3.6.4 Crankshaft + Camshaft + Injector + Secondary Ignition

Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with a black plug, and the red connector is pierced into the signal line of the crankshaft sensor with a needle;

Use a BNC to banana cable, one end is connected to channel 2 of the oscilloscope, the other end is grounded with a black plug, and the red connector is pierced into the signal line of the camshaft sensor with a needle;

Use a P130A probe, one end is connected to channel 3 of the oscilloscope, and the other end is grounded with a black clip. Use a needle to pierce the signal line at the end of the injector plug, and hook the probe to the metal needle of the needle;

Use a suitable secondary ignition probe, connect one end to channel 4 of the oscilloscope, and connect the other end to the secondary ignition part of the vehicle.

Turn on the key, start the vehicle, and check the waveform.

ATO oscilloscope can be used to perform combined test on crankshaft + camshaft + fuel injector + secondary ignition. The specific operation is shown in Figure 3-53.

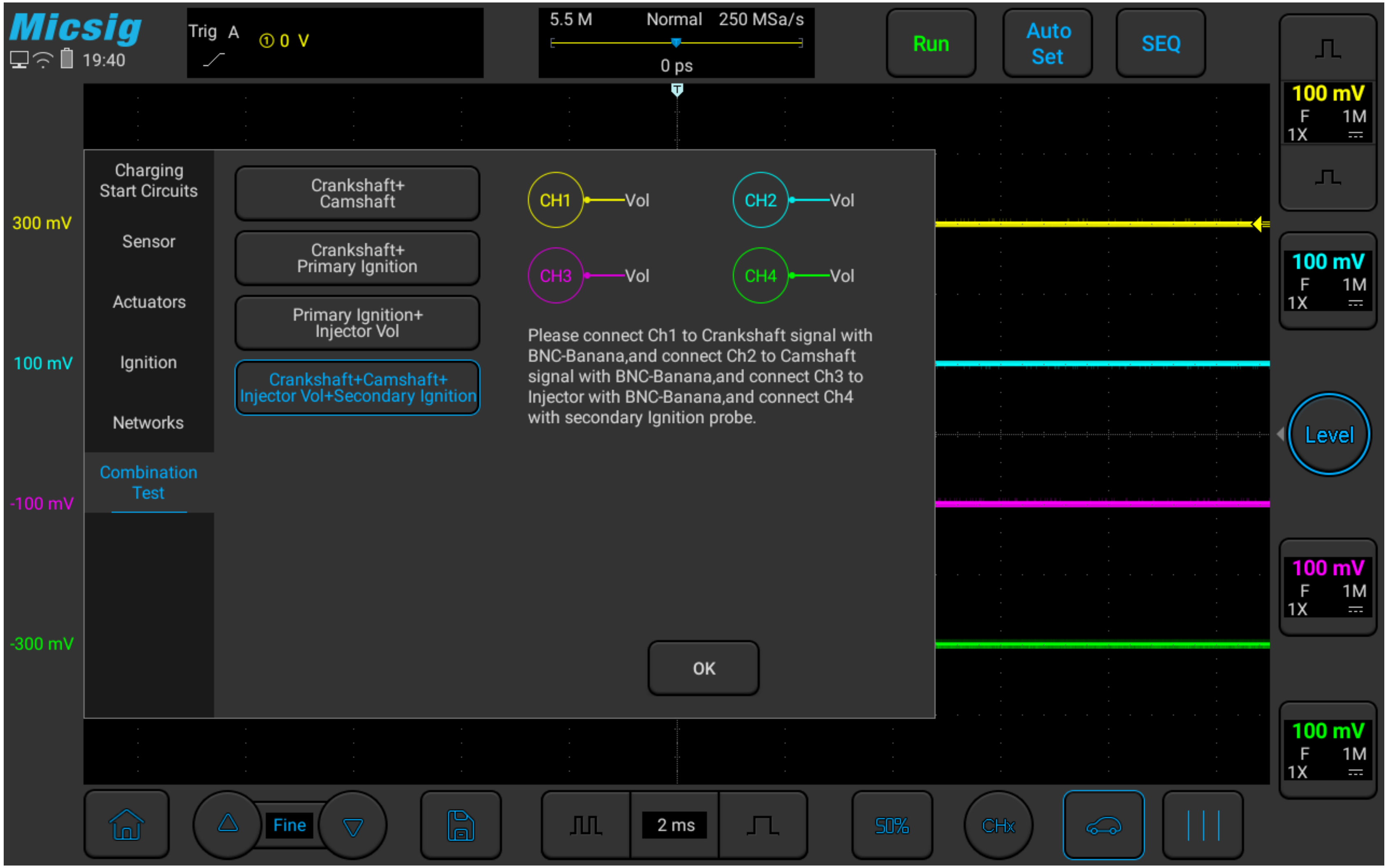


Figure 3-53 Combination test of Crankshaft + Camshaft + Injector + Secondary ignition

Chapter 4 Horizontal System

This chapter contains the detailed information of the horizontal system of the oscilloscope. You are recommended to read this chapter carefully to understand the set functions and operation of the horizontal system of the ATO series oscilloscope.

