pendulum

Wandermeters

WM-10 & WM-11

Users Manual

4031 600 10001
Rev. 05 (February 2003)

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EC DECLARATION OF CONFORMITY

Number: PQWM11200206

The undersigned, representing the following manufacturer:

Manufacturer: Pendulum Instruments AB
Karlsbodavägen 39, Box 20020
SE-161 02 Bromma, Sweden

Representative: Kali Rahman
Function: Quality Manager

herewith declares that the product:

Product Identification:

Product: Wandermeter
Brand: Pendulum
Model: WM-10, WM-11
Version: All models

Additional Information:
is in conformance with the EC Directive 89/336/EEC based on test results using harmonized standards in accordance with Article 10(1) of the directive LVD-73/23/EEC.

Harmonized Standards Used:

Safety: EN 61010-1 (1990) + A1 (1992) + A2 (1995)
Safety Requirements for Electronic Measuring Apparatus.

EMC: EN 61326-1 (1997)
Electrical equipment for measurement, control and laboratory use - EMC requirements.
EN 55022 (1994) + A1 (1995) + A2 (1997) Class B
Limits and methods for measurement of radio disturbance characteristics of information technology equipment (ITE).
EN 61000-6-2 (1999)
EMC - generic standards - immunity for industrial environments.

The tests have been performed in a typical configuration.

Place: Bromma Date: 2002-06-03 Signature:

This Conformity is indicated by the symbol CE, i.e. “Conformité européenne”.

Chapter 1

Preface

Introduction

A wander of the synchronization clock in digital communication networks can cause severe transmission problems. Quality control of the synchronization clock requires monitoring of wander over a long period (hours or days) using an ultra-stable clock as reference.

So far measurement of wander has involved bulky, complex and very expensive instrumentation. To be able to view the wander parameters MTIE and TDEV specified in international standards, external computers were needed.

Congratulations for choosing the Wandermeter from Pendulum Instruments. The portable, very accurate and easy-to-use solution for wander measurements on sync clocks and encoded data signals.

Applications

■ WM-10

The WM-10 Wandermeter can be used for several purposes:

1. Clock quality verification according to standards (ITU G811-813) for telephone network operators.

2. Clock quality verification according to ITU or ETSI standards for leasers of synchronization services, e.g. other telephone operators.

3. Troubleshooting in SDH or PDH networks when a node is suspected not to operate correctly.

4. Preventive (diagnostic) maintenance of local exchange stations (SDH or PDH).

5. Troubleshooting in GSM networks that use the E1 clock for synchronization.

■ WM-11

The Wandermeter WM-11 can be used for the same purposes as the WM-10 (see preceding paragraph) but has also additional areas of application:

1. Troubleshooting in SONET networks when a node is suspected not to operate correctly.

2. Preventive (diagnostic) maintenance of local exchange stations (SONET).

Product Key Features

■ WM-10

The WM-10 Wandermeter has the following features:

– Wandermeter for verifying 2.048 MHz (sync clock) or 2.048 Mbit/s (HDB3 data) in SDH-network nodes (ITU G811-813).
– Self-contained unit with built-in Rubidium Reference and graphical display. Can be left unattended for automatic measurements, without a PC, for diagnostic and troubleshooting measurements.
– Graphical presentation of TIE, MTIE and TDEV. Comparison with standard masks.
– Very easy to use.
– Transportable.
– Self-adjusting internal reference when connected to a stable reference, e.g. Cesium or GPS-controlled Rubidium frequency standard.

■ WM-11

The WM-11 Wandermeter can perform the same tasks as the WM-10 (see preceding paragraph) but has also additional features:

– Wandermeter for verifying 1.544 MHz (sync clock) or 1.544 Mbit/s (HDB3 data) in SONET network nodes.

– Wandermeter for other customary frequencies in data, video and frequency distribution systems:

  4 kHz, 8 kHz, 15.750 kHz (NTSC),
  15.625 kHz (PAL), 64 kbit/s, 5 MHz,
  10 MHz, 27 MHz, 34 Mbit/s, 45 Mbit/s,
  52 Mbit/s

– Ethernet interface for remote control over Internet.

– 48 V DC power supply as backup

Working Principle

The Pendulum WM-10/WM-11 Wandermeter is built in an EMI-proof metal cabinet and contains a Rubidium Reference and a special Time Interval Error (TIE) measuring circuitry that phase-compares the connected clock (or data) signal with the Rubidium reference. The Wandermeter communicates with the user via the front panel keyboard and a graphical display, and with a PC via an RS-232 port. The WM-11 has also an Ethernet port.

The Wandermeter operates in two different modes:

■ Local Mode:

The WM-10/WM-11 Wandermeter can be operated stand-alone. During the measurement, the TIE curve on the display is continuously updated, showing the performance of the sync-clock “so far”. This mode is intended for fully automated diagnostics and/or trouble-shooting measurement “on-site”, with direct visual feedback at any time. The sampling rate is approx. 1 Sa/s. The Wandermeter calculates and presents the MTIE or TDEV curves after a completed TIE measurement, and compares with stored masks.

■ Remote Mode

The Wandermeter can be remotely controlled from a PC, running a PC-SW called **WanderView™**. In this mode the Wandermeter acts as a sampling front-end and transfers the TIE values one by one to the PC. The local display of the Wandermeter is not updated. Sample speed is >30 TIE values/s and the storage is only limited by the PC, which means that the fast sample rate can be maintained during a 24h period (or longer if required). The PC-SW calculates and presents the TIE, MTIE or TDEV curves after a completed measurement period and compares with standard masks, but it is also possible to take snapshots during a running measurement. This mode is mainly intended for protocolled verification measurements according to ITU or ETSI standards.

Two additional presentation modes, ADEV and MADEV, can be used from WanderView™. See introduction on page 5-12.

RS-232 Connection

A PC is connected to the RS-232 port at the rear of the instrument. A suitable cable should have female DB9 connectors at both ends and be designed as a “null-modem” cable. Such a cable is delivered with the instrument.

Ethernet Connection (only WM-11)

After configuration by means of the WanderView SW over the auxiliary RS-232 interface marked CONFIG IP, the Ethernet interface lets the operator communicate with the Wandermeter in much the same way as with any Ethernet node. Remote control and data logging over the Internet is thus a simple task.

Standard Cat 5 patch cords of good quality with RJ45 connectors can be used.

Note: There are two types available, straight-through and cross-wired. The first one is used when connecting to a wall outlet or a hub, the second one when connecting directly to a PC or other controller.

Easy to Use

A fully automatic signal check informs the user whether he/she has connected the right signal from the rack (e.g clock or data signal).

The unit can be left unattended. It stops after set measuring time and can even delay its measurement start if certain conditions are met. This function is intended for letting the instrument warm up properly before a critical measurement. The invoked timer starts automatically on power-up, so if the desired delay has already passed when the command is entered, nothing will happen.

On-line context-sensitive help is available, making the users manual obsolete in most cases.

Chapter 2

Safety Instructions

Introduction

Read this page carefully before you install and use the instrument.

This instrument has been designed and tested according to safety Class 1 requirements of IEC publication EN61010-1 and CSA 22.2 No.231, and has been supplied in a safe condition. The user of this instrument must have the required knowledge of it. This knowledge can be gained by thoroughly studying this manual.

This instrument is designed to be used by trained personnel only. Removal of the cover for repair of the instrument must be done by qualified personnel who are aware of the hazards involved. There are no user-serviceable parts inside the instrument.

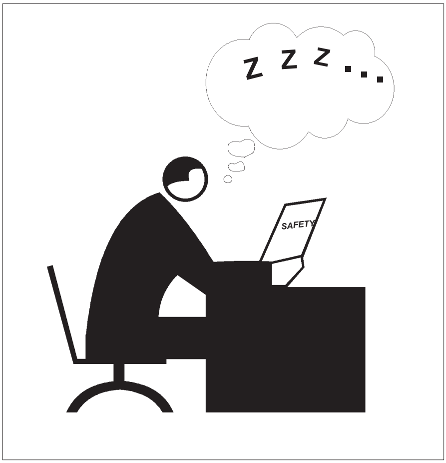

Figure 2-1 *Do not overlook the safety instructions!*

Safety Precautions

To ensure the correct and safe operation of this instrument, it is essential that you follow generally accepted safety procedures in addition to the safety precautions specified in this manual.

Caution and Warning Statements

CAUTION: Shows where incorrect procedures can cause damage to, or destruction of equipment or other property.

WARNING: Shows a potential danger that requires correct procedures or practices to prevent personal injury.

Symbols

Shows where the protective ground terminal is connected inside the instrument. **Never** remove or loosen this screw.

Indicates that the operator should consult the manual.

If in Doubt about Safety

Whenever you suspect that it is unsafe to use the instrument, you must make it inoperative by doing as follows:

– Disconnect the line cord.

– Clearly mark the instrument to prevent its further operation.

– Inform your local Pendulum Service Center..

For example, the instrument is likely to be unsafe if it is visibly damaged.

Grounding

Whenever an instrument is connected to the line voltage, a grounding fault will make it potentially dangerous. Before connecting any unit to the power line, you must make sure that the protective ground functions correctly. Only then can a unit be connected to the power line and only by using a three-wire line cord. No other method of grounding is permitted. Extension cords must always have a protective ground conductor.

WARNING: If a unit is moved from a cold to a warm environment, condensation may cause a shock hazard. Ensure, therefore, that the grounding requirements are strictly met.

WARNING: Never interrupt the grounding cord. Any interruption of the protective ground connection inside or outside the instrument or disconnection of the protective ground terminal is likely to make the instrument dangerous.

Power Switch

This instrument is equipped with a secondary power switch. It disconnects the main power-consuming circuits on the secondary side of the power supply but leaves the Rubidium oscillator active in order to retain its long-term characteristics. Line voltage is always present on the primary side.

WARNING: Always consider the instrument active as soon as it is connected to the primary ac power source with a power cord.

Disposal of Hazardous Material

This instrument uses a 3 V lithium cell to power a backup RAM. It is placed in a holder and can easily be exchanged.

WARNING: Disposal of lithium cells requires special attention. Do not expose them to heat or put them under excessive pressure. These measures may cause the cells to explode. Make sure they are recycled according to local regulations.

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Chapter 3

Preparations for Use

Unpacking Instructions

Check that the shipment is complete and that no damage has occurred during transportation. If the contents are incomplete or damaged, file a claim with the carrier immediately. Also notify your local Pendulum sales or service office in case repair or replacement may be required.

Check List

The shipment should contain the following:

– The Wandermeter.

– Line cord.

– *WM-11 only:* cable connector matching the -48 V DC rear panel connector.

– WanderView™ program disks.

– This Users Manual.

– RS-232 null-modem cable (DB9).

– 120/75 Ω Baluns.

– If you ordered option 35, it should already be installed. See “Identification” below.

– Other options you ordered, e.g. Transport case (option 27W) are shipped in separate boxes.

– Certificate of Calibration.

Identification

Options installed inside the cover are identified on the rear panel according to the list below.

Option 35 (Only WM-10): 2 BNC-connectors mounted in the area designated “optional 2.048 MHz output”.

Installation

AC Supply Voltage

■ Setting

The instrument may be connected to any AC supply with a voltage rating of 90 to 264 V_{rms}, 47 to 63 Hz. The instrument automatically adjusts itself to the line voltage.

■ Fuse

The high-voltage AC Power Supply is protected by a 2A/250V internal fuse that is used over the full voltage range. In case of failure, the instrument must be returned to a Pendulum Authorized Service Center. There are no user serviceable parts in the Power Supply.

CAUTION: If this fuse is blown, it is likely that the AC power supply is badly damaged. Do not replace the fuse. Send the instrument to the local Pendulum Service Center.

DC Supply Voltage (WM-11)

■ Setting

The instrument may be connected to any DC supply with a voltage rating of 38 to 72 V and capable of delivering up to 60 W. The instrument automatically adjusts itself to the terminal voltage of the power source and is protected against reverse polarization.

■ Fuse

The low-voltage DC power supply is protected by a 2A/250V internal fuse that is placed inside the instrument on the separate DC power supply PCB. It is used over the full voltage range.

CAUTION: If this fuse is blown, it is likely that the DC power supply is badly damaged. Do not replace the fuse. Send the instrument to the local Pendulum Service Center.

■ AC Power Supply Backup

If both AC and DC power are connected at the same time, the AC supply will take precedence. In this case the combined supply units will in fact work as a UPS (Uninterruptible Power Supply), however without the ability to reload an external battery used as a DC source.

Orientation and Cooling

The instrument is intended to be operated on a bench. Leave 5 centimeters (2 inches) of space around the instrument.

Fold-Down Support

For bench-top use, a fold-down support (2 plastic "feet") is available for use underneath the instrument.

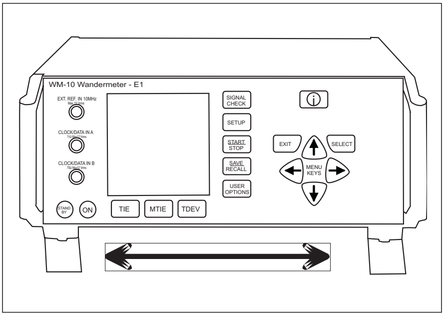


Figure 3-1 *Fold-down support for comfortable bench-top use.*

Carrying Handles

Two side handles can be used to carry the instrument.

