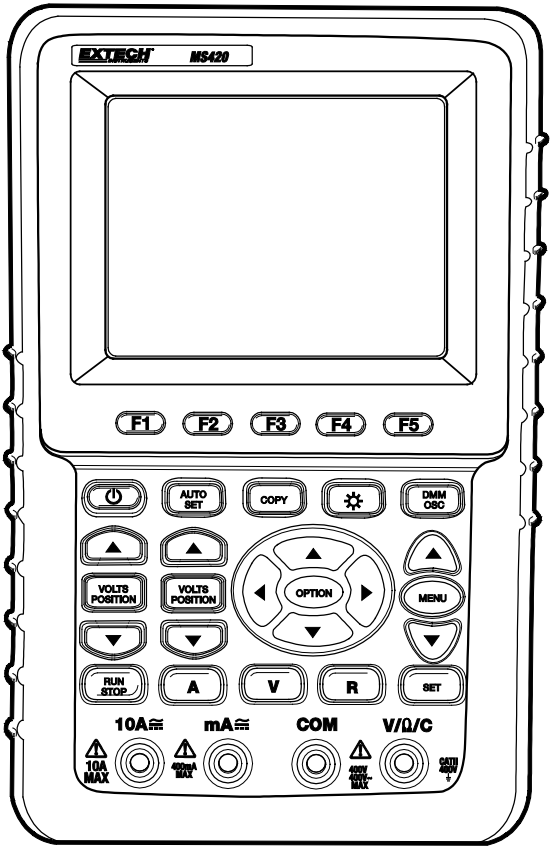
EXTECH®

User Manual

Digital 20MHz Oscilloscope

Model MS420 - 20MHz



INTRODUCTION

Congratulations on your purchase of the Extech Digital Oscilloscope. This manual is divided into two sections: Section One for the Oscilloscope functions and Section Two for the Multimeter functions. This meter is shipped fully tested and calibrated and, with proper use, will provide years of reliable service.

PRODUCT CONTENTS

1. MS420 Instrument
2. AC Adaptor
3. Oscilloscope Probes (2); Grey in color
4. Multimeter test leads (2); One black, one red
5. USB mass storage connection cable
6. Extension module for low capacitance measurements
7. Probe adjustment tools
8. USB or Serial PC Communication cable
9. User manual
10. CD-ROM Software Program
11. Carrying Case

SAFETY INFORMATION

Please read the user manual before use to ensure safety and precision

SAFETY SYMBOLS AND TERMS

WARNING: "WARNING" IDENTIFIES CONDITIONS &

ACTIONS THAT POSE A HAZARD TO THE USER

Caution: "Caution" identifies conditions and actions that may damage the product or external equipment

DANGER: High Voltage	Refer to the Manual	Protective Conductor Terminal	Chassis Ground	Earth (ground) Terminal
				

SAFETY TERMS

The following terms may appear on the instrument:

Danger: The term "Danger" is used in this manual to indicate that immediate personal injury can result

Warning: The term "Warning" is used in this manual to indicate that, although immediate personal injury is not likely, caution should be taken

Notice: The term "Notice" is used in this manual to indicate that damage to the meter or to other equipment can occur

GENERAL SAFETY INFORMATION

Carefully read the following safety information to avoid personal injury and damage to this product or to products connected to it. This product must only be used in the specified manner to prevent danger and hazard to products and persons.

 Warning:

To avoid fire or electrical shock please use the proper power adapter. Use only the power adapter recommended by the manufacturer.

 Warning:

To avoid fire or electrical shock do not connect meter to more than 42V peak (30Vrms) or on circuits of more than 4800VA:

- Use only the insulated voltage probes, test leads and adapter supplied with the test tool, or as indicated by Extech as suitable for the Oscilloscope & Multimeter.
- Before use, inspect voltage probes, test leads and accessories for mechanical damage. Replace the equipment when it appears damaged.
- Remove all probes, test leads and accessories when not in use.
- Always connect the power adapter first to the AC outlet before connecting it to the Oscilloscope & Multimeter.
- Do not apply voltages that exceed 400 V from earth ground to any input when measuring in a CAT II environment.
- Do not apply voltages that exceed 400 V to the isolated inputs when measuring in a CAT II environment.
- Use caution when using 1:1 test leads since the probe tip voltage will be directly transmitted to the Oscilloscope & Multimeter.
- Do not use exposed metal BNC or banana plug connectors.
- Do not insert metal objects into the connectors.

- Always use the Oscilloscope & Multimeter in the manner specified.
- Voltage ratings, mentioned in the warnings, are provided as “working voltage” limits. They represent V ac rms (50-60Hz) for AC sine wave applications and as V dc for DC applications. Overvoltage Category II refers to local level applicable for appliances and portable equipment.

Only qualified technical personnel should perform maintenance on these devices.

Observe the nominal value limits for all terminals: To avoid fire or electric shock, observe all nominal value limits, markings, and specifications for this product. Before connecting to this product, carefully read the user’s manual.

Do no operate this instrument without the cover plate secured: If the cover plate or panel has been removed, do not use this product.

Do not touch bare conductors

Do not use this meter in case of any undetermined failure: When in doubt consult qualified repair personnel

Do not hinder the meter’s ventilation: Refer to the user manual for detailed installation instructions and proper setup for adequate ventilation

Do not operate this meter in overly humid environments.

Do not operate this meter in potentially explosive environments.

Keep the meter’s surface clean and dry.

Use of this device in any manner inconsistent with the uses specified in this manual can possibly compromise the safety protection provided by the meter.

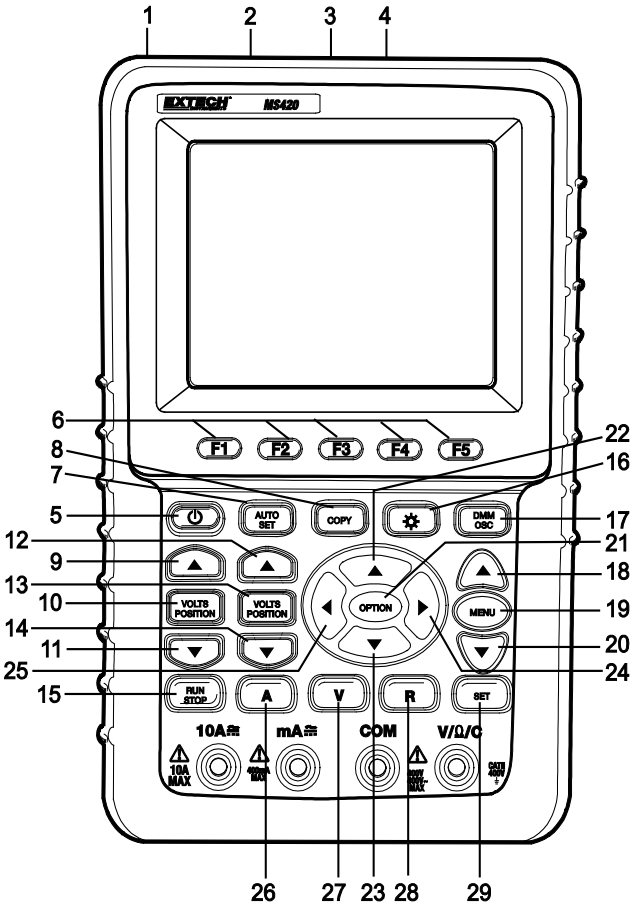
INPUT CONNECTIONS

Figure 2

Description

1. The power adapter is use to supply AC power and for battery recharging
2. Multimeter test leads
3. Multimeter input jacks (L to R: Current 2A-10A input, mA Current input, COM ground input, Voltage/Resistance/Capacitance input)
4. Oscilloscope probes
5. Oscilloscope channel inputs
6. Square wave output jack

FRONT PANEL AND KEYPAD OVERVIEW



Description of Meter Front Panel and Keypad (Figure 3)

1. AC adapter Port
2. RS-232C Port
3. USB Port
4. USB Mass Storage Port
5. Power switch

6. F1 – F5 Soft-key options
7. AUTO SET: In the Scope mode, the meter automatically selects the horizontal/vertical scale and trigger level
8. COPY: Press to store the waveform data into a USB storage device
9. ▲ (Red): Adjust the horizontal scale for Channel 1
10. VOLTS POSITION (Red): Switch between voltage and horizontal scales for Channel 1
11. ▼ (Red): Adjust the horizontal scale for Channel 1
12. ▲ (Blue): Adjust the horizontal scale for Channel 2
13. VOLTS POSITION (Blue): Switch between the voltage and horizontal scales for Channel 2
14. ▼ (Blue): Adjust the horizontal scale for Channel 2
15. RUN/STOP: Start/Stop the waveform capture process
16. BACKLIGHT: Turn the display backlight ON and OFF
17. DMM/OSC: Operation mode (switch between oscilloscope and multimeter)
18. MENU ▲: Choose a higher item on a menu list
19. MENU: Show / Hide menu
20. MENU ▼: Choose a lower item on a menu list
21. OPTION: Used in combination with the four (4) yellow arrow keys. This button is used to set the main time base, trigger horizontal position and trigger vertical position. Also used to adjust the display multiplier factors and display vertical position during waveform calculation. Further, it is used to adjust cursor 1 (V1 or T1) and cursor 2 (V2 or T2) position during cursor measurements
22. ▲ (yellow): Oscilloscope UP arrow adjustment key
23. ▼ (yellow): Oscilloscope DOWN arrow adjustment key
24. ► (yellow): Oscilloscope FORWARD adjustment key
25. ◄ (yellow): Oscilloscope BACKWARD adjustment key
26. A: Selects DMM Current measurement mode
27. V: Selects DMM Voltage measurement mode

28. R: Selects DMM impedance, diode, continuity, capacitance measurement mode
29. SET: Toggle AC/DC in the current or voltage multimeter measurement modes; also switches between resistance, diode and capacitance modes while in the resistance mode.

SECTION ONE - BASIC OSCILLOSCOPE FUNCTIONS

This chapter provides introductory Oscilloscope instructions. This introduction does not cover all of the oscilloscope capabilities but provides basic examples of menu navigation and operations. Detailed instructions are provided in the Advanced Oscilloscope functions section.

POWERING THE OSCILLOSCOPE

Connect the oscilloscope to an AC power source using the supplied AC adaptor.

If the battery is charged, the oscilloscope may be powered by the supplied and installed Li-ion battery. The meter will run for up to four (4) hours on a full charge.

Turn the oscilloscope on by pressing the power key.

Upon power up, the instrument performs a 'self check'. The display will show the "press any key to continue……" screen.

MAIN OSCILLOSCOPE DISPLAY SCREEN

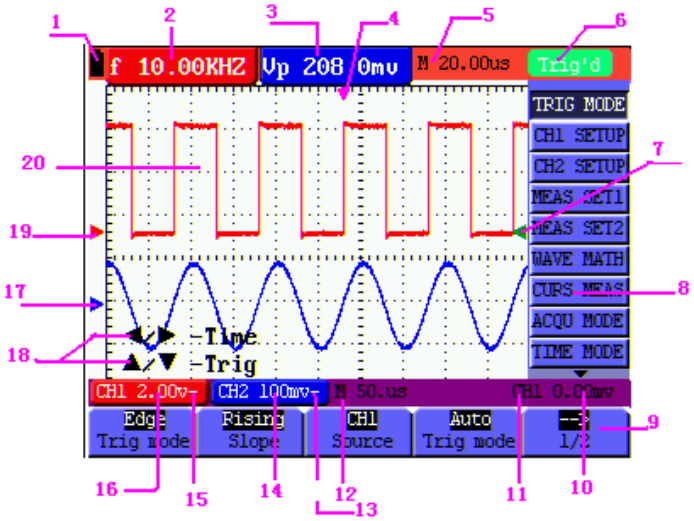


Figure 4: Oscilloscope Display Screen

Description of Oscilloscope Display Screen (Figure 4)

1. Battery power status icon (, , and)
2. Auto measurement screen No. 1 ("f" for frequency, "T" for cycle, "V" for average value, "Vp" is the peak-peak value and "Vk" is the root-mean-square value
3. Auto measurement screen No. 2
4. Horizontal triggering position
5. The difference in time between the horizontal triggering position and the screen's centerline (zero when the pointer is in the center of the screen)
6. The trigger modes:

   Auto: The oscilloscope is in the automatic mode and displaying the waveform in the non-trigger mode

   Trig'd: The oscilloscope has detected a trigger and is displaying the information generated after the trigger

Ready: All pre-triggered data has been captured and the oscilloscope is ready to receive trigger signals

Scan: The oscilloscope records and displays waveform data continuously

Stop: The oscilloscope has stopped collecting waveform data

7. Red and blue trigger pointer shows vertical position of alternate triggers. The trigger pointer turns green when it reaches an edge trigger or a video trigger
8. Hide or View the menu using the **MENU** key;
9. Menu setting options (vary with each function)
10. Trigger Voltage Level
11. **Trigger signal source**
12. Primary Time Base
13. The coupling mode for CH2; "~" AC, "-" DC, and ground
14. The vertical Voltage units scale for CH2
15. The coupling mode for CH1; "~" AC, "-" DC, and ground
16. Vertical Unit Scale for CH1
17. The blue pointer shows the ground point of the waveform for CH2 (zero position). If this pointer is not shown, the channel has not been opened.
18. OPTION (options vary with each function)
19. The red pointer shows the ground point of the waveform for CH1 (zero position). If this pointer is not shown, the channel has not been opened
20. Waveform display area. Red waveform represents CH1, blue represents CH2.

MENU DESCRIPTION

The following explains how to navigate the menus to select a function.

1. Press the **MENU** key to open the Function Menu. The Menu appears on the right of the screen with the corresponding options available on the bottom of the screen. Press **MENU** again to hide the Function Menu.
2. Use the **MENU ▲** or **MENU ▼** keys to navigate and select menu functions.
3. Use the soft-keys (**F1…F5)** to select an available option

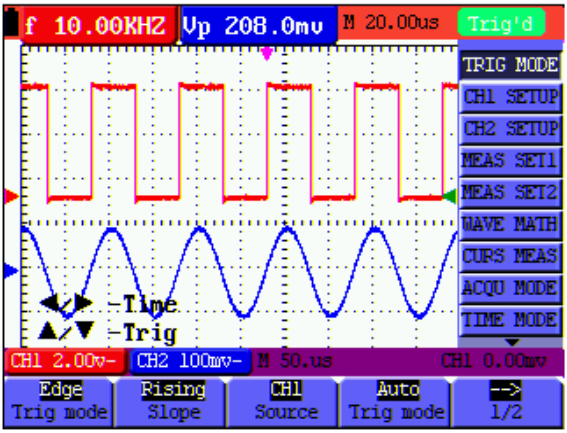


Figure 5: Menu

MANUALLY SETTING THE TRIGGER POSITION AND TIME BASE

Use the OPTION key to set the vertical trigger position, the main time base and the horizontal trigger position during Edge triggering and Video Triggering or vertical trigger position for Horizontal time base and vertical trigger position and horizontal level position during an Alternate trigger.

