User's Guide

RIGOL

DS-5000 Series Digital Storage Oscilloscope

DS5000CA, DS5000C, DS5000MA, DS5000M
DS5000CAE, DS5000CE, DS5000MAE, DS5000ME

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General Safety Summary

Review the following safety precautions carefully before operating the instrument to avoid any personal injuries or damages to the instrument and any products connected to it.

To avoid potential hazards use the instrument as specified by this user's guide only.

The instrument should be serviced by qualified personnel only.

To Avoid Fire or Personal Injury

Use Proper Power Cord. Use the power cord designed for the instrument and authorized in your country only.

Connect and Disconnect Accessories. Do not connect or disconnect probes or test leads while they are connected to a voltage source

Ground The Instrument. The oscilloscope is grounded through the grounding conductor of the power cord. To avoid electric shock the instrument grounding conductor(s) must be grounded properly, before making connections to the input or output terminals of the instrument.

Connect The Probe. The probes' ground terminals are at the same voltage level of the instrument ground. Do not connect the ground terminals to a high voltage.

Observe All Terminal Ratings. To avoid fire or shock hazard, observe all ratings and marks on the instrument. Follow the user's guide for further ratings information before making connections to the instrument.

Do Not Operate Without Covers. Do not operate the instrument with covers or panels removed.

Use Proper Fuse. Use the fuse of the type, voltage and current ratings as specified for the instrument.

Avoid Circuit or Wire Exposure. Do not touch exposed connections and components when power is on.

Do Not Operate With Suspected Failures. If suspected damage occurs with the instrument, have it inspected by qualified service personnel before further operations.

Provide Proper Ventilation. Refer to the installation instructions for proper ventilation of the instrument.

Do not operate in wet/damp conditions.

Do not operate in an explosive atmosphere.

Keep product surfaces clean and dry.

The disturbance test of all the models meet the limit values of A in the standard of EN 61326: 1997+A1+A2+A3, but can't meet the limit values of B.

Measurement Category

The DS5000 series Digital Oscilloscope is intended to be used for measurements in Measurement Category I.

Measurement Category Definitions

Measurement Category I is for measurements performed on circuits not directly connected to MAINS. Examples are measurements on circuits not derived from MAINS, and specially protected (internal) MAINS derived circuits. In the latter case, transient stresses are variable; for that reason, the transient withstand capability of the equipment is made known to the user.

WARNING

IEC Measurement Category I. The input terminals may be connected to circuit terminal in IEC Category I installations for voltages up to 300 VAC. To avoid the danger of electric shock, do not connect the inputs to circuit's voltages above 300 VAC.

Transient overvoltage is also present on circuits that are isolated from mains. The DS5000 series Digital Oscilloscopes is designed to safely withstand occasional transient overvoltage up to 500 Vpk. Do not use this equipment to measure circuits where transient overvoltage could exceed this level.

Safety Terms and Symbols

Terms in This Guide. These terms may appear in this guide:

WARNING: Warning statements identify 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.

Terms on the Product. These terms may appear on the product:

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

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

CAUTION indicates a hazard to property including the product.

Symbols on the Product. These symbols may appear on the product.

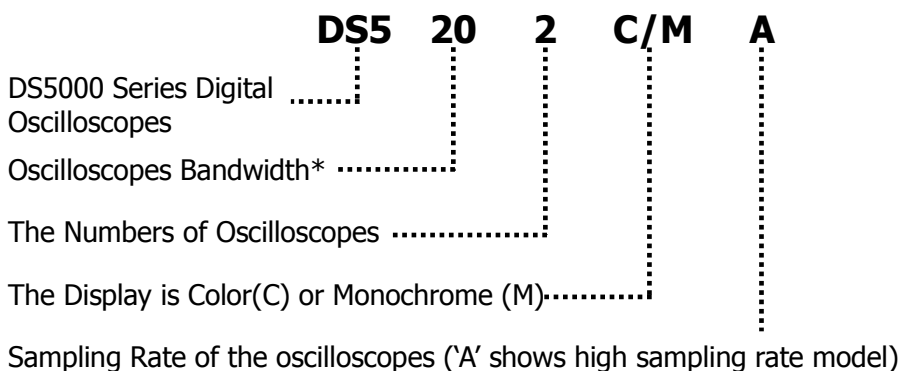| DANGER	ATTENTION	Protective	Frame	Earth
High Voltage	Refer to Manual	Conductor Terminal	or Chassis Terminal	Terminal

General-Purpose Oscilloscopes

The **RIGOL DS5000-Series** Digital Storage Oscilloscopes offer exceptional waveform viewing and measurements in a small, lightweight package. The DS5000 series are suited for production, field service, research and design labs, applications involving digital circuit test and troubleshooting, and education applications.
Each of these oscilloscopes gives you:

The DS5000 Series Digital Oscilloscopes naming rules:

<div align="center">

DS5 20 2 C/M A

</div>

DS5000 Series Digital
Oscilloscopes

Oscilloscopes Bandwidth*

The Numbers of Oscilloscopes

The Display is Color(C) or Monochrome (M)

Sampling Rate of the oscilloscopes ('A' shows high sampling rate model)

- Dual Channel, Bandwidth:
  - 200-MHz   (DS5202CA/CAE)
  - 150-MHz   (DS5152CA/CAE, DS5152C/CE, DS5152MA/MAE, DS5152M/ME)
  - 100-MHz   (DS5102CA/CAE, DS5102C/CE, DS5102MA/MAE, DS5102M/ME)
  - 60-MHz   (DS5062CA/CAE, DS5062C/CE, DS5062MA/MAE, DS5062M/ME)
  - 40-MHz   (DS5042M/ME)
  - 25-MHz   (DS5022M/ME)
- 4K/Channel Memory Depth
- Mono/Color LCD Display 320*240 resolution
- Real-time Sample Rate
  - 1GSa/s (DS5000CA/CAE series, DS5000MA/MAE series)
  - 500MSa/s (DS5000C/CE series, DS5000M/ME series)
- Equivalent Sample Rate
  - 50GSa/s (DS5202CAE/ MAE)
  - 25GSa/s (DS5152CE/CAE/ME/MAE, DS5102CE/CAE/ME/MAE)

10GSa/s (DS5062CE/CAE/ME/MAE)

5GSa/s (DS5042ME)

2.5GSa/s (DS5022ME)

- Automatic setup of the front panel
- 20 Automatic measurements
- Auto Calibration
- Storage 10 Waveforms, 10 setups
- Delayed Scan Function
- XY-PLOT
- Built-in FFT function, Frequency Counter
- Digital filter, includes LPF, HPF, BPF, BRF
- Selectable 50Ω/1MΩInput Impedance.(Certain models ONLY, see related section)
- Pass/Fail Function
- Trigger on Edger, Video, Pulse width
- Add, Subtract, Multiply and Divide Mathematic Functions
- Multiple Language User Interface

* The ten and hundred of the DS5000 series oscilloscopes module representative oscilloscope bandwidth. '20' representative 200M bandwidth, '15' representative 200M bandwidth, '10' representative 100M bandwidth, '06' representative 60M bandwidth, '02' representative 25M bandwidth.

# Content

Chapter 1 : The Oscilloscope at a glance

This chapter covers the following topics:

- ■ The front panel and user interface

- ■ To inspect the instrument

- ■ To take a functional check

- ■ To compensate probes

- ■ To display a signal automatically

- ■ To set up the vertical window

- ■ To set up the horizontal system

- ■ To trigger the oscilloscope

The front panel and the user interface

The first thing to do with your new oscilloscope is know the front panel. This chapter helps to familiarize with the layout of the knobs and keys and how to use them. Read the chapter carefully before further operations.

The knobs are used most often and are similar to the knobs on other oscilloscopes. The keys bring up soft button menus on the display that allow you access to many of the oscilloscope features and menus associated with channels, math, and reference or instant action features.
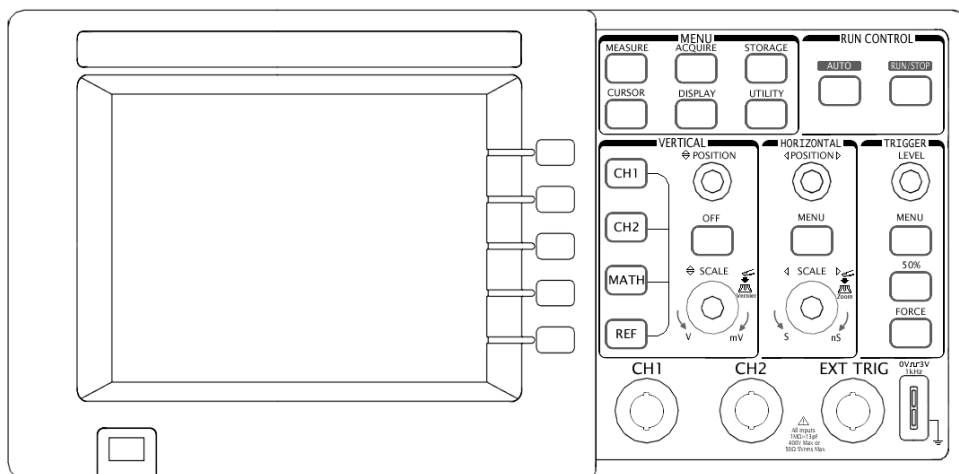
Figuer1-1

DS 5000-Series Oscilloscope's Front Panel

DS5000 series oscilloscopes provide an easy-to-use front panel, the definitions of the buttons and the knobs are listed as follows:

Menu buttons:
Associate with MEASURE, CURSOR, ACQUIRE, DISPLAY, STORAGE, and UTILITY menus.

Vertical buttons:
Associate with CH1, CH2, MATH and REF menus, the OFF button can set waveform or menu which currently active off.

Horizontal buttons:
Associate with horizontal MENU.

Trigger buttons:
Associate with trigger MENU, instant action to set 50% trigger level and FORCE trigger.

Action buttons:
Include Instant action buttons for AUTO and RUN/STOP.

Function buttons:
Five gray buttons from top to bottom on the right to the LCD screen, which set choice of operation in the currently active menu.

Knobs:
For the adjustment of vertical or horizontal POSITION, SCALE, and trigger LEVEL.
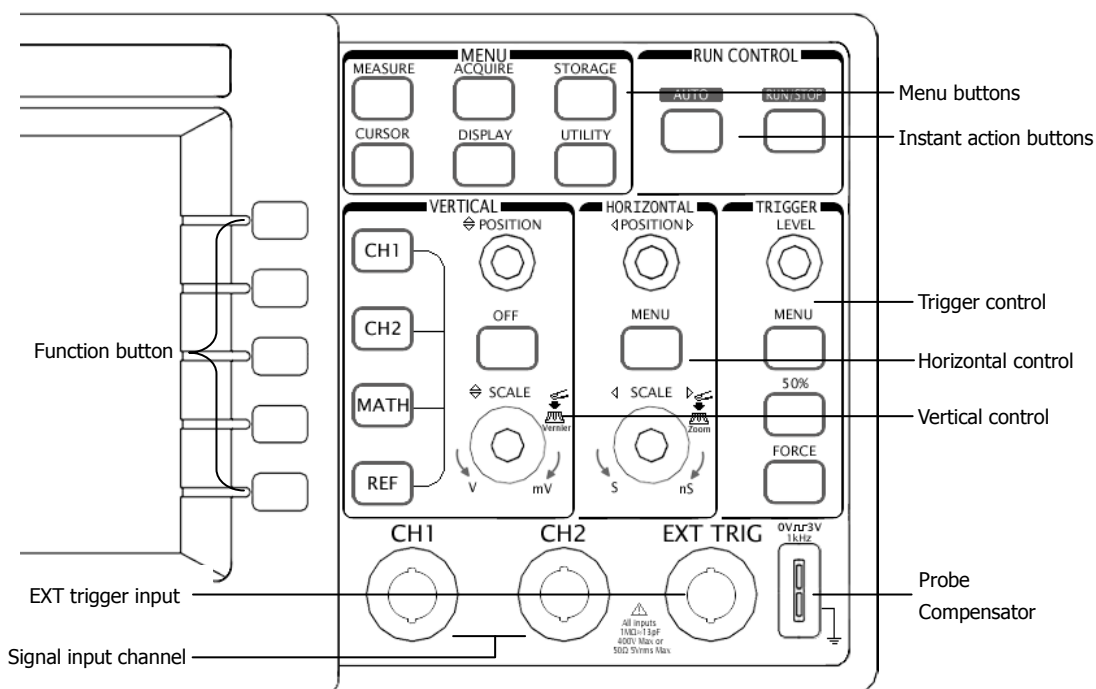

Figure 1-2
Front Panel Controls

Throughout this guide, a box around the name of the key denotes the front-panel keys, and the name with a sunken shadow denotes the soft buttons.

For example, CH1 is a front-panel key labeled **CH1** under the vertical portion of the front panel, and Coupling is a soft button. The word **Coupling** is on the top of the menu on the screen, directly on the left of an unlabeled soft button (which is also gray).

The position of current window in memory

Trigger position in memory

Trigger position in current window

Execute status

Channel 1 symbol

Channel 2 symbols

Operation menu

Waveform display

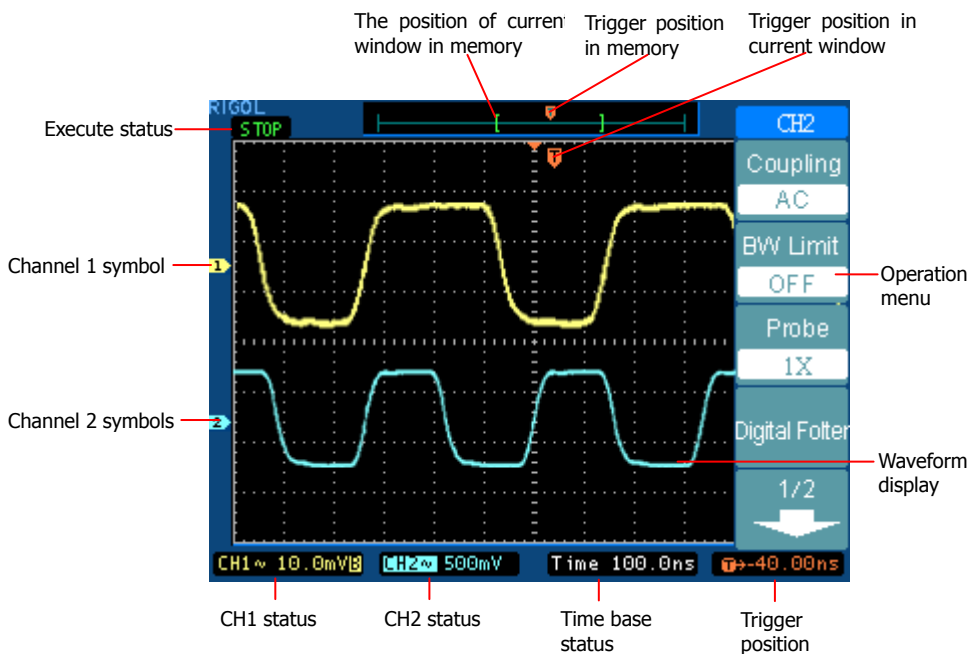CH1 status

CH2 status

Time base status

Trigger position

Figure 1-3
User Interface

To inspect the instrument

After you get a new DS5000 series oscilloscope, please inspect the instrument as followings:

1. Inspect the shipping container for damage.

Keep the damaged shipping container or cushioning material until the contents of the shipment have been checked for completeness and the instrument has been checked mechanically and electrically.

2. Check the accessories.

Accessories supplied with the instrument are listed in "Appendix A" in this guide. If the contents are incomplete or damaged notify your **RIGOL** sales office.

3. Inspect the instrument.

If there is mechanical damage or defect, or if the instrument does not operate properly or pass performance tests, notify your **RIGOL** sales office.

If the shipping container is damaged, or the cushioning materials show signs of stress, notify the carrier as well as your **RIGOL** sales office. Keep the shipping materials for the carrier's inspection.

The **RIGOL** office will arrange for repair or replacement at **RIGOL**'s option without waiting for claim settlement.

To take a functional check

Perform this quick functional check to verify that your instrument is operating correctly.

1. Turn on the instrument.

Use the power cords designed for your oscilloscope only. Use a power source that delivers 100 to 240 VAC$_{RMS}$, 50Hz. Turn on the instruments and wait until the display shows that all self-tests passed. Push the STORAGE button, select Setups in the top menu box and push the Factory menu box.
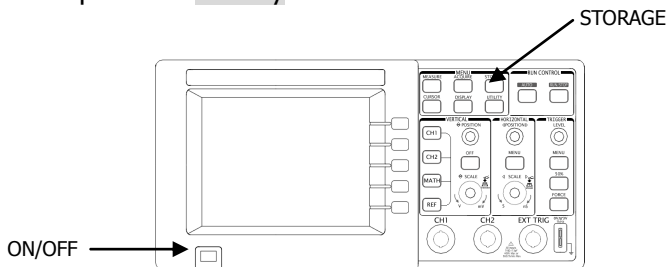

Figure 1-4

⚠ **WARNNING:**
To avoid electric shock, be sure the oscilloscope is properly grounded.

2．Input a signal to a channel of the oscilloscope

① Set the attenuation switch on the probe to 10X and connect the probe to channel 1 on the oscilloscope. To do this, align the slot in the probe connector with the key on the CH1 BNC, push to connect, and twist to the right to lock the probe in place.
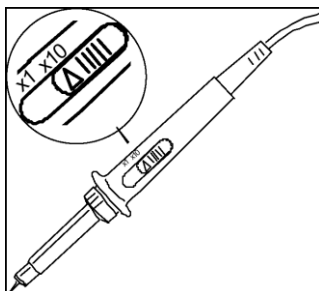Attach the probe tip and reference lead to the PROBE COMP connector.

Figure 1-5

⚠ **CAUTION:** To avoid damage the instrument, always ensure the input voltage at BNC does not exceed the maximum voltage (400Vpp when 1M Ω input impedance is selected, or 5Vrms when 50Ω input impedance is selected.)

Probe comp

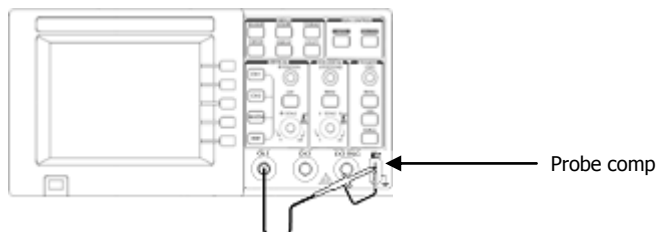Figure 1-6

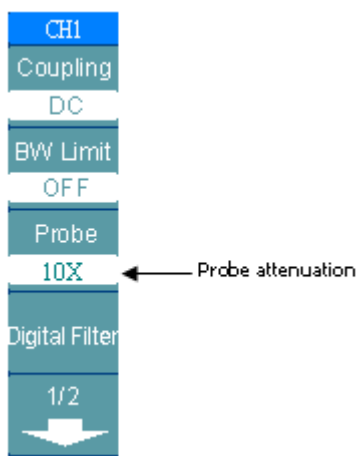② Set the probe attenuation to 10X. To do this, push CH1→Probe→10X.

Probe attenuation

Figure 1-7

③ Push the AUTO button. Within a few seconds, a square wave will display (approximately 1 kHz, 3 V peak- to- peak).

④ Push the OFF button to turn off Channel 1. Push the CH2 button to turn on channel 2, repeat steps 2 and 3.

To compensate probes

Perform this adjustment to match your probe to the input channel. This should be done whenever you attach a probe for the first time to any input channel.

