequency range: 1 $\mu$ Hz to          | 40 MHz  | 30 MHz   | 20 MHz   | 10 MHz   | 5 MHz   |
| Amplitude flatness                      | Relative to 1 kHz                                       |          |          |          |         |
| <100 kHz                                | $\pm 0.1$ dB  |          |          |          |         |
| <5 MHz                                  | $\pm 0.15$ dB   |          |          |          |         |
| <20 MHz                                 | $\pm 0.3$ dB (Amplitude $\leq 11$ V (22 $V_{pp}$ ))     |          |          |          |         |
| <30 MHz                                 | $\pm 0.4$ dB (Amplitude $\leq 9$ V (18 $V_{pp}$ ))      |          |          |          |         |
| <40 MHz                                 | $\pm 1$ dB (Amplitude $\leq 7.5$ V (15 $V_{pp}$ ))      |          |          |          |         |
| Spurious                                |   |          |          |          |         |
| <100 kHz                                | -75 dB <sub>c</sub>                                     |          |          |          |         |
| 100 kHz to 1 MHz                        | -70 dB <sub>c</sub>                                     |          |          |          |         |
| 1 MHz to 10 MHz                         | -60 dB <sub>c</sub>                                     |          |          |          |         |
| 10 MHz to 15 MHz                        | -55 dB <sub>c</sub>                                     |          |          |          |         |
| 15 MHz to 20 MHz                        | -45 dB <sub>c</sub>                                     |          |          |          |         |
| 20 MHz to 30 MHz                        | -35 dB <sub>c</sub>                                     |          |          |          |         |
| 30 MHz to 40 MHz                        | -30 dB <sub>c</sub>                                     |          |          |          |         |
| Square                                  | H55-540   | H55-530  | H55-220  | H55-110  | H55-055 |
| Frequency range: 1 $\mu$ Hz to          | 40 MHz <sup>2</sup>                                     | 30 MHz   | 20 MHz   | 10 MHz   | 5 MHz   |
| Rise/fall time                          | <8 ns   |          |          |          |         |
| Overshoot                               | <1%   |          |          |          |         |
| Variable duty cycle                     | 0.01 % to 99.99 %                                       |          |          |          |         |
| Asymmetry                               | <0 % of period + 5 ns (@ 50% duty cycle)                |          |          |          |         |
| Jitter (RMS)                            | <50 ps  |          |          |          |         |
| Triangle                                | H55-540   | H55-530  | H55-220  | H55-110  | H55-055 |
| Frequency range: 1 $\mu$ Hz to          | 40 MHz <sup>2</sup>                                     | 30 MHz   | 20 MHz   | 10 MHz   | 5 MHz   |
| Nonlinearity (of peak output)           | <0.01 %   |          |          |          |         |
| Symmetry                                | 0 % to 100 %, 0.1% steps                                |          |          |          |         |
| Pulse                                   |   |          |          |          |         |
| Period                                  | 100 ns to 1 Ms  |          |          |          |         |
| Pulse width                             | 1 digit to period-1 digit (min. 20 ns and period-20 ns) |          |          |          |         |
| Step size                               | 6 digits, minimum of 1 ns                               |          |          |          |         |
| Overshoot                               | <1 %  |          |          |          |         |
| Jitter (RMS)                            | <50 ps  |          |          |          |         |
| Noise                                   |   |          |          |          |         |
| Bandwidth (typical)                     | 30 MHz  |          |          |          |         |
| Arbitrary                               | H55-540   | H55-530  | H55-220  | H55-110  | H55-055 |
| Frequency range: 1 $\mu$ Hz to          | 30 MHz  | 30 MHz   | 20 MHz   | 10 MHz   | 5 MHz   |
| Maximum sample rate                     | 240 MS/s  | 240 MS/s | 200 MS/s | 100 MS/s | 50 MS/s |
| Pattern length                          | 1 to 64 MiSamples                                       |          |          |          |         |
| Rise/fall time                          | <8 ns   |          |          |          |         |
| Nonlinearity (of peak output)           | <0.01 %   |          |          |          |         |
| Settling time                           | <8 ns to 10 % final value                               |          |          |          |         |
| Jitter (RMS)                            | <50 ps  |          |          |          |         |
| <sup>2</sup> Above 30 MHz not specified |   |          |          |          |         |

