

Handyscope HS4 DIFF

Instrument manual

Rev. 2.1



TiePie engineering

ATTENTION!

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

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

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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. Save working tips are given below:

- Always work according (local) regulations.
- Work on installations with voltages higher than 25 V AC or 60 V DC should only be performed by qualified personnel.
- Avoid working alone.
- Observe all indications on the Handyscope HS4 DIFF 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 25V 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 personnel. If necessary, return the equipment to TiePie engineering for service and repair to ensure that safety features are maintained.

8.7 I/O connectors

Ch1-CH2	BNC
Generator out	BNC
Power	3.5 mm power socket
Extension connector	Sub-D 25 pins female

8.8 System requirements

PC I/O connection	USB 2.0 High Speed (480 Mbit/s) (USB 1.1 Full Speed (12 Mbit/sec) compatible)
Operating System	Windows 98/ME/2000/XP/Vista-32

8.9 Operating environment

Ambient temperature	0 - 55°C
Relative humidity	10 to 90% non condensing

8.10 Storage environment

Ambient temperature	-20 - 70°C
Relative humidity	5 to 95% non condensing

8.11 Certifications and Compliances

CE mark compliance	Yes
RoHS	Yes

8.12 Package

Instrument	Handyscope HS4 DIFP
Test lead	4 x low noise differential with 4 mm banana jacks
Accessories	4 x 1:10 differential attenuators PS2 power cable
Software	Windows 98/2000/ME/XP/Vista-32
Drivers	Windows 98/2000/ME/XP/Vista-32
Manual	Instrument manual and software user's manual

Trigger system

System	digital, 2 levels
Source	CH1, CH2, CH3, CH4, digital external, AND, OR,
Trigger modes	rising slope, falling slope, inside window, outside window
Level adjustment	0–100% of full scale
Hysteresis adjustment	0–100% of full scale
Resolution	0.025 % (12 bits)
Pre trigger	0–128 ksamples (0–100%, one sample resolution)
Post trigger	0–128 ksamples (0–100%, one sample resolution)
Digital external trigger	
Input	extension connector
Sensitivity	0 .. 5 V (TTL)
Coupling	DC

8.4

Interface

Interface	USB 2.0 High Speed (480 Mbit/s) (USB 1.1 Full Speed (12 Mbit/sec) compatible)
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8.5

Power

Input	from USB or external input
Consumption	500 mA max

8.6

Physical

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

Declaration of conformity



TiePie engineering
Koperslagersstraat 37
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The Netherlands

EC Declaration of conformity

We declare, on our own responsibility, that the product

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

for which this declaration is valid, is in compliance with

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

according to the conditions of the EMC standard 2004/108/EC.

Sneek, 1-11-2010

ir. A.P.W.M. Poelsma

8.1 Acquisition system

Number of input channels	4 analog
Ch1, Ch2, Ch3, Ch4	Isolated BNC
Maximum sampling rate	12 bit 5 MS/s; 10 MS/s; 25 MS/s or 50 MS/s 14 bit 3.125 MS/s 16 bit 195 kS/s
Sampling source	Internal quartz, external
Accuracy	±0.01%
Stability	±100 ppm over -40°C to +85°C
Memory	128 kSamples per channel (256 kSamples with disabled generator)

8.2 BNC inputs Ch1 – Ch4

Measure mode	Differential
Resolution	12, 14, 16 bit user selectable
Accuracy	0.3% ± 1 LSB
Sensitivity	200 mV .. 80 V full scale
Coupling	AC/DC
Impedance	2 MΩ / 30 pF
Maximum voltage	200 V (DC + AC peak <10 kHz)
Maximum voltage with 1:10 attenuator	500 V (DC + AC peak <10 kHz)
Maximum common mode voltage	200 mV - 800 mV ranges : 2 V 2 V - 8 V ranges : 20 V 20 V - 80 V ranges : 200 V
Common Mode Rejection Ratio	-48 dB
Channel Isolation	500 V
Channel Separation	-80 dB
Bandwidth (-3dB)	DC to 50 MHz
AC coupling cut off frequency (-3dB)	±1.5 Hz

