

User Manual

EXTECH[®]

INSTRUMENTS

A FLIR COMPANY

MS6000 Series

Digital Storage Oscilloscope



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- Safety Tips

1.1 General Safety Summary

Read the following safety precautions to avoid injury and prevent damage to this product or any products connected to it. To evade potential hazards, use this product only as specified.

Only qualified personnel should perform maintenance.

Avoid fire or personal injury.

Use suitable power cord. Use only the power cord specified for this product and certified for the country of use.

Connect and disconnect properly. Connect a probe with the oscilloscope before it is connected to measured circuits; disconnect the probe from the oscilloscope after it is disconnected from measured circuits.

Ground the product. This product is grounded through the grounding conductor of the power cord. To avoid electric shock, the grounding conductor must be connected to earth ground. Before making connections to the input or output terminals of the product, ensure that the product is properly grounded.

Connect the probe in a right way. The probe ground lead is at ground potential. Do not connect the ground lead to an elevated voltage.

Check all terminal ratings. To avoid fire or shock hazard, check all ratings and markings on the product. Refer to the product manual for detailed information about ratings before making connections to the product.

Do not operate without covers. Do not operate this product with covers or panels removed.

Avoid exposed circuitry. Do not touch exposed connections and components when power is present.

Do not operate with suspected failures. If damage to this product is suspected, have it inspected by qualified service personnel.

Assure good ventilation.

Do not operate in wet/damp environments.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

1.2 Safety Terms and Symbols

The following terms may appear in this manual:



WARNING Warning statements point out conditions or practices that could result in injury or loss of life.



CAUTION Caution statements identify conditions or practices that could result in damage to this product or other property.

1.3 Terms on Product

The following terms may appear on the product:

DANGER indicates an injury hazard immediately accessible as the marking is read.

WARNING indicates an injury hazard not immediately accessible as the marking is read.

CAUTION indicates a possible hazard to this product or other property.

1.4 Symbols on Product

The following symbols may appear on the product:



Protective
Ground
(Earth)
Terminal



Measurement
Ground
Terminal



CAUTION
Refer to Manual



Measurement
Input Terminal



Mains
Disconnected
OFF (Power)



Mains
Connected
ON (Power)



High Voltage

1.5 Product and Battery Disposal

Battery Recycling and Disposal



You, as the end user, are legally bound (EU Battery ordinance) to return all used batteries, disposal in the household garbage is prohibited! You can hand over your used batteries / accumulators at collection points in your community or wherever batteries / accumulators are sold!

Disposal: Follow the valid legal stipulations in respect of the disposal of the device at the end of its lifecycle

Chapter 2 - Overview

2.1 Brief Introduction on MS6000 Series

Model	Channels	Bandwidth	Sample Rate	LCD
MS6060	2	60MHz	1GS/s	5.6 inch color
MS6100	2	100MHz	1GS/s	5.6 inch color
MS6200	2	200MHz	1GS/s	5.6 inch color

Table 2-1 Model List of MS6000 Series

MS6000 Series oscilloscopes bandwidths range from 60MHz to 200MHz, and provide real-time and equivalent sample rates respectively up to 1GSa/s and 25GSa/s. In addition, they have maximum 1MB memory depth for better observation of the waveform details, and 5.6 inch color TFT LCD as well as WINDOWS-style interfaces and menus for easy operation.

Additionally, the generous menu information and the easy-to-operate buttons maximize the information available for each measurement; the multifunctional and powerful shortcut keys save time and maximize efficiency; the Autoset (**AUTO**) function allows the user to detect sine and square waves automatically.

Chapter 3 - Getting Started Guide

3.1 Installation

To keep proper ventilation of the oscilloscope in operation, leave a space of more than 5 cm (2") from the top and the two sides of the product.

3.2 Functional Check

Follow the steps below to perform a quick functional check to your oscilloscope.

3.3 Power ON the oscilloscope

Press the ON/OFF button. The start-up sequence will take up to 15 seconds to complete.

NOTE: The AC Charger is intended for **battery charging only**.

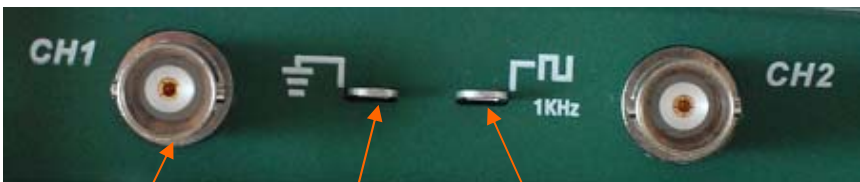
Use of charger during measurements is not recommended.



The default probe parameter

3.4 Connect the Probe to the oscilloscope

Set the switch on the probe to 10X and connect the probe to the Channel 1 BNC on the oscilloscope. Connect the probe tip to the 1 KHz Probe Compensation connector and the reference lead to the Ground connector. The CH1 default Probe option attenuation setting is 1X, change this to 10X.



Channel 1 Probe Connection

Connect Probe tip to 1-KHz signal when compensating

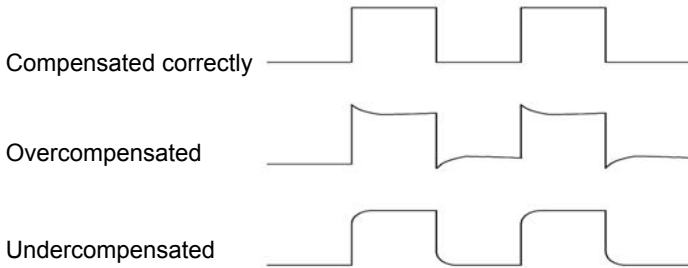
Ground connection for reference lead when compensating

3.8 Manual Probe Compensation

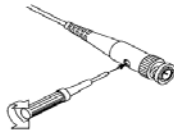
Upon the first connection of a probe to an input channel, manually perform this adjustment to match the probe to the input channel. Uncompensated probes may lead to errors or faults in measurement.

To adjust the probe compensation, follow the steps below.

1. Set the switch on the probe to 10X and connect the probe to Channel 1 on the oscilloscope. Attach the probe tip to the PROBE COMP ~5V@1KHz connector and the reference lead to the PROBE COMP Ground connector. Press CH1 button and set the Probe attenuation to 10X. Press the AUTO button and you should see the 1 KHz reference signal.
2. Check the shape of the displayed waveform.



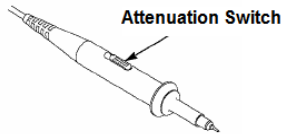
3. If necessary, use a nonmetallic screwdriver to adjust the variable probe capacitor until the shape of the waveform appears to be the same as shown in the above figure. Repeat this step as necessary for additional probes. Refer to the figure below for adjustment illustration.



3.9 Probe Attenuation Setting

Probes are of various attenuation factors which affect the vertical scale of the signal. Ensure that the attenuation switch on the probe matches the CH probe option in the oscilloscope. Switch settings are 1X and 10X. To set the probe attenuation to match the probe setting, push the vertical menu button (such as the CH1 button) and select the probe option that matches the attenuation factor of the probe in use.

When the attenuation switch is set to 1X, the probe limits the bandwidth of the oscilloscope to 6MHz. To use the full bandwidth of the oscilloscope, be sure to set the switch to 10X.

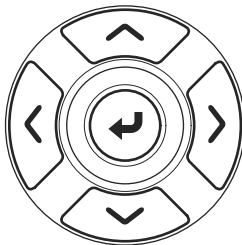


3.10 Self Calibration

The self calibration routine helps optimize the oscilloscope signal path for maximum measurement accuracy. The routine can be run at any time but should always be run if the ambient temperature changes by 5°C or more. For an accurate calibration, please power on the oscilloscope and wait 20 minutes before performing the Self calibration. To compensate the signal path, disconnect any probes or cables from the front-panel input connectors.

3.11 Multifunction Control

The Multifunction Control arrows are used to move the cursors and change menu item settings.



- Main Features

This chapter provides some general information the user should be aware of before using this oscilloscope. It contains:

4.1 Oscilloscope setup

4.2 Trigger

4.3 Data Acquisition

4.4 Waveform scaling and positioning

4.5 Waveform measurement

3.12 Oscilloscope Setup

While operating the oscilloscope, the AUTOSET feature will, in most cases, be used.

Autoset: This function can be used to adjust the horizontal and vertical scales of the oscilloscope automatically and set the trigger coupling, type, position, slope, level and mode, etc., to acquire a stable waveform display. Press the **AUTO** button to engage Autoset.

3.13 Trigger

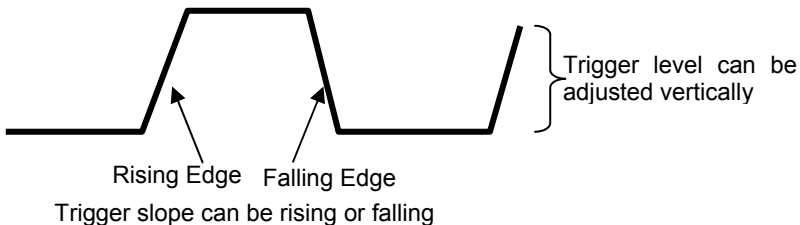
The trigger determines when the oscilloscope begins to acquire data and display a waveform. Once a trigger is properly set up, the oscilloscope can convert unstable displays or blank screens to meaningful waveforms. Basic information regarding triggering is provided below.

Trigger Source: The trigger can be generated from either CH1 or CH2. The input channel can trigger normally whether or not the input signal is displayed.

Trigger Type: The oscilloscope has six types of triggers: Edge, Video, Pulse Width, Slope, Overtime, and Alter. Press the **TRIG** button to engage this feature.

- **Edge Trigger** Triggering occurs when the input trigger source crosses a specified level in a specified direction.
- **Video Trigger** performs a field or line trigger through standard video signals.
- **Pulse Width Trigger** can trigger normal or abnormal pulses that meet trigger conditions.
- **Slope Trigger** uses the rise and fall times on the edge of a signal for triggering.
- **Overtime Trigger** occurs after the edge of a signal reaches the set time.
- **Alter Trigger** uses a specific frequency to switch between two analog channels (CH1 and CH2), so that the channels will generate swap trigger signals.

Slope and Level: (Set Trig Type to Edge or Slope) The Slope and Level controls help to define the trigger. The Slope option determines whether the trigger point is on the rising or falling edge of a signal. To perform the trigger slope control, press the TRIG button and then select Edge trigger (F1), and use the Slope button (F3) to select rising or falling. The LEVEL button controls where the trigger point is on the edge.

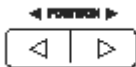


Trigger Mode: (Auto, Normal, Single) Select the Auto or Normal mode to define how the oscilloscope acquires data when it does not detect a trigger condition. **Auto Mode** performs the acquisition freely in absence of valid trigger. It allows the generation of untriggered waveforms with the time base set to 80ms/div or slower. **Normal Mode** updates the displayed waveforms only when the oscilloscope detects a valid trigger condition. Before this update, the oscilloscope continues to display the older waveforms. This mode should be used when it is desired to only view the effectively triggered waveforms. In this mode, the oscilloscope displays waveforms only after the first trigger.

Single mode will allow you to view a Single sweep of a waveform.

Trigger Coupling: (AC, DC, Noise Reject, HF Reject, LF Reject) Trigger Coupling determines which part of the signal will be delivered to the trigger circuit. This can help to obtain a stable display of the waveform. To use trigger coupling, push the TRIG button, select Edge, Pulse, Slope, or O.T. trigger, and then press F5 for page 2 and select a Coupling option.

Trigger Position: The horizontal position control establishes the time between the trigger position and the screen center.



3.14 Data Acquisition

When an analog signal is acquired, the oscilloscope will convert it to a digital one. There are two kinds of acquisitions: Real-time acquisition and Equivalent acquisition. The real-time acquisition has three modes: Normal, Peak Detect, and Average. The acquisition rate is affected by the time base.

Real-Time Acquisition:

Normal: In this mode, the oscilloscope samples the signal in evenly spaced intervals to establish the waveform. This mode accurately represents signals in most instances. However, it does not acquire rapid variations in the analog signal that may occur between two samples, which can result in aliasing and may cause narrow pulses to be missed. In such cases, use the Peak Detect mode to acquire data.

Peak Detect: In this mode, the oscilloscope obtains the maximum and minimum values of the input signal over each sample interval and uses these values to display the waveform. In this way, the oscilloscope can acquire and display narrow pulses that may have otherwise been missed in Normal mode. However, noise will appear to be higher in this mode.

Average: In this mode, the oscilloscope acquires several waveforms, averages them, and displays the resulting waveform. Use this mode to reduce random noise.

Equivalent Acquisition:

This type of acquisition can be utilized for periodic signals. In case the acquisition rate is too low when using the real-time acquisition, the oscilloscope will use a fixed rate to acquire data with a stationary (very small) delay after each acquisition of a frame of data. After repeating this acquisition for N times, the oscilloscope will arrange the acquired N frames of data by time to make up a new frame of data; and then the waveform can be recovered. The number of times (N) is related to the equivalent acquisition rate.

Time Base: The oscilloscope digitizes waveforms by acquiring the value of an input signal at discrete points. The time base helps to control how often the values are digitized. Use the TIME/DIV button to adjust the time base to a horizontal scale that suits your requirements.