1. From CH1 menu, set the Probe attenuation to 10X (Press CH1→Probe→10X). Set the switch to 10X on the probe and connect it to Channel 1 on the oscilloscope. When using the probe hook-tip, ensure a proper connection by firmly inserting the tip onto the probe.
   Attach the probe tip to the PROBE COMP connector and the reference lead to the PROBE COMP Ground connector, turn on Channel 1, and then press AUTO.

2. Check the shape of the displayed waveform.
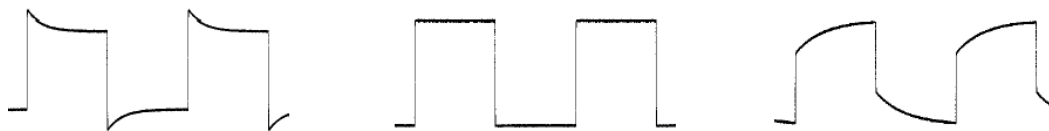
Overcompensated   Correctly Compensated   Under Compensated

Figure 1-8

3. If necessary, use a nonmetallic tool to adjust the trimmer capacitor on the probe for the flattest square wave possible as displayed on the oscilloscope.

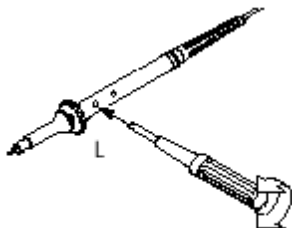Figure 1-9

4. Repeat as necessary.

⚠ **WARNNING:** To avoid electric shock while using the probe, be sure the perfection of the insulated cable, and do not touch the metallic portions of the probe head while it is connected with a voltage source.

To display a signal automatically

The oscilloscope has an Auto feature that automatically sets up the oscilloscope to best display the input signal. Using Auto requires signals with a frequency greater than or equal to 50 Hz and a duty cycle greater than 1%.

Press the AUTO button, the oscilloscope turns on and scales all channels that have signals applied, and it selects a time base range based on the trigger source. The trigger source selected is the lowest numbered input that has a signal applied.
The DS5000 series oscilloscopes have two-channels input and an external trigger input.

Connect a signal to the channel 1 input.

1. Connect a signal to the oscilloscope.

2. Press AUTO.

The oscilloscope may change the current setting to display the signal. It will automatically adjust the vertical and horizontal scaling, the trigger coupling, type, position, slope, level, and mode settings.

To set up the vertical window

Figure 1-10 shows the VERTICAL controls: CH1, CH2, MATH, REF, OFF buttons and vertical POSITION, SCALE knobs. The following exercise of the vertical buttons, knobs, and status bar will help you to familiar with the vertical parameters settings.
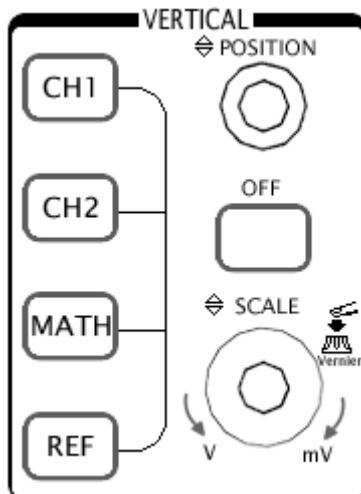
Figure 1-10

1 Center the signal on the display with the POSITION knob.

The POSITION knob moves the signal vertically, and it is calibrated. Notice that as you turn the POSITION knob, a voltage value is displayed for a short time indicating how far the ground reference is located from the center of the screen. Also notice that the ground symbol on the left side of the display moves in conjunction with the POSITION knob.

Measurement hints

If the channel is DC coupled, you can quickly measure the DC component of the signal by simply noting its distance from the ground symbol.

If the channel is AC coupled, the DC component of the signal is blocked, allowing you to use greater sensitivity to display the AC component of the signal.

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2 Change the vertical setup and notice that each change affects the status bar differently.

You can quickly determine the vertical setup from the status bar in the display.

- Change the vertical sensitivity with the SCALE knob and notice that it causes the status bar to change.
- Press CH1.
  A soft button menu appears on the display, and the channel turns on (or remains on if it was already turned on).
- Toggle each of the soft buttons and notice which button cause the status bar to change. Channels 1 and 2 have a venire soft button that allows the SCALE knob to change the vertical step size in smaller increments. To press Volts/Div soft button, you can change the step size into **Fine** or **Coarse** status.
- Press OFF to turn off the channel.

NOTE: OFF button can also shut the on-screen menu off.

Vernier Shortcut key

You can set the Coarse/Fine vertical control not only on the Volts/Div item in the CH1 or CH2 menus, but also by pressing the vertical SCALE knob.

To set up the horizontal system

Figure 1-11 shows the HORIZONTAL controls: MENU button, POSITION and SCALE knobs.   Follow the exercise to familiarize with these buttons, knobs, and status bar.
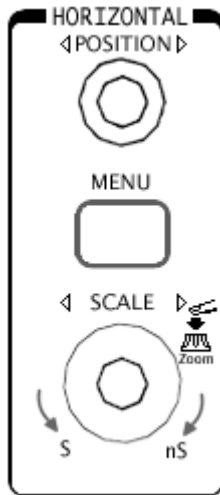
Figure 1-11

1. Turn the SCALE knob and notice the change in the status bar.

The horizontal SCALE knob changes the sweep speed in a 1-2-5 step sequence, and the value is displayed in the status bar. The time base ranges of the DS5000 series are listed as follows.

From 1 ns/div* to 50 s/div and they can reach 10ps/div* in Delayed Scan mode.

* NOTE: This characteristic varies by different model.

Delayed Scan Shortcut key

To press the SCALE knob in the horizontal control area on the front-panel is another way to enter or exit Delayed Scan mode and it is equal to the menu operations, MENU→Delayed.

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2 The horizontal POSITION knob move the displayed signal horizontally on waveform window.

3. Press the MENU key to display the TIME menu.

Enter or exit the Delayed Scan mode, set the display to Y-T or X-Y format, and to set the horizontal POSITION knob to **Trig-Offset** or **Holdoff** mode.

Horizontal position control

Trig-Offset: In this setting, the trigger's position will be changed horizontally when turning the POSITION knob.

Holdoff: Adjust Holdoff time when turning the POSITION knob.

To trigger the oscilloscope

Figure 1-12 is the TRGGER controls: LEVEL knob, MENU, 50% and FORCE. Follow the exercise to familiarize with the buttons and the trigger level knob and status bar.
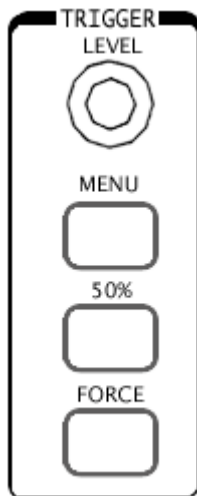
Figure 1-12

1 Turn the trigger Level knob and notice the changes on the display.

On the DS5000 series oscilloscopes, as you turn the LEVEL knob or press the 50% menu button, for a short time two things happen on the display. First, the trigger level value is displayed at the bottom-left of the screen. If the trigger is DC coupled, it is displayed as a voltage. If the trigger is AC coupled or LF reject, it is displayed as a percentage of the trigger range. Second, a line is displayed showing the location of the trigger level (as long as AC coupling or low frequency reject are not selected).

2 Change the trigger setup and notice these changes affects the status bar differently.

·Press MENU button in the TRIGGER control area.
A soft button menu appears on the display showing the trigger setting choices as shown in Figure 1-13.

·Pressing the trigger type button, it toggles between Edge Video Pulse.
·Pressing the trigger Slope button, it toggles between Rising Edge and Falling Edge.
Pressing the trigger Source button to select the trigger source.
·Pressing the trigger Mode button to select the triggering mode, it toggles between Auto, Normal and Single.
·Set the Coupling and notice affect   on the waveform display.

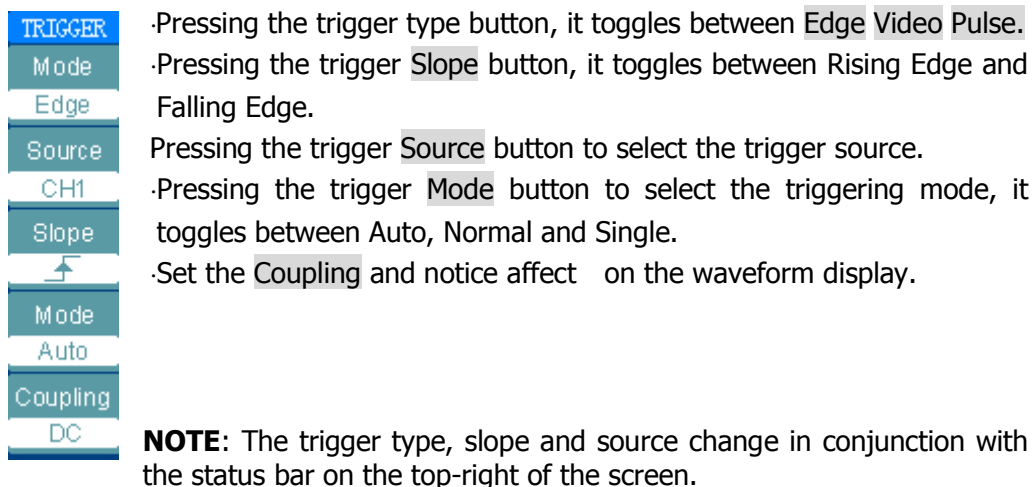**NOTE**: The trigger type, slope and source change in conjunction with the status bar on the top-right of the screen.

Figure 1-13

3 Press 50%

This key is an action button. Every time you press the 50% button, the oscilloscope sets the trigger level to the center of the signal.

4 Press FORCE

Press this button starts an acquisition regardless of an adequate trigger signal. This button has no effect if the acquisition is already stopped.

Chapter 2 : Operating your oscilloscope

By now you should understand the VERTICAL, HORIZONTAL and TRIGGER control system and know how to determine the system setup from the status bar of DS5000 series digital oscilloscope.

This chapter will go through all groups of front-panel buttons, knobs and menus; and further the knowledge of the operation by hints in this guide.

It is recommended to perform all of the following exercises to get the most of the powerful measurement capabilities of the oscilloscope.

■ Understand the vertical system

■ Understand the horizontal system

■ Understand the trigger system

■ How to set up the sampling system

■ How to set up the display system

■ How to save and recall waveforms or setups

■ How to set up utility

■ How to measure automatically

■ How to measure with cursors

■ How to use instant execute buttons

Understand the vertical system

Ⅰ. Settings of the channels

Each channel of DS5000 has an operation menu and it will display after pressing CH1 or CH2 button. The settings of all items in the menu are shown in the table below.

Table 2-1

| Menu	Settings	Comments
Coupling	AC DC GND	AC blocks the DC component of the input Signal DC passes both AC and DC components of the input signal GND disconnects the input signal
BW Limit	ON OFF	Limit the channel bandwidth to 20MHz to reduce display noise. Set "OFF" will get full bandwidth.
Probe	1X 10X 100X 1000X	Set this to match the probe attenuation factor to make the vertical scale readout correct
Digital filter		Setup digital filter
Volts/Div	Coarse Fine	Select the resolution of the SCALE knob coarse defines a 1-2-5 sequence. Change the resolution by small steps between the coarse settings.
Invert	ON OFF	Turn on the invert function. Restore to original display of the waveform.
Input	1MΩ 50Ω	Set 1MΩ input impedance Set 50Ω input impedance

NOTE: The input impedance select function (1MΩ/50Ω) is only provided in certain models.

1. Channel coupling

To use CH1 as an example, input a sine wave signal with DC shift
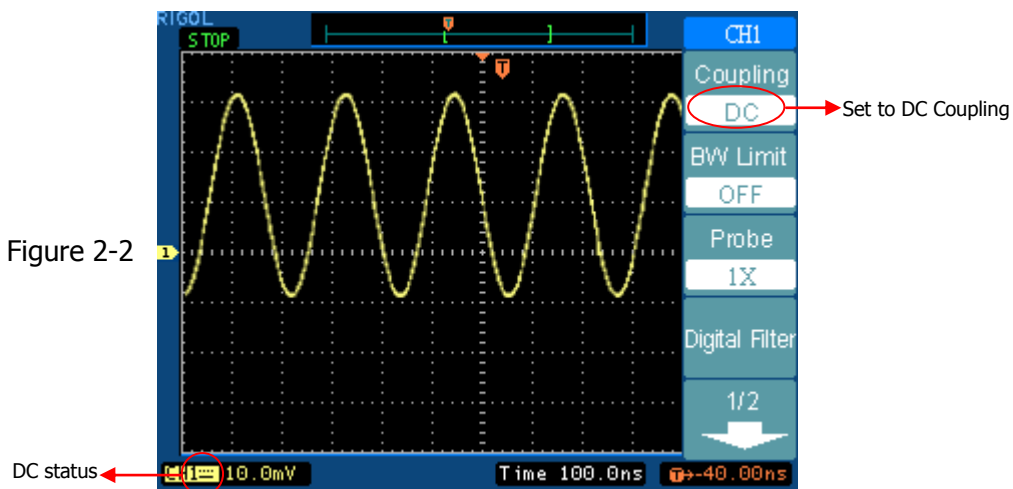
Press CH1→**Coupling**→AC, to set "AC" coupling. In this setting, it blocks the DC component of the input signal.
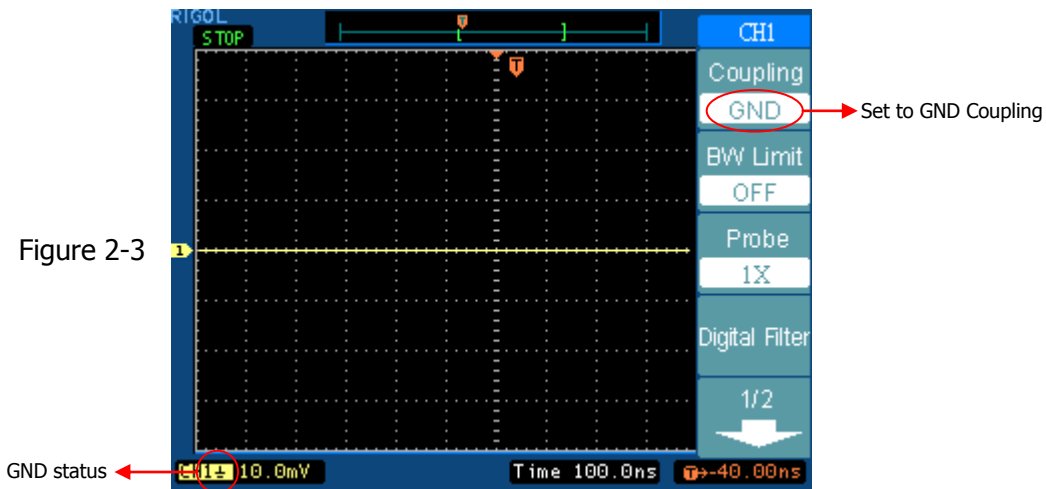
The waveform is displayed as Figure 2-1:
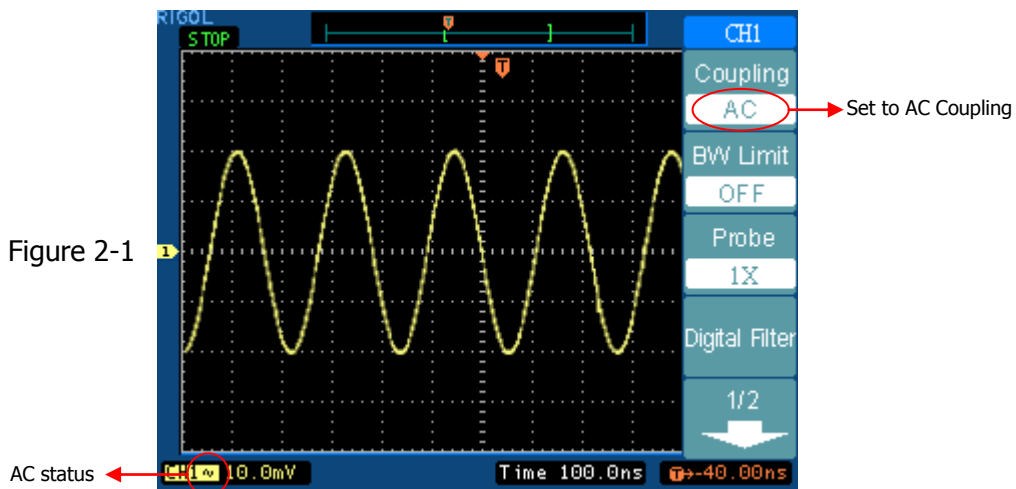
Figure 2-1

Press CH1→**Coupling**→DC, to set "DC" coupling. In this setting, it passes both AC and DC components of the input signal.

The waveform is displayed as Figure 2-2:

Figure 2-2

Press CH1→**Coupling**→GND, to set "GND" coupling. In this setting, it disconnects the input signal.

The screen displays as Figure 2-3:

Figure 2-3

2．**Set up the channel bandwidth limit**

To use CH1 as an example, input a signal that contains high frequency component. Press CH1→**BW Limit**→OFF , to set up bandwidth limit to "OFF" status. It will pass the high frequency component in the signal and the oscilloscope is set to full bandwidth.

The waveform is displayed as Figure 2-4:
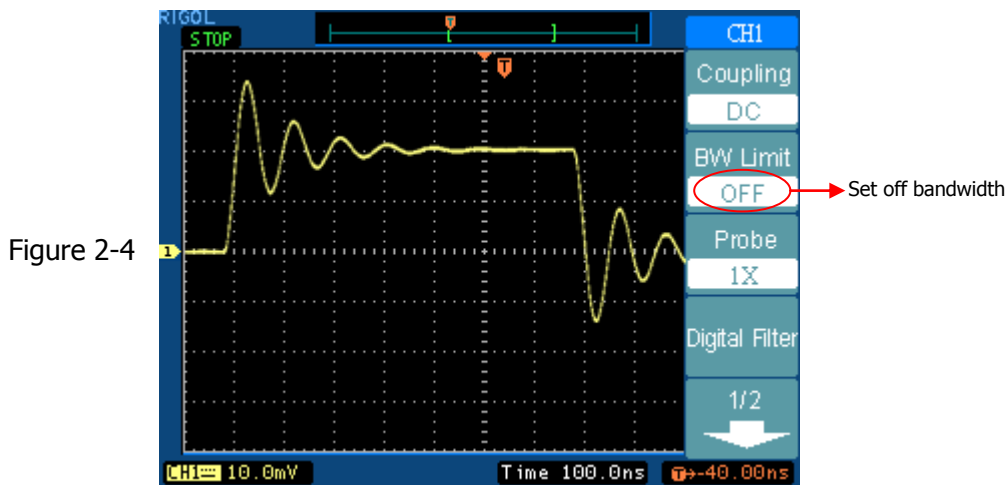
Figure 2-4

Press CH1→**BW Limit**→ON, to set up bandwidth limit to "ON" status. It will reject the frequency component higher than 20MHz.