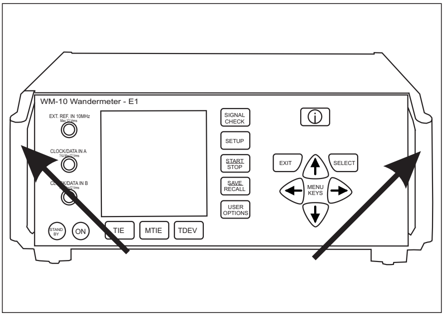


Figure 3-2 *Use the handles to carry the wandermeter.*

Connecting to a PC

A PC can be connected to the RS-232 port at the rear of the instrument. A suitable cable should have female DB9 connectors at both ends and be designed as a "null-modem" cable. Such a cable is enclosed with the shipment.

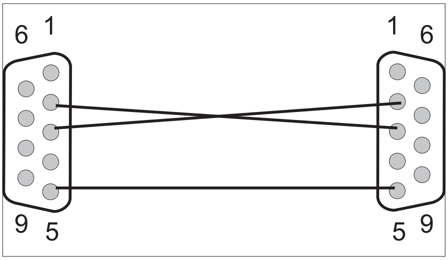


Figure 3-3 *Connecting to a PC*

Ethernet Connection (WM-11)

After configuration by means of the WanderView™ SW over the dedicated RS-232 port, the 10Base-T Ethernet interface lets the operator communicate with the Wandermeter in much the same way as with any Ethernet node. Remote control and data logging over the Internet is thus a simple task.

Standard Cat 5 patch cords of good quality with RJ45 connectors can be used.

Note: There are two types available, straight-through and cross-wired. The first one is used when connecting to a wall outlet or a hub, the second one when connecting directly to a PC or other controller.

Chapter 4

Using the Controls

About This Chapter

This chapter gives you a quick introduction to all the controls of the instrument, the design of the user interface, and front panel text. For the occasional user, the information in this chapter is often sufficient to solve a measurement problem.

Basic Controls

ON/STANDBY [1]

Press ON to switch on and STANDBY to switch off the Wandermeter. In the Stand-by mode, power is maintained for the internal Rubidium timebase, as long as the mains cord is connected to the mains outlet.

TIE [2]

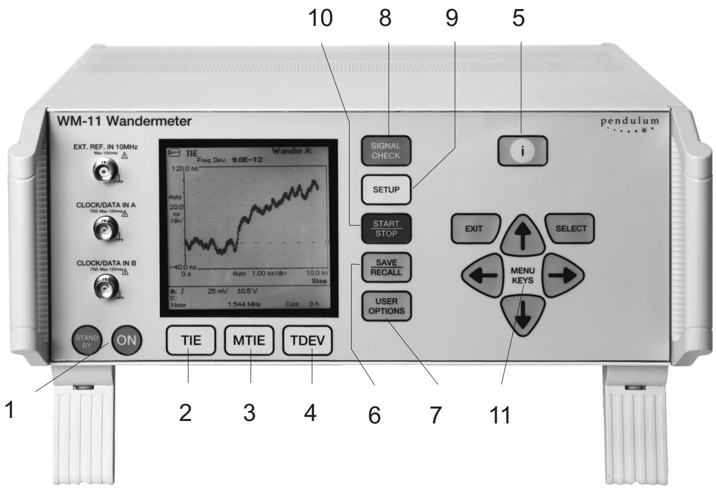
TIE = Time Interval Error. This is the default presentation mode, and is selected when the TIE key is pressed.

TIE is the basic measurement performed by the Wandermeter, and the TIE raw data is the input to the MTIE and TDEV processed presentation modes. During a TIE measurement in Local Mode, the graphical display is continuously updated. When a TIE measurement is in progress, the other presentation modes MTIE and TDEV are not accessible.

After a completed TIE measurement, also the other presentation modes can be selected.

Note that the default X-scale of the TIE graph is fixed if a fixed measuring time is selected. E.g. The X-scale is 0 to 10 000 s for a 2h measurement time (7200 s) and 0 to 100 000 for a 24h measurement time (86400 s). You can also set the scale manually to zoom in on a particular part of the graph, even during a measurement.

The X-scale changes automatically to the currently elapsed time, when continuous measuring is selected. The default mode for the Y-scale (TIE) is AUTO, but it is also possible to select MAN (manual), even during a measurement.



MTIE [3]

MTIE = Maximum Time Interval Error. This presentation mode is the calculated max. difference between any 2 TIE-values for various observation intervals (τ). The MTIE is calculated according to ETSI standards.

If test mode PRC (ETSI), SSU (ETSI), SEC (ETSI), SSU-L (ETSI), SEC-L (ETSI) or any of the "User-Defined" test modes is selected, the corresponding limit masks are also displayed in the graph. If Test Mode is set to "None", no limit masks are displayed. MTIE is also calculated in Measurement Mode "Differential".

MTIE can only be selected after a completed TIE measurement (only then all data is available for the MTIE processing). After a completed TIE measurement, you can toggle between the different test modes (SETUP menu) to display various limit masks for comparison with different standards.

The X-scale ("tau") is always fixed. The Y-scale (MTIE) is automatic for test mode PRC (ETSI), SSU (ETSI), SEC (ETSI), SSU-L (ETSI), SEC-L (ETSI), and automatic for "None" and "User-Defined".

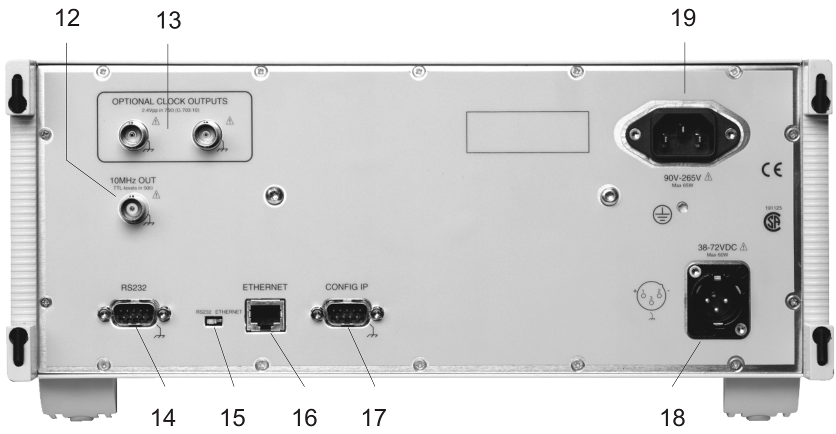
TDEV [4]

TDEV = Time DEViation. This presentation mode presents the TDEV of the input signal, calculated according to ETSI-standards.

If test mode PRC (ETSI), SSU (ETSI), SEC (ETSI), SSU-L (ETSI), SEC-L (ETSI) or any of the "User-Defined" test modes is selected, the corresponding limit masks are also displayed in the graph. If test mode is set to "None", no limit masks are displayed. TDEV is also calculated in Measurement Mode "Differential".

TDEV can only be selected after a completed TIE measurement (only then all data is available for the TDEV processing).

After a completed TIE measurement, you can toggle between the different test modes (SETUP menu) to display various limit masks for comparison with different standards.



The X-scale (”tau”) is always fixed. The Y-scale (TDEV) is automatic for test mode PRC (ETSI), SSU (ETSI), SEC (ETSI), SSU-L (ETSI), SEC-L (ETSI), and automatic for “None” and “User-Defined”.

INFO [5]

INFO gives an on-line help for the currently used function.

SAVE/RECALL [6]

Here you can save up to five measurement set-ups, three screen plots and one TIE data array (up to 16k samples). The data array can be sent to a PC.

USER OPTIONS [7]

Here you find some common settings that do not affect the current measurement.

- Display contrast /viewing angle
- Choice of external/internal reference
- RS-232 settings (baudrate)
- Self-tests
- Calibration of internal Rubidium timebase
- Choice of output frequency (WM-11)

SIGNAL CHECK [8]

The Wandermeter makes a test measurement of the signal to verify that the user has connected the correct signal for the wander measurement.

Different signal characteristics like frequency, pulse width, Vmax, Vmin, Vp-p and signal type are measured and displayed in an info-box window on screen.

In the signal type field, clock signals are recognized by “kHz” or “MHz” after the frequency, whereas data signals have “kbit/s” or “Mbit/s” instead.

SETUP [9]

■ Test Mode

This setting determines which limit masks are to be displayed in the MTIE and TDEV graphs, e.g. PRC (ETSI), SSU (ETSI) and SEC (ETSI) for the 2.048 Mbit/s signal. The PRC (ETSI) is the most demanding and the SEC (ETSI) is the least demanding specification in this example.

“None” mode gives no limit mask.

“User-Defined” mode means that user specific limit masks are displayed. These are defined in the WanderView™ SW and loaded into the instrument.

■ Measuring Mode

“Absolute” means that the TIE measurement shows the phase difference between a signal connected to CLOCK/DATA IN A and either the built-in rubidium reference or an external 10 MHz reference clock connected to EXT. REF IN 10 MHz.

“Differential” means that the TIE measurement shows the *relative* phase difference between two signals connected to CLOCK/DATA IN A and CLOCK/DATA IN B. One example is to compare the sync clock **into** a network element with the regenerated sync clock **out** of the network element.

■ Signal Types

The connected signal can be either symmetrical, unipolar (e.g. 2.048 MHz clock) or unsymmetrical, bipolar, (e.g. HDB3 or AMI coded data). The SIGNAL CHECK reveals what type of signal is connected, and does also a pre-setting of the Signal Type selection. See the specifications in Chapter 8 for a summary of the signal types that WM-10 resp. WM-11 can accept.

■ Measuring Time

Here you set the duration of the wander measurement (TIE measurement) The timer starts to count when the user presses the START/STOP key. There are four fixed time settings (30 min, 2h, 4h, 24h), where the measurement automatically stops after the elapsed time.

There is also a continuous time setting, where the measurement needs to be manually stopped via a second push on the START/STOP key.

If the measuring time is remotely controlled from WanderView™, the REMOTE indicator (Rem.) is shown in the selection box.

■ Warm-Up Time

This setting determines how long the instrument should be continuously connected to the mains voltage, before the actual measurement is allowed to start. A longer warm-up time means a more stable internal timebase.

The user should enter a long warm-up time (24h) for measurements on PRC (ETSI) clocks and a short (30 min) on SEC (ETSI) clocks.

For “Draft” measurements the instrument could start without any delay (warm-up time = 0). However, it takes about 5 minutes for the internal Rubidium timebase to lock, and before that no measurement is allowed to start, not even if 0 warm-up time is set.

■ Auto Trigger

Auto triggering occurs once after pressing SIGNAL CHECK.

For Clock signals, the trigger level is set to 50% of the input signal amplitude.

For Data signals, the trigger level is set to 25% of the input signal amplitude.

The Auto trigger handles input signal amplitudes between 60 mV and 10 V peak-to-peak.

■ Trigger Level

The automatically set values can be overridden by entering new values manually from the Trigger Level menu.

■ Trigger Slope

Here you can select between a positive (default setting) or a negative trigger slope.

START/STOP [10]

Here you press to start or to stop your wander measurement. The measurement will start either immediately or after elapsed warm-up time. If the measurement can not start immediately (warm-up time not yet elapsed) the user is notified via an infobox, with an indication of remaining delay to start.

Note: The delay time is counted from power-up. However, the Rubidium timebase must first lock. It takes about five minutes.

During a pending measurement, a press on this key will immediately stop the current measurement if a *continuous* measuring time is selected. When a *fixed* measuring time (30 min, 2h, 4h, 24h) is selected, a press on this key is a *request* to stop the measurement. An infobox will give the user a possibility to confirm this request, before the measurement actually stops.

A measurement with a fixed measuring time (30 min, 2h, 4h, 24h) will *automatically* stop after the set time has elapsed.

Navigation Keys [11]

Arrow keys are used to navigate in menus and between graph setting parameters in the display.

SELECT is used to confirm menu choices and to select parameters.

EXIT is used to quit menus.

Rear Panel

Reference Frequency Output [12]

Independent of the selection made in the USER OPTIONS menu, the internal 10 MHz reference frequency is always available here.

Clock Outputs [13]

■ WM-10

Optional double 2.048 MHz clock outputs (Option 35).

■ WM-11

Double clock outputs, 1.544 MHz or 2.048 MHz, depending on selection in the USER OPTIONS menu.

RS-232 Port [14]

Standard serial interface for commands and data I/O.

Ethernet/RS-232 Switch [15] (only WM-11)

Only one interface at a time can be active. However, the Ethernet interface must first be configured properly before it can be selected and operated.

Ethernet Connector [16] (only WM-11)

Standard RJ45 connector for connecting the instrument to a PC or LAN using the 10Base-T protocol, making remote control over the Internet possible.

Configuration Input [17] (only WM-11)

Auxiliary RS-232 port for configuring the Ethernet interface before information exchange over the RJ45 connector can take place.

Typically the interface has to be reconfigured when the instrument has been moved to a new location in order to establish a new IP address that is compatible with the local environment.

DC Power Connector [18] (only WM-11)

An external DC source between 38 V and 72 V, capable of delivering up to 60 W, can serve as a substitute for the ordinary AC source. You can also combine the two power sources to form an uninterruptible power supply (UPS) with limited characteristics.

