163/164

MultiFunction Counter

Users Manual

4031 600 64001, rev. 03 July 2003

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GUARANTEE STATEMENT

This guarantee is in addition to all rights, which the Buyer may have against his supplier under the sales agreement between the Buyer and the supplier and according to local legislation.

Pendulum Instruments AB guarantees this product to be free from defects in material and workmanship under normal use and service for a period of eighteen (18) months from the date of shipment. This guarantee does not cover possible required re-calibration and/or standard maintenance actions. This guarantee extends only to the original end purchaser and does not apply to fuses, batteries, power adapters, or to any product or part thereof that has been misused, altered, or has been subjected to abnormal conditions of operation and handling.

Pendulum Instruments' obligation under this guarantee is limited to repair or replacement of a product that is returned to the factory within the guarantee period, provided that Pendulum Instruments determines that the product is defective and that the failure has not been caused by misuse, alteration or abnormal operation. If a failure occurs, send the product, transportation prepaid, to Pendulum's delivery address:

Pendulum Instruments AB
Adolfsbergsvägen 2
P.O. Box 20020
SE-61 02 Bromma, Sweden

Attach a description of the malfunction. At Pendulum Instruments' option, repairs will be made or the product replaced. Pendulum Instruments shall return the repaired or replaced product to the Buyer, transportation prepaid. However, the Buyer shall pay all shipping charges, duties and taxes for products returned to Pendulum Instruments from another country. Pendulum Instruments assumes no risk for damage in transit.

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The foregoing guarantee is exclusive and is in lieu of all other guarantees, expressed or implied, including but not limited to any implied guarantee of merchantability, fitness, or adequacy for any particular purpose or use. We shall not be liable for any direct, indirect, special, incidental, or consequential damages, whether based on contract, tort, or otherwise.

EC DECLARATION OF CONFORMITY

Number: 4031 100 58901A041

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 declare that the product:
Product Identification
Product: MultiFunction Counter
Brand: Pendulum
Model: 164
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 and the directive LVD-73/23/EEC.

Harmonized standards used:
Safety: EN 61010-1 Cat. II (1993), UL1210
EMC: EN 50081-1 (1993)/EN 55011 (1991) Group1, ClassA
EN 50082-2 (1995)
/EN 61000-4-2: 4 kV CD, 8 kV AD
/ENV 50140: 10 V/m, AM 80% (1kHz) 80-1000 MHz
/EN 61000-4-4: 2 kV AC (mains), 1kV (signal lines)
ENV 50141: 10 V7m, AM 80% (1 kHz) 0.15-80 MHz

Other references or information required by the applicable EC directives:
SEMCO: TCF certificate 9918100T
TCF 981214

Signature of representative of manufacturer: *Kali Rahman*
Place: Bromma Date: 2003-05-05

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

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

⚠ Indicates that the operator should consult the manual.

One such symbol is printed on the TM-164/164H, near the input connectors, and one on the AC/DC Power Adapter. This symbol on the instrument should encourage the user to use the correct procedure for common instrument ground and maximum input voltages as described below.

The symbol on the AC/DC Power Adapter indicates that only the Option 51 AC/DC Power Adapter is allowed for the TM-164 and the TM-164H.

⊥ This symbol is printed on the MultiFunction Counters. It indicates that the signal ground of the connectors is internally connected to the other connectors with the same symbol, and to parts that are easily accessible for the user. The accessible parts are the BNC-connectors.

Warning

The metallic BNC-connector housings will all carry the same common voltage. Applying signals with a common potential of more than 30Vrms (42Vpk or 60Vdc) above ground potential will make the instrument dangerous.

Connections

The TM-164 and TM-164H are double-insulated and battery operated. The instrument is therefore floating with respect to ground potential. Before connecting probes to the instrument you must be aware of that the grounds of all BNC-connectors on the instrument are interconnected inside the instrument. This means that connecting the signal ground of one probe or test lead to 42VDC (30Vrms) or more above ground potential will make the signal ground of other probes and measuring leads dangerous.

Warning

To avoid electrical shock, remove any test leads that are not currently in use. Use safety designed probes without exposed metal connectors. Use probes and test leads within ratings and inspect before use.

Caution

Never apply signals with higher amplitude than 30Vrms to Input A or Input B, or 12Vrms to the other inputs for safety reasons.

If In Doubt About Safety

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

- Disconnecting the line cord
- Clearly marking the instrument to prevent its further operation
- Informing Pendulum Instruments' Service Center.

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

Chapter 1
Introduction

Contents **Page**

ABOUT THIS MANUAL

This manual contains the information required to use the TM-164 and TM-164H MultiFunction Counters from Pendulum Instruments AB. It also contains a training guide for MultiFunction Counter users.

The intended audience for this Users Manual is the installer and the Operator/User. It provides operating instructions, application information, specifications, and user maintenance instructions.

The MultiFunction Counter Users Manual contains fourteen chapters:

1 Introduction
2 Using the Controls
3 Tutorial
4 Measure Function
5 Input Trigger
6 User Options
7 WAVEFORM mode
8 VALUES mode
9 STATISTICS mode
10 Understanding your MultiFunction Counter
11 Specifications
12 User Maintenance
13 Appendices
14 Index

PRODUCT FEATURES AND USE

The MultiFunction Counter is more than just a high accuracy top-performance counter, it adds a wideband DVM and displays waveform information like an oscilloscope.

Three different presentation modes let you VIEW, MEASURE and ANALYZE your signal. These presentation modes supply measuring data, as seen from different perspectives, giving more insight and confidence.

- In the WAVEFORM mode, the bright LCD display shows the input signal and trigger level, so you can view what you are measuring is correct. At the same time you can read off the measurement, which is displayed at up to 10 digits resolution.
- The VALUES mode displays up to 10 different signal parameters simultaneously, giving a wealth of information from just a single measurement.
- The STATISTICS mode gives statistical data over any number of readings up to 1 000 000 and reveals trends, jitter, drift, etc. It reduces random errors by statistical averaging, so enhancing accuracy.

Best of all is the ease-of-operation of this new instrument. Simple menu selection and an intelligent AUTOSET makes everyone an expert user and takes all the hard work out of getting results. With just a few keystrokes, the MultiFunction Counter helps you measure more with better results, faster and with less effort.

Now you can VIEW, MEASURE and ANALYZE confidently parameters like: Frequency, Period, V_{max}, V_{min}, $V_{peak\text{-}peak}$, Pulse Width, Rise-/Fall Time, Duty Cycle, Time Interval, Phase, Burst Frequency, V_{dc}, true RMS V_{ac}, Jitter and Totalize of Counts.

The MultiFunction Counter delivers high-resolution, high-accuracy readings of up to 10 digits. The high-stability oven controlled oscillator in the TM-164H model enhances accuracy even further. This is the ideal instrument for verification, alignment, calibration and analysis when you need accurate results. It is easier to use than a traditional counter, and it is more accurate than an oscilloscope for timing and frequency measurements.

- Total signal characterization, with up to 10 parameters displayed simultaneously.
- 160 MHz / 2.7 GHz frequency counting.
- Up to 10-digits resolution.
- 700 ps single-shot time resolution.
- 0.01° phase resolution.
- See signals up to 50 MHz and read voltages, including true-RMS.
- Confident triggering through visual waveform verification.
- High-stability optional ovenized crystal oscillator.
- Easy to learn, easy to use, easy to get results.
- AUTO SET for foolproof results.
- Handheld, rugged, battery operation: Ideal for field use.
- 3 years warranty, 40 000 hours MTBF.
- RS-232 interface for programmability and downloading of data.

Using a MultiFunction Counter From a Computer

If you intend to use your 164 with the optical serial interface, use the Programming Instructions provided on the diskette that is delivered with the optional serial interface cable. This interface cable is available under product number Option 23/80.

Unpacking and first installation

UNPACKING AND INCOMING INSPECTION

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 sales representative or Pendulum Instruments AB directly, in case repair or replacement may be required.

Contents of Box

The shipment should contain the following:

1. One 164 MultiFunction Counter (including rechargeable battery)
2. One Protective Holster ***(if ordered)***
3. One AC/DC Power Adapter
4. One Certificate of Calibration
5. This Users Manual

IDENTIFICATION

The name strip on top of the display indicates what options are included in your instrument.

1. "164" indicates the basic model with a frequency measurement capability of 160 MHz (A- and B-inputs) and a separate 2.7 GHz HF-input.
2. "164**H**" indicates that you have also a **H**igh-stability Oven Controlled Crystal Oscillator, i. e. a time base with an aging of $1x10^{-7}$ per year.

USING THE HOLSTER AND TILT STAND

The MultiFunction Counter is cradled in an optional gray holster (option 23/01) that provides shock protection during rough handling. All keys and connections are accessible with the holster in place. You will need to remove the holster only to replace batteries. (See chapter 12 for battery replacement instructions.)

The MultiFunction Counter is also equipped with a multipurpose tilt stand, allowing viewing from different angles. The stand can also be used to hang the MultiFunction Counter at a convenient viewing position. Simply push up the quick release and tilt the stand. The tilt stand/bracket is fully usable with the gray holster in place. Typical positions are shown in Figure 1.

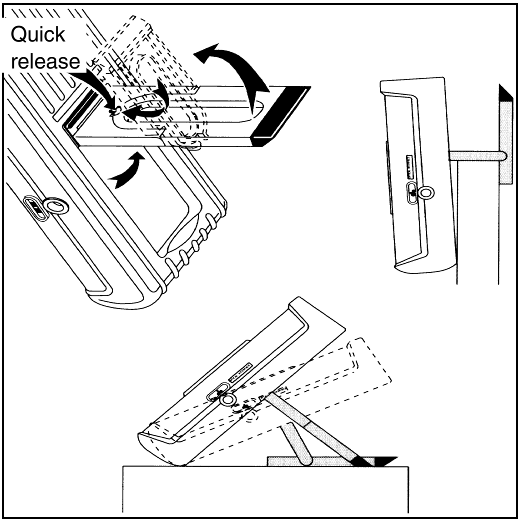


Figure 1 Multiposition Stand.

POWERING THE INSTRUMENT

The MultiFunction Counter can be powered from any of the following sources:

- Internal Battery Pack (Option 23/86). A rechargeable Ni-Cd Battery pack comes installed in the 163/164 MultiFunction Counter.
- C Cell Batteries. You can use alkaline batteries in place of the Ni-Cd battery pack. (The charger is defeated when standard C Cells are installed.)
- AC/DC Power Adapter (Option 51). The AC/DC Power Adapter/Battery Charger powers the MultiFunction Counter from a standard ac outlet. The MultiFunction Counter can be used during battery charging. Verify that your local line voltage is appropriate before using the AC/DC Power Adapter/Battery Charger.
- Connect the Adapter/Charger to the MultiFunction Counter before connecting it to the ac outlet.

Note

When measuring small signals where noise may be a problem, use the MultiFunction Counter on battery power only

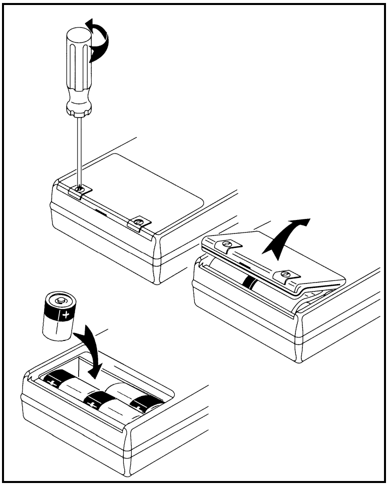


Figure 2 You can insert alkaline C-size batteries in the 163/164.

Charging the Batteries

Warning

To avoid electrical shock, use only an AC/DC Power Adapter/Battery Charger that is authorized for use with the MultiFunction Counter

Charge the batteries if the MultiFunction Counter does not start, or if a battery charge warning is shown.

To charge the batteries:

1. Connect the charger to the MultiFunction Counter.
2. Connect the charger to the ac outlet.
3. Charging starts directly when you plug in the charger to the MultiFunction Counter and to the ac outlet.
4. If the MultiFunction Counter is turned off, the batteries will quick-charge in 3 hours.
5. If you use the MultiFunction Counter as a line powered instrument during charge, 30 hours is needed for Full Charge.

Note

*To keep your batteries functional as long as possible, read about battery care in the **User Maintenance** chapter, page 12-3.*

Chapter 2
Using the Controls

Contents **Page**

INTRODUCTION

This chapter describes the various controls and related functions of the MultiFunction Counter.

The chapter is divided into four sections:

- Front Panel Keys
- What's on the Display
- On-screen controls
- Conventions
- Convenience keys

After reading this chapter you will be able to maneuver your MultiFunction Counter through most measuring situations.

If you don't like reading manuals

With only a few keystrokes you can make most measurements:

Select what to measure with MEASURE FUNCTION

Press AUTO SET twice (double-click) after changing function to get optimal working settings for the selected function. A single press will only affect voltage range, trigger level and waveform time-base settings

Select WAVEFORM mode with WAVEFORM, to see the signal like on an oscilloscope.

OR

Press VALUES to see the results as numerical values.

Press INFO to get context sensitive help on the subject currently pointed out by the cursor.

FRONT PANEL KEYS

Turning On

Switch on by pressing the ON/OFF key in the lower left corner. The MultiFunction Counter starts with the setup it had when turned off.

If you want default setup instead:

1. Press SAVE RECALL
2. Press **Recall Default Setup**

Presentation Mode Keys

(waveform key)	Shows the waveform of the signal.
1.234	Shows measurement results as numerical value
MAX MIN	Shows the variation of the signal over a set number of samples by presenting the maximum, minimum, maximum minus minimum, mean and standard deviation.

Setup Menu Keys

MEASURE FUNCTION	Selects what parameter to measure (Single Function), or what signal type to characterize (Signal Characterization).
INPUT TRIGGER	Selects input settings and measurement trigger conditions.
USER OPTIONS	Selects parameters that affect the MultiFunction Counter, not the measurement.

Cursor Control Keys

◀ ▶ ▲ ▼	Used to move a cursor on the screen
SELECT	Used to select items on the screen and to enter menus.
EXIT	Used to exit menus on the screen.

Convenience Keys

UNDO	Returns to the previous setting.
AUTO SET	Sets up the instrument to measure properly on the connected signal.
i	Gives help information on the topic that the cursor points at.

Measurement Control Keys

HOLD RUN	Freezes the measurement results or waveform on screen.
RESTART	Resets the measurement results and initiates a new measurement/waveformcapture.

Additional Keys

⏻	Turns the MultiFunction Counter on or off.
SAVE RECALL	Saves and recalls instrument setup and screen data in nonvolatile memory inside the MultiFunction Counter.
☼	Steps the intensity of the display backlight between high, medium or low. Low intensity means longer battery life.

WHAT'S ON THE DISPLAY

WAVEFORM mode

Figure 3 shows the waveform mode screen and explains its elements.

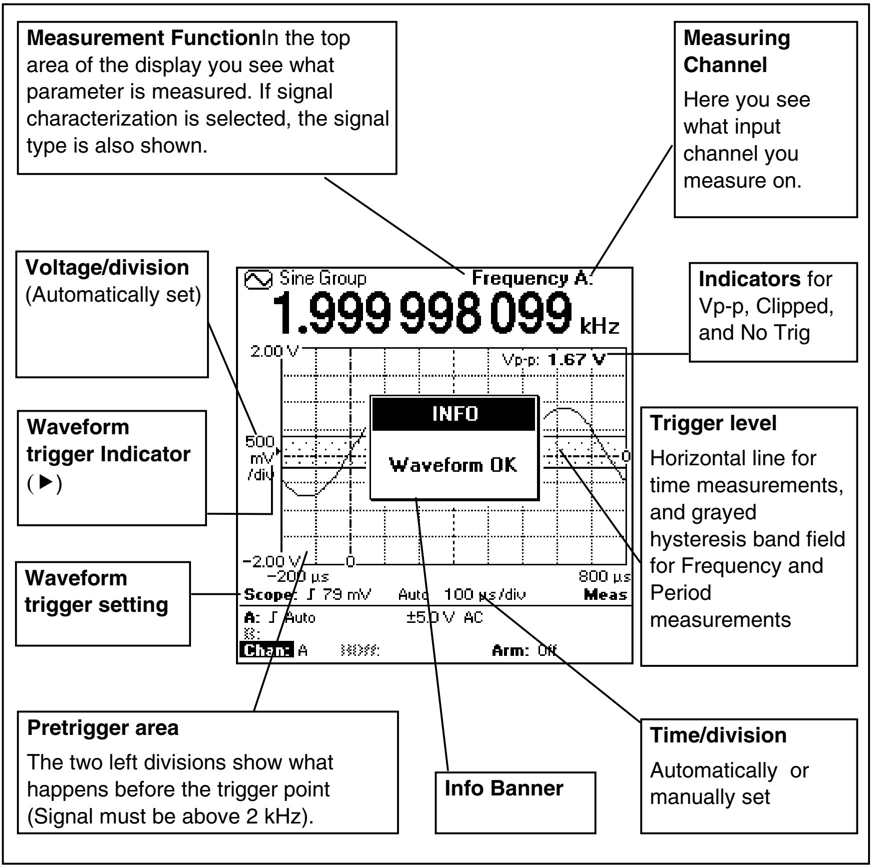


Figure 3 A typical WAVEFORM mode screen.

Note

The black field on **Chan:** *is the cursor. You can move it to the function you want to change with the cursor control* ✥*.*

VALUES mode

Figure 4 shows the different elements of the values screen. If a single measurement function is selected, only the large result and the voltage readings are shown.

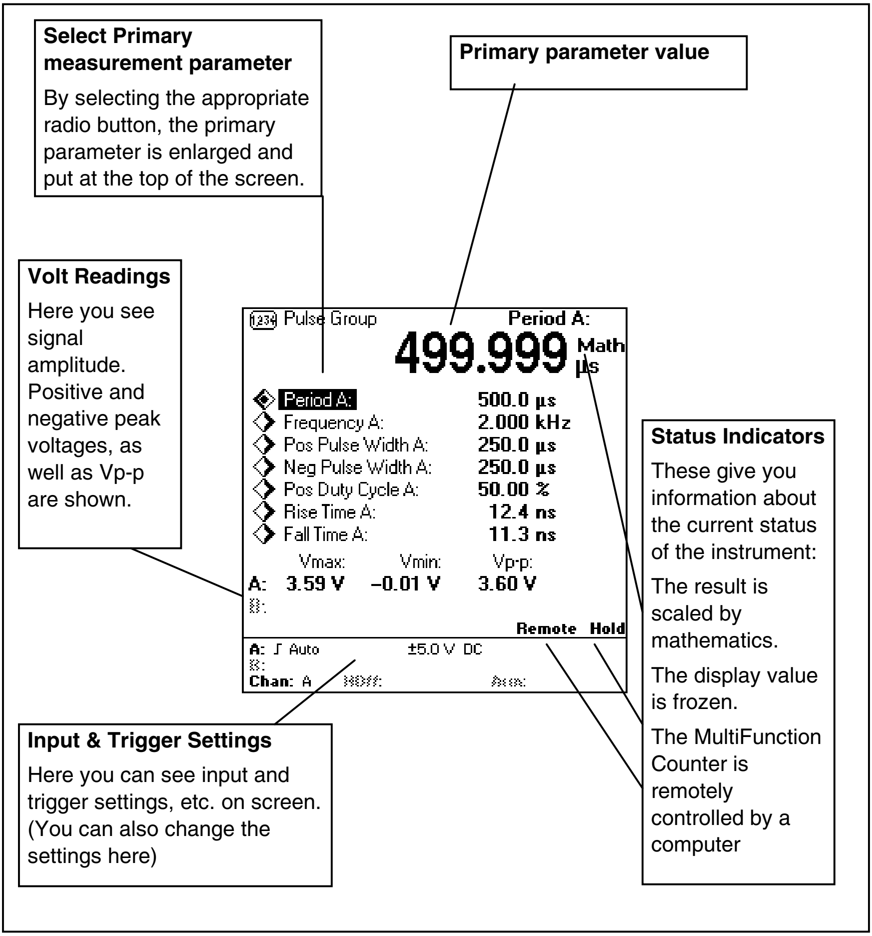


Figure 4 A typical VALUES mode screen.

STATISTICS mode

Figure 5 shows the different elements of the statistics screen.

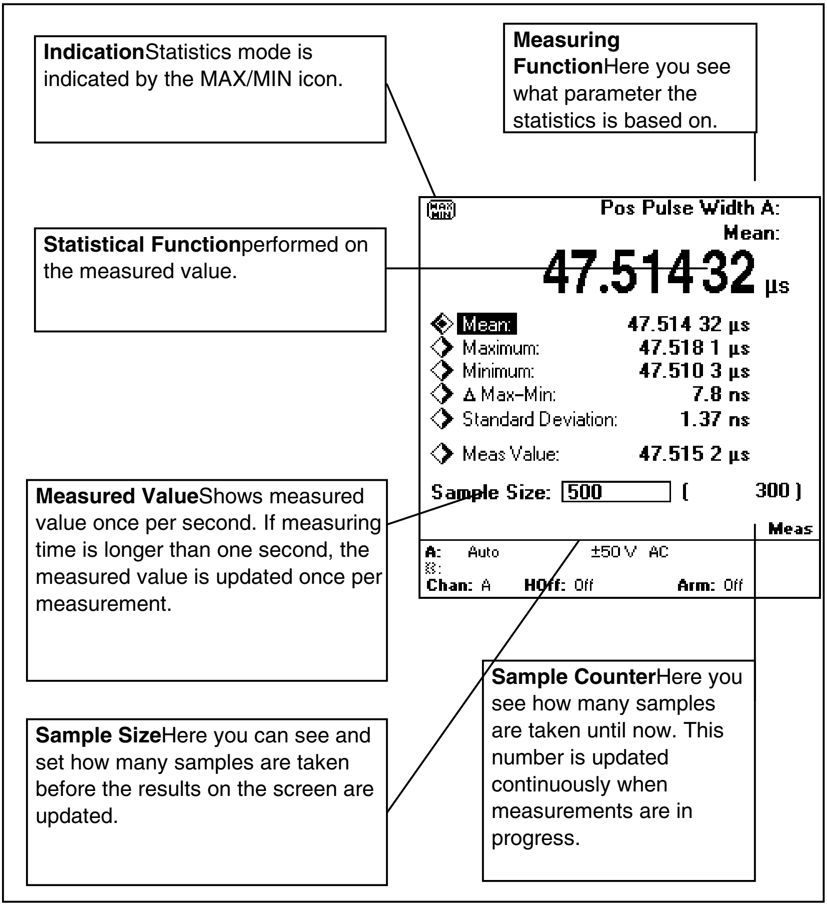


Figure 5 The STATISTICS screen.

Quick Input & Trigger settings

The bottom part of the display shows status information. These parameters are found in the INPUT TRIGGER menu.

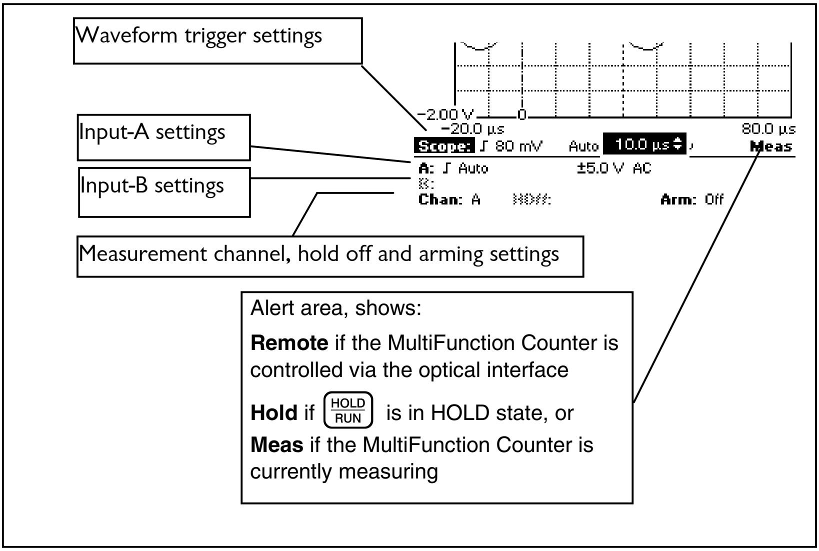


Figure 6 Interactive controls.

The most commonly used input settings can be changed directly in the display by moving the dark cursor to the parameter to be changed.

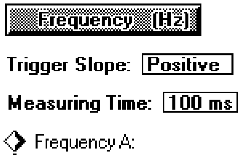
With the interactive controls you don't need to go via menus when you want to adjust Trigger level or Scope trace trigger, do it directly on the screen while watching the measurement results.

Above the horizontal line are Scope settings: trace trigger slope, trace trig level, and time/division. Below the horizontal line are the Counter settings: trigger level, trigger slope, voltage range, AC/DC settings, etc. At the very bottom you will find channel selection and measurement trigger information such as Hold Off and Arming.

ON-SCREEN CONTROLS

Apart from the keys on the front panel, the screen contains controls of four different kinds:

1. On screen buttons
2. List boxes
3. Numerical entries
4. Radio buttons (mutually exclusive buttons)



Moving the Cursor

To use the cursor, proceed as follows:

1. Press the arrow keys to move the black cursor from one on screen control to another. Unavailable selections are grayed, but you can still put the cursor on them and press to get an explanation of the control.
2. Press SELECT to select the parameter the cursor points at.
3. When your selection is made, leave by pressing the EXIT key.

Buttons

These controls look like buttons and you press them by positioning the cursor on them and then pressing SELECT. In this manual, the buttons will look like this:

List Boxes

A list box is an on-screen text that ends with a colon and a setting, for example **Voltage Range:±5.0 V.**

To make a selection in a list box, proceed as follows:

1. Put the cursor on the text. Voltage Range: ±0.5V
2. Press SELECT or ▶. A list with the available selections appears[1].

   ±50V
   ±5.0V
   Voltage Range: ±0.5V
3. Press ▲▼ to select the item you want from the list.

   ±50V
   ±5.0V
   Voltage Range: ±0.5V
4. Press EXIT, ◀ or ▶ to exit the list box.

   Voltage Range: ±5.0V

[1] In horizontally oriented menus, the list appears directly when you put the cursor on the text.

Numerical Entries

A numerical entry is almost like the list box, with the exception that a numerical value follows the colon.