- Move the waveform horizontally
- Adjust the horizontal time base (time/div)
- Pan and zoom single or stopped acquisitions
- Roll, XY
- Zoom mode

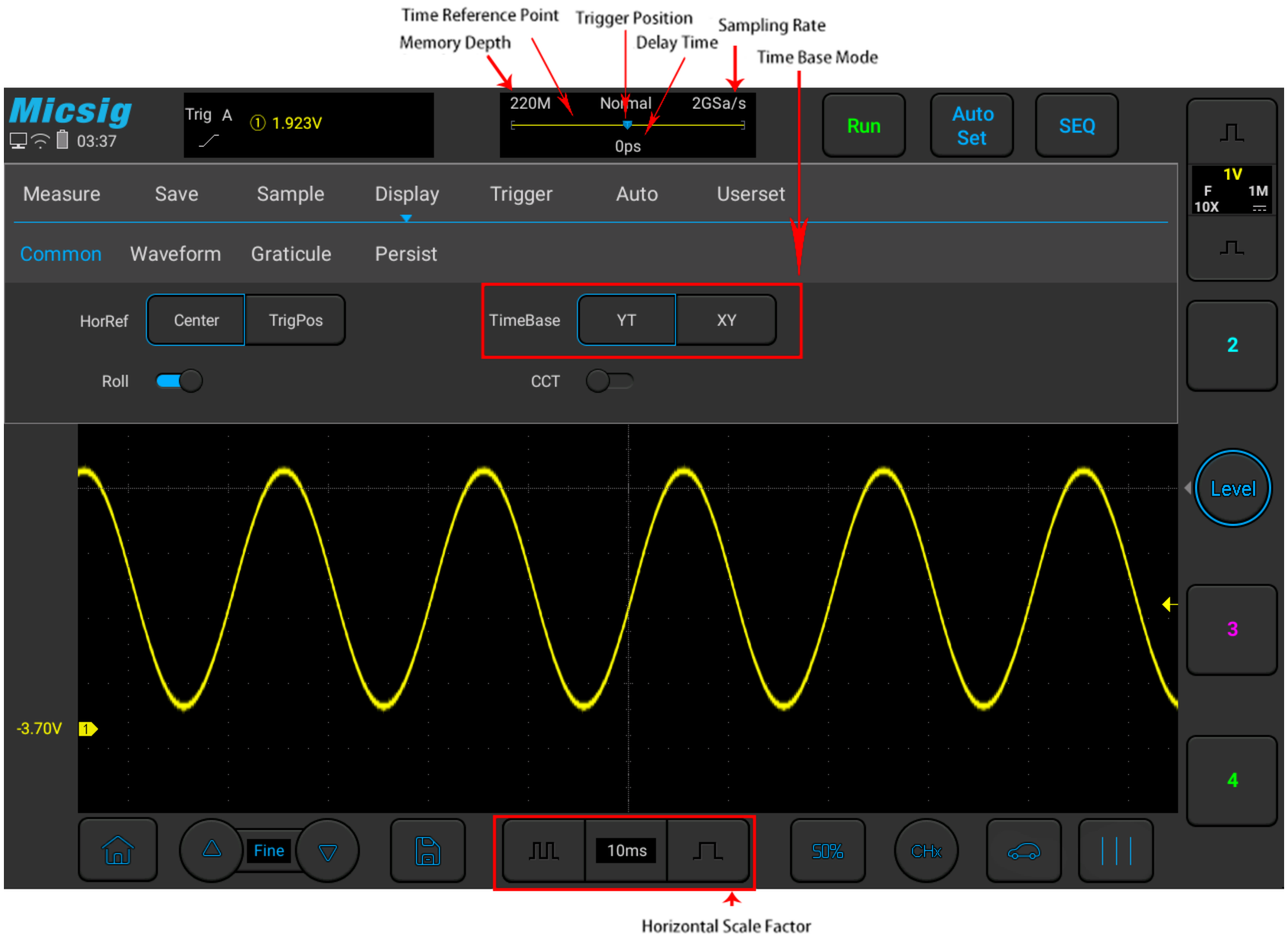


Figure 4-1 Horizontal system

4.1 Move the Waveform Horizontally

Put one finger on the waveform display area to swipe left and right, for the coarse adjustment of the waveform position horizontally of all analog channels; after moving the waveform, tap the fine adjustment button in the lower left corner of the screen for fine adjustment.