As long as the AC voltage is within the specified range, the DC supply is automatically disconnected internally from its load. However, the idle running current of the DC supply unit will eventually drain an external battery that is not being recharged regularly.

The no-load power consumption is less than 2 W.

AC Power Connector [19]

A wide specified voltage range (100-240 Vrms ± 10 %) covers all standard line voltages and line frequencies (47-63 Hz) in the world without needing a voltage selector.

Presentation Modes

TIE

A typical TIE graph is shown below.

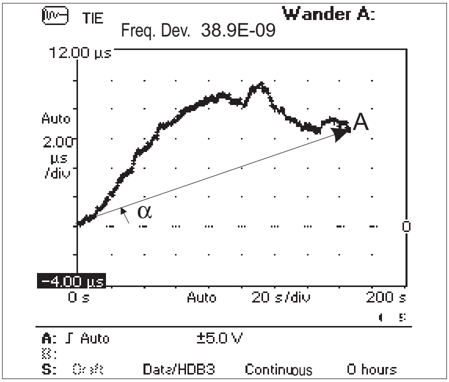


Figure 4-1 *TIE graph with line for equivalent relative frequency deviation at point A.*

The Y-axis shows the TIE-values (the accumulated phase error between the actual input signal and an ideal signal) and the X-axis shows elapsed time (real-time).

The display graph grid has a dotted graticule. The zero-line (TIE=0 ns) is a dashed horizontal line.

■ Rescaling Graph Axis

In the TIE graphs, the start value and time/div setting of both the x-axis and y-axis can be manually changed. This enables the user to move graphs and to zoom in/out.

Changing start value of the x-axis or y-axis:

– Move the cursor (with the arrow keys) to the x-axis start-value (normally 0 s) or y-axis start value.

– Press [SELECT] to enter the numerical entry mode. Press ▲▼ to increment the value in steps equal to the current time/div setting or press [SELECT] a second time to enter the keyboard entry mode, if you want exact control of the start value of the x-axis. Press [EXIT] to leave the numerical entry mode.

Changing time/div. setting of the x- or y-axis:

– Move the cursor to the time/div setting

– Press [SELECT] to enter the numerical entry mode . Press ▲▼ to increment the value in 1-2-5 steps or press [SELECT] to enter the keyboard entry mode, if you want exact control of the time/div setting. Press [EXIT] to leave the numerical entry mode.

Auto Scaling of x-axis or y-axis:

When a fixed measurement time (30 min, 2h, 4h, 24h) is selected, the x-scale is also fixed. When continuous measuring time is selected, the x-axis is auto-scaled. These are the default settings.

To swap between Auto or Manually set scales:

– Move the cursor to the MAN/AUTO setting

– Press [SELECT]. Press ▲▼ to toggle between MAN or AUTO. Press [EXIT] to leave with the new selection enabled.

■ Frequency Deviation

Above the graph window there is a numeric field that is updated continuously each time the Wandermeter takes a new TIE sample. The field is designated "Freq. Dev.", and the numeric value indicates the momentary relative frequency deviation from the reference frequency. The value is calculated by using the expression tan(α), where α is the angle between the x-axis and a line drawn from the origin of coordinates to the current (rightmost) measurement sample. See Figure 4-1.

Note that the real angle is much smaller due to the different time scales. A number of observations can be made by examining this value, for instance:

– A fixed frequency offset when the measurement starts results in a fixed relative frequency error and a corresponding graph consisting of a straight line with the differential coefficient (slope) equal to the relative frequency deviation.

– The frequency deviation at an arbitrary point on the curve can be interpreted as the equivalent relative frequency deviation caused by an oscillator having a corresponding fixed offset relative to the reference frequency.

– The frequency deviation is positive above and negative below the x-axis. Consequently it is always zero at the point where the curve intersects the x-axis.

– Even though the reference frequency and the test signal are not phase-locked, the phase difference at time t = 0 is mathematically nulled, so all TIE graphs start at the origin of coordinates.

– A typical TIE graph (Figure 4-1) gives a gradually lower relative frequency deviation as time passes. Momentary excursions of the TIE curve will be less and less visible in the numeric field. At the end of a long measurement this field presents a mean value that is normally close to zero. This means that the measured clock or data is locked to the system's PRC (ETSI)-clock.

MTIE

A typical MTIE graph is shown below.

MTIE is calculated from the measured TIE vs Time data. MTIE is the difference between the largest and the smallest TIE value inside an observation window τ (tau), that is "swept" over the entire data array (TIE vs Time). The width of the observation window is changed to give a

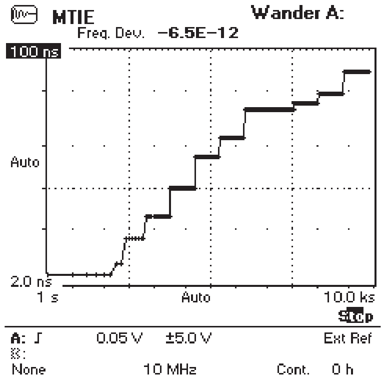


Figure 4-2 *MTIE graph.*

new τ and the sweep is repeated, etc. The Y-axis shows the MTIE-values and the X-axis shows the various observation windows τ in seconds.

The fast calculation of MTIE in the instrument's own control program, may result in a graph with limited accuracy. When using the WanderView™ program to calculate MTIE on PC-transferred data, the accuracy is much better.

The scaling of the X-axis and the Y-axis can be changed in the same way as in the TIE-graph to enable you to move and zoom in the graph.

When masks are used, MTIE is OK if the plot is below the mask all the time.

TDEV

A typical TDEV graph is shown below.

TDEV is calculated from the measured TIE vs Time data and is the RMS variation of TIE inside an observation window τ that is swept over the entire data array. The width of the observation window is changed to give a new τ, and the sweep is repeated, etc. The Y-axis shows the TDEV values and the X-axis shows the various observation windows τ in seconds.

Hunches on the TDEV curve suggest periodic variations of TIE.

When masks are used, TDEV is OK if the plot is below the mask all the time.

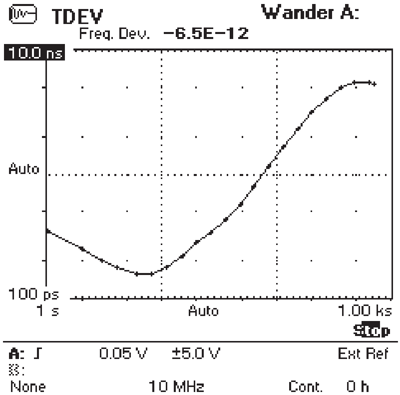


Figure 4-3 *TDEV graph.*

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Chapter 5

WanderView

Introduction

WanderView™ SW

WanderView™ is a Windows 95/98/NT- program that communicates with the Wandermeter via one of the standard RS-232 ports of a PC. The WM-11 has also an Ethernet interface that can be used for the same purpose after proper configuration. See page 5-4.

WanderView™ can perform the following tasks:

– Control the measurement process from a remote location.

– Make the Wandermeter an efficient sampling front-end for the PC that collects raw measurement data for postprocessing. The effective sampling rate increases by a factor of 30, and the memory depth is only limited by the PC itself.

– Transfer data from the non-volatile memory in the Wandermeter to the PC for documentation purposes.

■ Key Features

Send control commands to the Wandermeter:

– Send instrument measurement parameters.

– Start and stop a measurement.

– Perform internal self-tests of different complexity.

– Switch between being a stand-alone instrument and a sampling front-end.

– Read and store measurement results.

– Transfer up to four user-defined qualification masks to the instrument.

Graphical display (x-t graphs):

– TIE

– MTIE

– TDEV

– ADEV (Allan Deviation)

– MADEV (Modified Allan Deviation)

Text display:

- Underlying data.

Print-out:

- Any graph data.

Installation

– Connect the Wandermeter to one of the COM ports of a PC with a null-modem cable having 9-pole female D-sub connectors at both ends. Such a cable is part of the accessories delivered with the instrument.

– Run the installation program SETUP.EXE from Installation Disk #1. Follow the instructions on screen.

– Select the directory where you chose to install WanderView™ and start the application by running the program WANDERVIEW.EXE.

– Right-click on the program file if you want to create a shortcut to the application on your desktop.

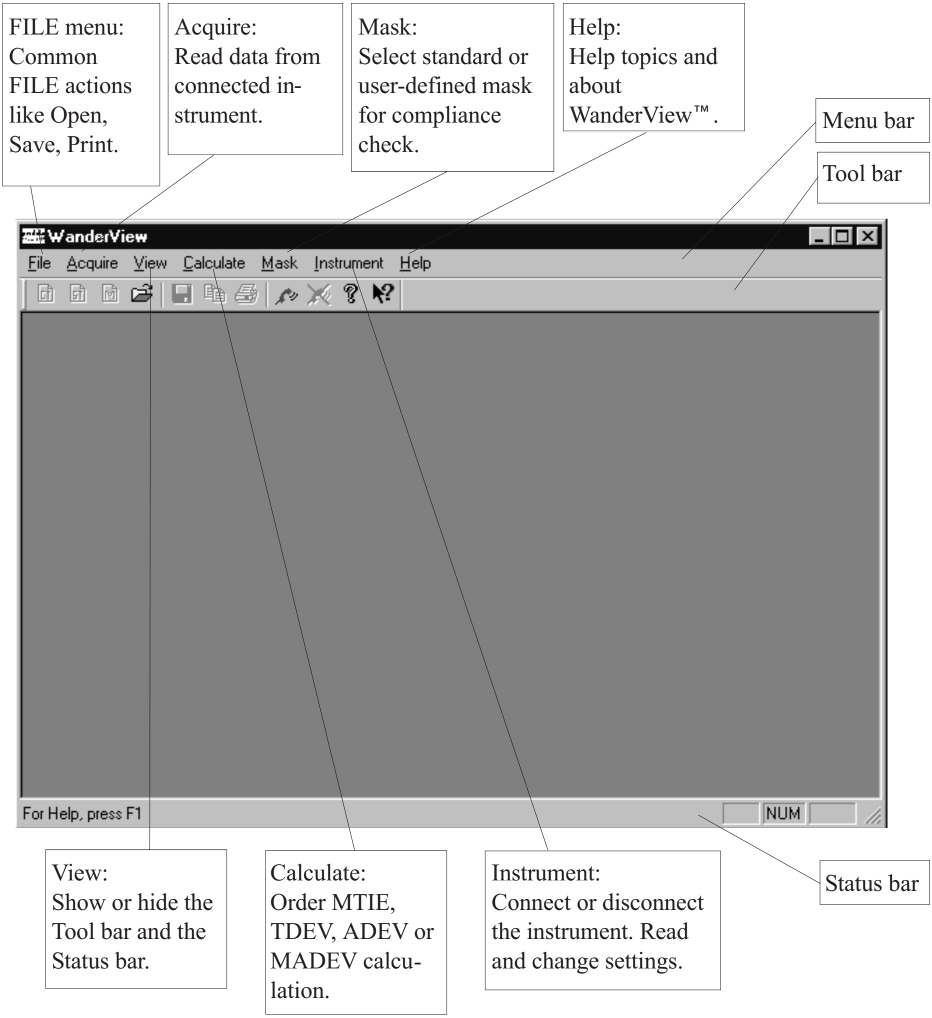
– Go to the *Instrument Menu* and *Change COM Port* to select the right serial communication port for your purpose.

– Go to *Change COM Speed* and press the button *Select Speed Automatically.*

– Select another speed if you want to change the automatically set value.

Now you should be able to communicate with the Wandermeter from the WanderView™ application program.

The WanderView™ Screen



Ethernet Configuration
(WM-11)

You have to configure the network parameters before first use. This is performed under *Instrument Change COM Port* on the menu bar. See picture on page 5-7.

Note: The network parameters are entered using the auxiliary RS-232 interface port marked CONFIG IP. The Ethernet cable must not be connected during configuration.

Check the box *Use Ethernet*, press the button *Configure Instrument* and follow the instructions on screen. After selecting the serial port to use, WanderView will connect to the instrument and retrieve the current network parameter settings. If you get the error message *Wrong response from instrument*, verify the following and try again:

– Correct *Communication Port* selected?
– Serial cable and connectors securely hooked up?

On the next screen you will enter the network parameters, i.e. IP Address, Network Mask and Gateway Address. These values are dependent on the configuration of the network where the instrument will be connected. Please contact your network administrator if in doubt. Entering incorrect values may cause instrument malfunction or conflicts with other equipment connected to the same network.

When the configuration is completed, disconnect the serial cable and connect the Ethernet cable between instrument and outlet/hub/controller. Set the rear panel switch [15] to *Ethernet*.

Ascertain that the protocol used is 10Base-T (10 Mbit/s, not 100 Mbit/s).

Make sure you use the right type of cable according to the instructions on page 3-4.

Establish the connection by pressing the button with the phone receiver icon on the tool bar.

FILE Menu

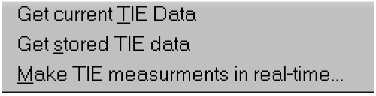
The figure shows the menu contents after a measurement.