To set a numerical value, proceed as follows:

1. Put the cursor on the text.

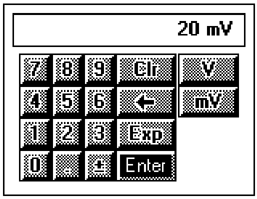

2. Press SELECT or ▶. An up/down arrow symbol appears to the right of the value.


3. Press ▲ to increase or ▼ to decrease the value in steps.


4. Press EXIT ◀ or ▶ to exit the numerical entry.


5. If you press SELECT directly after step 2, a keypad appears where you can fine-tune numbers.

Clr	Clears the number
←	Removes last digit
Exp.	Sets exponent
V, mV	sets suffix
Enter,	leaves keypad (Pressing EXIT will also leave the keypad)



Radio Buttons

Radio buttons are arranged like a table of text with a button to the left of each entry. Only one selection can be made.

Period A:	8.600 µs
Frequency A:	115.9 kHz
Pos Pulse Width A:	4.200 µs

To make a selection with radio buttons, proceed as follows:

1 Put the cursor on the text you want to select.

Period A:	8.700 µs
Frequency A:	115.5 kHz
Pos Pulse Width A:	4.300 µs

2 Press SELECT.

Period A:	8.700 µs
Frequency A:	115.5 kHz
Pos Pulse Width A:	4.300 µs

The button you select is depressed and any other previously selected button in the table is released.

CONVENTIONS

The following shortcuts are used in the procedure descriptions in this manual:

Press INPUT TRIGGER

This means that you should press and release the INPUT TRIGGER-*key* on the MultiFunction Counter.

Press Input A

This is a soft button in the display. For example "Press Input A" means that you should put the cursor on the soft button labeled "Input A" and press and release SELECT

Select **Timebase Reference: External**

This means that you should put the cursor on the text "Timebase Reference:", press SELECT , put the cursor on External in the list that appears, and press SELECT again. An alternative method is to put the cursor on "Timebase Reference" and press right arrow key, press up/down arrow keys until the cursor is on External, then press left arrow. Try this method; it is a very swift way of operating the list-boxes.

Set **Trigger Level: 2.5V**

This means that you should position the cursor on the text "Trigger Level", press SELECT and use up/down arrow-keys to increase/decrease the trigger level. You can also press SELECT twice when the cursor is on Trigger Level, and you will get a calculator style keypad where you can enter the value of your choice.

Select as Primary Parameter

This means that you should make a parameter display in large digits with full resolution at the top of the values screen display.

This is done in the values screen by positioning the cursor on the parameter that you want as primary, and pressing SELECT. This is explained in detail later.

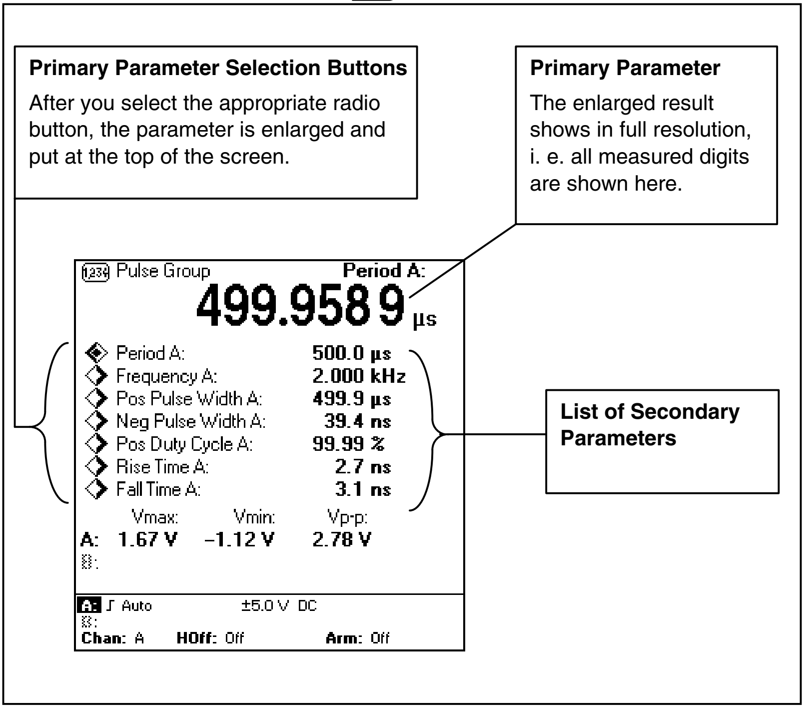


Figure 7 Selecting Primary Parameter.

CONVENIENCE KEYS

Figure 8 Position of the Convenience keys.

AUTO SET key

Make it a rule to press the green [AUTO SET] once after changing measuring function or changing input signal.

- One press on [AUTO SET] gives working settings for the measurements you are currently making.
- Double click [AUTO SET] (press twice quickly), will give a more extensive auto set by first presetting the MultiFunction Counter before the AUTO SET.
  The Preset performed turns on Auto trigger (see below), sets ideal Coupling, etc. It turns off all auxiliary functions like filter, arming and hold off. See **Table 4** on page 10-12 for the complete list.

When AUTO SET has determined the ideal settings, The MultiFunction Counter returns to measuring, and you can freely modify the setting.

TWO TYPES OF "AUTO"

AUTO SET key

Determines ideal settings for the current measurement once, then goes inactive until the next time the key is pressed.

Auto Triggering and Auto Scaling

When Auto Triggering is ON (as is the preset state), Auto Trig continuously checks the signal and sets correct trigger levels and hysteresis, before each measurement.

When Auto Time Scale is ON (as is the preset state), The Time/Division is set automatically so that the graph displays one to two cycles of the signal. (Volt/Division is always controlled automatically).

UNDO key

This key will undo the last selection made, that is, you change back to the previous setting. Pressing undo once more will return to the first setting again.

INFO key

Press the key whenever you need information about an on screen control. Information is given about the control that the cursor currently points at. To remove the Info window press again or press EXIT.

Note

"MORE ➢ " in the lower right corner shows that more Info pages are available and can be read by pressing .

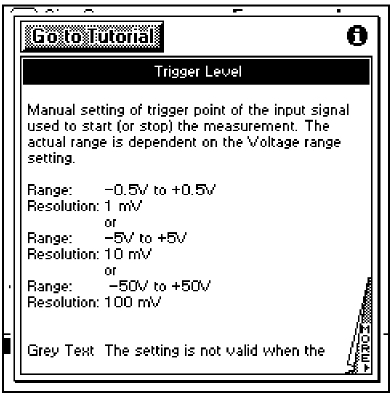


Figure 9 A typical Info Screen.

TUTORIAL

If you have questions about the MultiFunction Counter but don't have this manual available:

1. Press 
2. Press  to put the cursor on Tutorial
3. Press SELECT
4. Select a topic from the list.

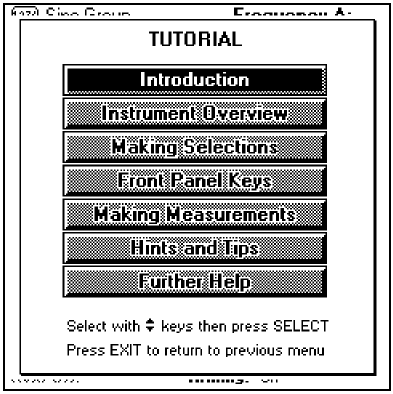


Figure 10 These topics are covered by the tutorial.

MEASUREMENT CONTROL KEYS

HOLD/RUN and RESTART keys

Figure 11 Measurement Control Keys.

HOLD RUN and RESTART are used to control the measurement progress of the MultiFunction Counter. When preset, the MultiFunction Counter measures continuously, that is, when one data acquisition is ready, a new data acquisition is automatically started, and the display is updated.

To use HOLD/RUN and RESTART, proceed as follows:

1. Press HOLD RUN to freeze the display.
2. The measurement result stays on the display until you start new captures by pressing HOLD RUN.
3. Pressing RESTART when the MultiFunction Counter is in hold will start one capture and then return to hold.
4. Pressing RESTART when the MultiFunction Counter is running will reset the results and start a new capture.
5. In STATISTICS mode, RESTART will start a new data capture of the set sample size.

Save/Recall key

SAVE RECALL will call up a menu where you can save 10 complete instrument setups and one screen copy.

SAVING A SETUP

1. Set up the MultiFunction Counter for the measurement you want to make.
2. Press SAVE RECALL.
3. Press Save Setup/Screen.
4. Put the cursor on a free memory location. You can see which locations are free in the Contents column of the Save Setup screen.
5. Press SELECT.

Now the setup is saved in battery backed-up memory.

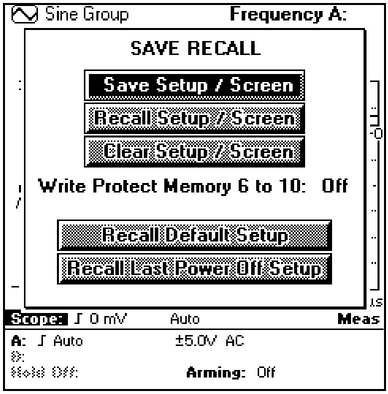


Figure 12 The SAVE/RECALL screen.

RECALLING A SAVED SETUP

1. Press SAVE RECALL.
2. Press Recall Setup/Screen.
3. Put the cursor on the memory location you want to recall. The Contents column shows the measurement function made by the saved setup.
4. Press SELECT.

Now the MultiFunction Counter is set up according to the saved setup.

CLEARING A MEMORY

1. Press SAVE RECALL.
2. Press Clear Setup/Screen.
3. Put the cursor on the memory you want to erase.
4. Press SELECT

Now that memory is cleared.

Note

You can save a new setup over an existing setup without first clearing the memory location.

PROTECTING MEMORY 6 TO 10

Memory locations 6 to 10 can be write protected like files on a diskette.

To activate memory protection:

1. Press SAVE RECALL.
2. Select : **Write Protect Memory 6 to 10: Yes**

To deactivate memory protection:

1. Press SAVE RECALL.
2. Select : **Write Protect Memory 6 to 10: No**

SAVING A SCREEN COPY

You can save the Waveform, Values or Statistics result screen.

1 Press SAVE RECALL.

2 Press Save Setup/Screen.

3 Put the cursor on Screen.

4 Press SELECT and the screen is saved

RECALLING THE SCREEN COPY

1 Press SAVE RECALL.

2 Press Recall Setup/Screen.

3 Put the cursor on Screen.

4 Press SELECT.

Now the saved screen is shown, see Figure 13.

Pressing any key will return the MultiFunction Counter to measuring.

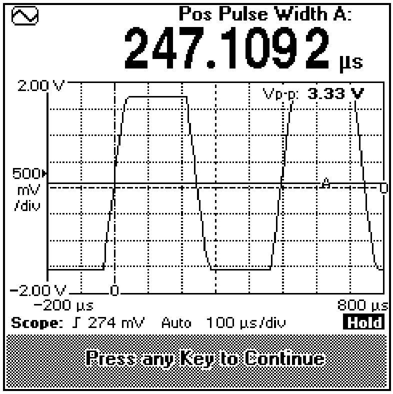


Figure 13 The bottom of the screen shows that this waveform is recalled from memory.

RECALL DEFAULT SETUP

This selection gives the MultiFunction Counter default setup as specified in **Table 4** on page 10-12. The difference from a Preset is that the measuring channels are set to Input A as Primary Channel and Input B as secondary Channel, the measurement function is set to Sine-type Signal Characterization, and the Presentation Mode is set to Waveform.

RECALL LAST POWER OFF SETTINGS

Recalls the settings the MultiFunction Counter had when turned on.

Chapter 3
Tutorial

Contents **Page**

INTRODUCTION

This part of the manual describes how you perform some common measurement tasks. These are not actual application notes, but more general solutions.

The topics are:

- Characterizing a signal
- Characterizing pulses
- Selecting a single function measurement
- Measure relations between two signals
- Time Interval between two channels
- Time Interval on one Channel
- Capturing single shot events

You will get the most out of these exercises if you have signals of your own to measure. If not, use signals generated on the MultiFunction Counter output.

In the exercises that follow, remember the following:

- Use MEASURE FUNCTION to select either a specific measuring function (single function) or a signal type for signal characterization.
- Select or 1.234 to choose waveform or values presentation mode.
- Press AUTO SET after change of function or change of signal.[2]
- Press whenever in doubt.

[2] Note: One press (single-click) auto-sets trigger level, voltage range and waveform time/div. Settings.

Two presses (double-click) PRESETS the MultiFunction Counter to optimal pre-defined input and trigger settings. A preset will turn off settings like filter, arming, hold-off and mathematics.

Exercise Setup

You'll need a MultiFunction Counter (any configuration), a T-Piece and two BNC cables. One cable should be long, a 2 m cable is suggested. If you use a different cable length, you can still do these exercises, but your measurement results for two channel measurements will differ from the results in the VIEW RESULT figures.

1. Put the T-piece on Input A of the MultiFunction Counter.
2. Connect the short cable between the T-Piece and the output.
3. Connect the long cable between the T-Piece and Input B.

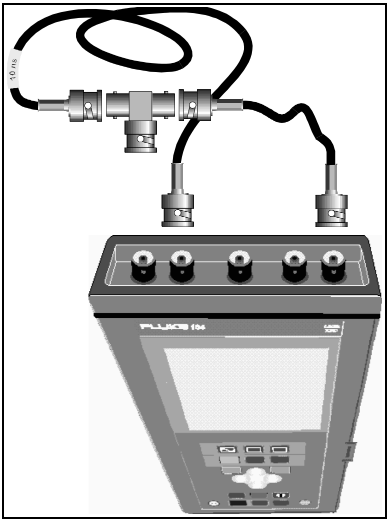


Figure 14 Exercise Setup. Connections for using the built-in generator for the exercises that require a pulse signal.

START WITH DEFAULT SETTINGS

1. Turn on the MultiFunction Counter.
2. Press SAVE RECALL
3. Put the cursor on Recall Default Setup.
4. Press SELECT.

GENERATING A PULSE SIGNAL AT THE OUTPUT

Normally no signal is present on the output, so you must turn it on.

Then follow the SETUP instructions below.

New instructions appear in the text whenever you need to change the signal.

1. Press: USER OPTIONS Output.
2. Select: **Output: On**.
3. Select: **Output Signal: 2kHz, Probe Adjust**.
4. Press EXIT EXIT (or press USER OPTIONS again to exit User Options menu).

CHARACTERIZING A SINEWAVE SIGNAL

The first task is to find out the basic parameters for an unknown signal. This is a simple task with the MultiFunction Counter.

Connect the signal

Normally you connect the signal to Input A. (For exercise, use a 3 Vp-p, 2 kHz signal from a Sinewave generator.)

Figure 15 Connect the signal to Input A.

View Values list

1. Press: MEASURE FUNCTION Sine SELECT
   Note that the presentation mode is automatically changed to "VALUES", so you don't have to press 1.234
2. Press AUTO SET AUTO SET (double-click) to set a wide hysteresis band for maximum noise rejection.

The Sine-group fits all continuous signals. A typical Sine Group Screen is shown in Figure 16.

You get Frequency, Period, Vmax, Vmin, and Vp-p in one and the same screen, and all measured values are updated regularly.

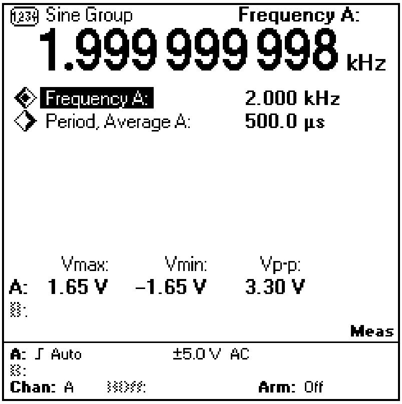


Figure 16 Signal Characterization. "Sine" gives a list with two values plus three voltage readings.

View waveform

1. Press: .
   After a few seconds you see the signal waveform on the screen as in Figure 17.
2. If necessary, press AUTO SET to optimize the graph settings for the connected signal.

If the signal displays properly no other adjustments need to be done. Pressing Auto Set also selects an automatic time/division setting that displays the signal properly.

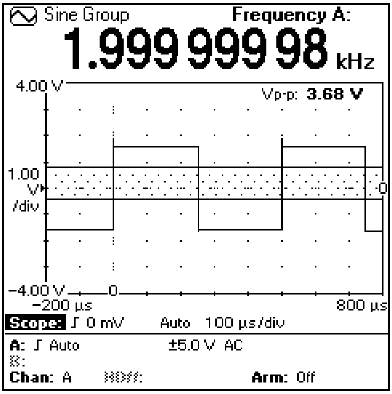


Figure 17 Results screen in WAVEFORM mode.

Additional selections

1. Press 1.234 to go to Values Screen.
2. Select primary parameter by positioning the cursor on Period Average A and pressing SELECT. This way you will get Period instead of Frequency as "Primary Parameter" in full resolution at the top of the screen. See Figure 18.

Note

The peak voltage parameters are always shown in full resolution, and cannot be selected as primary parameter in this screen. You can, however, select them as measurement function from the MEASURE FUNCTION menu.

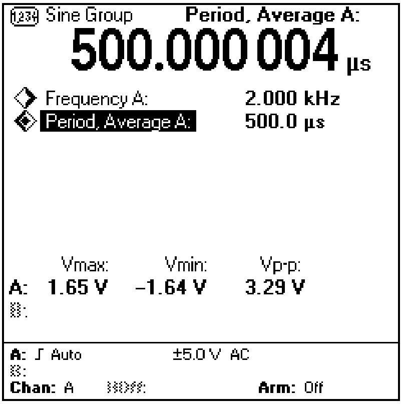


Figure 18 Period in full resolution.

CHARACTERIZING PULSES

Connect the pulse signal to Input A. (For exercise, use setup in Figure 14 which gives a 2 kHz square wave.)

Select Pulse Signal Type

1 Press MEASURE FUNCTION.

2 Press Pulse.

3 Press ∿.

4 Press AUTO SET AUTO SET (double-click).

Now you see the signal waveform on the screen. ”AUTO SET with PRESET” optimizes the settings for the connected signal. For Pulse signals this means minimum hysteresis width and DC coupling for accurate time measurements.

If the signal displays properly, no other adjustments need to be done. If not, see “Input Trigger Settings” in this manual.

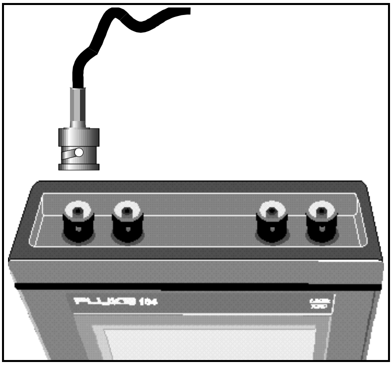


Figure 19 Connect the signal to Input A.

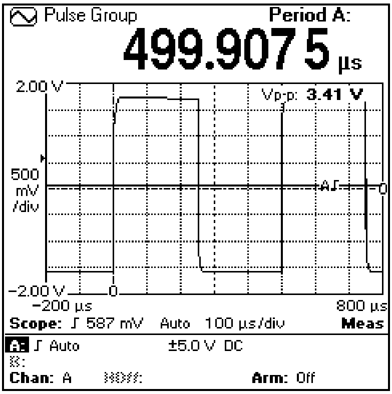


Figure 20 Results screen in WAVEFORM mode.

View Results

1. Press 1.234.

In a Pulse Group Screen (see Figure 21) you can see a list with the most common pulse parameters on screen at the same time.

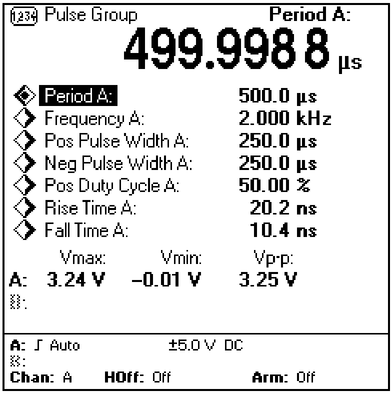


Figure 21 The VALUES screen for Pulse Signal type.

Additional selections

You can select another “Primary Parameter" to display, in the same way as described under “Characterizing a Sine-wave Signal" previously in this exercise.

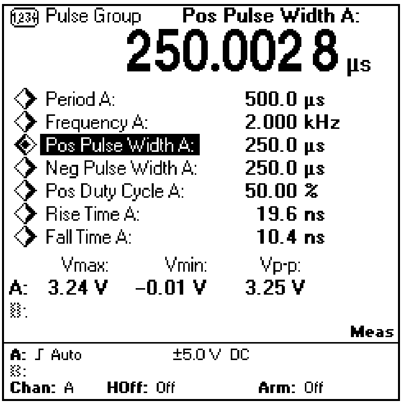


Figure 22 Primary Parameter. Positive Pulse Width selected as Primary Parameter.

SELECTING A SINGLE FUNCTION MEASUREMENT

Sometimes it is confusing to have many parameters on the screen at the same time, and at other times you want to make adjustments and need the fastest screen update possible. Then you select a single function from the left column in the Measure Function menu. In this example we select RPM, revolutions per minute:

1 Press MEASURE FUNCTION.

2 Select More Functions.

3 Select RPM.

Now the result is shown as RPM. (The 2 000 Hz from the test signal equals 120 000 RPM.)

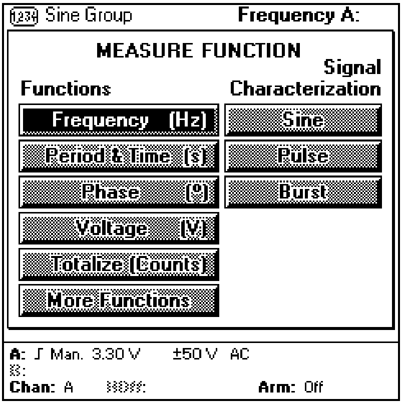


Figure 23 Measure Functions. The left column, FUNCTIONS, contain 26 different measuring functions in submenus.

In a real life situation the RPM transducer may produce several pulses/rev. If so, the transducer scaling factor can be set to obtain a correct RPM reading. Try it yourself!

1 Press MEASURE FUNCTION.

2 Select More Functions.

3 Set Pulses/Rev: 500

4 Select RPM.

The display now shows 240 rpm.

1. Press 1.234 to see only the result of the single measurement.

2. Press (waveform key) to see the result of the measurement as well as the waveform on the same screen.

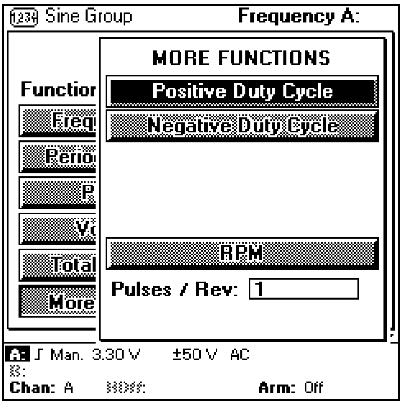


Figure 24 Select RPM from the more functions menu.

MEASURE RELATION BETWEEN TWO SIGNALS

The MultiFunction Counter can measure time interval, phase angle and frequency ratio between a signal on one input and another signal on the other input. It can also measure time between two events on the same input.

Connect the two signals

Connect the measuring signal to the primary channel (normally Input A) and the reference to the secondary channel (normally Input B).

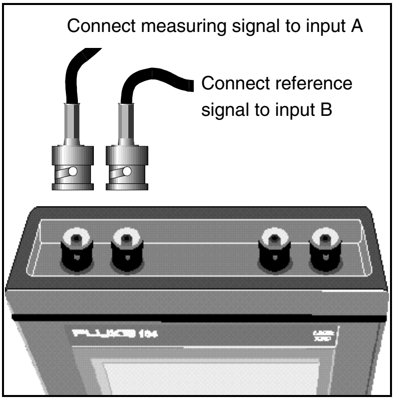


Figure 25 Connections for two-channel measurements.

Phase measurements are almost always made on sinewave signals. But sinewave generators seldom have dual outputs with selectable phase delay. So for this exercise, use the setup in Figure 14 but also put 50Ω terminators on Input A and Input B to get a clean signal without reflections.

1. Press USER OPTIONS.
2. Select Output.
3. Select Output signal: 1 MHz, Square and press SELECT.

This setup gives 10 ns (3.6°) between Input A and Input B.

Select Phase Group

1. Press MEASURE FUNCTION.
2. Select. Phase.
3. Select Phase Group.
4. Press AUTO SET AUTO SET (double-click).

View Results

Now you will see both phase, frequency of the reference signal, and frequency-ratio at the same time, See Figure 26.

The phase will be shown in respect to the secondary channel, so if the pulse in the primary channel comes before the pulse on the secondary input, the phase will be positive, and vice versa.

Note

Ratio must be 1.000, otherwise the phase measurement makes no sense.

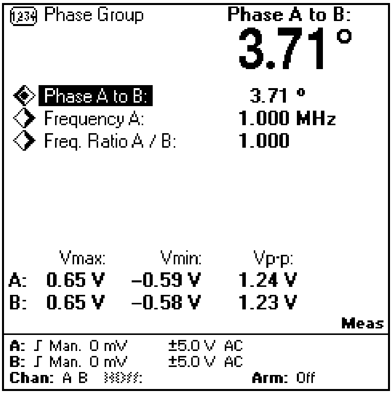


Figure 26 The Phase Group. Shows both Phase, Frequency and Ratio.

View signal

Press: .

Now you see both signal waveforms on the screen. AUTO SET optimizes the graph settings for the connected signals. If the signals display properly no other adjustments need to be done. If not, see ”

Input Trigger” Chapter.

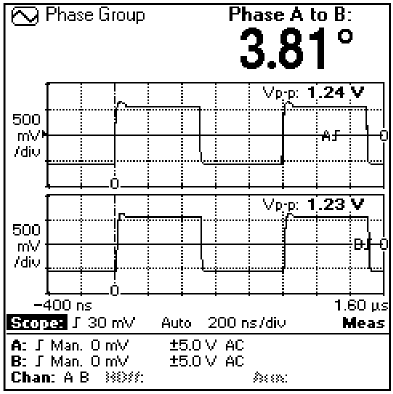


Figure 27 Both channels are shown in waveform mode.

In Figure 27 the phase delay is hardly visible, so we need to zoom in on the signals:

1. Put the cursor on 200 ns/div.
2. Press until 20 ns/div.

Now you see the phase delay clearly, see Figure 28.

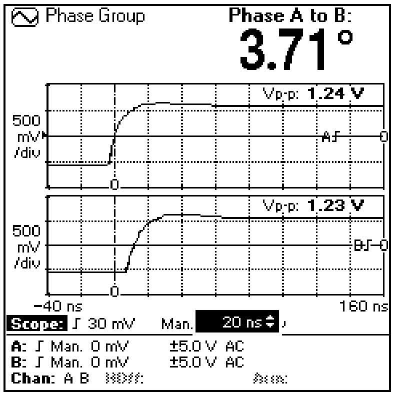


Figure 28 Zoom in on phase delay.