3.15 Waveform Scaling and Positioning

The display of waveforms on the screen can be changed by adjusting their scale and position. Once the scale changes, the waveform display will increase or decrease in size. Once the position changes, the waveform will move up, down, right, or left.

The channel reference indicator (located on the left of the graticule) identifies each waveform on the screen. It points to the ground level of the waveform record.

Vertical Scale and Position: The vertical position of a waveform can be changed by moving it up or down on the screen. To compare data, align one waveform over another.

Horizontal Scale and Position: Pretrigger Information

The HORIZONTAL POSITION control can be adjusted to view waveform data before the trigger, after the trigger, or some of each. When the horizontal position of a waveform is changed, the time between the trigger position and the screen center is being changed.

For example, to find the cause of a glitch in a test circuit, trigger on the glitch and make the pre-trigger period long enough to capture data before the glitch. Then analyze the pre-trigger data and perhaps find the cause. Change the horizontal scale of all the waveforms by clicking the TIME/DIV button; for example, to see just one cycle of a waveform to measure the overshoot on its rising edge. The oscilloscope shows the horizontal scale as time per division in the scale readout. Since all active waveforms use the same time base, the oscilloscope only displays one value for all of the active channels.

3.16 Waveform Measurement

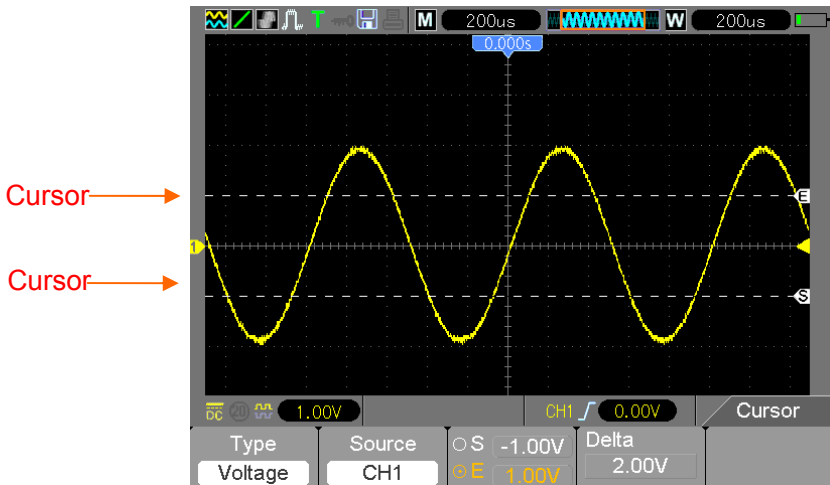
The oscilloscope displays graphs of voltage versus time (YT) and can help to measure the displayed waveform. There are several ways to take measurements, using the graticule, the cursors or performing an automatic measurement.

Graticule: This method allows a quick, visual estimate and takes a simple measurement through the graticule divisions and the scale factor.

For example, the user can take simple measurements by counting the major and minor graticule divisions involved and multiplying by the scale factor. If 6 major vertical graticule divisions are counted between the minimum and maximum values of a waveform and a scale factor of 50mV/division is selected, the peak-to-peak voltage can be calculated as follows:

$$6 \text{ divisions} \times 50\text{mV/division} = 300\text{mV}.$$

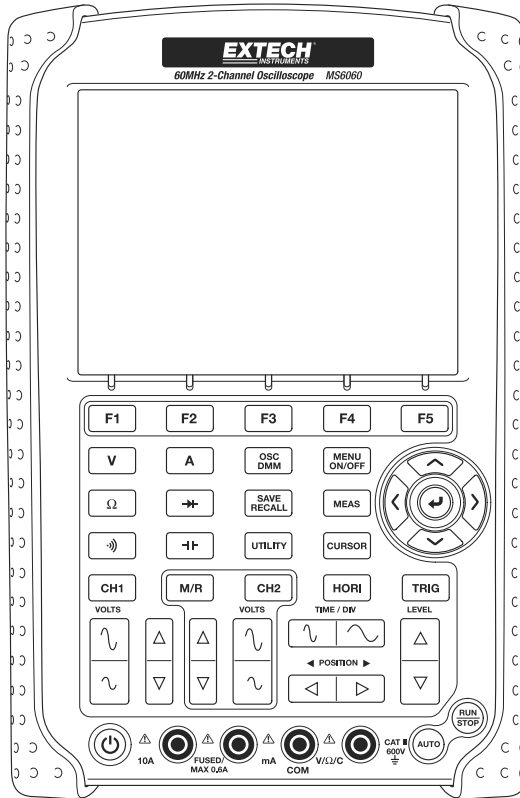
Cursor: This method allows the user to take measurements by moving the cursors. Cursors always appear in pairs and the displayed readouts are just their measured values. There are two types of cursors: Amplitude Cursor and Time Cursor. The amplitude cursor appears as a horizontal broken line, measuring the vertical parameters. The time cursor appears as a vertical broken line, measuring the horizontal parameters. When using the cursors please set the Source parameter to the desired waveform. To use cursors, push the CURSOR button.



Automatic Measurement: The oscilloscope performs all of the calculations automatically in this mode. As this measurement uses the waveform record points, it is more precise than the graticule and cursor measurements. Automatic measurements show the measurement results by readouts which are periodically updated with the new data acquired by the oscilloscope. To use the Measurement mode push the **MEAS** button.

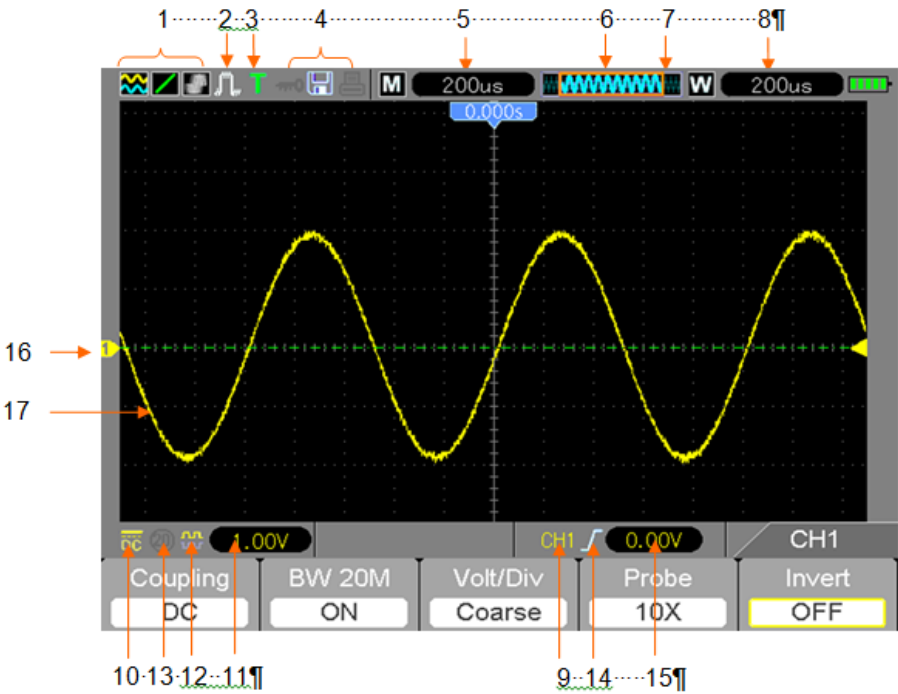
Chapter 4 - Basic Operation

The front panel of the oscilloscope is divided into several functional areas. A quick overview of all control buttons on the front panel as well as the displayed information on the screen and relative testing operations is provided in this chapter. The figure below illustrates the front panel of the MS6000 series digital oscilloscope.




Front Panel of the MS6000 Series

4.1 Display Area





1. Display Format:

-  : YT
-  : XY
-  : Vectors
-  : Dots

 : Gray indicates auto persistence; Green indicates persistence display is enabled. When the icon is set to green, the time for persistence display will be shown behind it.

2. Acquisition Mode: Normal, Peak Detect or Average

3. Trigger Status:

-  The oscilloscope is acquiring pre-triggered data.
-  All pre-triggered data have been acquired and the oscilloscope is ready to accept a trigger.
- T** The oscilloscope has detected a trigger and is acquiring the post-trigger information.



The oscilloscope is in auto mode and is acquiring waveforms in the absence of triggers.



The oscilloscope is acquiring and displaying waveform data continuously in scan mode.

- The oscilloscope has stopped acquiring waveform data.
- S** The oscilloscope has finished a single sequence acquisition.

4. Tool Icon:



If this icon appears, it indicates that the keyboard of the oscilloscope is locked by the host computer via USB control.



If this icon appears, it indicates that the USB disk has been connected.



This icon lights up only when the USB slave interface is connected with the computer.

5. Readout shows the main time base setting.
6. Main Time Base Window
7. Display of window's position in data memory and data length.
8. Window Time Base
9. Operating Menu shows information for the function keys.
10. Icon indicates channel coupling.
11. Level Range.
12. Icon indicates whether or not the waveform is inverted.
13. 20MB Bandwidth Limit. If this icon appears, it indicates that the bandwidth limit is enabled, (otherwise the bandwidth limit is disabled).
14. Trigger Type:



: Edge trigger on the rising edge.



: Edge trigger on the falling edge.



: Video trigger with line synchronization.



: Video trigger with field synchronization.



: Pulse Width trigger, positive polarity.



: Pulse Width trigger, negative polarity.

15. Trigger Level.
16. Channel Marker
17. Window displays waveform.

4.1.1 XY Format

The XY format is used to analyze phase differences, such as those represented by Lissajous patterns. This format plots the voltage on CH1 against the voltage on CH2, where CH1 is the horizontal axis and CH2 is the vertical axis. The oscilloscope uses the untriggered Normal acquisition mode and displays data as dots. The sampling rate is fixed at 1 MS/s.

The oscilloscope can acquire waveforms in normal operation mode (YT format) at any sampling rate. The same waveform can be displayed in XY format. To perform this operation, stop the acquisition and change the display format to XY.

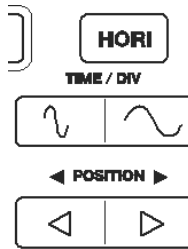
The table below covers several controls in XY format.

Controls	Capability of XY format
CH1 VOLTS and VERTICAL POSITION controls	Set the horizontal scale and position
CH2 VOLTS and VERTICAL POSITION controls	Continuously set the vertical scale and position
Reference or Math	Unusable
Cursors	Unusable
Auto (display format reset to normal operation - YT)	Unusable
Time base controls	Unusable
Trigger controls	Unusable

4.2 Horizontal Controls

Use the horizontal controls to change the horizontal scale and position of waveforms. The horizontal position readout shows the time represented by the center of the screen, using the trigger time as zero. When the horizontal scale is changed, the waveform will expand or contract to the screen center. The readout near the upper right of the screen shows the current horizontal position in seconds.

M represents 'Main Time Base', and W indicates 'Window Time Base'. The oscilloscope also has an arrow icon at the top of the graticule to indicate the horizontal position.



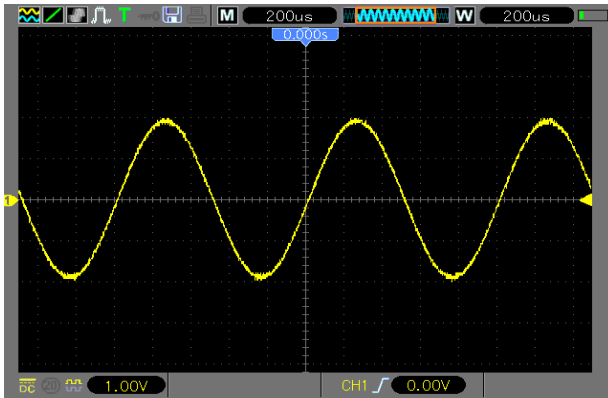
1. HORIZONTAL POSITION BAR: Used to control the trigger position against the screen center.

2. TIME/DIV: Used to change the horizontal time scale so as to magnify or compress the waveform horizontally. If the waveform acquisition is stopped (using the RUN/STOP button) the TIME /DIV control will expand or compress the waveform. In dual-window mode, push button F1 to select major or minor window. When the major window is selected, the F1 button provides the same functions as it provides in single-mode window. When the minor window is selected, press TIME/DIV button to scale the waveform (magnification can be set up to 1000x).