The waveform is displayed as Figure 2-5:

Figure 2-5
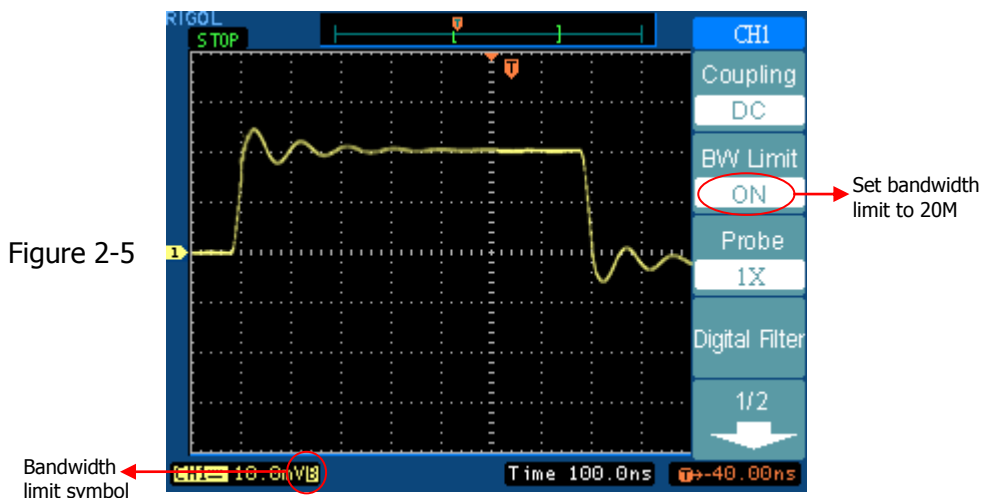
3．**Probe Attenuation Setting**

The oscilloscope allows you to enter the attenuation factor for the probe. The attenuation factor changes the vertical scaling of the oscilloscope so that the measurement results reflect the actual voltage levels at the probe tip.

To change (or check) the probe attenuation setting, press the CH1 or CH2 button (according to which channel you are using), toggle the Probe soft button to change the attenuation factor to match the probe you are using.
This setting remains in effect until changed again.

Figure 2-6 shows an example for using a 1000:1 probe and its attenuation factor.
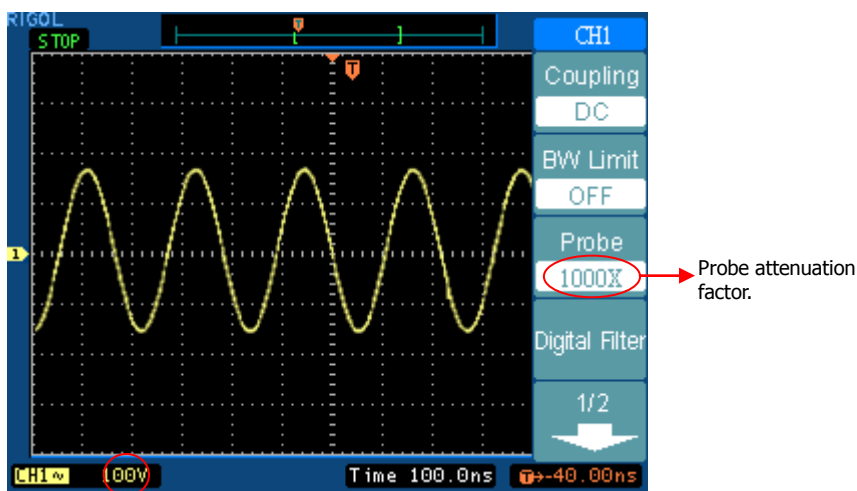
Status changes with
the probe attenuation   Figure 2-6

Table 2-2

Probe attenuation factors	Corresponding settings
1:1	1X
10:1	10X
100:1	100X
1000:1	1000X

4. Digital Filter:

Press CH1→Digital filter , display the digital filter menu. Turn horizontal position knob to set high and low limit of frequency.

Figure 2-7

Set filter Off
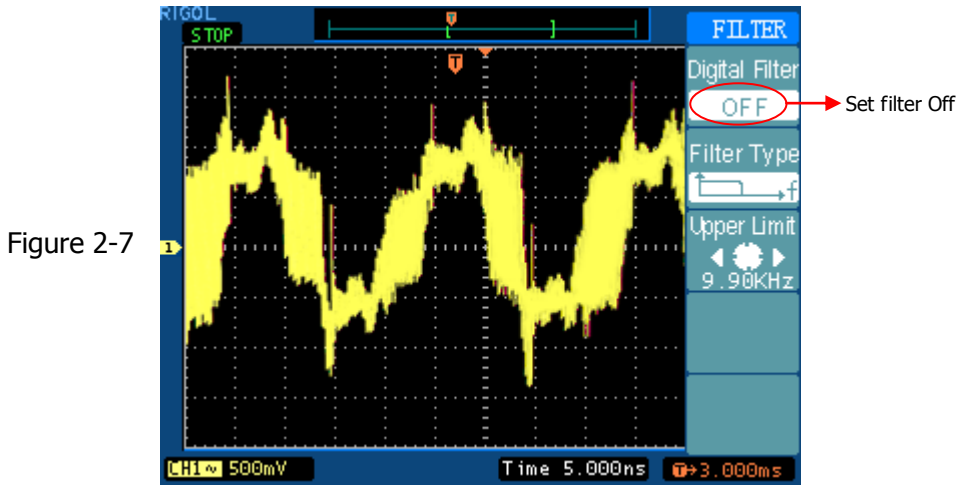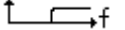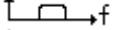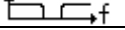
The waveform before filtered

Figure 2-8
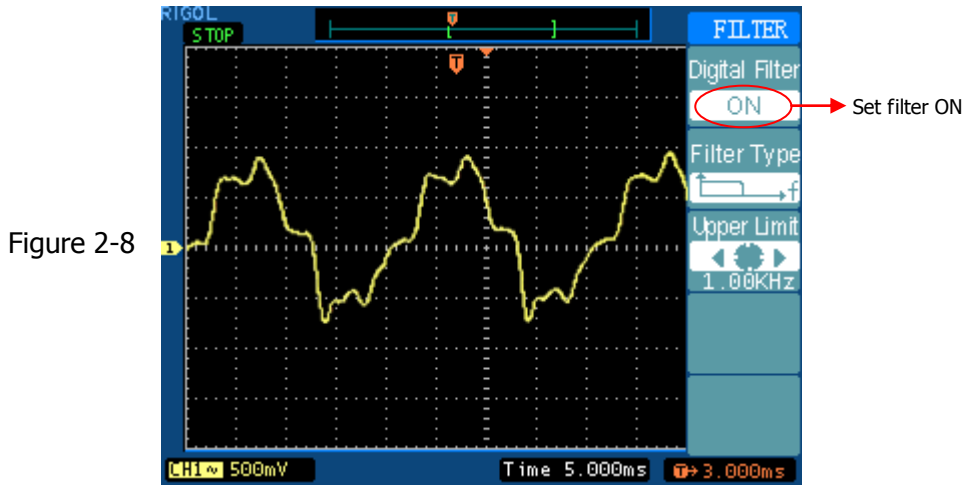
Set filter ON

The waveform after filtered

Table2-3

Menu	Settings	Comments
Digital Filter	On Off	Turn on the digital filter Turn off the digital filter

Filter Type	⊓→f └─┐→f └─⊓→f ⊓─⊔→f	Setup as LPF (Low Pass Filter) Setup as HPF(High Pass Filter) Setup as BPF (Band Pass Filter) Setup as BRF(Band Reject Filter)
Upper limit	◀ ✹ ▶	Turn horizontal position knob to set high limit
Lower limit	◀ ✹ ▶	Turn horizontal position knob to set low limit

5. Volts/Div settings
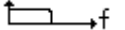
The Volts/Div control has **Coarse** or **Fine** configuration.

Coarse: It is the default setting of Volts/Div, and it makes the vertical scaling in a 1-2-5-step sequence from 2mV/div, 5mV/div, 10mV, to 5 V/div.

Fine: This setting changes the vertical scale to small steps between the coarse settings. It will be helpful to adjust the waveform's vertical size in smooth steps.
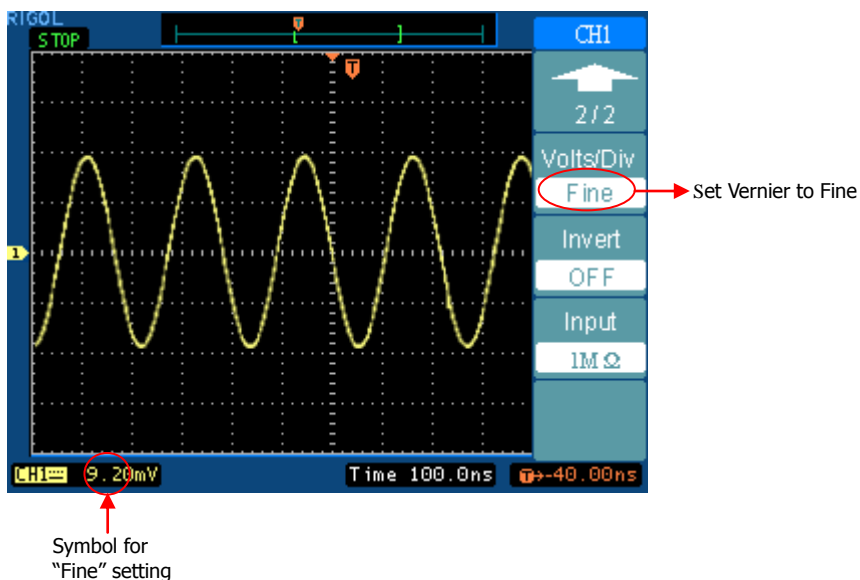
Figure 2-9

Coarse/Fine Shortcut key:

Changing Coarse/Fine function not only by menu but also by pressing vertical SCALE knob

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6．**To invert a waveform**

Invert turns the displayed waveform 180 degrees, as respect to the ground level, and is available for channel 1 and 2 only. When the oscilloscope is triggered on the inverted signal, the trigger is also inverted.

Push the CH1 or CH2 button and then press the Invert button to invert the waveform on this activated channel.

Figure 2-10 and 2-11 show the changes after inversion.
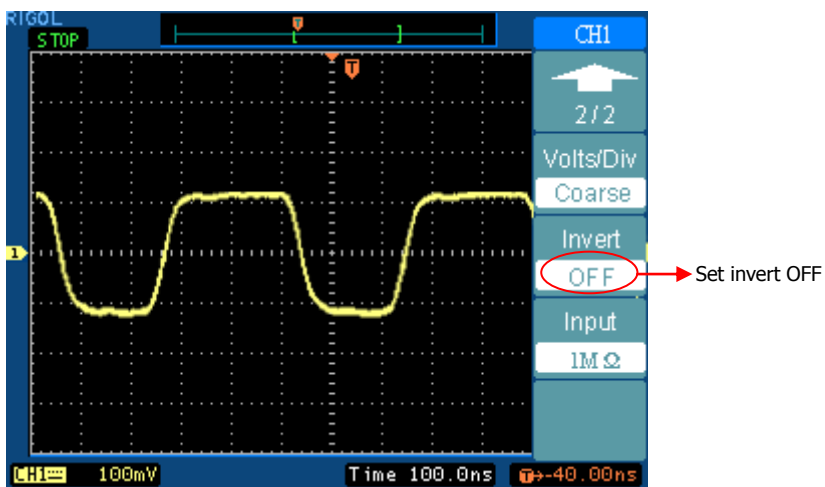
Figure 2-10
The waveform before inversion
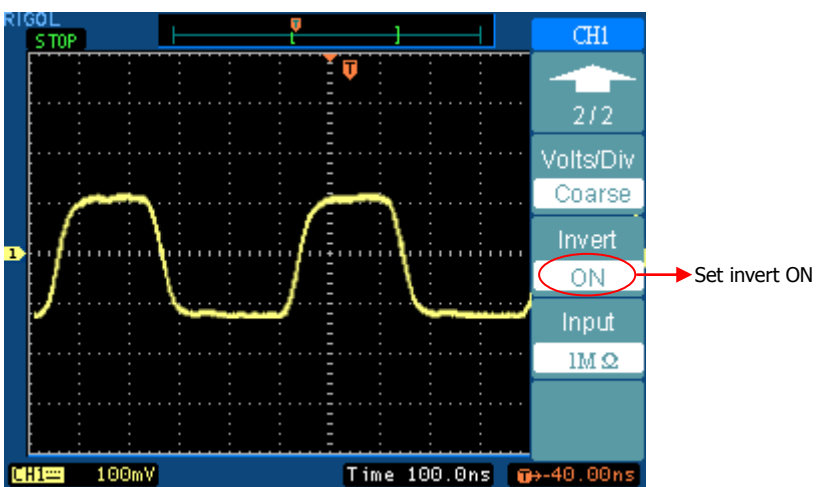
Figure 2-11
The waveform after inversion

7. Select input impedance

Select channel input impedance as 1MΩ or 50Ω. If 50Ω is selected, the input coupling is automatically set to DC.

⚠️ **CAUTION:** When 50Ω is selected, **ALWAYS ENSURE** the input voltage at BNC does **NOT** exceed the maximum voltage (5Vrms) to avoid damaging channel input components.

Do not use 50Ω with the standard probe.
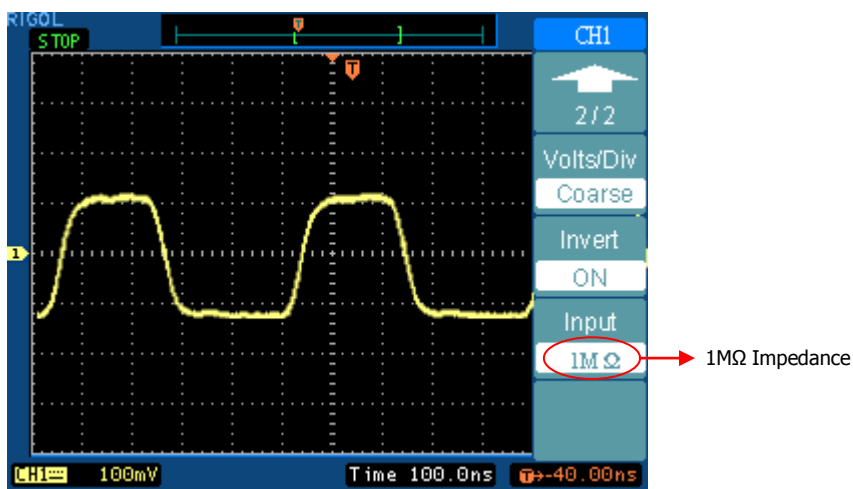
Figure 2-12

Table2-4

50Ω	Models
Available	DC5202 Series, DS5152 Series
Not Available	DS5102 Series, DS5062 Series, DS5102 Series, DS5062 Series, DS5042 Series, DS5022 Series

Ⅱ. Math functions

The mathematic functions include "add", "subtract", "multiply" and "divide" "FFT" for CH1 and CH2. The mathematic result can also be measured by the grid and the cursor.

Press MATH button to display the MATH menu, the settings of this menu are shown in table 2-5 below.

The amplitude of mathematic waveform can be adjust by the vertical SCALE knob in a 1-2-5 step from 0.1% to 1000%, such as0.1%; 0.2%; 0.5%…..1000%. The scale will be displayed on the status bar.

Figure 2-13

MATH scale →
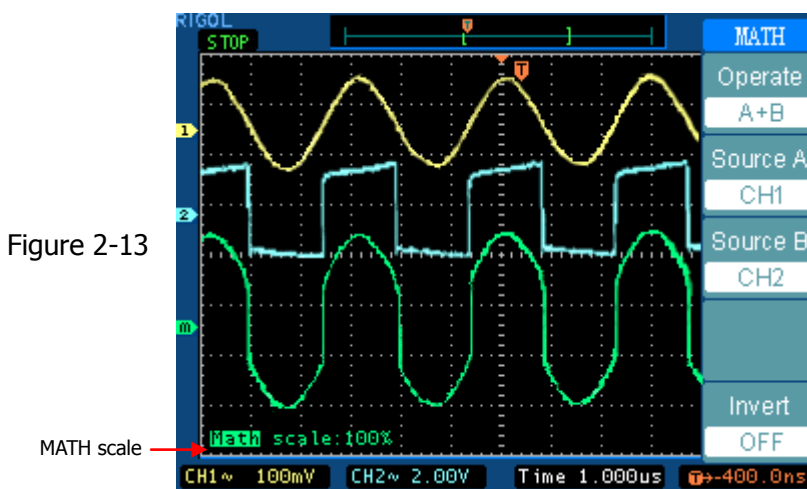
Table 2-5

Menu	Settings	Comments
Operation	A+B A-B A×B A÷B FFT	Add source A to source B Subtract source B from source A Multiply source B by source A Source A divided by source B Fast Fourier Transform
Source A	CH1 CH2	Define CH1 or CH2 as source A
Source B	CH1 CH2	Define CH1 or CH2 as source B
Invert	ON OFF	Set "ON" to invert the MATH waveform. Restore to original display of the waveform.

Using the FFT

The FFT (Fast Fourier Transform) process converts a time-domain signal into its frequency components mathematically. FFT waveforms are useful in the following applications:

• Measuring harmonic content and distortion in systems

• Characterizing noise in DC power supplies

• Analyzing vibration

Figure 2-14   Table2-6

Menu	Settings	Comments
Operation	A+B A- B AxB A÷B FFT	Add source A to source B Subtract source B from source A Multiply source B by source A Source A divided by source B Fast Fourier Transform
Source	CH1 CH2	Define CH1 or CH2 as FFT source
Window	Rectangle Hanning Hamming Blackman	Select window for FFT
Display	Split Full screen	Display FFT waveform on half screen Display FFT waveform on full screen
Scale	Vrms dBVrms	Set "Vrms " as vertical unit Set "dBVrms " as vertical unit

---

Key points for FFT(1024 points)

1 Signals that have a DC component or offset can cause incorrect FFT waveform component magnitude values. To minimize the DC component, choose AC Coupling on the source signal.

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

3 To display FFT waveforms with a large dynamic range, use the dBVrms scale. The dBVrms scale displays component magnitudes using a log scale.

Selecting an FFT Window

The DS5000 series oscilloscopes provide four FFT windows. Each window is a trade-off between frequency resolution and amplitude accuracy. What you want to measure and your source signal characteristics help determine which window to use. Use the following guidelines to select the best window.

Table2-7

Window	Characteristics	Best for measuring
Rectangle	Best frequency resolution, worst magnitude resolution. This is essentially the same as no window.	Transients or bursts, the signal levels before and after the event are nearly equal. Equal-amplitude sine waves with fixed frequencies. Broadband random noise with a relatively slow varying spectrum.
Hanning Hamming	Better frequency, poorer magnitude accuracy than Rectangular. Hamming has slightly better frequency resolution than Hanning.	Sine, periodic, and narrow-band random noise. Transients or bursts where the signal levels before and after the events are significantly different.
Blackman	Best magnitude, worst frequency resolution.	Single frequency waveforms, to Find higher order harmonics.

Key points:
FFT Resolution: The quotient between sampling rate and number of FFT points. With a fixed FFT points, the lower sampling rate results in better resolution.
Nyquist Frequency
The highest frequency that any real-time digitizing oscilloscope can acquire without aliasing. It's normally half of the sample rate. This frequency is called the Nyquist frequency. Frequency above the Nyquist frequency will be under sampled, causing a situation known as aliasing.

Ⅲ. **Using REF**

Reference Waveforms are saved waveforms to be selected for display. The reference function will be available after saving the selected waveform to the non-volatile memory.

Press REF button to display reference waveform menu.

Table2-8

Menu	Settings	Comments
Source	CH1 CH2	Select channel for REF
Save		Select reserved waveform as resource of REF
Invert	ON OFF	Set "ON" to invert the REF waveform. Restore to original display of the waveform.
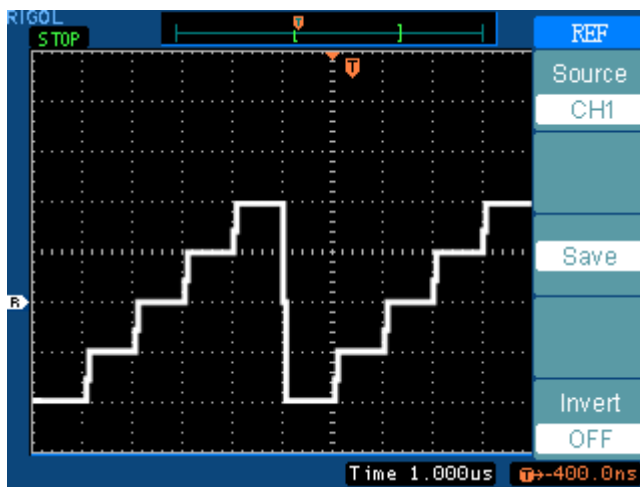
Figure 2-15

Displaying a Reference Waveform.