TIME INTERVAL BETWEEN TWO CHANNELS

Another two channel measurement in the MultiFunction Counter is Time Interval. We use the 10 MHz output signal.

1. Press USER OPTIONS.
2. Select Output.
3. Select Output signal: 10 MHz, Reference and press SELECT.

Put 50Ω terminations on Input A and Input B to get a clean signal without reflections.

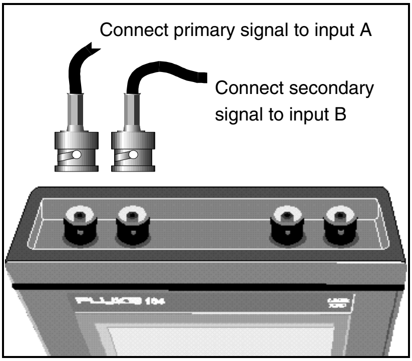


Figure 29 Connect like this for two-channel measurements.

Select Time Interval

1. Press MEASURE FUNCTION.
2. Select Period & Time (s).
3. Select Time Interval.
4. Press INPUT TRIGGER.
5. Press Measure Channels.
6. Select A, B
7. Press AUTO SET AUTO SET.

View Waveform Screen

The time between a trigger on the primary channel and a trigger on the secondary channel is measured. Normally, the primary channel is Input A and the Secondary channel is Input B, which makes the MultiFunction Counter measure Time Interval A to B.

Note that the trigger levels for both signals are visible on screen (horizontal lines).

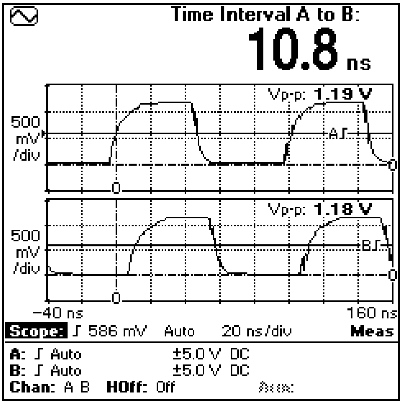


Figure 30 The time between the pulse on Input A and the pulse on Input B is about 10ns.

TIME INTERVAL ON ONE CHANNEL

By setting also the Secondary Channel to Input A, the MultiFunction Counter will measure Time Interval A to A. In this case the trigger level and trigger slope for Input B are used to set the stop trigger point on Input A.

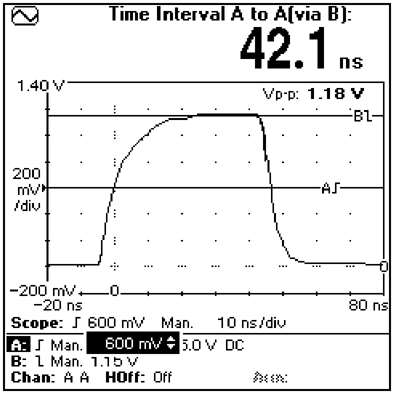


Figure 31 Select Input A as secondary as well as primary channel.

Connect the signal

Use the setup from the previous exercise.

Select Input A for both channels

1. Press INPUT TRIGGER.
2. Select Measure Channel(s).
3. Select A, A (Common).
   Note that this selection is only available when a two channel measurement like Time Interval is currently selected.

Set the Trigger Levels

Turn off Auto Trig for both channels. Select the time you want to measure by positioning Cursor A on the start point with Input A trigger level setting.

Position Cursor B on the stop point using the trigger level setting for Input B. Select start and stop trigger slope with the Input A and Input B slope settings.

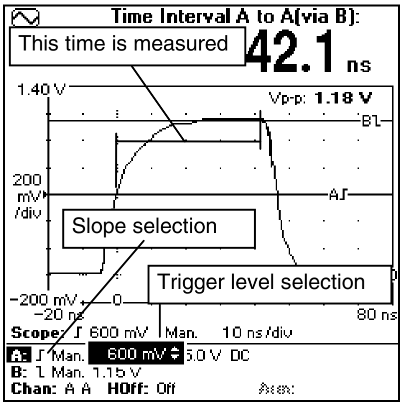


Figure 32 The time between the start trigger cursor (A) and the stop trigger cursor (B) is 42.1 ns.

MEASURING SINGLE SHOT EVENTS

The MultiFunction Counter can measure single pulse widths and periods. However, there exist limitations:

- The MultiFunction Counter cannot adjust itself to the measuring signal since there is no signal present to adjust to, so AUTO TRIG will not work.
- The MultiFunction Counter can only measure one parameter. The help parameters Vmax, Vmin and Vp-p will not be measured since they require a continuous signal.
- Signal characterization does not work for single shot events.
- The MultiFunction Counter cannot show the waveform of a single shot event.

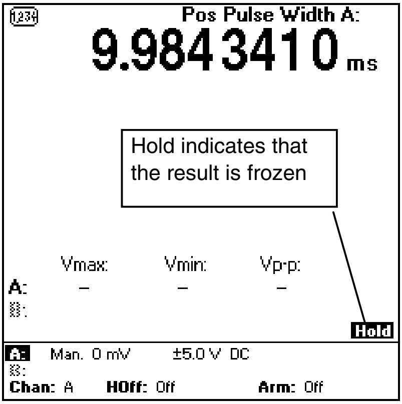


Figure 33 Single Shot.
Only the Pulse Width reading is shown, no voltage readings are possible for single shot events.

Connect the signal

Connect the signal to Input A (For exercise, use a pulse generator with Repetition Time set to Single Shot and Duration to 10 ms).

Turn off Auto Trigger and set Trigger Level Manually

1. Press INPUT TRIGGER.
2. Select Input A.
3. Select **Auto Trigger: OFF.**
4. Set Trigger Level to the desired level, in this example we use 0 V.
5. Select **Trigger Level: 0 mV**.
6. Press 1.234.

Select Pulse Width Measurements

1. Press MEASURE FUNCTION.
2. Select Period & Time (s).
3. Press Positive Pulse Width.

Capture the Single Event

1. Press HOLD RUN so that the MultiFunction Counter is in hold state (HOLD is shown in the display above the horizontal line separating the results screen from the input settings field, see Figure 33).
2. Press RESTART and the MultiFunction Counter is armed and will capture the next pulse that appears on the input, and then return to hold state.
3. Generate one pulse from the pulse generator.

Read Results

Now you will read the Pulse Width of the single event on the screen.

Chapter 4
Measure Functions

Contents **Page**

INTRODUCTION

This part of the manual describes how you select the parameter(s) to measure.

Each measurement function is described along with what it measures and what settings affect the measurement.

The chapter is divided into the following parts:

- Selecting Functions
- Frequency (Hz)
- Period & Time (s)
- Phase (°)
- Voltage (V)
- Totalize (Counts)
- More functions

The order of descriptions is the same as the order in the menu that appears when you press the MEASURE FUNCTION -key.

After reading this chapter you will know what the MultiFunction Counter can measure and how to select the functions.

SELECTING FUNCTIONS

Select what to measure by pressing the MEASURE FUNCTION key. A screen appears with two columns with the headlines: **Functions** and **Signal Characterization.**

Single Functions

Select the type of function you want by positioning the cursor on Hz, s, °, V etc., for example press Period & Time (s) and SELECT.

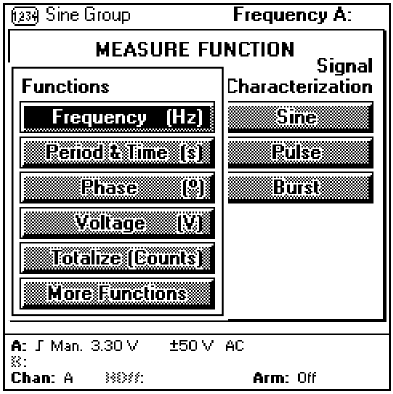


Figure 34 The left column contains Function types.

Make your final function selection by putting the cursor on for instance Rise Time, and pressing SELECT.

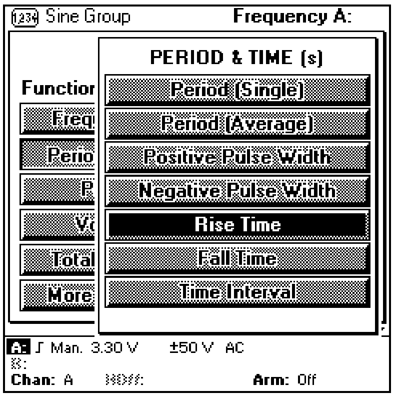


Figure 35 Making Final Function Selections.

Signal Characterization

Signal characterization gives all necessary data to describe a signal.

The number of parameters required to describe a signal varies with the signal shape. A sine signal is easily described by giving frequency and amplitude, while a pulse signal also needs rise/fall times and duty cycle to be accurately described.

The results from signal characterization are only shown in VALUES mode (when 1.234 has been pressed). Select a signal type and the MultiFunction Counter shows you all the relevant parameters on the screen simultaneously.

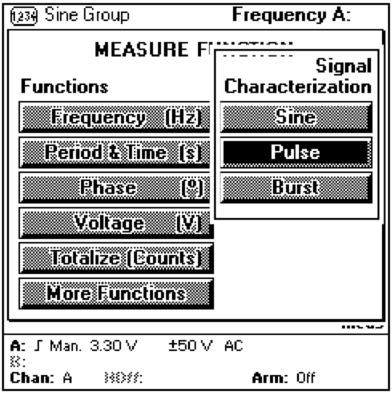


Figure 36 The right column of the Measure Function menu contains Signal types.

Sine gives you Frequency, Period, and positive and negative peak voltage of any continuous signal.

Pulse gives you Period, Pulse Width, Duty Factor, Rise/Fall-time, and positive and negative peak voltage.

Burst gives you Burst Frequency, Burst Repetition Rate and positive and negative peak voltage.

1. Position the cursor on the signal type you want.
2. Press SELECT to select the signal type and start measuring.

One parameter is always the primary parameter that is enlarged at the top of the display. You can select primary parameter by putting the cursor on it and pressing SELECT The radio button in front of the parameter will be depressed and its result enlarged at the top. The primary parameter is measured with higher resolution and this parameter will be analyzed if you press MAX MIN and shown if you press ∿.

FREQUENCY (Hz)

Frequency

Frequency is the number of cycles/second in a repetitive signal. The MultiFunction Counter measures the period time of the signal and calculates the frequency as:

$$Frequency = \frac{1}{Period}.$$

Resolution is set via measuring time under INPUT TRIGGER.

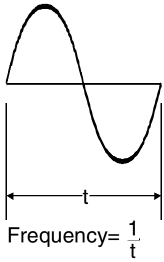


Figure 37 Frequency definition

Auto Trig selects 50% trigger level and 33% hysteresis for Frequency.

Frequency Ratio

Frequency ratio shows the relation between two frequencies:

$$Ratio = \frac{Primary\ \ Channel\ \ frequency}{Secondary\ \ Channel\ \ frequency}$$

.

In the MultiFunction Counter both frequencies are measured simultaneously in real time, so the result is always correct. You can use this to verify that logic dividers and rotary encoders work correctly, for example.

Always connect the lowest frequency to the secondary channel.

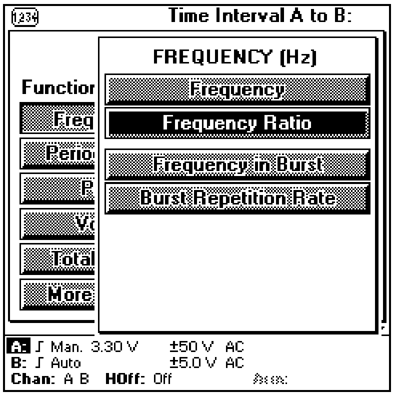


Figure 38 The FREQUENCY menu.

Frequency in Burst

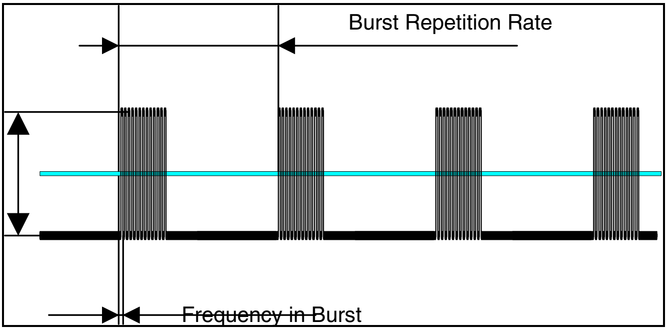


Figure 39 These parameters are measured in a burst.

This is the frequency within the actual burst.

Note that correct results require correctly set burst timing parameters in the INPUT TRIGGER menu. Pressing AUTO SET will set these correctly in most cases.

Burst Repetition Rate

This is the frequency at which the bursts repeat themselves.

Table 1 Signal requirements for successful burst measurements.

	Input A and B		Input C	
	Min. no. of cycles	**Min. Burst Duration**	**Min. no. of cycles**	**Min. Burst Duration**
Internal Sync. AUTO SET	6	0.5 µs	192	50 µs
Internal Sync. Man	4	0.5 µs	128	50 µs
External Sync.	2	-	128	-

PERIOD & TIME (S)

Period (Single)

That is the time for one cycle of the waveform. Single means that one single period is measured and the result is displayed.

Auto Trig selects 50% trigger level and minimum hysteresis for Period Single.

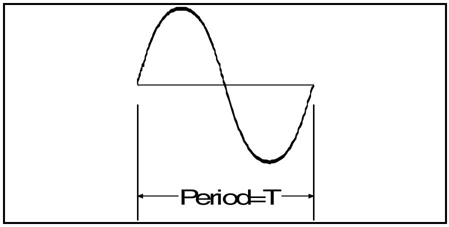


Figure 40 Period, Single.

Period (Average)

Here the period of many cycles are measured and the average period is calculated and displayed. Period average increases the resolution of the period measurement. The number of periods that are used in the averaging process is set by the measuring time. Longer time gives more cycles which gives more digits.

You find the measuring time in the Input Trigger menu.

Auto Trig selects 50% trigger level and 33% hysteresis for Period Average.

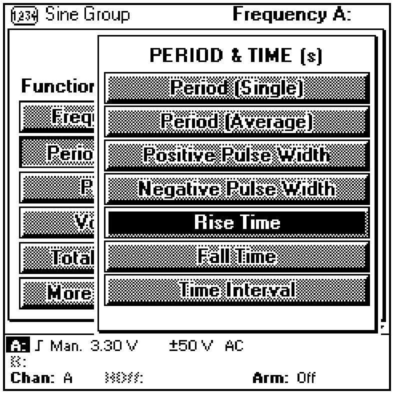


Figure 41 The PERIOD & TIME menu.

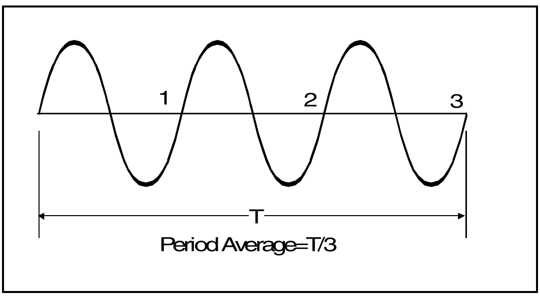


Figure 42 Period Average shows the average of several periods

Positive Pulse Width

This is the time from when a positive pulse passes the trigger level, until it returns to the trigger level again. Auto Set sets the trigger level to 50% of the amplitude.

Negative Pulse Width

This is the time from when a negative pulse passes the trigger level, until it returns to the trigger level again.

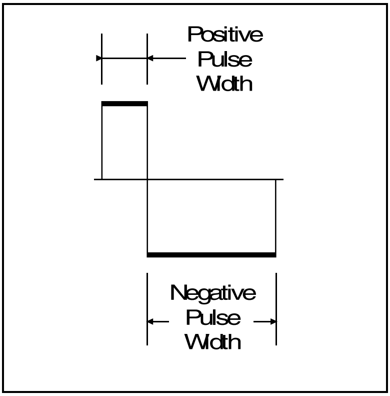


Figure 43 Definition of pulse width.

Rise Time

This is the time from when a rising (positive going) edge passes 10% of the amplitude, until it reaches 90% of the amplitude.

Fall Time

This is the time from when a falling (negative going) edge passes 90% of the amplitude, until it reaches 10% of the amplitude.

Note

Rise/Fall time as single function has both auto and manual trigger levels.

As part of the Pulse Group, Rise/Fall time only uses automatic trigger levels.

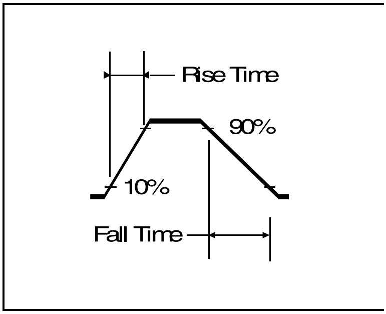


Figure 44 Definition of Rise and Fall-time.

Time Interval

This is the time between an event on the primary channel to an event on the secondary channel. By selecting for instance Input A for both primary and secondary channel you can measure between any two events on a signal.

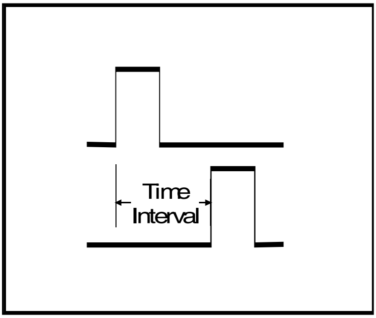


Figure 45 Time Interval.

PHASE (°)

Phase is the time between a signal on the primary channel, and a signal of *equal frequency* on the secondary channel, expressed in degrees of the period.

The phase will be shown with respect to the secondary channel, so if the pulse on the primary channel comes before the pulse on the secondary channel, the phase will be positive, and vice versa.

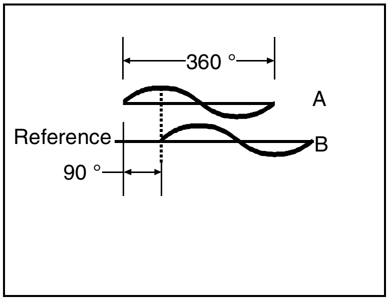


Figure 46 Phase.

Note
AC-coupling (Preset) is ideal for phase measurements on sine and other symmetrical signals. Use DC-coupling and manual trigger levels for pulse signals.

Phase

Phase gives only phase on the display.

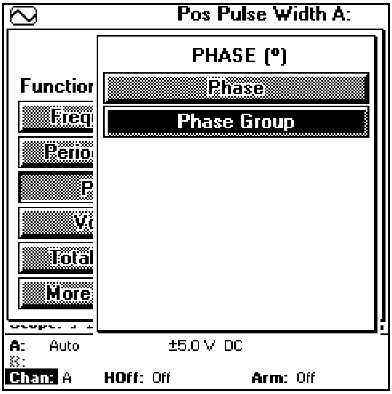


Figure 47 The Phase Menu.

Phase Group

Phase Group will give Phase plus a number of help parameters that are useful when measuring Phase. These Parameters are as follows:

FREQUENCY

Shows the frequency of the signal you measure phase on.

RATIO

Ratio shows you if both signals have equal frequency. Only at a ratio of 1 you successfully measure phase.

VOLTAGE

Amplitude for both Input A and Input B signals are shown. This is ideal for filter measurements: You can read both phase and attenuation in one and the same measurement.

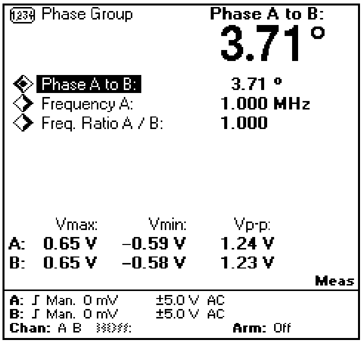


Figure 48 The Phase Group Screen.

VOLTAGE (V)

Voltages can be measured on Input A and B, *not* on Input C.

Always use a filter on all signals up to 1 kHz in voltage measurements.

VRMS AC

Shows the rms value of the ac component of the signal. The MultiFunction Counter samples the waveform of the signal and calculates the Vrms from the waveform data. This gives accurate rms values for any waveform that is correctly displayed.

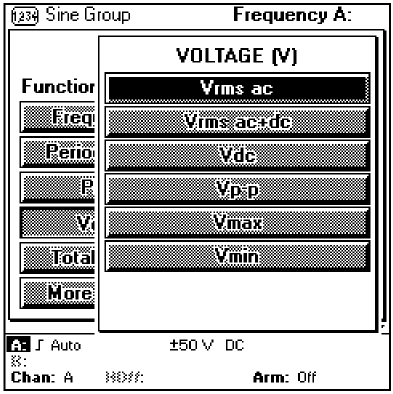


Figure 49 The Voltage Menu.

Note
Use VALUES mode for Vrms. If you select WAVEFORM mode with Vrms selected, the MultiFunction Counter will sample the signal once to update the graph, and once again to calculate Vrms, which doubles the update time.

VRMS AC+ DC

Shows the rms value of the ac and dc components of the signal. The measurement is made in the same way as Vrms AC.

VDC

Shows the dc value of the signal. Vdc is done on sampled waveform data, as Vrms.

VP-P

Shows the peak-to-peak voltage of the signal. This measurement is made by the auto trigger circuitry of the MultiFunction Counter and is the same voltage presented as a help parameter in the lower part of the values display in all measurement functions, and appears in the right corner of the waveform graphs.

VMAX

Shows the maximum (positive peak) voltage of the signal. The measurement is done in the same way as Vp-p.

VMIN

Shows the minimum (negative peak) voltage of the signal. The measurement is made in the same way as Vp-p.

TOTALIZE (COUNTS)

Counts positive or negative edges on the primary channel. You select which edges to count by selecting trigger slope on the primary channel.

The totalizing screen shows counts on A and Counts on B, as well as the difference and sum of these parameters simultaneously on screen in Manual Hold/Run and gated by time modes.

When the MultiFunction Counter is in hold, you can see each result in full resolution by selecting it as primary parameter.

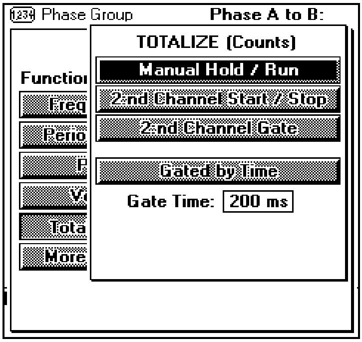


Figure 50 The TOTALIZE menu.

Note
Statistics is not available for Totalize.

Manual Hold/Run

1. Here you start the totalizing by pressing HOLD RUN.
2. The MultiFunction Counter counts each pulse until you press HOLD RUN again.
3. If you repeat the steps above, the new counts will be added to the previous ones.
4. Pressing RESTART resets the value to 0.

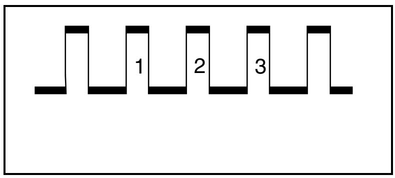


Figure 51 Totalize manually.

2:nd Channel Start/Stop

Here a pulse on the secondary channel starts the counting of pulses on the primary channel, and the next pulse stops the counting. The result is displayed and then reset. You can select if positive or negative edges should start/stop the signal by selecting trigger slope on the secondary channel.

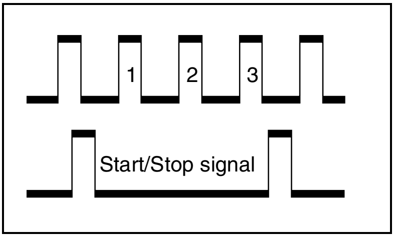


Figure 52 Totalize start/stop.

2:nd Channel Gate

Here an edge on the secondary channel starts the counting of pulses on the primary channel, and the opposite edge stops the counting. The result is displayed and then reset. You can select if positive or negative edges should start the measurement by selecting trigger slope on the secondary channel.

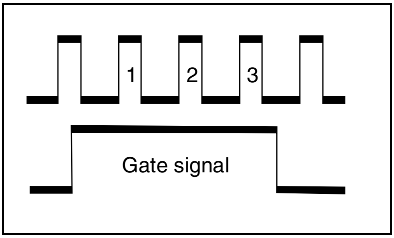


Figure 53 Totalize Gated.

Gated by Time

A timer in the MultiFunction Counter determines how long the gate is open.

The gate opens immediately (unsynchronized start) and closes again when the set time expires. The result is displayed and reset and a new cycle is started.

You can count positive or negative edges by selecting trigger slope on the primary channel.

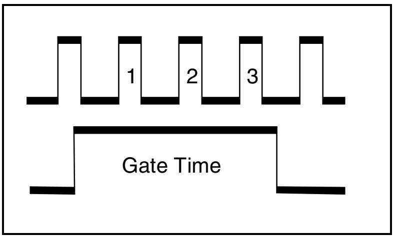


Figure 54 Totalize Timed.

MORE FUNCTIONS

These are functions that do not give results in Hz, s, degrees, or volt.

Positive Duty Cycle

Shows the percentage of a cycle that is “High”.

Negative Duty Cycle

Shows the percentage of a cycle that is “Low”.

RPM

Shows Revolutions per minute. Here you can enter the number of pulses that the transducer gives for each revolution to get a correct RPM readout.

For example, when measuring the RPM on a normal car engine, 2 pulses/rev. gives correct RPM for 4-cylinder engines, while 3 pulses/rev. gives correct RPM for 6-cylinder engines, and 4 pulses/rev. gives correct RPM for 8-cylinder engines, provided the ignition pulses are used as the indirect signal source.

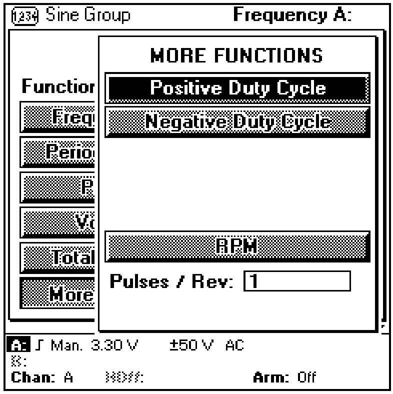


Figure 55 The MORE FUNCTIONS menu.

Chapter 5
Input Trigger

Contents **Page**

INTRODUCTION

This chapter is divided into two sections:

1. The INPUT section describes the basic concept of trigger levels and hysteresis, and how to use the input trigger settings to obtain the best timer/counter measurements.
2. The TRIGGER section describes measurement trigger. It starts with simple measurement control via the HOLD/RUN and RESTART keys; then it advances to arming, hold-off and burst synchronization.

The “Scope” settings that you access through the INPUT TRIGGER key are thoroughly described in Chapter 7.