Open:	open an existing data set
Close:	close the active graph
Save:	save the data of the active graph
Save as:	save the data of the active graph with a new name
Print graph:	print the active document
Print preview:	display the active graph in preview mode
Print setup:	change printer and printing options
Properties:	enter user data and display file info
Recent files:	shortcut to files recently stored
Exit:	quit the application

Edit Menu

Copy:	Copy the selection and put it on the clipboard

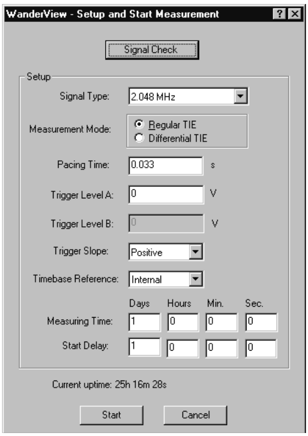
Acquire Menu



Reads data from connected instrument. You can choose between:

Get current TIE Data:	get TIE data from pending measurement
Get stored TIE Data:	get TIE data from saved measurement
Make TIE measurements in real time:	use instrument as sampling front-end

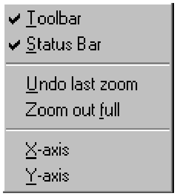
The third alternative switches off the local Wandermeter display in order to speed up measurements substantially. Parameters are entered using the dialog box below.



[1] See *Introduction to ADEV and MADEV* at the end of this chapter

View Menu

Toolbar:	show or hide the toolbar
Status bar:	show or hide the status bar
Undo last zoom:	select the preceding zoom setting
Zoom out full:	zoom out to full graph display
X, Y-axis:	edit the graph axes

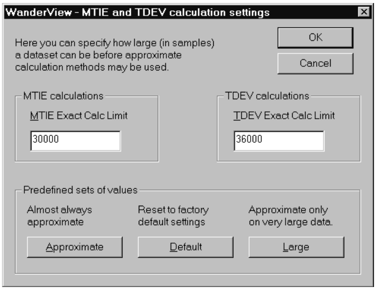


Zooming-in is done in the following way:

– Position the cursor at the upper left corner of an imaginary rectangle marking the interesting area.
– Draw the rectangle by pressing the left mouse button and moving the cursor diagonally to the opposite corner. Release the button.

Calculate Menu

MTIE:	order calculation of MTIE from TIE data in active window
TDEV:	order calculation of TDEV from TIE data in active window
ADEV:[1]	order calculation of ADEV from TIE data in active window
MADEV:[1]	order calculation of MADEV from TIE data in active window
Calculation options:	set limits for exact calculations according to dialog window overleaf

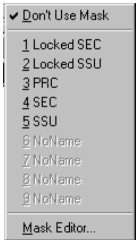


Mask Menu

WM-10: Select *Don't Use Mask* or select one of five standard masks or one of four user-defined masks.

WM-11: Select *Don't Use Mask* or, depending on signal type, select from a mix of standard and user-defined masks. The total number of masks can be up to nine for each signal type.

■ Entering User-Defined Masks

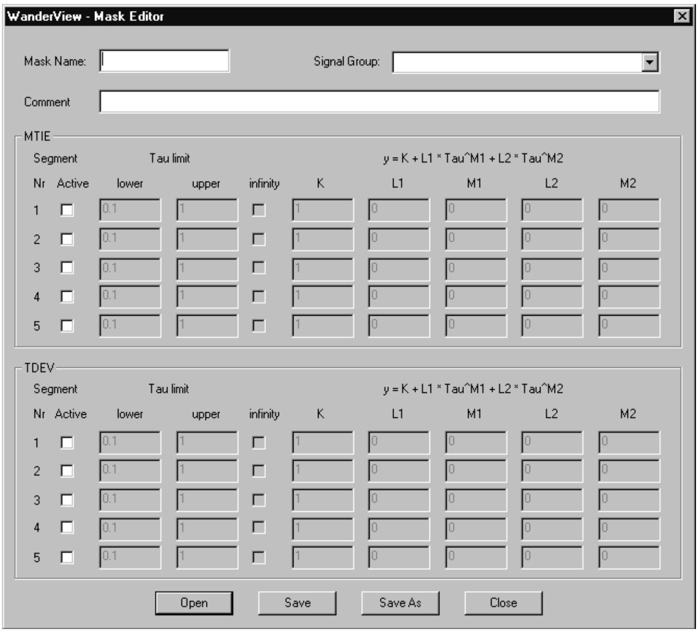


These masks are marked *NoName* until renamed and edited using the dialog box shown at the bottom of this page. Select *Mask Editor* from the menu to enter the dialog box.

Each mask can be divided into five segments that can be described using the formula:

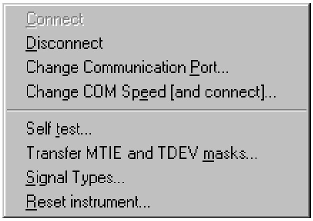
$$y(\tau) = K + L_1 \cdot \tau^{M1} + L_2 \cdot \tau^{M2}$$

Constants and exponents are entered in the respective data fields, and the segments are acti-



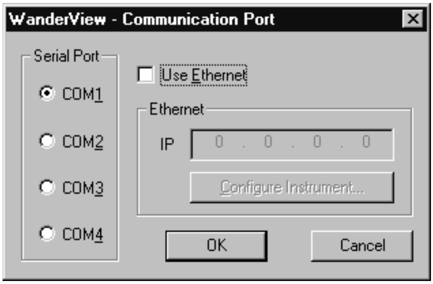
vated by checking the corresponding segment numbers.

There are separate editing areas for the different methods - MTIE, TDEV - of presenting the result of a measurement after internal reprocessing of the raw TIE data.



Instrument Menu

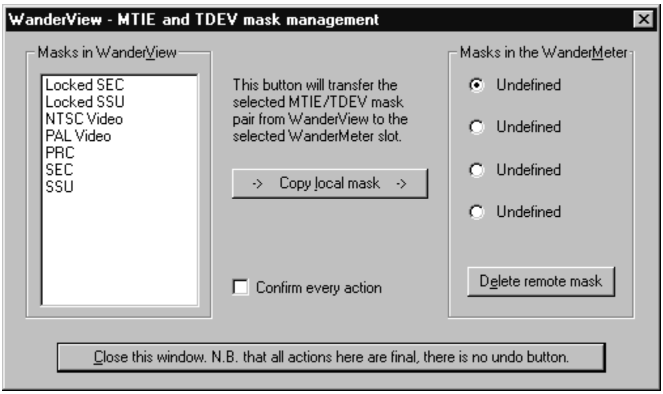
Connect:	connect controller to instrument
Disconnect:	disconnect controller from instrument
Change COM port:	change port and/or IP address used to communicate with the instrument
Change COM speed (and connect):	select RS-232 COM port speed
Self-test:	run instrument self test
Transfer MTIE and TDEV masks:	manage mask transfer between controller and instrument
Signal Types:	enable WM-11 to analyze additional signal types by downloading
Reset instrument:	restart the instrument



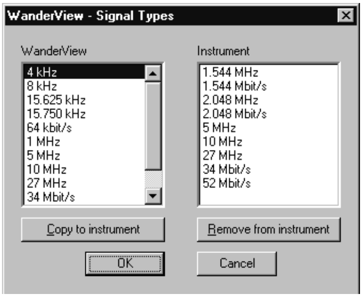
■ Transfer MTIE & TDEV Masks

The *Mask Management Window* can be examined at the bottom of this page.

You can transfer masks from WanderView to the instrument for local use by copying them, and you can erase masks that have been transferred earlier to the instrument. Masks coded in firmware - local standard masks - cannot be erased or edited without reloading a completely new firmware version.



■ Signal Types (WM-11)



The right list shows the current signal types that are recognizable by the instrument. The first four of them are fixed in firmware, but up to six more can be transferred from WanderView™ by copying one at a time from the left list.

If you want to add a signal type and the right list is full (10 items), you first have to remove one or more items. You cannot remove one of the fixed types.

The list of transferable signal types can be extended by replacing the file *wsignals.dat* by an updated version, if it is available. This file is located in the directory where you chose to install the WanderView™ SW.

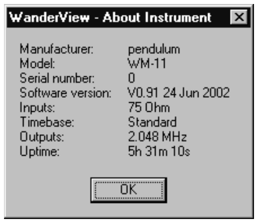
Window Menu

New window:	open another window for the active document
Cascade:	arrange open windows so they overlap
Tile:	arrange open windows as non-overlapping tiles
Arrange icons:	arrange icons at the bottom of the window
Files:	select active window among the open files

Help Menu

Help topics:	list help topics
About WanderView:	display program information, version number and copyright
About instrument:	display instrument information

■ About Instrument



You must first select *Connect* in the *Instrument* menu before obtaining this information, as it is fetched from the instrument.

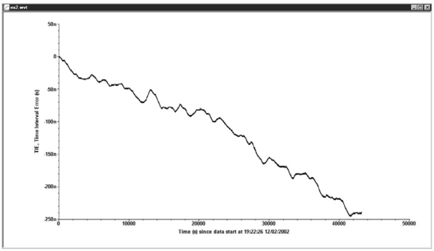
Uptime

The time elapsed since the instrument was last switched on.

Graphs in WanderView™

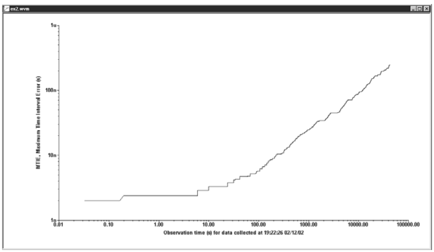
File Types

■ WVT: WanderView TIE Data



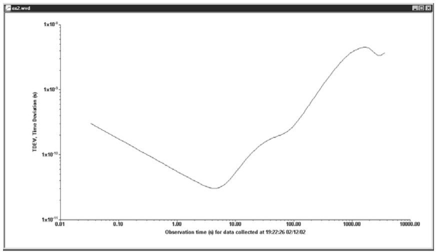
This is a file type containing the direct graphic representation of the measurement results, i.e. the phase deviation or Time Interval Error (TIE) versus time.

■ WVM: WanderView MTIE Data



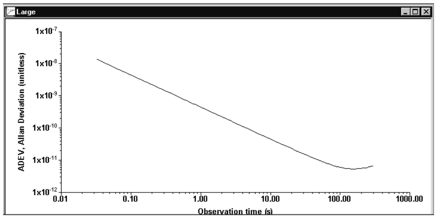
This graph shows the Maximum TIE (MTIE) versus gradually increasing observation windows (τ). It is calculated from the raw measurement data stored in a WVT file by ordering MTIE from the *Calculate* menu.

■ WVD: WanderView TDEV Data



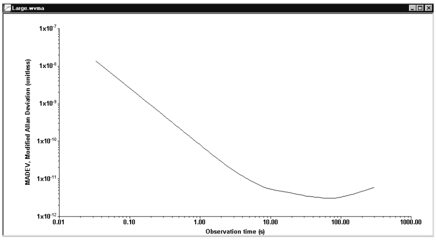
This graph shows the Time Deviation (TDEV) versus gradually increasing observation windows (τ). It is calculated from the raw measurement data stored in a WVT file by ordering TDEV from the *Calculate* menu. TDEV expresses the RMS variations of TIE. Pronounced periodicity will appear as hunches on the curve.

■ WVA: WanderView ADEV Data



This graph shows the Allan Deviation (ADEV) versus gradually increasing observation time. It is calculated from the raw measurement data stored in a WVT file by ordering ADEV from the *Calculate* menu. The ADEV data representation shows the short-term stability, eliminating the influence of aging and temperature drift in the device under test.

WVMA: WanderView MADEV Data



This graph shows the Modified Allan Deviation (MADEV) versus gradually increasing observation time. It is calculated from the raw measurement data stored in a WVT file by ordering MADEV from the *Calculate* menu. The MADEV data representation shows the short-term stability after filtering out white phase noise.

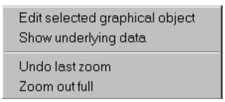
Viewing Graphs

Zooming

To zoom in a graph, hold down the left button on your mouse and drag the cursor. When you release the button, the selected area will be zoomed. You can undo the last zoom if you right-click and choose “Undo last zoom” or you can zoom to the full graph display if you choose “Zoom out full ”.

Editing Graphs

If you open a file with a graph you can edit the graph by using the right button on your mouse to right-click on the curve or the axes. Then you can change plot parameters and show underlying data.



If you click on the x- or y-axis, you can, for example, change the scale. This is the case regardless of file type.

If you want to make a copy of the graph, choose *Edit* and *Copy.* The selection will be put on the clipboard.

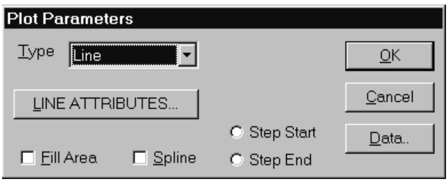
If you want to copy the underlying graph data to e.g. a spreadsheet program like Excel, then point at the curve, right-click your mouse, select “show underlying data”, watch the table of numeric data pop up, and finally select *copy.* After that, switch to your spreadsheet program and paste the data into your spreadsheet.