For triggering in edge and video trigger mode:

1. Press the OPTION key once; the following will appear at the screen's bottom left:

◄/► – Time Base

▲/▼ – Trig

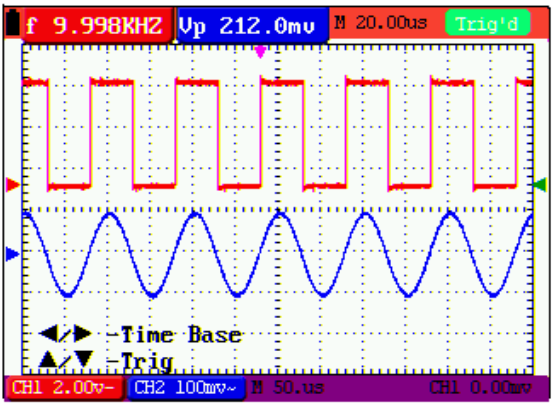


Figure 6

2. Press ◄ (yellow) or ► (yellow) to adjust the main time base. Press ▲ (yellow) or▼ (yellow) to adjust the trigger horizontal position.

3. Press OPTION again and the following will appear:

◄/► – Time

▲/▼– Trig

See Figure 7:

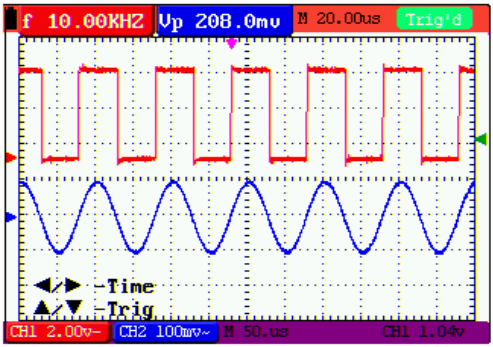


Figure 7

4. Press ◄ (yellow) or ► (yellow) to adjust time base horizontal position, press▲ (yellow) or ▼ (yellow) to adjust trigger position.

5. Use the OPTION key to toggle between the two modes described above.

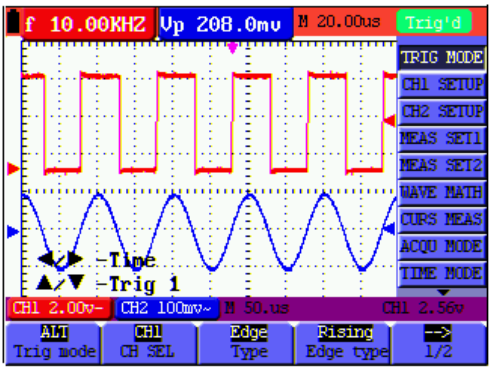
When triggering in the Alternate trigger mode:

7. Press OPTION and the following will appear:

◀/▶ —Time

▲/▼ —Trig 1

See Figure 8:



7. Press ◄ (yellow) or ► (yellow) to adjust the time base horizontal position and press ▲ (yellow) or ▼ (yellow) to adjust the trigger horizontal position for Channel 2.

8. Press OPTION again to display the following:

◄/► — Time Base

▲/▼ — Trig 2

See Figure 9:

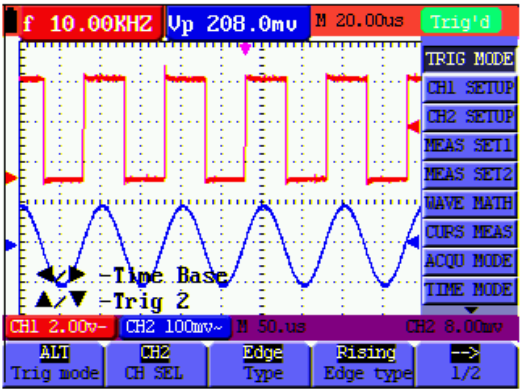


Figure 9:

9. Press ◄ (yellow) or ► (yellow) to adjust the main time base and press ▲ (yellow) or▼ (yellow) to adjust the trigger horizontal position for Channel 1.

10. Press OPTION again to return to step 6 above.

GLOSSARY OF TERMS

- **Vertical scale factor:** The voltage amplitude represented by a division in the vertical direction of the display area, through the adjustment of which the user can amplify or attenuate the signal and thus regulate the signal amplitude so that it is placed in the expected measurement range.
- **Vertical zero position:** Ground point, through the adjustment of which the user can regulate the display position of the waveform on the screen.
- **Main time base:** The time value represented by a division in the horizontal direction of the display area.
- **Trigger horizontal position:** The time difference between the actual trigger point and the screen central line, which will be displayed as 0 at the center point of the screen.
- **Trigger level position:** The voltage difference between the actual trigger level and the zero position of the triggering signal source channel.

RECALL THE FACTORY DEFAULT SETTINGS

To reset the Oscilloscope to the factory default settings, refer to the following:

1. Press the **MENU** key; the function menu will appear on the right side of the screen
2. Press the **MENU ▲** or **MENU ▼** key to select a **FUNCTION**; three options will be visible at the bottom of the screen.
3. Press **F1** (**Recall Factory**) to recall the factory settings.
4. Press **F2** to select “Auto calibration”. If the ambient temperature varies from the specified operating temperature by more than 5 degrees Celsius, an Auto Calibration should be performed.

OSCILLOSCOPE INPUT CONNECTIONS

The Oscilloscope has two (2) signal inputs (located on the lower right side) for CH1 and CH2 measurements.

Isolated inputs allow for independent floating measurements between Multimeter and Scope functions.

MEASURE UNKNOWN SIGNALS USING THE AUTO-SET FEATURE

The Auto-Set feature allows the Oscilloscope to measure and display unknown signals automatically. This function optimizes position, range, time-base, and triggering. It also assures a stable display of virtually any waveform. Auto Range is especially useful for quickly checking several signals.

To enable the Auto-Set feature, perform the following steps:

1. Connect the test probe to the circuit or device under test.
2. Press the **AUTO SET** key; the test signals will appear on the screen.

AUTO ZERO THE HORIZONTAL TRIGGER AND TRIGGER LEVEL POSITION

To configure the instrument so that the horizontal trigger and the trigger level position automatically return to zero.

1. Press the **V** key; the horizontal trigger position will automatically return to zero
2. Press the **R** key; the trigger level position will automatically return to zero

AUTOMATIC MEASUREMENT RANGING

The Oscilloscope offers five (5) ranges that adjust automatically as measurements are taken. Two numeric readings can be displayed: **MEAS SET1** and **MEAS SET2** (selectable independently); the measurements can be performed on the CH1 or CH2 waveform inputs.

To choose a frequency for CH1, perform the following procedure:

1. Press the **MENU** key; the function menu will appear on the right side of the screen.

2. Press **MENU ▲** or **MENU ▼** to select **MEAS SET 1**. Five selectable options will then be visible at the bottom of the screen.

3. Press the **F1** key and select **Freq CH1** from the root mean square (RMS) option. The **MEAS SET 1** window color will change to red and display CH1 frequency.

To choose Peak-Peak measurements for the CH2 input, refer to the following:

1. Press the **MENU** key; the function menu will appear at the right side of the screen.

2. Press **MENU ▲** or **MENU ▼** key to select **MEAS SET 2**. Five (5) selectable options will appear at the bottom of the screen.

3. Press the **F4** key to select **PK-PK CH2** from the Peak-Peak option. The **MEAS SET2** window color turns to blue and displays the peak-peak value for the CH2 input.

Refer to Figure 11:

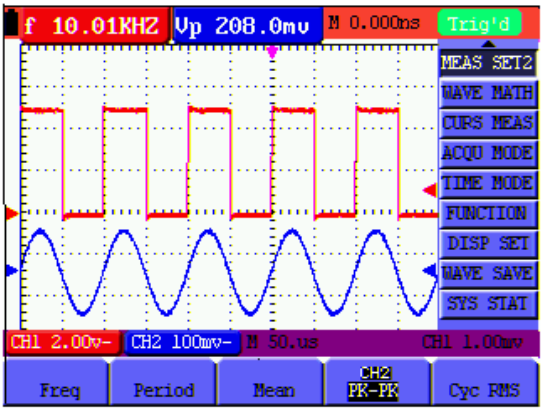


Figure 11: Automatic Scope Measurements

DATA HOLD (FREEZING THE DISPLAYED READING)

To freeze any displayed reading or waveform, follow these steps:

1. Press the **RUN/STOP** key to freeze the screen: **STOP** appears at the top (right) of the screen.

2. Press the **RUN/STOP** key again to resume normal mode. Refer to Fig. 12:

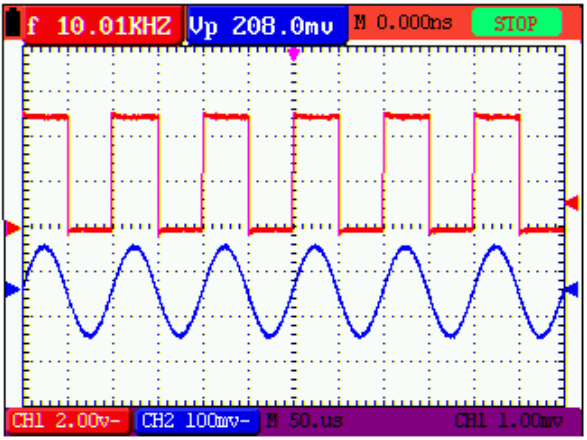


Figure 12: Freezing the Screen

USING THE AVERAGE MODE TO SMOOTH WAVEFORMS

Use the Average mode to smooth the displayed waveform; multiple data samples will be averaged. The number of samples to average is selectable from 4, 16, 64, up to 128.

Note: For best results, the waveform must be repetitive. As the number of average samples increases the waveform updating time increases. Refer to the following:

1. Press the **MENU** key; the function menu will appear on the right side of the screen.

2. Press **MENU** ▲ or **MENU** ▼ to select the **ACQU** (acquisition) mode; Four (4) selectable options will display at the bottom of the screen.

3. Press the **F3** key to select **Average Factors** and then press the **F4** key to jump to **Averages 16**. The meter then averages 16 samples (or acquisitions) and displays the final result. Refer to Figure 13:

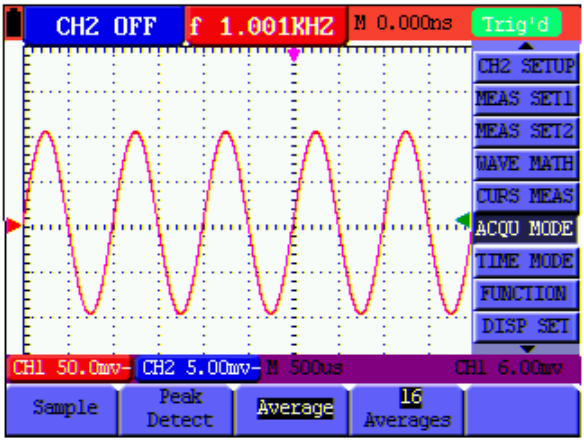


Figure 13: Average Factor Sampling Mode

PERSISTENCE MODE (SUPERIMPOSING WAVEFORMS)

Persistence Mode allows the user to hold a displayed waveform on the display while, at the same time, superimposing the current waveform. The user can select the amount of time (number of seconds or infinite) to retain the displayed waveform or set the feature OFF. Refer to the following:

1. Press the **MENU** key; the function menu will appear on the right side of the screen.

2. Press **MENU ▲** or **MENU ▼** to select **DISP SET.** Four (4) selectable options will appear at the bottom of the screen.

3. Press the **F2** key to select **1 sec, 2 sec, 5 sec, infinite or OFF**. Select a 1, 2, or 5 second waveform display duration as desired. When **Infinite** is

selected the waveform will remain on the screen indefinitely. When **OFF** is selected, the **Persistence** function has no effect on displayed waveforms.

Refer to Figure 14.

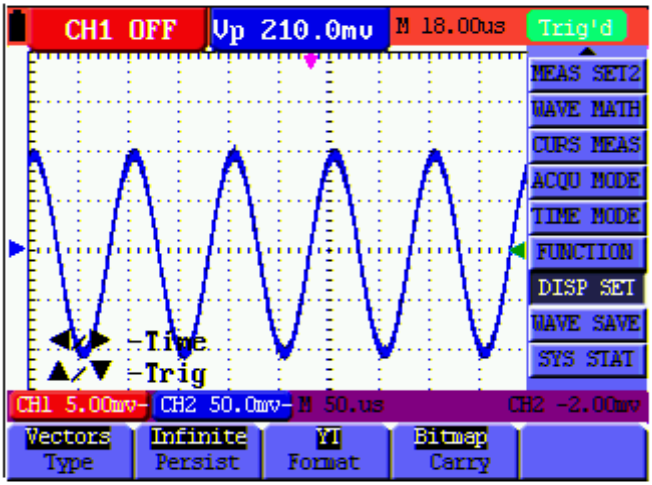


Figure 14: Persistence Mode to Observe Dynamic Signals

USING PEAK DETECTION TO CAPTURE GLITCHES

Use Peak Detect to display events (glitches or other asynchronous waveforms) down to 50 ns (nanoseconds).

1. Press the **MENU** key; the function menu will appear at the right side of the screen.
2. Press **MENU** ▲ or **MENU** ▼ to select the **ACQU** MODE. Four (4) selectable options will appear at the bottom of the screen.
3. Press the **F2** key to select **Glitch Detect**.

Refer to Figure 15.

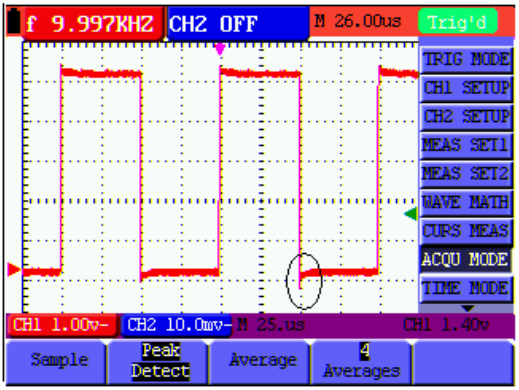


Figure 15: Peak Detection

GLOSSARY OF TERMS

- **Collecting mode:** The oscilloscope converts the collected analog data into digital data for each of the following three modes: Sampling, Peak Detect, and Averaging.
- **Sampling:** The waveform sampling resolution in seconds. Waveforms that change faster than the sample duration will not be accurately captured.
- **Peak value detection:** In peak detect mode the meter can capture very narrow pulses down to 50ns
- **Averaging values:** The oscilloscope averages a selectable number of measurements. Random noise can be minimized in this mode.
- **Duration time:** A waveform can be held as a new waveform is displayed. The amount of time the previous waveform is displayed is the 'duration time'.
- **Roll scan:** The oscilloscope updates the waveform sampling points by scrolling the screen from left to right (applicable only to primary time base settings above 50ms).