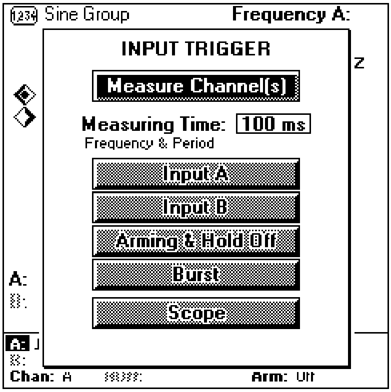


Figure 56 The INPUT TRIGGER Menu.

SELECTING MEASURING CHANNEL

With default settings[3], the MultiFunction Counter measures on Input A (primary channel) and uses Input B as secondary channel in two channel measurements.

On units with prescaler, Input C will be available for Frequency, Period or Ratio measurements.

1. Press INPUT TRIGGER and select Measure Channel(s) to change channel.

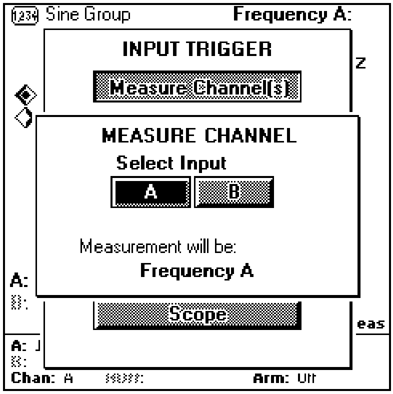


Figure 57 Channel selection in the Input Trigger menu.

Quick Selection

In the quick menu at the bottom of the display you can change channel without entering any menu.

Figure 58 Select input with Chan:

[3] To get Default Settings, press and select Recall Default Setup.

Two-Channel Measurements

If a two-channel measurement function like Time Interval, Phase or Ratio is selected, the Measure Channel Menu changes to include two-channel selections.

The indication ”Measurement will be:” shows how the inputs are used with the current Measure Function selection.

Common means that one input connector will be used for both measuring channels. That is A,A means that the Input A BNC connector is internally connected to both the Primary and the Secondary Channel. Input A settings are used for the Primary Channel and Input B settings are used for the Secondary Channel.

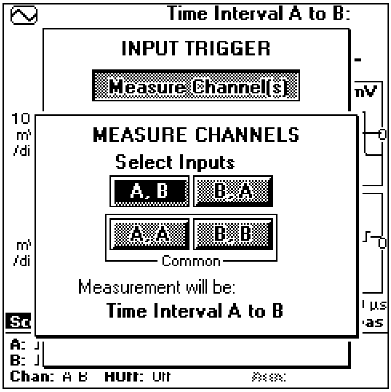


Figure 59 Two channel measurement gives Common selections.

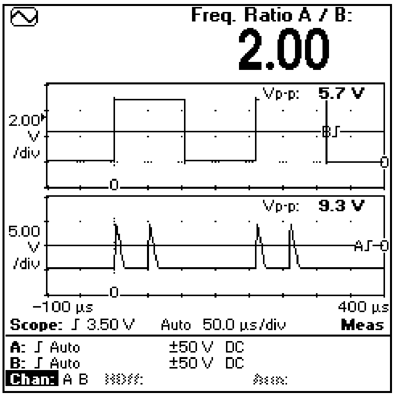


Figure 60 Channel selection in the quick menu.

The left position is Primary Channel and the right position is Secondary Channel.

INPUT A AND INPUT B

Trigger Level & Hysteresis

All measurements in the MultiFunction Counter are based on the assumption that you can set a trigger level that gives a unique trigger point for the part of the signal that you want to measure. For example, this means that a Period or Pulse Width measurement starts when the signal passes the trigger level, and stops again when the trigger level is passed again.

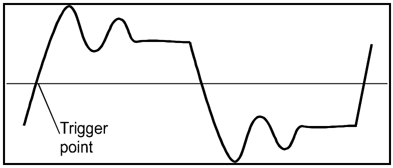


Figure 61 Signal with unique trigger point.

The trigger level is surrounded by a "dead zone" called the hysteresis band. The signal needs to cross the 20 mV[4] hysteresis band, before triggering occurs. Other names for trigger hysteresis are 'trigger sensitivity' or 'noise immunity', which explain the various characteristics of the hysteresis.

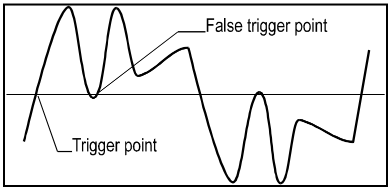


Figure 62 This signal has no unique trigger point.

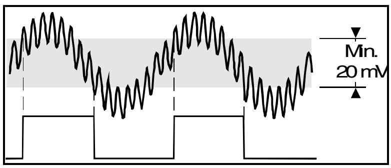


Figure 63 Hysteresis band ensures correct triggering.

[4] The hysteresis band is 200 mV in the ±50 V range. A wider hysteresis band is used for frequency, period average and RPM measurements when Auto Trigger is ON.

Input Amplifier

The input amplifiers are used to adapt measuring signals to the measuring logic of the MultiFunction Counter. These amplifiers have many controls and it is essential to understand how these controls work together and how they affect the signal. The block diagram below shows the order in which the different controls are connected.

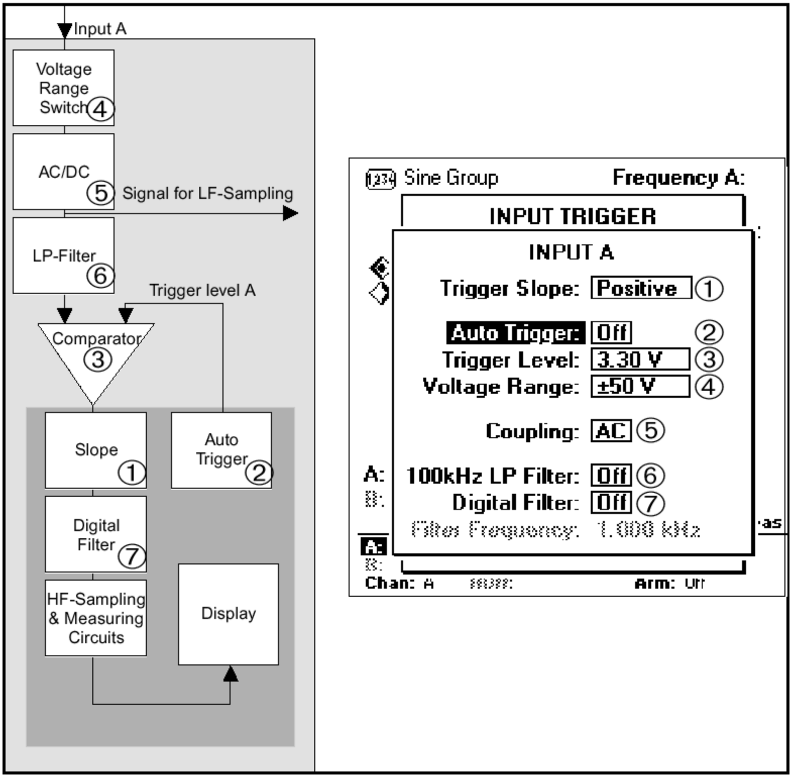


Figure 64 Input Amplifier Block Diagram.
This is not a complete technical diagram. It is only intended to help you understand the controls in the description that follows.

Impedance

The input impedance of Input A and Input B is fixed at 1M Ω, and for Input C it is 50 Ω. Should you need 50 Ω also for Input A and Input B, use a 50 Ω termination on the BNC connector, e.g. PM9581 from Pendulum.

WARNING

Never connect the MultiFunction Counter to signals above 30Vrms above ground, not even when using safety designed BNC connectors, feed-through terminations, coaxial attenuators (PADs) etc.

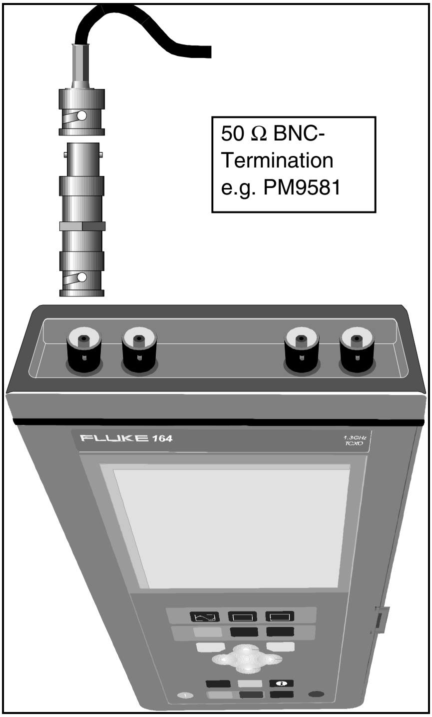


Figure 65 Select the input impedance you want by putting terminations on the BNC connectors.

Voltage Range

The voltage range setting (±0.5 V, ±5V or ±50 V) determines the range and resolution of the trigger level setting, and the sensitivity.

Select voltage range as follows:

INPUT TRIGGER Voltage Range: 5 V

Pressing AUTO SET selects a voltage range based on the amplitude of the input signal.

You can read and change the voltage range in the quick menu in the lower part of the screen.

ATTENUATOR

If you are used to traditional Timer/Counters, which have X1/X10 attenuators, the 0.5 V and 5 V ranges equals attenuation X1, and the 50 V range equals attenuation X10.

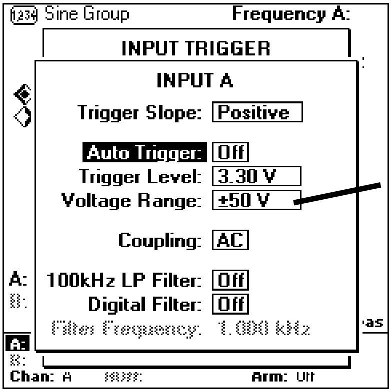


Figure 66 Voltage Range setup. Note that Auto Trigger only operates within the selected Voltage Range. To change Voltage Range, you must press AUTO SET, or set range manually.

WARNING

Never connect a MultiFunction Counter to signals more than 30Vrms above ground; not even with Safety-Designed probes.

Using a probe may be erroneously interpreted as though you can measure on 10x as high voltages. Lethal voltages may appear on the unshielded BNC connector of the MultiFunction Counter if measuring on high voltages.

Auto Trigger

With Auto Trigger on, the MultiFunction Counter automatically measures the peak-to-peak levels of the input signal and sets the trigger level to 50% of that value.

Turn on Auto trigger as follows:

INPUT TRIGGER | Input A | **Auto Trigger: ON**

You turn on Auto Trigger separately for Input A and Input B.

Auto Trigger works within the selected Voltage Range. So if your signal levels change you may have to press AUTO SET to change voltage range, or select voltage range manually.

If the Rise & Fall time function is selected, Auto Trigger sets the trigger levels to 10% and 90% of the amplitude.

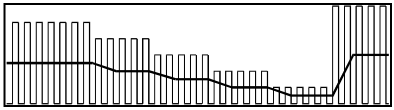


Figure 67 Auto Trigger.
Auto Trigger follows any signal changes so the MultiFunction Counter shows numerical results on the available signal. The waveform display is not affected by Auto Trig.

FREQUENCY LIMIT

Auto Trigger works on all signals from 20 Hz and up. To measure on signals below 20 Hz, turn off Auto Trigger and select trigger level manually.

STATISTICS

MultiFunction Counters measure amplitude and calculate trigger levels rapidly, but if you want to measure at top speed, for example when gathering statistical samples, turn off Auto Trigger.

Trigger Level

Turn off Auto Trigger as follows:

INPUT TRIGGER Input A **Auto Trigger: OFF**

When Auto Trigger is off, you can enter trigger levels manually, as follows:

INPUT TRIGGER Input A

Trigger Level: 100mV

You can use , or press SELECT to enter the “keypad” to set the value, see “Numerical Entries" on page 2-11.

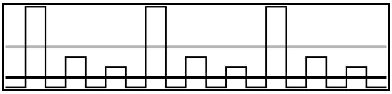


Figure 68 Manual Trigger Level. Complex signals like this one need manual trigger level (black line) to measure correctly. Auto Trigger would set trigger level at 50% (gray line). This results in frequency read-outs of 1/3 of the actual frequency.

FREEZE AUTO TRIGGER LEVELS

Press AUTO SET and the MultiFunction Counter will set the trigger levels to trigger correctly on the connected signal.

AUTO SET

Double clicking AUTO SET turns on Auto Trigger.

HYSTERESIS

The hysteresis (sensitivity) of the MultiFunction Counter is normally fixed at approximately 20 mVp–p. In frequency and period measurements, the Auto Trigger of the MultiFunction Counter can vary the width of the hysteresis band so that it is always 1/3 of Vp-p.

Note

Variable hysteresis is used only in Frequency and Period Average measurements.

TRIGGER INDICATORS

When the signal does not trigger the input, the measurement result is replaced by — — — — —.

In WAVEFORM mode, a NO TRIG annunciator appears on the screen when the scope trigger level is set so that the trace does not trigger.

Slope

The input amplifier can be set to trigger on positive (increasing voltages passing the trigger level) or negative slopes.

Slope settings are essential to time interval measurements, but unimportant[5] for frequency and period measurements.

This selection is grayed for measurement functions that have a predefined slope. For instance Rise Time and Positive Pulse Width trigger on positive slope, while Fall Time and Negative Pulse Width trigger on negative slope.

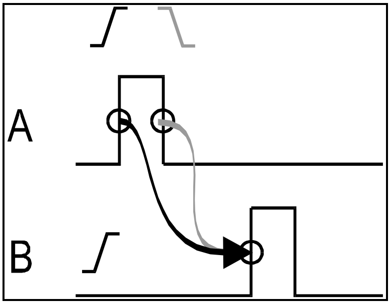


Figure 69 Trigger Slope. Change Trigger Slope in Time Interval measurements to select the interval to measure.

Note
Do not confuse Counter Trigger Slope with Waveform Trigger Slope!

Changing Input A or Input B Trigger Slope does not affect the waveform presentation, only the numerical measurements.

To trigger the waveform graph on negative slope instead of positive, change Scope Trigger Slope in the INPUT TRIGGER Scope menu.

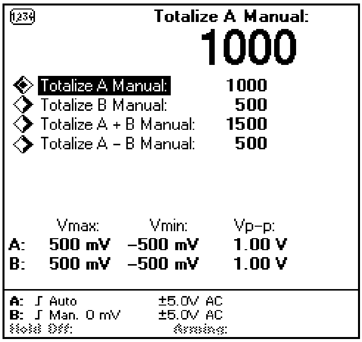


Figure 70

View and Select Trigger Slope for both Input-A and Input-B in the quick menu, or via INPUT TRIGGER.

[5] Slope control is removed for measuring functions which do not benefit from slope selection.

DC/AC Coupling

INPUT TRIGGER **Coupling: DC**

Changes coupling from AC to DC or from DC to AC. Check the annunciator in the lower part of the display to see selected coupling.

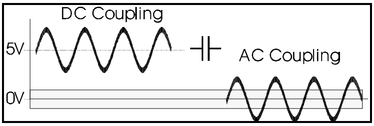


Figure 71 AC-coupling a symmetrical signal.
(The capacitor in the figure removes DC.)

Use the AC coupling feature to eliminate unwanted DC signal components. Always use AC coupling when the AC signal is superimposed on a DC voltage that is greater than can be offset with the MultiFunction Counter's trigger level setting.

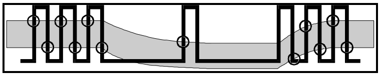


Figure 72 Missing trigger events due to AC coupling.

We recommend AC coupling in many other measurements because when you measure symmetrical signals, such as sine and square waves or triangles, AC coupling filters out all DC components. This means that a 0 V trigger level is always centered around the middle of the signal where triggering is most stable.

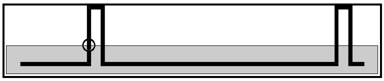


Figure 73 AC coupling a signal with very low duty cycle.
(without Auto Trigger).

Signals with changing duty cycle (or with a very low or high duty cycle) do require DC coupling when manually set trigger level is used. Figure 72 shows how pulses can be missed, while Figure 73 shows that triggering does not occur at all because the signal amplitude and hysteresis band are not centered.

AC-coupling limits the lowest repetition rate to 20 Hz. Double-clicking AUTO SET selects appropriate coupling for the selected measurement.

Rule of Thumb for Coupling

- **DC:** All time measurements, totalizing, duty cycle, Vmax, Vmin, Vp-p, Vdc + Frequency and period below 20 Hz.
- **AC**: Frequency, Period, Ratio, Phase, RPM, Vac.

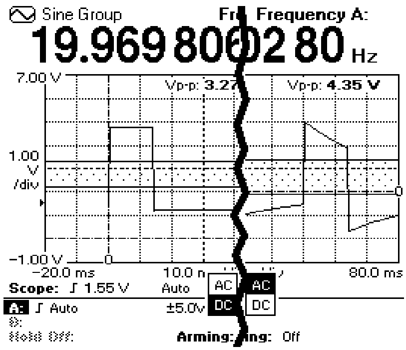


Figure 74 AC-coupling distortion. AC coupling (right side) distorts the waveform of low frequency signals. Note that the amplitude (Vp-p) read-out increases when AC coupling is used.

Filter

ANALOG OR DIGITAL FILTER

Both the Analog Low-pass Filter and the Digital Filter can be used to reduce the influence of noise superimposed on the measuring signal. The effects on noise reduction are similar, however with the following differences:

- The analog low-pass filter is more efficient in suppressing frequency components above 100 kHz. It can even suppress HF-interference with a higher amplitude than the signal itself.
- The digital filter has a variable cut-off frequency (1 Hz to 3 MHz) compared to the fixed 100 kHz limit for the analog filter.
- The analog filter is hardware controlled and always available for all measurement functions and on both input channels (A and B). The digital filter is software controlled and only available on one input channel at a time and only in some selected measurement functions.

The Analog Low-pass Filter is the preferred filter for frequency measurements of signals up to 100 kHz.

ANALOG LOW-PASS FILTER, INPUT A AND B

If you cannot obtain a stable reading, the signal-to-noise ratio may be too low. (It could also be a non-repetitive waveform, for example.)

If the signal is too noisy, you should try using the filter.

Accurate frequency measurements of noisy LF signals (up to 200 kHz) can be made, when the noise components have significantly higher frequencies than the fundamental signal.

Always use a filter on all input signals up to 1 kHz in voltage measurements.

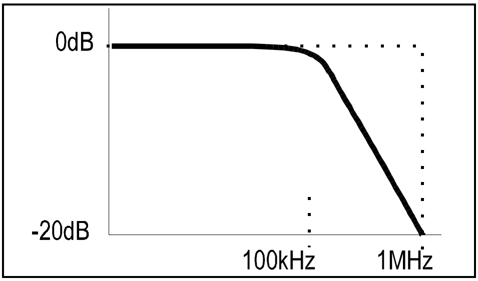


Figure 75 LP Filter.
Input A and Input B each have an analog LP filter with cutoff frequency of approximately 100 kHz, and a signal rejection of 20 dB at 1 MHz.

DIGITAL FILTER, INPUT A AND INPUT B

With the Digital Filter it is possible to insert a mask time in the input trigger circuit. This means that the input of the MultiFunction Counter ignores all hysteresis-band crossings made by the input signal during a preset time.

For all types of fundamental input signals, e.g. sinewave as in Figure 76, the signal crosses the hysteresis band twice every period, e.g. at $t = 0 + n \times T$, $t = T/2 + n \times T$

(T = period time of input signal). Once per period, the hysteresis band is crossed with a positive signal slope, and once per period the band is crossed with a negative signal slope. Heavy noise on the signal may instead cause multiple crossings of the hysteresis band at the "t=0"-point and the "t=T/2"-point. This would lead to erroneous input cycle counts without the use of a filter.

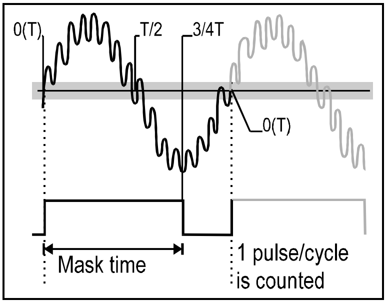


Figure 76 Digital Filter.
The digital filter operates in the instrument's measuring logic, not in the analog input signal path.

The purpose of the Digital Filter is to generate exactly one count per inut signal cycle, irrespective of noise triggering. The filter generates a "mask time" starting at the first triggering at the "t=0"-point. During this mask time, further input triggering is inhibited at the"t=0"-point as well as at the "t=T/2"-point. The mask time is derived from the set Filter Frequency value, so that the mask time ends at the "t=3T/4"-point, between the two "critical" "t=0"- and "t=T/2"-points. After that, the counter is ready to accept a new input trigger at the next "t=0"-point. In this way it is ensured that the MFC receives exactly one input count per input signal cycle. See Figure 76.

To use the digital filter effectively you must have a rough idea of the frequency to be measured; otherwise, setting the filter frequency is not easy.

The actual signal frequency must be in the range 50% to 200% of the Filter Frequency for correct results.

A too low filter frequency setting may give a perfectly stable reading, but at a frequency that is too low. In such a case, triggering occurs only on every 2nd ,3rd , or 4th cycle.

With too high filter frequency, more than twice the actual frequency may also lead to a stable reading, e.g., when exactly one noise pulse is counted for each half-cycle.

USING ATTENUATION AS FILTER

An alternative way to reduce noise is to attenuate the signal so that the noise is too small to trigger the input. For instance if you have a signal of 1 V with 100 mV of noise, you normally use the ±5V range. This range has an input sensitivity of 20 mV and will trigger perfectly on the noise, ruining the measurement. However, if you select the 50 V range, the sensitivity decreases to 200 mV, canceling out the noise totally.

When measuring Frequency, Period Average and RPM using auto trigger, the hysteresis band is automatically set to 33% of the signal amplitude. This gives excellent noise reduction, and using an attenuator under these circumstances will give no further improvement.

ARMING

Arming or actually Measurement Arming, is the process to enable the start and stop of measurements. The MultiFunction Counter has four arming modes.

1. Free Run (normal) or ARMING OFF
2. Manual Arming or HOLD/RESTART
3. External Arming or ARMING ON
4. Burst Arming (described on page 5-23).

The MultiFunction Counters always synchronize the start and stop of the actual measuring period to the input signal trigger events (because of the reciprocal counting technique).

The description “ARMING” used in the instrument refers to the *External Arming* mode.

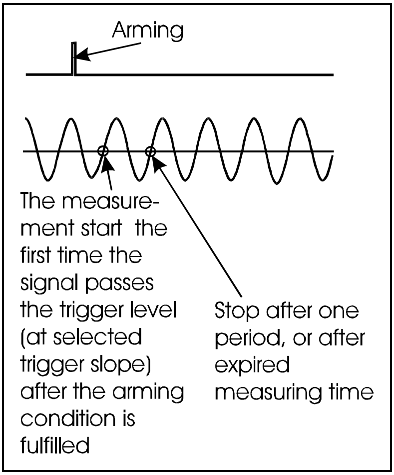


Figure 77 Measurement Trigger. A reciprocal counter synchronizes with the signal as shown in this figure.

Free-run Measurement Arming (ARMING OFF)

A new measurement automatically starts when the previous measurement is finished. This is ideal for continuous wave signals.

The *start of a measurement* takes place when the following conditions have been met (in order):

1. The counter has fully processed the previous measurement.
2. All preparations for a new measurement are made.
3. The input signal triggers the counter's measuring input.

The measurement ends when the input signal meets the stop trigger conditions. That happens directly after the following events:

1. The set measurement time has expired (in Frequency, Ratio, RPM, and Period Average).
2. The input signal fulfills the stop trigger conditions (which is normally the case when it passes the trigger window the second time).

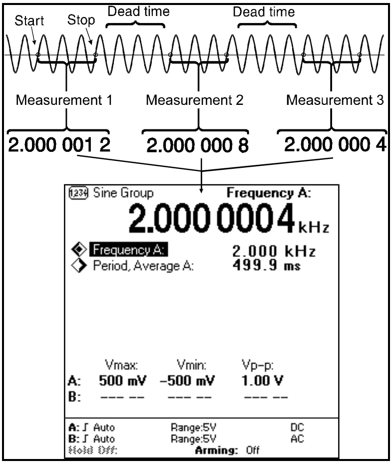


Figure 78 Free-run (Arming Off). This is the normal MultiFunction Counter arming, that is when a new measurement starts as soon as possible after the previous measurement is finished.

Manual Measurement Arming (HOLD/RUN)

HOLD/RUN

Pressing HOLD/RUN freezes the result on the display.

RESTART

RESTART triggers a new measurement. Use this manual arming mode to measure single-shot phenomena, which are either triggered manually or occur at long intervals. Another reason for using this manual arming could simply be to allow sufficient time to write down individual results.

HOLD/RUN has a special meaning in controlling manual totalizing, see Figure 79.

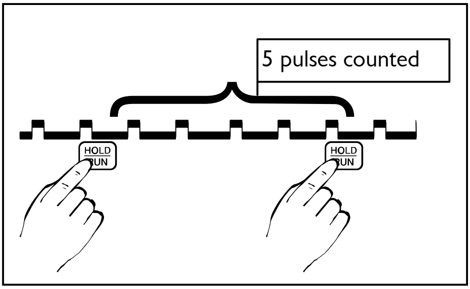


Figure 79 One press on HOLD/RUN starts, and the next press stops counting (this example is for Totalize Manual).

External Arming (Arming on)

The *external arming* (called ARMING in the MultiFunction Counter) is a pre-trigger condition (“ qualifier”), like an external trigger on an oscilloscope, that must be fulfilled before the counter allows a measurement to start. When you use external arming, you disable the normal free-run mode, and all individual measurements must be preceded by a valid External Arming signal transition.

WHEN DO I USE EXTERNAL ARMING

External Arming can be used for Frequency, Period, Pulse Width, RPM, and Duty Cycle measurements. It is useful for measurements in signals, such as the following:

1. Single-shot events or non cyclic signals.
2. Pulse signals where pulse width or pulse positions can vary.
3. Burst signals.
4. A selected part of a complex waveform signal.

Signal sources that generate complex wave forms, like pulsed RF, pulse bursts, TV line signals, or sweep signals, usually also produce a *sync* signal that coincides with the start of a sweep, length of an RF burst, or the start of a TV line. These sync signals can be used to arm the counter. See Figure 80.

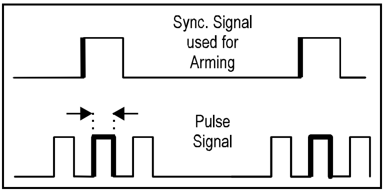


Figure 80 External Arming.
An external synchronization signal starts the measurement (positive pulse width in this example) when external arming is used.