Copy Format

#	X	Y
1	0	2.36468622e-11
2	1.67772162	4.72937245e-11
3	1.67772162	4.8748916e-10
4	3.35544324	2.36468622e-11
5	5.03316498	-4.16548573e-10
6	5.03316498	7.27595761e-11
7	6.71088648	7.27595761e-11
8	6.71088648	7.27595761e-11
9	8.38860798	-4.16548573e-10
10	8.38860798	7.27595761e-11
11	10.06633	7.27595761e-11
12	11.744051	7.27595761e-11
13	11.744051	-3.91082722e-10
14	13.421773	7.27595761e-11
15	13.421773	-4.16548573e-10
16	15.099494	-3.6743586e-10

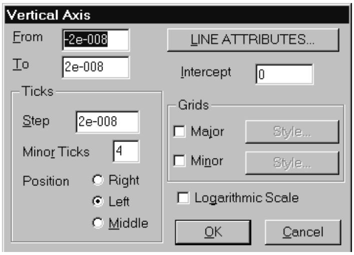
Figure 5-1 *Show underlying data.*

Editing the Plot



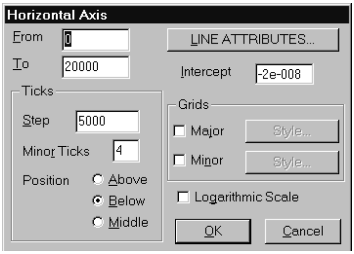
You can e.g. change the style and color of the plot.

■ Editing the Y-axis



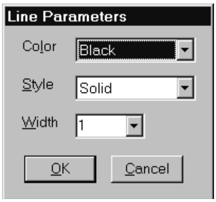
You can e.g. change the scale and add horizontal marker lines.

■ Editing the X-axis



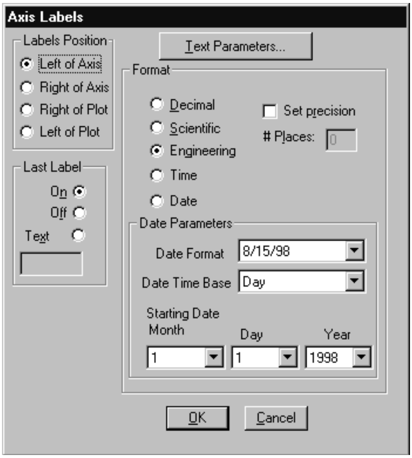
You can e.g. change the scale and add vertical marker lines.

■ Editing Lines



All graph editing windows have a button named *Line Attributes*. If you press it, the menu above opens up. You can then set color, style and width.

■ Editing Labels



Text information along the axes can be edited by right-clicking the area below the X-axis or to the left of the Y-axis. The menu above will be displayed.

Application Hints

Long-Distance Control (WM-11)

By using the Ethernet interface in conjunction with the Internet, you are not constrained to the short-distance characteristics of the RS-232 port.

Now it is quite feasible to monitor an instrument connected to a network node in Australia from a place in North America, for instance.

Monitoring Multiple Wandermeters (WM-11)

If you need to monitor more than one Wandermeter simultaneously, you should start one new WanderView™ session for each active instrument. Just make sure the instruments have unique IP addresses that are entered under the menu *Instrument* → *Change Communication Port*.

You will see the serial number of the instrument under each graph as a reminder of which WanderView™ session belongs to which Wandermeter.

If you need to operate the system through a firewall you might need to configure the firewall to allow TCP packets on the ports 5891 and 5892.

Introduction to ADEV and MADEV

In order to obtain adequate measurement accuracy, a signal source often has to be monitored for a considerable time. A disadvantage when measuring short-term properties during long intervals is that long-term properties like temperature drift and aging interfere, if you cannot find a means of filtering them out.

Instead of looking at the spread around the mean value of all samples in a population, as we do when calculating *Standard Deviation*, we can look at the spread between consecutive samples, thus virtually eliminating the influence of slow variations. *Allan Deviation* (ADEV) is such a statistical measure that can be used for visualizing short-term stability.

The ADEV graph shows this deviation as a function of observation time. The pacing time of the individual measurements is always 33 ms.

Modified Allan Deviation (MADEV) further diminishes the influence of e.g. white phase noise by averaging over several adjacent measurements.

These presentation modes can only be reached from WanderView™ under the *Calculate* menu.

Chapter 6

Performance Check

General Information

WARNING: Before turning on the instrument, ensure that it has been installed in accordance with the Installation Instructions outlined in Chapter 3 of the User's handbook.

This performance procedure is intended for incoming inspection to determine the acceptability of newly purchased instruments.

Note: The procedure does not check every facet of the instrument. It is concerned primarily with those parts of the instrument which are essential for determining the function of the instrument.

It is not necessary to remove the cover of the instrument to perform this procedure.

Recommended Test Equipment

– DSO with 50 Ω input

– CNT-81R timer/counter

– Synthesized LF generator with external 10 MHz reference input.

Preparations

Power-On Test

Connect the power cord. Press the green ON button. The display backlight shall light up. At power-on the Wandermeter performs an automatic test of the following:

– RAM

– ROM

– Measuring circuits

If any test fails, an error message is shown.

The Internal Rubidium reference needs approx. five minutes to lock. If the START/STOP key is pressed during the first minutes, an info box tells the user that the reference has not yet locked, and no measurement is possible.

Check that this infobox is no longer present approx. 5-7 minutes after power-on.

Power up your instrument at least 30 minutes before continuing. This will allow the instrument to reach normal operating temperature.

Outputs

10 MHz OUT

– Connect a CNT-81R (50 Ω input termination) to the **10 MHz OUT** BNC-connector, on the rear panel. Verify that the frequency is 10.000000 MHz ± 0.01 Hz.

– Connect the DSO (50 Ω input termination) to the output and check the waveform and amplitude (square wave, low level <0.4 V, high level >1.8 V).

Clock Output 1.544/2.048 MHz (WM-11)

– Connect a CNT-81R (50 Ω input termination) to one of the BNC connectors in the

OPTIONAL CLOCK OUTPUTS area, on the rear panel. Verify that the frequency is 1.54000000 MHz ± 0.01 Hz or 2.04800000 ± 0.01 Hz depending on the selection made under **USER OPTIONS → Output**.

– Check that you can toggle this output **ON** and **OFF** via the menu.

– Connect the DSO (75 Ω input termination) to the output and check the waveform and amplitude (square wave, low level -1.2 V± 10%, high level +1.2 V ±10%).

– Repeat the tests above for the other output connector.

Option 35 (WM-10)

– If a 2.048 MHz output option is installed, then connect a CNT-81R counter (50 Ω input termination) and verify that the frequency is 2.04800000 MHz ± 0.01Hz.

– Connect the DSO (75 Ω input termination) to the output and check the waveform and amplitude (square wave, low level -1.2 V± 10%, high level +1.2 V ±10%).

Test of PC Connection

RS-232

This test is only required if you intend to operate the Wandermeter from a PC over the RS-232 port.

– Connect the RS-232 cable.

– Start and run WanderView™.

– Select the correct COM port from the Instrument menu.

– Select “connect to instrument” and make sure that you get no error messages.

– Run the self-test under the *Instrument* menu and make sure that you get no error messages.

Ethernet (WM-11)

This test is only required if you intend to operate the Wandermeter from a PC over the Ethernet interface.

– Follow the instructions under *Ethernet Configuration* on page 5-4.

– Run the self-test under the *Instrument* menu and make sure that you get no error messages.

Front Panel Controls

Preparations

– Connect **10 MHz OUT** on the Wandermeter to the *Ext. Ref. Input* on the LF generator, and select *External Reference* on the generator.

– Set the generator to output 2.048 MHz, 1 Vpp square wave, and connect it to **CLOCK/DATA IN A** on the Wandermeter.

Keyboard and Indicator Test

■ Signal Check

– Press **SIGNAL CHECK**. After a few seconds an info box appears with the result. The frequency should be 2.048 MHz and the signal characteristics should correspond to the signal from the LF generator. *Signal Type* should be *2.048 MHz*.

■ Setup #1

– Press **SETUP**. Check that *Signal Type* is *2.048 MHz* and *Trigger Level* is automatically set to (V_{p+} + V_{p-}) / 2, where V_{p+} and

V_{p-} are the positive resp. negative peak DC levels of the input signal according to the results from **SIGNAL CHECK**.

■ User Options

– Press **USER OPTIONS** and move the cursor to *Display Contrast* with the **UP** or **DOWN** arrow navigation keys.

– Press the **RIGHT** arrow navigation key to enter the adjustment field.

– Press **UP** or **DOWN** to find the optimum contrast ratio to your taste.

– Press **EXIT** and move the cursor to *Timebase Reference*.

– Press **RIGHT**.

– Press **DOWN** to select *External* reference.

– Select *Internal Reference* on the LF generator and connect the **10 MHz OUT** output to the **EXT. REF. IN 10 MHz** input.

– Press **SIGNAL CHECK** and note the result: Type 2.048 MHz.

– Remove the cable to **EXT. REF. IN 10 MHz** on the Wandermeter.

– Press **SIGNAL CHECK** again and note the result: Type Unknown.

– Press **EXIT** and select *Internal* reference.

– Press **SIGNAL CHECK** again and note the result: Type 2.048 MHz.

– Restore the connection between **10 MHz OUT** on the Wandermeter and the *Ext. Ref. Input* on the LF generator and switch to *External Reference*.

– Select *Internal* on the Wandermeter and press **EXIT**.

– Move the cursor to *Test & Adjust* and press **SELECT**.

– Go to *Select Self-Test* and select *All Self-Tests*.

– Go to *Run Self-Test* and press **SELECT**. Make sure the instrument passes all tests.

– Press any key to continue.

– Press **EXIT**.

– Go to *About* and press **SELECT**. Check when timebase was last adjusted. See page 7-2 for further information on preventive maintenance.

– Press **EXIT** twice to leave the USER OPTIONS menu.

■ Setup #2

– Press **SETUP**.

– Select *Test Mode* by pressing **UP** or **DOWN**. Press **RIGHT** and select *None* from the list. Press the **LEFT** navigation key or **EXIT**. Go on in the same way and select *Measuring Time*: *Continuous* and *Warm-up Time*: *0 hours*. Press **EXIT** to leave the SETUP menu.

■ START/STOP

– Press **START/STOP** and **SELECT** to start measurement. Let the measurement proceed for at least one minute. Check the automatic scaling when the curve intersects the boundaries of the X and Y axes of the graph window.

– Press **START/STOP** to stop measurement. The STOP indicator to the right below the X-axis shall blink.

■ MTIE

– Press **MTIE** to start calculation of the MTIE graph. Watch the hourglass symbol. It will take a while depending on how many stored measurement samples there are to process.

■ TDEV

– Press **TDEV** to start calculation of the TDEV graph. Watch the hourglass symbol.

It will take a while depending on how many stored measurement samples there are to process.

– Press **TIE** to restore the original TIE curve.

■ SAVE/RECALL

– Press **SAVE/RECALL**. Move the cursor to *Write Protect Memory* and select *OFF.*

– Move the cursor to *Clear Setup/Screen/Data* and press **SELECT**.

– Move the cursor to *Setup 1* and press **SELECT** if the info text is not *FREE*. Repeat the steps for *Screen 1, Screen 2*, *Screen 3* and *TIE Data*.

– Press **EXIT**.

– Move the cursor to *Save Setup/Screen/Data* and press **SELECT**.

– Move the cursor to *Setup 1* and press **SELECT**. Info box *Setup is saved* should appear for a second.

– Press **SAVE/RECALL** and **SELECT** again.

– Move the cursor to *Screen 1* and press **SELECT**. Info box *Screen is saved* should appear for a second.

– Press **MTIE**, **SAVE/RECALL** and **SELECT**. Note the text at *Screen 1*. It should read *TIE*.

– Move the cursor to *Screen 2* and press **SELECT**. Info box *Screen is saved* should appear for a second.

– Press **TDEV**, **SAVE/RECALL** and **SELECT**. Note the text at *Screen 2*. It should read *MTIE*.

– Move the cursor to *Screen 3* and press **SELECT**. Info box *Screen is saved* should appear for a second.

– Press **TIE**, **SAVE/RECALL** and **SELECT**. Note the text at *Screen 3*. It should read *TDEV.*

– Move the cursor to *TIE Data* and press **SELECT**. Info box *Measurement data is saved* should appear for a second.

– Press **SAVE/RECALL**. Move the cursor to *Recall Setup/Screen* and press **SELECT**.

– Move the cursor to Screen 1 and press **SELECT**. The original TIE graph should reappear.

– Press **EXIT**.

– Move the cursor to Screen 2 and press **SELECT**. The original MTIE graph should reappear.

– Press **EXIT**.

– Move the cursor to Screen 3 and press **SELECT**. The original TDEV graph should reappear.

– Press **EXIT**.

■ Differential Wander

– Remove the cable to **CLOCK/DATA IN A**.

– Put a BNC ‘T’ connector on **CLOCK/DATA IN A**.

– Restore the cable connection between the LF generator and **CLOCK/DATA IN A.**

– Interconnect the open end of the BNC ‘T’ and **CLOCK/DATA IN B** with a short cable.

– Select **SETUP→MEAS MODE→Differential Wander A to B**.

– Press **SIGNAL CHECK** and note the two lists of parameters, one for each input, containing more or less identical data.

– Repeat the measurement procedure under the heading START/STOP above.

– Note that each graph window has the text *Wander A to B* at the top.