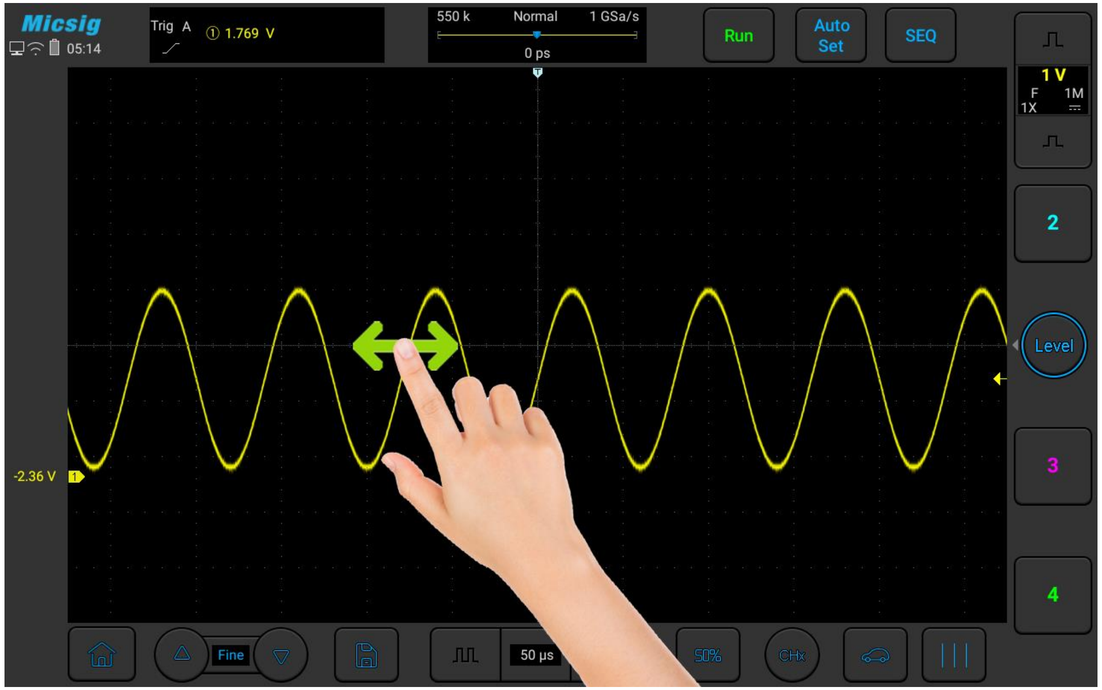


Figure 4-2 Move the Waveform Horizontally on the Screen

4.2 Adjust the Horizontal Time Base (time/div)

Method 1: Soft Keys

Tap , buttons to adjust the horizontal time base of all analog channels (current channels). Tap button to increase the horizontal time base; tap button to zoom out the horizontal time base (see Figure 4-3 Adjust the Horizontal Time Base). The horizontal time base is stepped in 1-2-5, while the waveform changes as the time base changes.