WHEN DO I USE ARMING WITH DELAY

In a complex signal you may want to select a certain part to measure. For this purpose there is an arming delay function, which delays the actual start of measurement with respect to the arming pulse, similar to a ''delayed time base'' in an oscilloscope.

You can delay the start arming point with respect to the external arming signal. Use this function when the external arming signal does not coincide with the part of the signal that you are interested in. The range for time delay is 200 ns to 1.6 seconds with a setting resolution of 100 ns.

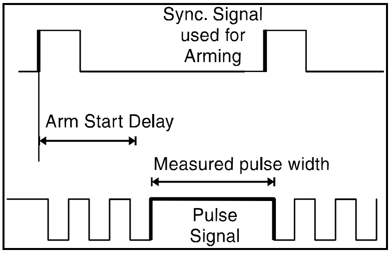


Figure 81 Arm Start Delay.
Use Arm Start Delay to select a part of the signal that does not coincide with the sync signal.

ACTIVATE EXTERNAL ARMING AS FOLLOWS:

1. Press INPUT TRIGGER.
2. Press Arming & Hold Off.
3. Select **External Arming: On Input B**. (You can also select On Input A)
4. Select **Arming Start Delay: ON**
5. Select **Start Delay Time**: and enter the delay you want between 200 ns and 1.6s in 100 ns increments.

Note
You can also turn on and off arming, and select arming channel in the quick menu at the bottom of the display.

HOLD OFF

Hold off inhibits re-triggering and stop-triggering for the set hold off time. This means that after a measurement has started, nothing can disturb the measurement process during the hold off time. Hold off can be used to effectively ignore contact bounces and distortion.

The start of the measurement also starts the hold off timer, disabling any further triggering.

When the set time elapses, the MultiFunction Counter accepts measurement stop and measurement start triggering again, see Figure 82.

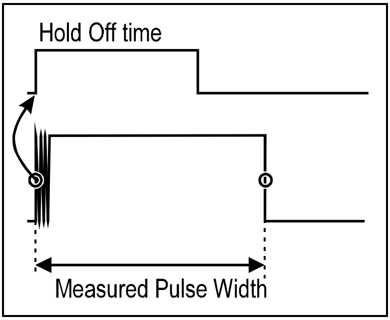


Figure 82 Hold Off.
Hold Off disables measurement stop and restart during contact bounce.

Turning on Hold Off

1. Press INPUT TRIGGER.
2. Press Arming & Hold Off.
3. Select **Trigger Hold Off: On**.
4. Set **Hold Off Time**: It must exceed the bounce time and expire before the next period starts. The range is 200 ns to 1.6 s, the resolution is 100 ns, and preset value is: 10 µs.

Note

The actual Hold Off time varies between the set time and 100 ns below.

BURST

Here you manually set the sync. parameters for burst measurements. After pressing AUTO SET you can read the auto set burst timing parameters selected by entering this menu.

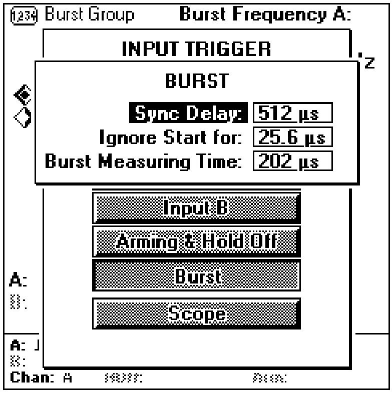


Figure 83 Burst Timing parameters.

SYNC. DELAY

This delay should be longer than the duration of the burst, but shorter than the burst repetition period. The manual setting range is 200 ns to 5s. Pressing AUTO SET will increase Sync. Delay in steps until synchronization is obtained.

IGNORE START FOR:

Bursts often start slowly and require a certain time before they are stable. Adding this delay from the start of the burst until the actual measurement starts gives a more accurate burst frequency. The manual setting range is 800 ns to 5s. Pressing AUTO SET will set Ignore Start to 5% of the sync. delay.

BURST MEASURING TIME

The Burst Measuring time starts when the ignore start delay has elapsed and must end before the burst ends. The manual setting range is 200 ns to 5s. Pressing AUTO SET will set the burst measuring time to 40% of the sync. delay.

For AUTO SET to set these burst timing parameters correctly, a burst on Input A or Input B must have:

- less than 50% duty cycle
- at least six cycles
- more than 50 µs burst duration

See also **Table 1 Signal requirements** for successful burst measurements. on page 4-6.

SCOPE

The scope settings are explained in the Waveform chapter.

MEASURING TIME

The measuring time affects the resolution in Frequency, Ratio, RPM, and Period Average measurements, and in Sine Signal Characterization. To get higher resolution the MultiFunction Counter can average the counted periods in a longer time. The measuring time is preset to 100 ms. This gives 8 digits on the display, and 1 to 2 measurements each second. Increasing the measuring time gives more digits, but fewer measurements per second.

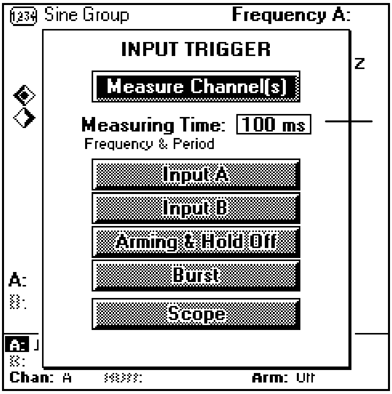


Figure 84 Measuring time setting in the INPUT TRIGGER menu.

To Change the Measurement Time:

1. Press INPUT TRIGGER.
2. Select Measuring Time: 100 ms.

Set Measuring Time to the desired time in 1/2/5 steps, using the arrow keys, or continuously variable using the keyboard.

The range is 0.2 µs to 15 s, and preset measurement time is 100 ms.

Table 2 Resolution versus measuring time.

Measuring Time	Resolution
200 ns	5 digits
1 µs	6 digits
10 µs	7 digits
100 µs	8 digits
1s	9 digits
10 s	10 digits

Chapter 6
User Options

Contents **Page**

INTRODUCTION

User options make settings that do not influence the measurement.

If you press USER OPTIONS .you will get a screen where you can do the following:

- Set Display Contrast
- Select between Internal or External Time base
- Select Digit Blanking
- Select dotted or full Scope Grid
- Select Dot or Line Scope Trace
- Select signal for the Output
- Set up Mathematical expressions to scale or offset the measurement result
- Set up the Serial Interface
- Perform self tests and adjustments
- Read what program version and installed options the MultiFunction Counter has, and when it was last adjusted.

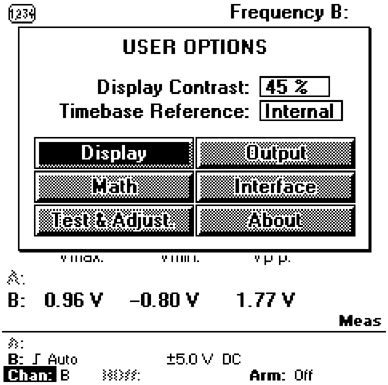


Figure 85 User Options menu. This menu contains measurement independent settings.

DISPLAY CONTRAST

The display contrast can be changed from almost totally black (100%) to almost white (0%). The factory default value is 45%.

1. Press USER OPTIONS.
2. Position the cursor on Display Contrast.
3. Press ▶ or SELECT.
4. Press ▲ to increase, or ▼ to decrease the contrast.
5. Press SELECT EXIT when you have found the best setting.

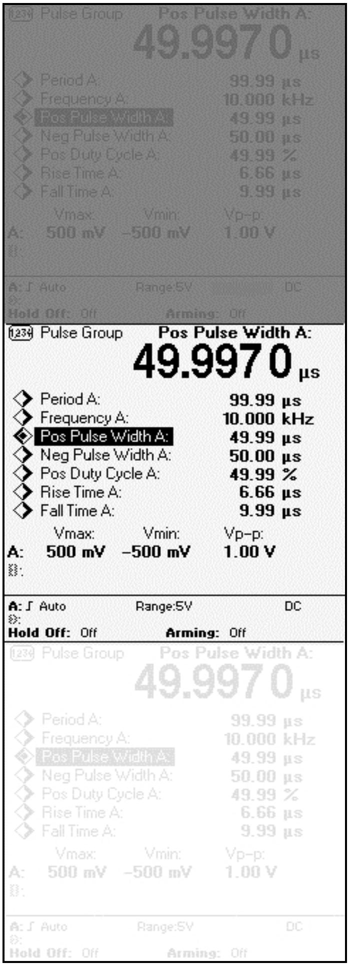


Figure 86 Display Contrast. The display contrast can be varied between 100% (top) and 0% (bottom).

TIME BASE REFERENCE

Selects if the internal time base or an external time base reference is to be used. The MultiFunction Counter uses the internal time base by default, but if you make measurements with extreme demands on accuracy and traceability you can use an external reference.

1. Connect a 10 MHz reference signal with an amplitude between 0.5 Vrms and 12 Vrms, to the REF INPUT on the MultiFunction Counter.
2. Press USER OPTIONS.
3. Select **Timebase Reference: External**.
4. Press SELECT to return to measuring.

An annunciator in the quick menu indicates that external reference is used.

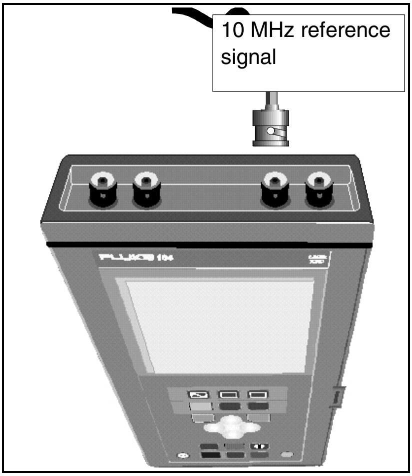


Figure 87 Reference Signal.
A 10 MHz reference signal can be connected to REF INPUT. The amplitude can be between 0.5Vrms and 12Vrms.

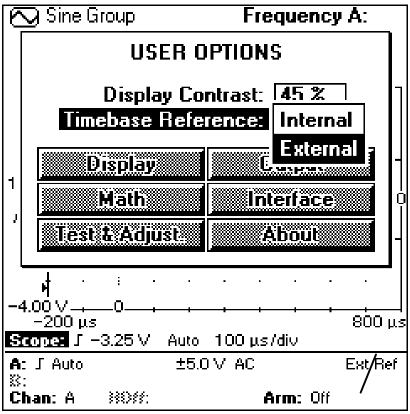


Figure 88 Timebase Reference.
External/Internal is selected in USER OPTIONS Menu.

DISPLAY

Digit Blanking

The MultiFunction Counter can truncate the measuring result by blanking irrelevant digits. This is useful, for example, when using the MultiFunction Counter for frequency alignment. Here you don't want to see more digits than you should adjust.

TURNING ON DIGIT BLANKING:

1. Press USER OPTIONS.
2. Select **Digit Blanking: On**.
3. Position the cursor on Blank Digits.

Use ▲ and ▼ to select the number of digits you want to blank out.

1. Press SELECT to return to measuring.

Now the selected number of digits is replaced by _.

TURN OFF DIGIT BLANKING

Select **Digit Blanking: Off** when you want to see all measured digits.

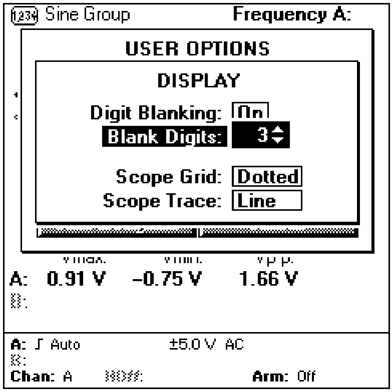


Figure 89 Blanking Setup.
You can select to blank out (remove) between 0 and 9 digits.

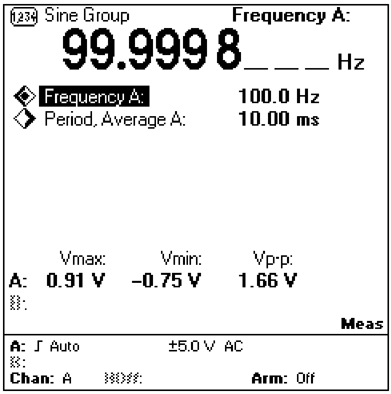


Figure 90 Three Blanked Digits.
Blanked digits are replaced by an underline character.

Scope Grid

Here you can select between the dot grid (Default) and Full grid. See also "**Grid (graticule) Display**" on page 7-11.

Scope Trace

Here you select Line (Default) or Dot Trace. See also "**Trace Display**" on page 7-10.

OUTPUT

Here you enable/disable the signal on the OUTPUT connector, and select what to output on the connector. The selections are 11 different pulse signals, and a gate open signal. The pulse signals can be used for probe adjustment, to excite the device under test, or as a reference signal for other instruments.

Note

For maximum battery life; turn off the output when not in use.

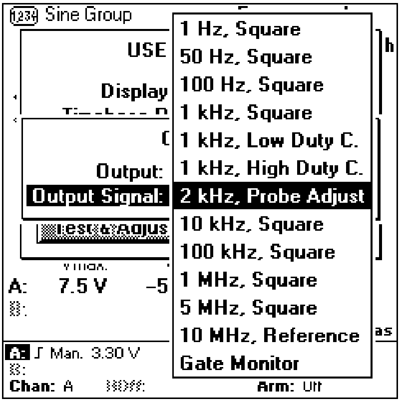


Figure 91 Output Signal menu.
There are many signals to choose from.

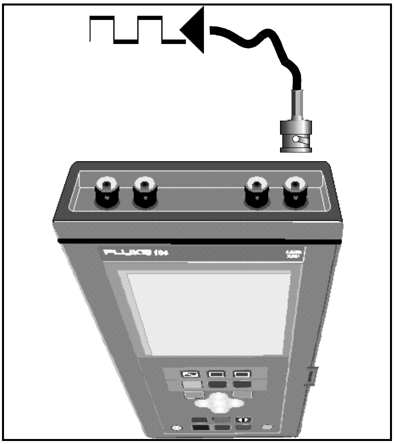


Figure 92 Output.
The signals are available at the OUTPUT BNC connector.

MATH (SCALING & OFFSET)

The MultiFunction Counter can mathematically scale and offset the primary measuring result before displaying it.

Use mathematics to display, for example, the temperature when you have a probe that outputs 2kHz/° C, or subtract the 10.7 MHz intermediate frequency from a frequency measurement of the local oscillator in a radio (heterodyne receiver) when calibrating analog tuning scales.

The mathematical operation remains if you change presentation mode; if you for instance scale Period in VALUES mode, you will scale Period in Waveform and STATISTICS mode too.

Mathematics is automatically disabled when the measurement function or primary parameter is changed.

The scaling factors are not affected by the automatic disabling. They remain set until you change them manually.

Hint
Math simplifies adjustments. It is much simpler to turn the trimmer until the display shows 0, than turning until it shows 4.1954304MHz".

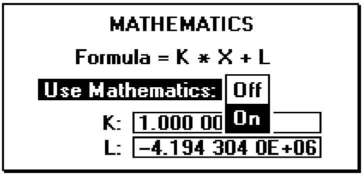


Figure 93 Math setup.
The constant K scales the result, while the constant L offsets the result.

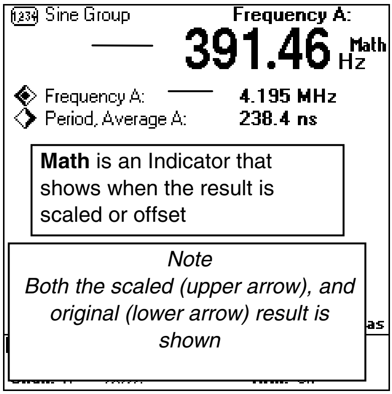


Figure 94 Math example.
In this example math is used to subtract the correct result, 4.194304 MHz, from the measured result., 4.195....MHz.

INTERFACE

Here you can select baud-rate for the communication on the optical serial interface. The character length is fixed at 8-bits with even parity bit and one stop bit.

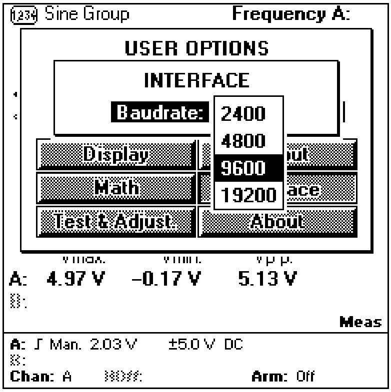


Figure 95 Baud rate Setup.
Set both the MultiFunction Counter and the PC COM-port to the same interface settings.

Connecting to a PC

Use the optional Optically Isolated RS-232 Adapter/Cable (Option 23/80) to connect a PC to the MultiFunction Counter. See Figure 96.

The Option 23/80 comes with instructions on how to use the MultiFunction Counter via the optical interface.

The possibilities are:

- Screen dump: Output the screen as a bitmap.
- Values output: Get numerical measurement data.
- Fetch/Send: Get, store and load data to repeat an exact setup of a previous measurement.
- Program update: If you receive/buy another MultiFunction Counter software release, the optical interface is used to load the program into the instrument.

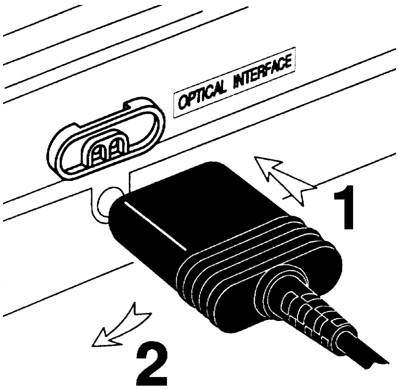


Figure 96 Option 23/80 Hookup.

TEST AND ADJUSTMENT

Here you can test the MultiFunction Counter if you suspect an error in the instrument

See the User Maintenance Chapter.

The qualified service technician can also adjust the time base and the voltage reference of the MultiFunction Counter in this menu. These functions are password protected to avoid destruction of the instrument adjustment. The procedure can be obtained from Pendulum Instruments representative on request.

You can check when adjustment was made in the About menu under USER OPTIONS.

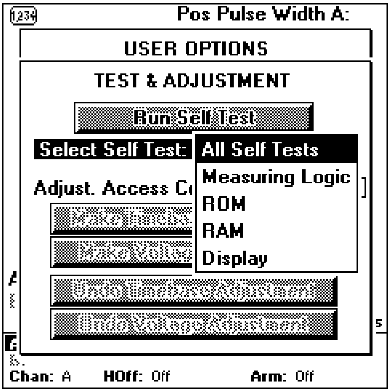


Figure 97 The Self Tests in the TEST & ADJUSTMENT menu.

ABOUT

Here you will see information about this MultiFunction Counter:

- Instrument Type (164 or 164H)
- Program Version (Version number and date)
- Input-C (2.7 GHz)
- Timebase Adjusted: (Calibration date)
- Voltage Adjusted: (Calibration date)

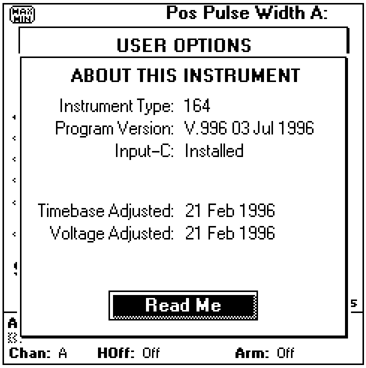


Figure 98 A typical "About This Instrument" screen.

Chapter 7
Waveform

Contents **Page**

INTRODUCTION

This chapter describes the waveform display function of the MultiFunction Counter.

The chapter is divided into four sections:

- Using WAVEFORM mode
- The Waveform screen
- Waveform Trigger
- Scope Trigger Settings

After reading this chapter you will be able to use the waveform screen to view various signals and to make input trigger settings for the timer/counter functions of the MultiFunction Counter.

Note

The Waveform function displays signals from 1Hz to 50 MHz on Input A and Input B. It can show one or two traces on the screen.

Signals between 1Hz and 20 Hz may require manual selection of LF sampling mode, DC coupling, Trigger Level, Time/Division etc. If the waveform is shown together with the No Trig annunciator, the trace is not synchronized with the input signal.

No waveform is shown for the signal on the 2.7 GHz prescaler, nor for Totalize manual

USING WAVEFORM mode

It is often convenient to see that your input signal looks the way you expect. So make it a rule to start a measurement in Waveform mode.

1. Press [∿] to turn on WAVEFORM mode.

Note
*WAVEFORM mode shows the signal amplitude versus time like an oscilloscope, but the method of obtaining the graph is quite different from both analog and digital oscilloscopes. Read more about the way a MultiFunction Counter measures waveforms in "**Understanding your MultiFunction Counter**" on page 10-1.*

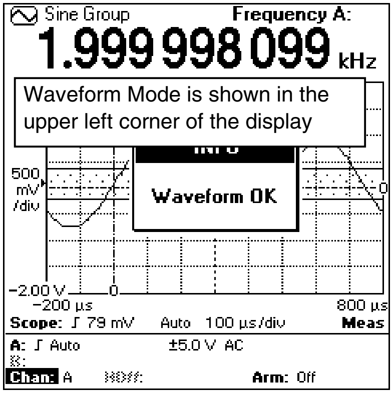


Figure 99 One-trace display.
Select a one-channel measurement to show one trace.

THE WAVEFORM SCREEN

The *values area* shows the measurement result from the selected measurement function. See "Selecting Functions" on page 4-3.

The *graph area* shows Volt versus time traces:

- One trace if the MultiFunction Counter makes one-channel measurements like Period
- Two traces if it makes two-channel measurements like Phase A to B, and if arming is enabled.

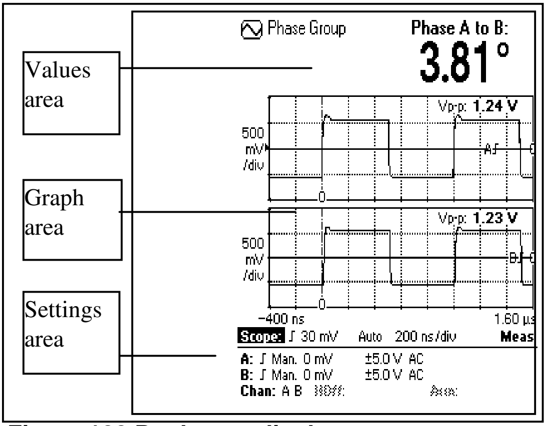


Figure 100 Dual trace display.
Select a two channel measurement to show two traces.

The *settings area* is the same as in values presentation mode, see page 2-8.

Dual Waveform Display

To get a two-channel display, press MEASURE FUNCTION and select a measurement function that uses two channels, that is Ratio, Phase, or Time Interval. Arming (in the lower right corner of the settings area) will also turn on the second channel.

Single Waveform Display

To get a one-channel display, press MEASURE FUNCTION and select any one-channel measurement function.

Settings

The *scope menu line* in the graph area (above the line) shows the scope trig slope, scope trigger level, and time/div.

The quick menu below the line contains the settings of the input(s) in use, and the measurement trigger settings (Hold Off and Arming).

- *Above the line:* Scope trigger and time-scale settings
- *Below the line:* Input & measurement trigger settings

WAVEFORM TRIGGER

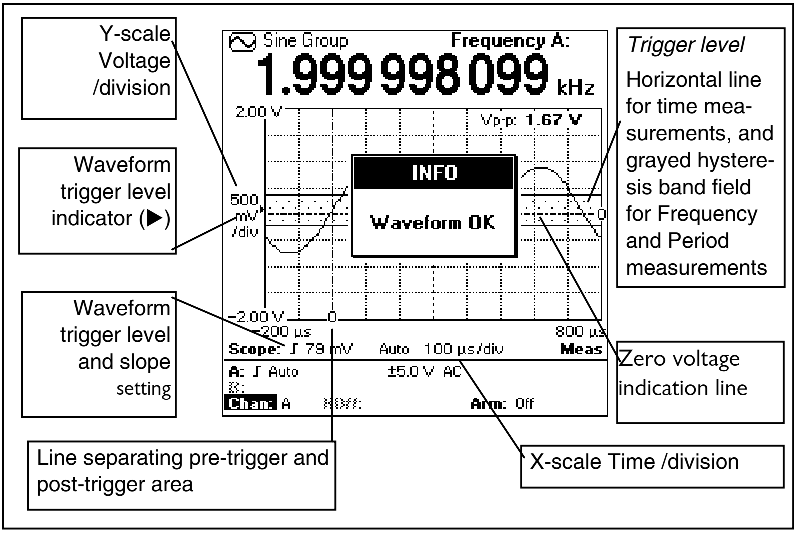


Figure 101 When you select a single channel measurement, only one trace is shown.

The trace starts at the vertical ”0-line” (separating the pre- and post-trigger areas), at the *Scope Trigger Level.* The trace normally starts upwards, on the positive slope like in Figure 101. For frequencies above 2kHz (HF sampling) pre-trigger information is shown, for lower frequencies this area will be empty.

Trigger channel is automatically selected in two-channel measurements, and positioned as the top trace. The selection is based on measurement function. To change slope and/or scope trigger level:

1. Position the cursor on Scope:
2. Press ▶ to move the cursor to the scope slope list box.
3. Put the cursor on the slope you want with ▲▼.
4. Press ▶ to move the cursor to the scope trigger level field.
5. Change the scope trigger level with ▲▼. Note that the scope trigger level indicator (▶) moves up/down.

6. Press to move the cursor to the time/division field. Time/division is normally scaled automatically, as indicated by *Auto* in Figure 101.
7. Change the time/div with . Note that the Auto indicator is changed to Man. Change back to Auto when you want Auto scaling again.
8. Press EXIT to leave the waveform trig level control.

SCOPE TRIGGER SETTINGS

To change scope trigger, time-scale and sampling mode with INPUT TRIGGER:

1. Press INPUT TRIGGER, then
2. Select Scope

Sampling Mode

You can select AUTO, LF, or HF sampling.

LF-sampling is like an ordinary oscilloscope and works up to approximately 5 kHz.

HF is the unique transitional sampling technique used by the MultiFunction Counters. It works on repetitive signals from 500 Hz to 50 MHz. Read more about the different principles for sampling in Chapter 0.

AUTO means that the MultiFunction Counter itself selects appropriate sampling mode based on the pulse width of the input signal.

On LF signals with much noise, the MultiFunction Counter may detect short pulse widths and wrongfully select HF-mode. This may result in distorted traces and excessive sampling times. Select LF sampling in such cases.

The preset selection is AUTO.