SELECTING AC-COUPLING

After a reset, the Oscilloscope is dc-coupled so that ac and dc voltages appear on the screen. Use ac-coupling to observe a small ac signal that rides on a dc signal. To select ac-coupling, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right side of the screen.

2. Press **MENU** ▲ or **MENU** ▼ to select the **CH1** Setting**.** Four (4) selectable options appear at the bottom of the screen.

3. Press the **F1** key and select **AC**. The AC coupling icon will appear on the screen.

Refer to Figure 16.

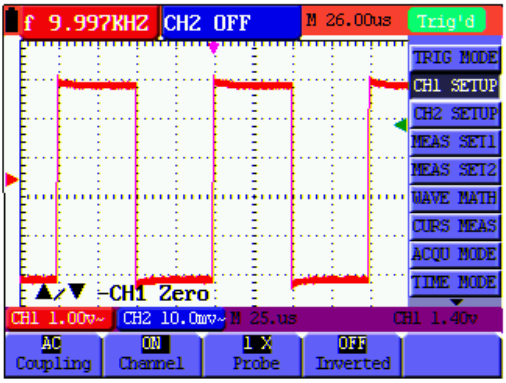


Figure 16: AC-Coupling

REVERSING THE POLARITY OF THE DISPLAYED WAVEFORM

To invert the input CH1 waveform, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right side of the screen.
2. Press **MENU** ▲ or **MENU** ▼ to select **CH1** setting. Four (4) selectable options will appear at the bottom of the screen.

3. Press the **F4** key to select **Inverted.** The CH1 inverted waveform will then be displayed on the screen.

Refer to Figure 17.

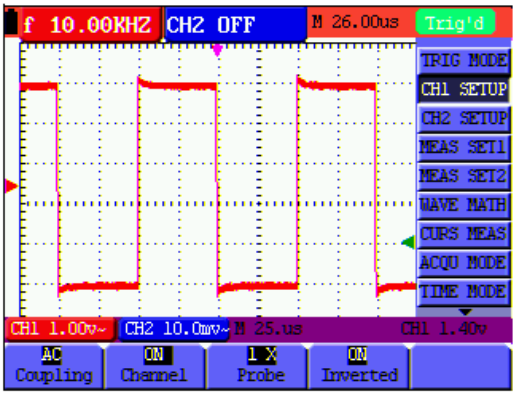


Figure 17: Inverted Waveform

USING MATHEMATICAL FUNCTIONS ON WAVEFORMS

When adding (CH1 + CH2), subtracting (CH1 – CH2, CH2 – CH1), multiplying (CH1 * CH2) or dividing (CH1/CH2) the input waveforms of CH1 and CH2, the oscilloscope will display the mathematical result waveform M and the input waveforms of CH1 and CH2 on the screen. The Mathematical functions perform a point-to-point calculation on the waveforms (CH1 and CH2).

To use a Math function, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right side of the screen.
2. Press **MENU ▲** or **MENU ▼** to select **WAVE MATH.** Five (5) selectable options will appear at the bottom of the screen.

3. Press the **F3** key to select **CH1+CH2**; the calculation resulting waveform M (green) will then appear on the screen. Press the **F3** key again to exit the Waveform Calculation mode.
4. Press **OPTION** and the screen will show the following on the bottom left:

◀/▶ —CH Math Volts/Div

▲/▼ —CH M Zero

5. Press▲(yellow) or ▼(yellow) to adjust the vertical display position of waveform M. Press ◀(yellow) or ▶(yellow) to adjust the display time factor for waveform M.

Refer to Figure 18.

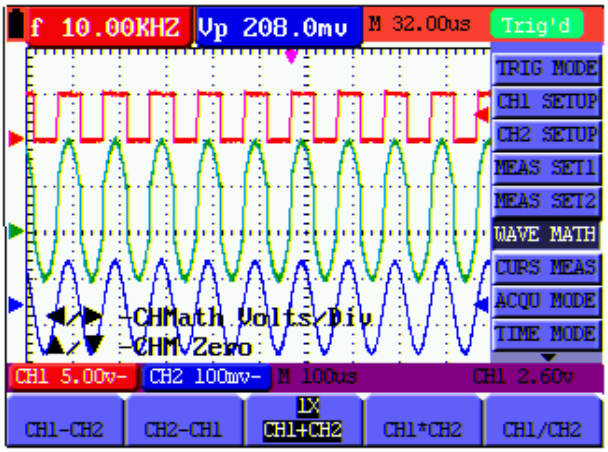


Figure 18: Waveform Mathematical Calculations

SAVE WAVEFORM DATA - USB MASS STORAGE DEVICE

Connect a USB mass storage device to the USB port on the meter using the supplied cable. Press the **COPY** key. The current waveform data will then be saved (the file names are automatically sequenced (WAVE1.bin, WAVE2.bin, etc.). Now connect the USB Mass Storage device to a Personal

Computer and use the supplied software to transfer and manipulate the stored data.

Note: Refer to the HELP utility in the supplied software for further instructions.

ADVANCED OSCILLOSCOPE FUNCTIONS

VERTICAL SETTINGS FOR CH1 AND CH2

Each channel has its own independent vertical menu and each item can be set respectively based on the specific channel.

To make vertical CH1 and CH2 settings, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right of the screen.
2. Press **MENU ▲** or **MENU ▼** to select **CH1 SETUP.** Four **(**4) selectable options will appear at the bottom of the screen.
3. Use the soft function keys (**F1** through **F4)** to adjust settings as desired.

Refer to Figure 19.

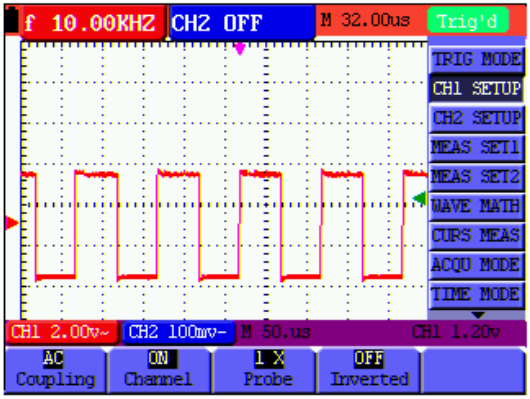


Figure 19: Vertical Settings

Vertical Channel menu

Function menu	Setting	Description
Coupling	AC DC	The dc component in the input signal is blocked The ac and dc components of the input signal are available
Channel	OFF ON	Close the channel Open the channel
Probe	1X 10X 100X 1000X	Select the desired probe attenuation
Inverted	OFF ON	Waveform is displayed normally Open the **Invert** function for the waveform setting

SETTING THE CHANNEL COUPLING

CH1 will be used in this example.

Press **F1 Coupling** and then **AC** to set AC coupling. The DC component contained in the tested signal is blocked.

Press **F1 Coupling** and then **DC** to set DC coupling. Both DC and AC components contained in the tested signal are permitted.

Refer to Figures 20 and 21.

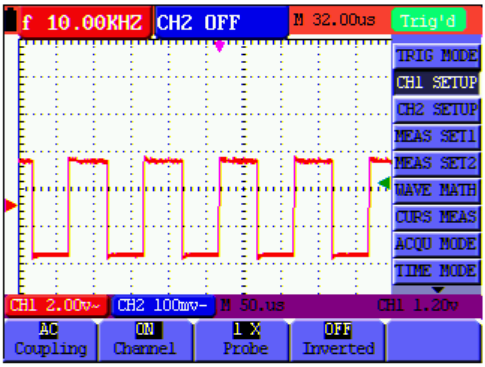


Figure 20: AC Coupling

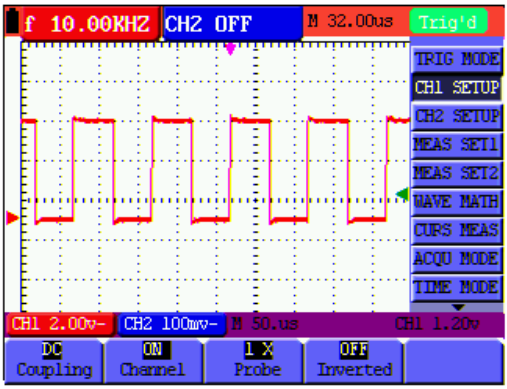


Figure 21: DC Coupling

Open and Close Measurement Channels

CH1 will be used in this example**.**

Press the **F2 Channel** key and then **OFF** to Close CH1.

Press the **F2 Channel** key and then **ON** to Open CH1.

SETTING THE PROBE ATTENUATION

To prevent excessive input voltage, set the probe attenuation level to the 10X position.

Next, magnify the display by 10X to match the displayed amplitude to the actual amplitude.

Press **F3 Probe** to adjust the probe attenuation level.

Table: Probe attenuation level and the corresponding menu setting

Probe attenuation level	Corresponding Menu Setting
1:1	1X
10:1	10X
100:1	100X
1000:1	1000X

INVERT A WAVEFORM

Inverted waveform: The displayed signal reverses 180 degrees relative to ground.

Press F4 Invert to invert the waveform; press F4 Invert again to exit the inversion mode.

WAVE MATH FUNCTION MENU SETTINGS

The **WAVE MATH** functions show the calculation results (adding, subtracting, multiplying or dividing CH1 and CH2 channel waveforms). Arithmetic operation results can be displayed using a grid or a cursor. The amplitude of the calculated waveform can be adjusted with **CHM VOL**, which is displayed in the scale factor form. The amplitude ranges from 0.001 through 10 (in 1, 2, and 5 step increments) that is, it can be expressed as 0.001X, 0.002X, 0.005X…10X. The position of the calculated waveform can be adjusted up and down using the **CHM ZERO** key.

The corresponding operation function table

Setting	Description
CH1-CH2	CH1 waveform minus CH2 waveform
CH2-CH1	CH2 waveform minus CH1 waveform
CH1+CH2	Add CH1 waveform to CH2 waveform
CH1*CH2	Multiply CH1 and CH2 waveforms
CH1/CH2	Divide CH1 by CH2

To perform a **CH1+CH2** waveform calculation, perform the following:

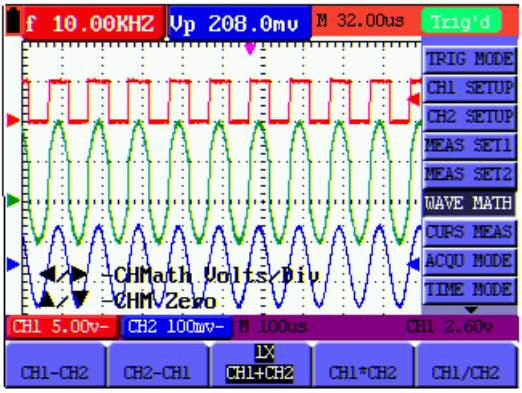
1. Press the **MENU** key; the function menu will appear at the right of the screen.
2. Press MENU ▲ or MENU ▼ to select **WAVE MATH. Five** (5) selectable options will then be displayed at the bottom of the screen.
3. Press the **F3 CH1+CH2** key and waveform **M** appears on the screen. Press the **F3** key again to close waveform **M**.
4. Press OPTION and the display will show the following:

◀/▶ — CH Math Volts/Div

▲/▼ — CH M Zero

5. Press ◄ (yellow) or ► (yellow) to adjust the range of the M waveform
6. Press ▲ (yellow) or ▼ (yellow) to adjust the position of the M waveform

Refer to Figure 22.



SETTING THE TRIGGER SYSTEM

The trigger determines when the acquisition and display of waveform data occurs. When starting to acquire data, the oscilloscope collects sufficient information to draw the waveform at the left side of the triggering point. While waiting for a triggering condition, the oscilloscope gathers data continuously. After a trigger is detected, the oscilloscope gathers data continuously to draw the waveform at the right side of the triggering point.

To set a trigger mode, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right of the screen.
2. Press **MENU ▲** or **MENU ▼** to select **TRIG MODE. Five (5)** selectable options will then be available at the bottom of the screen.
3. Use the soft-keys (**F1** to **F5)** to select and configure the desired options.
4. Press OPTION; the following will appear on the display during edge triggering and video triggering modes:

◀/▶ — Time ◀/▶ — Time Base

▲/▼ — Trig ▲/▼ — Trig

During alternate triggering the following will be displayed:

◀/▶ —Time Base ◀/▶ — Time

▲/▼ —Trig1 ▲/▼ — Trig2

5. Press ▲ (yellow) or ▼ (yellow) to adjust the vertical trigger position, Press ◄ (yellow) or ► (yellow) to adjust the time base horizontal position or adjust the horizontal position.

TRIGGERING CONTROL

There are three triggering modes: Edge triggering, Video triggering, and Alternating triggering. Each trigger mode has its own function menu.

Edge triggering: The edge trigger triggers on the incoming signal edge. Use the edge trigger for all signals except for video.

Video triggering: Perform video field trigger or line trigger on standard video signals.

Alternate trigger: Use this mode when the CH1 and CH2 signal frequency differs.

The following describes the Edge triggering, Video triggering and Alternating triggering menus respectively.

Edge Triggering

Edge triggering is a mode by which triggering occurs at the threshold of the input signal's edge. With **Edge triggering** selected, the trigger occurs on the rising or falling edge of the input signal (Figure 23).