Introduction



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

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

The Handyscope HS4 DIFF is a portable four channel measuring instrument with differential inputs. The Handyscope HS4 DIFF is available in several models with different maximum sampling frequencies: 5 MS/s, 10 MS/s, 25 MS/s or 50 MS/s. The native resolution is 12 bits, but user selectable resolutions of 14 and 16 bits are available too, with adjusted maximum sampling frequency:

resolution	Maximum sampling frequency
12 bit	5, 10, 25 or 50 MS/s, depending on model
14 bit	3.125 MS/s
16 bit	195 kS/s

Table 3.1: Maximum sampling frequencies

With the accompanying software the Handyscope HS4 DIFF 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 Differential input

Most oscilloscopes are equipped with standard, single ended inputs, which are referenced to ground. This means that one side of the

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

Table 7.2: Pin description Extension connector

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

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

input is always connected to ground and the other side to the point of interest in the circuit under test.

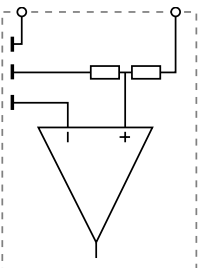


Figure 3.1: Single ended input

Therefore the voltage that is measured with an oscilloscope with standard, single ended inputs is always measured between that specific point and ground.

When the voltage is not referenced to ground, connecting a standard single ended oscilloscope input to the two points would create a short circuit between one of the points and ground, possibly damaging the circuit and the oscilloscope.

A safe way would be to measure the voltage at one of the two points, in reference to ground and at the other point, in reference to ground and then calculate the voltage difference between the two points. On most oscilloscopes this can be done by connecting one of the channels to one point and another channel to the other point and then use the math function Ch1 - Ch2 in the oscilloscope to display the actual voltage difference.

There are some disadvantages to this method:

- a short circuit to ground can be created when an input is wrongly connected
- to measure one signal, two channels are occupied
- by using two channels, the measurement error is increased, the errors made on each channel will be combined, resulting in a larger total measurement error
- The Common Mode Rejection Ratio (CMRR) of this method is relatively low. If both points have a relative high voltage, but the voltage difference between the two points is small, the voltage difference can only be measured in a high input range, resulting in a low resolution

A much better way is to use an oscilloscope with a differential input.

7.1.2

Power adapter

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

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

7.2

USB

The Handyscope HS4 DIFP is equipped with a USB 2.0 High speed (480 Mbit/sec) 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/sec.

7.3

Extension Connector

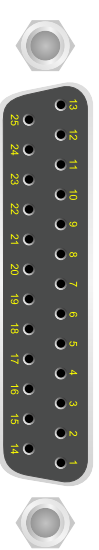


Figure 7.4: Extension connector

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

Minimum	Maximum
4.5 Volt DC	14 Volt DC

Table 7.1: Maximum voltages

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

7.1.1

USB power cable

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



Figure 7.3: USB power cable

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



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

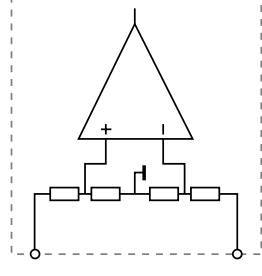


Figure 3.2: Differential input

A differential input is not referenced to ground, but both sides of the input are "floating". It is therefore possible to connect one side of the input to one point in the circuit and the other side of the input to the other point in the circuit and measure the voltage difference directly.

Advantages of a differential input:

- No risk of creating a short circuit to ground
- Only one channel is required to measure the signal
- More accurate measurements, since only one channel introduces a measurement error
- The CMRR of a differential input is high. If both points have a relative high voltage, but the voltage difference between the two points is small, the voltage difference can be measured in a low input range, resulting in a high resolution

3.1.1 Differential attenuators

To increase the input range of the Handyscope HS4 DIFF, it comes with a differential 1:10 attenuator for each channel. This differential attenuator is specially designed to be used with the Handyscope HS4 DIFF.



Figure 3.3: Differential attenuator

For a differential input, both sides of the input need to be attenuated.

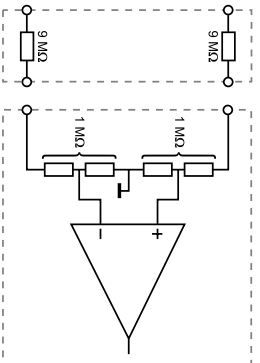


Figure 3.4: Differential input

Standard oscilloscope probes and attenuators only attenuate one side of the signal path. These are not suitable to be used with a differential input. Using these on a differential input will have a negative effect on the CMRR and will introduce measurement errors.