■ Test Measurement

Finish the performance check by setting up and performing a 2-hour measurement on the phase-locked LF generator. Then you can observe the natural wander of a clock with close relation to the internal reference clock in the Wandermeter. Network clocks encountered in real life normally have wander figures that are orders of magnitude greater.

– Press **SETUP** and go to *Measuring Time*. Select *2 hours* and press **EXIT**.

– Press **START/STOP** and **SELECT**.

– Check that the default scaling for the X-axis is fixed and equal to 1000 s/div. The default setting for the Y-axis should be AUTO.

– Check that the measurement terminates automatically after two hours.

– Check that MTIE and TDEV calculations can be executed on the collected data set by pressing the corresponding front panel buttons. The time needed for each calculation is about one minute.

Chapter 7

Preventive Maintenance

Calibration and Adjustment

If the instrument has not been continuously connected to mains power during at least 24h, the automatic calibration process will not start until this time limit has been passed.

Note 1: You can override the default delay and start calibrating whenever you want if you are satisfied with less than maximum accuracy.

Note 2: You can interrupt the calibration process prematurely when you have obtained adequate but not maximum accuracy.

Connect an ultra-stable frequency standard, either a Cesium standard or a GPS-controlled Rubidium standard to **CLOCK/DATA IN A** on the front panel. Press USER OPTIONS and select *Test & Adjust*. Then select *Make Timebase Adjustment*. Follow the instructions on screen.

The instrument compares its internal timebase with the connected standard and adjusts its frequency as close as possible to the external signal. The setting resolution is $<2*10^{-12}$.

Once the calibration process is started, there is no need for user intervention. The complete calibration and adjustment takes between 2 and 10 hours. The calibration and adjustment can thus be performed overnight. After finished adjustment, the Wandermeter will prompt the user to input a cal. date, and that is all.

There is also a possibility to recall the previous calibration by selecting *Undo Timebase Adjustment* from the *Test & Adjust* menu. A reason could be e.g. that you discover that the frequency standard used is not accurate enough.

How often should you calibrate?

Although a Rubidium oscillator is extremely stable, it still exhibits small but measurable aging. See the specifications in Chapter 8.

Depending on what you are going to measure, the calibration intervals can span the range from 5 days to more than 10 years. The main requirements are set by the masks used and the measuring times.

The table below shows the calculated results for different combinations of network limits and measuring times.

Calibration Interval		
Meas. Time (s)	Sync Level	
	PRC (ETSI)	SSU/SEC (ETSI)
1000	>1 year	>10 years
10000	2 weeks	>1 year
100000	5 days	1 month

A calibration interval in the table is the worst-case time before the Rubidium timebase approaches the network limits according to ETSI.

Backup Battery

The 3 V lithium cell used for RAM backup should be exchanged every three years to avoid loss of data.

See page 2-3 regarding disposal of used cells.

Replacement

– Disconnect the instrument from the power line.

– Remove the two side plates that are fixed with four screws and a Velcro lock. Use a Torx 10 screwdriver.

– Lift the lid. You have to apply some force, as the lid is grounded to the frame with friction clips.

The battery cell is located on the small PCB behind the RS-232 connector to the right on the rear panel, if you are facing the front of the instrument.

Warning: When you have removed the battery, you must replace it within 30 seconds to avoid losing data saved locally. Therefore we recommend to transfer all saved information to a PC before battery replacement.

Warning: Do not touch the contact surfaces of the battery and its holder with bare hands. Do not use electrically conducting tools.

– Make sure the replacement is a Lithium 3.0 V cell, size ½ AA.

– Remove the old cell by gently lifting it right up.

– Observe the polarity on the screen print when inserting the new cell, as the battery clips are symmetrical.

– Put the lid back with care and make sure the clips and the frame snap together.

– Align the side plates over the screw holes and press the Velcro locks together.

– Put the screws back and tighten them.

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Chapter 8

Specifications

Technical Specification

Note 1: Specifications apply after 30 minutes warm-up time.

Note 2: Specifications apply to both WM-10 and WM-11 where not explicitly denoted.

Operation Modes

Local: The Wandermeter operates stand-alone and measures the wander of a connected clock or coded data signal. Alternatively the differential phase (Time Interval) between two connected clocks or data signals is measured. During the measurement, the TIE curve is continuously updated on the display. This mode has limitation in sampling rate and number of stored samples.

Remote: The Wandermeter is controlled from a PC running the WanderView™ PC-software and measures the wander of a connected clock or coded data signal. During the measurement, the Wandermeter acts as a sampling front-end and the display is not updated.

Measurement Modes

Absolute:	Absolute wander (TIE, MTIE and TDEV) between clock or data signal and internal Rubidium reference
Differential:	Relative wander (TIE, MTIE and TDEV) between two clocks or data signals

Presentation Modes

TIE:	Time Interval Error is displayed and continuously updated in Local Mode
MTIE:	MTIE is calculated from the measured and stored TIE values and displayed after completed measurement in Local Mode
TDEV:	TDEV is calculated from the measured and stored TIE values and displayed after completed measurement in Local Mode
ADEV:	ADEV is calculated from the measured and stored TIE values and displayed after completed measurement in Remote Mode
MADEV:	MADEV is calculated from the measured and stored TIE values and displayed after completed measurement in Remote Mode

Test Modes (MTIE and TDEV masks)

The internal Rubidium clock is not used as reference during “Differential” measurements. Mask applies to MTIE and TDEV graphs.

None:	No masks
PRC (ETSI):	Masks for G811-clock (ETS 300 462-3)
SSU (ETSI):	Masks for G812-clock (ETS 300 462-3)
SEC (ETSI):	Masks for G813-clock (ETS 300 462-3)
SSU-L (ETSI):	Masks for G812-clock (ETS 300 462-4)
SEC-L (ETSI):	Masks for G813-clock (ETS 300 462-5)

Input Signal Characteristics

Frequency

WM-10:	2.048 MHz, 2.048 Mbit/s
WM-11:	4, 8 kHz, 64 kbit/s, 1.544 MHz, 1.544 Mbit/s, 2.048 MHz, 2.048 Mbit/s, 5, 10, 27 MHz, 34, 45, 52 Mbit/s, 15.625 kHz (PAL), 15.750 kHz (NTSC)

Amplitude:	inside -5V…+5V
Signal type WM-10:	Symmetrical pulse (Clock signal) HDB3-coded data (Data signal)
WM-11:	Symmetrical pulse (Clock signal) Unsymmetrical repetitive pulse (Clock signal) HDB3-coded data (Data signal) AMI B8ZS, B3ZS (Data signal)

Time Interval Error (TIE)

Ref. clock:	Built-in Rubidium clock or an external 10 MHz clock signal connected to Ext. Ref. In 10 MHz
Meas. time:	30 min, 2h, 4h, 24h or continuously (local mode)
Local Mode update rate	
30 min, 2h, 4h:	approx. 1 Sa/s
24h:	approx. 0.2 Sa/s (1Sa/6s)
Continuously:	16000/time Sa/s; max. approx. 1 Sa/s. Data compression after approx. 4h
Remote Mode update rate at any meas. time:	up to 30 Sa/s
Differential mode:	The time interval between the leading edges of two connected clock or data signals (Clock/Data In A and Clock/Data In B) is measured. Approximately once/second.

Internal Data Storage

Size:	Approx. 16000 stored TIE values
Type:	Non-volatile storage

Measuring Time

Time:	Short (30 min, 2h, 4h), Long (24h) and Continuous
Start/Stop:	A new measurement is initiated by pressing START/STOP. Confirm by pressing SELECT. A continuous measurement in progress is stopped by pressing START/STOP. A timed measurement in progress is stopped by pressing START/STOP. Confirm by pressing SELECT. When a measurement has been stopped, the current TIE curve stays frozen on the display.
Start delay:	Selectable delay before measurement starts, to allow the instrument to warm up properly.
Delay time:	0, 30 min, 4h or 24h from power-up.

Signal Check

Measures and displays the following parameters for each of the signal inputs:

Signal type:	‘ID label’ or ‘Unknown’
Frequency:	For clock signals
Pulse width:	For data signals
Vmax:	Maximum voltage level
Vmin:	Minimum voltage level
Vp-p:	Peak-to-peak voltage level

Self-Test

Power-up:	Test of critical dig. functions
On demand (user opt.):	Test of most digital functions

INFO

A built-in context-sensitive help function gives guidance for all manual settings.

SAVE/RECALL

No. of instrum. set-ups: 5

No. of screen images: 3 (TIE, MTIE or TDEV)

Stored TIE value array: 16k values (1 set)

Write protect: Saved set-up, screen image or TIE value array can be protected against accidental over-writing

Graph Display

Display modes: TIE, MTIE or TDEV

Vertical scale: Displayed TIE, MTIE or TDEV value in ns or μs. AUTO scaled by default, MAN on demand.

Horiz. scale: Real-time axis (TIE) or "τ"-axis (MTIE/TDEV). AUTO scaled by default, MAN on demand (continuous measurement and differential test mode) or fixed scale (2h/24h full scale) by default, AUTO/MAN on demand.

No of div: 8x10 (vert. x horiz.)

Masks WM-10: MTIE and TDEV masks according to selected test mode: PRC (ETSI), SSU (ETSI), SEC (ETSI)

Masks WM-11: MTIE and TDEV masks according to selected test mode

Clock/Data Inputs A and B

Connector: BNC

Coupling: DC

Voltage range: ± 5.00V

Sensitivity: 60 mVpp

Impedance: 75 Ω , VSWR <2:1

Max input voltage w/o damage: 12 Vrms up to 2 MHz, decreasing to 6 Vrms at 10 MHz.

■ Trigger Level:

Range: ± 5.00V

Resolution: 10 mV

Uncertainty: ± 1% + resolution

Setting: AUTO, Manual.

■ AUTO ONCE Trigger

Level: Automatically set at 50% (Clock) or 25% (Data) of input signal's amplitude

Sensitivity: 120 mVpp

Ext. Reference Input

Connector: BNC

Input freq.: 10 MHz

Voltage range: 0.5 Vrms to 12 Vrms

Impedance: approx. 500 Ω

Coupling: AC

Reference Frequency Output

Connector: BNC

Ref. freq.: 10 MHz square-wave, derived from the internal rubidium oscillator

Freq. stability: See timebase oscillator spec.

Output levels: Fixed TTL: low <0.4V high >1.8V into 50 Ω

2.048 MHz Clock Output (WM-10 option 35)

Connector: BNC

Ref. frequency: 2.048 MHz square-wave

Freq. stability: See timebase oscillator spec.

Jitter: <0.01 UI

Wander: MTIE < 15 ns + τ x (freq. offset)$^{-1}$

Output level: Acc. to G703:10 ±1.2 V± 10% in 75 Ω

1.544/2.048 MHz Clock Output (WM-11)

Connector: BNC
Ref. frequency: 1.544/2.048 MHz sq. wave
Freq. stability: See timebase oscillator spec.
Jitter: <0.01 UI
Wander: MTIE < 15 ns + τ x (freq. offset)$^{-1}$
Output level: Acc. to G703:10 ±1.2 V± 10% in 75 Ω

RS-232 Data I/O

Connector: 9-pin male D-Sub connector
Baud rate: 4800, 9600, 19200 bit/s,
Data format: 8 data bits, 1 stop bit, no parity

Ethernet (WM-11)

Communication port
Connector: RJ45
Protocol: 10Base-T
Configuration port
Connector: DSub9 male, RS-232

WanderView™ SW

Operating system:
Windows 95/98/NT
Data transfer from Wandermeter:
TIE-values (real-time or stored values)
Instrument ID
Serial number
Data transfer rate: >30 values/s
Calculating functions: MTIE, TDEV, ADEV, MADEV
Instrument control functions to Wandermeter:
Local or Remote mode
Instrument setup
Custom mask editor:
Unlimited number of user defined MTIE+TDEV masks
File save/retrieve:
Any graph can be saved, printed out and retrieved. You can also save data in a format suitable for import to a spreadsheet for postprocessing.

Calibration

■ Principle

Closed-Case Calibration with automatic adjustment of the Rubidium timebase.

■ Calibr. Reference

Cs-oscillator or GPS-controlled Rb-oscillator

■ Calibr. Reference Frequency

0.1, 1, 1.544, 2.048, 5 or 10 MHz

Internal Time Base Stability

	Type	Rubidium
Temperature	20° to 26° 0° to 50°	$<2x10^{-11}$ $<3x10^{-10}$
Aging Rate per:	24h	$<2x10^{-12}$ (typ.)
	month	$<5x10^{-11}$
Short-term stability per:	1s 10s	$<3x10^{-11}$ $<1x10^{-11}$
Warm-up stability:	10 min	$<4x10^{-10}$

Factory adjustment uncertainty (+23°C)	10 MHz ± 0.0001 Hz

Display

Type:	Super Twisted Liquid Crystal
Size:	84 x 84 mm, 4.7" diagonal
Resolution:	240x240 pixels
Backlight:	Cold Cathode Fluorescent (CCFL) tube. Brightness approx. 50 cd/m^2
Contrast ratio:	User-adjustable, max. 1:15 (typical at 20°C)

Environmental Data

Temperature:

Operating:	0°C to 50°C
Storage:	-20°C to 70°C

Humidity:

Operating:	20°C to 30°C, 90% RH non-condensing 30°C to 50°C, 70% RH non-condensing
Storage:	95% RH

Altitude:

Operating:	3000 m (10 000 ft)
Storage:	12000 m (40 000 ft)

Vibration: 3G @ 55 Hz per MIL-T-28800D, Class 3, Style D

Shock: Half-sine 40G per MIL-T-28800D, Class 3, Style D. Bench handling.