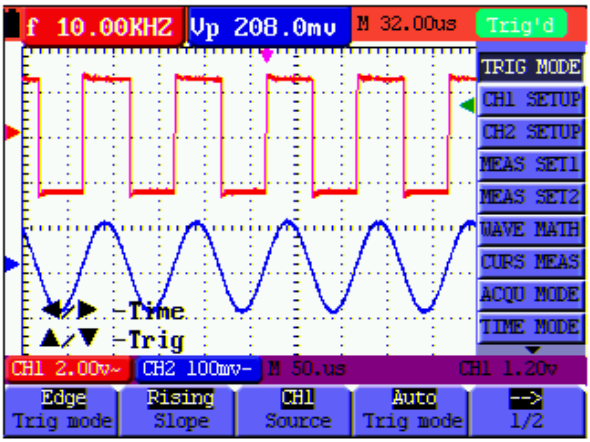


Figure 23: Edge Trigger

Edge triggering menu

Function menu	Settings	*Description*
Slope	Rising Falling	Triggering on the rising edge of the signal Triggering on the falling edge of the signal.
Source	CH1 CH2	CH1 is used as the trigger source CH2 is used as the trigger source
Trig mode	Auto Normal Single	Acquisition of waveforms is possible even if there is no triggering condition detected Acquisition of waveforms can only be performed when the triggering condition is satisfied Sampling is performed on a waveform when one trigger is detected (sampling then stops).
		Move to the next menu
Coupling	AC DC HF Rjc LF Rjc	The DC component is blocked All components are allowed HF part of the signal is blocked; only the LF component is allowed The LF part of the signal is blocked; only the HF component is allowed
SENS		Trigger sensitivity*
Hold-off		Move to the Hold-off menu
		Return to previous menu

***Sensitivity**: Sensitivity is an adjustment that allows the meter to obtain a stable trigger by excluding the influences of signal noise. The sensitivity is adjustable from 0.2div~1.0div.

VIDEO TRIGGERING

The video trigger is designed to capture a video signal format, **NTSC, PAL** or **SECAM**. For any other signal type, use the Edge trigger mode. Refer to Figure 24a & b, Figure 25 and Figure 26.

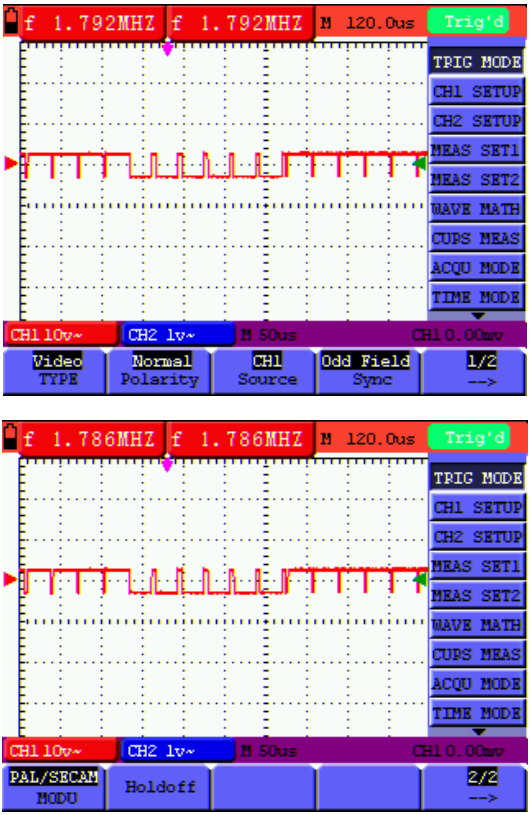


Figure 24a (screen 1) and 24b (screen 2): Odd Field Video Trigger

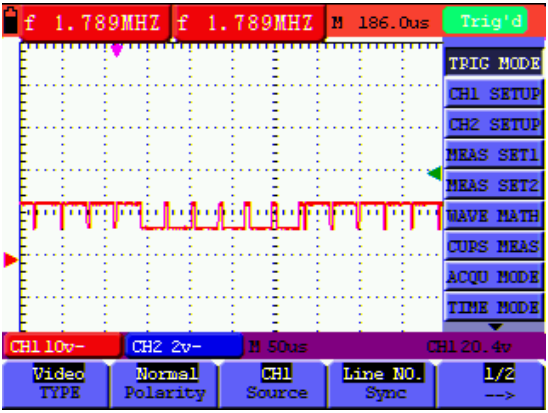


Fig. 25: Video Line trigger (screen 1)

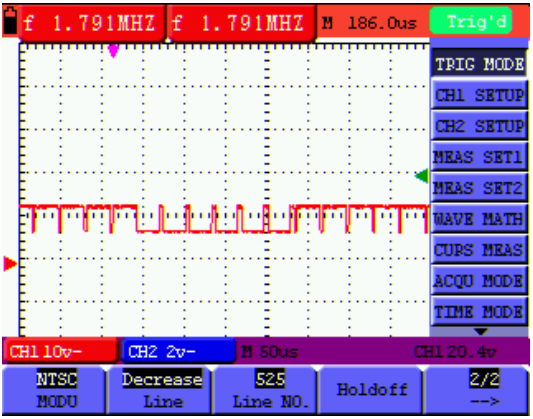


Fig. 26: Video Line Trigger (screen 2)

Video triggering menu

Function menu	Settings	Description
First screen		
Polarity	Normal Inverted	For video signals with low black levels For video signals with high black levels

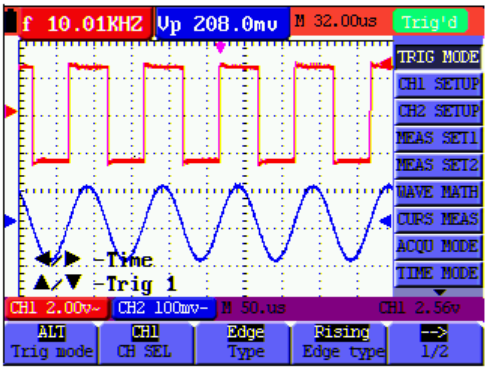
Source	CH1 CH2	Select CH1 as the trigger source Select CH2 as the trigger source
Sync (Synchronization)	Line Field Odd field Even field Line NUM	Set synchronous trigger in video line Set synchronous trigger in video field Set synchronous trigger in video odd line Set synchronous trigger in video even line Set synchronous trigger in video Line NUM
		Move to next menu
When the sync is Line, Field, Odd Field, Even Field, the second page is as follows:		
MODU (Modulation)	NTSC PAL/SECAM	National Television System Committee standard (most common) Less common video standard (used in Europe)
Hold-off		Move to the Hold-off menu
		Return to previous menu
When the sync is Designed Line, the second page is as follows:		
MODU (Modulation)	NTSC PAL/SECAM	National Television System Committee standard (most common) Less common video standard (used in Europe)

Line	Increase Decrease	The Line value will increase The Line value will decrease
Line No.		Set and show the Line value
Hold-off		Move to the Hold-off menu
2/2 -->		Return to previous menu

ALTERNATE TRIGGER

In Alternate trigger mode, the trigger signal is taken from two vertical channels. Alternate trigger mode can be used to observe two signals of differing frequencies. From this menu the user can set a different trigger type for two separate vertical channels.

Refer to Figure 27a.



Alternate triggering menu

Function menu	Settings	Description
When EDGE TRIGGERING is selected:		
CH SEL	CH1 CH2	Set trigger type and other parameters for Channel 1 Set trigger type and other parameters for Channel 2
Type	Edge Video	Set vertical channel trigger as edge trigger Set vertical channel trigger as video trigger
Edge type	Rising Falling	Triggering on the rising (leading) edge of the signal Triggering on the falling (trailing) edge of the signal
		Move to the next menu
Coupling	AC DC HF Rjc LF Rjc	The DC component is blocked All components are allowed to pass The HF part of the signal is blocked and only the LF component is allowed The LF part of the signal is blocked and only the HF component is allowed
SENS		Set trigger sensitivity

Hold-off		Move to the Hold-off menu
		Return to previous menu

Function menu	**Settings**	Description
When VIDEO TRIGGERING is selected:		
CH SEL	CH1 CH2	Set trigger type and other parameters for CH1 Set trigger type and other parameters for CH2
Type	Edge Video	Set vertical channel trigger as edge trigger Set vertical channel trigger as video trigger
Video type Polarity	Normal Inverted	For video signals with low black level For video signals with high black level
Sync (Synchronization)	Line Field Odd field Even field Line NUM	Set synchronous trigger in video line Set synchronous trigger in video field Set synchronous trigger in video odd line Set synchronous trigger in video even line Set synchronous trigger in video Line NUM
When the sync is Line, Field, Odd Field, Even Field, the menu is as follows:		

MODU (Modulation)	NTSC PAL/SECAM	Common video standard (used in the U.S.) Least common standard (common in Europe)
Hold-off		Move to the Hold-off menu
When the sync is Designed Line, the menu is as follows:		
MODU (Modulation)	NTSC PAL/SECAM	Common video standard (used in the U.S.) Least common standard (common in Europe)
Line	Increase Decrease	The Line value will increase The Line value will decrease
Line No.		Set and show the Line value
Hold-off		Move to the Hold-off menu

When the 'Hold-off' menu is accessed the screen will appear as below:

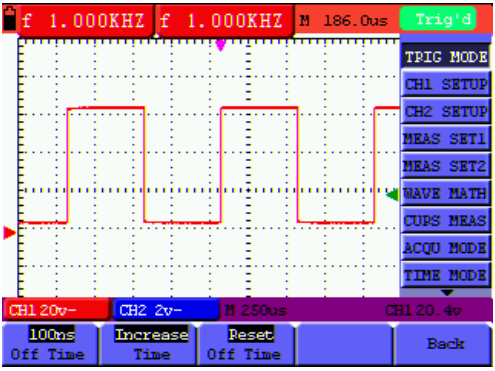


Figure 27b: 'Hold-off' menu screen

Refer to the Table below for details on the 'Hold-off' mode:

Function menu	Settings	*Description*
OFF Time		Select a time duration (hold-off time) that will act as a delay before each trigger event
Time	Increase Decrease	Increase the time Decrease the time
Reset the Time		Reset the hold-off time to 100ns
Back		Return to the previous menu

Note:

Trigger Hold-off can stabilize complex waveforms. Hold-off time is the oscilloscope's waiting period before starting a new trigger. During Hold-off, oscilloscope will not trigger.

GLOSSARY OF TERMS

- **Hold-off time:** Programmable time period between trigger events (100ns default).
- **Trigger modes**: There are three trigger modes: Auto (acquires signal continuously), Normal (acquires signal when trigger conditions are met) and Single (manually triggers the signal).
- **Automatic trigger mode:** In this mode, the oscilloscope can acquire a waveform without a triggering condition
- **Normal trigger mode:** In this mode, the oscilloscope cannot acquire the waveform until it is triggered. When no trigger is present, the oscilloscope will display only the original waveform; no new waveforms can be captured until a trigger is detected.
- **Single mode:** In this mode, the oscilloscope will detect a trigger and capture a waveform each time the user presses the RUN/STOP key.

ACQUISITION MODE

Acquiring Mode menu

Function menu	Settings	**Description**
Sample		The waveform data sampling time interval. The sample mode accurately reconstructs the waveform, but cannot respond to rapid changes and sudden peaks.
Peak Detect	50ns max.	The peak detect mode captures rapid changes and sudden peaks.
Average		Multiple samples are averaged. The average mode reduces the noise level (for best results, the waveform must be repetitive)
Averages	4, 16, 64 or 128	Select the number of samples to average

DISPLAY SETTING

The **Display Setting** menu is described in the following table.

Function menu	*Settings*	Description
Type	Vectors Dots	Shows the waveform as a smooth line, connecting each data point Shows the waveform as a collection of independent data points
Persist	OFF 1s 2s 5s Infinite	Sets the duration of time that previous waveforms remain on the display (useful for observing waveform variations)
Format	YT XY	Displays the relative relationship between vertical voltage and horizontal time. Displays CH1 on the horizontal axis and CH2 on the vertical axis
Carry	Bitmap Vectors	Data transmitted in bitmap format (dots) Data transmitted in vector format (line)

DISPLAY STYLE

The display style includes **Vector** and **Dot** display types.

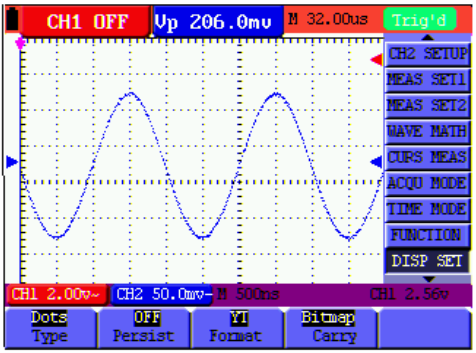


Figure 28: Dot Style

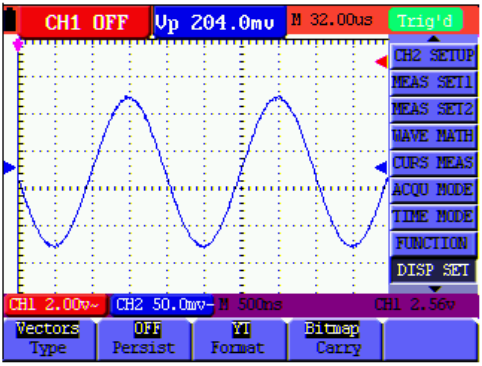


Figure 29: Vector Style

PERSISTENCE

The user can select the duration of time that past traces remain on the display. The selections are 1, 2, 5 seconds, Infinite, and OFF.

XY MODE

This mode is only applicable to simultaneous CH1 and CH2 measurements. The X-Y format plots the CH1 input as X-axis and CH2 input as Y-axis. This display mode is convenient for viewing the phase relationship between CH1 and CH2; if the oscilloscope does not detect triggering the data appear in light spots.

Description of Control Keys:

- The **CH1 VOL** and **CH1 ZERO** keys for CH1 are used to set the horizontal scale and position.
- The **CH2 VOL** and **CH2 ZERO** keys for CH2 are used to set the vertical scale and position continuously.

The following functions are not available in the XY display mode:

- Reference or digital value waveform
- Cursor
- Time base control
- Trigger control

STORING WAVEFORMS

The oscilloscope can save four (4) waveforms that can be displayed on the screen along with the present waveform. The recalled waveforms cannot be adjusted.

The **waveform Store / Recall menu** is described in the following Table.

Function menu	Setups	Description
Source	CH1 CH2 MATH	Select the signal source of the waveform to save (the waveform to save must be on the display)
WAVE	A, B, C and D	Select the memory address for saving or recalling data
Save		Store the waveform of the selected signal source into the selected address

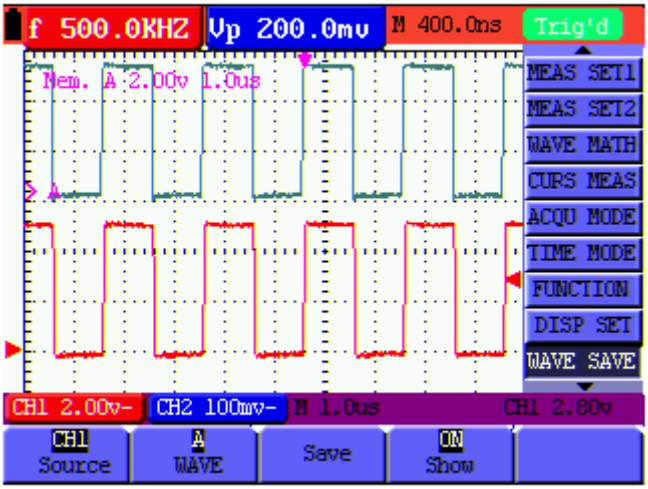
Show	ON OFF	Set ON to display the waveforms stored in address A, B, C or D. Choose OFF to exit this feature.