1. Push REF button to show the reference waveform menu.

2. Select Source CH1 or CH2 to display the channel you want.

3. Turn the vertical position and vertical scale to change positions

4. Press save to save the currently displayed waveform as REF.

NOTE:

1. The reference function is not available in X-Y mode.

2. You cannot adjust the horizontal position and scale on the reference waveform.

IV. Remove Waveforms from the Display

The CH1, CH2 of DS5000 series are signals input channels. The operations for MATH and REF are also regarded as independent channels.

Press MATH and REF buttons to select these channels, press OFF button to remove the selected waveform from the screen.

Table2-9

Channel	Status	Symbol	
		DS5000M	**DS5000C**
Channel 1 (CH1)	Selected ON OFF	CH1 CH1 No status symbol	CH1 CH1 No status symbol
Channel 2 (CH2)	Selected ON OFF	CH2 CH2 No status symbol	CH2 CH2 No status symbol
Mathematic operation (MATH)	Selected ON OFF	Math Math No status symbol	Math Math No status symbol

Ⅴ**. Using Vertical** POSITION **and** SCALE

Use the vertical controls to display waveforms by adjusting the vertical scale and position, and setting the input parameters.

1. Using vertical POSITION knob.

    The vertical position of waveforms (including MATH and REF) can be changed by moving them up or down on the screen. To compare data, you can align a waveform above one another or you can align waveforms in superposition.

2. Using vertical SCALE knob.

    The vertical scale of a waveform (including MATH and REF) can be changed. The waveform display will contract or expand about the ground level.

    If the Volts/Div is set to "Coarse", the waveform scales in a 1-2-5 step sequence from 2 mV to 5 V. If the Volts/Div is set to "Fine", it scales to small steps between the coarse settings.

    When scaling MATH waveform, amplitude can be changed with the SCALE knob in a 1-2-5 step from 0.1% to 1000%.

    The FINE vertical control can be achieved by pressing the vertical SCALE knob.

3. Adjust the vertical position and scale only when the waveform is selected.

4. When changing the vertical position, the position message is displayed on the left bottom of the screen.

Understand the Horizontal System

The oscilloscope shows the time per division in the scale readout. Since all active waveforms use the same time base, the oscilloscope only displays one value for all the active channels, except when using Delayed Scan.

The horizontal controls can change the horizontal scale and position of waveforms. The horizontal center of the screen is the time reference for waveforms. Changing the horizontal scale causes the waveform to expand or contract around the screen center.

Horizontal position changes the point, relative to the trigger, where the waveform appears on the center of the screen.

The Horizontal Knobs

POSITION: The horizontal POSITION knob adjusts the horizontal position of all channels and math or REF waveforms. The resolution of this control varies with the time base.

The oscilloscope digitizes waveforms by acquiring the value of an input signal at discrete points. The time base allows you to control how often the values are digitized.

SCALE: To adjust the time base to a horizontal scale that suits your purpose, use the horizontal SCALE knob.

The SCALE selects the horizontal time/div (scale factor) for the main or the Delayed Scan time base. When Delayed Scan is enabled, it changes the width of the window zone by changing the Delayed Scan time base.

Horizontal Menu.
Press the horizontal MENU button to display the horizontal menu. The settings of this menu are listed in the following table.

Table 2-10

Menu	Settings	Comments
Delayed	ON OFF	Turn on the Enter Delayed Scan mode Turn off the Delayed Scan mode
Time Base	Y-T X-Y	Show the relation between vertical voltage and horizontal time. Show CH1 value at X axis; CH2 value at Y axis.
◄ ● ►	Trig-offset Holdoff	Adjust horizontal position in memory Adjust Holdoff time
Trig-offset Reset		Adjust to the center
Holdoff Reset		Reset Hold off time to 100ns
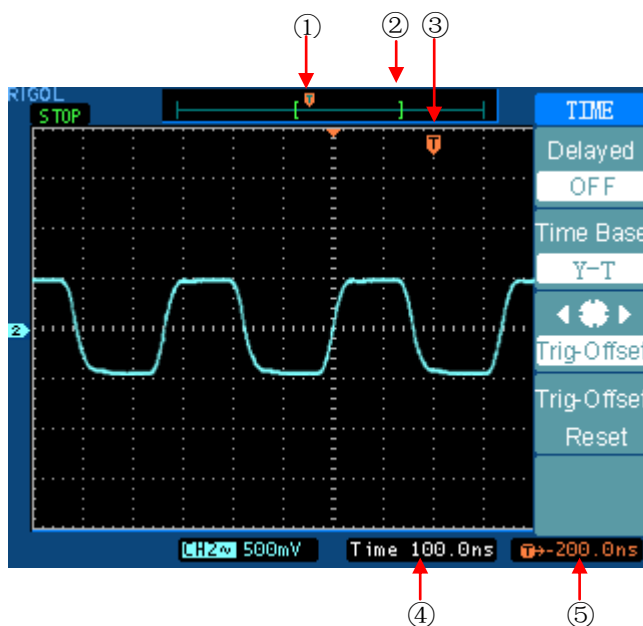
Figure 2-16 Status bar and mark for Horizontal control

Marks and status bar

①. This mark displays the trigger position in the memory.

②. The mark "[   ]" represent the current waveform window's position in the memory.

③. This mark displays the trigger position in the waveform windows.

④. Status bar displays the horizontal time base (main time base).

⑤. Status bar displays the trigger's horizontal offset according to the center of the window.

Key Points

Y-T: The conventional oscilloscope display format. It shows the voltage of a waveform record (on the vertical axis) as it varies over time (on the horizontal axis).

X-Y: XY format displays Channel 1 in the horizontal axis and Channel 2 in the vertical axis.

Time/Div: Horizontal scale. If the waveform acquisition is stopped (using the RUN/STOP button), the Time/Div control expands or compresses the waveform.

Delayed Scan:

The Delayed Scan is a magnified portion of the main waveform window. You can use Delayed Scan to locate and horizontally expand part of the main waveform window for a more detailed (higher horizontal resolution) analysis of signal. Use Delayed Scan to expand a segment of a waveform to see more detail. The Delayed Scan time base setting cannot be set slower than the Main time base setting.
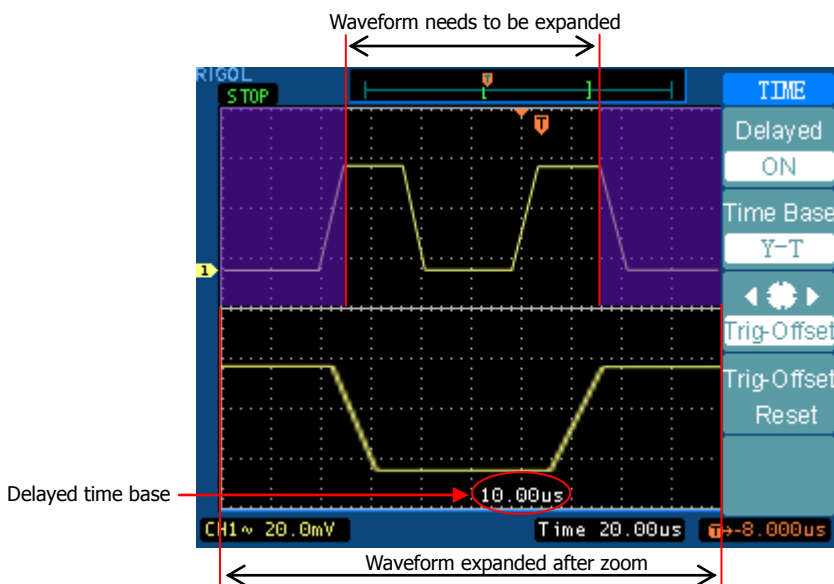
Figure 2-17 Delayed Scan window

The following steps show you how to use Delayed Scan.

1. Connect a signal to the oscilloscope and obtain a stable display.

2. Press horizontal MENU→Delayed →**ON** or press horizontal SCALE knob to enter Delayed Scan mode.

The screen splits into two parts. The upper half displays the main waveform window and the lower half displays an expanded portion of the main waveform window. This expanded portion of the main window is called the Delayed Scan window. Two blocks shadow the upper half; the un-shadowed portion is expanded in the lower half. The horizontal POSITION and SCALE knobs control the size and position of the Delayed Scan. The symbol in the middle of the screen is the main time base and the symbol on the center bottom is the Delayed Scan time base (see Figure 2-17).

☐

- Use the horizontal $\boxed{\text{POSITION}}$ knob to change the position of the expanded portion.

- Use the horizontal $\boxed{\text{SCALE}}$ knob to adjust the Delayed Scan resolution.

- To change the main time base, turn off the Delayed Scan mode.

- Since both the main and Delayed Scan are displayed; there are half as many vertical divisions so the vertical scaling is doubled. Notice the changes in the status bar.

Delayed Scan Shortcut Key:
Delayed Scan function can be activated not only in the menu but also by pressing horizontal $\boxed{\text{SCALE}}$ knob.

X-Y Format

This format is useful for studying phase relationships between two waveforms.

This format only applies to Channels 1 and 2. Choose X-Y display format to display channel 1 in the horizontal axis and channel 2 in the vertical axis. The oscilloscope uses the untriggered sample acquisition mode and data displays as dots. The sampling rate can vary from 4 KS/s to 100 MS/s, and the default sampling rate is 1 MS/s.
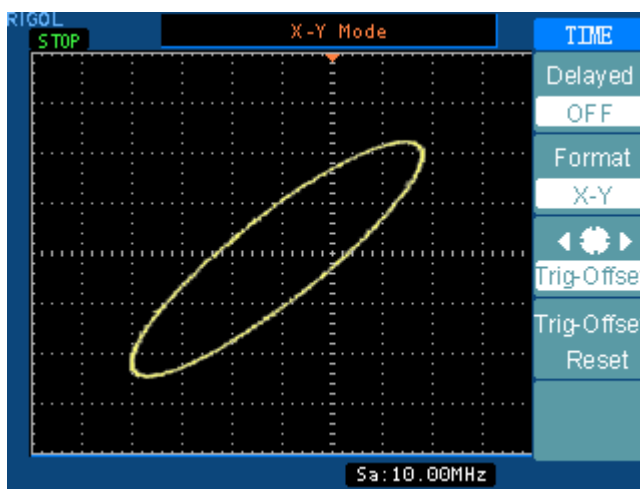
Figure 2-18 X-Y display format

The following modes or functions will not work in X-Y format.

■ Automatic Measurements

■ Cursor Measurements

■ Pass/Fail test

■ REF and MATH Operations

■ Delayed Scan Mode

■ Vector Display Mode

■ Horizontal POSITION knob

■ Trigger Controls

Trigger Holdoff

Trigger Holdoff can stabilize waveform. Holdoff time is the oscilloscope's waiting period before starting a new trigger. During the Holdoff oscilloscope will not trigger until Holdoff ends

Figure 2-19 Trigger Holdoff

To use trigger Holdoff:

1. Push TIME, display time base menu

2. Push 3rd function key, select trigger Holdoff function

3. Adjust horizontal POSITION to change Holdoff time until waveform is stable

4. Push 4th function key can reset the Holdoff time to it's 100ns minimum value

Understand the Trigger System

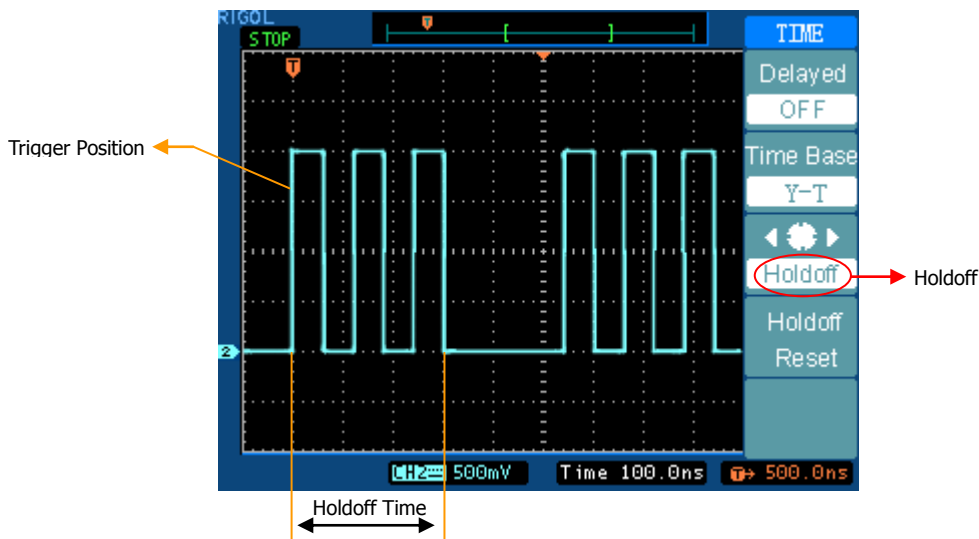The trigger determines when the oscilloscope starts to acquire data and display a waveform. When a trigger is set up properly, it can convert unstable displays or blank screens into meaningful waveforms.

When the oscilloscope starts to acquire a waveform, it collects enough data so that it can draw the waveform to the left of the trigger point. The oscilloscope continues to acquire data while waiting for the trigger condition to occur. After it detects a trigger, the oscilloscope continues to acquire enough data so that it can draw the waveform to the right of the trigger point.

The trigger control area on the front panel includes a knob and three buttons:

LEVEL: The knob that set the trigger level

50%:   The instant executes button setting the trigger level to the vertical midpoint between the peaks of the trigger signal

FORCE: Starts an acquisition regardless of an adequate trigger signal. This button has no effect if the acquisition is already stopped.

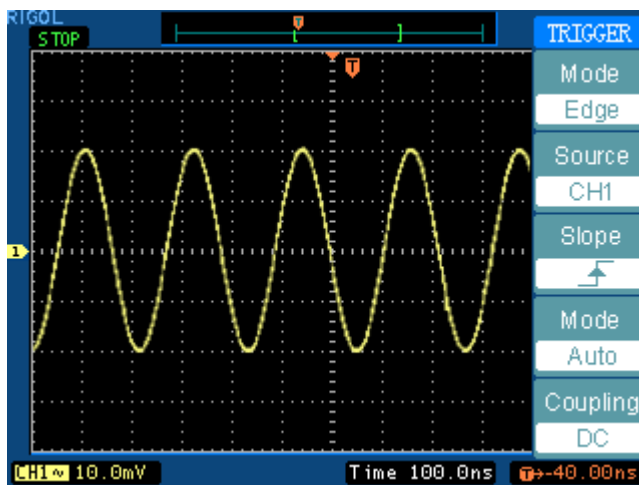MENU: The button that activates the trigger controls menu.

Figure 2-20 Trigger controls

Trigger Types

The oscilloscope provides three trigger types: Edge, Video and Pulse.

Edge: Edge trigger can be used in analog and digital circuits. An edge trigger occurs when the trigger input passes through a specified voltage level in the specified slope direction.

Video: Use video trigger on fields or lines for standard video signals.

Pulse: Use this trigger type to catch pulses with certain pulse width.

Settings for Edge Trigger

The Slope and Level controls help to define the trigger. The Slope control determines whether the oscilloscope finds the trigger point on the rising or the falling edge of a signal. To access the trigger slope control, press the MENU button, select Edge, and use the Slope button to select Rising or Falling.

Table 2-11

Menu	Settings	Comments
Source	CH1 CH2 EXT EXT/5 AC Line EXT (50Ω)	Selects CH1 as the trigger signal Select CH2 as the trigger signal Select EXT TRIG as the trigger signal Select EXT TRIG/5 as the trigger signal Select power line as the trigger signal Select EXT TRIG (50Ω) as the trigger signal,
Slope	Rising Falling	Trigger on rising edge Trigger on falling edge
Mode	Auto Normal Single	Acquire waveform even no trigger occurred Acquire waveform when trigger occurred. When trigger occurs, acquire one waveform then stop
Coupling	AC DC LF Reject HF Reject	Selects the components of the trigger signal applied to the trigger circuitry

Settings for Video Trigger

Choose video triggering to trigger on fields or lines of NTSC, PAL, or SECAM standard video signals. Trigger coupling preset AC.

Table 2-12

Menu	Settings	Comments
Source	CH1 CH2 EXT EXT/5 EXT (50Ω)	Selects CH1 as the trigger signal Select CH2 as the trigger signal Select EXT TRIG as the trigger signal Select EXT TRIG/5 as the trigger signal Select EXT TRIG (50Ω) as the trigger signal
Polarity	Ⅱ Normal polarity	Triggers on the negative edge of the sync pulse
	Ⅲ Inverted polarity	Triggers on the positive edge of the sync pulse
Sync	All Lines Line Num	Trigger on all lines Trigger on an Specified line
	Odd field Even field	Select to trigger on odd field or even field
Standard	PAL/SECAM/NTSC	Setup synchronization and line number count to certain video system

Key points

Sync Pulses: When Normal Polarity is selected, the trigger always occurs on negative-going sync pulses. If the video signal has positive-going sync pulses, use the Inverted Polarity selection.

Source-EXT (50Ω)**:** This function is only in models that the bandwidth is higher than 100MHz. And normally used ONLY for a signal source that requires 50Ω termination.

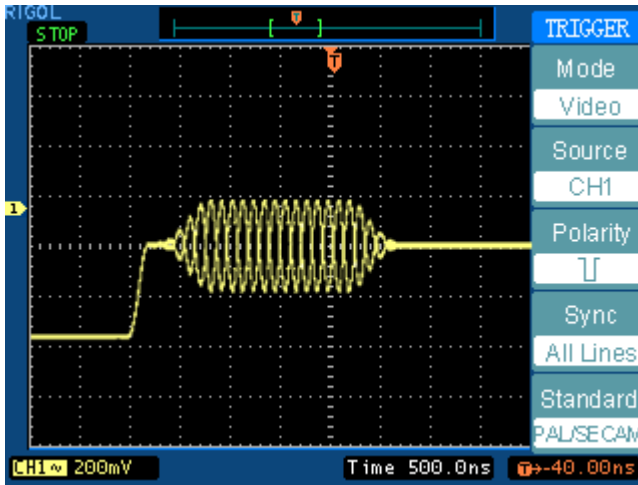The figure 2-21 and 2-22 display the waveforms with Line and Field synchronization.

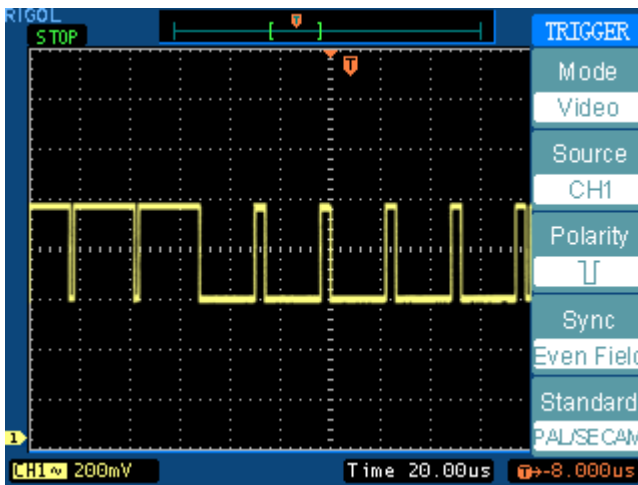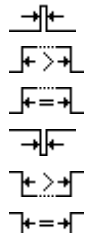Figure 2-21 Line synchronization

Figure 2-22 Field synchronization

Settings for Pulse width trigger

Pulse trigger occurs according to the width of pulse.