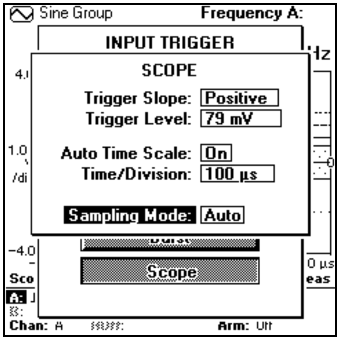


Figure 102 The Scope Trigger Setup Menu.

Time/Division (X-Scale)

The time base is automatically set to display two to five cycles of the signal, using Auto Time Scale. When the input frequency changes significantly, so will the time/division setting.

You can also manually set a time/div. when you for instance want to see more cycles than normal, or zoom in on an edge.

1. Press INPUT TRIGGER.
2. Press Scope.
3. Set Time/Div: 10. 0 ms.

If AUTO SET is pressed in WAVEFORM mode, Auto Time Scale is turned on.

PRE-TRIGGER

Note that the zero point of the time scale is positioned two divisions from the left side of the grid. The first two divisions show pre-trigger information, that is, what happened before the trigger point. This pre-trigger information is only available in HF-sampling.

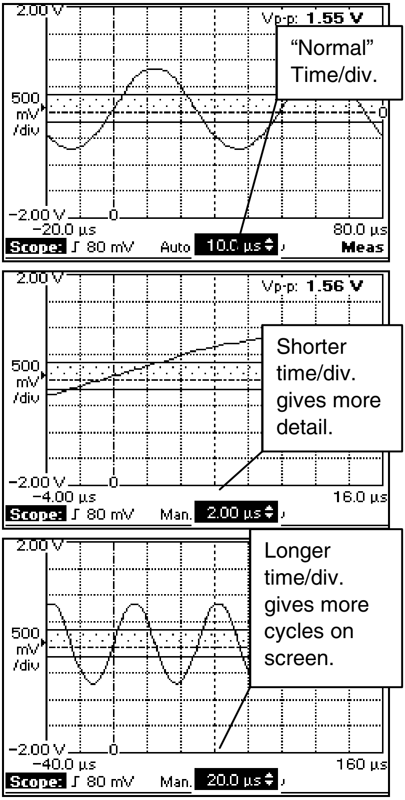


Figure 103 Manually set time/div. affects screen appearance.

Amplitude (Y-Scale)

The Y-scale is always set automatically. The graph is scaled so that you see the Vmax and Vmin of the signal, and the trigger level cursors. If the amplitude on the screen is distorted or clipped, the Voltage range setting is wrong.

1. Press AUTO SET to let the MultiFunction Counter select a new voltage range, or change range manually

You can set Voltage Range and other common input settings directly in the waveform screen. This way you can see the effect directly in the graph. See Figure 105.

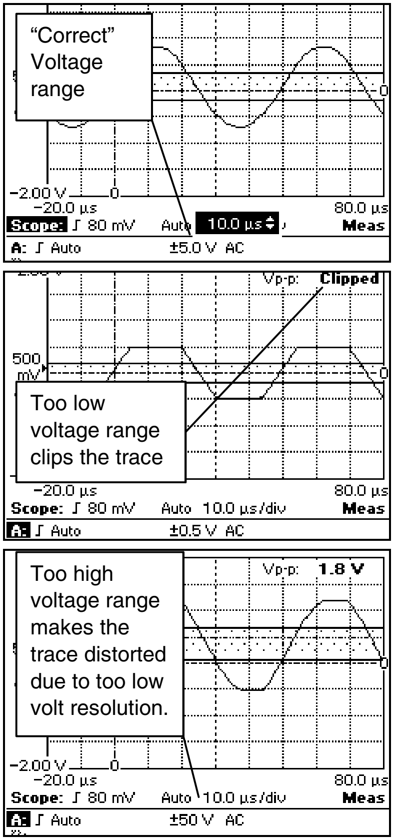


Figure 104 Voltage Range.

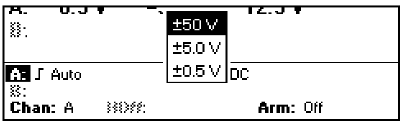


Figure 105 Quick Menu.

Trace Display

You can set the trace to Line or Dot.

1. Press USER OPTIONS.
2. Press Display.
3. Select Trace Display: Line (or Dot).

The MultiFunction Counter samples the input signal. This means that you get a series of “dots” in the X-Y diagram on the screen. The MultiFunction Counter does not know what happens in between these dots. So showing only these dots on the display is the correct way of presenting the measurement results.

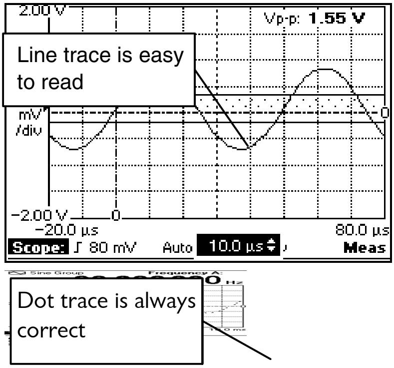


Figure 106 Trace Display.

Normally, however, you want to see the trace on the screen as a continuous line. This makes it easy to follow the signal with the eye. To do this, the MultiFunction Counter interconnects the samples with a straight line. This is the default setting.

For some measurements on noisy, modulated or complex signals it can be very difficult for the MultiFunction Counter to know what samples to interconnect on the screen. In such cases it is much easier to get information out of the graph by just seeing the individual samples as dots.

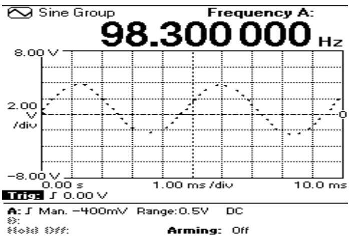


Figure 107 Dot Shape.

A close-up of the “Dots” shows that

Note

“Line” is suitable for most signals like sine, square and triangle, while “Dot” is suitable for signals with much distortion and noise.

Grid (graticule) Display

You can set the grid to Full or Dotted.

1. Press USER OPTIONS.
2. Select Display.
3. Set Scope Grid: to Dotted or Full.

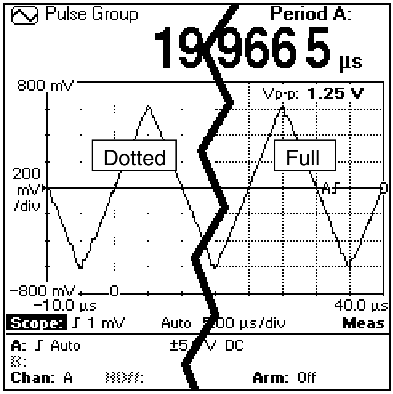


Figure 108 Example of Scope Grids.

SELECTING MEASUREMENT FUNCTIONS

Select what to measure by pressing the MEASURE FUNCTION key.

In WAVEFORM mode only one measurement function is measured at a time. So select function from the left column in the functions menu.

1. To select the function, position the cursor on it and press SELECT.

If you select a signal type for signal characterization while in WAVEFORM mode, the MultiFunction Counter automatically switches to VALUES mode. Switching from Values to Waveform means measuring and displaying the Primary Parameter from the selected group.

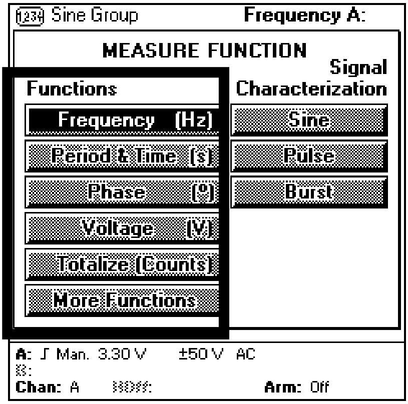


Figure 109 The left column contains Functions.

Chapter 8
Values

Contents **Page**

INTRODUCTION

This chapter describes the Values Presentation Mode of the MultiFunction Counter.

The chapter is divided into four sections:

- Selecting VALUES mode
- The Single Values Screen
- The Multiple Values Screen

After reading this chapter you will be able to use the elements of a values screen.

SELECTING VALUES MODE

Viewing the signal is great when you need to verify its shape, but to characterize a signal you often need several parameters measured with high precision.

1. Press 1.234 to switch to VALUES mode

Note
VALUES mode will be selected automatically when you select Signal Characterization (SINE, PULSE, BURST, Phase Group or Totalize Manual).

THE SINGLE VALUES SCREEN

This screen numerically displays one (this page), or several (next page) measurement results.

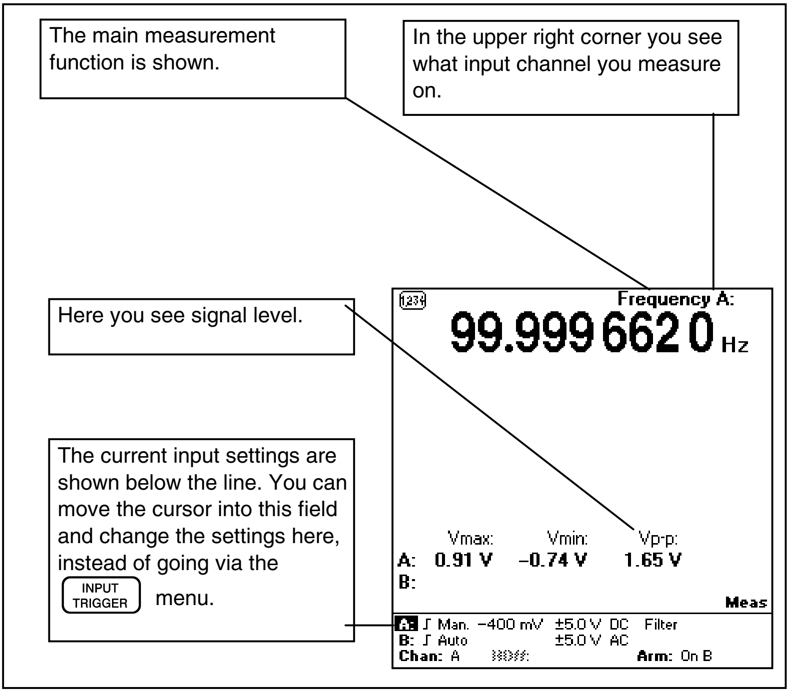


Figure 110 The Values Screen for a single measurement function.

THE MULTIPLE VALUES SCREEN

Signal characterization on the VALUES screen

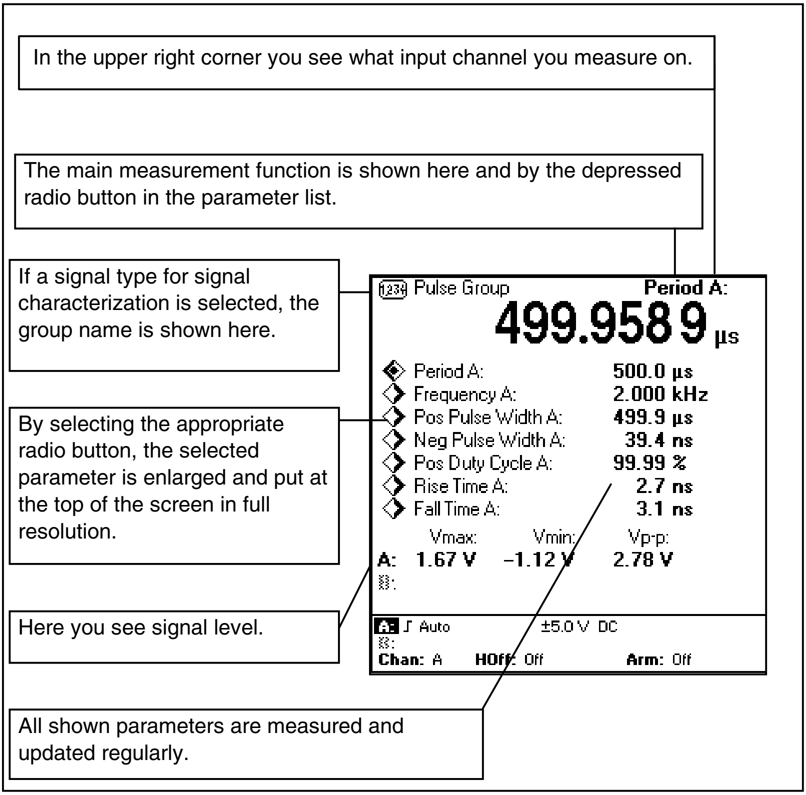


Figure 111 The Values Screen with several results. This is the kind of screen you get when you select Signal Characterization.

Chapter 9
Statistics

Contents **Page**

INTRODUCTION

This chapter describes the statistical functions of the MultiFunction Counter. The chapter is divided into five sections:

- The Statistics Screen
- Why Statistics
- Increasing the Resolution
- Jitter
- FM Measurements

After reading this chapter you will be able to understand the benefits of using the statistical functions of your MultiFunction Counter.

Note

Statistics is not available for totalize functions.
For Frequency, Ratio, RPM and Period Average, the measuring time sets the sampling speed — short measuring time means fast sampling.

THE STATISTICS SCREEN

To enter STATISTICS mode proceed as follows:

1. Press MAX MIN.

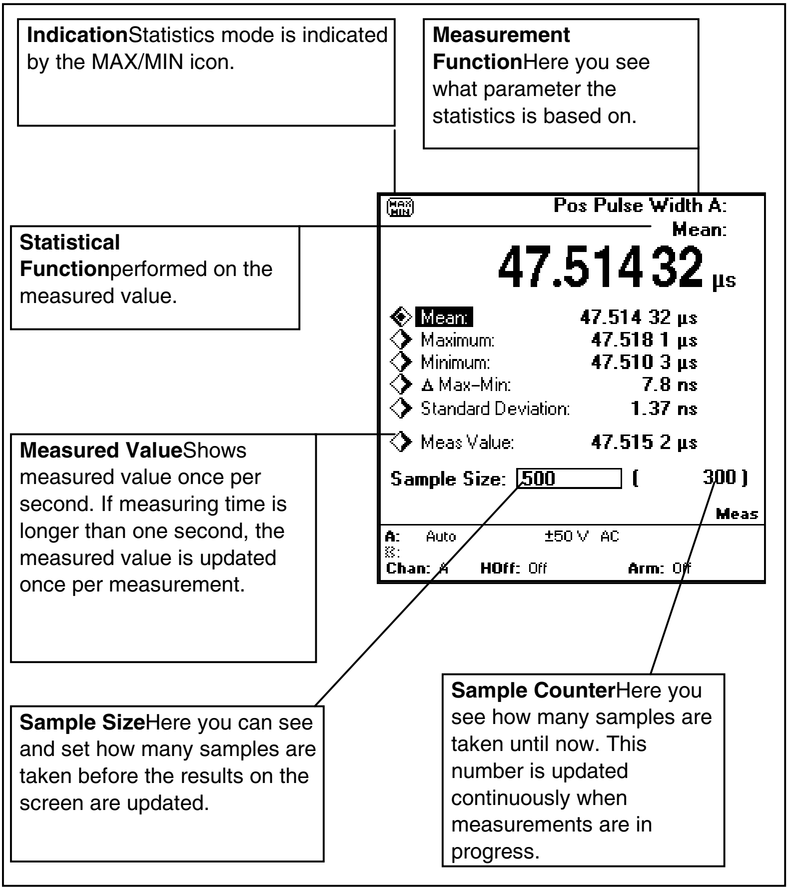


Figure 112 The statistics screen.

WHY STATISTICS

A parameter that fluctuates (jitters) shows as a wider trace in WAVEFORM mode, and as unstable digits in VALUES mode. The statistics presentation is used to quantify such variations.

1. Press [MAX MIN] and you will see:

- Mean
- Maximum
- Minimum
- Δ Max. minus Min.
- Standard Deviation (Jitter)
- Measured Value

With Default settings, the MultiFunction Counter takes 100 samples, then calculates the statistical parameters and shows the result.

SAMPLES

A sample is one measurement in a set of identically performed measurements.

You can change the number of samples taken by moving the cursor to the Sample Size field and changing the numerical values. Range is 2 to 1 000 000 samples.

Table 3 Example, statistics.

A 10 sample statistical gathering, and how the results are calculated.

Measurement No. (Sample No.)	Result (X)	Statistical function
1	250. 0123	
2	250. 0231	
3	250. 0067	Minimum
4	250. 0472	
5	250. 0871	
6	250. 1034	Maximum
7	250. 0248	
8	250. 0309	
9	250. 0195	
10	+250. 0463	
Sum	2500. 4013	
Sum divided by No. of samples (n)	250. 0401	Mean
Sample 6 minus sample 3	0. 0967	Maximum minus Minimum
$\sqrt{\frac{1}{n-1}\left(\sum x_i^2 - \frac{1}{n}\left(\sum x_i\right)^2 \right)}$	0. 0320	Standard Deviation

INCREASING THE RESOLUTION

Statistical Mean gives more digits in the result than the normal VALUES mode result. Calculating Mean on 50 samples justifies one more digit in the result while 5000 samples gives two more digits etc. The resolution is increased with a factor of $\sqrt{n}$, where n is the number of samples. You can use this on all measuring functions. The drawback is that the time to make the measurement will of course increase with a factor of 50, 5000 etc.

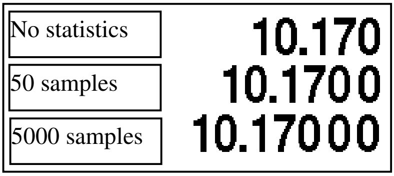


Figure 113 More samples give more digits.

JITTER

To measure period jitter of, for example, a data communications clock:

1. Press MEASURE FUNCTION.
2. Press Period & Time.

Press Period (Single).

3. Select a suitable sample size, for example ≥1000.
4. Select Standard Deviation as primary parameter.

Read the result. Standard deviation equals Jitter RMS, and ΔMaximum-Minimum equals Jitter peak-to-peak.

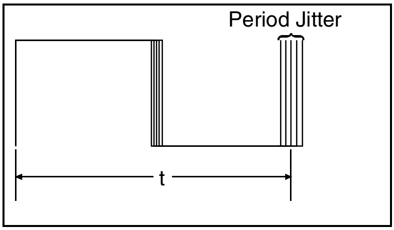


Figure 114 Jitter.
Jitter is the fast variation of a signal that is supposed to be stable.

FM MEASUREMENTS

Statistical mode can be used to characterize an FM-modulated signal having a center frequency f_c, a modulation frequency f_{mod}, causing a deviation of the carrier of $\pm f_{dev}$.

1. Select Frequency, and a measuring time that is ≈10% of one modulation cycle $\left(Measuring\ time = 0.1/f_{\text{mod}}\ (s)\right)$
2. Set the number of samples to more than 1000.
3. Turn off auto trigger to speed up the sampling.
4. Read the results as follows:

   Mean = f_c (Carrier frequency)

   0.5x(ΔMaximum-Minimum) = f_{dev} (frequency deviation)

The modulation frequency cannot be measured using statistics.

Chapter 10
Understanding your MultiFunction Counter

Contents **Page**

INTRODUCTION

This part of the manual is dedicated to you who want more information on the MultiFunction Counter. This chapter explains how the MultiFunction Counter makes a specific measurement, and what types of measurement errors are involved in the measurement. From the MultiFunction Counter's point of view, some measurements are made in roughly the same way.

The following descriptions relate to these groups:

WAVEFORM SAMPLING BASED MEASUREMENTS

Waveform
Volt RMS
Volt DC

TIME INTERVAL BASED MEASUREMENTS

Time interval
Pulse Width
Rise Time
Fall Time

PERIOD BASED MEASUREMENTS

Frequency
Period
RPM
Burst Frequency
PRF

VOLTAGE PEAK MEASUREMENTS

Auto trigger
Volt p-p
Volt max.
Volt min.

COMBINED MEASUREMENTS

Phase
Duty Factor
Ratio

PULSE COUNTING

Totalize Manual
Totalize Start/Stop
Totalize Gated
Totalize Timed

LF-(TIME SEQUENTIAL) AND HF-(TRANSITIONAL) SAMPLING

The waveform visualization in the MultiFunction Counter is based on two sampling principles called Transitional and Time Sequential Sampling.

Normal DSO's have Time Sequential Sampling. This means that they measure the amplitude at a fixed sampling rate, and store the results in memory. When triggering is in progress, the results are shown at fixed intervals along the horizontal axis. This is the principle used by the MultiFunction Counter for low frequency input signals (LF-sampling up to a few kHz). *In this mode the time is incremented and the voltage is sampled.*

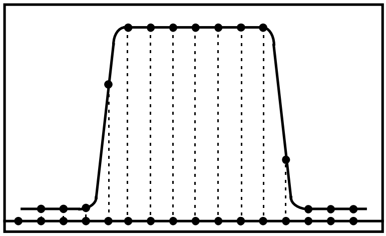


Figure 115 Time Sequential Sampling.
Only a few samples are taken on transitions, creating the risk that very narrow pulses be missed. This sampling is traditionally used in DSOs.

The MultiFunction Counter also has Transitional Sampling™. From the start trigger point, many time intervals are measured at different trigger levels, scanned over the entire waveform. This technique concentrates sample data on transitions, where high time resolution is most needed. Vertical resolution is defined by the 8-bit trigger level DAC s, supplying 256 vertical steps.

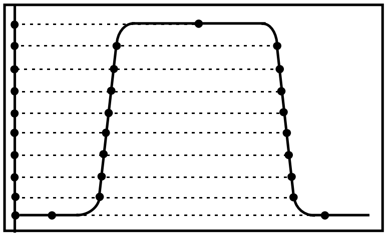


Figure 116 Transitional Sampling.
Concentrates sample data on transitions, obtaining a high time resolution of <1ns in all time base positions (>1 GSa/s effective sample rate).

Pros and cons

By comparing Figure 115 and Figure 116 you immediately see one of the benefits of Transitional Sampling: When the signal changes amplitude, many samples are taken, and when the level is constant, few samples are taken. This means that when an edge appears, no matter how fast it is, it will be represented by many samples with high accuracy. The MultiFunction Counter will reveal short spikes that normal DSO's never will detect.

If you look at the two figures you also see a drawback with the technique: Signals with much activity will result in very many samples and will therefore take longer time to process compared to Time Sequential Sampling.

Transitional Sampling also results in high resolution along the very important time axis. Each measurement is made with 700 ps resolution.

Transitional sampling requires repetitive signals and it is slower than LF-sampling (Time Sequential Sampling). So, for low frequencies, the MultiFunction Counter uses LF-sampling.

WHY ARE VRMS AND VDC AND WAVEFORM THE SAME KIND OF MEASUREMENT

These voltages are not measured with specific circuits, nor obtained by any coarse approximation, but are calculated from the actual waveform samples. This gives accurate measurements of DC and true rms voltages up to high frequencies and for complex waveforms.

LF (Time Sequential) sampling

LF sampling is used for signals up to approximately 2 kHz. Here values of Vrms and Vdc are always available.

Vrms and Vdc measurements have only guaranteed specifications up to 2 kHz. HF sampling is used between 2 kHz and 50 MHz.

Vdc

Vdc is calculated over 200 ms as the average of the voltage samples. Only LF sampling is used.

Vac

Vac is calculated over N periods as the Root Mean Square of the voltage samples. LF or HF sampling is used depending on the input signal.

TIME INTERVAL MEASUREMENTS

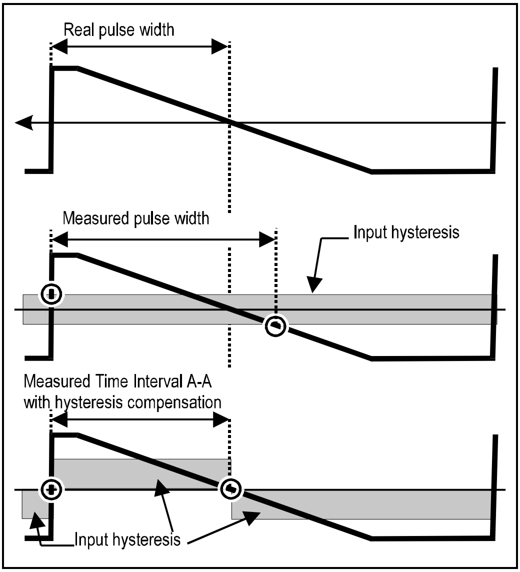


Figure 117 The hysteresis band is asymmetrical to increase time accuracy.

Time interval is the measured time from a start event to a stop event. The start event is the crossing of a trigger level and the stop event is the crossing of the same or another trigger level in the same or another signal.

The accuracy in time measurements is affected by the trigger level setting, especially on signals with low slew rate.

The MultiFunction Counter addresses this problem by adding hysteresis compensation to the auto trigger function.

Basic time interval measurements are made also in pulse width, rise time, and fall time measurements.

Positive Pulse Width

To make a Pulse Width measurement on Input A, the MultiFunction Counter selects:

- Primary and Secondary Channels are set to Input A.
- Start (Input A) trigger level 50% of signal amplitude (Auto Set).
- Start Slope Positive (Input A slope).
- Stop (Input B) trigger level 50% of signal amplitude (Auto Set).
- Stop Slope Negative (Input B slope).

Negative pulse width

Same as positive pulse width but start slope is negative and stop slope is positive.

Note

Hysteresis compensation is only active in Time Interval, Rise/Fall Time and Phase measurements. Not in Pulse width and Duty Cycle. To make a very accurate Pulse Width measurement, where trigger accuracy is essential, use one-channel Time Interval, with manual start/stop trigger settings.

Rise Time

To make a rise time measurement on Input A, the MultiFunction Counter selects:

- Primary and Secondary Channels are set to Input A.
- Start Slope Positive (Input A slope)
- Stop Slope Positive (Input B slope)

With auto trigger on, start (Input A) trigger level is set to 10%, and stop (Input B) trigger level to 90% of signal amplitude.

Note

To measure on single shot phenomena, or for instance rise time between 20% and 80%, use manual trigger levels

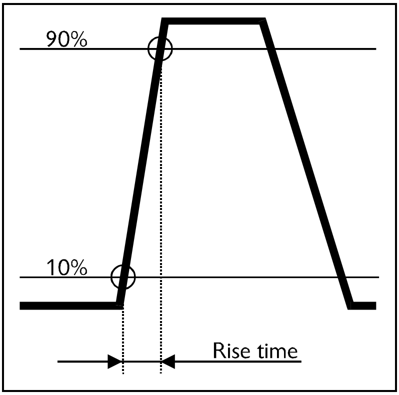


Figure 118 Rise Time.
Rise time is a time Interval measurement between the start trigger level on 10% of the amplitude, and the stop trigger level on 90% of the amplitude.

Fall Time

Same as rise time but start level is 90%, stop level 10% and both slopes are negative.

.

