Handyscope TP450

User manual

TiePie engineering

ATTENTION!

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

Revision 2.49, August 2024

Contents

1 Safety

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

- Always work according (local) regulations.
- Work on installations with voltages higher than 25 V_{AC} or 60 V_{DC} should only be performed by qualified personnel.
- Avoid working alone.
- Observe all indications on the Handyscope TP450 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.

TiePie engineering
Koperslagersstraat 37
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The Netherlands

EC Declaration of conformity

We declare, on our own responsibility, that the product

Handyscope TP450-250(XM)
Handyscope TP450-50(XM)

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

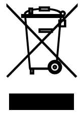
and is categorized as CAT II 600 V_{RMS}, 800 V_{pk}, 800 V_{DC}

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

Environmental considerations

This section provides information about the environmental impact of the Handyscope TP450.

End-of-life handling



Production of the Handyscope TP450 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 TP450'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 TP450 in an appropriate system that will ensure that most of the materials are reused or recycled appropriately.

The shown symbol indicates that the Handyscope TP450 complies with the European Union's requirements according to Directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

3 Introduction

Before using the Handyscope TP450 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 TP450 is a single channel, 16 bits measuring instrument with galvanically isolated differential input with high input range. It is available in two models with different maximum sampling and streaming rates:

Maximum sampling rate	Model 250	Model 50
Block mode	250 kSa/s	50 kSa/s
Streaming mode	250 kSa/s	50 kSa/s

Table 3.1: Maximum sampling rates

The Handyscope TP450 is available with two memory configurations, these are:

Memory	Model 250	Model 50
Standard model	16 KiSa	16 KiSa
Option XM	1 MiSa	1 MiSa

Table 3.2: Maximum record length per channel

With the accompanying software the Handyscope TP450 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 input is always connected to ground and the other side to the point of interest in the circuit under test.

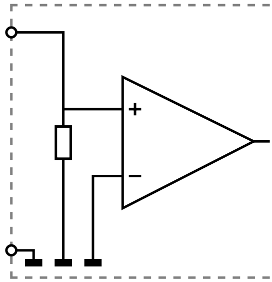


Figure 3.1: Single ended input

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.

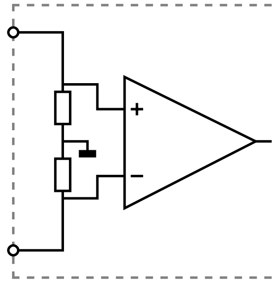


Figure 3.2: Differential input

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

The Handyscope TP450 is galvanically isolated. This means that there is no electrical connection between the inputs and the USB connection. It is therefore not possible to damage the connected computer when (accidentally) making a wrong connection.

3.1.1 Differential test lead

The Handyscope TP450 comes with a special differential test lead This test lead is specially designed to ensure a good CMRR and to be immune for noise from the surrounding environment.

The special differential test lead provided with the Handyscope TP450 is heat resistant and oil resistant.

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.

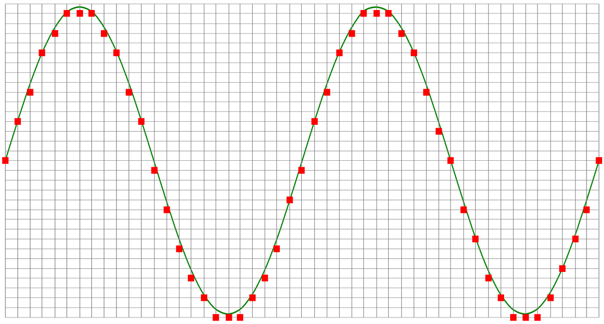


Figure 3.3: Sampling

The sine wave in figure 3.3 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 3.4.