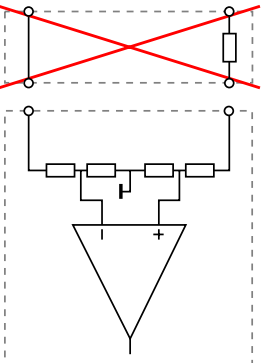


Figure 3.5: Differential input



The Differential Attenuator and the inputs of the Handy-scope HS4 Diff are differential, which means that the outside of the BNC's are not grounded, but carry life signals.

When using the attenuator, the following points have to be taken into consideration:

- do not connect other cables to the attenuator than the ones that are supplied with the instrument
- do not touch the metal parts of the BNC's when the attenuator is connected to the circuit under test, they can carry

7.1 Power

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

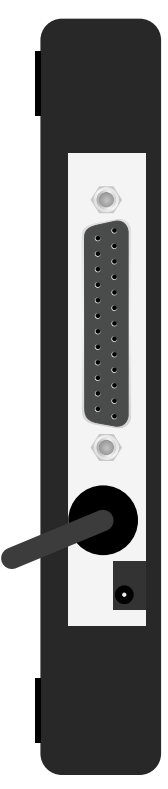


Pin	Dimension	Description
Center pin	Ø1.3 mm	ground
Outside bushing	Ø3.5 mm	positive

Figure 7.2: Power connector

Besides the external power input, it is also possible to power the instrument through the extension connector, the 25 pin Sub-D connector at the rear of the instrument. The power has to be applied to pin 3 of the extension connector. Pin 4 can be used as ground. The following minimum and maximum voltages apply to both power inputs:

Figure 7.1: Rear panel



a dangerous voltage. It will also influence the measurements and create measurement errors.

- do not connect the outside of the two BNC's of the attenuator to each other as this will short circuit a part of the internal circuit and will create measurement errors
- do not connect the outside of the BNC's of two or more attenuators that are connected to different channels of the Handyscope HS4 Diff to each other
- do not apply excessive mechanical force to the attenuator in any direction (e.g. pulling the cable, using the attenuator as handle to carry the Handyscope HS4 DIFF, etc.)

3.1.2

Differential test lead

The Handyscope HS4 DIFF comes with a special differential test lead. This test lead is specially designed to ensure a good CMRR. The special heat resistant differential test lead provided with the Handyscope HS4 DIFF is designed to be immune for noise from the surrounding environment.

3.2

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.

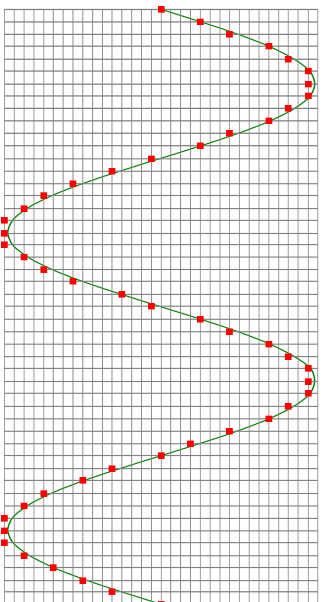


Figure 3.6: Sampling

The sine wave in figure 3.6 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 3.7.

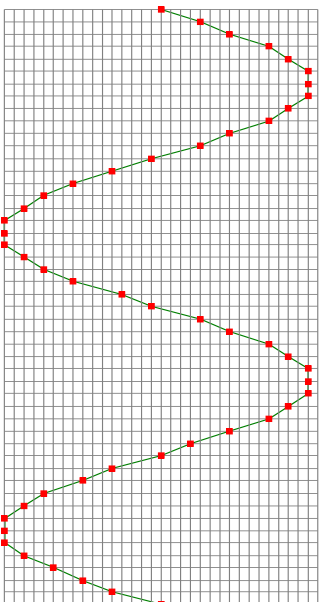


Figure 3.7: "connecting" the samples

3.3 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 3.8, with a higher sampling frequency, the original signal can be reconstructed much better from the measured samples.

6.1 Channel input connectors

The CH1 – CH4 BNC connectors are the main inputs of the acquisition system. The isolated BNC connectors are not connected to the ground of the Handyscope HS4 DIFP.