To save a CH 1 waveform in address A, perform the following steps:

1. Press the **MENU** key; the function menu will appear at the right of the screen.
2. Use the **MENU ▲** or **MENU ▼** key to select **Wave Save**. Four (4) selectable options will then appear at the bottom of the screen.
3. Press the **F1** key to select **CH1** as the signal source.
4. Press the **F2** key to select Address **A**.
5. Press the **F3** key to save the waveform on CH1 in address **A.**

To display the saved waveform on the screen, perform the following steps:

1. Press **F4** to select Start for Address **A**. The waveform saved in Address **A** will be displayed in green. The zero point, voltage the time will display in purple



FUNCTION SETTING MENU (REFER TO TABLE BELOW)

Press the **MENU** button and use the up/down arrow keys to scroll to **FUNCTION**

Function menu	**Description**
Recall Factory	Set the meter's settings to their factory default conditions
Auto Calibration	Perform an Auto-calibration procedure
Language	Select the desired display language (English, Chinese, Deutsch, or Greek)

AUTO-CALIBRATION

The Auto-calibration function automatically configures internal parameters to maintain the sensitivity and accuracy of the meter. Use the Auto-calibration in the following cases:

- When the temperature changes by more than 5 degrees Celsius during operation
- When operating the oscilloscope in a new bench top or field environment

1. Press **MENU** and select the **FUNCTION** menu using the **MENU** ▲ or **MENU** ▼ key

2. Press **F2** (Auto calibration). A message appears asking the user to remove all cables and probes from the oscilloscope

3. After removing all cables, press **F2** (Auto calibration) again. The Auto-calibration automatically starts and a status message appears.

To interrupt calibration, press any key during the calibration.

AUTOMATIC RANGING MEASUREMENTS

The oscilloscope can perform twenty (20) automatic measurements: Frequency, cycle, average, peak-to-peak, root mean square, Vmax, Vmin, Vtop, Vbase, Vamp, overshoot, pre-shoot, rise time, fall time, +width, -

width, +duty, -duty, delayA->B ↓ and delayA->B ↑. Two measurement results can be displayed simultaneously on the screen.

Automatic measurements

Function menu	Settings	*Description*
Freq	CH1 CH2	Measure the frequency of CH1 Measure the frequency of CH2
Period	CH1 CH2	Measure the period of CH1 Measure the period of CH2
Mean	CH1 CH2	Measure the average value of CH1 Measure the average value of CH2
Peak-Peak	CH1 CH2	Measure the peak-to-peak value of CH1 Measure the peak-to-peak value of CH2
Cyc RMS	CH1 CH2	Measure Root Mean Square (RMS) value of CH1 Measure Root Mean Square (RMS) value of CH2
Vmax	CH1 CH2	Measure the Vmax of CH1 Measure the Vmax of CH2
Vmin	CH1 CH2	Measure the Vmin of CH1 Measure the Vmin of CH2
Vtop	CH1 CH2	Measure the Vtop of CH1 Measure the Vtop of CH2
Vbase	CH1 CH2	Measure the Vbase of CH1 Measure the Vbase of CH2
Vamp	CH1 CH2	Measure the Vamp of CH1 Measure the Vamp of CH2
Overshoot	CH1 CH2	Measure the Overshoot of CH1 Measure the Overshoot of CH2
Preshoot	CH1 CH2	Measure the Preshoot of CH1 Measure the Preshoot of CH2
RiseTime	CH1	Measure the RiseTime of CH1

	CH2	Measure the RiseTime of CH2
Fall Time	CH1 CH2	Measure the Fall Time of CH1 Measure the Fall Time of CH2
+Width	CH1 CH2	Measure the +Width of CH1 Measure the +Width of CH2
-Width	CH1 CH2	Measure the -Width of CH1 Measure the -Width of CH2
+Duty	CH1 CH2	Measure the +Duty of CH1 Measure the +Duty of CH2
-Duty	CH1 CH2	Measure the -Duty of CH1 Measure the -Duty of CH2
DelayA->B	CH1 CH2	Measure the DelayA->B of CH1 Measure the DelayA->B of CH2
DelayA->B	CH1 CH2	Measure the DelayA->B of CH1 Measure the DelayA->B of CH2

FREQUENCY MEASUREMENT

To measure the frequency of CH1 with **MEAS SET 1** and the frequency of CH2 with **MEAS SET 2**, perform the following steps:

1. Press the **MENU** key; the function menu will appear on the right side of the screen
2. Press the **MENU** ▲ or **MENU** ▼ key to select **MEAS SET 1**. Five (5) selectable options will then appear at the bottom of the screen
3. Press the **F1** key to select the frequency measurement of **CH1.** The measurement window will appear red in color and show the frequency of CH1
4. Press the **MENU** ▲ or **MENU** ▼ key to select **MEAS SET 2**. Five (5) selectable options will then appear at the bottom of the screen
5. Press the **F4** key to select the peak-to-peak value of **CH2**. The measurement window will appear blue in color and show the peak-to-peak value of CH2

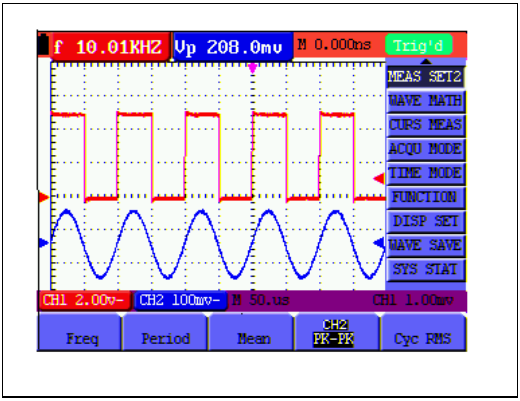
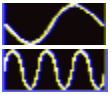


Figure 31: Automatic Measurements

Autoscale

Autoscale enables the instrument to automatically configure the trigger mode, voltage division and time scale according to the type, amplitude and frequency of a signal.

Function Menu	Setting	Instruction
Autoscale	OFF ON	Turn OFF Autoscale Turn ON Autoscale
Mode	Vertical Horizontal HORI—VERT	Adjust vertical scale without changing horizontal setting Adjust horizontal scale without changing vertical setting Adjust the vertical and horizontal settings
		Display one or two periods Display multi-period waveforms

To measure CH1 voltage:

1. Press **MENU**, the function menu will appear on the right side of the screen.
2. Press **MENU** ▲ or **MENU** ▼ and choose AUTOSCALE; three (3) options will appear at the bottom of the screen
3. Press **F1** to select **ON**
4. Press **AUTOSET** to enter the Autoscale mode; the symbol  flickers every half second at the top left of the display
5. Press **F2** to select the Horizontal/Vertical mode
6. Press **F3**  and refer to the display examples below:

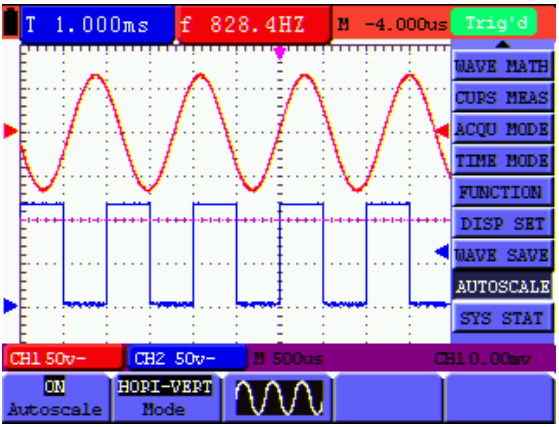


Fig 32: Autoscale Horizontal - Vertical multi-period waveforms

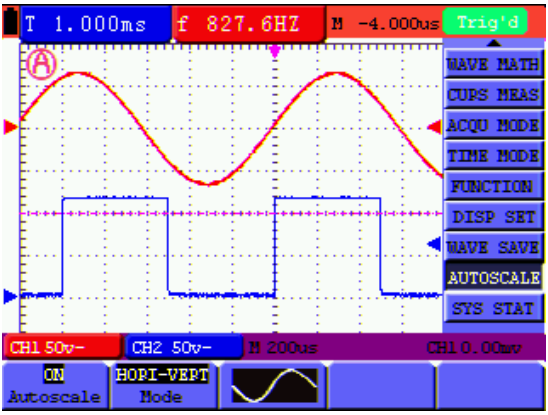


Fig 33: Autoscale Horizontal - Vertical mono-period waveform

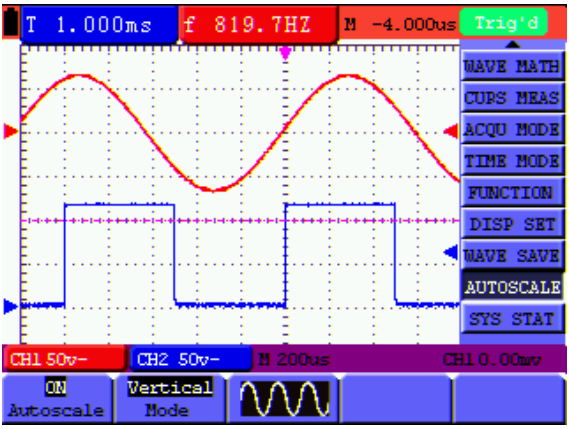


Fig 34: Vertical mode multi-period waveform

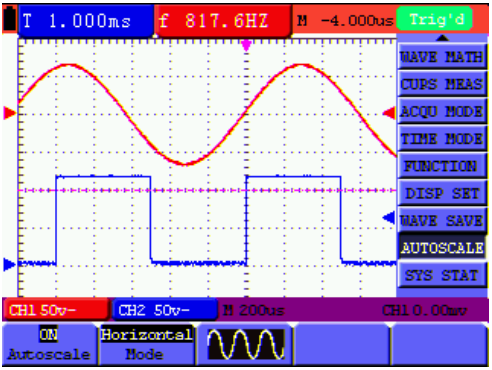


Fig 35: Horizontal mode multi-period waveform

Notes:

1. In Autoscale mode the meter can automatically set the Trigger mode (Edge, Video, and Alternate) and Type (Edge, Video)
2. In Autoscale mode the meter switches to YT Mode (Auto) from XY mode (STOP)
3. In Autoscale, the meter defaults to DC coupling and AUTO triggering mode
4. If the user attempts to manually adjust the vertical position, voltage division, trigger level or time scale while in the Autoscale mode the meter will automatically exit the Autoscale mode
5. When video triggering, the horizontal time scale is 50us

CURSOR MEASUREMENTS

Two cursors can be used to make instantaneous Time and Voltage measurements for CH1 and CH2 signals. Refer to the following table for more information.

Function menu	Settings	Description
Type	OFF	Exit the cursor measurement mode

	Voltage Time	Display voltage measurement cursor and menu Display time measurement cursor and menu
Source	CH1, CH2	Select the waveform channel on which the cursor measurement will be performed
Delta (MS460)		Display the difference between CH1 and CH2 values
Cursor 1 (MS460)		Data for cursor 1
Cursor 2 (MS460)		Data for cursor 2

To use the cursor for a **Voltage** measurement on CH1, perform the following steps:

1. Press the **MENU** key; the function menu will then display at the right of the screen.
2. Press the **MENU** ▲ or **MENU** ▼ key to select **Curs Meas**. two (2) selectable options (MS420) appear at the bottom of the screen.
3. Press the **F1** key to select the measurement type **Voltage**. Two dashed lines **V1** and **V2** will appear on the screen.
4. Press the **F2** key to select **CH 1**.
5. Press OPTION and the display will show the following:

Cursor 2 ◀/▶

Cursor 1 ▲/▼

Use ▲ (yellow) and ▼ (yellow) to move V1 up and down; the voltage value (relative to the zero position) will display at the bottom of the screen. Use ◄ (yellow) and ► (yellow) to move V2 up and down; the voltage value (relative to the zero position) will display at the bottom of the screen. The display will also show the result of V1 - V2. Refer to Figure 36-a.

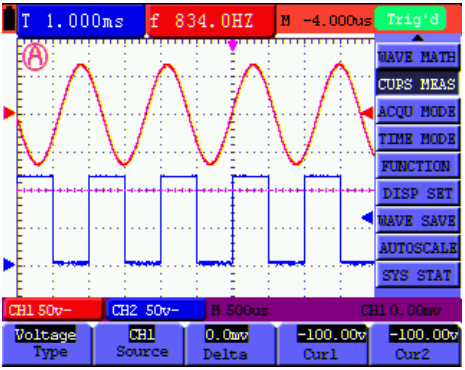


Figure 36-a: Use the Cursor for a Voltage Measurement

When the MENU button is pressed, the data table appears as shown in Figure 36-b:

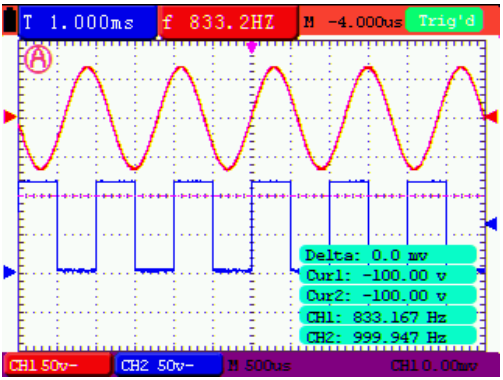


Figure 36-b: Data Table

To use the cursor for a **Time** measurement on CH1, perform the following steps:

1. Press the **MENU** key; the function menus will appear at the right of the screen.
2. Press the **MENU** ▲ or **MENU** ▼ key to select **Cursor measurement**. Two (2) selectable options will then appear at the bottom of the screen.

3. Press the **F1** key to select the measurement type **Time.** Two vertical dashed lines T1 and T2 will appear on the screen.
4. Press the **F2** key and select the channel CH1.
5. Press OPTION and the display will show:

—Cursor 2 ◀/▶

—Cursor 1 ▲/▼

6. Press ▲ (yellow) or ▼ (yellow) to move T1 left and right; the value of T1 (relative to the middle of the screen) will display.
7. Press ◀(yellow) or ▶(yellow) to move T2 left and right; the value of T2(relative to the middle of the screen) will display as shown in Figure 37-a:

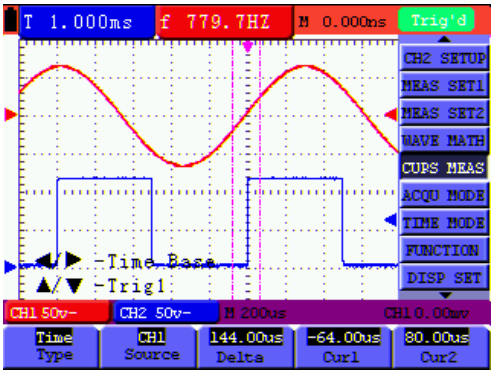


Figure 37-a: Time Measurement using cursor

When the MENU button is pressed, the data table appears as shown in Fig. 37-b.