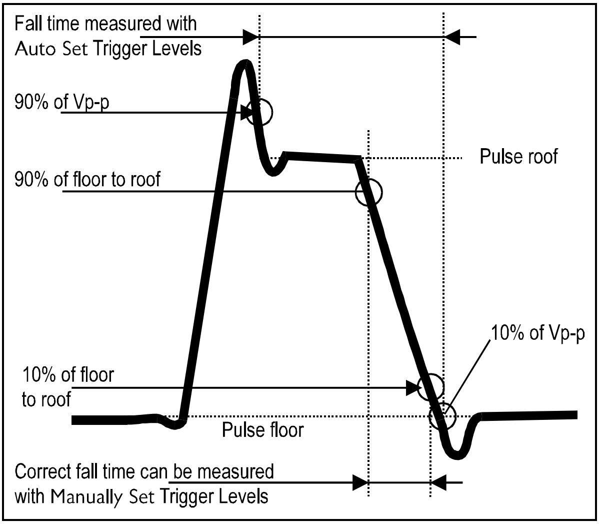


Figure 119 Rise/Fall time, from pulse floor to pulse roof. Use manual trigger levels if the signal has over- and undershoots.

Note

Auto Set Trigger levels are set at 10% and 90% of Vp-p including over and undershoot. On distorted pulses this may lead to incorrect trigger settings which can be visually observed in WAVEFORM mode. If so, identify the pulse roof and pulse floor in the graph and use manually set trigger levels to 10% and 90% thereof.

PERIOD MEASUREMENTS

The MultiFunction Counter has two methods for period based measurements: Single and Average.

- Period (Single) means that you measure the period of one single period and display the result.
- Period (Average) means that you measure the number of complete periods that occur in a preset time and then calculate the average period time as:

$$\frac{\textit{Elapsed time (Number of clock cycles)}}{\textit{Number of counted cycles}} .$$

The Period average method is used for Frequency, Ratio, RPM, Period (average), and Sine-type Signal-Characterization.

Frequency, Period, RPM, Burst Frequency or PRF is calculated from the measured period.

Frequency

$$Frequency = \frac{1}{Period}$$

RPM

$$RPM \quad \frac{Frequency \quad 60}{Pulses / Revolution}$$

Frequency in Burst

Here the MultiFunction Counter makes an ordinary frequency measurement, but the special burst arming ensures that the measurement start synchronizes with the start of the burst. Read more about burst trigger settings in Chapter 0.

Burst Repetition Rate

Here the MultiFunction Counter makes an ordinary frequency measurement, but the special burst arming ensures that the period measured is from the start of one burst to the start of the next burst.

VOLTAGE PEAK MEASUREMENTS

Maximum voltage, minimum voltage and peak-to-peak voltage are measured with the auto trigger function of the MultiFunction Counter. The method is successive approximation of the trigger level setting and means that the MultiFunction Counter starts by setting the trigger level to one level and checks if the input triggers. If it does, the trigger level is incremented, and the MultiFunction Counter again checks if the input triggers. If not, the MultiFunction Counter sets a trigger level between (at 50%) the one that triggers, and the one that does not trigger, and checks for triggering. This procedure is continued until the difference in trigger levels between trigger and no trigger is as small as possible. Now the MultiFunction Counter knows the maximum voltage of the signal.

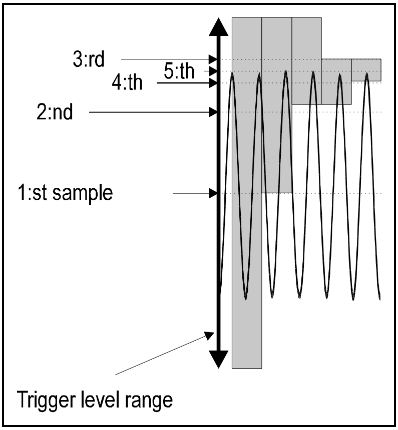


Figure 120 Sampling the Vmax value.
The gray field indicates the band where the real Vmax may be. This field decreases quickly after just a few samples.

The procedure to obtain minimum voltage is similar.

Voltage peak-to-peak is calculated as the difference between maximum and minimum.

The trigger level method for measuring peak voltages is fast, has the same resolution as the trigger level setting, and works very well over a wide frequency range. In fact, it works from 20 Hz to 50 MHz with specified accuracy, and up to 100 MHz with reduced accuracy.

COMBINED MEASUREMENTS

Combined measurements are measurements where several parameters are measured, and the result is calculated from these measurements. Phase, Duty Cycle, and Ratio are such measurements.

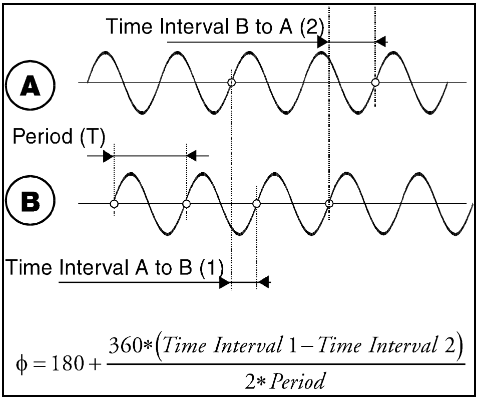


Figure 121 Combined Measurement. Two Time Interval measurements and one Period measurement equals phase.

Phase

Phase is the time difference between the zero crossings of two signals with equal frequency expressed as an angle. The MultiFunction Counter measures phase as three consecutive measurements:

- A period measurement
- A time interval A to B measurement
- A time interval B to A measurement

Phase is then calculated as

$$180 \quad \frac{360 \quad (\mathit{Time\ Interval\ 1} \quad \mathit{Time\ Interval\ 2})}{2 \quad \mathit{Period}}$$

The signal must be stable and continuous during the measurement.

The basic source of error for sine wave phase measurements is the zero crossing time error (phase error). The MultiFunction Counter has hysteresis compensation which reduces the offset level.

Duty Cycle

Duty cycle is the high/low relationship of a signal. If a signal with a period of 100 ms is high for 30 ms and low for 70 ms, the Duty cycle is 30%.

DUTY FACTOR

The names Duty Cycle and Duty Factor are both used for expressing this high/low relationship. Duty cycle is expressed in percent, while duty factor is a ratio.

Consequently, for the 30 ms High and 70 ms low signal, the Duty Cycle is 30% and the Duty Factor is 0. 3.

POSITIVE DUTY CYCLE

The MultiFunction Counter measures the Period of the signal, then the Positive Pulse Width and then it calculates the result as:

$$\textit{Positive duty cycle} \quad \frac{\textit{Pos. Pulse Width}}{\textit{Period}} \quad 100\%$$

NEGATIVE DUTY CYCLE

The MultiFunction Counter measures the Period of the signal, then the Negative Pulse Width and then it calculates the result as:

$$\textit{Negative duty cycle} \quad \frac{\textit{Neg. Pulse Width}}{\textit{Period}} \quad 100\%$$

Frequency Ratio

Frequency Ratio is one frequency divided by another frequency.

The MultiFunction Counter, however, never measures the frequencies. Instead it simultaneously counts the number of triggerings on Input A, and Input B. After the set measuring time, the result is calculated as:

$$\textit{Ratio} \quad \frac{\textit{No. of counts on Input A}}{\textit{No. of counts on Input B}}$$

AUTO SET, AUTO SET WITH PRESET AND DEFAULT SETUP

This table is a help to the user to understand what the difference between the auto-set, preset, and default setups means. The intention with automatic setup is that the measurements should be as good as possible without manual fine tuning.

Note
The table was created using version 1.0 of the MultiFunction Counter program and may be altered in future program versions.

Table 4 Settings after Autoset, Preset and Default Setup

Function	AUTO SET	AUTO SET AUTO SET (Double-click)	SAVE RECALL Recall Default Setup	Menu	Button
Trigger Level	Set to 50% of Vp-p	Not applicable (Set continuously by Auto trigger)	Not applicable (Set continuously by Auto trigger)	INPUT TRIGGER	Input A
Voltage Range	Selected to match input signal	Selected to match input signal	5V	INPUT TRIGGER	Input A
Coupling	Checks If AC coupling allows for lower voltage range. If it does, AC is selected	Selects DC for time measurements and AC for frequency, period average and phase	AC	INPUT TRIGGER	Input A
Auto Time Scale	On	On	On	INPUT TRIGGER	Scope
Auto Volt Scale	Always On	Always On	Always On	INPUT TRIGGER	Scope
Measuring Time	-	100 ms	100 ms	INPUT TRIGGER	
Auto trigger	-	On	On	INPUT TRIGGER	Input A
100 kHz LP Filter	-	Off	Off	INPUT TRIGGER	Input A

Function	AUTO SET	AUTO SET AUTO SET (Double-click)	SAVE RECALL Recall Default Setup	Menu	Button
Digital Filter	-	Off	Off	INPUT TRIGGER	Input A
External Arming	-	Off	Off	INPUT TRIGGER	Arming & Hold Off
Trigger Hold Off	-	Off	Off	INPUT TRIGGER	Arming & Hold Off
Sync Delay	-	Set to 75% of burst period	50 µs	INPUT TRIGGER	Burst
Ignore Start for	-	Set to 5% of Sync Delay	0.0 µs	INPUT TRIGGER	Burst
Burst Meas-uring Time	-	Set to 40% of Sync Delay	10 µs	INPUT TRIGGER	Burst
Sampling Mode	-	Auto	Auto	INPUT TRIGGER	Scope
Measure Function	-	-	Frequency A	MEASURE FUNCTION	Measure Function
Totalize Gate Time	-	-	100ms	MEASURE FUNCTION	Measure Function
RPM Pulses/Rev.	-	-	1	MEASURE FUNCTION	Measure Function
Select Input	-	-	A, B	INPUT TRIGGER	Measure Channels
Common	-	-	Off	INPUT TRIGGER	Measure Channels
Trigger Slope	-	-	Positive	INPUT TRIGGER	Input A
Filter Frequency	-	-	1 kHz	INPUT TRIGGER	Input A
Arm Start Delay	-	-	Off	INPUT TRIGGER	Arming & Hold Off
Start Delay Time	-	-	0.1 µs	INPUT TRIGGER	Arming & Hold Off
Hold Off Time	-	-	0.1 µs	INPUT TRIGGER	Arming & Hold Off
Trigger Slope	-	-	Positive	INPUT TRIGGER	Scope
Trigger Level	-	-	0 mV	INPUT TRIGGER	Scope

Function	AUTO SET	AUTO SET AUTO SET (Double-click)	SAVE RECALL Recall Default Setup	Menu	Button
Timebase Reference	-	-	Internal	USER OPTIONS	
Digit Blanking	-	-	Off	USER OPTIONS	Display
Blank Digits	-	-	0	USER OPTIONS	Display
Scope Grid	-	-	Dotted	USER OPTIONS	Display
Scope Trace	-	-	Line	USER OPTIONS	Display
Output	-	-	Off	USER OPTIONS	Output
Output Signal	-	-	2 kHz Probe Adjust	USER OPTIONS	Output
Math	-	-	Off	USER OPTIONS	Math
K:	-	-	1	USER OPTIONS	Math
L:	-	-	0	USER OPTIONS	Math
Baud-rate	-	-	9600	USER OPTIONS	Interface
Select Self Tests	-	-	All Self Tests	USER OPTIONS	Test & Adjustments
Display Contrast	-	-	-	USER OPTIONS	

Chapter 11
Specifications

Contents **Page**

Note

Specifications apply after 30 minutes warm-up time
For timer / counter functions, the minimal frequency specified is valid with manual trigger setting. When using AUTO TRIGGER or AC-coupled inputs, the minimal frequency is 20 Hz.

PRESENTATION MODES

Waveform: Displays recurrent signals and trigger settings. Eliminates the need for a separate oscilloscope to verify the input signal and correct triggering. Displays additionally one selected timer/counter read-out with up to 10 digits resolution plus the input signal's Vp-p value.

Values: Up to 10 simultaneous readings of frequency, time and voltages like a Counter, DVM and Phasemeter.

Statistics : Mean, Maximum, Minimum plus Peak-to-Peak and Standard Deviation of a selected number of samples; sample size: 2 to 10^6.

TIMER / COUNTER FUNCTIONS

Frequency

Range:

Input A & B:	1µHz to 160 MHz
Input C:	140 MHz to 2.7 GHz
Resolution:	9 digits/s measuring time, max. 10 digits resolution

Burst Frequency, Burst Repetition Rate

Synchronization timing:

Manual:	Manually set timing parameter
Automatic:	AUTO SET sets suitable timing parameters for bursts with a duration of 50 µs to 100 ms, min. 3 cycles on Input A or B and min. 192 cycles on Input C.

Burst duration:

Input A & B:	0.5 µs to 1.5 s, min. 2 cycles in burst
Input C:	50 µs to 1.5 s, min. 128 cycles in burst.
Burst ON/OFF ratio:	< 1:1
Burst Frequency Range:	
Input A & B:	3 Hz to 140 MHz
Input C:	140 MHz to 2.7 GHz
Resolution:	9 digits/s burst measuring time, max. 10 digits resolution
Burst repetition rate:	
Input A & B:	Up to 1 MHz
Input C:	Up to 20 kHz
Resolution:	9 digits/s measuring time, max. 10 digits resolution

Note

If an external control signal (burst synchronization) is available, Input C Burst frequency can be measured in bursts with a duration from 0.5 µs and min. 128 cycles using normal Frequency measurement with External Arming.

Period

Range:	
Input A & B:	6 ns to 10^6s (averaged, to 160 MHz) 20 ns to 10^7s (single, to 50 MHz)
Input C:	370 ps to 7 ns (140 MHz to 2.7 GHz)
Modes:	Single cycle (Input A, B) or Multiple cycles averaged (Input A, B, C)
Resolution:	
Single:	700 ps
Averaged:	9 digits/s measuring time, max. 10 digits resolution

Frequency Ratio f_1/f_2

Range:	10^{-9} to 10^{9}
Frequency Range:	
Input A & B:	1 µHz to 160 MHz
Input C:	140 MHz to 2.7 GHz
Measurement Modes:	f_A / f_B, f_B / f_A, f_C / f_A and f_C / f_B

RPM

Range (Input A or B):	10^{-5} RPM to 10^{9} RPM (with 1 pulse/revolution)
Transducer scaling factor:	1 to 10^{6} pulses/revolution

Time Interval

Range:	0 ns to 10^{7} s
Measurement Modes:	Input A to B, Input B to A, (separate) Input A to A, Input B to B (common)
Frequency Range:	up to 50 MHz
Pulse Width:	≥6 ns at set trigger level
Resolution:	700 ps

Positive/Negative Pulse Width

Range (Input A or B):	6 ns to 10^{7} s
Frequency Range:	up to 50 MHz
Resolution:	700 ps

Rise/Fall Time

Range (Input A or B):	6 ns to 10^{7} s
Frequency Range:	up to 50 MHz
Pulse Width:	≥ 6 ns at set trigger level
Resolution:	700 ps

Duty Cycle

Range:	0.000 1 to 99.999 9%
Frequency Range:	10 mHz to 50 MHz
Pulse Width:	≥ 6 ns at set trigger level
Resolution:	0.000 1% or $Frequency/1GHz$ 100 % whichever is greatest

Phase

Range:	-180.00° to +360.00°
Measurement Modes:	Input A to B or Input B to A
Frequency Range:	10 mHz to 50 MHz
Resolution:	0.01° or $Frequency/1GHz$ 360 whichever is greatest

Totalize with manual control and / or set measuring time

Range:	0 to 10^{14} counts
Measurement modes:	
Manual:	Counts simultaneously pulses on inputs A and B and displays A, B, A-B and A+B
Timed:	Counts on one input, A or B
Start/Stop:	- With Run/Hold key - Totalize during the set time 200 ns to 15 s
Frequency Range:	0 Hz to 100 MHz
Pulse Width:	≥ 5 ns at set trigger level

Totalize with external control signal

Range:	0 to 10^{14} counts
Measurement modes:	Counts pulses on Input A (or B), starts and stops counting via external control signal on input B (or A)
Start/Stop:	- By two consecutive pulses - Totalize during presence of gating signal
Frequency Range:	0 Hz to 100 MHz
Pulse Width:	≥ 5 ns at set trigger level

MEASURING TIME AND SYNCHRONIZATION

Measuring Time

Multiple cycles:	200 ns to 15 s with 100 ns resolution. Used for averaging of Frequency, Burst Frequency, Burst Repetition Rate, RPM, Period and Ratio measurements.
Single cycle:	Equal to the time duration to be measured. Used for Single Period A & B, Time Interval, Pulse Width and Rise-/Fall times.
Display time:	Measuring time or 200 ms whichever is greater.
HOLD / RUN:	HOLD freezes last result. RESTART starts new measurement.

Additional Trigger Control

Normally, measurements are immediately started/stopped by the first input event, that meets the trigger conditions. Arming, Arming Delay and Hold-Off are additional trigger control features that enable the counter to measure on a specific point in a stream of pulses on input A (or B), by ignoring triggering during a set delay time and/or as long as an additional trigger condition on input B (or A) has not been fulfilled.

Arming ON:	Start triggering on input A is enabled directly after an external arming signal has triggered the arming input B. Applies to Frequency, Period or Pulse Width measurements.
Start Arming Delay:	After arming, an additional delay is inserted before the instrument can be start-triggered for a new measurement. Range: 200 ns to 5s Resolution: 100 ns
Trigger Hold-Off:	Stop triggering is inhibited during the set trigger Hold-Off time. Applies to Time Interval, Pulse Width, and Rise/Fall Time measurements. Range: 200 ns to 5s Resolution: 100 ns

VOLTAGE FUNCTIONS

Inputs:	A or B
Voltage range selection:	Manually in three steps or automatically via Auto Set key.
Over-ranging indicator:	Screen indicator “Clipped” indicates over-ranging.
Uncertainty:	Uncertainties specified apply from 10% to 100% of full range - and from 18 °C to 28 °C, after 30 minutes warm-up time. Add (specified uncertainty) x 0.1/ °C at < 18 °C or > 28 °C. Confidence level corresponds to 2σ for a normal Gaussian distribution (>95%).

Peak Voltage (V max, V min, V p-p)

Voltage Range:	500 mV, 5.00 V, 50.0 V
Frequency Range:	20 Hz to 50 MHz
Resolution	1, 10, 100 mV
Uncertainty:	
20 Hz to 2 kHz:	2% + 0.2% of range
2 kHz to 5 MHz	4% + 0.2% of range
5 MHz to 20 MHz	10% + 1% of range
20 MHz to 50 MHz	25% + 1% of range

DC Voltage (DC or DC-component from AC-signal)

Range:	500 mV, 5.00 V, 50.0 V
Resolution:	1, 10, 100 mV
Uncertainty:	2% + 0.2% of range

AC or AC+DC True-RMS Voltage

Range:	300 mV, 3.00 V, 30.0 V
Peak voltage limits:	±500 mV, ±5 V, ±50 V
Resolution	1 mV, 10 mV, 100 mV
Uncertainty (sinewaves):	
20 Hz to 50 Hz:	2% + 0.2% of range (DC +AC), 4% + 0.2% of range (AC)

50 Hz to 2 kHz:	2% + 0.2% of range
2 kHz to 5 MHz:	4% + 0.2% of range (4% + 2% of range in 300 mV range)
5 MHz to 10 MHz:	10% + 1% of range (10% + 2% of range in 300 mV range)
RMS-principle:	The rms-value is calculated from input signal volt-vs-time samples. Specified uncertainty applies only when triggering is correct, resulting in a correctly displayed waveform.
Crest Factor:	Any crest factor tolerated for signals within Vp limits. The instrument is calibrated to the rms value of a sinewave input. For non-sinusoidal input signals, with crest factors up to 3.0, add 2% + 2% of range (typically).

MULTIPLE PARAMETER DISPLAY

Automatic waveform characterization with simultaneous display of all parameters, relevant for selected signal type:

Signal typeParameters displayed simultaneously

SINE and similarcontinuous symm. signals:

Frequency, Period, Vmax, Vmin, Vp-p

PULSE and similar cont. asymm. signals:

Frequency, Period, Positive Pulse Width, Negative Pulse Width, Rise Time, Fall Time, Duty Cycle, Vmax, Vmin, Vp-p.

BURST and similar — Burst Frequency, Burst Repetition Rate, Vmax, Vmin, Vp-p.

WAVEFORM DISPLAY FUNCTION

Displays the waveform of recurrent input signals. Eliminates for most signals the need for a separate oscilloscope to verify the input signal and correct triggering. Uses the same inputs A & B as for Timer/Counter and Voltage measure functions. For viewing complex signal patterns, dynamically changing signals or low amplitude signals, a fully featured oscilloscope can be expected to give a better signal representation..

Vertical Sampling(Voltage sequential)**:**

Suitable for recurrent signals of 200 Hz to 50 MHz. The waveform is captured by measuring Time vs. Voltage samples. Measured time intervals start at one unique start trigger point and stop at consecutive stop trigger points at different trigger levels, scanned over the entire signal.

Bandwidth / rise time:	50 MHz / 3.5ns. Note. Vertical sampling technique causes a different relationship between bandwidth and rise-time, compared to traditional oscilloscopes. The -3dB loss in amplitude is like on a 50 MHz oscilloscope, while the pulse response is 3.5 ns rise time i.e. like a 100 MHz oscilloscope.
Effective sampling rate:	3 Gsa/s, ≤ 20 ns/div. 1 GSa/s, > 20 ns/div.
Glitch detect:	≥6 ns repetitive pulses. Always active and independent of time-base setting.
Horizontal Sampling:	Suitable for recurrent signals of 1 Hz to 2 kHz. (Time sequential)
Frequency Range:	1 Hz to 2 kHz
Sampling Rate:	Up to 40 kS/s
AUTO Sampling:	Automatic selection between Vertical- and Horizontal Sampling. Selection is based on detected input signal frequency and pulse width.

Vertical deflection

Display Modes:	One input (A or B), or two input (A *and* B). Fixed selection depending on selected measurement function.
Frequency response:	1 Hz to 50 MHz (-3dB in Vp-p display)
AC coupled:	20 Hz to 50 MHz (-3dB in Vp-p display)
Coupling:	AC/DC
Rise time:	3.5 ns (vertical sampling mode)
Display Voltage Range:	100 mV to 50 V
Sensitivity:	20 mV/div. to 10V/div. AUTO and manual scaling
Accuracy:	2% + 25 mV
Number of divisions:	8
Pixels/division:	21

Horizontal deflection

Time Coefficients:	5 ns/div. to 0.2 s/div. in a 1-2-5-sequence, auto-scaling (2 cycles of signal) or manually set
Accuracy:	700 ps + 1 pixel (vertical sampling) 25 µs + 1 pixel (horizontal sampling)
Number of divisions:	8 divisions with post trigger data 2 divisions with pre trigger data (vertical sampling mode only)
Pixels/division:	21
Max. display length:	5 input signal cycles

Waveform (Scope) Triggering

Sources:	Input A or B, AUTO selected, depending on set measurement function
Trigger sensitivity:	60 mVp-p to 10 MHz 90 mVp-p to 50 MHz 120 mVp-p to 75 MHz
Trigger Point:	AUTO SET or manually set trigger level and slope
Pre-trigger:	2 divisions, max. 1 cycle (vertical sampling mode only)

Display

Trace: Dot or dot-joined line

Grid graticule: Dotted or full line

INPUT A & B

Coupling: DC or AC

Frequency Range:
0 Hz to 160 MHz (DC-coupled)
20 Hz to 160 MHz (AC-coupled)
Frequency limits for MEASURE FUNCTIONS and WAVEFORM display are separately specified (see Timer/Counter, Voltage and Waveform Functions).

Trigger Level Range: ± 500 mV, ± 5.00 V or ±50.0 V

- Resolution: 1, 10 or 100 mV
- Uncertainty: ± 1% + resolution
- Setting: AUTO, Manual
- Read-out: Digital read-out, or with trigger lines on WAVEFORM display.

Trigger sensitivity, manual trigger setting:

- ± 0.5 V / ± 5 V range: 20 mVrms sine (up to 50 MHz)
  40 mVrms sine (50 MHz to 160 MHz)
- ± 50 V range: 200 mVrms sine (up to 50 MHz)
  400 mVrms sine (50 MHz to 160 MHz)

AUTO Trigger:

- Level: Automatically set at 50% of input signal's Vp-p value, or at 10% and 90% of Vp-p for Rise/Fall Time measurements
- Trigger hysteresis: In Frequency and Period Average modes, hysteresis is automatically set to approx. 33% of input signal's Vp-p value to provide optimal noise immunity. For all other functions, the hysteresis is equal to the specified trigger sensitivity (manual setting) up to 120 MHz. Above 120 MHz the trigger hysteresis increases to 100 mV (0.5V/5V range), and to 1V (50V range) at 160 MHz.

Min. Frequency:	20 Hz.
Impedance:	1 MΩ//15 pF
Low Pass Filter:	≤ 100 kHz
Digital Low-Pass Filter:	≤ 1 Hz to 3 MHz
Maximum input voltage:	
No instrument damage:	240 Vrms up to 1 kHz, decreasing linearly to 6 Vrms at 10 MHz.
Safe for user:	30 Vrms.

INPUT C

Frequency Range:	140 MHz to 2.7 GHz
Prescaler Factor:	64
Operating Input Voltage:	
140 MHz to 300 MHz:	20 mVrms to 5 Vrms
0.3 to 2.1 GHz:	10 mVrms to 5 Vrms
2.1 to 2.4 GHz:	20 mVrms to 5 Vrms
2.4 (*2) to 2.7 GHz:	70 mVrms to 5 Vrms
Impedance:	50 Ω nominal, AC-coupled, VSWR <2:1
Maximum Voltage Without Damage:	12 Vrms during 60s, PIN-diode protected

EXT. REFERENCE INPUT

Frequency:	10 MHz
Voltage Range:	500 mVrms to 12 Vrms
Impedance:	Approx. 500 Ω, AC coupled

TEST SIGNALS OUTPUT

Reference frequency:	10 MHz square-wave
Probe Compensation:	2 kHz square-wave
Gate Monitor:	Gate open: low, gate closed: high
Test Signal Source:	Square-waves, selectable: 1 Hz, 50 Hz, 100 Hz, 1 kHz, 10 kHz, 100 kHz, 1 MHz and 5 MHz Low- and high-duty cycle pulses: 1 kHz/0.2 µs and 1 kHz / 999.8 µs.
Output levels:	Fixed TTL: low ≤0.4 V, high ≥1.8 V into 50 Ω:

RS232 Data in/output

Connector:	Isolated optical connector, for use with optional optical-to-RS232 adapter Option 23/80
Input:	Full programmability via LEARN data strings and RECALL of up to 10 complete instrument settings. Full description available on Option 23/80 software diskette.
Output:	Measurement data, bitmap screen dump etc.