3. Each option in **HORI MENU** is described as follows:

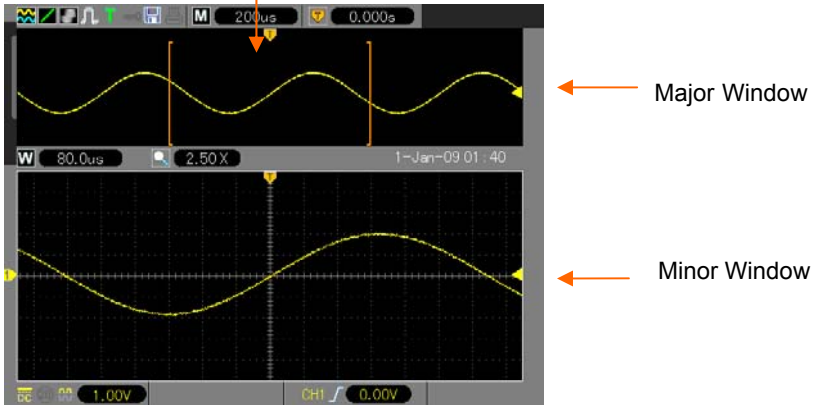
Options	Settings	Comments
Window Control (F1) (Menu page 1)	Double Window Single Window	Selects either Single or Double window mode (see figures below table). Press this option button in single-window mode to enter the dual-window mode.
Window Selection (F2) (menu page 1)	Major Window Minor Window	Selects the major (upper) or minor (lower) window in dual-window mode. The window is highlighted once selected.
Holdoff (F3) (menu page 1)		Select this menu and click the up and down Arrow keys to adjust the trigger hold-off time within the range of 100ns-10s.
Reset (F4) (menu page 1)		
Page (F5)		Change Menu pages 1 to 3 when Window Control is set to <u>Double Window</u>
Pre Mark (F2) (menu page 2)		Used when Marks are set in place. This button will position the display to view the signal at any marks to the Left of your present view.
Next Mark (F3) (menu page 2)		Used when Marks are set in place. This button will position the display to view the signal at any marks to the Right of your present view.
Set/Clear (F4) (menu page 2)		Sets a mark or Clears the indicated mark. To place a Mark on the signal, place that portion of the signal to be observed at the center verticle line (Bottom window) using the Horizontal Position button. Press the Set button to add or remove that mark.
Clear All (F2) (menu page 3)		Clear all Marks
Play/Stop (F3) (menu page 3)		Push this button to auto move the signal from left to right. Set the signal window to the left most position using the Horizontal position button. Press Play to start the signal moving across the screen. Press Stop to halt the movement.

Single-window Mode



Dual-window Mode

Location of expanded window data



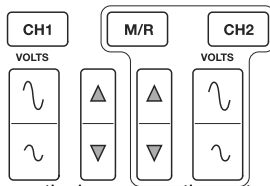
4.2.1 Scan Mode Display (Roll Mode)

With the TIME/DIV control set to 80ms/div or slower and the trigger mode set to Auto, the oscilloscope works in the scan acquisition mode. In this mode, the waveform display is updated from left to right without any trigger or horizontal position control.

4.3 Vertical Controls

Vertical controls can be used to display and remove waveforms, adjust vertical size and position of the signal, set input parameters and perform math calculations. Each channel has a separate vertical menu. See below for menu description.

1. **VERTICAL POSITION Bar:** Move the channel waveform up and down on the screen. In dual-window mode, move the waveforms in both windows at the same time in the same direction.



2. **Menu (CH1, CH2):** Display vertical menu options; turn ON or OFF the display of channel waveforms. Press the **MENU** button to turn on the Menu. Press the CH1 or CH2 button to select the channel you want to adjust. Press the F5 key to switch from Menu page 1 to page 2.

Options	Settings	Comments
Coupling (F1) (menu page 1)	DC AC Ground	DC passes both DC and AC components of the input signal. AC blocks the DC component of the input signal and attenuates signals below 10Hz. Ground disconnects the input signal and applies a zero volt input.
20MHz Bandwidth Limit (F2) (menu page 1)	OFF ON	Limits the bandwidth to reduce display noise; filters the signal to eliminate noise and other unnecessary HF components.
VOLTS/Div (F3) (menu page 1)	Coarse Fine	Selects the resolution of the VOLTS bar. 'Coarse' defines a 1-2-5 sequence. 'Fine' changes the resolution in smaller steps between the Coarse settings.
Probe Attenuation (F4) (menu page 1)	1X 10X 100X 1000X	Select a value to match the probe attenuation factor so as to ensure correct vertical readouts. Reduce bandwidth to 6MHz when using a 1X probe.

Invert (F2) (menu page 2)	Off On	Inverts the waveform relative to the reference level.
Reset (F3) (menu page 2)		Resets Vertical settings to default

Ground Coupling

Ground Coupling is used to display a zero-volt waveform. Internally, the channel input is connected with a zero-volt reference level.

Remove Waveform Display

To remove a waveform from the screen, first push the menu button to display the vertical menu, and then push the appropriate Channel button to remove the waveform. A channel waveform which is unnecessary to display can be used as a trigger source or for math operations.

3. VOLTS

Control the oscilloscope to magnify or attenuate the source signal of the channel waveform. The vertical size of the display on the screen will change (increase or decrease). The key F3 may be used to switch between Coarse and Fine. In the Fine resolution setting, the vertical scale readout displays the actual VOLTS setting. The vertical scale changes only when the control is set to Course and the VOLTS control is adjusted.

4. **MATH MENU:** Display the waveform math operations. See the table below for details.

The MATH menu contains source options for all math operations. Press the **M/R** button.

Operations	Source Options	Comments
Enable (F1)	ON OFF	ON enables the Math functions
Operate (F2)	CH1+CH2	Add Channel 1 to Channel 2.
	CH1-CH2	Subtract the Channel 2 waveform from the Channel 1 waveform.
	CH2-CH1	Subtract the Channel 1 waveform from the Channel 2 waveform.
	CH1xCH2	Multiply CH1 with CH2
	CH1/CH2	Divide CH1 by CH2
	CH2/CH1	Divide CH2 by CH1
FFT (F2)	Source(F3) CH1 or CH2	WINDOW (F4) – There are 5 types of window settings available: Hanning, Flattop, Rectangular, Bartlett, and Blackman
		Zoom (F2 page 2): Use the FFT Zoom button to adjust the window size. Scale: x1, x2, x5, x10.
		Vertical Base (F3 page 2): dBrms or Vrms

Note: All selected menus are highlighted orange.

4.3.1 Math FFT

This chapter elaborates on the Math FFT (Fast Fourier Transform) functionality. The Math FFT mode may be used to convert a normal time-domain (YT) signal to its frequency components (spectrum), and to observe the following:

- Analyze harmonics in power cords;
- Measure harmonic content and distortion in systems;
- Characterize noise in DC power supplies;
- Test impulse response of filters and systems;
- Analyze vibration.

To use the Math FFT mode, perform the following tasks:

- Set the source (time-domain) waveform;
- Display the FFT spectrum;
- Choose a type of FFT window;
- Adjust the sample rate to display the fundamental frequency and harmonics without aliasing;
- Use zoom controls to magnify the spectrum;
- Use cursors to measure the spectrum.

4.3.1.1 Setting Time-domain Waveform

It is necessary to set the normal time-domain (YT) waveform before using the FFT mode. Follow the steps below:

1. Push the AUTO button to display a standard YT waveform.
2. Click the VOLTS Key to ensure the entire waveform is visible on the screen. If the waveform is invisible, the oscilloscope may display erroneous FFT results by adding high-frequency components.
3. Click the Vertical Position key to vertically move the YT waveform to the center (zero division) so as to ensure the FFT will display a true DC value.
4. Click the Horizontal Position key to position the part of the YT waveform to be analyzed in the center eight divisions of the screen. The oscilloscope uses the 2048 center points of the time-domain waveform to calculate the FFT spectrum.
5. Click the TIME/DIV key to provide the resolution needed in the FFT spectrum.
If possible, set the oscilloscope to display multiple signal cycles. If the TIME/DIV key is clicked to select a faster setting (fewer cycles), the FFT spectrum will display a larger frequency range and reduce the possibility of FFT aliasing.

6. To set the FFT display, follow the steps below:
 1. Push the M/R button;
 2. Set the Operate key (F2) to FFT;
 3. Select the Math FFT Source (F3) channel.

In many situations, the oscilloscope can also generate a useful FFT spectrum despite the YT waveform not being triggered. This is true if the signal is periodic or random (such as noise).

Note: Trigger and position transient or burst waveforms as close as possible to the screen center.

Nyquist Frequency

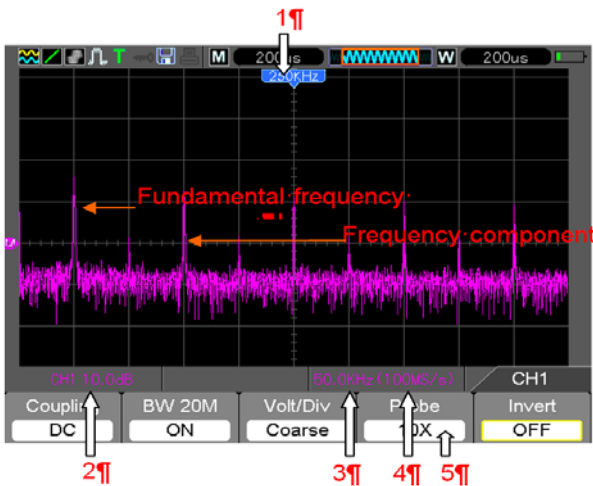
The highest frequency that any real-time digital oscilloscope can measure without errors is half of the sample rate, which is called the Nyquist frequency. Frequency information beyond the Nyquist frequency is under sampled which brings about the FFT aliasing. The math function can convert the center 2048 points of the time-domain waveform to an FFT spectrum. The resulting FFT spectrum contains 1024 points from DC (0Hz) to the Nyquist frequency. Usually, the screen compresses the FFT spectrum horizontally to 250 points, but you can use the FFT Zoom function to expand the FFT spectrum so that you can clearly view the frequency components at each of the 1024 data points in the FFT spectrum.

Note: The oscilloscope's vertical response is slightly larger than its bandwidth (60MHz, 100MHz or 200MHz, depending on the model; or 20MHz when the Bandwidth Limit option is set to Limited). Therefore, the FFT spectrum can display valid frequency information above the oscilloscope bandwidth. However, the amplitude information near or above the bandwidth will not be accurate.

4.3.1.2 Displaying FFT Spectrum

Push the MATH (M/R) button to display the Math menu. Use the options to select the Source channel, the Window algorithm, and the FFT Zoom factor. Only one FFT spectrum can be displayed at a time.

Math FFT Options	Settings	Comments
Source (F3) (menu page 1)	CH1, CH2	Choose a channel to be the FFT source.
Window (F4) (menu page 1)	Hanning, Flat Top, Rectangular(None), Bartlett, Blackman	Select a type for the FFT window. For more information, refer to Section 5.3.1.3.
FFT Zoom (F2) (Menu page 2)	X1, X2, X5, X10	Change the horizontal magnification of the FFT display. For detailed information, refer to Section 5.3.1.6.



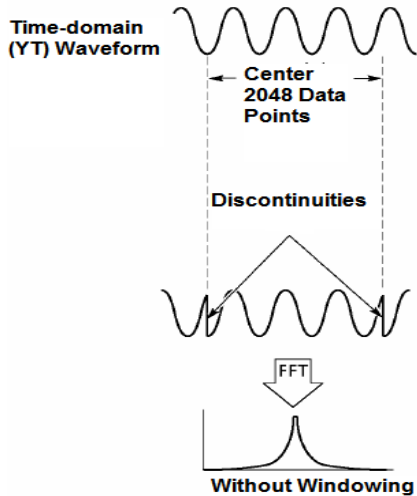
Refer to image above for the following:

1. Frequency at the center graticule line
2. Vertical scale in dB per division (0dB=1V_{RMS}, (Math menu page 2 – F3))
3. Horizontal scale in frequency per division
4. Sample rate in number of samples per second
5. FFT Window type is set to desired type.

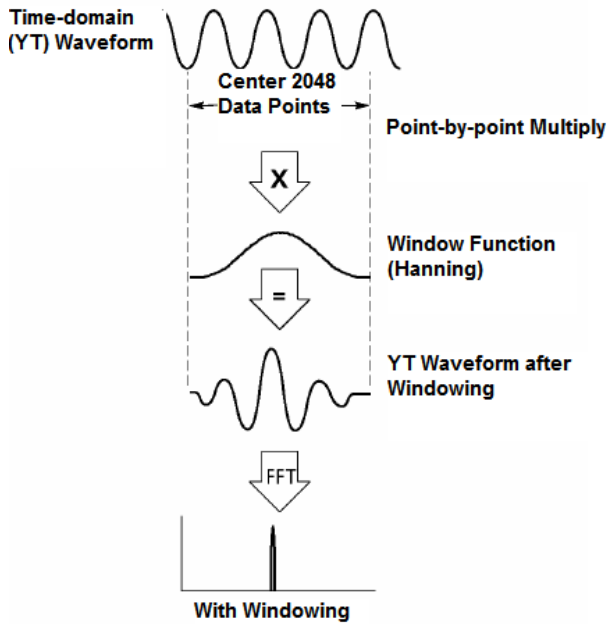
4.3.1.3 Selecting FFT Window

Using FFT windows can eliminate the spectral leakage in the FFT spectrum. The FFT algorithm assumes that the YT waveform repeats all the time. When the number of cycles is integral (1, 2, 3 ...), the YT waveform starts and ends at the same amplitude and there are no discontinuities in the signal shape.

If the number of cycles is non-integral, the YT waveform starts and ends at different amplitudes and the transitions between the start and end points will cause discontinuities in the signal that introduce high-frequency transients.



Applying a FFT window to the YT waveform changes the waveform so that the start and stop values are close to each other, thereby reducing the discontinuities. (Figure - Hanning window).