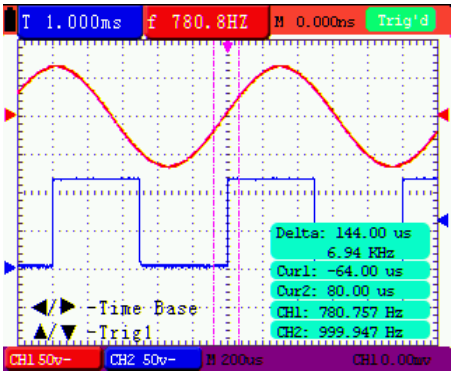


Figure 37-b: Data Table

SQUARE WAVE OUTPUT TEST SIGNAL (5V, 1 KHZ)

The 5V Square Output is available on the jack at the left side of the meter. The 5V digital output has a frequency of 1 KHz and can be used to adjust the probe, as shown as Fig.39

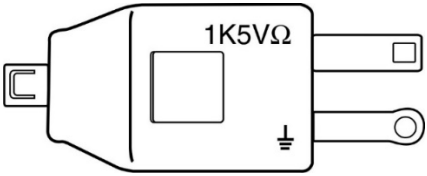


Fig 40: 5V square wave output adaptor

USING FFT (FAST FOURIER TRANSFORM)

FFT breaks down signals into component frequencies, which the oscilloscope uses to display a graph of the frequency domain of a signal (as opposed to the oscilloscope's standard time domain graph). These frequencies can then be matched with known system frequencies, such as system clocks, oscillators, or power supplies.

The FFT in this oscilloscope can transform 2048 points of a time-domain signal into its frequency components with the final frequency containing 1024 points ranging from 0Hz to the Nyquist frequency.

FFT menu

Function Menu	Setting	Instruction
FFT	ON OFF	Turn on FFT function Turn off FFT function
Source	CH1 CH2	Select CH1 as FFT source Select CH2 as FFT source
Window	Rectangle Blackman Hanning Hamming	Select window for FFT (details below)
Format	dB Vrms	Set Vrms as the vertical scale unit of measure

		Set dBVrms as the vertical scale unit of measure
Zoom	*1 *2 *5 *10	Set multiple *1 Set multiple *2 Set multiple *5 Set multiple *10

The steps below instruct on the operation of the FFT feature:

1. Press the **MENU** key; the function menu will appear on the right side of the screen.
2. Press **MENU ▲** or **MENU ▼** to select **FFT MODE**. Five options will then be available at the bottom of the screen.
3. Press **F1** to turn FFT ON/OFF (the green waveform F will be shown on the screen after the FFT calculation is completed).
4. Press **F2** to switch between channel **CH1** and **CH2;** the currently selected channel is indicated at the top left of the screen.
5. Press **F3** to switch to **WINDOW** with the following available options: **HAMMING**、**RECTANGLE**、**BLACKMAN,** and **HANNING**.
6. Press **F4** to switch to **Format** with the options: **dB** and **Vrms**.
7. Press **F5** to zoom in/out; the magnification selections are: *1, *2, *5, *10.
8. If the FFT source is CH1, press the red button **VOLTS POSITION** ,

- One of the following three prompts will appear at the bottom-left of the screen when the **Format** selection is set to **dB**.

▲/▼ — FFT dB level

▲/▼ — CH1 voltage level

— FFT vertical position

- One of the following two prompts will display at the bottom-left of the screen when the **Format** is set to **Vrms**.

  — CH1 voltage level

  ▲/▼ — FFT vertical position

Press the blue button **VOLTS POSITION**; the following will appear:

— CH2 OFF

9. If the FFT source is CH2, press the blue button **VOLTS POSITION** ,

- One of the following three prompts will display at the bottom-left of the screen when the **Format** is set to **dB**.

  ◀/▶ — FFT dB level

  ▲/▼ — CH2 voltage level

  — FFT vertical position

- One of the following two prompts will display at the bottom-left of the screen when the **Format** is set to **Vrms**.

Press the red button **VOLTS POSITION**; the following screen will appear:

/ / —CH1 OFF

10. When the FFT source is CH1:

- If the display at the bottom left side of the screen is "-FFT dB level ", use the red buttons VOLTS POSITION▲ and ▼ to adjust the dB value (the DIV selections include 1dB 2dB 5dB 10dB and 20dB).

- If the display at the bottom left side of the screen is "/ /-CH1 voltage level", use the red buttons VOLTS POSITION▲ and ▼ to adjust the voltage of CH1 ("CH1 2v~ " appears at bottom side of the screen);

- If the display at the bottom left side of the screen is " —FFT vertical position", use the red buttons VOLTS POSITION▲ and ▼ to adjust the position of the waveform along the vertical position. For example, "FFT 1.20 DIV (24.0dB)" indicates that the cursor departs from the center line for 1.20 DIV and "CH1 20dB" is shown on the bottom left side of the screen; the arithmetic product is 24.0dB.

  The operational steps are the same as above for the FFT source CH2:

11. Press the yellow **OPTION** key, the following prompts appear at the bottom left side of the screen.

◀/▶ — CH1 horizontal base

▲/▼ — CH1 trigger level

Or

◀/▶ — CH1 horizontal position

▲/▼ — CH1 trigger level

Use the **OPTION ◄ and OPTION ►** menu buttons to adjust the position of the waveform along the horizontal position. "FFT -2.00DIV (500.0Hz) " shown on the bottom left indicates that the starting section of the waveform departs from the beginning for 2.00DIV (250Hz/DIV). The displayed frequency M is the exact frequency of the cursor point in the middle of spectrum (shown in Figure 41 below). Use the **OPTION ◄ and OPTION ►** buttons to adjust the horizontal base; for example, "250Hz/DIV （5KS/s".

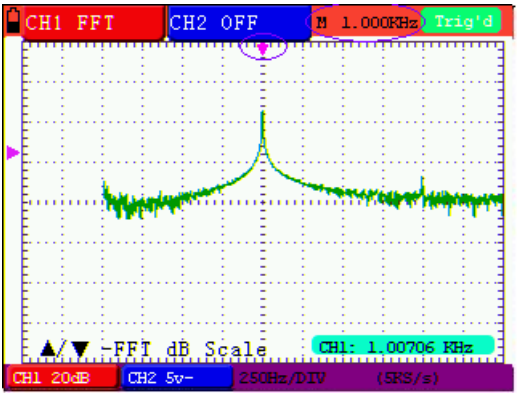


Figure 41

SELECTING AN FFT WINDOW

■ The FFT feature provides four (4) windows. Each is a trade-off between frequency resolution and magnitude accuracy. What is measured and what the source signal characteristics are help determine which window to use. Use the following guidelines to select the best window.

Type	Description	Window
Rectangle	Rectangle is the ideal window type for resolving frequencies that are very close to the same value but least desirable for accurately measuring the amplitude of those frequencies. It is the ideal type for measuring the frequency spectrum of aperiodic signals and measuring frequency components near DC. Use rectangle for measuring transients or surges where the signal level before and after the event are nearly equal. Also, use this window for equal-amplitude sine waves with frequencies that are very close and	

	for broadband random noise with a relatively slow varying spectrum.	
Hamming	This is a good window for resolving frequencies that are very close to the same value with somewhat improved amplitude accuracy over the rectangle window. It has a slightly better frequency resolution than the Hanning selection. Use Hamming for measuring sine, periodic, and narrow band random noise. This window works on transients or surges where the signal levels before and after the event are significantly different.	
Hanning	This is a good window for amplitude accuracy but less so for resolving frequencies. Use Hanning for measuring sine, periodic, and narrow band random noise. This window works on transients or surges where the signal levels before and after the event are significantly different.	
Blackman	This is the best window for measuring the amplitude of frequencies but least useful for resolving frequencies. Use Blackman-Harris for measuring predominantly single frequency waveforms to examine higher order harmonics.	

Fig 42, 43, 44, 45 show four types of window functions referring to a sine wave of 1KHz.

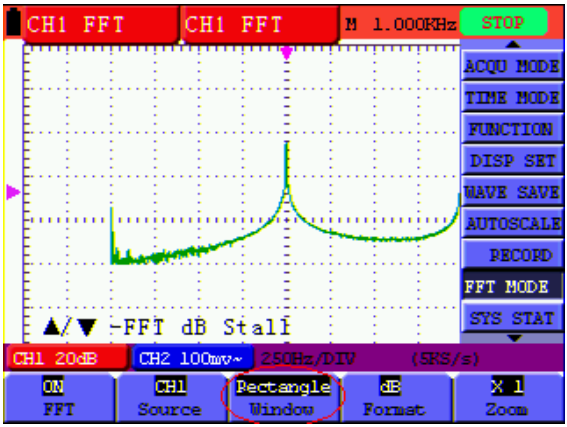


Fig 42 - Rectangle window

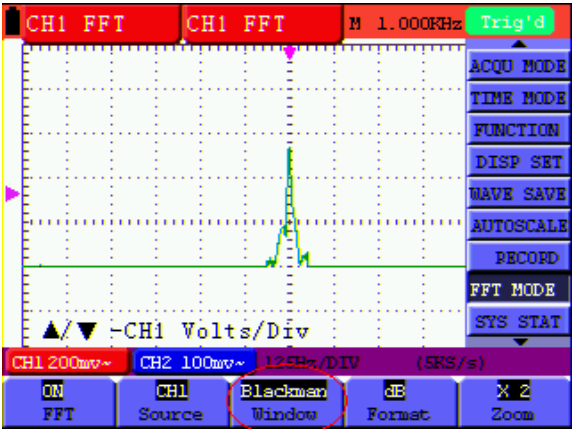


Fig 43 - Blackman window

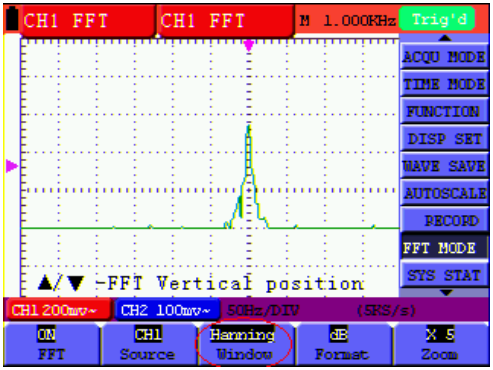


Fig.44 - Hanning window

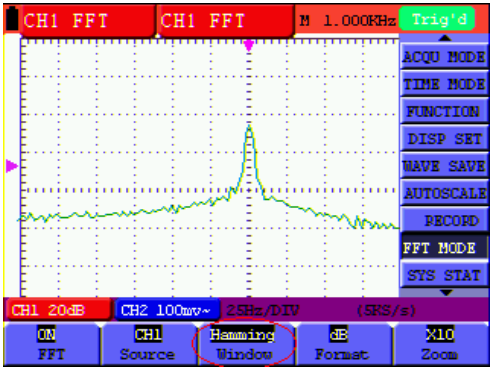


Fig.45 - Hamming window

Quick Tips

- If desired, use the zoom feature to magnify the FFT waveform.
- Use the default dBV RMS scale to see a detailed view of multiple frequencies, even if their amplitudes vary greatly. Use the linear RMS scale to see an overall view of how frequencies compare.
- Signals that have a DC component or an offset can cause incorrect FFT waveform component magnitude values. To minimize the DC component, choose AC Coupling on the source signal.

- To reduce random noise and aliased components in repetitive or single-shot events, set the oscilloscope acquisition mode to 'average'.

NOTE 1:

Nyquist frequency: The highest frequency that a Real Time Digital Oscilloscope can measure at exactly half the sampling rate is called the Nyquist frequency. If under-sampling occurs when the frequency sampled is higher than the Nyquist frequency, "False Wave" phenomenon will occur. The relationship between the frequency being sampled and measured is of great importance in this context.

NOTE 2:

In FFT mode, the following settings are prohibited:

1) Window set
2) Changing the source channel (in CH1 Setup or CH2 Setup menu)
3) XY Formatting in the DISPLAY SET mode
4) "SET 50%" (trigger level at the vertical point of the signal amplitude) in the Trigger setting mode
5) Autoscale
6) Wave recording
7) Measure 1 and Measure 2

SYSTEM STATUS MENU

The system status menu is used to display configuration information concerning horizontal, vertical, trigger, and other systems. Follow the steps below to check status:

1. Press the **MENU** key; the function menu will then appear at the right side of the screen.
2. Press the **MENU ▲** or **MENU ▼** key to select **SYSTEM STAT.** Four (4) selectable options will then appear at the bottom of the screen.
3. Sequentially press **F1** through **F4** to view the corresponding status information.

Refer to Figure 46.

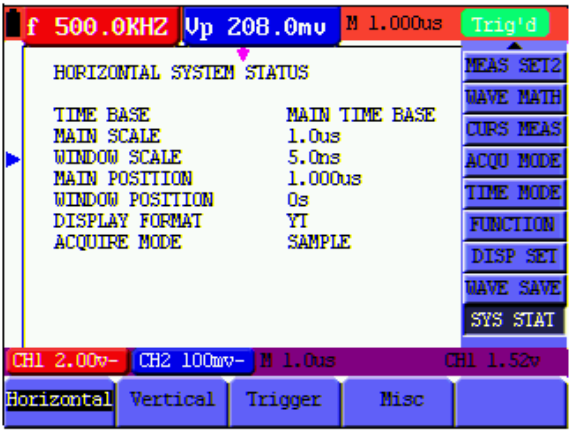


Figure 46: System Status

MAIN TIME BASE MODE

The time base mode menu is explained as the following table.

Function menu	Setting	Explanation
Main Time Base		Horizontal main time base
Zone Window		Use the two cursors to define a zoom window area
Window		Full-screen display

To zoom in on a small area of the display, perform the following steps:

1. Press **MENU** to view the function menu on the right side of the screen.
2. Press **MENU** ▲ or **MENU** ▼ to select the **TIME MODE**. Three (3) selectable options will then appear at the bottom of the display.
3. Use the Soft-keys **F1**, **F2**, and **F3** to select the Main **Time Base**, **Zone Window**, or **Window** functions as described in the Table above.
4. Use the **OPTION** key and the ◄ (yellow) and ► (yellow) keys to adjust and vary the Time Base and size of the window zoom.