## 9.5 Power

|                             |   |
|-----------------------------|---|
| Power                       | From USB or external input  |
| Consumption                 | 5 V <sub>DC</sub> , 500 mA max  |
| Power adapter               | External  |
| Input                       | 110 to 240 V <sub>AC</sub> , 50 to 60 Hz<br>0.85 A Max., 50 VA to 80 VA |
| Output                      | 5.5 V <sub>DC</sub> , 2 A   |
| Dimension                   |   |
| Height                      | 30 mm / 1.2"  |
| Width                       | 45 mm / 1.8"  |
| Length                      | 75 mm / 3"  |
| Order number                | TP-UE15WCP1-055200SPA   |
| Replaceable mains plugs for | EU, US, AU, UK  |

## 9.6 Multi-instrument synchronization

|                               |  |
|-------------------------------|--|
| Maximum number of instruments | Limited by available number of USB ports |
| Synchronization accuracy      | 0 ppm                                    |

## 9.7 Physical

|                 |                  |
|-----------------|------------------|
| Height          | 25 mm / 1.0"     |
| Length          | 170 mm / 6.7"    |
| Width           | 140 mm / 5.2"    |
| Weight          | 430 g / 15 ounce |
| USB cord length | 1.8 m / 70"      |

## 9.8 I/O connectors

|                              |   |
|------------------------------|---|
| CH1, CH2                     | BNC                                     |
| AWG                          | BNC                                     |
| USB                          | Fixed cable with USB type A plug, 1.8 m |
| Extension connector          | D-sub 9 pins female                     |
| Power                        | 3.5 mm power socket                     |
| Auxiliary I/O connectors 1–2 | HDMI type C socket                      |

## 9.9 Interface

|           |  |
|-----------|--|
| Interface | USB 2.0 High Speed (480 Mbit/s)<br>(USB 1.1 Full Speed (12 Mbit/s) and USB 3.0 compatible) |
|-----------|--|

## 9.10 System requirements

|                   |                                      |
|-------------------|--------------------------------------|
| PC I/O connection | USB 1.1, USB 2.0 or newer            |
| Operating System  | Windows 7 / 8 / 10<br>32 and 64 bits |

## 9.11 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  |

## 9.12 Certifications and Compliances

|                                 |     |
|---------------------------------|-----|
| CE mark compliance              | Yes |
| RoHS                            | Yes |
| EN 55011:2009/A1:2010           | Yes |
| EN 55022:2006/A1:2007           | Yes |
| IEC 61000-6-1/EN 61000-6-1:2007 | Yes |
| IEC 61000-6-1/EN 61000-6-1:2007 | Yes |
| Canada: ICES-001:2004           | Yes |
| Australia/New Zealand: AS/NZS   | Yes |

## 9.13 Probes

|                                |  |  |
|--------------------------------|--|--|
| Model                          | HP-9250                                |  |
|                                | X1                                     | X10  |
| Bandwidth                      | 6 MHz                                  | 250 MHz  |
| Rise time                      | 58 ns                                  | 1.4 ns   |
| Input impedance                | 1 M $\Omega$<br>oscilloscope impedance | 10 M $\Omega$<br>incl. 1 M $\Omega$ oscilloscope impedance |
| Input capacitance              | 47 pF<br>+ oscilloscope capacitance    | 17 pF  |
| Compensation range             | -                                      | 10 to 35 pF  |
| Working voltage (DC + AC peak) | 300 V CAT I                            | 600 V CAT I  |
|                                | 150 V CAT II                           | 300 V CAT II   |

## 9.14 Package contents

|             |                                       |
|-------------|---------------------------------------|
| Instrument  | Handyscope HS5                        |
| Probes      | 2 x X1 / X10 switchable, HP-9250      |
| Accessories | External power adapter                |
|             | USB power cable                       |
| Software    | Windows 7 / 8 / 10                    |
| Drivers     | Windows 7 / 8 / 10                    |
| Manual      | Instrument manual and software manual |

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

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