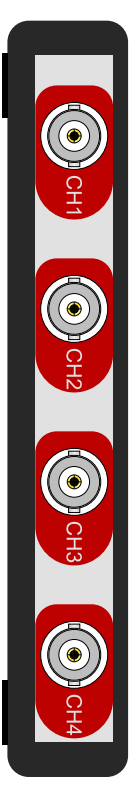


Figure 6.1: Front panel

6.2 Power indicator

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

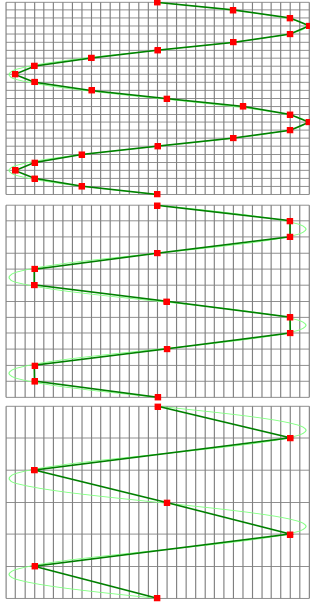


Figure 3.8: The effect of the sampling frequency

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.

3.3.1 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	$-1000 + 1250 = 250$	$-1000 - 1250 = -2250$
0	$0 + 1250 = 1250$	$0 - 1250 = -1250$
1000	$1000 + 1250 = 2250$	$1000 - 1250 = -250$
2000	$2000 + 1250 = 3250$	$2000 - 1250 = 750$
...		

Table 3.2: 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.

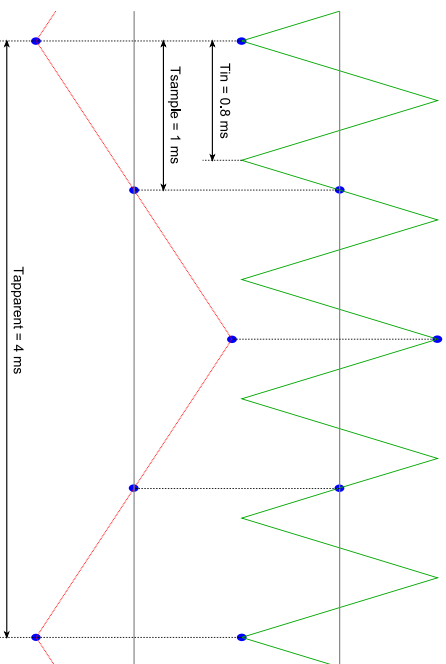


Figure 3.9: Aliasing

In figure 3.9, 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.



Figure 5.4: Hardware install: step 4

The first part of the new driver is now installed. Click *“Finish”* to close the wizard and start installation of the second part, which follows identical steps.

Once the second part of the driver is installed, measurement software can be installed and the Handyscope HS4 DIFP can be used.

5.3 Plug into a different USB port

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

3.4

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 3.10, the same signal is digitized, using two different amounts of levels: 16 (4-bit) and 64 (6-bit).

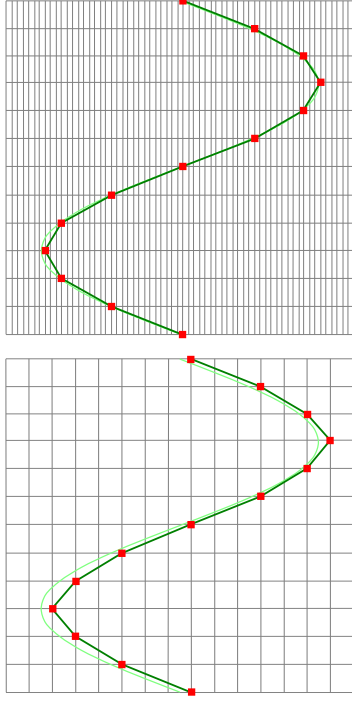


Figure 3.10: The effect of the resolution

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

$$VoltageStep = FullInputRange / LevelCount$$

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

3.5

Signal coupling

The Handyscope HS4 DIFF has two different settings for the signal coupling: AC and DC. In the setting DC, the signal is directly