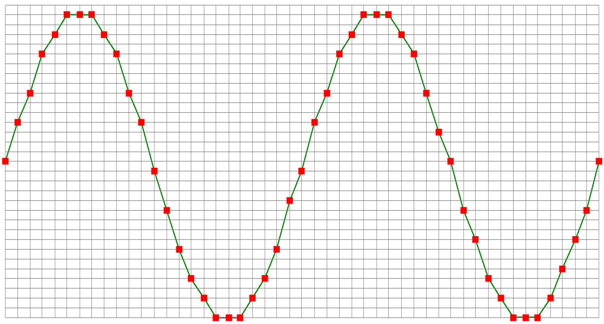


Figure 3.4: "connecting" the samples

3.3 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 3.5, with a higher sampling rate, the original signal can be reconstructed much better from the measured samples.

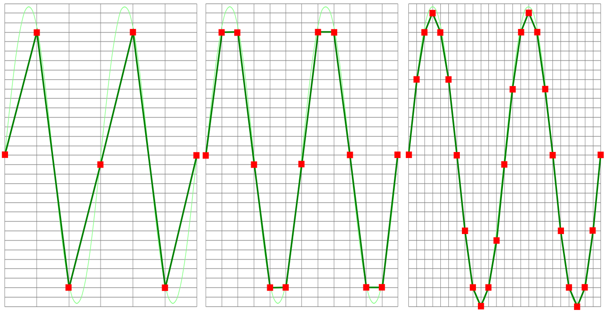


Figure 3.5: The effect of the sampling rate

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.

3.3.1 Aliasing

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

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

Table 3.3: Aliasing

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

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

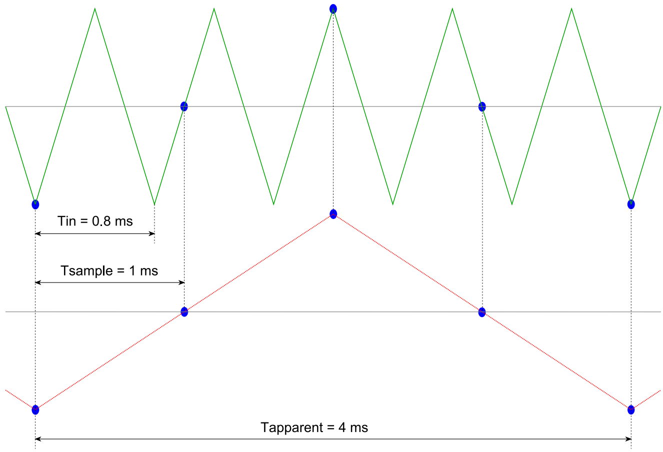


Figure 3.6: Aliasing

In figure 3.6, 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.

3.4 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 3.7, the same signal is digitized, using two different amounts of levels: 16 (4-bit) and 64 (6-bit).

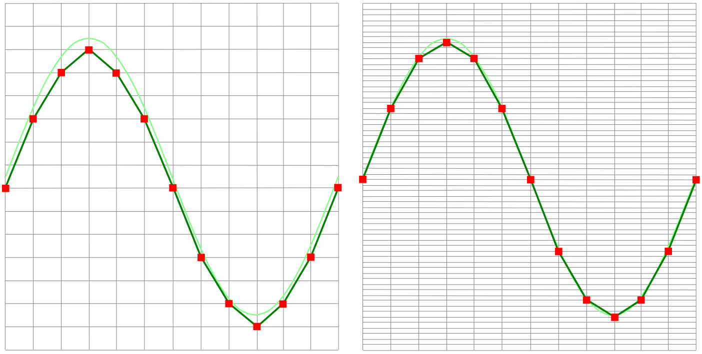


Figure 3.7: The effect of the resolution

The Handyscope TP450 measures at 16 bit resolution (2^{16}=65536 levels). The smallest detectable voltage step depends on the input range. This voltage can be calculated as:

$$VoltageStep = FullInputRange/LevelCount$$

For example, the 80 V range ranges from -80 V to +80 V, therefore the full range is 160 V. This results in a smallest detectable voltage step of 160 V / 65536 = 2.44 mV.

Driver installation 4

Before connecting the Handyscope TP450 to the computer, the drivers need to be installed.

4.1 Introduction

To operate a Handyscope TP450, 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 TP450 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.