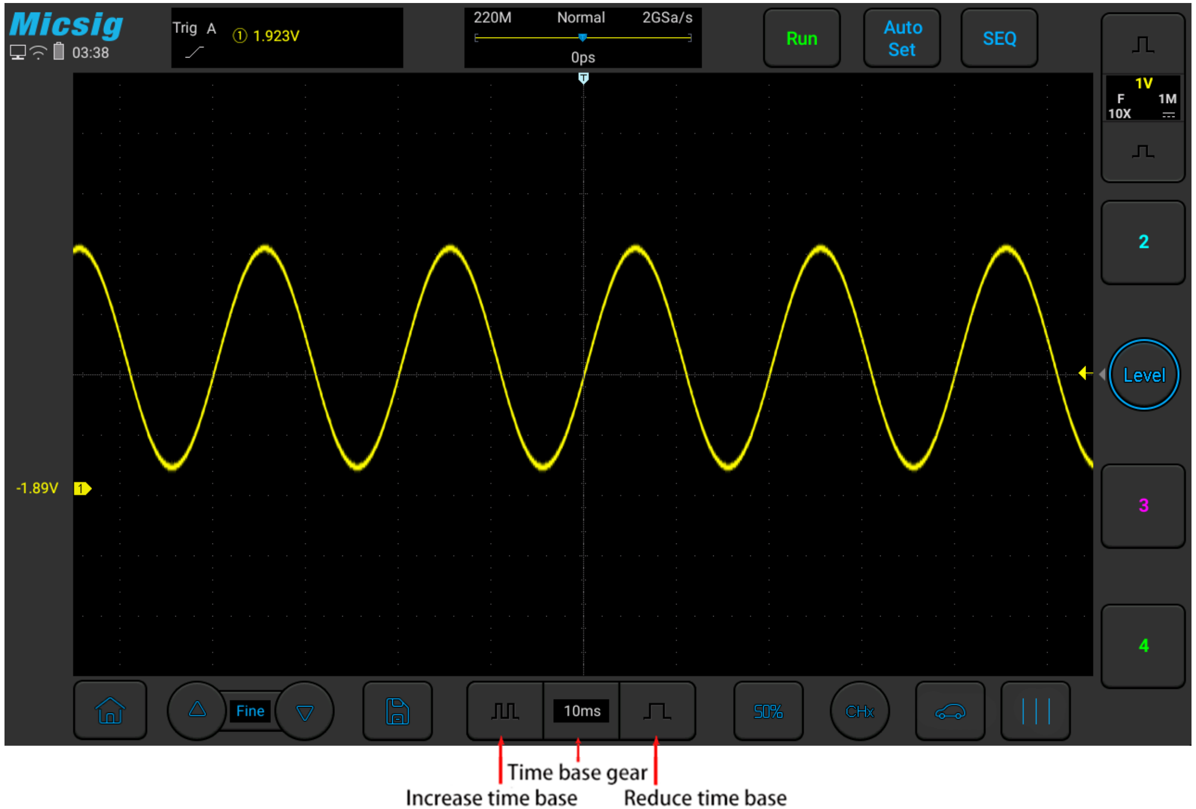
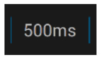


Figure 4-3 Adjust the Horizontal Time Base

Method 2: Time Base Knob

Tap 

to open the time base list (see Figure 5-4 Horizontal Time Base List), then tap the list to select the appropriate time base. The time base with the blue filled background is the currently selected time base.