FFT Window Selection: The Math FFT function has Five FFT Window options. There is a trade-off between frequency resolution, Spectral Leakage, and amplitude accuracy for each type of the window choices. Determine which one to choose according to the desired object to be measured and the source signal characteristics.

Window	Measurement	Characteristics
Hanning	Random Waveform	Good frequency resolution, Fair amplitude accuracy, and Good Spectral leakage.
Flat Top	Sinusoid Waveform	Poor frequency resolution, Best amplitude accuracy, and Good Spectral Leakage.
Rectangular (None or Boxcar)	Pulse or Transient Waveform	Special-purpose window applicable to discontinuous waveforms. Best frequency resolution, Poor amplitude accuracy, and Poor Spectral Leakage.
Bartlett	Random Waveform	Good frequency resolution, Fair amplitude accuracy, and Fair Spectral Leakage.
Blackman	Random or Mixed Waveform	Poor frequency resolution, Best amplitude accuracy, and Best Spectral Leakage.

4.3.1.4 FFT Aliasing

Problems occur when the time-domain waveform acquired by the oscilloscope contains frequency components higher than the Nyquist frequency. The frequency components above the Nyquist frequency will be under sampled and displayed as lower frequency components that ‘fold back’ from the Nyquist frequency. These erroneous components are called aliases.

4.3.1.5 Eliminating Aliases

To eliminate aliases, use the following methods.

- Click the TIME/DIV key to set a faster sample rate. Since the Nyquist frequency increases as the sample rate is increased, the aliased frequency components will be displayed correct. If too many frequency components appear on the screen, use the FFT Zoom option to magnify the FFT spectrum.
- If there is no need to observe the frequency components above 20MHz, set the CH Bandwidth Limit option to Limited.
- Filter the signal input and limit the bandwidth of the source waveform to lower than the Nyquist frequency.
- Identify and ignore the aliased frequencies.
- Use zoom controls and cursors to magnify and measure the FFT spectrum.

4.3.1.6 Magnifying and Positioning FFT Spectrum

The FFT spectrum may be scaled, and the cursors used, to measure through the FFT Zoom option which enables horizontal magnification. To vertically magnify the spectrum, use the vertical controls.

Horizontal Zoom and Position

The FFT Zoom option (page 2 of FFT option) may be used to magnify the FFT spectrum horizontally without changing the sample rate. The available zoom factors are X1 (default), X2, X5 and X10. When the zoom factor is set to X1 and the waveform is located at the center graticule, the left graticule line position is 0Hz and the right position is the Nyquist frequency.

The FFT spectrum is magnified to the center graticule line when the zoom factor is adjusted. That is, the axis for horizontal magnification is the center graticule line. Click the Horizontal Position Key to move the FFT spectrum to the right.

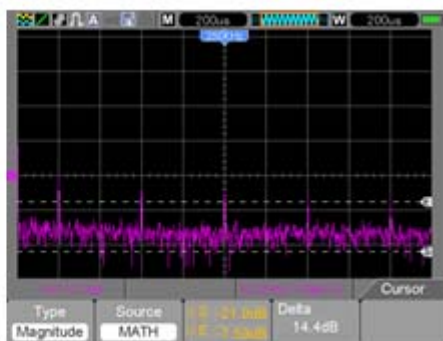
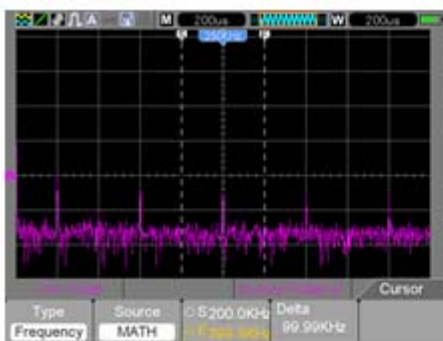
Vertical Zoom and Position

When the FFT spectrum is being displayed, the channel vertical keys become the zoom and position controls corresponding to their respective channels. The VOLTS key provides the following zoom factors: X1 (default), X2, X5 and X10. The FFT spectrum is magnified vertically to the marker M (math waveform reference point on the left edge of the screen). Click the Vertical Position key to move the spectrum upward.

4.3.1.7 Using Cursors to Measure FFT Spectrum

Cursors may be used to take two measurements on the FFT spectrum: amplitude (in dB) and frequency (in Hz). Amplitude is referenced to 0db equaling 1VRMS. Use cursors to measure at any zoom factor as desired.

Push the CURSOR button and if the Type option is OFF select Voltage or Time. Click the Source option and select Math. Press the Type option button to select between Voltage or Frequency. Click the SELECT CURSOR option (F3) to choose a cursor, S or E. When highlighted move Cursor S and Cursor E. Use the horizontal cursor to measure the amplitude and the vertical cursor to measure the frequency. Now the display at the DELTA menu is just the measured value, and the values at Cursor S and Cursor E. Delta is the absolute value of Cursor S minus Cursor E.



4.4 Trigger Controls

The trigger can be defined through the Trigger Menu. There are six types of triggering: Edge, Video, Pulse Width, Swap, Slope and Overtime. Refer to the following tables to view the options for each type of trigger.

TRIG MENU

Push the **TRIG** button to display trigger menus. The edge trigger is most commonly used. See the table below for details.

Options	Settings	Comments
Type (F1)	Edge, Video, Pulse, Slope, and Overtime	By default the oscilloscope uses the edge trigger which triggers the oscilloscope on the rising or falling edge of the input signal when it crosses the trigger level (threshold).
Source (F2)	CH1 CH2	Select the input source as the trigger signal. CH1, CH2: Whether or not the waveform is displayed, the channel will be triggered.
Slope (F3)	Rising Falling	When Type (F1) is set to Edge, Set the edge to trigger for rising or falling
Mode (F4)	Auto Normal Single	When Type (F1) is set to Edge, Slope, Pulse, and OT select a trigger mode. Auto mode (default): In this mode, the oscilloscope is forced to trigger when it does not detect a trigger within a certain amount of time based on the TIME/DIV setting. The oscilloscope goes into the scan mode at 80ms/div (or slower) time base settings. Normal mode: the oscilloscope updates the display only when it detects a valid trigger condition. New waveforms are not displayed until they replace older ones. Use this mode to just view valid triggered waveforms (the display appears only after the first trigger occurs). Single mode: This mode will allow you to view a Single sweep of a waveform.

Coupling (menu page 2)	AC DC HF Reject LF Reject Noise Reject	AC: Blocks DC components and attenuates signals below 10Hz. DC: Passes all components of the signal to the trigger circuit. HF Reject: Attenuates the high-frequency components above 80kHz. LF Reject: Blocks DC components and attenuates the low-frequency components below 8kHz. Rejects power-line hum. Noise Reject: Similar to DC coupling, except the sensitivity is reduced to minimize false triggering on very noisy signals.
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NOTE: Trigger coupling only affects the signal passed through the trigger system. It does not affect the bandwidth or coupling of the signal displayed on the screen.

Video Trigger

Options	Settings	Comments
Video (F1)	None	With Video highlighted, an NTSC, PAL or SECAM standard video signal will be triggered. The trigger coupling is preset to AC.
Source (F2)	CH1 CH2	Select the input source as the trigger signal.
Polarity (F3)	Normal Inverted	Normal: Triggers on the negative edge of the sync pulse. Inverted: Triggers on the positive edge of the sync pulse.
Standard (F4)	NTSC Pal/SECAM	
Sync (F5)	All Lines Line Number Odd Field Even Field All Fields	Choose a proper video sync. When selecting Line Number for the Sync option, use the User Select option to specify a line number.

Note: With 'Normal Polarity', the trigger always occurs on negative-going sync pulses. If the video signal contains positive-going sync pulses, use the Inverted Polarity option.

Pulse Width Trigger

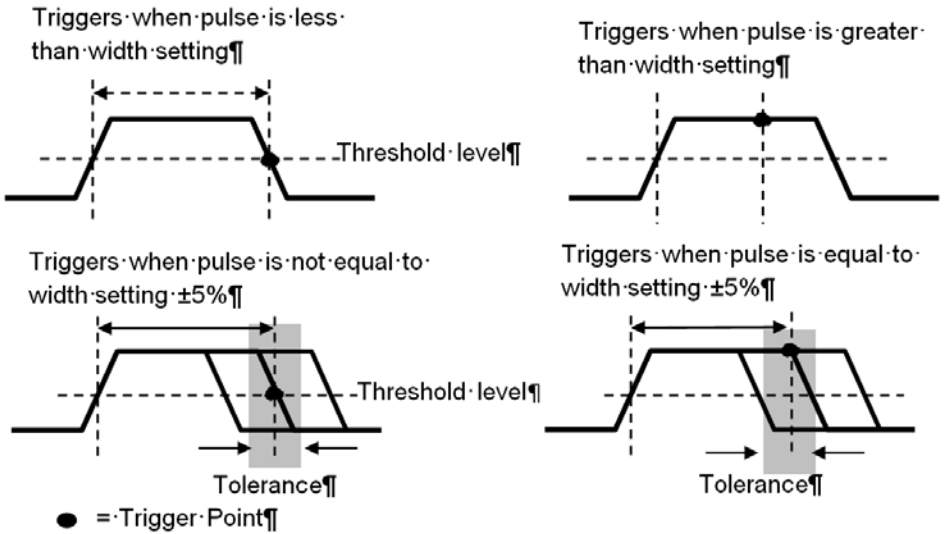
Use to trigger on aberrant or abnormal pulses.

Options	Settings	Comments
Pulse (F1) (menu page 1)		With Pulse highlighted, the trigger occurs on pulses that meet the trigger condition (defined by the 'Source', 'When' and 'Set Pulse Width' options).
Source (F2) (menu page 1)	CH1 CH2	Select the input source as the trigger signal.
Polarity (F3) (menu page 1)	Positive Negative	Polarity
Mode (F4) (menu page 1)	Auto Normal Single	Select the type of trigger. The Normal mode is best for most pulse width trigger applications.
Coupling (F2) (menu page 2)	DC AC HF Reject LF Reject Noise Reject	Select the component of the trigger signal applied to the trigger circuit. HF Reject: Attenuates the high-frequency components above 80kHz. LF Reject: Blocks DC components and attenuates the low-frequency components below 8kHz. Noise Reject: Similar to DC coupling, except the sensitivity is reduced to minimize false triggering on very noisy signals.
When (F3) (menu page 2)	= ≠ > <	Select the trigger condition.
PulseWidth (F4) (menu page 2)	20ns to 10.0sec	With Set Pulse Width highlighted, set the pulse width.
F5		Switch between submenu pages

Trigger “When”: The pulse width of the source must be $\geq 5\text{ns}$ so that the oscilloscope can detect the pulse.

□, ≠: Within a $\pm 5\%$ tolerance, triggers the oscilloscope when the signal pulse width is equal to or not equal to the specified pulse width.

□, □: Triggers the oscilloscope when the source signal pulse width is less than or greater than the specified pulse width.



Slope Trigger: Judges trigger according to the rising or falling time (more flexible and accurate than the Edge trigger).

Options	Settings	Comments
Slope (F1)		Choose which slope the signal is triggered from.
Source (F2)	CH1 CH2	Select the input source as the trigger signal.
Slope (F3)	Rising Falling	Select which slope of the signal is triggered on.
Mode (F4)	Normal Auto Single	Select the type of trigger. The Normal mode is best for most applications.
Coupling (F2) (menu page 2)	DC AC Noise Reject HF Reject LF Reject	Selects the components of the trigger signal applied to the trigger circuitry.
Vertical (F3) (menu page 2)	V1 V2	Adjust the vertical window by setting two trigger levels.
When (F4) (menu page 2)	= ≠ > <	Select the trigger condition.
Time (F2) (menu page 3)	20ns to 10.0sec	With this option highlighted, set the time span using the multifunction control.

Alter Trigger: (A feature of analog oscilloscopes) provides stable displays of signals at two different frequencies. Mainly it uses a specific frequency to switch between two analog channels CH1 and CH2 so that the channels will generate swap trigger signals through the trigger circuitry.