Refer to Figures 47 and 48.

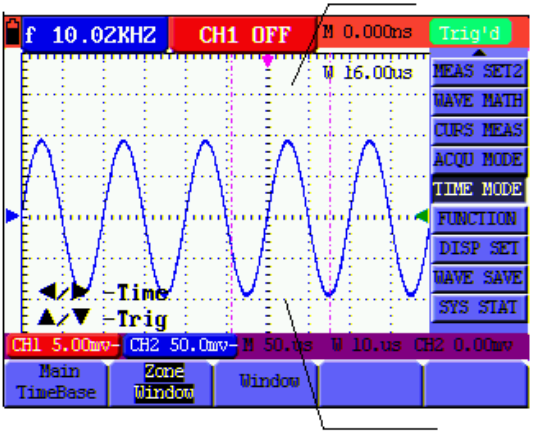


Figure 47: Original Window Setting

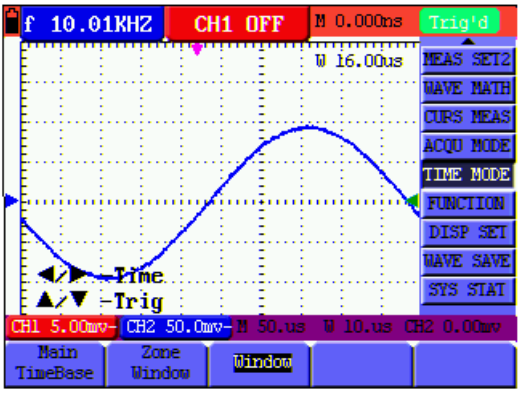


Figure 48: Window Zoom

PC DATA TRANSMISSION

For PC data transmission, perform the following steps:

1. Press **MENU**; the function menu will then appear on the right side of the screen
2. Press **MENU ▲** or **MENU ▼** to select the display setting mode **DISP SET**; the display will show four (4) selectable options at the bottom of the screen
3. Press the **F4** key; select **Bitmap** or **Vectors**
4. Connect the oscilloscope to the PC using the supplied data transmission cable
5. Install and open the supplied software

   Note: refer to Extech.com/software/downloads for the latest versio9n of the software.

6. Refer to the software help guide

SECTION TWO: MULTIMETER OPERATION

USING THE MULTIMETER

This chapter provides step-by-step instructions for using the Multimeter functions. These instructions also provide basic examples of menus and other basic operations.

MAKING METER CONNECTIONS

Use the four 4-mm safety banana jack inputs for the Meter functions:

COM, V/Ω/C, 10A, mA.

The four (4) banana jack inputs on the face of the meter are, L to R, 10A current, mA current, COM (ground/negative), and Volts/Resistance/Capacitance

MULTIMETER DISPLAY WINDOW

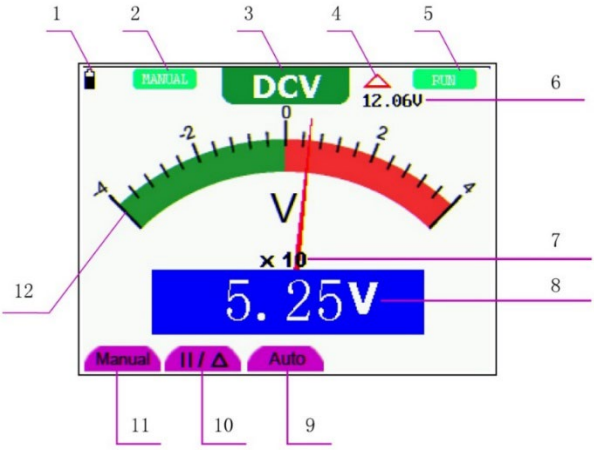


Figure 1: Multimeter Display Window

Description

1. Battery status indicator
2. Manual range indicator. In **MANUAL** mode the user selects the measurement range
3. Measurement mode indicators:

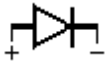
   DCV: DC Voltage measurement

   ACV: AC voltage measurement

   DCA: Direct current (DC) measurement

   ACA: AC current measurement

   R: Resistance measurement

   : Diode measurement

   
   : Continuity measurement

   C: Capacitance measurement
4. Relative measurement mode indicator
5. **RUN**: Continuous update mode. **STOP**: Display data hold mode
6. The reference value in the relative measurement mode
7. (X10) reading multiplier
8. Unit of measure indicator and measurement reading
9. Automatic range mode (AUTO). Meter automatically selects measurement range
10. Absolute / Relative measurement modes: The "**||**" symbols represents absolute measurement (normal) mode. The "△" symbol represents the relative mode
11. Manual measurement control (user selects measurement range)
12. Color coded scale indicator; Each test mode has a unique color scheme

MAKING MULTIMETER MEASUREMENTS

Press the **DMM/OSC** key; the oscilloscope will switch to the multimeter mode. The meter will prompt the user to correctly insert the test leads. Use the A, V, and R keys to select the desired multimeter function.

MEASURING RESISTANCE

To measure resistance, first remove power from the component or circuit under test and then follow these steps:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **V/Ω/C** banana jack input
2. Press the **R** key. An '**R**' appears at the top of the screen
3. Connect the red and black test leads to the resistor or circuit under test. The resistance value will appear on the screen (unit of measure: Ohms)

Refer to the example diagram below in Figure 2.

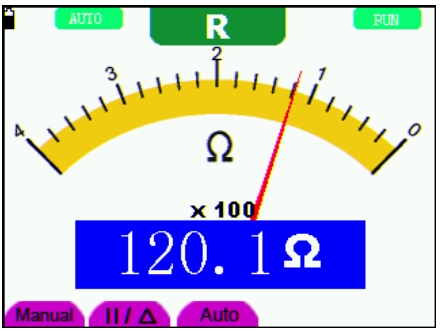


Figure 2: Resistance Measurement

MEASURING DIODE VOLTAGE

To make a measurement on the diode, do the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **V/Ω/C** banana jack input
2. Press the **R** key. An '**R**' appears at the top of the screen
3. Press the **SET** key repeatedly until the diode symbol is displayed

4. Connect the red and black leads to the diode and read the displayed voltage (V)
5. Reverse the test lead polarity and perform the test again Refer to the example display screen in Figure 3.

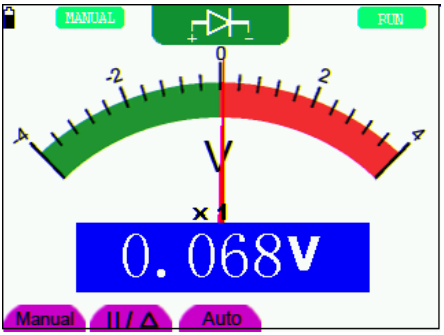


Figure 3: Diode Measurement

CONTINUITY TEST

To perform a resistance continuity test, refer to the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **V/Ω/C** banana jack input
2. Press the **R** key. An '**R**' appears at the top of the screen
3. Press the **SET** key repeatedly until the following is shown on the screen: 
4. Connect the red and black leads to the test points. If the resistance value is lower than 50Ω the meter will emit an audible tone

The meter display will also show the resistance as shown in example

Figure 4.

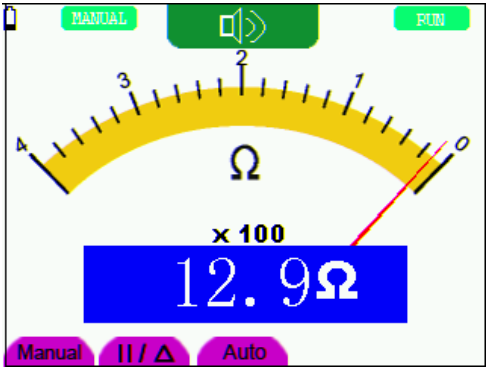


Figure 4: Continuity Test

MEASURING CAPACITANCE

To measure Capacitance, refer to the following:

1. Insert the black lead into the **COM** jack, and the red lead into the **V/Ω/C jack**
2. Press the **R** key. An '**R**' appears at the top of the screen
3. Press the **SET** key until the **C** appears at the top of the screen
4. Connect the black and red leads to the capacitor or circuit under test; the meter will display the reading (Unit of measure: Farad)

Notes: To improve accuracy when the measured value is lower than 5 nF, select the lowest capacitance range and use the Relative mode.

Please allow approx. 30 seconds for capacitance measurements larger than 40uF.

Refer to the example diagram in Figure 5.

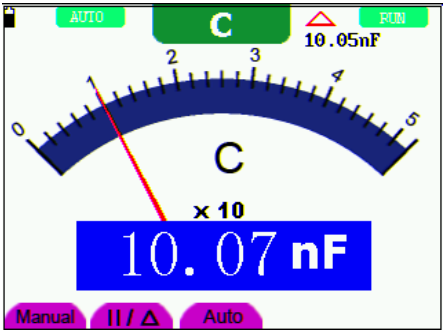


Figure 5: Capacitance Measurement

MEASURING DC VOLTAGE

To measure DC voltage, refer to the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **V/Ω/C** banana jack input
2. Press the **V** key and the **DCV** symbol will appear at the top of the screen
3. Connect the red and black test leads to the measurement points on the circuit under test; the voltage value will be displayed on the screen

Refer to the example diagram, Figure 6.

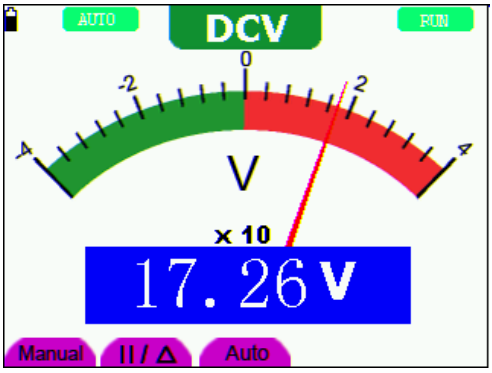


Figure 6: DC Voltage Measurement

MEASURING AC VOLTAGE

To measure AC voltage, refer to the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **V/Ω/C** banana jack input.
2. Press the **V** key and then press **SET** so that the **ACV** symbol appears at the top of the screen
3. Connect the red and black leads to the measured points and the AC voltage values of measured points will be displayed on the screen.

Refer to the example diagram in Figure 7.

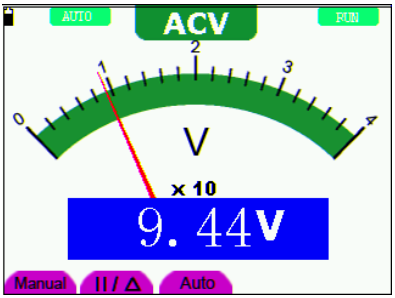


Figure 7: AC Voltage Measurement

MEASURING DC CURRENT

To measure a DC current lower than 400 mA, do the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **mA** banana jack input
2. Use the **A** key and the **SET** key as needed to select the DCA mode (the **DCA** symbol will appear at the top of the screen
3. Ensure that the displayed unit of measure on the main reading screen is **mA.** Use the **F4** soft-key to select **mA** if necessary.
4. Connect the red and black leads to the measured points on the circuit under test; the DC current value will be displayed on the screen.

Refer to the example diagram in Figure 8.

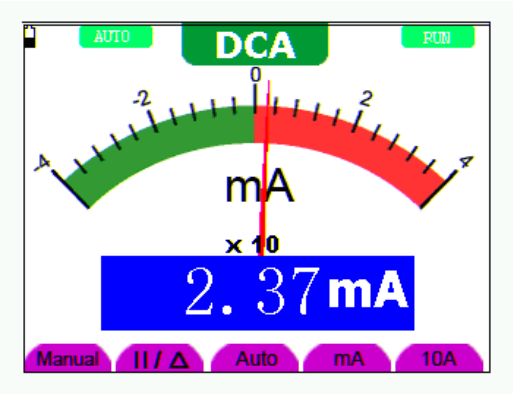


Figure 8: 400mA DC Current Measurement

To measure a DC current larger than 400 mA, perform the following:

1. Press the **A** key and the **DCA** symbol should appear at the top of the screen. Use the **SET** key to select **DCA** if necessary.
2. Press the **F5** soft-key to select the 10A measurement mode, the unit of measure on the main reading screen should be **A.**
3. Connect the red and black test leads to the measured points on the circuit under test; The **DC** current value will be displayed on the screen.
4. Press the **F4** soft-key to return to the **mA** measurement mode

Refer to the example in Figure 9.

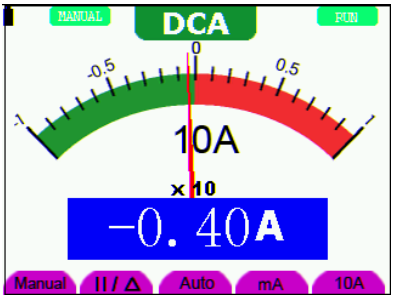


Figure 9: 10A DC Current Measurement

MEASURING AC CURRENT

To measure AC current lower than 400 mA, perform the following:

1. Insert the black lead into the **COM** banana jack input and the red lead into the **mA** banana jack input
2. Press the **A** key and then the use the **SET** key to select the ACA mode. The **ACA** symbol will appear at the top of the screen when selected
3. Use the **F4** soft-key to select the **mA** mode
4. Connect the red and black leads to the measured points on the circuit under test; The **AC** current value will be displayed on the screen.

Refer to the example in Figure 10.

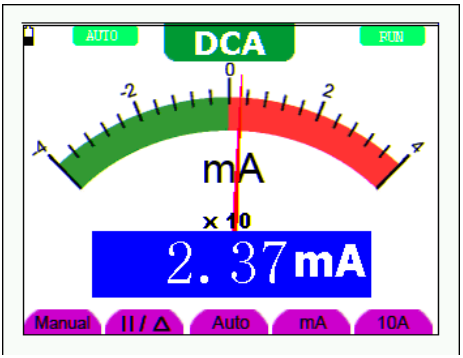


Figure 10: 400mA AC Current Measurement

To measure AC current larger than 400 mA, perform the following:

5. Press the **A** key and use the **SET** key to select the ACA mode (**ACA** symbol will appear at the top of the screen when selected)
6. Press the **F5** soft-key to select the 10A measurement mode, the unit of measure on the main reading screen should be **A**
7. Connect the red and black test leads to the measured points on the circuit under test; The **AC** current value will be displayed on the screen.

8. Press the **F4** soft-key to return to the **mA** measurement mode

Refer to the example in Figure 11.