Table 2-13

Menu	Settings	Comments
Source	CH1 CH2 EXT EXT/5 EXT (50Ω)	Selects CH1 as the trigger signal Select CH2 as the trigger signal Select EXT TRIG as the trigger signal Select EXT TRIG/5 as the trigger signal Select EXT TRIG (50Ω) as the trigger signal
When	⇥⊩⇤	Positive pulse width less than
	⊢>⇥	Positive pulse width larger than
	⊢=⇥	Positive pulse width equal to
	⇥⊩⇤	Negative pulse width less than
	⊢>⇥	Negative pulse width larger than
	⊢=⇥	Negative pulse width equal to
Setting	◄ ⬟ ▶ <Width>	Adjust pulse width
Mode	Auto Normal Single	Acquire waveform even no trigger occurred Acquire waveform when trigger occurred. When trigger occurs, acquire one waveform then stop
Coupling	DC AC HF Reject LF Reject	Allow all signals pass Block DC signals Reject high frequency signals Reject DC and Low frequency signals

Note: The Pulse width adjust range is 20ns - 10s. The oscilloscope will be trigged when signal meets the preset condition.

Trigger Key Points

1. Trigger Source:

Trigger occurs from several sources: Input channels (CH1 or CH2), AC Line, Ext, Ext/5. EXT (50Ω)

CH1 or CH2: it is the most commonly used trigger source. The channel will function when selected as a trigger source whatever displayed or not.

Ext Trig: The instrument can be triggered from a third source while acquiring data from CH1 and CH2. For example, you might want to trigger from an external clock or with a signal from another part of the test circuit.

The Ext, Ext/ 5 and Ext (50Ω) trigger sources use the external trigger signal connected to the EXT TRIG connector. Ext uses the signal directly, it has a trigger level range of +1.6 V to -1.6 V.

The EXT/ 5 trigger source attenuates the signal by 5X, which extends the trigger level range from +8 V to -8 V, allowing the oscilloscope to trigger on a larger signal.

EXT (50Ω) sets the input impedance to 50Ω. It is normally used for high frequency signals where a 50Ω low impedance termination is required

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CAUTION: When 50Ω is selected, **ALWAYS ENSURE** the input voltage at BNC connector does **NOT** exceed the maximum voltage (5Vrms) to avoid damaging channel input components.

Do not use 50Ω with the standard probe.

AC Line: AC power can be used to trigger DS5000 oscilloscope to display signals related to the power line frequency, such as lighting equipment and power supply devices. The oscilloscope gets triggered on its AC power cord, so you do not have to input an AC trigger signal.

When AC Line is selected as trigger source, the oscilloscope automatically set coupling to DC, set trigger level to 0v.

2. Trigger Mode:

The trigger mode determines how the oscilloscope behaves in the absence of a trigger event. The oscilloscope provides three trigger modes: Auto, Normal, and Single.

Auto: This trigger mode allows the oscilloscope to acquire waveforms even when it does not detect a trigger condition. If no trigger condition occurs while the oscilloscope waits for a specific period (as determined by the time-base setting), it will force itself to trigger.

When forcing invalid triggers, the oscilloscope cannot synchronize the waveform, and the waveform seems to roll across the display. If valid triggers occur, the display becomes stable on the screen.

NOTE: When horizontal control is set under 50ms/div, Auto mode allows the oscilloscope go to the rolling mode without trigger.

Normal: The Normal mode allows the oscilloscope to acquire a waveform only when it is triggered. If no trigger occurs, the oscilloscope keeps waiting, and the previous waveform, if any, will remain on the display.

Single: In Single mode, after pressing the RUN/STOP key, the oscilloscope waits for trigger. While the trigger occurs, the oscilloscope acquires one waveform then stop.

3. Coupling:

Trigger coupling determines what part of the signal passes to the trigger circuit. Coupling types include AC, DC, LF Reject and HF Reject.

AC: AC coupling blocks DC components.

DC: DC coupling passes both AC and DC components.

LF Reject: LF Reject coupling blocks DC component, and attenuates all signal with a frequency lower than 8 kHz.

HF Reject: HF Reject coupling attenuates all signal with a frequency higher than 150 kHz.

4. Pretrigger/delayed trigger: the data before and after trigger

The trigger position is typically set at the horizontal center of the screen. In the full-screen display the 6div data of pretrigger and delayed trigger can be surveyed. More data (14div) of pretrigger and 1s delayed trigger can be surveyed by adjusting the horizontal POSITION.

This feature is very useful because you can see the events that led up to the trigger point. Everything to the right of the trigger point is called posttrigger information. The delay range (pre-trigger and post-trigger information) depends on the sweep speed selected.

How to Set Up the Sampling System

Figure 2-23 shows the ACQUIRE button for sampling system.

Acquire Menu Key
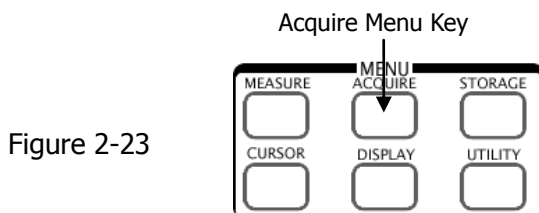
Figure 2-23

Press ACQUIRE button, the interface menu shows as follows:

Figure 2-24   Table 2-15

Menu	Settings	Comments
Acquisition	Normal Average Analog Peak Detect	Normal Acquisition mode Average Acquisition mode Analog Acquisition mode Peak Detect Acquisition mode
Sampling	Real-Time Equal-Time	Real-time sampling mode Equivalent sampling mode
Averages	2 to 256	Step by multiple of two. Set average times from 2 to 256
Intensity	◀ ⬤ ▶ < i % >	Adjust the analog display intensity
Anti-Aliasing	ON OFF	Turn on Anti-Aliasing function Turn off Anti-Aliasing function

The waveform displayed on the screen will change in conjunction with the setting of
ACQUIRE menu.

Figure 2-25: Signal that contains noise, and without average sampling

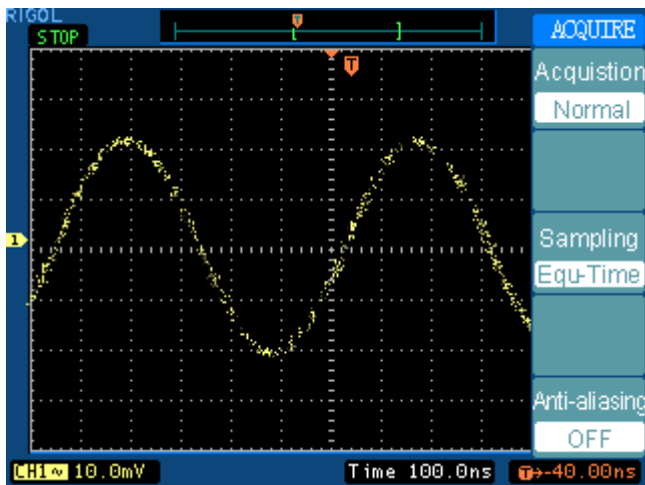Figure 2-26: Display signal after average sampling
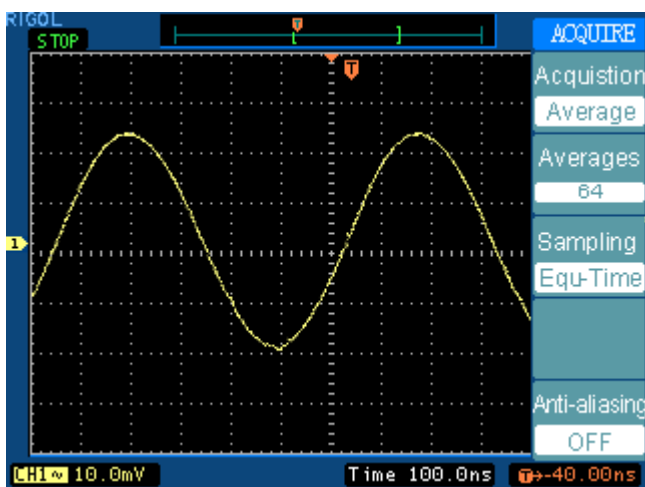
Note:
- Select **Real-time** acquisition to observe the single-shot or pulse signals. Select
  Equal-Time to observe high frequency repetitive signal.
- To reduce the displayed random noise, select the **Averages** Acquisition. This
  mode would make the screen refresh slower.
- To Avoid signal aliasing, select **Peak Detect** Acquisition.

Figure 2-27 Signal with Peak Detect Acquisition

The Peak Detect is shown as the figure above, and the signal is displayed with the diagonal between the envelopes.

Stop acquisition

When acquisition stopped, the freeze waveform is displayed. It can be moved by vertical horizontal control.

Key Points

Real-time Sampling: DS5000 has Real-time sampling rate up to 1GSa/s. At the time base 20ns or faster, the oscilloscopes use the sine(x)/x interpolation to expand the horizontal time base.
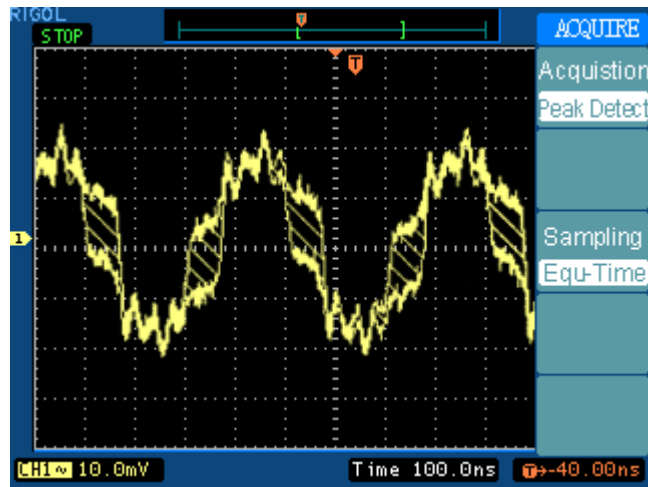
Equivalent sampling: Known as Repetitive sampling. In this mode, you can get up to 20 ps of horizontal resolution (equivalent50Gsa/s). This mode is good for observing repetitive signals, and it will not be available for single-shot or pulse.

Average Acquisition: Apply averaging to your signal to remove uncorrelated noise and improve measurement accuracy. Reduces random or uncorrelated noise in the signal display. The averaged waveform is a running average over a specified number of acquisitions from 2 to 256.

Analog acquisition: The oscilloscope calculates a probability based on how often a dot is lit on throughout multiple acquisitions and displays the dot intensity according to that probability, to make the waveform looks like an analog oscilloscope display.

Peak Detect: Peak Detect mode captures the maximum and minimum values of a signal. Finds highest and lowest record points over many acquisitions.

Anti-Aliasing: Aliasing is the condition that oscilloscope acquires frequency is lower than twice the max frequency of input signal. Anti-Aliasing prevents it. The Anti-Aliasing function could detect the max signal frequency to avoid aliasing.

How to Set Up the Display System

Figure 2-28 shows the menu button for the display system on the front panel.

Figure 2-28

Display Setting Menu
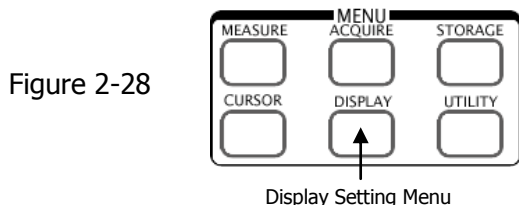
Press the DISPLAY button, the interface menu for settings shows as follows:

Figure 2-29   Table 2-16

Menu	Setting	Comments
Type	Vectors Dots	Display waveforms as vectors Display waveforms as dots
Grid	▦▦ ⊞ ▢	Display grids and coordinates on the screen Turn off the grids Turn off the grids and coordinates
☼ ➕		Press to increase display contrast
☼ ➕		Press to decrease display contrast

Figer2-30   Table2-17

Menu	Settings	Comments
Persist	Infinite OFF	The sample points remain displayed until turn the persistence "OFF". Turn off the persistence function
Menu Display	1s 2s 5s 10s 20s Infinite	Set the time before hiding menu. The menu will be hidden according to the time after last button pressing.
Screen	Normal Invert	Set to normal mode Set to invert color display mode

Key points:

Display type: Display type contains Vectors and Dots. In vectors type, oscilloscope connects with dots through digital interpolation and contains linearity with $\sin(x)/x$. $\sin(x)/x$ interpolation is suitable for Real-time sampling and will be more effective at 20ns or faster time base.

Refresh rate: It is an important performance of digital oscilloscopes. It means times of oscilloscopes' refreshing per second and will affect the ability to observe signal. The refresh rate of DS5000 series digital oscilloscope is over 1K per second.

How to Store and Recall Waveforms or Setups

Figure 2-31 shows the menu button for the storage system on the front panel.

Storage Setting Key
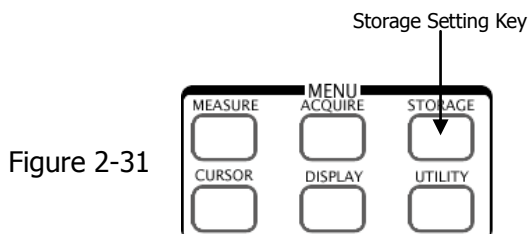
Figure 2-31

Press the STORAGE button to show the menu for the settings of the storage system.

Figure 2-32   Table 2-18

Menu	Settings	Comments
Storage	Waveforms Factory Setups	Store or recall waveforms Recall factory setups Store or recall instrument setups
Waveform	No.1 No.2 No.3 ... No10	Select storage location of waveform
Setup	No.1 No.2 No.3 ... No10	Select storage location of setup
Load		Set recalling of stored documents
Save		Set storage of waveform data

Key Points for Storage System

Factory Setup: The oscilloscope is set up for normal operation when it is shipped from the factory. You can recall the factory default setup any time you want to operate the oscilloscope using or starting from the factory default settings.

Waveform: The oscilloscope can save 10 waveforms of two channels and 10 settings in the nonvolatile memory of the oscilloscope and overwrite previously saved contents as needed. By default, the oscilloscope saves the setup each time it is powered off. The oscilloscope automatically recalls this setup the next time it is powered on.

Load: The stored waveforms, setups and factory setup can be recalled out.

Save: Store current waveforms or setups.

NOTE:

- The **Save** stores not only the waveforms, but also the current settings of the oscilloscope

- Wait at least five seconds before turning off the instrument if the settings are changed. This ensures the setup be saved properly. The oscilloscope can store 10 settings permanently and can restore at anytime.

How to Set Up the Utility

Figure 2-33 shows the MENU button for the Utility on the front panel.

Figure 2-33

Utility function setting
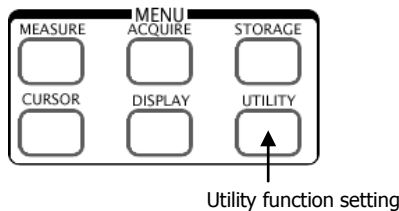
Press the [UTILITY] button to show the menu of the settings of the Utility system.

Figure 2-34   Table 2-19

Menu	Setting	Comments
I/O settings		Setup I/O configuration
Sound	◁) (ON) ◁× (OFF)	Switch beeper sound on/off
Counter	OFF ON	Turn off Frequency Counter Turn on Frequency Counter
Language	Simplified Chinese Traditional Chinese English Korean Japanese	Select languages (More languages may be added in later software versions)

Figure 2-35   Table2-20

Menu	Settings	Comments
Pass/Fail		Setup Pass/Fail test
Record		Setup Waveform Recorder
Self-Cal		Execute Self-calibration
Self-Test		Execute Self-test

The I/O Setup:

Press UTILITY→ I/O Setup to enter the following menu

Figure 2-36   Table2-21

Menu	Display	Comments
RS-232 Baud	******	Set RS-232 communication baud rate. This function is only available when EM5-CM or EM5-COM is attached to the instrument
GPIB Address	****	Set GPIB address. This function is only available when EM5-CM or EM5-COM is attached to the instrument
⟜⛛✕		USB unconnected

Figure 2-37   Table 2-22

Menu	Settings	Comments
RS-232 Baud	300 … 38400	Set RS-232 baud rate as 300, 2400, 4800, 9600, 19200 or 38400.
GPIB Address	0 … 30	Set GPIB address from 0 to 30, steps by 1.
⟜⛛✓		USB connected

NOTE:

• Before install or uninstall an extension module, the oscilloscope power must be off.

• More details could be found in the user's guide for extension module.

Auto Calibration

The Auto-Calibration adjusts the oscilloscope's internal circuitry to get the best accuracy. Use these functions to calibrate the oscilloscope's vertical and horizontal systems.

For maximum accuracy at any time, run the routine if the ambient temperature changes by 5° C or more.

Before running this procedure, do these steps:
1. Disconnect any probes or cables from all channel inputs, otherwise failure or damage to the oscilloscope may occur.
2. Push the UTILITY button and select Self-Cal
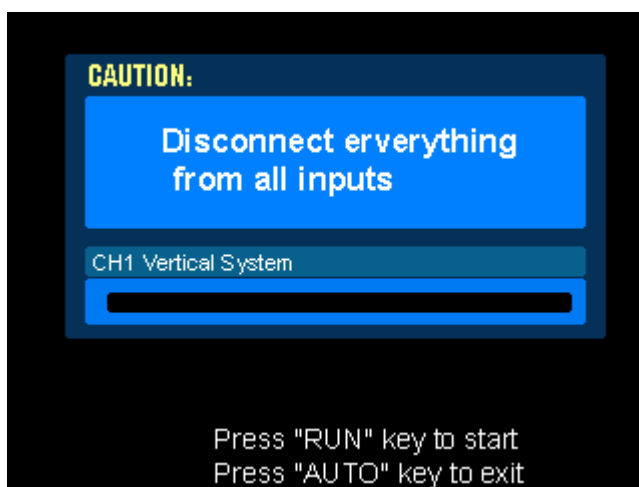
The self-calibration menu is as shown in Figure 2-38.

Figure 2-38

NOTE:
The oscilloscope must have been working or warm-up at least 30-minutes before running self-calibrate

Pass/fail

The Pass/Fail function can monitor changes of signals and output pass or fail signals by judging the input signal if it is within the pre-defined mask or not.

Figure 2-39   Table 2-23

Menu	Setting	Comments
Enable Test	On	Turn on Pass/Fail test
	Off	Turn off Pass/Fail test
Source	CH1	Select pass/fail test on CH1
	CH2	Select pass/fail test on CH2
Operation	▶ (RUN)	Pass/fail test stopped, press to run
	■ (STOP)	Pass/fail test running, press to stop
Msg display	On	Turn on pass/fail information display
	Off	Turn off pass/fail information display

Figure 2-40   Table 2-24

Menu	Settings	Comments
Output	Fail	Output when Fail condition detected
	Fail + 🔊	Output and beep when Fail condition detected
	Pass	Output when Pass condition detected
	Pass + 🔊	Output and beep when Pass condition detected
Stop on Output	On	Stop test when output occur
	Off	Continue test when output occur
Load		Load a pre-defined test mask

Figure 2-41   Table 2-25

Menu	Settings	Comments
X Mask	◄ ✷ ► < x div >	Set horizontal clearance to the waveform (0.04div-4.00div)
Y Mask	◄ ✷ ► < y div>	Set vertical clearance to the waveform (0.04div-4.00div)
Create Mask		Create a test mask according to the above clearance
Save		Store created test mask

NOTE: Pass/Fail function is unavailable in X-Y mode.

Waveform recorder

Waveform recorder can record input waveform from CH1 and CH2, with a maximum record length of 1000 frames. This performance can also be activated by the Pass/Fail test output, which makes this function especially useful to capture abnormal signals in long term without keeping an eye watching it.