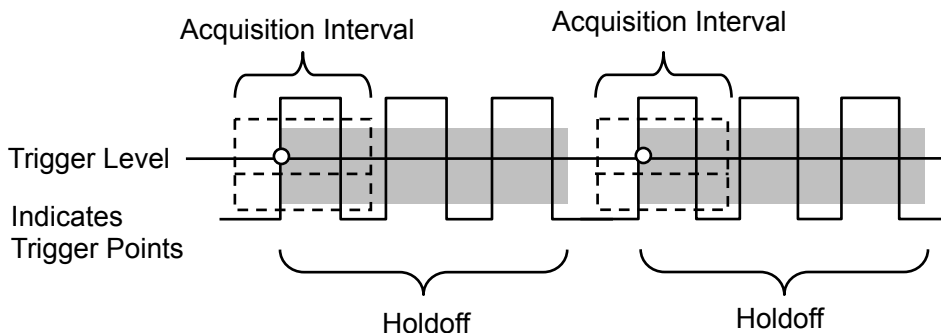
Options	Settings	Comments
Alter (F1)		Press CH1 (F2) or CH2 (F3) Must be in Single Window mode (HORZ)
Channel	CH1 (F2) CH2 (F3)	Push an option such as CH1, select the channel trigger type and set the menu interface.
Options in submenus. Alter (Swap) Trigger allows CH1 and CH2 to select trigger modes and to display waveforms on the same screen. That is, both channels can choose from the four trigger modes.		
Type	Edge	
Slope (F2)	Rising Falling	Select which slope of the signal is triggered on.
Coupling (F3)	AC DC HF Reject LF Reject Noise Reject	Select the components of the trigger signal applied to the trigger circuitry.
Back (F4)		Displays initial Alter mode Trigger screen to allow CH selection
Type	Video	
Polarity (F2)	Normal Inverted	Select to trigger on positive or negative pulses.
Standard (F3)	NTSC PAL/SECAM	
Sync (F4)	All Lines All Fields Even Field Odd Field Line Number	
Back (F5)		Displays initial Alter mode Trigger screen to allow CH selection

Type	Pulse	
Polarity (F2)	Positive Negative	Select to trigger on positive or negative pulses.
When (F3)	= ≠ < >	Select the trigger condition.
Set PW (F4)	Pulse Width	Use Multifunction control to set Pulse width.
Page (F5)		Set Menu page to 1 or 2
Coupling (F2)	AC DC HF Reject LF Reject Noise Reject	Select the components of the trigger signal applied to the trigger circuitry.
Back (F3)		Displays initial Alter mode Trigger screen to allow CH selection
Type	O.T.	
Polarity (F2)	Positive Negative	Select to trigger on positive or negative pulses.
Overtime (F3)		Use Multifunction control to set Overtime timing.
Coupling (F4)	AC DC HF Reject LF Reject Noise Reject	Selects the components of the trigger signal applied to the trigger circuitry.
Back (F5)		Displays initial Alter mode Trigger screen to allow CH selection

Overtime Trigger: In Pulse Width trigger mode, it may take some time for a trigger to occur. Since a complete pulse width is not needed to trigger the oscilloscope, it may be desired to trigger just upon the overtime point. This is called Overtime Trigger. Press on **TRIG** to enter Trigger mode.

Options	Settings	Comments
Type	O.T.	
Source (F2)	CH1 CH2	Select channel to source the trigger
Polarity (F3)	Positive Negative	Select to trigger on positive or negative pulses.
Mode (F4)	Normal Auto Single	Select the type of trigger. The Normal mode is best for most applications.
Page (F5)		Change page from 1 to 2
Overtime (F2) (menu page 2)		Adjust timing using the Multifunction control.
Coupling (F3) (menu page 2)	AC DC HF Reject LF Reject Noise Reject	Selects the components of the trigger signal applied to the trigger circuitry.
50% (F4)		
Page (F5)		Change page from 2 to 1

Holdoff: To use Trigger Holdoff, push the **HORI** button and set the Holdoff Time option (F3). The Trigger Holdoff function can be used to generate a stable display of complex waveforms (such as pulse trains). Holdoff is the time between when the oscilloscope detects one trigger and when it is ready to detect another. During the holdoff time, the oscilloscope will not trigger. For a pulse train, the holdoff time can be adjusted to let the oscilloscope trigger only on the first pulse in the train. Use the Multifunction control to adjust the timing for this feature.



4.5 Menu and Option Buttons

As shown below, these four buttons on the front panel are used mainly to recall relative setup menus.

SAVE/RECALL: Displays the Save/Recall menu for setups and waveforms. (**Save/Recall**)

MEASURE: Displays the Measure menu. (**MEAS**)

CURSOR: Displays the Cursor menu. (**CUSOR**)

UTILITY: Displays the Utility menu. (**UTILITY**)

DISPLAY: Displays the Display menu. Click **Utility** button and go to menu page 4, **Display** is F3.

ACQUIRE: Displays the Acquire menu. Click **Utility** button and go to menu page 4, **Acquire** is F4.

4.5.1 SAVE/RECALL

Press the SAVE/RECALL button to save or recall oscilloscope setups or waveforms.

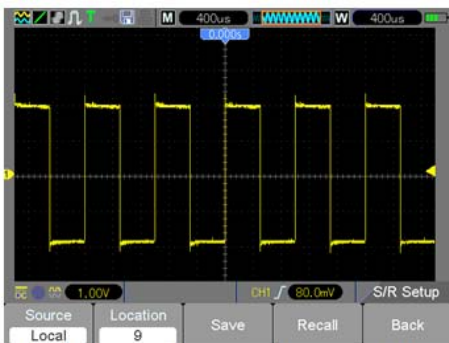
The first page shows the following menu.

Options	Settings	Comments
Wave	F1	Press F1 to engage Waveform mode
Source (F1)	CH1 CH2	Select a waveform display to store.
Media (F2)	SD USB Flash	Select the location for saving the data
Location (F3)		Used with SD and Flash only. Select the memory location
Save (F4)		Save the current set up
Page (F5)		Change page from 1 to 2
Recall (F2) (menu page 2)		Recall a specified setup based on the memory and location.
Delete (f3) (menu page 2)		Delete a specified setup based on the memory and location.

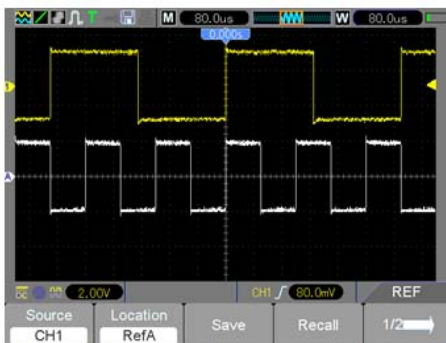
Press the **Save/Recall** button to view the Save/Recall main menu.

Options	Settings	Comments
SetUp (F2)		From the main Setup/Recall menu, Press F2 to engage SetUp mode
Source (F1)	Local USB	Store the current setups to the USB disk or the Local internal memory of the oscilloscope.
Location (F2)	0 to 9	Specify the memory location in which to store the current waveform settings or from which to recall the waveform settings.
Save (F3)		Complete the saving operation.
Recall (F4)		Recall the oscilloscope settings stored in the location selected in the Setup field.
Back (F5)		Returns you to the Save/Recall main menu
Options	Settings	Comments
CSV (F3)		From the main Setup/Recall menu, Press F3 to engage CSV mode
Source (F1)	CH1 CH2	Select a waveform display to store.
File List (F2)	Close Open	Open a file to save the waveform in. A USB device must be connected in order to save the waveform. Close file after saving.
Save (F3)		Complete the saving operation.
Recall (F4)		Recall the oscilloscope waveform stored in the location selected in the Setup field. USB device must be attached and contain saved file
Delete (F5)		Delete the highlighted waveform file from the USB device.

See below for waveform menus.



At most 9 groups of setups can be stored



The white waveforms on the menu is the recall RefA waveform

Note: The oscilloscope will save the current settings 5 seconds after the last modification, and it will recall these settings the next time the oscilloscope is powered ON.

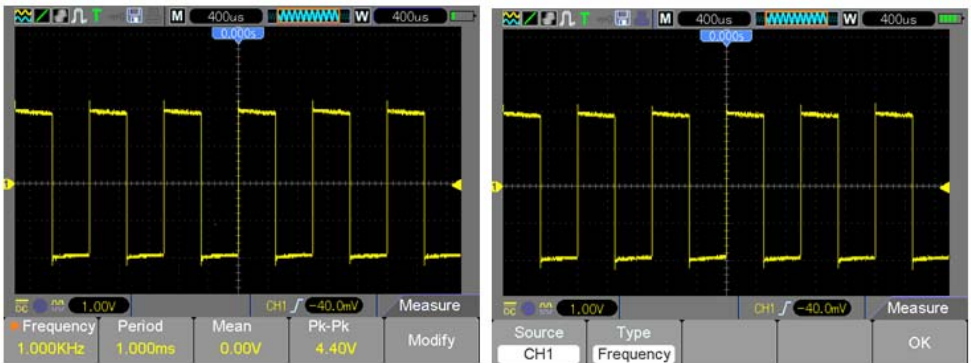
4.5.2 MEASURE

Push the **MEAS** key to view the following menu.

There are 23 types of measurements and up to 8 can be displayed at a time.

Options	Settings	Comments
Modify (F5)		Press F5 to Select the measure Source and Type.
Source (F1)	CH1 CH2	Select the measure source.
Type (F2)	Frequency	Calculate the waveform frequency by measuring the first cycle.
	Period	Calculate the time of the first cycle.
	Average/Mean	Calculate the arithmetic mean voltage over the entire record.
	Pk-Pk	Calculate the absolute difference between the greatest and the smallest peaks of the entire waveform.
	CRMS	Calculate the actual RMS voltage measurement of the first complete cycle of the waveform.
	Minimum	Examine the waveform record of all points in the current window and display the minimum value.
	Maximum	Examine the waveform record of all points in the current window and display the maximum value.
	Rising	Measure the time between 10% and 90% of the first rising edge of the waveform.
	Falling	Measure the time between 90% and 10% of the first falling edge of the waveform.
	+ Width	Measure the time between the first rising edge and the next falling edge at the waveform 50% level.
	- Width	Measure the time between the first falling edge and the next rising edge at the waveform 50% level.
	Delay 1-2 ↑	The delay of the rising time between Channel 1 and Channel 2
	Delay 1-2 ↓	The delay of the falling time between Channel 1 and Channel 2
	+ Duty	Positive duty cycle = (Positive pulse width)/Period x 100%. Measured from the first waveform.
	- Duty	Negative duty cycle = (Negative pulse width)/Period x 100%. Measured from the first waveform.
	Base	Voltage of the statistical minimum level, measured over the entire waveform
	Top	Voltage of the statistical maximum level, measured over the entire waveform

	Middle	Voltage at the 50% level of the base to the top
	Amplitude	Amplitude = Base – Top, measured over the entire waveform
	Overshoot	Negative overshoot = (Base – Min)/Amp x100%, measured over the entire waveform
	Preshoot	Positive overshoot = (Max – Top)/Amp x100%, measured over the entire waveform
	RMS	The Root Mean Square voltage over the entire waveform
	Off	Do not take a measurement.
OK (F5)		Press to engage Measurement after Source and Type is selected.



The readouts in larger font size on the menu are the results of the corresponding measurements only.

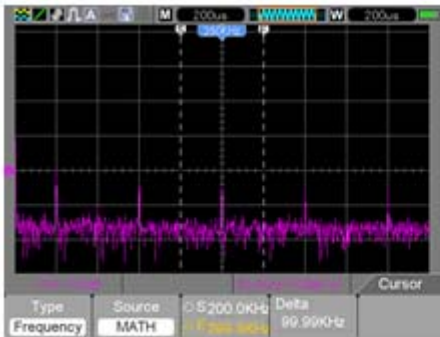
Taking Measurements: For a single waveform (or a waveform divided among multiple waveforms), up to 8 automatic measurements can be displayed at a time. The waveform channel must stay in an 'ON' (displayed) state to facilitate the measurement. The automatic measurement cannot be performed on reference or math waveforms, or in XY or Scan mode.

4.5.3 CURSOR

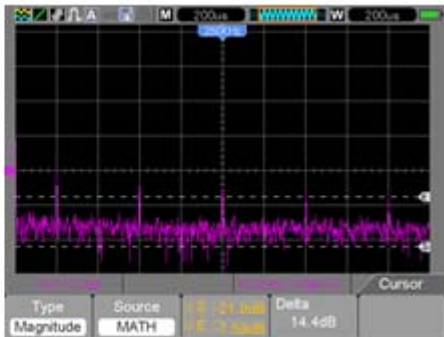
The Cursor Menu is accessed by pressing the **CURSOR** button.

Options	Settings	Comments
Type (F1)	Off Voltage Time	Select a measurement cursor and display it. Voltage measures amplitude while Time measures frequency and time.
Source (F2)	CH1 CH2 MATH REFA REFB	Select a waveform to take the cursor measurement. Use the readouts to show the measurement.
Select Cursor (F3)	S E	'S' indicates Cursor 1. 'E' indicates Cursor 2. A selected cursor can be moved independently using the Multifunction ring control. When neither cursor is highlighted, they both are moved at the same time using the arrow keys on the Multifunction control.
Delta (F4)		Displays the measurement of the difference between the two cursors.

Moving Cursors: Press the Select Cursor (F3) key to select a cursor (S, E, or both) and move it using the multifunction control. Cursors can be moved only when the Cursor Menu is displayed.



Frequency Cursors



Amplitude Cursors

4.5.4 UTILITY

Push the **UTILITY** button to display the Utility Menu as follows.