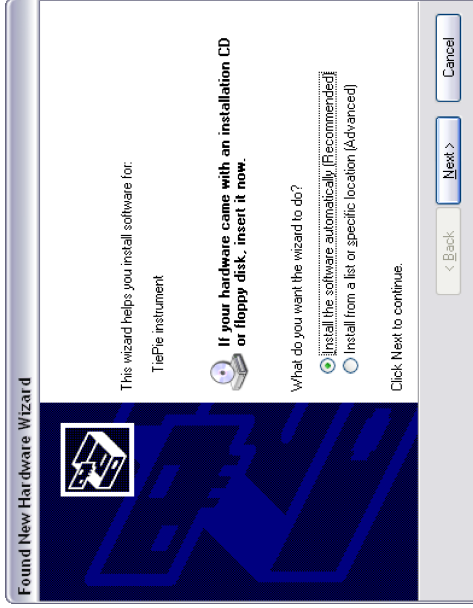


Figure 5.2: Hardware install: step 2

Since the drivers are already pre-installed on the computer, Windows will be able to find them automatically. Select **“Install the software automatically”** and click **“Next”**.

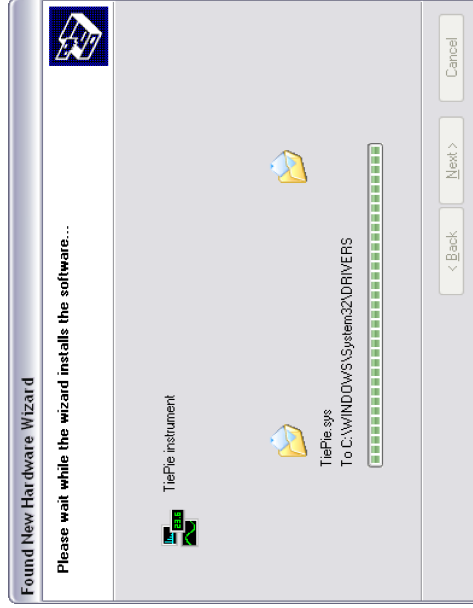


Figure 5.3: Hardware install: step 3

The New Hardware wizard will now copy the required files to their destination.

5.2.1 Found New Hardware Wizard

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.

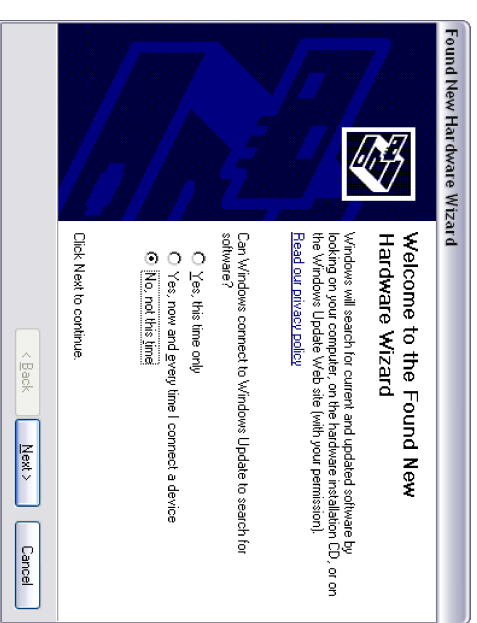


Figure 5.1: Hardware install: step 1

This window will only be shown in Windows XP SP2 or newer. No drivers for the Handyscope HS4 DIFB can be found on the Windows Update Web site, so select *“No, not this time”* and click *“Next”*.

Handyscope HS4 DIFF. Refer to paragraph 7.1 for specifications of the external power input.

5.2 Connect the instrument to the computer

After the new driver has been pre-installed (see chapter 4), the Handyscope HS4 DIFF can be connected to the computer. When the Handyscope HS4 DIFF is connected to a USB port of the computer, Windows will report new hardware. The Found New Hardware Wizard will appear.

Depending on the Windows version, the New Hardware Wizard will show a number of screens in which it will ask for information regarding the drivers of the newly found hardware. The appearance of the dialogs will differ for each Windows version and might be different on the computer where the Handyscope HS4 DIFF is installed.



The driver consists of two parts which are installed separately.

Once the first part is installed, the installation of the second part will start automatically. Installation of the second part is identical to the first part, therefore they are not described individually here.