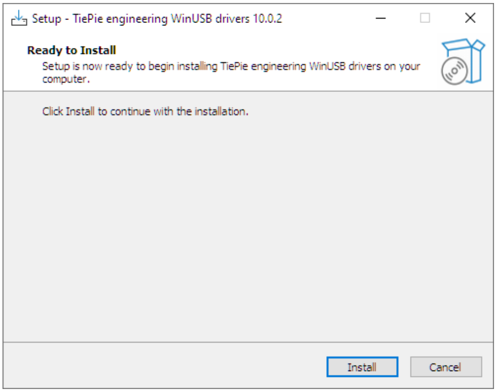


Figure 4.1: Driver install: step 1

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 TP450 is disconnected from the computer prior to starting the driver install utility.

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.

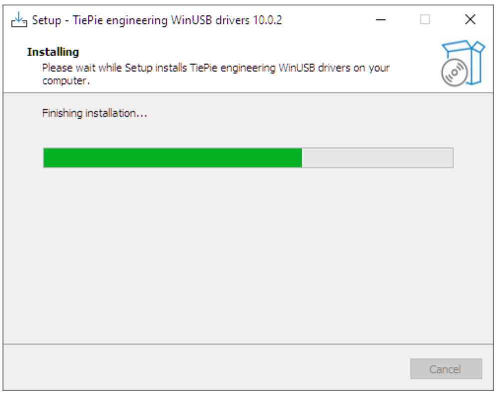


Figure 4.2: Driver install: Copying files

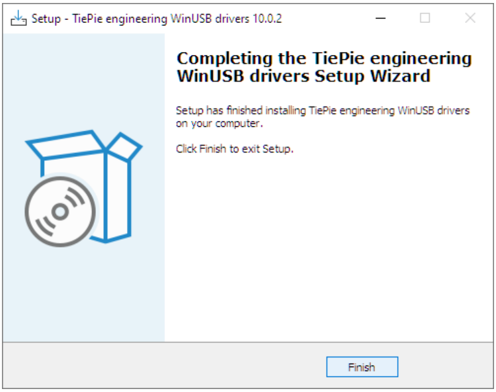


Figure 4.3: Driver install: Finished

5 Hardware installation

Drivers have to be installed before the Handyscope TP450 is connected to the computer for the first time. See chapter 4 for more information.

5.1 Power the instrument

The Handyscope TP450 is powered by the USB, no external power supply is required. Only connect the Handyscope TP450 to a bus powered USB port, otherwise it may not get enough power to operate properly.

5.2 Connect the instrument to the computer

After the new driver has been pre-installed (see chapter 4), the Handyscope TP450 can be connected to the computer. When the Handyscope TP450 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 TP450 can be used.

5.3 Plug into a different USB port

When the Handyscope TP450 is plugged into a different USB port, some Windows versions will treat the Handyscope TP450 as different hardware and will install the drivers again for that port. This is controlled by Microsoft Windows and is not caused by TiePie engineering.

6 Input connnectors

Figure 6.1: Connection

The CH1 slide contact connectors are the inputs of the acquisition system. The Handyscope TP450 is delivered with four different mains wall socket adapters, which can be placed on the instrument body. The Handyscope TP450 can then be plugged in a matching wall socket to measure the mains voltage directly.

6.1 Using the Measure lead TP-C812C

The Handyscope TP450 is delivered with a Measure lead TP-C812C. To connect the TP-C812C to the Handyscope TP450, first place the European wall socket adapter on the Handyscope TP450. The dual 4 mm banana socket of the TP-C812C can then be connected to the two prongs of the wall socket adapter.

Figure 6.2: TP-C812C connected

Test probes and clips with 4 mm banana sockets can then be connected to the 4 mm banana plugs at the other end of the TP-C812C.