Options	Comments
Sys Info (F1) (menu page 1)	Display the software and hardware versions, serial number and other information about the oscilloscope.
Update (F2) (menu page 1)	Insert a USB disk with an upgrade program; the disk icon at the top left corner is highlighted. Press F4 to Confirm the Update Program button; the Software Upgrade dialog will pop up. Press F2 (Highlighted Update) to cancel operation.
Self Cal* (F3) (menu page 1)	Press this option and the Self Calibration dialog will pop up. Press F4 to Confirm and perform the self calibration. Press F3 (Highlighted Self Cal) to cancel. Remove all probes before test.
System (F2) (menu page 2)	Set System parameters. Sound (On/Off), Language (English, Chinese), Interface color, Time Set (Date and Time), PC Set (USB or NET*).
Shutdown (F3) (menu page 2)	Set the meters Auto-Off timing when Action is set to PowerOff. Set Auto-Off time (F2) using the Multifunction control arrow keys. Press F3 to confirm setting changes, Press F4 to cancel changes, Press F5 to go back to main Utility menu.
Video (F4) (menu page 2)	Record a video of your waveforms. Play USB to SD SD to USB Delete Back – go back to the main Utility menu
Probe Ck (F2) (menu page 3)	Probe Check Probe - (CH-1x, CH2-1x, CH1-10x, CH2-10x) Set to match probe setting. Check - Turn on 1KHz Comp signal Finish - Turn off Comp signal Cancel - Cancel Probe Check

* Ethernet port reserved for future use

Utility Mode menu continued ...

<p>Pass/Fail (F3) (menu page 3)</p>	<p>(menu page 1 of Pass/Fail) Enable Test - Open / Close (On / Off) Source - CH1 or Ch2 Start End</p>
<p>Pass/Fail</p>	<p>(menu page 2 of Pass/Fail) Msg display (F2) - Open/Close – turn On/Off Message display Out (F3) – Pass, Fail, Pass Ring, Fail Ring - Alarm settings Out Stop (F4) – Pass , Fail - Stop test on pass or fail Page (F5) – Change to page 3 of Pass/Fail menu</p>
<p>Pass/Fail</p>	<p>(menu page 3 of Pass/Fail) Regular (F2) - Alter vertical or horizontal divisions of the test Mask Create (F3) - Adjust Vertical and Horizontal div and press Create to set Mask Save (F4) – Save Mask division settings to SD or USB memory Back (F5) – Go back to main Utility menu</p>
<p>Record (F4) (menu page 3)</p>	<p>Type Off, Record, Play, Save Rec, Source, Time Interval, End Frame Start / End on page 2</p>
<p>Filter (F2) (menu page 4)</p>	<p>Type Off, Low Pass, High Pass, Band Pass, Band Stop. Source Up Down</p>
<p>Display (F3) (menu page 4)</p>	<p>This menu item controls the Display. See section 5.5.5 for these settings</p>
<p>Acquire (F4) (menu page 4)</p>	<p>This menu item controls the signal Acquire mode. See section 5.5.6 for these settings.</p>
<p>DMM (F2) (menu page 5)</p>	<p>On – Turn on the Digital multimeter functions. Off – Turn off the Digital multimeter functions.</p>
<p>Frequency (F3) (menu page 5)</p>	<p>On – OFF -</p>
<p>More (F4) (menu page 5)</p>	<p>Fan Test – SD Status – System Features – Store Depth, SD Card, Video, Net Card (Ethernet port reserved for future use)</p>

***Self Calibration:** The self calibration routine can optimize the precision of the oscilloscope to accommodate the ambient temperature. To maximize the accuracy, perform the self calibration when the ambient temperature changes by 5°C or more. Follow the instructions on the screen.

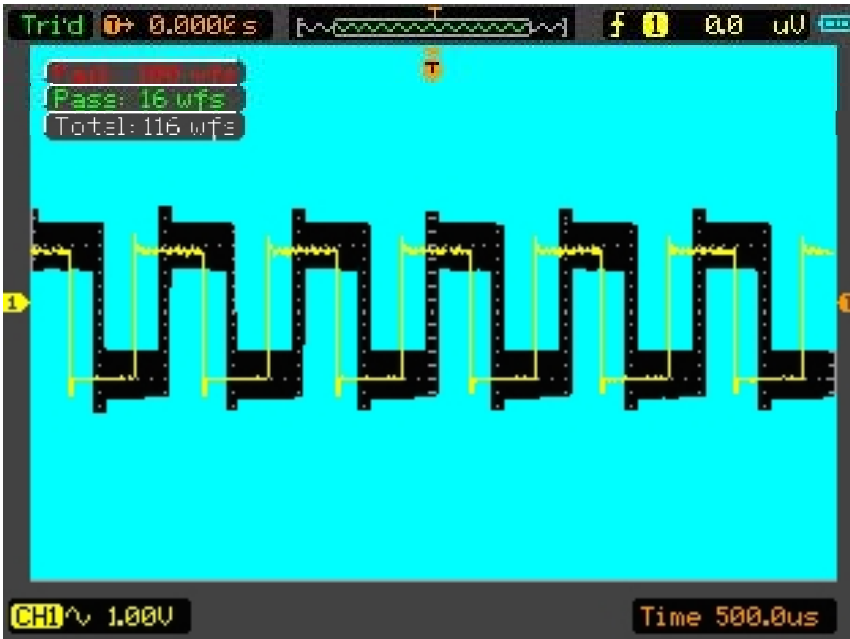
Tip: Press any menu button on the front panel to remove the status display and to enter a corresponding menu.

Pass/Fail Example:

The Pass/Fail Test is one of the enhanced special functions of this oscilloscope. By this function, the Scope can compare the input signal with the established waveform mask (Shown in blue in figure). If the waveform “touches” the mask, a “Fail” signal occurs, otherwise the test passes. When needed, a programmable output can be used for external automatic control applications. The output is built in as a standard feature and is optically isolated. Do the steps as follows:

1. Save a waveform as the reference for comparison.
2. Input the reference waveform into CH1 and press AUTO to sync on that waveform.
3. Press the M/R button to enter the REF mode. Set Source to CH1 and Location to RefA. Press SAVE button (F3)
4. Press the **Utility** key to enter the Utility menu.
5. Press the F5 key to go to page 3.
6. Press Pass/Fail (F3) button to enter the Pass/Fail menu.
7. On page 1, Set Enable to Open to turn On Pass/Fail, Select Source to CH1 (the input source).
8. On Page 2 of the Pass/Fail menu, set OUT STOP to Open (on) or Close (off) to enable the Stop-on function.
Set OUT to pass or fail to choose Stop-on pass or fail.
Set OUT to Pass Ring or Fail Ring to set an alarm tone.
Set Msg Display to Open (On) or Close (Off).
9. Create the Pass/Fail Mask: Go to page 3 of the Pass/Fail menu and Click on Regular.
Change the Vertical or Horizontal values of the mask (shown in blue in figure) by clicking the up or down keys on the multifunction control to set the div of the vertical and horizontal values.
Press the Create button to enter these new values into the mask.
Press the Save button to enter mask save mode. Set up the memory device and location to save the mask settings. This can be to either the local SD memory or a USB memory device.
Press Save to save the mask or Recall to retrieve a previously saved mask.
Click Back twice to return to the Pass/Fail menu.
10. From page 1 or the Pass/Fail menu, Press Start to start the Pass/Fail function. Press End to stop the test. See the Pass/Fail test display in the figure below.
Note the Message Display in the upper left corner.
11. To Turn off Pass/Fail testing, Set Enable Test on page 1 of the Pass/Fail menu to Close

Pass/Fail test – Mask (Blue) and signal (yellow) display



4.5.5 DISPLAY

The waveform display is affected by settings of the oscilloscope. A waveform can be measured once it is captured. The different styles to display a waveform on the screen give significant information about it. There are two modes to display waveforms; Single-window and Double window. Refer to [Horizontal Controls](#) for more information.

Press the **Utility** button and then the **DISPLAY** button on page 4 of the Utility menu.

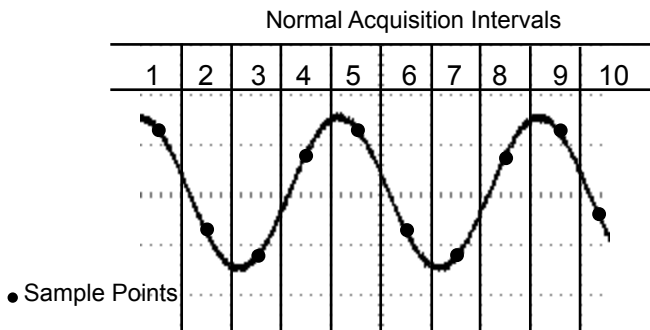
Options	Settings	Comments
Type (F1)	Vectors Dots	'Vectors' fills up the space between adjacent sample points in the display; 'Dots' displays the sample points only.
Persistency (F2)	Auto 0.2S-8S selectable Infinite	Length of time to display each displayed sample point.
DSO mode (F3)	YT XY	YT – normal or standard signal view XY – XY format
Contrast (F4)	0-15	Use the Multifunction control to set the display contrast.
Menu page 2		
Grid (F2)	Dotted Line Real Line Off	Set up for display of the grid lines.
Grid Intensity (F3)		Use the Multifunction control to set the brightness of the displays Grid lines.
Refresh Rate (F4)	Auto 30, 40, 50 Frames	Set refresh rate of display (default is Auto)
Menu Page 3		
Wave Bright (F2)		Use multifunction control arrow keys to change waveform brightness.
BL Keep (F3)	Unlimited 5, 10, 30, 60 Sec	Set how long the Backlight is on before it turns off
Menu Keep (F4)	Unlimited 5, 10, 30, 60 Sec	Set how long the Menu is displayed before it turns off

4.5.6 ACQUIRE

The acquisition modes of an oscilloscope control how waveform points are generated from sample points. Press the **Utility** button and then the **ACQUIRE** key on page 4 of the Utility menu.

Options	Settings	Comments
Type (F1)	Real Time Equi-Time	Acquire waveforms by real-time digital technique. Rebuild waveforms by equivalent sample technique.
Mode (F2) (Real Time)	Normal Peak Average	Normal: Acquire and accurately display most waveforms. Peak: Detect glitches and eliminate the possibility of aliasing. Average: Reduce random or uncorrelated noise in signal display. The number of averages is selectable.
Averages (F3) (Real Time)	4 16 64 128	Mode (F2) must be set top Average. Select the number of averages.
LongMem (F4)	4K, 40K, 512K	Memory depth - Select the memory depth.
Back (F5)		Go back to the main Utility menu

Normal: (Sample mode) creates a waveform in the oscilloscope by saving a collection of sample points. The samples are taken at each waveform interval.



Normal Mode Acquires a Single Sample Point in each Waveform Interval

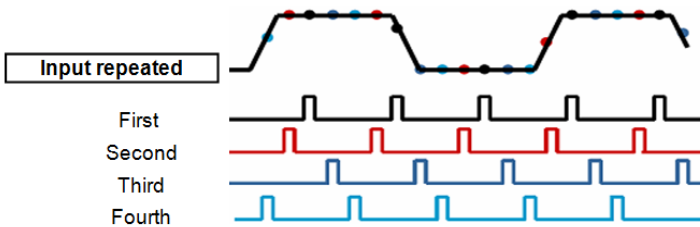
Peak Detect: Use this mode to detect glitches within 10ns and to limit the possibility of aliasing. This mode is valid at the TIME/DIV setting of 4 μ s/div or slower. Once the TIME/DIV setting is adjusted to 4 μ s/div or faster, the acquisition mode will change to Normal because the sample rate is fast enough and Peak Detect is unnecessary. The oscilloscope does not display a message that the mode has been changed to Normal.

Average: Use this mode to reduce random or uncorrelated noise in the signal to be displayed. Acquire data in Normal mode and then average some number of waveforms. Choose the number of acquisitions (4, 16, 64 or 128) to average for the waveform.

Stopping the Acquisition: When running acquisition mode, the waveform display is LIVE. Stop the acquisition (press the **RUN/STOP** button) to freeze the display. In either mode, the waveform display can be scaled or positioned by vertical and horizontal controls.

Equivalent Acquisition: Repeats the Normal acquisition. Use this mode to take a specific observation on repeatedly displayed periodic signals. A resolution of 40ps can be obtained, (i.e. 25GS/s sample rate), which is much higher than that obtained in real-time acquisition mode.

The acquisition principle is as follows.



As shown above, acquire a repeatable input signal. Sample the signal at various intervals. Store the digital values in memory. The Sample points can now be used to recreate the waveform.

4.5.7 Fast Action Buttons



AUTO: Automatically set the oscilloscope controls to generate a usable display of the input signals. Refer to the following table for relative content.

RUN/STOP: Continuously acquire waveforms or stop the acquisition.

4.5.8 AUTOSET

Autoset is one of the most useful modes of the digital oscilloscope. When the **AUTO** button is pressed, the oscilloscope will identify the type of waveform (sine or square) and adjust controls according to the input signal so that it can accurately display the waveform.

Functions	Settings made automatically
Acquire Mode	Adjusts to Normal or Peak Detect
Cursor	Off
Display Format	Sets to YT
Display Type	Sets to Vectors for an FFT spectrum; otherwise, unchanged
Horizontal Position	Adjusted
TIME/DIV	Adjusted
Trigger Coupling	Adjusts to DC, Noise Reject, LF Reject or HF Reject
Trigger Holdoff	Minimum
Trigger Level	Sets to 50%
Trigger Mode	Auto
Trigger Source	Adjusted
Trigger Slope	Adjusted
Trigger Type	Edge
Trigger Video Sync	Adjusted
Trigger Video Standard	Adjusted
Vertical Bandwidth	Full
Vertical Coupling	DC (if GND was chosen before); AC for the video signal; otherwise, unchanged
Volts	Adjusted

The Autoset function examines all channels for signals and displays corresponding waveforms. Autoset determines the trigger source according to the following conditions.