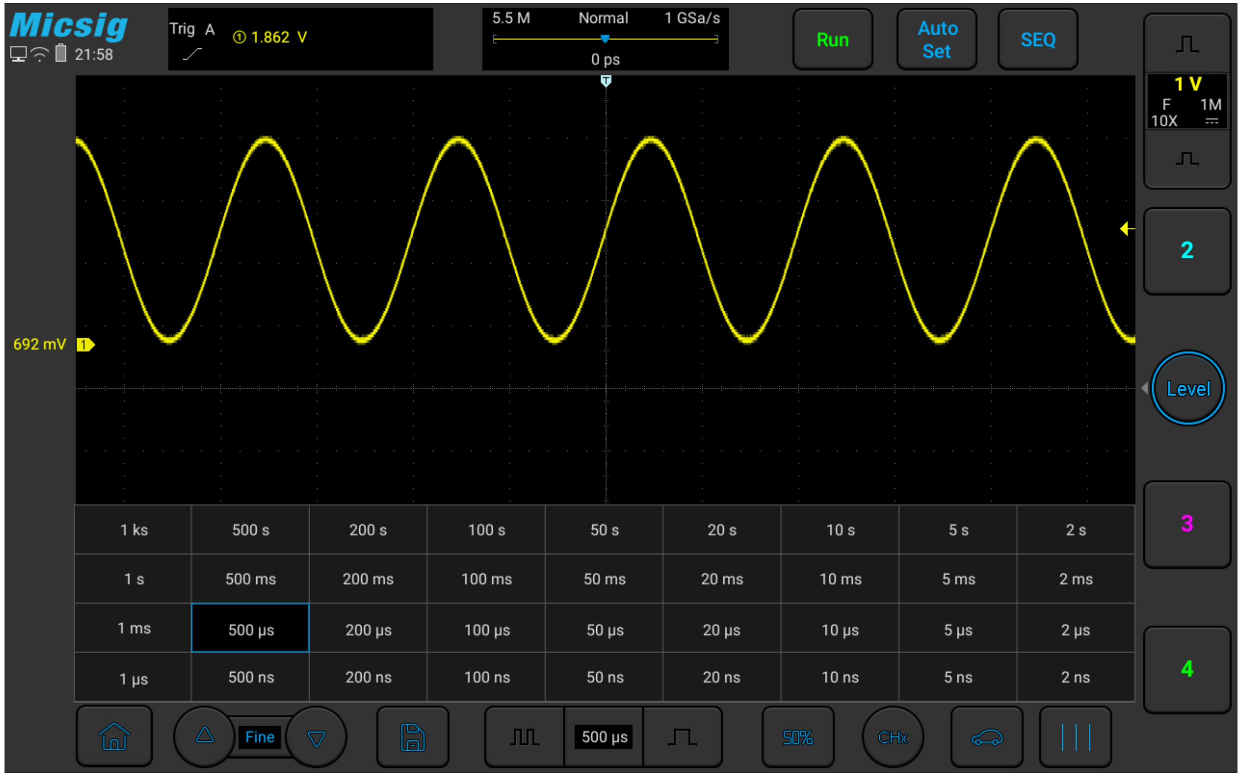


Figure 4-4 Horizontal Time Base Knob

4.3 Pan and Zoom Single or Stopped Acquisitions

After the oscilloscope is stopped, the stopped display screen may contain several acquired data with useful information, but only the data in the last acquisition can be horizontally moved and zoomed. The data of the single acquisition or stopped acquisition is moved horizontally and zoomed. For details, refer to "5.1 Move the Waveform Horizontally" and "5.2 Adjust the Horizontal Time Base (time/div)".

4.4 Roll, XY

In the main menu, tap the soft key Display, then select the desired time base mode. The time base mode is divided into YT, ROLL, and XY.

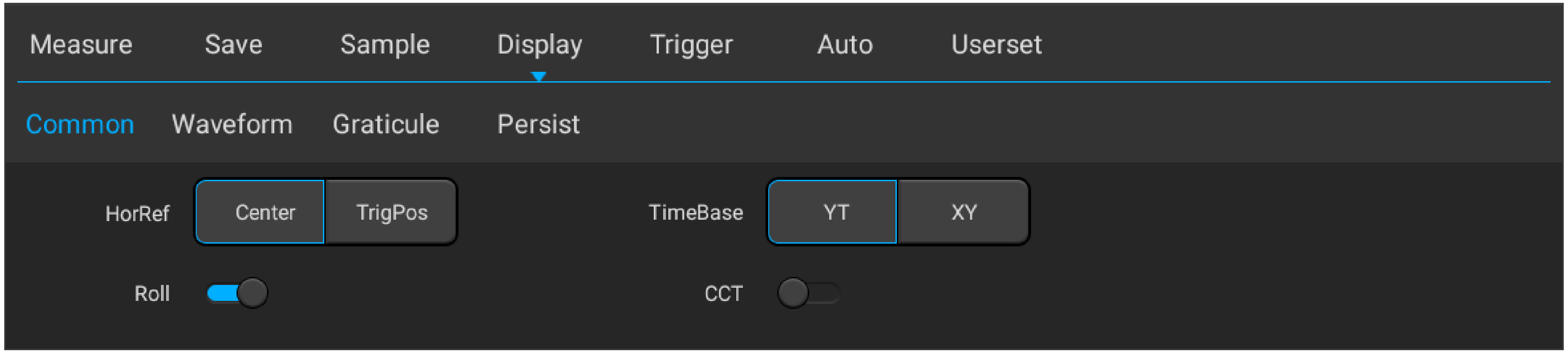


Figure 4-5 Display Mode

YT——Normal View Mode of Oscilloscope

In YT mode, the relative relationship between vertical voltage and horizontal time is displayed. Y axis represents the voltage, X axis represents the time, and the waveform is displayed after triggering (waveform displayed from left to right).

Note: When the time base is large (such as 200ms and above), sometimes the waveform will not be displayed for a long time; this is because in YT mode, the waveform must be triggered before display. It is closely related to the time base and can be roughly calculated as: the number of divisions on the left side of the trigger position * time base level position; if you want to reduce the waiting time, move the trigger position to the left.

The case that trigger position is moved out of the waveform screen is not considered here.

ROLL—— ROLL Mode

In ROLL mode, the waveform rolls from right to left to refresh the display (see Figure 4-6 ROLL Mode). The horizontal time base adjustment range of the ROLL mode in the running state is 200ms/div~1ks/div.

In ROLL mode, trigger related information is invalid, including trigger position, trigger level, trigger voltage, etc.

