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.

Revision 2.49, August 2024

Contents

Safety 1

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 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_{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 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.

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 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

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

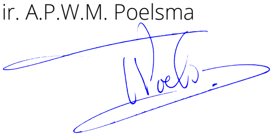
Canada: ICES-001:2004	Australia/New Zealand: AS/NZS CISPR 11:2011

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}

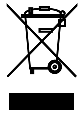
Sneek, 1-9-2022
ir. A.P.W.M. Poelsma



Environmental considerations

This section provides information about the environmental impact of the Handyscope 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 shown symbol 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).

Introduction 3

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 rates: 50 MSa/s, 100 MSa/s, 200 MSa/s or 500 MSa/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 rates:

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

Table 3.1: Maximum sampling rates

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 MSa/s	20 MSa/s	6.25 MSa/s
	CH1+CH2	20 MSa/s	10 MSa/s	
Model 530	CH1	40 MSa/s	20 MSa/s	6.25 MSa/s
	CH1+CH2	20 MSa/s	10 MSa/s	
Model 220	CH1	20 MSa/s	10 MSa/s	3.125 MSa/s
	CH1+CH2	10 MSa/s	5 MSa/s	
Model 110	CH1	10 MSa/s	5 MSa/s	1.25 MSa/s
	CH1+CH2	4 MSa/s	2 MSa/s	
Model 055	CH1	4 MSa/s	2 MSa/s	625 kSa/s
	CH1+CH2	2 MSa/s	1 MSa/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 KiSa	128 KiSa	128 KiSa	128 KiSa	128 KiSa
Option XM	32 MiSa	32 MiSa	32 MiSa	32 MiSa	32 MiSa

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.

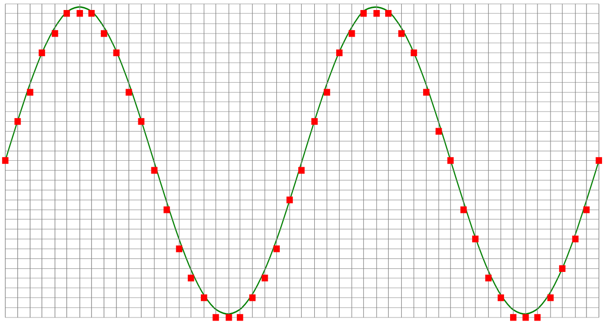


Figure 3.1: Sampling

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.

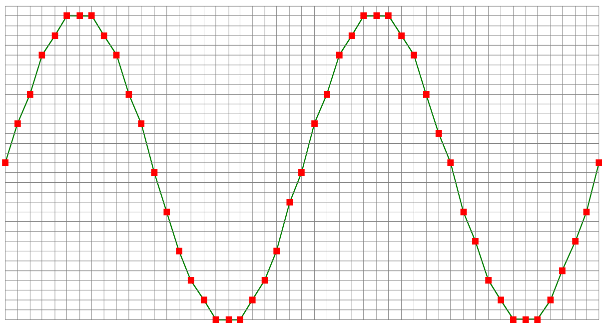


Figure 3.2: "connecting" the samples

3.2 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.

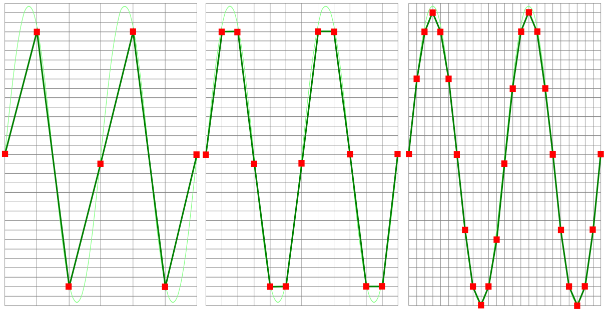


Figure 3.3: The effect of the sampling rate

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 3.4: 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.