AUXILIARY FUNCTIONS

Statistics

Statistical functions:	Maximum-, Minimum- Mean- values, plus Standard Deviation and Peak-Peak Deviation (= Max-Min). Not available in Totalize functions.
Error reduction:	Random uncertainties for instance from noise and jitter can normally be reduced by $\sqrt{N}$, by averaging a number of measurement readings.
N (Sample Size):	2 to 1 000 000

Mathematics

Mathematics:	Displayed value = K x measurement + L, where K and L are selectable constants
Constants K and L range:	0 and $\pm(10^{-20}$ to $10^{20})$, 12 digits resolution

INFO

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

Tutorial

A built in tutorial description of the MultiFunction Counter

SAVE / RECALL

No. of instrument set-ups:	10
No. of screen images:	1 (WAVEFORM, VALUES or STATISTICS).

GENERAL

Quality and maintenance

Quality assurance:	ISO 9001 Quality System
Warranty:	3 years parts and labor
MTBF	40 000 hours
Calibration:	Closed Case Calibration, recommended interval: 12 months

Display

Type:	Super Twisted Liquid Crystal
Size:	84 x 84 mm, 4.7" diagonal
Resolution:	240x240 pixels
Backlight:	Cold Cathode Fluorescent (CCFL) tube.
Brightness:	3 user selectable levels: max. 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:	<90% RH non-condensing, 20°C to 30°C, <70% RH non-condensing, 30°C to 50°C,
Storage:	<95% RH
Altitude:	
Operating:	3000 m (10 000 ft)
Storage:	12000 m (40 000 ft)
Vibration:	Up to 3G at 55 Hz, per MIL-T-28800E, Class 3
Shock:	Half-sine shock pulse 30G, per MIL-T-28800E, Class 3
Safety:	EN 61010-1:1993, Cat. II
EMC:	Emission: EN 55011 ISM Group 1, Class A.
	Susceptibility: EN 50082-2

Safety

Safe Operation:	30 Vrms
Compliance:	EN 61010-1:1993, Cat. II CE
	CSA CAN / CSA - C22.2 No.1010.1 - 92
AC/DC adapter:	UL: UL1310 Class 2
	C22.2 No. 223

Power Supply

Line voltage:	Via Option 51 AC/DC adapter: 90 to 130 Vrms or 190 to 255 Vrms, 45 Hz to 440 Hz, 18 VA
Internal Ni-Cd Battery:	Type Option 23/86, 4.8 V
Battery Operating Time:	Pulse output and external reference input switched off, lowest backlight brightness level and full battery capacity
Model 164:	typical 2¼ hours
Model 164H:	typical 1½ hours
Battery Charging Time:	3 h typical (instrument switched OFF) 30 h typical (instrument switched ON)
Alternate Battery:	4 alkaline C cells (not included)
External DC Supply:	10 V to 20 V DC, 10 W typical
Current at 12 Vdc:	0.8 A (operating) 0.5 A (non operating, charging only)
Input Connector:	5 mm power jack, DIN 45323

Mechanical Data

Height x Width x Length:	60 x 130 x 260 mm / 2.4 x 5.1 x 10.2 in., excl. holster 65 x 140 x 275 mm / 2.5 x 5.5 x 10.8 in., incl. holster
Weight:	1.5 kg /3.3 lb., excl. holster, 1.8 kg/4.0 lb., incl.holster
Transport weight:	3.4 kg / 7.5 lb.

TIMER/COUNTER MEASUREMENT UNCERTAINTY

Uncertainty examples

Uncertainty examples below are a simplified way to quickly obtain the magnitude of accuracy for commonly made measurements. The figures are overall figures, taking into account all instrument error contributors, such as quantization error, trigger errors, timebase oscillator aging, temperature drift and one year calibration interval.

Exact calculations of the measurement's uncertainties are described in the following section ”Uncertainty Calculation Formulas” (random, systematic and total values), taking into account specific manual settings, ambient temperature and input signal characteristics as slew-rate and noise.

FREQUENCY MEASUREMENTS ON SINEWAVE SIGNALS

Table 1 shows the uncertainty for measurements on undistorted 1Vrms sinewave input signals, with instrument settings obtained through AUTO-SET and making use of the internal timebase reference at room temperature.

Table 5 Uncertainty for measurements on sinewave input signals

Model	**164**	**164H**
Mode and input signal	Absolute uncertainty	Absolute uncertainty
Frequency & Period Average: (Period =1 ÷ Frequency) ≤ 100 Hz	1 mHz	1 mHz
1 kHz	5 mHz	1 mHz
10 kHz	50 mHz	1 mHz
100 kHz…2.7 GHz	$5x10^{-6}$ x Frequency	$1x10^{-7}$ x Frequency
Phase: f: ≤100 kHz	0.1°	0.1°
1 MHz	0.5°	0.5°
10 MHz	5°	5°
Frequency Ratio f_1 / f_2: f_2: 100 Hz	0.1	0.1
10 kHz	0.001	0.001
1 MHz	0.00001	0.00001
100 MHz	0.0000001	0.0000001

Conditions that lead to a better accuracy (reduced uncertainty) are: steeper trigger transitions (for instance through higher input amplitude and higher input frequency), use of STATISTICS to average the result of a number of readings, the use of a more accurate external timebase reference and a shorter calibration interval than 12 months. In LF Frequency measurements, the internal trigger uncertainty is the dominating error contributor, whereas for HF Frequency measurements the internal timebase uncertainty dominates.

FREQUENCY MEASUREMENTS ON PULSE SIGNALS

Table 2 shows the uncertainty for measurements on undistorted 1Vp-p pulse signals with 10 ns rise/fall times (except where otherwise noted for rise/fall-time measurements), with instrument settings obtained through AUTO-SET and making use of the internal timebase at room temperature.

Table 6 Uncertainty for measurements on pulse input signals

Model	**164**	**164H**
Mode and input signal	Absolute uncertainty	Absolute uncertainty
Frequency & Period Average: (Period =1 ÷ Frequency) 20 Hz to 2.7 GHz	$5x10^{-6}$ x Frequency	$1x10^{-7}$ x Frequency
Period Single: ≤ 1 µs	700 ps	700 ps
1 ms	5 ns	1 ns
1 s	5 µs	100 ns
Time Interval, Pulse width: ≤ 1 µs	1.5 ns	1.5 ns
1 ms	5 ns	1.5 ns
1 s	5 µs	100 ns
Rise/Fall time (@ 100 kHz): ≤ 10 ns	2 ns	2 ns
100 ns	5 ns	5 ns
1 µs	50 ns	50 ns
Duty Cycle: ≤ 100 Hz	0.0001 %	0.0001 %
10 kHz	0.0015 %	0.0015 %
1 MHz	0.15 %	0.15 %

Conditions that lead to a better accuracy (reduced uncertainty) are: steeper trigger transitions (for instance through shorter rise-/fall time and higher input amplitude), use of STATISTICS to average the result of a number of readings, the use of a more accurate external timebase reference and a shorter calibration interval than 12 months. For short duration Time measurements, the 700 ps resolution is the dominating error contributor, whereas for long duration Time measurements, the internal timebase uncertainty dominates.

UNCERTAINTY CALCULATION FORMULAS:

TIME INTERVAL, PULSE WIDTH, RISE/FALL TIME (S)

Uncertainty due to Random Effects (rms or standard deviation)

$$\sqrt{700\,ps^{2} + Start\ Trigger\ Error^{2} + Stop\ Trigger\ Error^{2}}$$

Uncertainty due to Systematic Effects (maximum values)

$$Trigger\ Level\ Timing\ Error \quad 1\,ns \quad Time\ Base\ Error \quad Measurement\ Value$$

LSD Displayed

$$500\ ps$$

FREQUENCY, PERIOD (HZ OR S)

Uncertainty due to Random Effects (rms or standard deviation)

$$\frac{\sqrt{700\,ps^{2} \quad 2 \quad StartTriggerError\ ^{2}}}{MeasuringTime} \quad Frequency\ or\ Period$$

Uncertainty due to Systematic Effects (maximum values)

$$Time\ Base\ Error \quad Measurement\ Value \quad \frac{1\,ns}{Measuring\ time} \quad Frequency\ or\ Period$$

LSD Displayed

$$\frac{500\ ps \times Freq.\,or\ Per.}{Measuring\ Time} = \text{(Rounded to nearest decade)}$$

RATIO F_1 / F_2

Uncertainty due to Random Effects (rms or standard deviation)

$$\frac{\sqrt{Prescaler\ Factor^{2} + 2\times(f_1 \ \times\ Start\ Trigger\ Error\ f_2\ )^{2}}}{f_2\ \times\ Measuring\ Time}$$

LSD Displayed

$$\frac{Prescaler\ Factor}{Measuring\ Time \times f_2} = \text{(Rounded to nearest decade)}$$

PHASE (DEGREES)

Uncertainty due to Random Effects (rms or standard deviation)

$$\sqrt{(700ps^2 + Start\ Trigger\ Error^2 + Stop\ Trigger\ Error^2)} \quad Frequency \quad 360$$

Uncertainty due to Systematic Effects (maximum values)

$$Trigger\ Level\ Timing\ Error \quad Freq. \quad 360 \qquad 1\,ns \quad Frequency \quad 360$$

LSD Displayed

$0.01°$

DUTY CYCLE (%)

Uncertainty due to Random Effects (rms or standard deviation)

$$\sqrt{(700ps^2 + Start\ Trigger\ Error^2 + Stop\ Trigger\ Error^2)} \quad Frequency \quad 100\%$$

Uncertainty due to Systematic Effects (maximum values)

$$Trigger\ Level\ Timing\ Error \quad Freq. \quad 100\% \qquad 1\,ns \quad Frequency \quad 100\%$$

LSD Displayed

0.0001%

Internal Timebase Stability

Table 7 Timebase Stability.

	Type	**Standard**	**High Stability Oven**
	Model	**164**	**164H**
Aging Rate per:	24h		<1.5 x 10^{-9} (first year)
	Month	<5 x 10^{-7}	<3 x 10^{-8}
	Year	<5 x 10^{-6}	<1 x 10^{-7} (after first year)
Temperature	0° to 50°	<5 x 10^{-6}	<2 x 10^{-7}
Stability:	10° to 40°		<1 x 10^{-7} (after 15 min.)
(referenced to +23°C)	18° to 28°	<2 x 10^{-6} (after 15 min.)	<5 x 10^{-8} (after 15 min)
Factory adjustment uncertainty (+23°C):		10 MHz ± 50 Hz	10 MHz ± 1 Hz

Start/Stop Trigger Error due to Random Effects

Trigger error, caused by external and internal noise, results in too early or too late start- and stop- triggering. The rms trigger errors associated with each trigger point is:

$$Start\ /\ Stop\ Trigger\ Error\ =\ \frac{\sqrt{(Vnoise\text{ - }input\,)^2\ +\ (Vnoise\text{ - }signal\,)^2}}{Signal\ slew\ rate\ (V/s)\ at\ trigger\ point}$$

Vnoise-input: 0.5 mVrms noise of the input amplifier

Vnoise-signal: rms noise of the input signal over a 160 MHz bandwidth

Trigger Level Timing Error due to Systematic Effects

Trigger level timing error is the sum of two error sources:

1. The trigger level setting error due to deviation of the actual trigger point from the set (indicated) trigger level and

2. The width of the input amplifier hysteresis band (only in Pulse Width & Duty Cycle measurements)

The magnitude of both errors depends on the input signal slew rate:

$$Trigger\ Level\ Setting\ Error = \frac{2 \times trig.lev.resol. + 1\%\ of\ start\ trigger\ level}{Slew\ rate\ (V/s)\ at\ start\ trigger\ point} + \frac{2 \times trig.lev.resol. + 1\%\ of\ stop\ trigger\ level}{Slew\ rate\ (V/s)\ at\ stop\ trigger\ point}$$

$$Input\ Amplifier\ Hysteresis\ Error = \frac{0.01}{Slew\ rate\ (V/s)\ at\ start\ trigger\ point} - \frac{0.01}{Slew\ rate\ (V/s)\ at\ stop\ trigger\ point}$$

Calculation of Measurement Uncertainty (2 σ)

The total uncertainty of a measurement is calculated as twice the combined standard uncertainty (two standard deviations or 2 σ) using the following formula:

$$Total\ Combined\ Standard\ Uncertainty = 2x\sqrt{s^2 + \frac{S\,a_i^2}{3}}$$

where:

s = uncertainty due to random effects, calculated from the formula, specified for each measuring function.

a_i = uncertainty due to systematic effects, calculated for each contributing error, specified for each measurement function.

ORDERING INFORMATION

Selection guide

Table 8 Features.

Models	**164**	**164H**
160 MHz Frequency Counter 50 MHz Time and Vp-p meter 100 MHz PulseTotalizer V dc and 10 MHz true-RMS V ac meter	●	●
50 MHz Waveform presentation mode	●	●
Frequency in Burst and Burst Repetition Rate	●	●
2.7 GHz Frequency and Period	●	●
Timebase stability / Accuracy	5×10^{-6}	5×10^{-7}
Statistics, including Jitter measurements	●	●
Mathematics	●	●
Trigger Hold-Off, Arming and Arming Delay	●	●
Optional PC-support: RS232 adapter	●	●

164	50MHz / 2.7 GHz MultiFunction Counter with Standard Timebase
164H	50 MHz / 2.7 GHz MultiFunction Counter with High Stability Oven Timebase

Included Accessories

9446 601 64001	Users Manual, English
Calibration Certificate	
Ni-Cd Battery Pack	
Option 51/00X	Line Voltage Adapter/Battery Charger X = 1 for Europe (190V-255V) X = 3 for USA and Japan (90V-130V) X = 4 for UK (190V-255V) X = 8 for universal (90V-130V or 190V-255V)

Optional Accessories

Option 23/01	Grey Protective holster
Option 23/80	RS-232C Optically isolated interface adapter
Option 23/86	Spare Ni-Cd Battery Pack
Option 25/164	PendulumView SW for TM-164/164H
PM9585/01	50Ω Feedthrough Termination, 1W
PM9588/01	50Ω BNC-BNC cable set (5x0.2 m – 1ns, 4x0.4 m – 2ns, 3x0.6 m – 3ns , 3x2 m –10ns).

Chapter 12
User Maintenance

Contents **Page**

REPLACING THE BATTERIES

Note

This instrument contains a Nickel-Cadmium battery. Do not dispose of this battery with other solid waste. Used batteries should be disposed of by a qualified recycler or hazardous materials handler.

1. Disconnect the MultiFunction Counter from the charger.
2. Remove the holster.
3. Unscrew the two screws holding the battery cover.
4. Remove the old batteries.
5. If installing a Ni-Cd battery pack, make sure the charging tab on the pack springs out about 30° from the battery pack.
6. Insert new batteries or battery pack according to Figure 122.
7. Fasten the battery cover with the two screws. Do not overtighten!

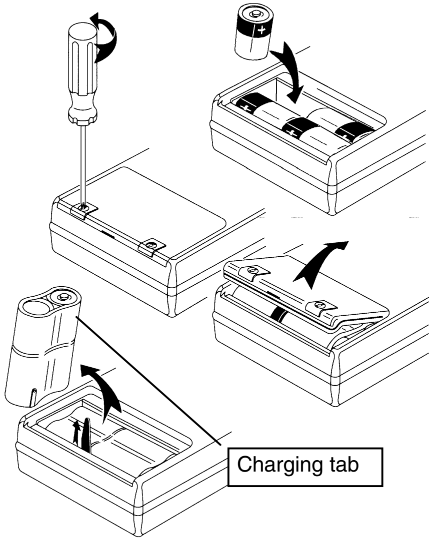


Figure 122 Replacing Batteries. Follow the procedure in this figure to replace batteries. Note that you can insert Non-rechargeable Alkaline C-Cells also.

BATTERY CARE

For All Batteries

- Remove batteries if the MultiFunction Counter is to be stored for 6 months or more.
- Do not expose the MultiFunction Counter to high temperatures; for example, never leave it in the sun.

For Alkaline Batteries

- Turn off the MultiFunction Counter when not in use.
- Do not leave batteries in the MultiFunction Counter during storage.

For Ni-Cd Batteries

- Charge batteries fully as often as possible.
- Fully discharge the batteries occasionally by leaving the MultiFunction Counter turned on. It will turn itself off when the batteries are sufficiently discharged. Then recharge the batteries.
- When you replace old batteries, remember to recycle them.

CALIBRATION INTERVALS

To maintain the performance of the MultiFunction Counter we recommend that you calibrate the timebase of your instrument every year, or more often if you require greater time base accuracy. Calibration should be performed with traceable references and instruments at a certified calibration laboratory. To know the present status of your instrument, test your counter from time to time. The test can be made according to the information in “Appendix 1, Acceptance Test.”

Voltage Reference

The built-in voltage reference is the main factor that influences voltage measurement accuracy. The voltage reference should be calibrated once a year. The adjustment procedure is a ”closed case” procedure described in the service manual.

Oscillator

The frequency of the reference crystal oscillator is the main parameter that influences time, frequency and phase accuracy of a MultiFunction Counter. External conditions, such as ambient temperature and supply voltage, affect the frequency, but aging is also a factor. When calibrating and adjusting, you compensate the reference crystal oscillator only for deviation in frequency due to aging.

SOME IMPORTANT POINTS:

The high-stability oscillators have been built into an oven to keep the oscillator temperature as stable as possible.

The stability shown for the oscillators is valid within a temperature range of 0 to 50° C, with a reference temperature of 23° C. If the counter is used in a room temperature of 18 to 28 °C, the temperature stability of a standard oscillator or Oven Oscillator will be improved by a factor of 3 typically.

The stability for standard oscillators is mainly dependent on the ambient temperature. During the first 30 minutes after power-on there is always a temperature increase inside the counter that will influence the oscillator.

Timebase Uncertainty (room temperature)

What time base uncertainty can you expect when operating in room temperature (18º-28ºC) and calibrate once per month, once per year, once per two years, and once per three years

Table 9 Timebase uncertainty at room temperature.

	Month	Year	2 Years	3 Years
164	2.4×10^{-6}	6.2×10^{-6}	1.2×10^{-5}	1.7×10^{-5}
164H First year	7.8×10^{-8}	6.3×10^{-7}	7.4×10^{-7}	8.6×10^{-7}
164H Following year	6.7×10^{-8}	1.3×10^{-7}	2.4×10^{-7}	3.1×10^{-7}

Timebase Uncertainty (full temperature range)

What time base uncertainty can you expect when operating in the temperature range 0º-50ºC and calibrate once per month, once per year, once per two years, and once per three years

Table 10 Timebase uncertainty, full temperature range.

	Month	Year	2 Years	3 Years
164	5.8×10^{-6}	8.2×10^{-6}	1.3×10^{-5}	1.8×10^{-5}
164H First year	2.4×10^{-7}	6.6×10^{-7}	7.7×10^{-7}	8.9×10^{-7}
164H Following year	2.3×10^{-7}	2.6×10^{-7}	3.3×10^{-7}	4.2×10^{-7}

When calibrating, keep in mind that the reference crystal oscillator will be compensated only for frequency deviation caused by aging.

For other calibration intervals the ”internal Timebase Stability” table in the technical specifications will give all necessary information.

CLEANING

Keep your MultiFunction Counter clean by wiping it off with a cloth and a mild detergent. Never use alcohol or other chemicals.

HOW TO GET SERVICE & REPAIR

To get service and repair, contact your local sales representative or Pendulum Instruments’ Service center at the address below:

Pendulum Instruments AB
Karlsbodavägen 39
Box 20020
SE-161 02 Bromma
Sweden
Phone: +46 8 5985 1000
Fax: +46 8 5985 1040
e-mail: info@pendulum.se

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Chapter 13
Appendices

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APPENDIX 1, ACCEPTANCE TEST

General Information

The MultiFunction Counter should be calibrated and in operating condition when you receive it.

WARNING:

Before turning on the instrument, ensure that it has been installed in accordance with the installation instructions outlined in chapter 1 of the Users Manual.

This procedure is intended to:

- be used for incoming inspection to determine the acceptability of newly purchased instruments and recently calibrated instruments.
- check the necessity of calibration adjustment after the specified recalibration intervals.

Note

The procedure does not check every aspect of the instrument's calibration; rather, it is concerned primarily with those parts of the instrument which are essential to the function of the instrument.

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

If the instrument fails any of the tests, calibration adjustments and/or repair is necessary.

Extensive Performance Verification

The MultiFunction Counter Service Manual contains a Complete Performance Verification Procedure intended to verify the specifications listed in chapter “Specifications” on page 11-1. If the instrument passes the tests, it is considered to be calibrated and can carry a calibration sticker.

Required Test Equipment

Table 11 Recommended Test Equipment.

Equipment Type	Required Characteristics	Recommended Model
50Ω Power Splitter		PM 9584/02
50Ω Feedthrough Termination (2 pcs)		PM 9585
50Ω Coaxial Cable (3 pcs)	BNC to BNC, 2 pcs of equal length	

Operational Verification

The operational verification is a quick way to check that the instrument operates properly without performing the complete performance verification. Because of the highly integrated design of the MultiFunction Counter, it is not always necessary to check all features separately.

Note

Power up the MultiFunction Counter and the test equipment at least 30 minutes before testing to let them reach normal operating temperature. Failure to do so may result in certain test steps not meeting the specifications.

SELF TEST

Procedure

1. Press ⏻ to turn on the MultiFunction Counter.
2. Select Default Settings by: Pressing SAVE RECALL and choosing Recall Default Setup and then pressing SELECT.
3. Press USER OPTIONS.
4. Position the black cursor on Test&Adjust and press SELECT.
5. Check that **Select Self Test: All Self Tests** is displayed.
6. Position the black cursor on Run Self Tests and press SELECT.
7. Check that all tests are passed. If the test is not applicable, dashes (----) will show instead of ”Passed”.
8. End the self test by pressing any key.

PRESENTATION MODE

These tests verify the operation of the PRESENTATION MODE.

Test setup

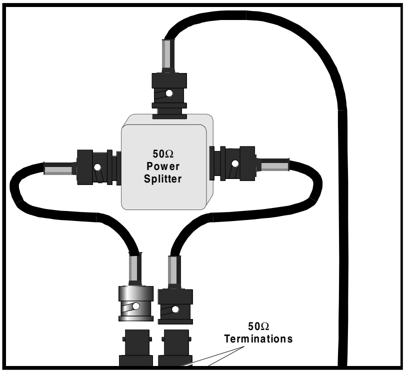

Figure 123 Test setup.

WAVEFORM Test Procedure

1. Select Default Settings by: Pressing SAVE RECALL and choosing Recall Default Setup and then pressing SELECT.
2. Press USER OPTIONS, then choose Output, then press SELECT.
3. Set OUTPUT as follows:
   Output: On
   Output Signal: 1 MHz, Square
4. Press [sine-wave key], then verify that the 1 MHz, 0.9 Vp-p square wave is displayed.
5. Press MEASURE FUNCTION and choose Frequency (Hz), press SELECT, select Frequency Ratio and press SELECT.
6. Verify that the two 1 MHz, 0.9 Vp-p square wave traces are displayed.
7. Press UNDO to return to the one trace screen.

VALUES Test Procedure

1. Press 1.234.

2. Verify the following measured values:
   Frequency A: 1.000 MHz
   Period Average A: 1.000 µs
   Vmax: approx. 0.45V
   Vmin: approx. 0.45V
   Vp-p: approx. 0.90V

STATISTICS Test Procedure

1. Press MAX MIN.
2. Verify the following measured values:
   Mean: 1.000 MHz
   Standard Deviation: <5 mHz
   Maximum: 1.000 MHz
   Minimum: 1.000 MHz
   Max-Min: < 30 mHz

MEASURE FUNCTION

These tests verify the operation of MEASURE FUNCTION.

Test setup

As test setup in Figure 123.

Time Interval A to B Test Procedure

1. Select Default Settings by: Pressing SAVE RECALL and choosing Recall Default Setup and then pressing SELECT.
2. Press USER OPTIONS, then choose Output, then press SELECT.
3. Set Output as follows:
   Output: On
   Output Signal: 1 kHz, Square
4. Press MEASURE FUNCTION, then choose Period&Time, then press SELECT.
5. Choose Time Interval, then press SELECT.
6. Press INPUT TRIGGER, choose Input A, then press SELECT.

7. Set Input A conditions to:
   Trigger Slope: Positive
   Auto Trigger: On
   Voltage Range: ±5.0V
   Coupling: DC
   100 kHz LP Filter: Off
8. Press EXIT to exit Input A settings.
9. Choose Input B, then press SELECT.
10. Set input B conditions to:
    Trigger Slope: Negative
    Auto Trigger: On
    Voltage Range: ±5.0V
    Coupling: DC
    100 kHz LP Filter: Off
11. Press EXIT to exit input B settings.
12. Choose Arming&Hold Off, then press SELECT.
13. Set Hold Off conditions to
    Trigger Hold Off: On
    Hold Off Time: 2.00 ms
14. Press 1.234.
15. Verify the following approximate measured values:

Time Interval A to B: 2.5 ms

16. Verify the following approximate voltage readings

Vmax	Vmin	Vp-p
0.90V	0.00V	0.90V
0.90V	0.00V	0.90V

Totalize, Gated by Time Test Procedure

1. Press MEASURE FUNCTION, then choose Totalize (Counts), then press SELECT.
2. Choose Gated by Time, then press SELECT.
3. Use the INFORMATION MENU at the bottom of the display and set A trigger to MAN, then press AUTO SET.
4. Verify the following measured value:
   Totalize A Timed: 100 ±1

Pulse Group Test Procedure

1. Press MEASURE FUNCTION, then choose Pulse, then press SELECT.
2. Use the INFORMATION MENU and set Hold-Off to Off.
3. Verify the following approximate measured values:

Period A:	1.000 ms
Frequency A:	1.000 kHz
Positive Pulse Width A:	500.0 µs
Negative Pulse Width A:	500.0 µs
Positive Duty Cycle A:	50.00%
Rise Time A:	15 ns
Fall Time A:	10 ns

10 MHz REFERENCE INPUT

This test verifies the operation of the External Timebase Reference Input.

Test setup

As test setup in Figure 123. Also connect the Frequency Standard to the MultiFunction Counter's REF INPUT.

Test Procedure

1. Select Default Settings by: Pressing SAVE RECALL and choosing Recall Default Setup and then pressing SELECT.
2. Press USER OPTIONS, then choose **Timebase Reference: External**.
3. Choose Output, then press SELECT.
4. Set OUTPUT as follows:
   Output: On
   Output Signal: 10 MHz, Reference.
5. Press 1.234.

Verify that the display reads approximately 10.000 000 XX MHz and the Ext Ref on the INFORMATION MENU is lit.

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