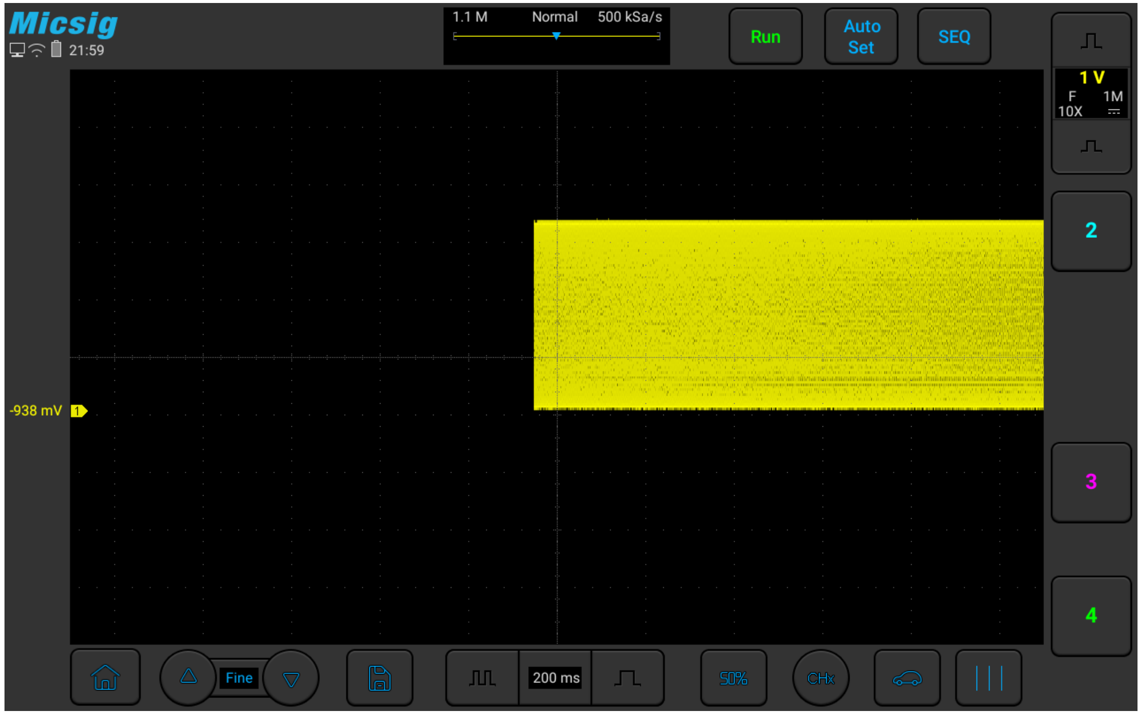
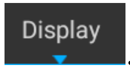


Figure 4-6 ROLL Mode

In ROLL mode, press Run to stop waveform display; press Stop again to clear waveform display and restart acquisition; press SEQ to execute single sequence, it will stop automatically after completing a full screen acquisition.

ROLL mode is generally used to observe waveforms with frequencies below 5 Hz.

ROLL mode is defaulted as open. When the time base is greater than 100ms, it automatically enters the ROLL mode. If the signal to be triggered under a large time base needs to be viewed, turn off the ROLL mode.

Roll mode on and off: In the main menu, tap the soft key 

. In the "Common" option, you can turn the roll mode on and off (refer to Figure 4-7). When the roll mode is on and the time base is within 200ms~1ks, the oscilloscope automatically enters the roll mode.

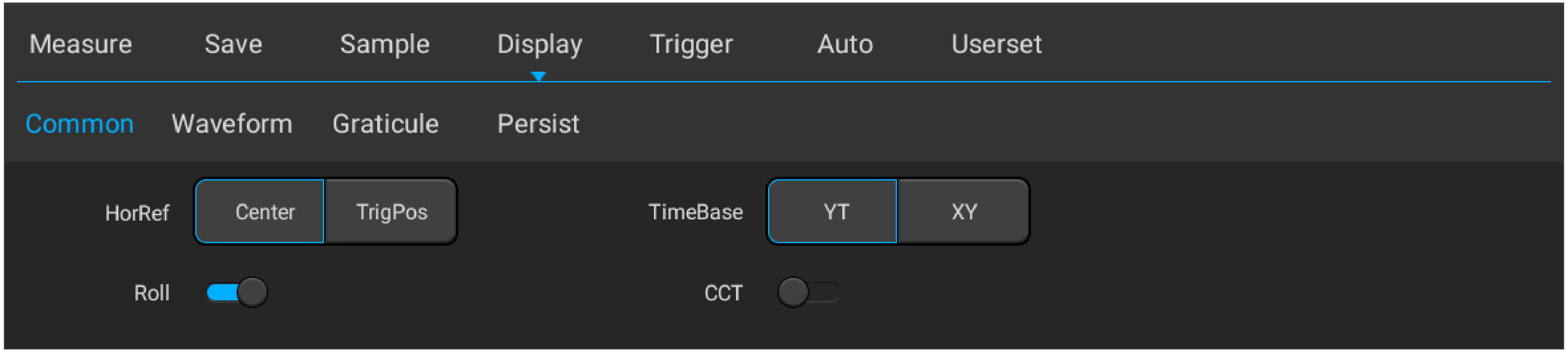


Figure 4-7 Roll Mode On/Off

XY——XY Mode

The vertical amount of CH1 is displayed on the horizontal axis in XY mode, and the vertical amount of CH2 is displayed on the vertical axis (see Figure 4-8 XY Mode).