Press UTILITY → Record → Mode → Record

Waveform recorder: Record the waveforms with specified interval.

Figure 2-42   Table2-26

Menu	Settings	Comments
Mode	Record Play back Storage Off	Select record mode Select play back mode Select storage mode Turn off all recorder functions
Source	CH1 CH2	Select record source channel
Interval	◀⬤▶ <1.00ms-1000s>	Set time interval between record frames
End Frames	◀⬤▶ <1-1000>	Set number of record frames
Operate	⬤ (Record) ■ (Stop)	Record stopped, press to Start recording Recording, press to stop

Play back: Play back the recorded waveforms.

Figure 2-43   Table2-27

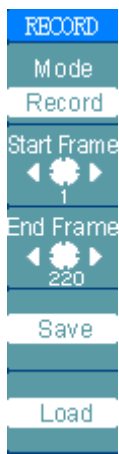| Menu	Settings	Comments
Operation	▶ (Play) ■ (Stop)	Play stopped, press to Start playback Playing, press to stop
Msg Display	On Off	Turn on recorder information display Turn off recorder information display
Play mode	↺ ▶→■	Set circular play mode Set single time play mode

Figure 2-44   Table2-28
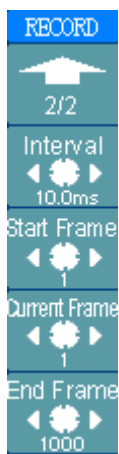
Menu	Settings	Comments
Interval	◀ ✹ ▶ <1.00ms-20s>	Set time interval between frames
Start frame	◀ ✹ ▶ <1-1000>	Set start frame
Current frame	◀ ✹ ▶ <1-1000>	Select current frame to be played
End frame	◀ ✹ ▶ <1-1000>	Set End frame

Note: the RUN/STOP button can also control playback run/stop.

Storage: Store recorded waveforms to non-volatile memory according to setup frames.

Figure 2-45   Table2-29

Menu	Settings	Comments
Start frame	◀ ✹ ▶ <1-220>	Set first frame to be saved
End frame	◀ ✹ ▶ <1-220>	Set last frame to be saved
Save		Store the waveforms between start frame to End frame
Load		Recall the saved waveforms from non-volatile memory

Self-Test

Press UTILITY → Self-Test to enter the following menu.

Figure 2-46   Table 2-30
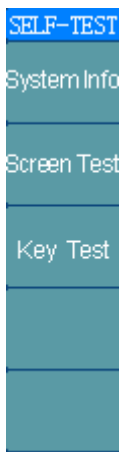
Menu	Settings
System Info	Press to display the information of scope.
Screen Test	Press to run screen test program.
Key Test	Press to run keypad test program.

1. System Info:

Press this soft button to display the information of oscilloscope. It contains Model, Power up times, Serial No., Software version and Installed module of the oscilloscope. And you could follow the prompting message of "<<Press 'RUN' Key to Exit The Test>>" to exit this interface.

2. Screen Test:

Press this soft button to run Screen Test program. Fellow the prompt message on the screen "Press 'RUN' Key to Continue the Test". The screen of DS5000M series turns black or white in sequence (Mono) and the screen of DS5000C series turns red, green and blue in sequence (Color) when keep pressing the RUN/STOP button. You could check the screen for display failures.

3. Key Test:

Press this soft button to run Keyboard Test program and start the keyboard test routine. The blocks represent the buttons on the front-panel; the rectangular boxes with two arrows beside represent the knobs on the front-panel; the square boxes represent the pressing function for the SCALE knobs. Test all keys and knobs, and check whether the blocks on the screen response whether or not.

NOTE:

1. The corresponding block on the screen will temporary turn into green (Color models) or white (Mono models) when pressing a key.
2. The blocks will reverse its color to red (Color models) or black (Mono models) when the corresponding key or knob get pressed, and the color will keep reversed during the test.
3. Follow the prompting message of " <<Press RUN' Key Three Times to Exit The Test>>" to exit the test.

Language:

The DS5000 series oscilloscopes have multi-language user menu, choose as desired.

Press UTILITY → Language to select the language.

How to Measure Automatically

The MEASURE button in MENU area actives the automatic measurement function. The instruction below will show how to use the DS5000 series measurement function.
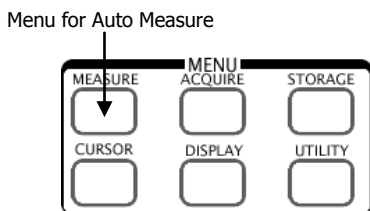
Menu for Auto Measure

Figure 2-47

Menu explanation:

Press the MEASURE button to display the menu of the Automatic Measurements settings.

The oscilloscopes provide 20 parameters for auto measurement, including Vpp, Vmax, Vmin, Vtop, Vbase, Vamp, Vavg, Vrms, Overshoot, Preshoot, Freq, Period, Rise Time, Fall Time, Delay1-2⌐, Delay1-2⌐, +Width, -Width, +Duty, -Duty, include 10 voltage and 10 time measurements.

Figure 2-48   Table 2-31

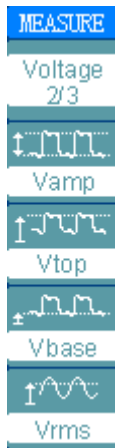| Menu	Settings	Comments
Source	CH1 CH2	Select CH1 or CH2 as source channel for measurement
Voltage		Select voltage measurement parameter
Time		Select time measurement parameter
Clear		Clear measurement result on screen
Display All	OFF ON	Turn off all measurement result Turn on al measurement result

Page 1 for voltage measurements

Figure 2-49   Table 2-32

Menu	Settings	Comments
Voltage	1/3	Page 1 for voltage parameters measurements
Vpp		Measure Peak-to-Peak Voltage
Vmax		Measure maximum voltage of a waveform
Vmin		Measure minimum voltage of a waveform
Vavg		Measure average voltage of a waveform

Page 2 for voltage measurements

Figure 2-50   Table 2-33

Menu	Settings	Comments
Voltage	2/3	Page 2 for voltage parameters measurements
Vamp		Measure voltage between Vtop and Vbase
Vtop		Measure a flat top voltage of a square waveform
Vbase		Measure a flat base voltage of a square waveform
Vrms		Measure Root Mean Square Voltage of a waveform

Page 3 for voltage measurements

Figure 2-51   Table 2-34

Menu	Settings	Comments
Voltage	3/3	Page 3 for voltage parameters measurements
Overshoot		Measure overshoot in percentage of a square waveform
Preshoot		Measure preshoot in percentage of a square waveform

Page 1 for time measurements

Figure 2-52   Table 2-35

Menu	Settings	Comments
Time	1/3	Page 1 for time parameters measurement
Freq		Measure Frequency of a waveform
Period		Measure Period of a waveform
Rise time		Measure Rise Time of a waveform
Fall time		Measure Fall Time of a waveform

Page 2 for time measurements

Figure 2-53   Table 2-36

Menu	Settings	Comments
Time	2/3	Page 2 for time parameters measurement
+Width		Measure +Pulse Width of a waveform
-Width		Measure –Pulse Width of a waveform
+Duty		Measure +Duty Cycle of a waveform
-Duty		Measure –Duty Cycle of a waveform

Page 3 for time measurements

Figure 2-54   Table 2-37

Menu	Settings	Comments
Time	3/3	Page 3 for time parameters measurement
Delay1→2 ƒ		Measure the signals delay between two channels at the rising edge
Delay1→2 ꝉ		Measure the signals delay between two channels at the falling edge

NOTE: The results of the automatic measurements will be displayed on the bottom of the screen. Maximum 3 results could be displayed at the same time. The next new measurement result will make the previous results moving left out of screen.

Using Automatic Measurement as the following steps demonstrate:

1. Select the signal channel for measuring. You could select CH1 or CH2 according to the signal you are interested in.

    Press soft buttons as follows: MEASURE→Source→ **CH1** or **CH2**.

2. To see all measurement value, set the Display All to ON. 18 measurement parameters will be displayed on the screen.

3. Select parameters page for measuring. You could select voltage or time parameters pages by pressing soft button as follows: MEASURE→Voltage or time   **Voltage1/3**, **Voltage2/3**…

4. To get the measured value on the screen. You could select the parameters you are interested in by pressing the soft button on the right of the menu, and read the data on the bottom of the screen.

    If the data is displayed as "*****", that means the parameter cannot be measured in current condition.

5. Clear the measure values: press Clear. Now, all of the auto measured values would disappear from the screen.

Figure 2-55

Clear the display measure parameter

Display 18 measurements
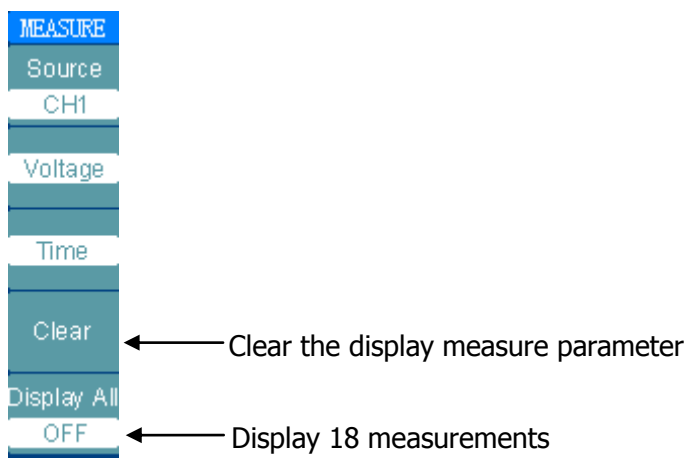
The automatic measurement of the voltage parameters

The DS5000 series oscilloscopes provide voltage measurements including Vpp, Vmax, Vmin, Vavg, Vamp, Vrms, Vtop, Vbase, Overshoot and Preshoot. Figure 2-55 below shows a pulse with some of the voltage measurement points.
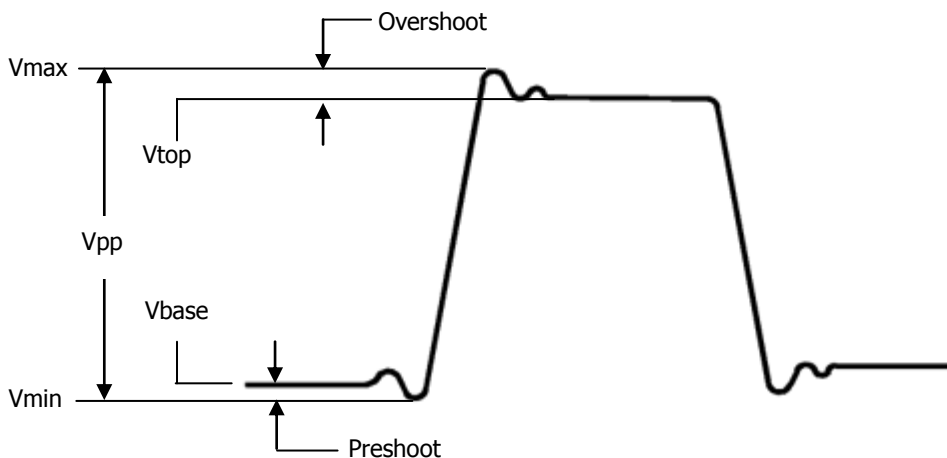

Figure 2-56

Vpp: Peak-to-Peak Voltage.

Vmax: The maximum amplitude. The most positive peak voltage measured over the entire waveform.

Vmin: The minimum amplitude. The most negative peak voltage measured over the entire waveform.

Vamp: Voltage between Vtop and Vbase of a waveform

Vtop: Voltage of the waveform's flat top, useful for square and pulse waveforms.

Vbase: Voltage of the waveform's flat base, useful for square and pulse waveforms.

Overshoot: Defined as (Vmax-Vtop)/Vamp, useful for square and pulse waveforms.

Preshoot: Defined as (Vmin-Vbase)/Vamp, useful for square and pulse waveforms.

Average: The arithmetic mean over the entire waveform.

Vrms: The true Root Mean Square voltage over the entire waveform.

The automatic measurement of the time parameters

The DS5000 series oscilloscopes provide time parameters auto-measurements; Frequency, Period, Rise Time, Fall Time, +Width, -Width, Delay 1→2�, Delay 1→2⌐, +Duty and -Duty.

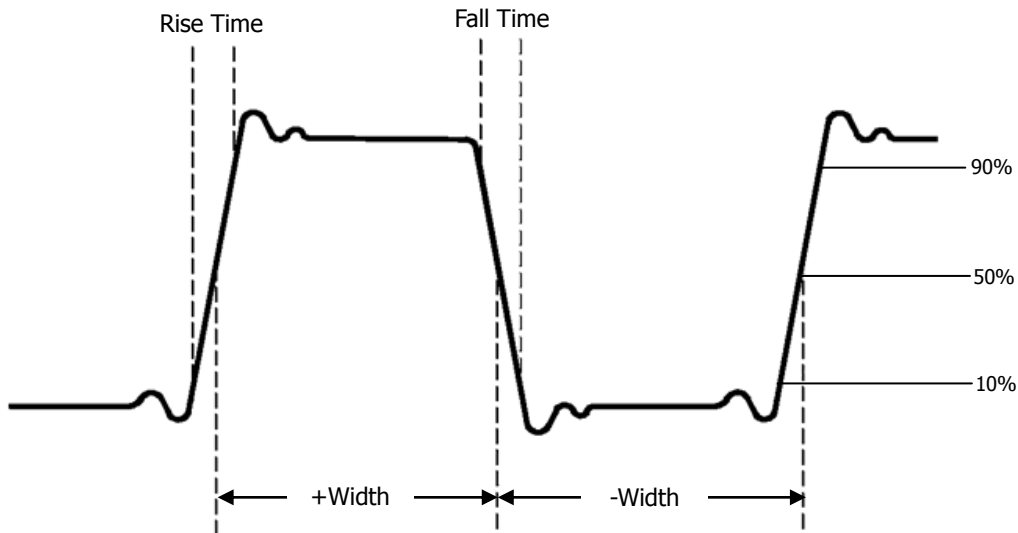Figure 2-56 shows a pulse with some of the time measurement points.

Figure 2-57

Rise Time: Time that the leading edge of the first pulse in the waveform takes to rise from 10% to 90% of its amplitude.

Fall Time: Time that the falling edge of the first pulse in the waveform takes to fall from 90% to 10% of its amplitude.

+Width: The width of the first positive pulse in 50% amplitude points.

-Width: The width of the first negative pulse in the 50% amplitude points.

Delay 1→2⌐ : The delay between the two channels at the rising edge.

Delay 1→2⌐ : The delay between the two channels at the falling edge.

+Duty: +Duty Cycle, defined as +Width/Period

-Duty: -Duty Cycle, defined as -Width/Period

How to measure with cursors
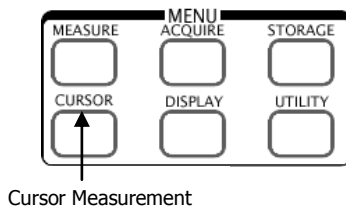
Figure 2-58 shows the CURSOR button on the front-panel.

Figure 2-58

Cursor Measurement

The cursor measurement has three modes: Manual, Track and Auto Measure.

1. **Manual:** In this mode, the screen displays two parallel cursors. You can move the cursors to make custom voltage or time measurements on the signal. The values displayed on the boxes below the menu. Before using cursors, you should make sure that you have set the Signal Source as the channel for measuring.

2. **Track:** In this mode, the screen displays two cross cursors. The cross cursor sets the position on the waveform automatically. You could adjust cursor's horizontal position on the waveform by turning the horizontal POSITION knob in conjunction with the cursor. The oscilloscope displays the values of the coordinates on the boxes below the menu.

3. **Auto Measure:** This mode will take effect with Automatic Measurements. The instruments will display cursors while measuring parameters automatically. These cursors demonstrate the physical meanings of these measurements.

   NOTE: The Auto Measure mode for Cursor measuring will take no effect without automatic measurements.

Menus and operations of Cursor Measurements

1. Manual Mode

Figure 2-59   Table 2-38

Menu	Settings	Comments
Mode	Manual	Set Manual mode in cursor measurement
Type	Voltage Time	Use cursor to measure voltage parameters. Use cursors to measure time parameters
Source	CH1 CH2 MATH	Select the measurement signal source.

In this mode, the oscilloscope measures the cursors' coordinate values for voltage or time, and the increment between the two cursors.

To do manual Cursor Measurements, follow these steps:

(1). Select the **Manual** mode for cursor measurement by pressing soft button as: CURSOR→**Mode**→Manual.

(2). Select channel **Source** for measurements by pressing soft button as: CURSOR→**Source**→**CH1**, **CH2** or **MATH**.

   NOTE: While measuring the channel of MATH, the results are valued with "d" (division) as units.

(3). Select the cursors type by pressing soft button as CURSOR→ **Type**→ **Voltage** or **Time**.

(4). Move the cursors to adjust the increment between the cursors: (Details in the following Table)

Table 2-39

Cursor	Increment	Operation
Cursor A	Voltage	Turn the vertical POSITION knob to move cursor A vertically
	Time	Turn the vertical PSSITION knob to move cursor A horizontally
Cursor B	Voltage	Turn the horizontal POSITION knob to move cursor B vertically
	Time	Turn the horizontal PSSITION knob to move cursor B horizontally

NOTE: Cursor could be moved only when the cursor is only possible with cursor function menu displayed.

(5). To gain measurement value:

Display Cursor 1 (time cursor centered on the midpoint of screen;
Voltage cursor centered on channel ground level)
Display Cursor 2 (same as above)
Display horizontal space between cursor 1 and 2 ($\triangle$ X): Time between cursors
Display (1/$\triangle$ X), units in Hz, kHz, MHz, GHz
Display vertical space between cursor 1 and 2 ($\triangle$ Y): Voltage between cursors

NOTE: The values will be automatically displayed on the right upper corner of the screen when the cursor function menu is hidden or displaying other menus.
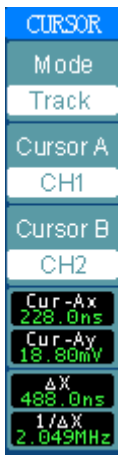

Key Points

Voltage Cursors: Voltage cursors appear as horizontal lines on the display and measure the vertical parameters.

Time Cursors: Time cursors appear as vertical lines on the display and measure the horizontal parameters.

2. Track Mode

Figure 2-60   Table 2-40

Menu	Settings	Comments	
Mode	Track	Set Track mode in cursor measurement	
Cursor A	CH1 CH2 None	Set Cursor A in conjunction with CH1, CH2 or turn off Cursor A	
Cursor B	CH1 CH2 None	Set Cursor B in conjunction with CH1, CH2 or turn off Cursor B	
Coordinate	Cur-Ax Cur-Ay	Display X or Y axis values of Cursor A	Switch the value display between Cursor A or B by pressing the key beside this menu
	Cur-Bx Cur-By	Display X or Y axis values of Cursor B	
Increment	△X 1/△X	Display the X-axis increment and its reciprocal between the cursors	Switch the value display between △X or △Y by pressing the key beside this menu
	△Y	Display the Y-axis increment between the cursors	

In cursor track mode, the cursors move together with the selected waveform.

To do Track mode Cursor Measurements, follow these steps:

(1). Select the **Track** mode for cursor measurement by pressing soft button as: CURSOR→**Mode**→**Track**.

(2). Select channel **Source** for Cursor A and Cursor B by pressing soft button as: CURSOR→**Cursor A** or **Cursor B**→**CH1**, **CH2** or **None**.