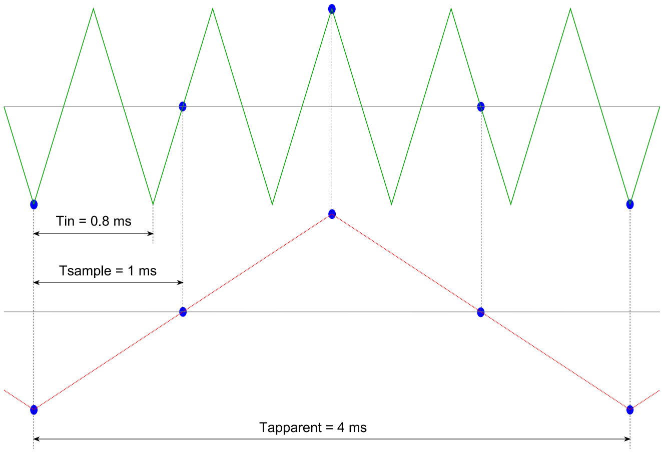


Figure 3.4: Aliasing

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).

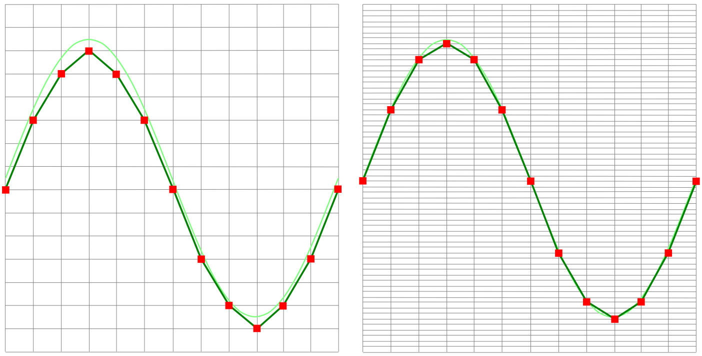


Figure 3.5: The effect of the resolution

The Handyscope 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:

$$VoltageStep = FullInputRange/LevelCount$$

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 / 16384 = 24.41 μV.

3.4 Signal coupling

The Handyscope 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.

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

3.5 Probe compensation

The Handyscope 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 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.

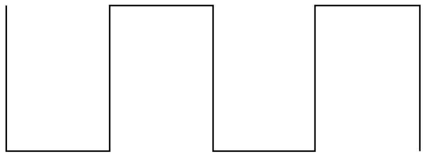


Figure 3.6: correct

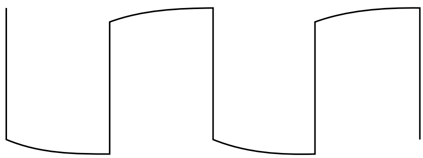


Figure 3.7: under compensated

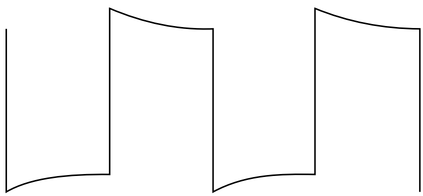


Figure 3.8: over compensated

4 Driver installation

Before connecting the Handyscope 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.

4.1.1 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.

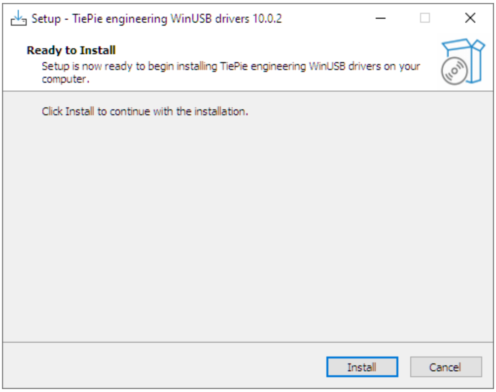


Figure 4.1: Driver install: step 1

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

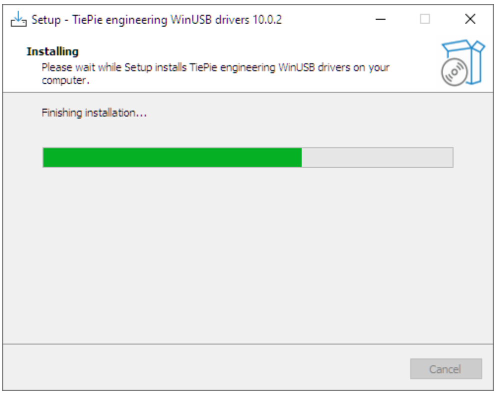


Figure 4.2: Driver install: Copying files

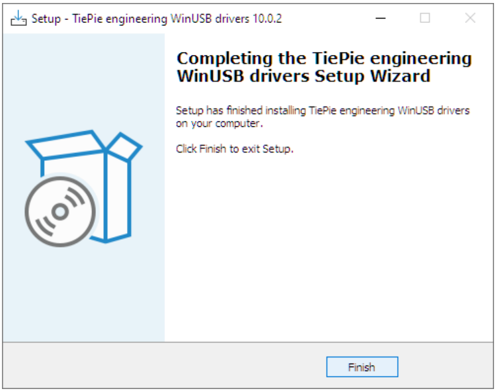


Figure 4.3: Driver install: Finished

5 Hardware installation

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 intput.