You can use XY mode to compare the frequency and phase relationship of two signals.

XY mode can be used for sensors to display stress-displacement, flow-pressure, voltage-frequency or voltage-current, for example: plotting a diode curve.

You can also use the cursor to measure the waveform in XY mode.

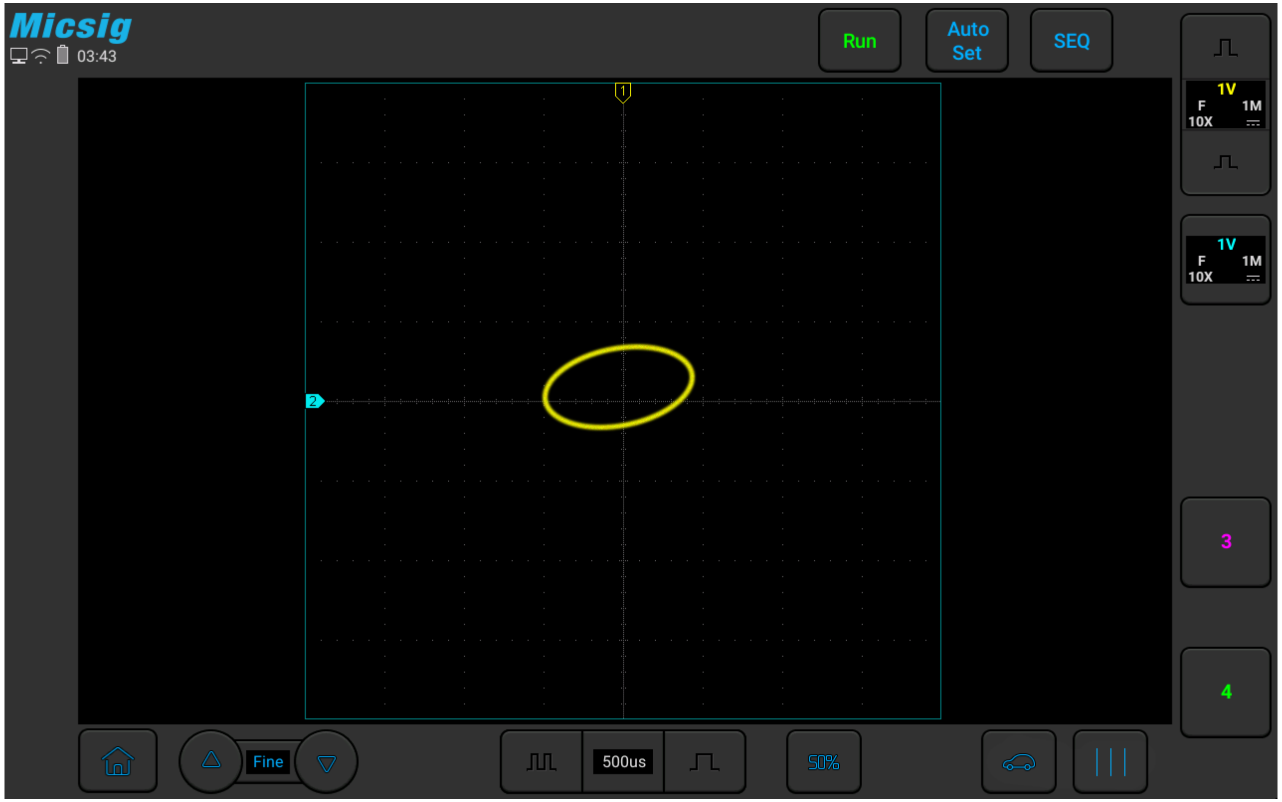


Figure 4-8 XY Mode

XY Mode Example

This exercise shows the usual practice of XY display mode by measuring the phase difference between two signals of the same frequency using the Lissajous method.

1) Connect sine wave signals to CH1 and connect sine wave signals of the same frequency and different phases to CH2.

2) Press “Auto” set button, tap “Display” in the main menu, then select “XY” in “Time Base”.

3) Drag signals so that they are centered on the display screen. Adjust the vertical sensitivity of CH1 and CH2, and extend signals for viewing.