(3). Move the cursors to adjust the horizontal positions of the cursors: (Details in the following Table)

Table 2-41

Cursor	**Operation**
Cursor A	Turn the vertical POSITION knob to move Cursor A horizontally
Cursor B	Turn the horizontal POSITION knob to move Cursor B horizontally

NOTE: Horizontally moving cursor is only possible with cursor track menu displayed.

(4)   To gain measurement value:
  Display Cursor 1 (Time cursor centered around the midpoint of screen;
                              Voltage cursor centered around channel ground level)
  Display Cursor 2 (same as above)
  Display horizontal space between cursor 1 and 2 ($\triangle$ X): Time between cursors
  Display (1/$\triangle$ X), units in Hz, kHz, MHz, GHz
  Display vertical space between cursor 1 and 2 ($\triangle$ Y): Voltage between cursors

NOTE: The values will be automatically displayed on the right upper corner of screen when the cursor function menu is hidden or displaying other menus.

3. Auto mode:

Figure 2-61   Table 2-42

	CURSOR
	Mode
	Auto

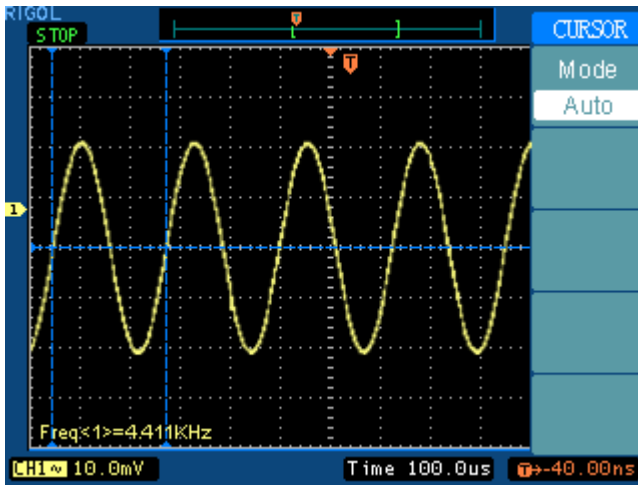| Menu	Settings	Comments
Mode	Auto	Display the cursors applied by the current automatic measuring. (See the following figure)

Figure 2-62: Auto Measure Mode of Cursor Measurement

There will be no cursor display if no parameter were chosen in MEASURE menu. This oscilloscope could move cursor automatically to measure 20 parameters in the MEASURE menu.
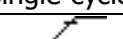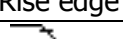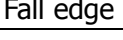
How to use instant execute buttons

The action buttons include AUTO (auto setting) and RUN/STOP .

Auto:

The AUTO features automatic adjustments to produce a usable display of the input signal. When AUTO button is pressed, the following menu will appear.

Table2-63   Table 2-43

Menu	Settings	Comments
ᒊᒊᒊᒊᒊ Multi-cycle		Press to display multi- cycle waveform on the screen
ᒊᒊᒊ Single-cycle		Press to display single cycle waveform on the screen
Rise edge		Press to display the waveform's rising edge and measure its rise time automatically
Fall edge		Press to display the waveform's falling edge and measure its fall time automatically
↰ (Cancel)		Press to cancel all the Auto Set actions, the oscilloscope will recover to its previous status

Auto-set functions

After the AUTO is pressed the oscilloscope is configured to the following defaults:

Table 2-44

Menu	Settings
Display format	Y-T
Sampling mode	Equal-time
Acquire mode	Normal
Vertical coupling	Adjust to AC or DC according to the signal.
Vertical "V/div"	Adjusted
Volts/Div	Coarse
Bandwidth limit	Full
Signal Invert	OFF
Horizontal position	Center
Horizontal "S/div"	Adjust to right position
Trigger type	Edge
Trigger source	Measure the channel with input signal automatically.
Trigger coupling	DC
Trigger voltage	Midpoint setting
Trigger mode	Auto
◁POS▷ knob	Trigger offset

RUN/STOP:

To Run or Stop waveform acquiring.

NOTE: In STOP status, the volts/div and horizontal time base can be adjusted in a fixed limit. That is, to zoom in/out the signal in vertical and horizontal directions. When the horizontal s/div is 50ms/div or faster, the horizontal time base can be expand 5 div up or down.

Chapter 3 : Application & Examples

Example 1: Taking Simple Measurements

To observe an unknown signal in a circuit, to quickly display the signal and measure the frequency, period, and peak-to-peak amplitude.

To quickly display a signal, do these steps as follow:

1. Set the probe and the channel attenuations to 10X
2. Connect signal to CH1 with the probe
3. Press the AUTO button

The oscilloscope sets the vertical, horizontal, and trigger controls at the best status automatically. To optimize the display of the waveform, adjust these controls manually.

Selecting Automatic Measurements
The oscilloscope could take automatic measurements on most signals. To measure the frequency and peak-to-peak amplitude, do these steps as follow:

1. Measure peak-to-peak amplitude
   Press MEASURE →Source →**CH1** to set measurement source
   Press Voltage →Voltage1/3 to select measurement page
   Press Vpp to select peak-to-peak measurements and the result will be displayed on the screen.
2. Measure frequency
   Press Time → Time1/3 to select measurement page
   Press Freq to select frequency measurements
3. Measure period
   Press Time → Time1/3 to select measurement page
   Press Period to select period measurements

NOTE: The frequency, period, and peak-to-peak measurements are shown on the screen and are updated periodically.

Example 2: View a signal delay caused by a circuit

This example is to test the input and output signals of a circuit and observe the signal delay. First, set the probe and the channel attenuation to 10X and connect CH1 probe to the input, CH2 to the output of the circuit.

Do these steps as follow:

1.   Display the signals (CH1 and CH2):

1)   Pressing the AUTO button

2)   Adjust the vertical and the horizontal scale by turning the SCALE knobs to appropriate ranges for display.

3)   Press the CH1 button to select CH1, and turn the vertical POSITION knob to adjust the vertical position of CH1's waveform.

4)   Press the CH2 button to select CH2, and turn the vertical POSITION knob to adjust the vertical position of CH2's waveform.

2. Measure the delay time when a signal going through the circuit

Auto-measuring the delay:

Press MEASURE →Source→ **CH1** to set measurement source

Press Time to select measurement Type

Press Time3/3 to select measurement page.

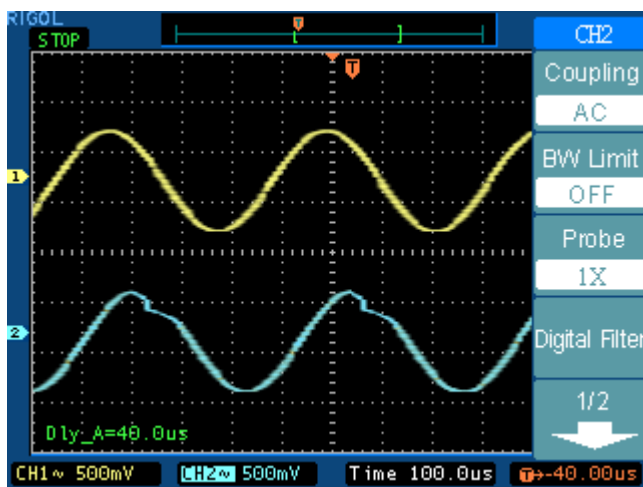Press Delay1→2 � to display the result on the screen.

Figure 3-1 Delay of the signals

Example 3: Capture a Single-Shot Signal

To capture a single event, it needs to gather some pre-test knowledge of the signal in order to set up the trigger level and slope correctly. For example, if the event is derived from TTL logic, a trigger level of 2 volts should work on a rising edge.

The following steps show how to use the oscilloscope to capture a single event.

1. Connect a signal to the oscilloscope.

2. Set up the trigger.

• Press the MENU button in the Trigger control area to display the menu.

• Press Edge to select trigger mode

• Press Slope to select **Rising**

• Press Source to select **CH1**

• Press Mode to select **Single**

• Press Coupling to select **DC**

• Turn the vertical and horizontal SCALE knobs to adjust the Volts/Div and the Time base in a proper range for the signal

• Turn the LEVEL knob to adjust trigger level

3. Press RUN/STOP button to start capturing

When the trigger conditions are met, data appears on the display representing the data points that the oscilloscope obtained with one acquisition. Press the RUN/STOP button again rearms the trigger circuit and erases the display.

Example 4: To reduce the random noise on a signal

If the signal is noisy (Figure 3-2), set up the oscilloscope to reduce the noise on the waveform. First, stabilize the displayed waveform by removing the noise from the trigger path. Second, reduce the noise on the displayed waveform.
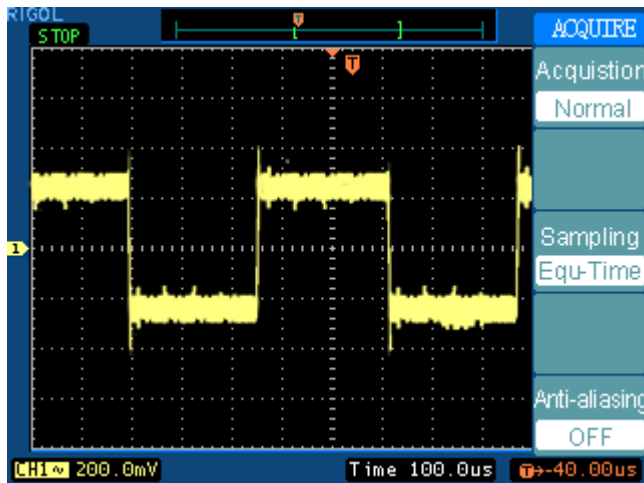

Figure 3-2

1. Connect a signal to the oscilloscope and obtain a stable display.

2. Remove the noise from the trigger path by turning on **HF Reject**.

    HF Reject (High frequency reject) adds a low pass filter with the 3 dB point at 150 kHz. Uses **HF reject** to remove high frequency noise such as AM or FM broadcast stations from the trigger path.

    LF Reject (Low frequency reject) adds a high pass filter with the 3 dB point at 8 kHz. Use **LF Reject** to remove low frequency signals such as power line noise from the trigger path.

3. Use averaging to reduce noise on the displayed waveform.

To use Average follow these steps.

· Press soft button as ACQUIRE→Acquisition→**Average**

·Toggle the Averages soft button to select the number of averages that eliminates the noise best from the displayed waveform. The higher the number of averages is, the more noise that is removed from the display. However, the higher number of averages, the slower the displayed waveform response to waveform changes. You need to choose between how quickly the waveform responds to changes and how much noise there is on the signal. (See Figure 3-3)
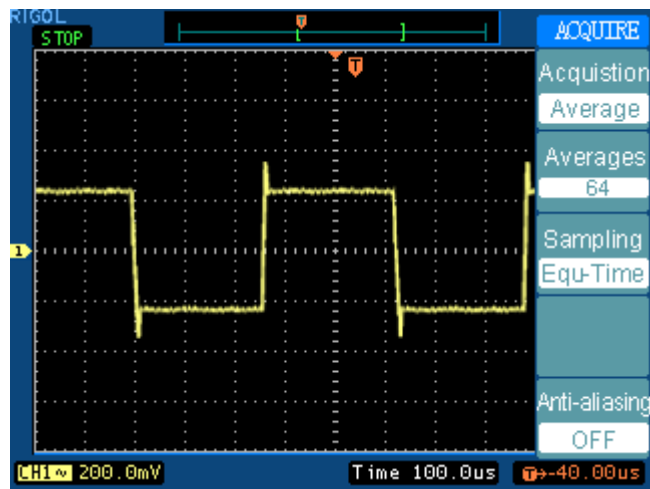

Figure 3-3

Example 5: Making Cursor Measurements

There are 20 most desired parameters that could be automatically measured with the oscilloscope. These parameters can also be measured using cursors. You could use the cursors to quickly make time and voltage measurements on a waveform.

Measuring Ring Frequency

To measure the ring frequency at the rising edge of a signal, do these steps:

1.   Press CURSOR key to see the Cursor menu.

2.   Press Mode to set **Manual** mode.

3.   Press Type to select **Time** measurement

4.   Rotate vertical POSITION knob to place cursor A on the first peak of the ring.

5.   Rotate horizontal POSITION knob to place cursor B on the second peak of the ring.

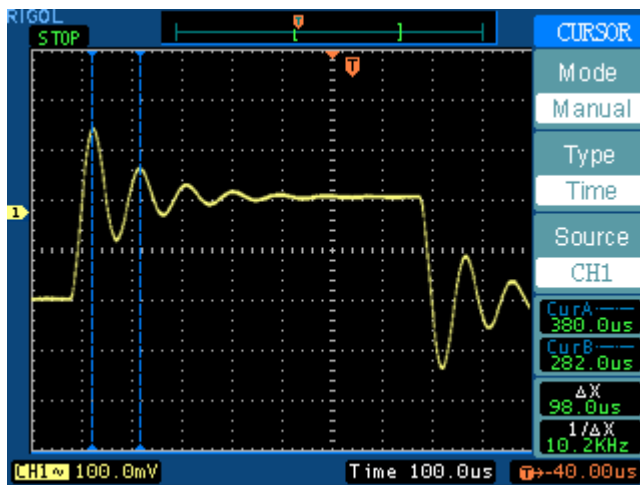You can read the delta time and frequency (the measured ring frequency) in the Cursor menu.

Figure 3-4

Measuring Ring Amplitude

Now let's measure the amplitude of the ringing. To measure the amplitude, do these steps:

1. Press CURSOR key to see the Cursor menu.

2. Press Mode to set **Manual** mode

3. Press Type to select **Voltage**.

4. Rotate vertical POSITION knob to place cursor A on the top of the first positive peak of the ring.

5. Rotate horizontal POSITION knob to place cursor B on the bottom of the first negative peak of the ring.

You can see the following measurements in the cursor menu: (See Figure 3-5)

■ The delta voltage (peak-to-peak voltage of the ringing)
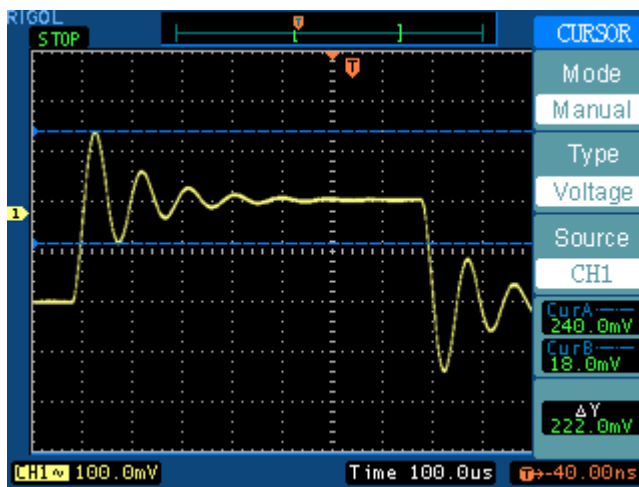
■ The voltage at Cursor 1

■ The voltage at Cursor 2

Figure 3-5

Example 6: The application of the X-Y operation

Viewing Phase Changes through a Network

Connect the oscilloscope to monitor the input and output of the circuit and capture the phase changes through the circuit.

To view the input and output of the circuit in an x-y display, do these steps:

1. Set the probe menu attenuation to 10X. Set the switch to 10X on the probes.

2. Connect the channel 1 probe to the input of the network, and connect the channel 2 probe to the output.

3. If the channels are not displayed, press the CH1 and CH2 buttons.

4. Press the AUTO button

5. Adjust the vertical SCALE knob to display approximately the same amplitude signals on each channel

6. Press the MENU in HONRIZONTAL control area to display the menu

7. Press the Time Base soft button to select **X-Y**

   The oscilloscope displays a Lissajous pattern representing the input and output characteristics of the circuit

8. Adjust the vertical SCALE and POSITION knobs to display a desirable waveform.

9. Apply the Ellipse method to observe the phase difference between the two channels.
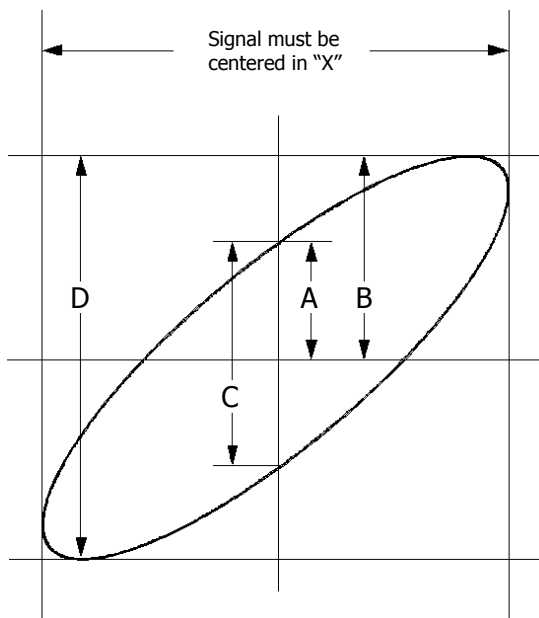
   (See Figure 3-6)

Figure 3-6

Sinθ=A/B or C/D   where θ= phase shift (in degrees) between the two signals. From the formula above, you could get

$$\theta=\pm \text{ arcsine (A/B) or } \pm\text{arcsine (C/D)}$$

If the main axis of the ellipse is at I and III quadrant, θ must be in the range of (0~ π /2) or (3π /2~2π). If the main axis is at I and III quadrant, θ must be in the range of (π /2~π) or (π ~3π /2).

Example 7: Triggering on a Video Signal

Test a video circuit and display the video signal. Use video trigger to obtain a stable display.

Triggering on Video Fields

To trigger on the video fields, do the following steps:

1. Press the MENU key in the Trigger control area to see the Trigger menu.

2. Press Mode to select **Video** mode

3. Press Source to select **CH1** as trigger source

4. Press Polarity to select ⊓

5. Press Sync as **Odd Field** or **Even Field**

6. Turn the horizontal SCALE knob to see a complete waveform on the screen.
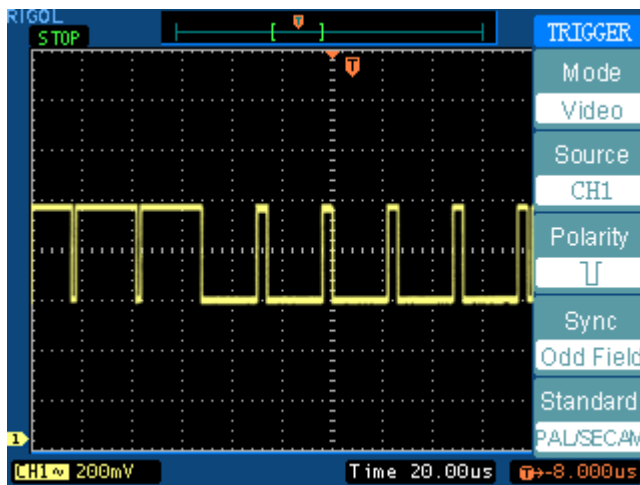

Figure 3-7

Triggering on the Video Lines

1. Press the MENU key in the triggering control area to see the trigger menu.

2. Press Mode to select **Video** mode

3. Press Source to select **CH1** as trigger source

4. Press Polarity to select ⊔

5. Press Sync to select Line Num

6. Turn LEVEL to trigger on a specified line number

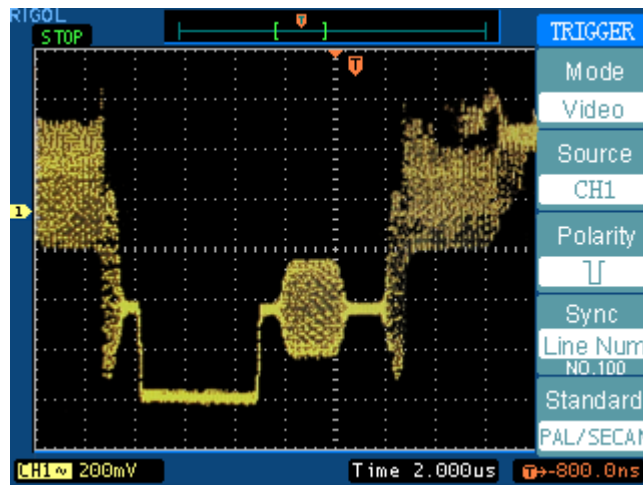7. Turn the horizontal SCALE knob to see a complete waveform on the screen

Figure 3-8

Example 8: FFT Cursor measurement

FFT measurements include: amplitude measurement (Vrms or dBVrms) and Frequency measurement (Hz).