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.

Combining and synchronizing instruments

6

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.

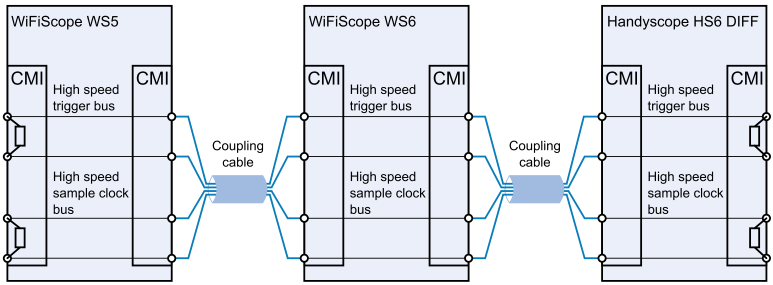


Figure 6.1: CMI diagram

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.

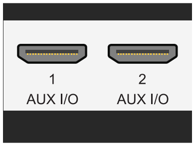


Figure 6.2: CMI connectors

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 6.3: Multiple 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 other instruments including Handyscope HS6 DIFFs and/or WiFiScope WS6s and/or WiFiScope WS6 DIFFs and/or Automotive Test Scope ATS610004D-XMSGs and/or Automotive Test Scope ATS605004D-XMSs and/or Automotive Test Scope ATS610004DW-XMSGs and/or Automotive Test Scope ATS605004DW-XMS s, the daisy chained CMI bus must begin or end with a Handyscope HS6, Handyscope HS6 DIFF, WiFiScope WS6, WiFiScope WS6 DIFF, Automotive Test Scope ATS610004D-XMSG, Automotive Test Scope ATS605004D-XMS, Automotive Test Scope ATS610004DW-XMSG or Automotive Test Scope ATS605004DW-XMS. Additionally, the maximum sampling rate is limited to 100 MSa/s at 14 bit resolution.

Front panel 7

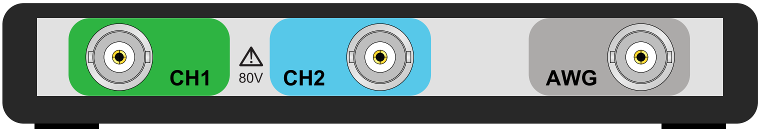


Figure 7.1: Front panel

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.

When the generator is switched **off** in the software, the generator output is switched to a high impedance, floating state, the output voltage is then undefined.

When the generator is switched **on** in the software and set to **pause**, the generator output is switched to a low impedance (50 Ω), the output voltage is at the selected offset level.

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.

Rear panel

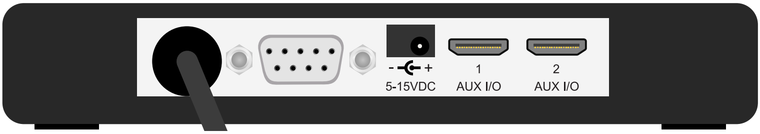
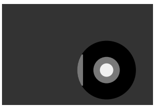


Figure 8.1: Rear panel

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_{DC} / 2 A max.
Maximum	15 V_{DC} / 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_{AC}, 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

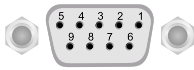


Figure 8.5: Extension connector

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

Pin	Description	Pin	Description	Pin	Description
1	EXT 1 (LVTTL)	4	I^2C SDA	7	Power IN
2	EXT 2 (LVTTL)	5	I^2C SCL	8	Power OUT
3	EXT 3 (LVTTL)	6	GND	9	reserved

Table 8.2: Pin description Extension connector

Pins EXT 1, EXT 2 and EXT 3 have 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^2C pins have 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 USB powered, it is at USB power level. When 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 are used to combine multiple instruments to a single combined instrument to perform synchronized measurements.

They can also be used to provide or get an external sampling clock.