7 Specifications

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

When the accuracy is specified as ±0.5% of the Full Scale range ± 1 LSB, and the input range is 4 V, the maximum deviation the measured value can have is ±0.5% of 8 V = ±40 mV. ±1 LSB equals 8 V / 3327 (= number of LSB at 11.7 bit) = ± 2.4 mV. Therefore the measured value will be between 42.4 mV lower and 42.4 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 3.7076 V and 3.7924 V.

7.1 Acquisition system

Number of input channels	1 analog		
Connector	2 slide contacts		
Type	galvanically isolated differential		
Ranges (full scale)	±2 V ±4 V ±8 V	±20 V ±40 V ±80 V	±200 V ±400 V ±450 V
Resolution (per input range)	2 V : 10.7 bit 4 V : 11.7 bit 8 V : 12.7 bit	20 V : 14 bit 40 V : 15 bit 80 V : 16 bit	200 V : 14.8 bit 400 V : 15.8 bit 450 V : 16 bit
Amplitude Accuracy	0.5% of full scale ± 1 LSB		
Coupling	DC		
Noise	1.6 mV_{RMS} (2 V range, 250 kSa/s)		
Impedance	1 MΩ / 20 pF		
Protection	600 V_{RMS} CAT II (DC + AC peak < 10 kHz)		
Maximum Common Mode voltage	600 V in all ranges		
	TP450-250		TP450-50
Bandwidth (-3dB)	200 kHz		25 kHz
Galvanic isolation			
between input and USB port	5000 V_{RMS} for 1 minute		
Sampling rate	TP450-250		TP450-50
Block mode real time			
Maximum	250 kSa/s		50 kSa/s
Minimum	1 Sa/s		1 Sa/s
Streaming mode real time			
Maximum	250 kSa/s		50 kSa/s
Minimum	1 Sa/s		1 Sa/s
Sampling source	internal		
Accuracy	±0.25 ppm		
Memory	standard model		**XM** option
	16 kS		1 MS

7.2 Trigger system

System	digital, 2 levels	
Source	CH1	
Trigger modes	TP450-250	TP450-50
	rising slope, falling slope, inside window, outside window	rising slope, falling slope
Level adjustment	0 to 100% of full scale	
Hysteresis adjustment	0 to 100% of full scale	
Resolution	0.025% (16 bits)	
Pre trigger	0 to selected record length (0 to 100%, one sample resolution)	
Post trigger	0 to selected record length (0 to 100%, one sample resolution)	

7.3 Interface

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

7.4 Power

Power	from USB port
Consumption	5 V_{DC}, 100 mA max

7.5 Physical

Instrument height	70 mm / 2.75"
Instrument length	72 mm / 2.83"
Instrument width	42 mm / 1.65"
Weight	160 gram / 5.6 ounce
USB cord length	3 m / 118"

7.6 I/O connectors

CH1	slide contacts with exchangable adapters for EU, US, AU and UK mains wall sockets
USB	fixed cable with USB 2 type A plug

7.7 System requirements

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

7.8 Environmental conditions

Operating	
Ambient temperature	20°C to 25°C (10°C to 40°C without specs)
Relative humidity	10 to 90% non condensing
Storage	
Ambient temperature	-20°C to 70°C
Relative humidity	5 to 95% non condensing

7.9 Certifications and Compliances

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

7.10 Measure lead

Model	TP-C812C
Type	differential
Connectors	
Instrument side	dual 4 mm banana socket, 19 mm apart
Test point side	red and black 4 mm shrouded banana plugs
Bandwidth	7 MHz
Safety	CAT III, 1000 V, double isolated
Dimensions	
Total length	2000 mm
Length to split	800 mm
Length individual ends	1200 mm
Weight	75 g
Color	black
Heat resistant	yes
Certification and compliances	
CE conformity	yes
RoHS	yes
Accessories	
Color coding rings	5 x 3 rings, various colors
Suitable instrument	Handyscope TP450

7.11 Package contents

Instrument	Handyscope TP450
Test lead	low noise differential with 4 mm banana plugs
Accessories	2 test probes with 4 mm banana socket 2 crocodile clips with 4 mm banana socket Color coding rings Mains wall socket adapters for EU, US, AU and UK
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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