Do these steps as follow:

1. Press CURSOR key to display menu

2. Press Type to select **Time** or **Voltage**

3. Press Source to select **FFT**

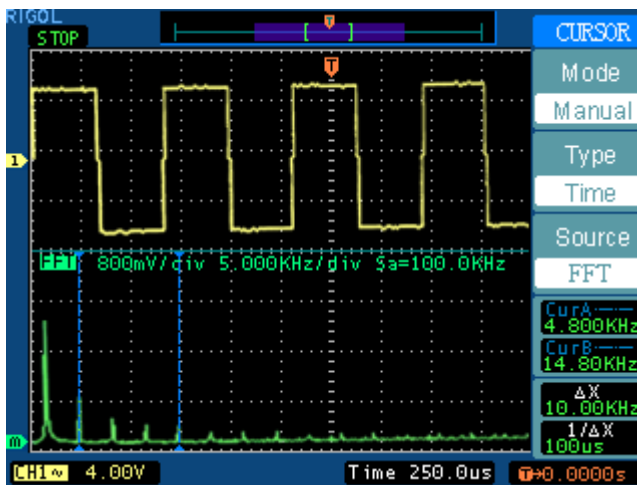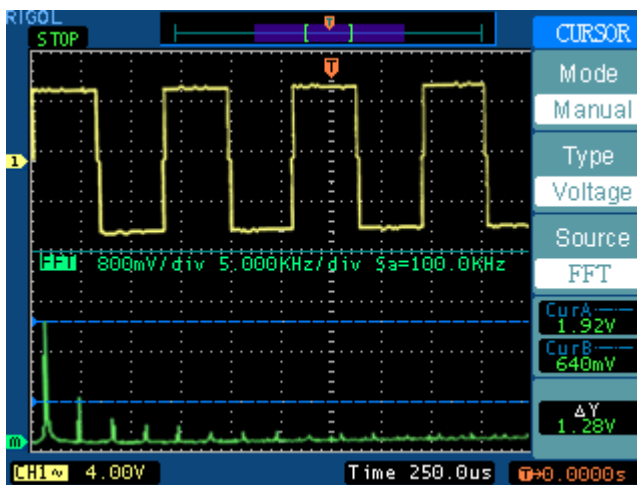4. Turn vertical and horizontal POSITION to an interested point.

Figure 3-9

Figure 3-10

Example 9: Pass/Fail Test

The Pass/Fail Test is one of enhanced special functions of DS5000 series. In this test function, the oscilloscope compares the input signal to the established waveform mask. If the waveform "touches" the mask, a "Fail" signal will occur, otherwise the test will pass. If oscilloscope has built in Pass/Fail output module, it could output fail pulse signals (open collector output).

Do the steps as following:

1. Press UTILITY key to show the UTILITY menu.
2. Press Enable Test and select ON to open the test.
3. Press Load to recall the saved mask or press X Mask and Y Mask to adjust the horizontal limit and vertical limit then press Create Mask to create a new mask.
4. Press Output to select the expected outputting waveforms.
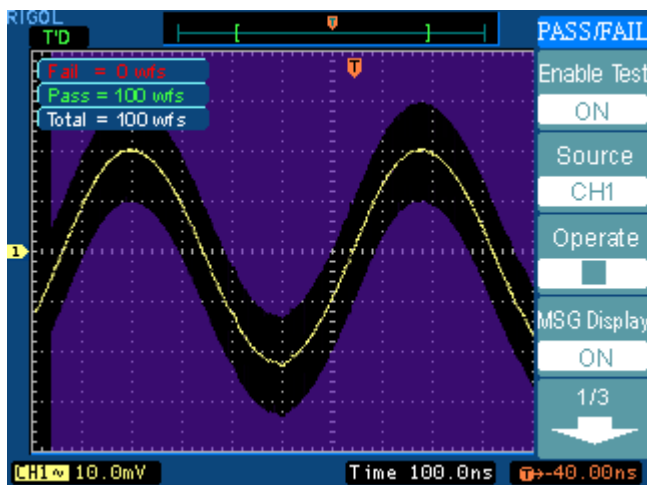5. Press Operate to start the test.

Figure 3-11 Running Pass/Fail Test

Chapter 4 : Prompt messages & troubleshooting

Prompting messages

Dot display only: Only use Dots type for display under this setting.

Function not available: This function is not available under current setting.

Measurement already selected: The measurement parameter you pressed is already displayed on screen.

Memory position at limit: The Memo Offset is at the full range of the memory.

No active cursor: The cursor source was not set while using the Track cursor measurements.

No signal found: There is no signal connected to the instrument, or the signal is out of the AUTO range for detecting while pressing the AUTO button.

No zoom at this Time/Div: Under some time bases or X-Y mode, the Delayed Scan function is not available.

Position at limit: The channel offset is at limit while turning the vertical POSITION knob to adjust the vertical position of the channel.

Real Time Div at limit: The time base is up to the highest horizontal resolution under the Real-Time sampling mode.

Sampling at limit: The sampling rate is at limit under the X-Y mode.

Save finished: The storage progress finished.

Time/Div at limit: The Time/Div is at limit while turning the horizontal SCALE knob to adjust time base.

The storage is empty: Current position of the memory is empty for waveforms or settings saved.

Trigger level at limit: The trigger level is at limit while turning the LEVEL knob.

Trigger position at limit: Prompts that the trigger position is at the start or the end point of the memory while turning the horizontal POSITION knob to adjust the trigger offset.

Volts/Div at limit: The Volts/Div is at full range while turning the vertical SCALE knob.

Delay scale at limit: It is at the full range of horizontal resolution under the Delayed Scan mode while turning the horizontal SCALE knob.

Delay position at limit: The horizontal position of the zoom window is at limit under the Delayed Scan mode while turning the horizontal POSITION knob.

Troubleshooting

1. After the oscilloscope is powered on, the screen remains dark, please inspects the instrument following these steps:

(1) Check the power cable connection
(2) Ensure the power switch is turned on
(3) After the inspections above, restart the oscilloscope
(4) If the problem still remains, please contact RIGOL for help

2. After the signal acquisition the waveform does not appear, please check according to the following steps:

(1) Check the probes connected with the signals
(2) Check the probes connected to the channels firmly
(3) Check the circuit that generates the signal at the test point
(4) Repeat the acquisition

3. The measurement result is 10 times higher or lower than the value expected.

Check if the probe attenuation is the same as the channel attenuation.

4. If the oscilloscope does not get a stable waveform display, please check according to the following steps:

(1) Check the **Trigger Source** and notice if it is set to the channel in use
(2) Check the **Trigger Type**. Use "Edge" for normal signals, and use "Video" for VIDEO signals.

5. After pressing the RUN/STOP button, the oscilloscope does not display a waveform on screen.

Check whether the **Trigger Mode** is set to "Normal" or "Single" and check if the trigger level is out of the signal range or not.
If yes, set the trigger level in proper range by turning the LEVEL knob or pressing the 50% button. Or set the Trigger Mode as "AUTO". Moreover, push AUTO button to display the waveform on screen.

6. After the Acquisition is set to "Averages" or Display Persistence is set ON, the waveform refreshes slowly.

It is normal in these settings.

7. The signal is displayed as ladder like waveform.

The time base maybe is too slow. Turn the horizontal SCALE knob to increase horizontal resolution to improve the display.
Maybe the display **Type** is set to "Vectors". Set it to "Dots" mode to improve the display.

Chapter 5 : Specifications

All specifications apply to the DS5000-Series Digital Oscilloscopes and a probe with the Attenuation switch set to 10X unless noted otherwise. To meet these specifications, two conditions must first be met:

- The instrument must have been operating continuously for twenty minutes within the specified operating temperature.
- You must perform the Self Cal operation, accessible through the Utility menu, if the operating temperature changes by more than 5 ℃.

All specifications are guaranteed unless noted "typical".

Specifications

Acquisition		
Sampling Modes	Real-Time	Equivalent
Sampling Rate	1GSa/s (DS5000A Series) 500MSa/s (DS5000 Series)	* 50GS/s
Averages	N time acquisitions, all channels simultaneously, N is selectable from 2, 4, 8, 16, 32, 64, 128 and 256	

Probe	1X position	10X position
Bandwidth	DC to 6 MHz	DC to full bandwidth
Attenuation ratio	1:1	10:1
Compensation Range	10pf-35pf Oscilloscope with 1MΩ input	
Input resistance	1MΩ ±2%	10MΩ ±2%
Input capacitance	85pf-115pf	14.5pf-17.5pf
Input voltage	150V RMS CAT I or 150V DC CAT I 150V RMS CAT II or 150V DC CAT II 100V RMS CAT III or 100V DC CAT III	300V RMS CAT I or 300V DC CAT I 300V RMS CAT II or 300V DC CAT II 100V RMS CAT III or 100V DC CAT III

- The probe index of different models is following its attached specification.

Inputs	
Input Coupling	AC, DC, GND
Input Impedance, DC Coupling	1MΩ ±2%, in parallel with 13pF±3pF
	50Ω±2%, see the following table for availability
Probe Attenuation Factors	1X, 10X, 100X, 1000X
Maximum input voltage	400V (DC＋AC Peak, 1MΩ, 10X)
	5V (Vrms, 50Ω, BNC)
Time delay between channel (typical)	150ps

50Ω	Models
Provided	DC5202CA/CAE, DS5152CA/CAE, DS5152C/CE, DS5152MA/MAE, DS5152M/ME
Not provided	DS5102CA/CAE, DS5102C/CE, DS5062CA/CAE, DS5062C/CE DS5102MA/MAE, DS5102M/ME, DS5062MA/MAE, DS5062M/ME, DS5042M/ME, DS5022M/ME

Horizontal	
Sample Rate Range	10S/s-1GS/s (Real-Time), 50GS/s (Equivalent) (DS5000A Series)
	10S/s-500MS/s (Real-time), 50GS/s (Equivalent) (DS5000 Series)
Waveform Interpolation	(Sin x)/x
Record Length	4K samples for each channel
Sec/div Range	1ns/div-50s/div* in 1-2-5 steps
	Delayed Scan to 10ps/div*
Sample Rate and Delay Time Accuracy	±50ppm over any ≥1ms time interval
Delta Time Measurement Accuracy (Full Bandwidth)	Single-shot: ±(1 sample interval+50ppm×reading+0.6 ns)
	>16 averages: ±(1sample interval+50ppm×reading+0.4 ns)

** This characteristics varies by different models

Vertical	
A/D converter	8-bit resolution, each channel samples simultaneously*
Volts/div Range	2mV/div-5V/div at input BNC
Offset Range	±40V(200mV-5V), ±2V(2mV-100mV)
Analog Bandwidth	200MHz(DS5202 Series) 150MHz(DS5152 Series) 100MHz(DS5102 Series) 60MHz(DS5062 Series) 40MHz(DS5042 Series) 25MHz(DS5022 Series)
Single-shot Bandwidth	Full bandwidth (DS5000A Series), 50MHz (DS5000 Series)
Selectable Analog Bandwidth Limit (typical)	20MHz (DS5022M/ME no Bandwidth Limit)
Lower Frequency Limit (AC −3dB)	≤5Hz (at input BNC)
Rise Time at BNC, typical	<1.8ns, <2.3ns, <3.5ns, <5.8ns, <8.7ns, <14ns correspondingly at bandwidth of (200M) (150M) (100M) (60M) (40M) (25M)
DC Gain Accuracy	2mV/div-5mV/div, ±4% (Sample or Average acquisition mode) 10mV/div-5V/div, ±3% (Sample or Average acquisition mode)
DC Measurement Accuracy, Average Acquisition Mode	Average of ≥16 Waveforms with vertical position at zero: ±(4%×reading+0.1div+1mV) at 2mV/div or 5mV/div ±(3%×reading+0.1div+1mV) at settings 10mV/div Average of ≥16 Waveforms with vertical position not at zero: ±[3%×(reading vertical position)+(1% of vertical position)+0.2div] Add 2mV for settings from 2mV/div to 200 mV/div Add 50mV for settings from 500mV/div to 5V/div
Delta Volts Measurement Accuracy (Average Acquisition Mode)	Delta Volts between any two averages of ≥ 16 waveforms acquired under same setup and ambient conditions: ±(3%×reading + 0.05 div)

* When sampling rate is at 1GS/s, only one channel is available for use.

Trigger		
Trigger Sensitivity, (Edge Trigger Type)	DC	CH1, CH2: 1div(DC~10MHz) EXT: 100mV(DC~10MH), 200mV(10MHz ~ Full) EXT/5: 500mV(DC ~ 10MHz), 1V(10MHz ~ Full)
	AC	Same as DC at 50Hz and above
	LF REJ	Same as the DC- coupled limits for frequencies above 100 kHz, attenuates signals below 8kHz.
	HF REJ	Same as the DC- coupled limit from DC to 10 kHz, attenuates signals above 150 kHz
Trigger Level Range	Internal	±12 divisions from center of screen
	EXT	±1.6V
	EXT/5	±8V
Trigger Level Accuracy, (typical)	Internal	±(0.3div×Volts/div) (±4 divisions from center of screen)
	EXT	±(6% of setting + 40 mV)
	EXT/5	±(6% of setting + 200 mV)
Trigger offset	Pretrigger 14div, delay trigger 1s	
Trigger Holdoff range	100ns-1.5s	
Set Level to 50%, (Typical)	Operates with input signals ≥50 Hz	
Default Settings, Video Trigger	Trigger mode is Auto and Coupling is AC	
Sensitivity, (Video Trigger Type, typical)	Internal	Pk-pk amplitude of 2 divisions
	EXT	400mV
	EXT/5	2V
Signal Formats and Field Rates, Video Trigger Type	Supports NTSC, PAL, and SECAM broadcast systems for any field or any line	
Pulse trigger:		
Pulse Trigger mode	(≥,≤,=)+width (≥,≤,=)-width	
Pulse width range	20ns-10s	

Measurements		
Cursors Measure	Manual	Voltage difference between cursors (ΔV) Time difference between cursors (ΔT) Reciprocal of ΔT in Hertz (1/ΔT)
	Track	Voltage value for Y-axis waveform Time value for Y-axis waveform
	Auto Measure	Cursors are visible for Automatic Measurement
Auto Measure	Vpp, Vamp, Vmax, Vmin, Vtop, Vbase, Vavg, Vrms, Overshoot, Preshoot, Freq, Period, Rise Time, Fall Time, +Width, -Width, +Duty, -Duty, Delay1→2 ↟ Delay1→2 ⨍	

User's Guide for DS5000 Series

General Specifications

Display	
Display Type	5.7 in. (145 mm) diagonal Liquid Crystal Display
Display Resolution	320 horizontal by 240 vertical pixels
Display Color	VGA color, 256 (DS5000C Series) Mono color (DS5000M Series)
Display Contrast	Adjustable
Backlight Intensity, typical	60 lux/㎡

Probe Compensator Output	
Output Voltage, typical	3 Vp-p into ≥1 MΩ load
Frequency, typical	1KHz

Power	
Source Voltage	100 ~ 240 VAC$_{RMS}$, 50Hz, CATII
Power Consumption	Less than 50VA
Fuse	2 A, T rating, 250 V

Power Cable
IEC60245/IEC60227 (250V, 10A)

Environmental	
Temperature	Operating 10℃~ 40℃
	No operating -20℃~ +60℃
Cooling Method	Fan force air
Humidity	+40℃ or below: ≤90% relative humidity
	+40℃~ +50℃: ≤60% relative humidity
Altitude	Operating 3,000 m
	No operating 15,000 m

Mechanical		
Dimensions	Height	288 mm
	Width	350 mm
	Depth	145 mm
Weight (approximate)	Without package	4.5 kg
	Packaged	5.6 kg

IP Degree
IP2X

Adjustment Interval
The recommended calibration interval is one year

Notes:
- Distinguish DS5000A and DS5000 from whether an A is included in a model, the model with A has a higher sample rate than the model without A.
- Distinguish DS5000C and DS5000M from the letter C and M included in the model, the model with C refers to color while the model with M refers to monochrome.
- The numbers in DS5202, DS5152, DS5102, DS5062, DS5042, DS5022 series are for the use of distinguishing the models, in which the second number and the third one from left to right refers to centesimal and tens respectively.
  For example, the bandwidth of DS5202 is 200MHz, the bandwidth of DS5062 is 60MHz.

Chapter 6 : Appendix

Appendix A: Accessories

Standard Accessories:
- Probe×2 (1.5m), 1:1, (10:1) Passive Probes
- The passive probes have a 6MHz bandwidth with a rating of 150V CAT II when the switch is in the 1X position, and a Full oscilloscope bandwidth with a rating of 300 V CAT II when the switch is in the 10X position.
- Power Cable that fits the standard of destination country.
- User's Guide
- User Registration Form

Optional Accessories:
- EM5-CM integration
- Communication module: RS232, GPIB, Pass/Fail output
- EM5-COM communication module: RS232, GPIB
- EM5-P/F Pass/Fail output module
- UltraScope for WIN98/ 2000/XP software
- Accessories case: PA-5000

All accessories (standard and optional) are available by contacting your local RIGOL office.

Appendix B: Warranty

Warranty (DS5000 Series Digital Oscilloscopes)

RIGOL Technologies, Inc. warrants its products' mainframe and accessories in materials and technics within the warranty period. During the period concerned, **RIGOL** guarantees the free replacement or repair of products which are approved defective.

To get repair service or obtain a copy of the whole warranty statement, please contact with your nearest **RIGOL** sales and service office.

RIGOL does not provide any other warranty items except the one being provided by this summary and the warranty statement. The warranty items include but not being subjected to the hinted guarantee items related to tradable characteristic and any particular purpose.

RIGOL will not take any responsibility in cases regarding to indirect, particular and ensuing damage.

Appendix C: Maintenance

General Care

Do not store or leave the instrument in where the LCD display will be exposed to direct sunlight for long periods of time.

⚠ **CAUTION:** To avoid damage to the instrument or probes, do not expose them to sprays, liquids, or solvents.

Cleaning

If this instrument requires cleaning, disconnect it from all power sources and clean it with a mild detergent and water. Make sure the instrument is completely dry before reconnecting it to a power source.

To clean the exterior surface, perform the following steps:

1. Remove loose dust on the outside of the instrument and probes with a lint- free cloth. Take care to avoid scratching the clear plastic display filter.

2. Use a soft cloth dampened with water to clean the instrument.

NOTICE: To avoid damage to the surface of the instrument or probes, do not use any abrasive or chemical cleaning agents.

Appendix D: Contact **RIGOL**

If you have any problem or requirement during using our products, please contact **RIGOL** Technologies, Inc. or the local distributors.

Domestic: Please call
    Tel: (86-10) 8070 6688
    Fax:(86-10) 8070 5070
    Service & Support Hotline: 800 810 0002
    9:00 am –5: 00 pm from Monday to Friday

    Or by e-mail:
    service@rigol.com

    Or mail:
    RIGOL Technologies, Inc.
    156# CaiHe Village, ShaHe Town, ChangPing District, Beijing, China
    Post Code: 102206

Overseas: Contact the local **RIGOL** distributors or sales office.

For the latest product information and service, visit our website: www.rigolna.com

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