Safety:

EN 61010-1:1997, CAT II, pollution degree 2, CE

EMC:

EN 55022B EN 61000-6-2 CE

Power Supply

WM-10 & WM-11

Line voltage:	100 to 240 Vrms ± 10% 47 Hz to 63 Hz, <60 W

WM-11

DC voltage:	38-72 V, <60 W

Mechanical Data

H x W x D	177 x 342 x 305 mm

Weight:

WM-10	5 kg / 11 lb.
WM-11	6 kg / 13 lb.

Transport weight:

WM-10	7 kg / 15 lb.
WM-11	8 kg / 17 lb.

Note: Specifications are subject to change without prior notice.

Note: Specifications apply after 30 minutes warm-up time.

Ordering Information

WM-10 Wandermeter

Wandermeter for E1 (2.048 MHz) clock or data signals (HDB3).

WM-11 Wandermeter

Wandermeter for general clock or data signals.

■ Included Accessories

1 Users Manual
1 Line Power Cord
1 WanderView™ SW
1 Certificate of Calibration
1 RS-232 Null-Modem Cable (DB9 female)
2 120/75 Ω Baluns
1 Cable Connector for DC supply (WM-11)

■ Option (factory built-in)

Option 35:	Dual 2.048 MHz clock output for WM-10

■ Optional Accessories

Option 27W:	Heavy duty hard transport case

Chapter 9

Program Commands

Remote Control

Remote control and programming reference for the Pendulum Wandermeters WM-10 or WM-11.

First-Time Installation of the Wandermeter

– Connect the Wandermeter to the RS-232 port of the computer using a suitable serial null-modem cable, e.g. the one included in the shipment..

– Turn on the computer and the Wandermeter.

– Make sure the computer RS-232 port settings match the corresponding instrument settings.

The fixed instrument settings are as follows:
9600 baud, No parity, 8 data bits, 1 stop bit

You can modify the computer RS-232 settings to match the above settings with the following DOS command:

MODE COM1:9600,N,8,1

This example assumes that COM1 is the RS-232 port chosen for instrument control. Replace COM1 in the above command by COM2, COM3, or COM4 if one of the latter ports is used instead..

Introduction to Programming

■ Basic Programming Information

You can control the instrument from the computer with simple communication facilities, such as QuickBASIC and QBASIC (programming languages from Microsoft Corporation).

■ Example Language

Small examples are given at various places in the text. These examples are not in BASIC or C, nor are they written for any specific controller. They only contain the characters you should send to the instrument and the responses that you should read with the controller.

Example:
SEND → FETCH?
SEND → means that you should write your program so that it will output the succeeding string to the serial port.

READ← 1.234567890E-6
READ← means that you should write your program so that it will input the succeeding string from the serial port.

■ SCPI Programming Language

SCPI (Standard Commands for Programmable Instruments) is a standardized set of commands used to remotely control programmable test and measurement instruments.

Reason for SCPI

For each instrument function, SCPI defines a specific command set. The advantage of SCPI is that programming an instrument is only function dependent and no longer instrument dependent. Several different types of instruments, for example an oscilloscope, a counter and a multimeter, can carry out the same function, such as frequency measurement. If these instruments are SCPI compatible, you can use the same commands to measure the frequency on all three instruments, although there may be differences in accuracy, resolution, speed, etc.

The Wandermeter firmware is compliant with the SCPI. It defines the syntax and semantics that the controller must use to communicate with the instrument. This chapter is a short overview of SCPI and shows how SCPI is used in this particular instrument.

SCPI is based on IEEE-488.2 to which it owes much of its structure and syntax. SCPI can, however, be used with any of the standard interfaces, such as RS-232. This programming

reference assumes that the user has good knowledge of SCPI syntax. Such knowledge can be gained by studying commercially available books about SCPI programming. Useful information can also be found in the Pendulum CNT-80/81/85 Timer/Counter/Analyzers Programmer's Handbook:
Order No. 4031 600 80201

Short Summary of Syntax

A typical command string may look like this:
:SYST:MASK:MTIE|TDEV:READ?_
<mask #>,<signal group #><nl>

: (colon)
A leading colon shows that the following command starts from the root level of the command tree. A colon within a string separates different parts of a compound header.
_ (space)
Separates header from data.
" (quote)
Single or double quote indicates string data.
; (semicolon)
Separates several program messages in a string.
? (question)
Indicates that a response is requested.
<nl> (new line) or <cr> (carriage return)
Ends a message.

Typographic Conventions in This Chapter

UPPERCASE
Like in PERiod *PER* is the short form and *period* is the long form. The instrument will act exactly in the same way whichever form you use.
<...>
An expression between these brackets is a code, such as <nl> (new line) that can not be expressed as a printable character, or it is a parameter that is further specified. Do not insert the brackets in the command!
[...]
The item between these brackets is optional. This means that you may omit it. Do not insert the brackets in the command!
|
This is a separator between selectable items. This means that you must choose only one of the items (exclusive or). Example: 1|2 means you can type either 1 or 2.

Overview of Command Subsystems

SCPI Commands

Timing Commands
Controls measurement start/stop.

Remote / Local Commands
Selects control mode: remote (program) or local (manual)

Functional Mode Commands
Selects measurement mode or checks operating time.

Mask Commands
Controls user-defined MTIE or TDEV masks.

Measurement Data Transfer Commands
Requests the instrument to return an array of measured values.

∗ Commands Defined by IEEE 488.2

Internal Operations Commands
Used for resetting and testing purposes.

Status and Event Commands
Used for obtaining information about what is happening in the instrument at the moment.

Program Sequence

A typical program sequence consists of the following user actions:
1. Set the communication parameters for the RS-232 port of the computer to match the instrument settings.
2. Output a command or query, or a list of com-

mands and queries, to the instrument. In some situations it is needed to synchronize the execution of the programming sequence with the actions in the controller. This is done by adding the *OPC? at the end of the command sequence. This command will output a 1 to the controller when all pending commands have been executed.

3. If a query was output to the instrument, input its response.
4. The sequence of points 2, and 3 may be repeated for different commands or queries.
5. Close the communication channel.

Order of Execution

All commands are sequential, i.e. they are executed in the same order as they are received. Commands, separated by semicolons on a single line, are executed in succession without interrupting one another.

Quick Alphabetical Overview of Commands

*CLS Clear Status Command
*ESE and *ESE? Standard Event Status Enable
*ESR? Event Status Register
*IDN? Identification Query
*OPC? Operation Complete Query
*OPT? Option Query
*PUD and *PUD? Protected User Data
*RST Reset
*SRE and *SRE? Service Request Enable (Query)
*STB? Status Byte Query
*TST? Self-Test
*WAI Wait-to-Continue Command
:ABORt Stop Measurement
:ARM:SOURce IMMediate Inhibit Delayed Start
:ARM:SOURce TIMer Activate Start Delay
:ARM:TIMer Set Start Delay Time
:DISPlay:MENU REMote Activate Remote Mode
:DISPlay:MENU TRENd Activate Local Mode
:INITiate Initiate Measurement
:INPut’1|2’:LEVel <TrigLevel> Set Trigger Level
:INPut1:SLOPe POSitive|NEGative Set Trigger Slope
:SENSe:AUTO ONCE Signal Check
:SENSe:FUNCtion “TIError 1” Select Normal Wander

:SENSe:FUNCtion “TINTerval 1,2” Select Differential Wander
:SYSTem:COMMunicate:SERial: TRANsmit:PACE XON|NONE Activate/Deactivate SW handshake
:SYSTem:MASK:DELete Delete Mask
:SYSTem:MASK:MTIE|TDEV:READ? Get MTIE / TDEV Mask
:SYSTem:MASK:MTIE|TDEV:WRITe Set MTIE / TDEV Mask
:SYSTem:MASK:NAME:READ? Get Name of Mask
:SYSTem:MASK:NAME:WRITe Set Name of Mask
:SYSTem:UPTime? Check Operating Time
:TRACe:DATA? CH1|MEMStore Fetch Data Array - TIE
:TRIGer:TIMer Set Pacing Time
:TRIGger:COUNt Set Number of Samples
:TRIGger:SOURce IMMediate Switch off Pacing
:TRIGger:SOURce TIMer Switch on Pacing

Command Reference Guide

■ Timing Commands

Stop Measurement *:ABOR*

Purpose:
Abort all activities and enter *Idle State*.

Syntax:
:ABORt<nl>

Initiate Measurement *:INIT*

Purpose:
Start measurement or delayed measurement, depending on whether a start delay command has been sent prior to the :INIT command or not.

Syntax:
:INITiate<nl>

Inhibit Delayed Start *:ARM:SOUR IMM*

Purpose:
Prepare start of measurement without delay. This is the default condition, but it is recommended to send the command anyhow to avoid unintended start delay.

Syntax:
:ARM:SOURce_IMMediate<nl>

Activate Start Delay *:ARM:SOUR TIM*

Purpose:
Prepare start of measurement after delay.

Syntax:
:ARM:SOURce_TIMer<nl>

Set Start Delay Time *:ARM:TIM*

Purpose:
Set the number of seconds to wait between :INIT and the actual start of measurement.

Syntax:
:ARM:TIMer_<numeric value><nl>

Switch off Pacing — *:TRIG:SOUR IMM*

Note:
Possible but not recommended measurement mode.

Syntax:
:TRIGger:SOURce_IMMediate<nl>

Switch on Pacing — *:TRIG:SOUR TIM*

Purpose:
Try to keep the time between measurements constant. It is recommended to send this command before starting a measurement.

Syntax:
:TRIGger:SOURce_TIMer<nl>

Set Pacing Time — *:TRIG:TIM*

Purpose:
Set the time between measurements in seconds, with the maximum resolution in ms, e.g. 1.234.

Syntax:
:TRIGger:TIMer_<numeric value><nl>

Set Number of Samples — *:TRIG:COUN*

Purpose:
Set the number of samples to be taken before a measurement will stop.

Syntax:
:TRIGger:COUNt_<numeric value><nl>

■ Remote/Local Commands

Activate Local Mode — *:DISP:MENU TREN*

Purpose:
Switch on the normal display mode with graphics etc.

Syntax:
:DISPlay:MENU_TRENd<nl>

Activate Remote Mode *:DISP:MENU REM*

Purpose:
Switch on remote mode; no graphics and few digits.

Syntax:
:DISPlay:MENU_REMote<nl>

■ Functional Mode Commands

Signal Check *:SENS:AUTO ONCE*

Purpose:
Check the signal(s) at the input(s) before start of measurement to find and set optimum trigger levels.

Note:
Corresponds to pressing the Signal Check button on the front panel.

Syntax:
:SENSe:AUTO_ONCE<nl>

Select Normal Wander *:SENS:FUNC “TIE 1”*

Purpose:
Set normal one-channel wander measurement.

Syntax:
:[SENSe:]FUNCtion_“TIError_1”<nl>

Select Differential Wander *:SENS:FUNC “TINT 1,2”*

Purpose:
Set differential (two-channel) wander measurement.

Syntax:
:[SENSe:]FUNCtion_“TINTerval_1,2”<nl>

Check Operating Time *:SYST:UPT?*

Purpose:
Query returning the number of seconds passed since the last Power On / Reset.

Syntax:
:SYSTem:UPTime?<nl>

Response format:
<ss><nl>

The number of seconds is an integer.

■ Input Settings Commands

Get Input Trigger Level — *:INP1LEV?* *:INP2LEV?*

Purpose:
Query returning the current input trigger level.

Syntax:
:INPut'1|2'LEVel?<nl>

Response format:
<numeric value><nl>

Get Input Trigger Slope — *:INP1:SLOP?*

Purpose:
Query returning the current trigger slope for CLOCK/DATA IN A.

Syntax:
:INPut1:SLOPe?<nl>

Response format:
<string><nl>

The string can be either "POS" or "NEG".

Set Input Trigger Level — *:INP1LEV* *:INP2LEV*

Purpose:
Set the input trigger levels in order to change the values set automatically by the SIGNAL CHECK function. See the specification for range and resolution.

Syntax:
:INPut'1|2'LEVel_<TrigLevel><nl>

Set Input Trigger Slope *:INP1:SLOP POS*
:INP1:SLOP NEG

Purpose:
Set the circuitry for the CLOCK/DATA IN A input to trigger on either the leading or the trailing edge of the input signal.

Syntax:
:INPut1:SLOPe_POSitive|NEGative<nl>

■ Interface Commands

Activate/Deactivate Software Handshake *:SYST:COMM:SER:*
TRAN:PACE

Purpose:
Set the data exchange handshake mode to XON/XOFF or to NONE.

Syntax:
:SYSTem:COMMunicate:SERial:TRANsmit:PACE_XON|NONE<nl>

Check Software Handshake Mode *:SYST:COMM:SER:*
TRAN:PACE?

Purpose:
Query returning the SW handshake mode.

Syntax:
:SYSTem:COMMunicate:SERial:TRANsmit:PACE?<nl>

Response format:
<string><nl>

The string can be either “XON” or “NONE”.