Driver installation

4



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

4.1

Introduction

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

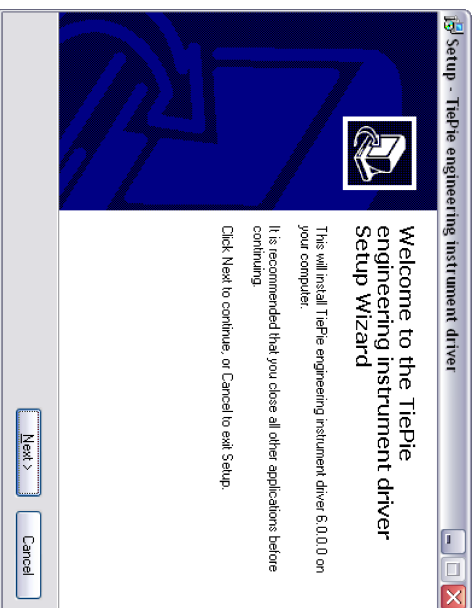


Figure 4.1: Driver install: step 1

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 Handyscope HS4 DIFP is disconnected from the computer prior to starting the driver install utility. When the Handyscope HS4 DIFP is used with an external power supply, this must be disconnected too.



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

5.1 Power the instrument

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

5.1.1 External power

In certain cases, it can be that the Handyscope HS4 DIFP cannot get enough power from the USB port.

When a Handyscope HS4 DIFP is connected to a USB port, the hardware will be powered, resulting in an inrush current, which is higher than the nominal current. After the inrush current, the current will stabilize at the nominal current.

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

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

In order to power the Handyscope HS4 DIFP externally, an external power input is provided for. It is located at the rear of the

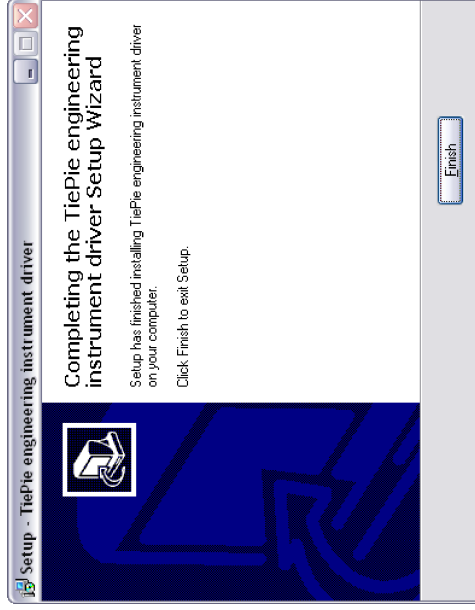


Figure 4.8: Driver install: Finished

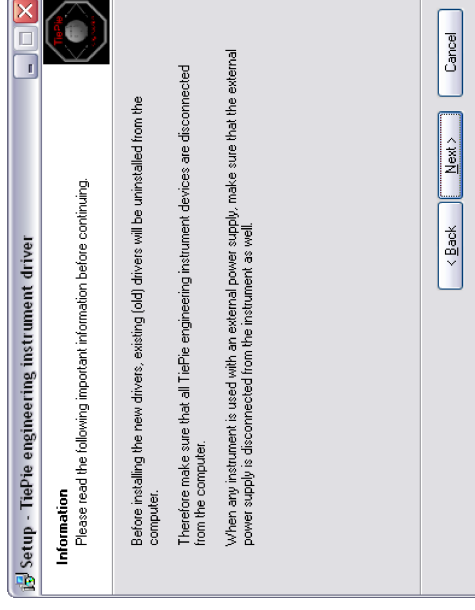


Figure 4.2: Driver install: step 2

When the instrument is still connected, the driver install utility will recognize it and report this. You will be asked to continue anyway.

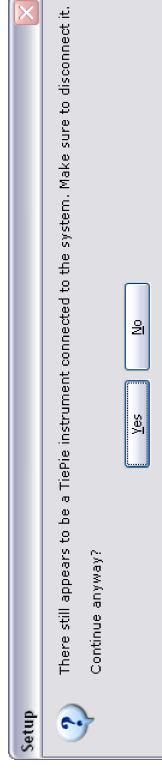


Figure 4.3: Driver install: Instrument is still connected

Clicking **"No"** will bring back the previous screen. The instrument should now be disconnected. Then the removal of the existing driver can be continued by clicking **"Next"**. Clicking **"Yes"** will ignore the fact that the instrument is still connected and continue removal of the old driver. This option is **not** recommended, as removal may fail, after which installation of the new driver may fail as well.