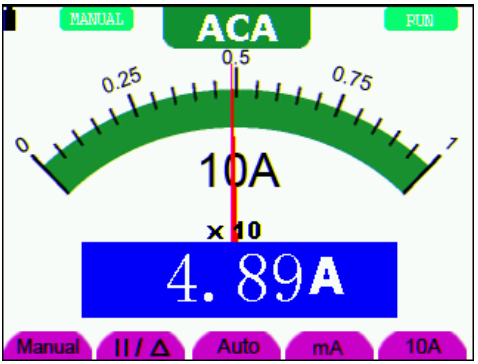


Figure 11: AC Current Measurement for 10A

FREEZING THE READINGS (DATA HOLD)

You can hold the displayed readings at any time.

1. Press the **RUN /STOP** key to freeze the screen. **STOP** will be displayed at the top right of the screen
2. Press the **RUN /STOP** key again to resume normal measurement operation

Refer to the example in Figure 12.

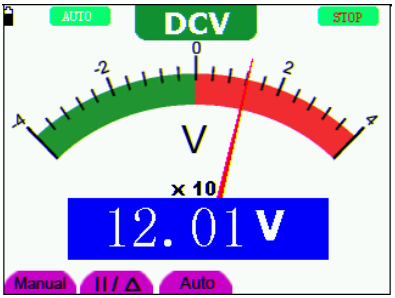


Figure 12: Freezing the Readings

TAKING A RELATIVE MEASUREMENT

The meter can display a reading 'relative' to a user-selectable reference value. Refer to the following discussion on how to make a relative measurement.

First program a reference value. To do so, take a measurement and when the desired reading is displayed press the "**|I/△**" soft-key until the '△' symbol is displayed at the top of the screen; this indicates that the unit is in the Relative mode. The reference value is shown on the display screen just below the relative mode symbol. Now all subsequent readings in the main display area will be displayed relative to the reference value.

SELECTING THE AUTOMATIC / MANUAL RANGE MODES

The default mode of the instrument is the automatic range. To switch to the manual range, perform the following steps:

1. Repeatedly press the **F1 MANUAL** soft-key until the desired range is selected on the meter's display. **MANUAL** will be displayed on the upper left hand corner of the meter's display when in the manual mode
2. In the manual range mode, the measuring range is increased by one stage with each press of the **F1** key. When the highest range is reached, the meter jumps to the lowest range
3. Press the **F3** soft-key to select the **AUTO** range mode. **AUTO** will display on the upper left side of the screen.

Refer to the display example in Figure 13.

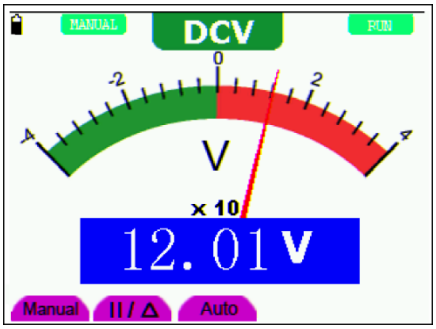


Figure 13: Automatic/Manual Range Adjustment

FAQ

The oscilloscope does not power up check that the battery is charged. Charge the battery for at least 15 minutes before using the Oscilloscope.

Check the displayed battery status symbol. The ▯ symbol indicates that the battery is exhausted and must be charged.

The meter displays ERR when in the Multimeter mode

The measurement mode is likely not selected. In this case, press any of the three mode keys V, A or R

The measured voltage value is 10 times larger or smaller than the actual value indicated in the oscilloscope mode

Check that the channel attenuation level matches the actual probe attenuation ratio

A waveform is displayed on the oscilloscope screen but is not stable

Check whether the signal item in the trigger mode menu matches the actual signal channel.

Check the trigger mode: The edge trigger mode is typically used for most applications; the video trigger mode is applicable for video signals. Only when the proper trigger mode is applied can the waveform be stable.

Change the trigger coupling into the HF rejection and LF rejection to filter the HF or LF noise trigger by the interference.

No display when the RUN/STOP key is pressed in oscilloscope mode

Check whether the trigger mode in the trigger mode menu is in Normal or Single Shot and whether the trigger level is outside of the waveform's range.

In such conditions, adjust the trigger level to be in the middle of the range or select the non-auto trigger mode. Additionally, press the AUTO SET key and re-try the previous suggestions.

APPENDIX A: SPECIFICATIONS

OSCILLOSCOPE

Unless otherwise indicated, all technical specifications are applicable to the 10X probe attenuation switch setting. The oscilloscope should meet the following requirements in order to meet the published specifications.

■ The instrument should be allowed to run continuously for more than 30 minutes under the specified operating temperature

■ If the operating temperature is exceeded by more than 5 degrees Celsius, an “Auto- calibration” must be performed (system function menu)

Sampling

Sampling modes	Normal sampling, Peak detection, Average value
Sampling rate	100MS/s (MS420), 250MS/s (MS460)

Input

Input coupling	DC, AC
Input impedance	1MΩ ±2% connected in parallel with 20pF ±5pF
Probe attenuation coefficients	1X, 10X, 100X, 1000X
Max. Input voltage	400V (peak)
Channel delay time （ typical）	150ps

Horizontal

Sampling rate range	10S/s～100MS/s
Waveform interpolation	（sin x） /x
Data record length	6K points for each channel

Scanning speed range（S/div）	5ns/div～5s/div, steps in “1-2.5-5” mode
Sampling rate relay time accuracy	±100ppm (time interval equal to or larger than 1ms)
Time interval (△T) measurement accuracy（full bandwidth）	Single: ± (1 sampling interval time + 100ppm × rdg + 0.6ns) Average 16 : ± (1 sampling interval time +100ppm×reading+0.4ns)

Vertical

Analog digital converter（A/D）	8 bits resolution (both channels synchronously)
Sensitivity range （V/div）	5mV/div～5V/div(for the BNC connector input）
Displacement range	± 10 div (MS420), ±2V(5mV/div ~ 200mV/div), ±50V(500mV/div ~5 V /div) (MS460)
Analog bandwidth	60MHz (MS460); 20MHz (MS420)
Single bandwidth	Full bandwidth
Low frequency response (A/D coupling, -3dB)	≥ 5Hz (BNC connector）
Rise time	≤17.5ns (MS420) , ≤5.8ns (MS460)
DC gain accuracy	±5%
DC measurement (accuracy average value sampling mode）	The voltage difference between any two points on the waveform after averaging the captured waveforms is greater than 16: ± (5% reading + 0.05 divisions)

Trigger

Trigger sensitivity （Edge trigger）	DC coupling	CH1 and CH2: 1div (DC～full bandwidth)
	AC coupling	Same as the DC coupling when it is equal to or larger than 50Hz.

Triggering level range		±6 divisions from the screen center
Triggering level accuracy (typical) which is applicable to the signal with rise and fall time equal to or longer than 20ns	±0.3 divisions	
Trigger displacement	655 divisions for pre-triggering and 4 divisions for post- triggering	
50% level setting (Typical).	Operation with the input signal frequency equal to or larger than 50Hz.	
Trigger sensitivity (Video triggering and typical mode)	2 divisions of peak-to-peak value	
Signal system and line/field frequency (Video triggering mode)	Supports NTSC, PAL and SECAM broadcasting systems of any field or line frequency	

Measurement

Cursor measurements	Voltage difference and time difference between cursors
Auto measurements	Peak-to-Peak voltage, mean voltage, root mean square value, frequency and period (MS420 0nly):Vmax, Vmin, Vtop, Vbase, Width, Overshoot, Pre-shoot, Rise time, Fall time, + Width, - Width, + Duty, - Duty, Delay A→B↑, Delay A→B↓

Probe

	1X position	10X position
Bandwidth	Up to 6 MHz (DC)	Up to full bandwidth (DC)
Attenuation rate	1: 1	10: 1
Compensation range	20pf～40pf	
Input resistance	1MΩ ±2%	10MΩ ±2%
Input impedance	85pf～115pf	14.5pf～17.5pf
Input voltage	150 V DC	300 V DC

MULTIMETER

Voltage (VDC)

Input Impedance: 10MΩ

Max. Input Voltage: 1000V (DC or AC peak-to-peak value)

Range	**Accuracy**	**Resolution**
400.0mv	±1.5% ±2 digit	100uV
4.000V	±1% ±1 digit	1mV
40.00V		10mV
400.0V		100mV

Voltage (VAC)

Input Impedance: 10MΩ.

Max. Input Voltage: 750V (AC)

Frequency range: from 40Hz to 400Hz

Range	**Accuracy**	**Resolution**
4.000V	±1% ±3 digits	1mV
40.00V		10mV
400.0V		100mV

Direct Current (DC)

Range	Accuracy	Resolution
40.00mA	±1.5% ±1 digit	10uA
400.0mA	±1.5% ±1 digit	100uA
10A	±3% ±3 digit	10mA

Diode

Voltage reading: 0 V ～1.5 V

Continuity Test

Audible tone when resistance is lower than 50Ω

Alternating Current (AC)

Range	Accuracy	Resolution
40.00mA	±1.5% ±3 digit	10uA
400.0mA	±2% ±1 digit	100uA
10A	±5% ±3digit	10mA

Resistance

Range	Accuracy	Resolution
400.0 Ω	±1% ±3 digit	0.1Ω
4.000KΩ	±1% ±1 digit	1Ω
40.00KΩ		10Ω
400.0KΩ		100Ω
4.000MΩ		1KΩ
40.00MΩ	±1.5% ±3 digit	10KΩ

Capacitance

Range	Accuracy	Resolution
51.20nF	±3% ±3 digit	10pF
512.0nF		100pF
5.120uF		1nF
51.20uF		10nF
100uF		100nF

GENERAL SPECIFICATIONS

Dimensions	7.1 x 4.5 x 1.6” (18 × 11.5 × 4cm)
Weight	1.4 lbs. (645 g)
Power consumption	＜ 6 W
Display type	3.7" color liquid crystal display (LCD)
Display resolution	640 (horizontal) × 480 (vertical) pixels
Display color	65536 colors

Power Adapter

Power supply	100-240 V AC 50/60Hz
Power output	8.5 VDC
Current output	1500 mA

Ambient Environmental Specifications

Operation Temperature:

On Battery power 0 to 50 °C (32 to 122 °F)

With Power adapter 0 to 40 °C (32 to 104 °F)

Storage Temperature -20 to +60 °C (-4 to 140 °F)

Relative Humidity and Temperature

Operation:

0 to 10 °C (32 to 50 °F) no condensation

10 to 30 °C (50 to 86 °F) 95 %

30 to 40 °C (86 to 104 °F) 75 %

40 to 50 °C (104 to 122 °F) 45 %

Storage:

-20 to +60 °C (-4 to +140 °F) no condensation

APPENDIX B: MAINTENANCE AND CLEANING

Do not store or place this instrument where the liquid crystal display (LCD) may be directly exposed to sunlight for extended periods

Warning: Do not allow the instrument to become wet

CLEANING

Inspect the instrument and the probe frequently in accordance with operating conditions. Clean the outer surface of the instrument according to the following steps:

1. Wipe the outside of the instrument and the probe using a soft cloth. Use care when cleaning the LCD display screen.

2. Use a slightly damp cloth and mild detergent when cleaning and only clean the instrument when it is powered down. Do not use abrasive chemical detergents

 **Warning:** Before use, please confirm that the instrument is dry so as to avoid electrical short circuits and personal injury

STORAGE OF INSTRUMENT

If the test tool is to be stored for an extended time, the lithium battery must be charged before storage

APPENDIX C: CHARGING THE INSTRUMENT

The lithium battery may ship un-charged. The battery must be initially charged for 4 hours (the instrument must be turned off during charging). The battery can supply power for 4 hours after being charged completely. When supplying power by using the battery, a battery indicator is displayed on the top of the screen. The battery symbols appear as follows: , , and , where indicates that the battery can only be used for about 5 minutes. To charge the battery and power the instrument, connect the oscilloscope using the supplied power adapter. The charging speed can be increased by turning off the meter.

Note: To avoid battery overheating during charging, do not charge the meter in an area where the ambient temperature exceeds the specified operating temperature.

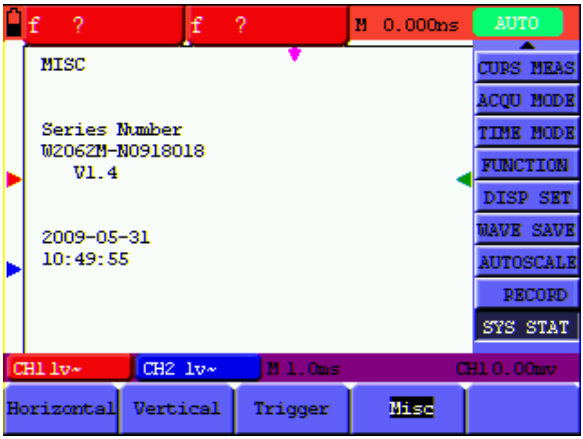
Note: The meter can be charged for extended periods. After it is charged it switches to a low charge status and may remain in the charging configuration for extended periods.

REPLACING THE LITHIUM BATTERY UNIT

It is usually not required to replace the battery but if it is required only qualified personnel should carry out this operation. Use only the same type of lithium battery currently installed in the meter. To access the battery remove the three (3) Philips screws on the rear of the instrument at the top of the stand behind the rubber protective jacket.

APPENDIX D: SET THE REAL-TIME CLOCK

1. Press the **MENU** key; the function menu will display on the right side of the screen.
2. Use the **MENU** ▲ or **MENU** ▼ key to select SYS STAT; four (4) options will appear at the bottom of the screen.
3. Use the **F4** key to select the MISC option and the system time, along with other information, will appear as shown below:



4. Press **OPTION** to enter the Time setting mode. The highlighted field can be edited.
5. Use the ◄ and ► keys to highlight a value for editing; Use the ▲ and ▼ arrow keys to change the corresponding value for year, month, date, hours, minutes and second
6. Press the **MENU** ▲ up arrow key to exit the programming mode

TWO-YEAR WARRANTY

Teledyne FLIR warrants this Extech brand instrument *to be free of defects in parts and workmanship for* ***two years*** *from date of shipment (a six-month limited warranty applies to sensors and cables). To view the full warranty text please visit: http://www.extech.com/support/warranties.*

CALIBRATION AND REPAIR SERVICES

Teledyne FLIR offers calibration and repair services for the Extech brand products we sell. We offer NIST traceable calibration for most of our products. Contact us for information on calibration and repair availability, refer to the contact information below. Annual calibrations should be performed to verify meter performance and accuracy. Product specifications are subject to change without notice. Please visit our website for the most up-to-date product information: www.extech.com.

Contact Customer Support

Customer Support Telephone List: https://support.flir.com/contact

Calibration, Repair, and Returns: repair@extech.com

Technical Support: https://support.flir.com

www.extech.com

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