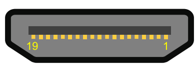


Figure 8.6: Auxiliary I/O connector

Pin	Description
1	GND
2	EXT CLK IN/OUT P (LVDS)
3	EXT CLK IN/OUT N (LVDS)

Table 8.3: Pin description Auxiliary I/O connector

When using the the LVDS external clock (pins 2 and 3) as clock input, the signal must be 10 MHz, ±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.

9 Specifications

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 Definition of accuracy

The accuracy of an input 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 ±0.25% of the Full Scale range ± 1 LSB, and the input range is 4 V, the maximum deviation the measured value can have is ±0.25% of 8 V = ±20 mV. ±1 LSB equals 8 V / 65536 (= number of LSB at 16 bit resolution) = ± 122 μV. Therefore the measured value will be between 20.122 mV lower and 20.122 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 3.770122 V and 3.729878 V.

9.2 Acquisition system

Number of input channels	2 analog		
CH1, CH2	BNC, female		
Type	Single ended		
Resolution	8, 12, 14, 16 bit user selectable		
Accuracy	0.25% 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 / 25 pF		
Noise			
Ch1	325 μV_{RMS} (200 mV range, 12 bit, 50 MSa/s) 90 μV_{RMS} (200 mV range, 16 bit, 6.25 MSa/s)		
Ch2	220 μV_{RMS} (200 mV range, 12 bit, 50 MSa/s) 70 μV_{RMS} (200 mV range, 16 bit, 6.25 MSa/s)		
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)	±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 μs		

Acquisition system (continued)

Maximum sampling rate	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
8 bit, 12 bit					
Measuring 1 channel	500 MSa/s	500 MSa/s	200 MSa/s	100 MSa/s	50 MSa/s
Measuring 2 channels	200 MSa/s	200 MSa/s	100 MSa/s	50 MSa/s	20 MSa/s
14 bit	100 MSa/s	100 MSa/s	50 MSa/s	20 MSa/s	10 MSa/s
16 bit	6.25 MSa/s	6.25 MSa/s	3.125 MSa/s	1.25 MSa/s	625 kSa/s
Maximum streaming rate[1]	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
8 bit					
Measuring 1 channel	40 MSa/s	40 MSa/s	20 MSa/s	10 MSa/s	4 MSa/s
Measuring 2 channels	20 MSa/s	20 MSa/s	10 MSa/s	4 MSa/s	2 MSa/s
12 bit, 14 bit					
Measuring 1 channel	20 MSa/s	20 MSa/s	10 MSa/s	5 MSa/s	2 MSa/s
Measuring 2 channels	10 MSa/s	10 MSa/s	5 MSa/s	2 MSa/s	1 MSa/s
16 bit	6.25 MSa/s	6.25 MSa/s	3.125 MSa/s	1.25 MSa/s	625 kSa/s

[1] 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
Sampling source		
Internal	TCXO	
Accuracy	±0.0001%	
Stability	±1 ppm over 0 °C to +55 °C	
Time base aging	±1 ppm per year time base aging	
External	LVDS, on auxilary 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
Digital external trigger	
Input	Extension connector pins 1, 2 and 3
Range	0 to 2.5 V (TTL)
Coupling	DC

Trigger system (continued)

Jitter	Depending on source and sampling rate
Source = channel	$\lesssim$ 1 sample
Source = external or generator	
Sampling rate = 500 MSa/s	$\lesssim$ 8 samples
Sampling rate < 500 MSa/s	$\lesssim$ 4 samples
Sampling rate $\lesssim$ 100 MSa/s	$\lesssim$ 1 sample
Segmented trigger	Available via libtiepie-hw SDK
Maximum number of segments	1024
Minimum segment length	1 sample
Maximum segment length	64 M / number of segments measuring 1 channel 32 M / number of segments measuring 2 channels
Trigger rearm time	Sampling rate dependent, < 700 ns on highest sampling rate

9.4 Arbitrary Waveform Generator

Output channel	1 analog, female BNC				
DAC resolution	14 bit @ 240 MSa/s				
Output range	-12 to +12 V (open circuit), frequency $\lesssim$ 10 MHz -11 to +11 V (open circuit), frequency $\lesssim$ 20 MHz -9 to +9 V (open circuit), frequency $\lesssim$ 30 MHz -7.5 to +7.5 V (open circuit), frequency $\lesssim$ 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 μV_{RMS}				
1.2 V	1.3 mV_{RMS}				
12 V	1.5 mV_{RMS}				
Coupling	DC				
Impedance	50 Ω				
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	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
	240 MSa/s	240 MSa/s	200 MSa/s	100 MSa/s	50 MSa/s
Sampling source	Internal TCXO				
Accuracy	0.0001 %				
Stability	±1 ppm over 0 °C to +55 °C				
Time base aging	±1 ppm per year				