- If multiple channels receive signals, the oscilloscope will use the channel with the lowest frequency signal as the trigger source.
- If no signals are found, the oscilloscope will use the lowest-numbered channel displayed in Autoset as the trigger source.
- If no signals are found and no channels are displayed, the oscilloscope will display and use Channel 1 as the trigger source.

Sine Wave:

When the Autoset function is used and the oscilloscope determines that the signal is similar to a sine wave, the oscilloscope displays the following options:

Sine Wave Options	Details
Multi-cycle Sine	Display multiple cycles that have appropriate vertical and horizontal scales.
Single-cycle Sine	Set the horizontal scale to display approx. one cycle of waveform.
FFT	Convert the input time-domain signal to its frequency components and display the result as a graph of frequency versus amplitude (spectrum). See Section 5.3.1 Math FFT for more information.
Cancel Setup	Allow the oscilloscope to recall the previous setup.

Square Wave or Pulse:

When the Autoset function is used and the oscilloscope determines that the signal is similar to a square wave or pulse, the oscilloscope displays the following options:

Square Wave Options	Details
Multi-cycle Square	Display multiple cycles that have appropriate vertical and horizontal scales.
Single-cycle Square	Set the horizontal scale to display approx. one cycle of waveform. The oscilloscope displays Min., Mean and Positive Width automatic measurements.
Rising Edge	Display the rising edge.
Falling Edge	Display the falling edge.
Cancel Setup	Allow the oscilloscope to recall the previous setup.

Chapter 5 - Multimeter Operation

Multimeter Operation Window

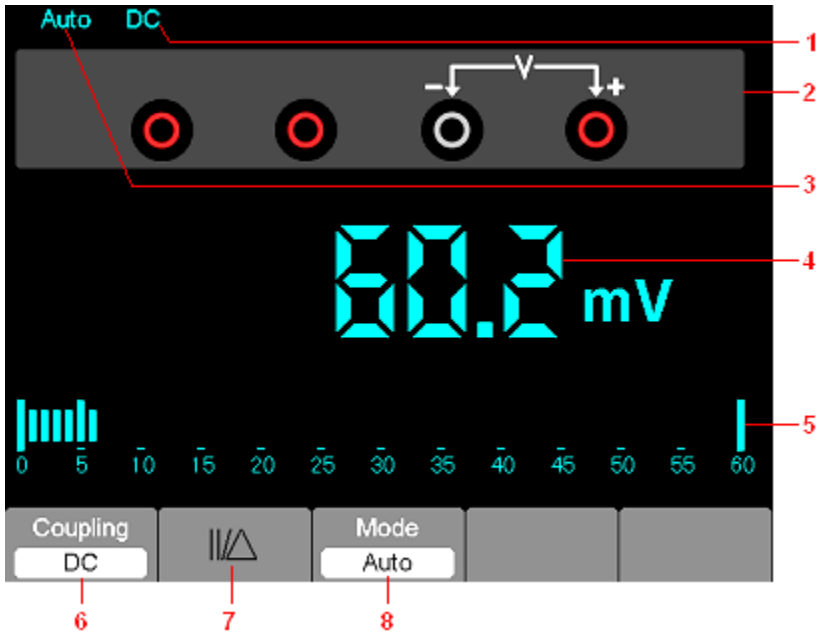


Figure 7-1 Multimeter operation window

Description

- 1) Measurement mode indicators:
 - DC: Direct current measurement
 - AC: Alternating current measurement
- 2) Input jacks and connection diagrams.
- 3) Manual/Auto range indicators, among which the MANUAL refers to measuring range in manual operation mode and Auto means the measuring range in automatic operation mode.
- 4) Measured value display.
- 5) Bar graph indicator.
- 6) DC or AC Measurement mode control.
- 7) Absolute/Relative magnitude measuring control: The sign "||" expresses the absolute magnitude measuring control and "Δ" represents the relative magnitude measuring control.
- 8) Manually or automatically measuring range control.

Operating the Multimeter

From the the oscilloscope window, press the OSC/DMM key, the oscilloscope will switch to the multimeter mode window. The screen will then display the measurement mode window that was in use the last time the multimeter was switched OFF. When switching to the multimeter measurement mode for the first time, the default measurement mode is DC voltage.

Measuring Resistance Values

To measure a resistance, perform the following:

- 1) Press the R key; the resistance measurement window appears on the screen.
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 3) Connect the red and black test leads to the resistor. The resistance value is shown on the screen in Ohms. Refer to the screen image in figure 7-2.



Figure 7-2 Resistance Measurement

Making a Diode Measurement

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

- 1) Press the diode key; the diode symbol appears at the top of the screen. .
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 3) Connect the red and black leads to the diode; the voltage value of the diode is displayed on the screen in volts. The screen will then resemble the image in figure 7-3.



Figure 7-3 Diode Measurement

Making a Continuity Measurement

To perform a Continuity test, perform the following:

- 1) Press the \llcorner key; the \llcorner indicator appears at the top of the screen.
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 3) Connect the red and black leads to the test points. If the resistance value of the tested points is less than 30 Ω , a beep will sound from the test tool. The screen will resemble the image in figure 7-4.



Figure 7-4 Continuity Measurement

Making a Capacitance Measurement

To measure a capacitance, do the following:



- 1) Press the  key; the  symbol appears at the top of the screen.
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 3) Connect the red and black leads to the capacitor; the capacitance value is displayed on the screen in μF or nF. The screen will resemble the image in figure 7-5.



Figure 7-5 Capacitance Measurement

Making a DC Voltage Measurement

To measure a DC voltage, perform the following:

- 1) Press the V key; the Auto DC icon appears at the top of the screen.
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 3) Connect the red and black leads to the measurement points; the voltage value of the measured points is displayed on the screen. The screen will resemble the image in figure 7-6.



Figure 7-6 DC voltage Measurement

Making an AC Voltage Measurement

To measure the AC voltage, perform the following:

- 1) Press the V key; the DC icon appears on the screen.
- 2) Press the F1 key; the AC icon appears on the screen.
- 3) Insert the black lead into the COM banana jack input and the red lead into the V/ Ω /C banana jack input.
- 4) Connect the red and black leads to the measured points; the AC voltage value of the measured points will be displayed on the screen. The screen will resemble the image in figure 7-7.



Figure 7-7 AC voltage Measurement

Making a DC Current Measurement

To measure a DC current smaller than 600 mA, perform the following:

- 1) Press the A key; the DC icon appears on the screen. The unit of measure on the main reading screen is mA. Press F2 to switch the measurement between mA and 10A. 600mA is acquiescence.
- 2) Insert the black lead into the COM banana jack input and the red lead into the mA banana jack input.
- 3) Connect the red and black leads to the measured points; the DC current value of measured points will be displayed on the screen. The screen will resemble the image in figure 7-8.

NOTE: For current measurements 5 amps and above, limit the measurement time to 15 seconds and allow for a 1 minute cool down between measurements.



Figure 7-8 DC current Measurement for 600 mA

To measure a DC current greater than 600 mA, perform the following:

- 1) Press the A key; the DC icon appears on the screen. The unit of measure on the main reading screen is mA.
 - 2) Press the F2 key to switch to 10A measurement, the unit of measure on the main reading is A.
 - 3) Insert the black lead into the COM banana jack input and the red lead into the 10A banana jack input.
 - 4) Connect the red and black leads to the measured points; the DC current value of the measured points will be displayed on the screen.
 - 5) Press F2 to return to 600 mA measurement.
- The screen will resemble the image in figure 7-9.



Figure 7-9 DC Current Measurement for 10A

Making an AC Current Measurement

To measure an AC current smaller than 600 mA, perform the following:

- 1) Press the A key; the DC icon appears on the screen. The unit of measure on the main reading screen is mA; the mA icon will display on the bottom of the screen, press F2 to switch the measurement between mA and 10A. 600mA is acquiescence.
- 2) Press the F1 key once; the AC icon will display on the screen.
- 3) Insert the black lead into the COM banana jack input and the red lead into the mA banana jack input.
- 4) Connect the red and black leads to the measured points; the AC current value of measured points will be displayed on the screen. The screen will resemble the image shown in figure 7-10.

NOTE: For current measurements 5 amps and above, limit the measurement time to 15 seconds and allow for a 1 minute cool down between measurements.



Figure 7-10 AC Current Measurement for 600 mA

To measure an AC current greater than 600 mA, perform the following:

- 1) Press the A key; the DC icon appears on the screen. The unit on the main reading screen is mA.
 - 2) Press F2 key to switch to the 10A measurement mode, the unit on the main reading screen is A.
 - 3) Press the F1 key once and the AC icon will display on the the screen.
 - 4) Insert the black lead into the COM banana jack input and the red lead into the 10A banana jack input.
 - 5) Connect the red and black leads to the measured points and the AC current value of the measured points will be displayed on the screen.
 - 6) Press F2 to return to the 600 mA measurement mode.
- The screen will resemble the image shown in figure 7-11.



Figure 7-11 AC Current Measurement for 10A

Taking a Relative Measurement

A relative measurement is a measurement taken and compared to a stored reference value. The resultant display represents the measurement minus the reference value.

The following example illustrates the relative measurement process. The first step is to store a reference value.

- 1) Press the 'Ω' key.
- 2) Insert the black lead into the COM banana jack input and the red lead into the V/Ω/C banana jack input.
- 3) Connect the red and black test leads to a resistor. The resistance value is shown on the screen in Ohms.
- 4) When the reading stabilizes, press the F1 key; the \square/\square is displayed on the top of the screen.

The saved reference value is displayed.

The screen will resemble the image shown in figure 7-12.



Figure 7-12 Relative Measurement

Selecting Automatic/Manual Range Adjustment

The default mode is the automatic range mode. For example: In the DC voltage mode, to switch to the manual range, perform the following steps:

- 1) Press F3 to enter the manual range mode; the Manual icon is displayed.
- 2) In the manual range mode, the measuring range is increased each time the F4 is pressed. When the highest range is reached, the next F4 key press moves the meter to the lowest range.
- 3) Press F3 to revert to the automatic range mode; the Auto icon is displayed again.

Attention: Capacitance measurements cannot be made in the manual range mode. The screen will resemble the image shown in figure 7-13.

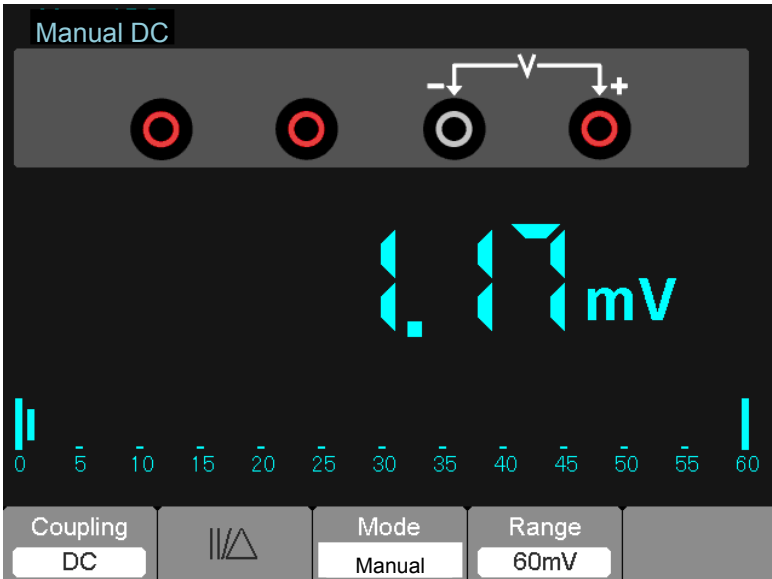


Figure 7-13 Manual Range Mode

Chapter 6 - Troubleshooting

6.1 Problem Solving

1. If the oscilloscope will not power ON, follow these steps:

- 1 Check the power cord to verify it has been connected properly;
- 2 Check the power on/off button to ensure it has been pushed;
- 3 Restart the oscilloscope.

Contact your local Extech distributor or the Extech Technical Support department if the problem persists.

2. If waveforms will not display when the oscilloscope is switched ON:

- 1 Check the probe to assure it is properly connected to the input BNC;
- 2 Check the channel switch (such as CH1, CH2 menu buttons) to make sure it has been turned on;
- 3 Check the input signal to verify it has been connected to the probe correctly;
- 4 Verify that all measured circuits indeed have signals to output;
- 5 Raise the magnitude for DC signals;
- 6 Press the **Auto** button to perform an automatic detection of signals.

Contact Extech Technical Support department if there is still no display of waveforms.

3. If the waveform of the input signal is seriously distorted, follow these steps:

- 1 Check the probe to assure a proper connection to the channel BNC;
- 2 Check the probe to assure a good connection to the measured object;
- 3 Check the probe to verify that it has been well calibrated. Otherwise, refer to the content regarding Calibration in this manual.