■ Mask Commands

Set MTIE/TDEV Mask *:SYST:MASK:MTIE:WRIT*
:SYST:MASK:TDEV:WRIT

Purpose:
Send a user-defined MTIE or TDEV mask to the instrument.

Syntax:
:SYSTem:MASK:MTIE|TDEV:WRITe_<mask #>,<signal group #>,<mask parameter 1>, ...<nl>

Mask number is 1, 2, 3 or 4. Each mask is divided into five segments, each of which is characterized by seven constants – A, B, K, L_1, L_2, M_1, M_2 – according to the formula given below:

$$y(\tau) = K + L_1 \cdot \tau^{M_1} + L_2 \cdot \tau^{M_2} \text{ for } A < \tau \leq B$$

Thus a complete mask is defined by 35 parameters separated by commas and entered in the order A, B, K, L_1, L_2, M_1, M_2,...etc.

Non-active segments are entered as zeros.

Signal group number is an integer according to the list below:

Signal Group

Number	Description
1	E1 (2.048 MHz, 2.048 Mbit/s)
2	T1 (1.544 MHz, 1.544 Mbit/s)
10	4 kHz
20	8 kHz
50	64 kbit/s
70	1 MHz
80	5 MHz
90	10 MHz
100	Video (15.625 kHz, 15.750 kHz, 27MHz)
110	34 Mbit/s
120	45 Mbit/s
130	52 Mbit/s

Only Signal Group 1 is applicable to the WM-10.

Get MTIE/TDEV Mask — *:SYST:MASK:MTIE:READ?* *:SYST:MASK:TDEV:READ?*

Purpose:
Fetch an MTIE or TDEV mask from the instrument.

Syntax:
:SYSTem:MASK:MTIE|TDEV:READ?_<mask #>,<signal group #><nl>

Mask number is 1, 2, 3 or 4.
Signal group number is one of the integers in the list found under *Set MTIE/TDEV Mask* above.

Response format:
<A, B, K, L_1, L_2, M_1, M_2,...><nl>

The return data is a list of 35 parameters. This data string can be stored for later use as input parameters for the *Set MTIE/TDEV Mask* command. See *Set MTIE/TDEV Mask* for further information on data interpretation.

Set Name of Mask — *:SYST:MASK:NAME:WRIT*

Purpose:
Give the MTIE/TDEV mask with the specified mask number a name.

Syntax:
:SYSTem:MASK:NAME:WRITe_<mask #>,<signal group #>,"string"<nl>

Mask number is 1, 2, 3 or 4. The name must be within quotation marks and no longer than 13 characters.
Signal group number is one of the integers in the list found under *Set MTIE/TDEV Mask* above.

Get Name of Mask — *:SYST:MASK:NAME:READ?*

Purpose:
Fetch name of specified mask number.

Syntax:
:SYSTem:MASK:NAME:READ?_<mask #>,<signal group #><nl>

Mask number is 1, 2, 3 or 4.
Signal group number is one of the integers in the list found under *Set MTIE/TDEV Mask* above.

Response format:
<string><nl>

Delete Mask — *:SYST:MASK:DEL*

Purpose:
Reset all parameters for the specified mask number to zero.

Note:
You need not delete a mask before entering a new one.

Syntax:
:SYSTem:MASK:DELete_<mask #>,<signal group #><nl>

Mask number is 1, 2, 3 or 4.
Signal group number is one of the integers in the list found under *Set MTIE/TDEV Mask* above.

■ Measurement Data Transfer Commands

Fetch Data Array - TIE — *:TRAC? CH1* *:TRAC? MEMS*

Purpose:
Retrieve a stored array of TIE measurements or frequency offset values based on these TIE measurements.

Syntax:
:TRACe[:DATA]?_CH1|MEMStore<nl> (get TIE values array)

The MEMStore parameter is used for retrieving data from the RAM having battery backup.
The TIE values occupy max. 16000+ values.

Example:
SEND → :TRACe?_CH1<nl>

This example shows a request for TIE values array data.

Response format:
<header><binary block><nl>

Header:
A header consists of several parameters, both strings and numerical values in ASCII format. Strings are written within double quotes, e.g. "Hz", Strings may be empty, i.e. "".

Header format:
<Channel>,<Y-unit>,<X-unit>,<Y-zero>,<X-zero>,<Y-resolution>,<X-resolution>,<Reserved>,<Samples>,<max-Y>,<min-Y>,<max-Y-X>,<min-Y-X>,<binary block><nl>

<Channel> is a string and is either "Channel 1" or "Memory Storage".

<Y-unit> and <X-unit> are strings, "s" for both Y (TIE) and X (timescale).

<Y-zero> and <X-zero> are numerical values (ASCII format) indicating the start value for the X- and Y-values.

<Y-resolution> and <X-resolution> are numerical values (ASCII format) indicating the unit value of the data in the binary block, e.g. 1E-10 for TIE, saying that the data in the binary block should be multiplied with 100 ps (TIE) to obtain the actual value.

<Samples> is a numerical value (ASCII format) that equals the number of samples for TIE in the following binary block.

<Max-Y>, <min-Y>, <max-Y-X> and <min-Y-X> defines the boundaries of the trace data window when MEMStore is selected. If CH1 is selected, the graph window defines the boundaries.

The binary data contains TIE values together with the corresponding time stamp for these values. Each value occupies 2 bytes of binary data in the 16-bit signed integer format, in so-called little endian format (negative numbers as 2-complement). This means that the binary data block size is:
2 * <Samples> * 2 bytes stored in the order X1 Y1 X2 Y2... Etc.

The absolute value (in seconds) of TIE corresponding to the binary value Y_i is calculated as: Y_i * Y-resolution + Y-zero.

The relative time stamp value in seconds, since first measurement is calculated as:
X_i * X-resolution (first measurement has time stamp value zero).

Binary block:
A binary block has the format: “#ds<binary data>” (without the quotes).
# = Mandatory first character of binary block
d = the first character after the #, tells the number of digits in the block size number
s = the block size, that is s bytes of binary data will follow.
The value of s contains d characters.

Example:
#217actually a string<nl>

In this example, the block size number has 2 digits, the block size is 17 and the following17 characters form the data, in this example no binary number but a string for the sake of visibility. Binary data are generally not printable. An empty block is written “#10".

■ ✱ Commands Defined by IEEE 488.2

Identification Query **IDN?*

Purpose:
Read out the manufacturer, model, serial number and firmware level, as an ASCii response data element.

Note:
The query must be the last one in a program message.

Syntax:
*IDN? <nl>

Response format:
<Manufacturer>,<Model>,<Serial Number>,<Firmware Level>_<date><nl>

Example:
SEND → *IDN?<nl>
READ ← Pendulum, WM-10, 123456, V1.01 16 Feb 2001<nl>

Protected User Data *PUD?*

Purpose:
Write any data up to 64 characters in a special memory area.

Note:
The data can always be read, but you can only write data after unprotecting the data area. A typical use would be to hold owner/user name, usage time, inventory control numbers, etc.

Syntax:
*PUD?<nl>

Response format:
<Arbitrary block response data><nl>
where: <arbitrary block program data> is the data last programmed with *PUD.

Example:
SEND → :SYST:UNPR; *PUD #240ACME Inc. Bobby Brown, inventoryNo.1234 <nl>
means that <arbitrary block program data> will follow. 2 means that the two following digits will specify the length of the data block. 40 is the number of characters in this example.
SEND → *PUD?<nl>
READ ← #240ACME Inc. Bobby Brown, inventory No.1234<nl>

Note:
:SYST:UNPR means unprotect and enables writing of protected user data. This command is only used here and not further explained.

■ Internal Operations Commands

Operation Complete Query *OPC?

Purpose:
This command is used to synchronize the execution of the programming sequence with the actions in the controller. This is used by adding the *OPC? at the end of the command sequence. The operation complete query places an ASCII character 1 in the devices output queue when all pending selected device operations have been finished.

This command causes the device to generate the operation complete message in the Standard Event Status Register when all pending selected device operations have been finished.

Response format:
1 <nl>

Example:
SEND → :SENS:AUTO ONCE;*OPC?<nl>
READ ← 1<nl>
SEND → :INIT<nl>

Reset *RST

Purpose:
Resets the instrument to the same state as after Recall Default Setup via the keyboard.

Note:
Baudrate is not affected by this command

Syntax:
*RST<nl>

Example:
SEND → *RST<nl>

Self-Test *TST?

Purpose:
The self-test query causes an internal self-test and generates a response indicating whether or not the device completed the self-test without any detected errors. Use :TEST:SEL to select which test to run.

Syntax:
*TST?<nl>

Example:
SEND → *TST?<nl>

Response format:
<Integer><nl>
where: <Integer> = a number indicating errors according to the table below.

<Integer>	Error
0	No Error
1	Display Failure
2	Logic Failure
4	RAM Failure
8	ROM Failure

■ Status and Event Commands

Status Byte Query *STB?

Purpose:
Status Byte Query Reads out the value of the Status Byte.

Syntax:
*STB?<nl>

Response format:
<Integer><nl> = the sum (between 0 and 255) of all bits that are true. See table below:

<Integer>	Status
128 (Bit 7)	Measurement started
64 (Bit 6)	Master Summary Status
32 (Bit 5)	A bit in the standard event status register is set
16 (Bit 4)	Message available (always set)
8 (Bit 3)	Not used
4 (Bit 2)	Error available
2 (Bit 1)	Not used
1 (Bit 0)	Not used

Example:
SEND → *STB?<nl>
READ ← 16<nl>

In this example, a message is available.

Event Status Register *ESR?

Purpose:
Reads out the contents of the standard event status register. Reading the Standard Event Status Register clears the register.

Syntax:
*ESR?<nl>

Response format:
<dec.data><nl> = the sum (between 0 and 255) of all bits that are true.<nl>

<Integer>	Status
128 (Bit 7)	Not used
64 (Bit 6)	Not used
32 (Bit 5)	A command error has occurred
16 (Bit 4)	An execution error has occurred
8 (Bit 3)	A device dependent error has occurred
4 (Bit 2)	A query error has occurred
2 (Bit 1)	Not used
1 (Bit 0)	Operation complete

Example:
SEND → *ESR?<nl>
READ ← 4<nl>

In this example, a query error has occurred.

Clear Status Command **CLS?*

Purpose:
The *CLS command clears the status data structures by clearing all event registers and the error queue. It does not clear enable registers. It clears any pending *WAI, *OPC and *OPC?

Syntax:
*CLS<nl>

Example:
SEND → *CLS<nl>

Standard Event Status Enable **ESE* **ESE?*

Purpose:
Sets and Reads out the contents of the standard event status enable register.

Syntax:
*ESE<dec.data><nl>

<dec.data> = the sum (between 0 and 255) of all bits that are true<nl>

<Integer>	Status
128 (Bit 7)	Not used
64 (Bit 6)	Not used
32 (Bit 5)	Command error event enable
16 (Bit 4)	Execution error event enable
8 (Bit 3)	Device dependent error event enable
4 (Bit 2)	Query error event enable
2 (Bit 1)	Not used
1 (Bit 0)	Operation complete event enable

Example:
SEND → *ESE 33<nl>

In this example, the Command Error (bit 5) and Operation Complete (bit 0) enable bits are set.

Query Syntax:
*ESE?<nl>

Response format:
<dec.data> = the sum (between 0 and 255) of all bits that are true<nl>

Example:
SEND → *ESE?<nl>
READ ← 4<nl>

In this example, only the query error enable bit is set.

Option Query — **OPT?*

Purpose:
Lists the options of the instrument.

Syntax:
*OPT?<nl>

Response format:
<Inputs>,<Timebase>,<Outputs><nl>
Inputs is currently always “75 Ohm”, Timebase is “Rubidium”, Outputs is “0” or “2.048 MHz” (option 75).

Example:
SEND → *OPT?<nl>
READ ← 75 Ohm, Rubidium, 0<nl>

Service Request Enable (Query) — **SRE* / **SRE?*

Purpose:
The SRE command sets the Service Request Enable Register bits. A bit that is set true in the SRE register enables the corresponding bit in the Status Byte Register to generate a Service Request.

Syntax:
*SRE<dec.data><nl>

<dec.data> = the sum (between 0 and 255) of all bits that are true.

<Integer>	Status
128 (Bit 7)	Measurement started
64 (Bit 6)	Request Service
32 (Bit 5)	Event status bit
16 (Bit 4)	Message available
8 (Bit 3)	Not used
4 (Bit 2)	Error available
2 (Bit 1)	Not used
1 (Bit 0)	Not used

Example:
SEND → *SRE 32<nl>

In this example, the Event Status bit (bit 5) is set, and an Event Status bit that is set true in the Status Byte Register will generate a Service Request.

Query Syntax:
*SRE?<nl>

Response format:
<dec.data> = the sum (between 0 and 255) of all bits that are true.<nl>

Example:
SEND → *SRE?<nl>
READ ← 32<nl>

In this example, only the query error enable bit is set.

Wait-to-Continue Command **WAI*

Purpose: The wait-to-continue command prevents the instrument to execute any further commands and queries, until all previous commands or queries have been completed.

Syntax:
<commands>;*WAI;<commands><nl>

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Chapter 11

Service

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