Arbitrary Waveform Generator (continued)

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				
Signal characteristics					
Sine	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
Frequency range: 1 µHz to	40 MHz	30 MHz	20 MHz	10 MHz	5 MHz
Amplitude flattness	Relative to 1 kHz				
<100 kHz	±0.1 dB				
<5 MHz	±0.15 dB				
<20 MHz	±0.3 dB (Amplitude ≤ 11 V (22 V_{pp}))				
<30 MHz	±0.4 dB (Amplitude ≤ 9 V (18 V_{pp}))				
<40 MHz	±1 dB (Amplitude ≤ 7.5 V (15 V_{pp}))				
Spurious					
<100 kHz	-75 dB_c				
100 kHz to 1 MHz	-70 dB_c				
1 MHz to 10 MHz	-60 dB_c				
10 MHz to 15 MHz	-55 dB_c				
15 MHz to 20 MHz	-45 dB_c				
20 MHz to 30 MHz	-35 dB_c				
30 MHz to 40 MHz	-30 dB_c				
Square	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
Frequency range: 1 µHz to	40 MHz[2]	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	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
Frequency range: 1 µHz to	40 MHz[2]	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, mininum of 1 ns				
Overshoot	<1 %				
Jitter (RMS)	<50 ps				
Noise					
Bandwidth (typical)	30 MHz				

[2] Above 30 MHz not specified

Arbitrary Waveform Generator (continued)

Arbitrary	HS5-540	HS5-530	HS5-220	HS5-110	HS5-055
Frequency range: 1 μHz to	30 MHz	30 MHz	20 MHz	10 MHz	5 MHz
Maximum sampling rate	240 MSa/s	240 MSa/s	200 MSa/s	100 MSa/s	50 MSa/s
Pattern length					
Standard model	1 to 256 KiSamples				
XM option	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				

9.5 Power

Power	From USB or external input
Consumption	5 V_{DC}, 500 mA max
Power adapter	External
Input	110 to 240 V_{AC}, 50 to 60 Hz, 500 mA
Output	12 V_{DC}, 2 A
Dimension	
Height	57 mm / 2.2"
Width	30 mm / 1.2"
Length	88 mm / 3.4"
Cable length	1.8 m / 70"
Order number	TP-UES24LCP-120200SPA
Replaceable mains plugs for	EU, US, AU, UK

9.6 Multi-instrument synchronization

Using CMI	Combining instruments is only available when all instruments are connected via USB. When connected via LAN or WiFi, combining via CMI is not available.	
Maximum number of instruments	Limited by available number of USB ports	
Synchronization accuracy	0 ppm	
CMI interface	2x, CMI 1, CMI 2	
Required coupling cable	TP-C50H Coupling cable CMI	
Maximum coupling cable length	50 cm	
Using WCMI		
Maximum number of instruments	No limitation	
Required coupling module	WCMI-8 and WCMI-9	
Clock synchronization accuracy	$\leq$ 1 ppm, typical $\leq$ 0.2 ppm	
Trigger jitter at sample rate *	$\leq$ 1 MSa/s	$>$ 1 MSa/s
2 x "5"	$\leq \pm 2$ samples	$\leq \pm 2$ μs
"5" and "6"		
Trigger source = "5"	$\leq \pm 2$ samples	$\leq \pm 2$ μs
Trigger source = "6"	$\leq \pm 8$ samples	$\leq \pm 8$ μs
2 x "6"	$\leq \pm 8$ samples	$\leq \pm 8$ μs

* "5" = WiFiScope WS5 or Handyscope HS5

"6" = WiFiScope WS6 (DIFF) or Handyscope HS6 (DIFF)

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 Interface

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

9.9 I/O connectors

CH1, CH2	BNC, female
AWG	BNC, female
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

9.10 System requirements

PC I/O connection	USB 1.1, USB 2.0 or newer
Operating System	Windows 10 / 11, 64 bits

9.11 Environmental conditions

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

9.12 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

9.13 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

9.14 Package contents

Instrument	Handyscope HS5
Probes	2 x X1 / X10 switchable, HP-3250I
Accessories	External power adapter 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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