4. If the waveform is moving continuously on the screen and can not be triggered:

- 1 Check the trigger source to ensure that it is consistent with the input channel;
- 2 Check the trigger level to assure a correct setting.
- 3 Check the trigger mode to confirm that it is an appropriate selection for the input signal.

The default trigger mode is Edge trigger. However, edge triggering it is not suitable for every type of input signal.

5. If the meter will not display current measurements:

The internal fuses may have opened. The meter is protected by two fast acting fuses not accessible to the user. The fuses are rated: 1A (600V) and 12A (600V) fast acting. Please contact a local Extech distributor or the Extech Technical Support department for assistance in locating a local service center.

Chapter 7 - Specifications

7.1 Technical Specifications

All published specifications apply to the MS6000 series oscilloscopes. Before checking an oscilloscope to verify its compliance with these specifications, ensure that the oscilloscope meets the following conditions:

- The oscilloscope must have undergone a twenty minute warm-up period under the specified operating temperature.
- The 'Do Self Cal' operation must be performed through the Utility menu if the operating temperature changes by more than 5°C.
- The oscilloscope must be within the factory calibration interval.

All specifications are guaranteed unless noted 'typical'.

Oscilloscope Specifications

Horizontal

Sample Rate Range	1GS/s	
Waveform Interpolation	(sin x)/x	
Record Length	Maximum 1M samples per single-channel; maximum 512K samples per dual-channel	
TIME/DIV Range	MS6060 MS6100	MS6200
	4ns/div to 40s/div, in a 2, 4, 8 sequence	2ns/div to 40s/div, in a 2, 4, 8 sequence
Sample Rate and Delay Time Accuracy	±50ppm over any ≥1ms time interval	

Delta Time Measurement Accuracy (Full Bandwidth)	Single-shot, Normal mode $\pm (1 \text{ sample interval} + 100\text{ppm} \times \text{reading} + 0.6\text{ns})$		
	>16 averages		
	$\pm (1 \text{ sample interval} + 100\text{ppm} \times \text{reading} + 0.4\text{ns})$		
	Sample interval = $s/\text{div} \div 200$		
Position Range	MS6060		
	MS6100		
	4ns/div to 8ns/div	(-8div \times s/div) to 20ms	
	20ns/div to 80 μ s/div	(-8div \times s/div) to 40ms	
	200 μ s/div to 40s/div	(-8div \times s/div) to 400s	
	MS6200		
2ns/div to 10ns/div	(-4div \times s/div) to 20ms		

Vertical

A/D Converter	8-bit resolution, each channel is sampled simultaneously		
VOLTS Range	2mV/div to 5V/div at input BNC		
Position Range	2mV/div to 200mV/div, $\pm 2\text{V}$ >200mV/div to 5V/div, $\pm 50\text{V}$		
Analog Bandwidth in Normal and Average modes at BNC or with probe, DC Coupled	2mV/div to 20mV/div, $\pm 400\text{mV}$ 50mV/div to 200mV/div, $\pm 2\text{V}$ 500mV/div to 2V/div, $\pm 40\text{V}$ 5V/div, $\pm 50\text{V}$		
Selectable Analog Bandwidth Limit, typical	20MHz		
Low Frequency Response (-3db)	$\leq 10\text{Hz}$ at BNC		
Rise Time at BNC, typical	MS6060	MS6100	MS6200
	<5.8ns	\square 3.5ns	<1.8ns

DC Gain Accuracy	<p>±3% for Normal or Average acquisition mode, 5V/div to 10mV/div</p> <p>±4% for Normal or Average acquisition mode, 5mV/div to 2mV/div</p>
DC Measurement Accuracy, Average Acquisition Mode	<p>Measurement Type: Average of ≥16 waveforms with vertical position <u>at zero</u></p> <p>Accuracy: ± (3% × reading + 0.1div + 1mV) when 10mV/div or greater is selected</p> <hr/> <p>Measurement Type: Average of ≥16 waveforms with vertical position <u>not at zero</u></p> <p>Accuracy: ± [3% × (reading + vertical position) + 1% of vertical position + 0.2div]</p> <p>Add 2mV for settings from 2mV/div to 200mV/div; add 50mV for settings from 200mV/div to 5V/div</p>
Volts Measurement Repeatability, Average Acquisition Mode	Delta volts between any two averages of ≥16 waveforms acquired under same setup and ambient conditions

Note: Bandwidth reduced to 6MHz when using a 1X probe.

Trigger

Trigger Sensitivity (Edge Trigger Type)	Coupling	Sensitivity		
	DC	Source	MS6060 MS6100	MS6200
		CH1 CH2	1div from DC to 10MHz; 1.5div from 10MHz to Full	1.5div from 10MHz to 100MHz; 2div from 100MHz to Full
	AC	Attenuates signals below 10Hz		
	HF Reject	Attenuates signals above 80kHz		
	LF Reject	Same as the DC-coupled limits for frequencies above 150kHz; attenuates signals below 150kHz		
Trigger Level Range	Source	Range		
	CH1, CH2	±8 divisions from center of screen		
Trigger Level Accuracy, typical (Accuracy is for signals having rise and fall times ≥20ns)	Source	Accuracy		
	CH1□CH2	0.2div × volts/div within ±4 divisions from center of screen		
Set Level to 50%, typical	Operates with input signals ≥50Hz			

Note: Bandwidth reduced to 6MHz when using a 1X probe.

Video Trigger Type	Source	Range
	CH1, CH2	Peak-to-peak amplitude of 2 divisions
Signal Formats and Field Rates, Video Trigger Type	Supports NTSC, PAL and SECAM broadcast systems for any field or any line	
Holdoff Range	100ns to 10s	

Pulse Width Trigger	
Pulse Width Trigger Mode	Trigger when < (Less than), > (Greater than), = (Equal), or ≠ (Not Equal); Positive pulse or Negative pulse
Pulse Width Trigger Point	<p>Equal: The oscilloscope triggers when the trailing edge of the pulse crosses the trigger level.</p> <p>Not Equal: If the pulse is narrower than the specified width, the trigger point is the trailing edge. Otherwise, the oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.</p> <p>Less than: The trigger point is the trailing edge.</p> <p>Greater than (also called overtime trigger): The oscilloscope triggers when a pulse continues longer than the time specified as the Pulse Width.</p>
Pulse Width Range	Selectable from 20ns to 10s

Slope Trigger	
Slope Trigger Mode	Trigger when < (Less than), > (Greater than), = (Equal), or ≠ (Not Equal); Positive slope or Negative slope
Slope Trigger Point	<p>Equal: The oscilloscope triggers when the waveform slope is equal to the set slope.</p> <p>Not Equal: The oscilloscope triggers when the waveform slope is not equal to the set slope.</p> <p>Less than: The oscilloscope triggers when the waveform slope is less than the set slope.</p> <p>Greater than: The oscilloscope triggers when the waveform slope is greater than the set slope.</p>
Time Range	Selectable from 20ns to 10s
Overtime Trigger	The leading edge: Rising edge or Falling edge; Time Setting: 20-10s

Alter (Swap) Trigger	
CH1	Internal Trigger: Edge, Pulse Width, Video, Slope
CH2	Internal Trigger: Edge, Pulse Width, Video, Slope

Acquisition

Acquisition Modes	Normal, Peak Detect, and Average	
Acquisition Rate, typical	Up to 2000 waveforms per second per channel (Normal acquisition mode, no measurement)	
Single Sequence	Acquisition Mode	Acquisition Stop Time
	Normal, Peak Detect	Upon single acquisition on all channels simultaneously
	Average	After N acquisitions on all channels simultaneously, N can be set to 4, 8, 16, 32, 64 or 128

Inputs

Input Coupling	DC, AC or GND	
Input Impedance, DC coupled	1M Ω \pm 2% in parallel with 20pF \pm 3pF	
Probe Attenuation	1X, 10X	
Supported Probe Attenuation	1X, 10X, 100X, 1000X	
Maximum Input Voltage	Overvoltage Category	Maximum Voltage
	CAT I and CAT II	300V _{RMS} (10 \times), Installation Category
	CAT III	150V _{RMS} (1 \times)
	Installation Category II: derate at 20dB/decade above 100kHz to 13V peak AC at 3MHz* and above. For non-sinusoidal waveforms, peak value must be less than 450V. Excursion above 300V should be of less than 100ms duration. RMS signal level including all DC components removed through AC coupling must be limited to 300V. If these values are exceeded, damage to the oscilloscope may occur.	

Measurements

Cursors	Voltage difference between cursors: $\square V$ Time difference between cursors: $\square T$ Reciprocal of $\square T$ in Hertz ($1/\Delta T$)
Automatic Measurements	Frequency, Period, Mean, Peak-to-peak, CycleRMS, Minimum, Maximum, Rise Time, Fall Time, Positive Width, Negative Width, Delay 1-2 \uparrow , Delay 1-2 \downarrow , +Duty, -Duty, Base, Top, Middle, Amplitude, Overshoot, Preshoot, RMS, Off

General Specifications

Display	
Display Type	5.6 Inch width LED Backlight Display
Display Resolution	240 (Vertical) X 320 (Horizontal) pixels
Display Contrast	Adjustable (16 steps) with a progress bar

Probe Compensator Output	
Output Voltage, typical	About 2Vpp into $\geq 1M\Omega$ load
Frequency, typical	1kHz

Internal Memory	
2G SD Card	Accommodates up to 32G card (accessible through battery compartment)

Power Supply	
Supply Voltage	100-120VAC _{RMS} ($\pm 10\%$), 45Hz to 440Hz 120-240VAC _{RMS} ($\pm 10\%$), 45Hz to 66Hz
Power Consumption	<30W, (approx. 3 hours)
Fuses	Two (2) fast-acting internal fuses: 1A (600V) and 12A (600V)
Battery	7.4V li-ion rechargeable

Environmental		
Temperature	Operating: 32°F to 122°F (0°C to 50°C)	
	Nonoperating: -40°F to 159.8°F (-40°C to +71°C)	
Cooling Method	Convection	
Humidity	+104°F or below (+40°C or below): ≤90% relative humidity	
	106°F to 122°F (+41°C to 50°C): ≤60% relative humidity	
Altitude	Operating and Non-operating	3,000m (10,000 feet)
	Random Vibration	0.31g _{RMS} from 50Hz to 500Hz, 10 minutes on each axis
	Non-operating	2.46g _{RMS} from 5Hz to 500Hz, 10 minutes on each axis
Mechanical Shock	Operating	50g, 11ms, half sine

Mechanical		
Size	Length	245mm (10")
	Height	163mm (6.4")
	Depth	52mm (2")
Weight	Excludes packing and accessories	1.2 Kg (2.6 lbs.)

Meter Mode

Maximum Resolution	6000 Counts
DMM Testing Modes	Voltage, Current, Resistance, Capacitance, Diode & Continuity
Maximum Input Voltage	AC : 600V DC : 800V
Maximum Input Current	AC : 10A DC : 10A
Input Impedance	10M Ω

Meter Specification

Range		Accuracy (of rdg.)	Resolution
DC Voltage	60.00mV(manual)	$\pm 1\% \pm 1$ digit	10uV
	600.0mV		100uV
	6.000V		1mV
	60.00V		10mV
	600.0V		100mV
	800V		1V
AC Voltage	60.00mV(manual)	$\pm 1\% \pm 3$ digits	10uV
	600.0mV(manual)		100uV
	6.000V		1mV
	60.00V		10mV
	600.0V		100mV
DC Current	60.00mA	$\pm 1.5\% \pm 1$ digit	10uA
	600.0mA	$\pm 1\% \pm 1$ digit	100uA
	6.000A	$\pm 1.5\% \pm 3$ digits	1mA
	10.00A		10mA
AC Current	60.00mA	$\pm 1.5\% \pm 3$ digits	10uA
	600.0mA	$\pm 1\% \pm 1$ digit	100uA
	6.000A	$\pm 1.5\% \pm 3$ digits	1mA
	10.00A		10mA

Resistance	600.0	$\pm 1\% \pm 1 \text{ digit}$	0.1 Ω
	6.000K		1 Ω
	60.00K		10 Ω
	600.0K		100 Ω
	6.000M		1K Ω
	60.00M	$\pm 1.5\% \pm 3 \text{ digits}$	10K Ω
Capacitance	40.00nF	$\pm 1.75\% \pm 10 \text{ digits}$	10pF
	400.0nF		100pF
	4.000uF		1nF
	40.00uF		10nF
	400.0uF		100nF
	Note: The smallest capacitance value that can be measured is 5nF		
Diode	0V~2.0V		
On-off Test	< 30 Ω		

Chapter 8 - General Care and Cleaning

8.1 General Care

Do not expose the LCD display to direct sunlight for long periods of time.

To avoid damage to the oscilloscope or probes, do not expose them to sprays, liquids, or solvents.

8.2 Cleaning

Examine the oscilloscope and probes as often as operating conditions require. To clean the exterior surface, perform the following steps:

- 1 Use a lint-free cloth to remove floating dust on the outside of the oscilloscope and probes. Take care to avoid scratching the display.
- 2 Use a soft cloth dampened with water to clean the oscilloscope. For more efficient cleaning, you may use an aqueous solution of 75% isopropyl alcohol.

Note: To avoid damage to the surface of the oscilloscope or probes, do not use corrosive or chemical cleaning agents.

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