When no existing driver was found or the existing driver is removed, the location for the pre-installation of the new driver can be selected.

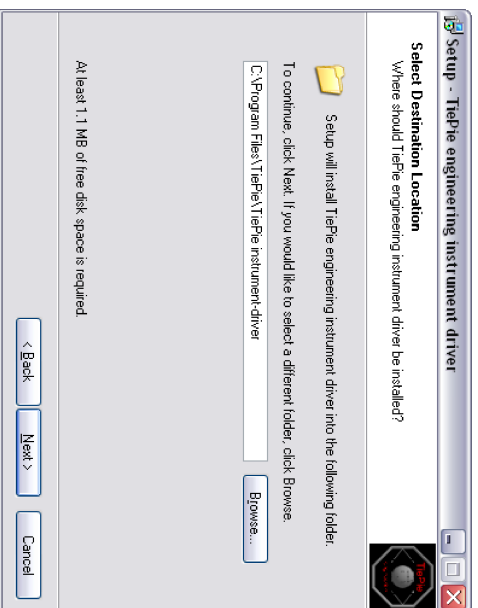


Figure 4.4: Driver install: step 3

On Windows XP and newer, the installation may inform about the drivers not being "Windows Logo Tested". The driver is not causing any danger for your system and can be safely installed. Please ignore this warning and continue the installation.

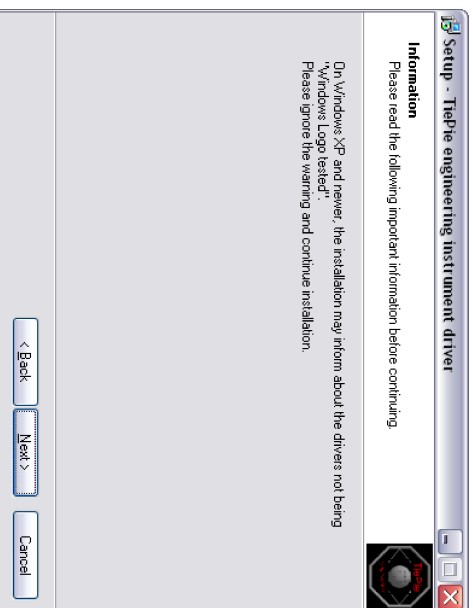


Figure 4.5: Driver install: step 4

The driver install utility now has enough information and can install the drivers. 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.

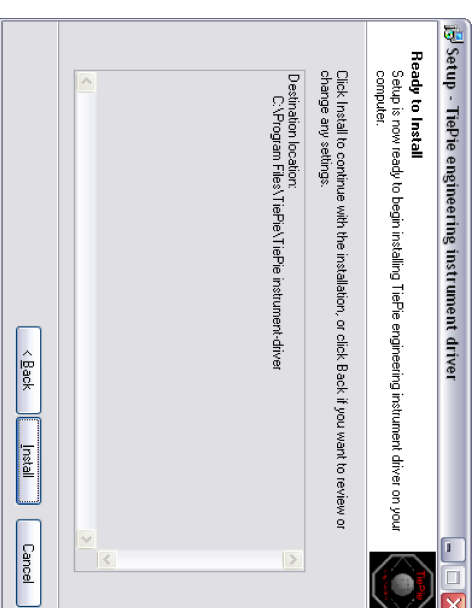


Figure 4.6: Driver install: step 5

As mentioned, Windows XP SP2 and newer may warn for the USB drivers not being Windows Logo tested. Please ignore this warning and continue anyway.

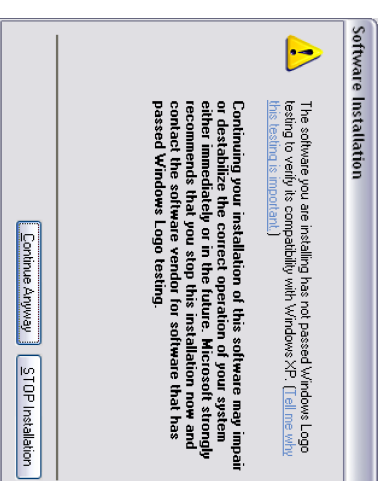


Figure 4.7: Driver install: Ignore warning and continue