The phase difference (θ) can be calculated using the following formula (assuming that the amplitudes of the two channels are the same):

$$\sin\theta = \frac{A}{B} \text{ or } \frac{C}{D}$$

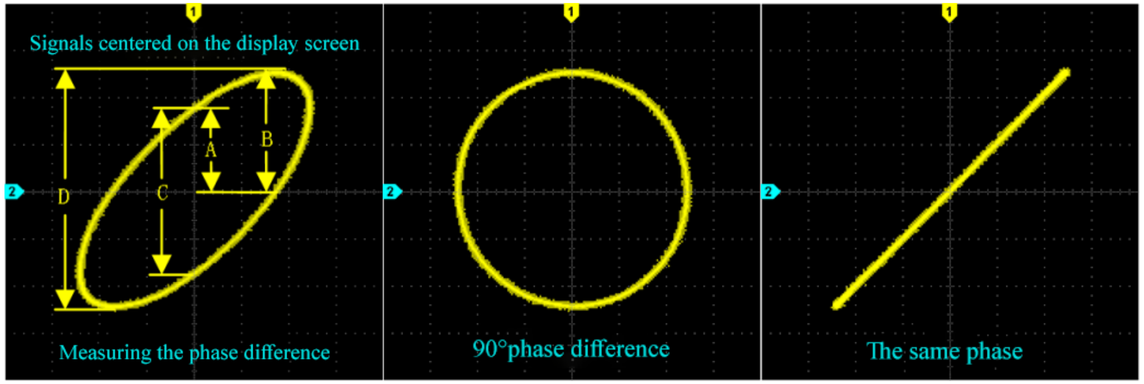


Figure 4-9 XY Time Base Mode Signal, Center on the Display Screen

4) Tap the “Cursor” button to open the horizontal cursor.

5) Set the cursor y2 at the top of the signal and the cursor y1 at the bottom of the signal. Record the Δy value in the upper right corner of the screen.

6) Move y1 and y2 cursors to the intersection point of the signal and the y-axis. Record the Δy value again.

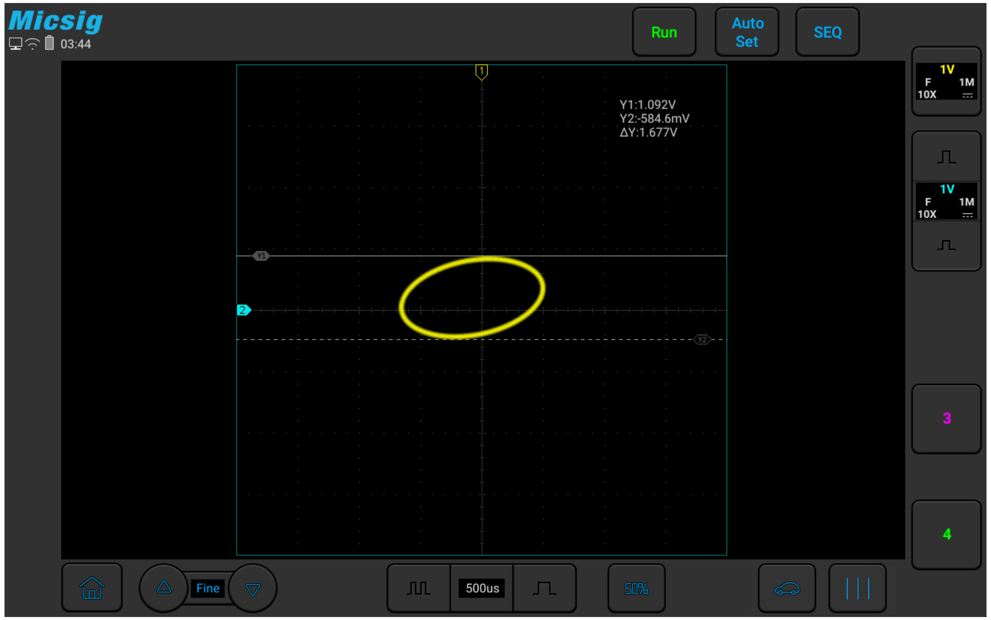


Figure 4-10 Phase Difference Measurement and Using the Cursor

7) The following formula is used to calculate the phase difference.

$$\sin\theta = \frac{Y2}{Y1}; \quad \theta = \arcsin\frac{Y2}{Y1}$$

For example, if the first Δy value is 9.97V, the second Δy value is 5.72V:

$$\sin\theta = \frac{5.72}{9.97}; \quad \theta = \arcsin\frac{5.72}{9.97}$$

4.5 Zoom Mode

Zoom is a horizontally expanded version of the normal display. Open the zoom function, the display is divided into two parts (see Figure 4-11 Zoom Interface). The upper part of the display screen shows the normal display window view and the lower part shows the zoomed display window.

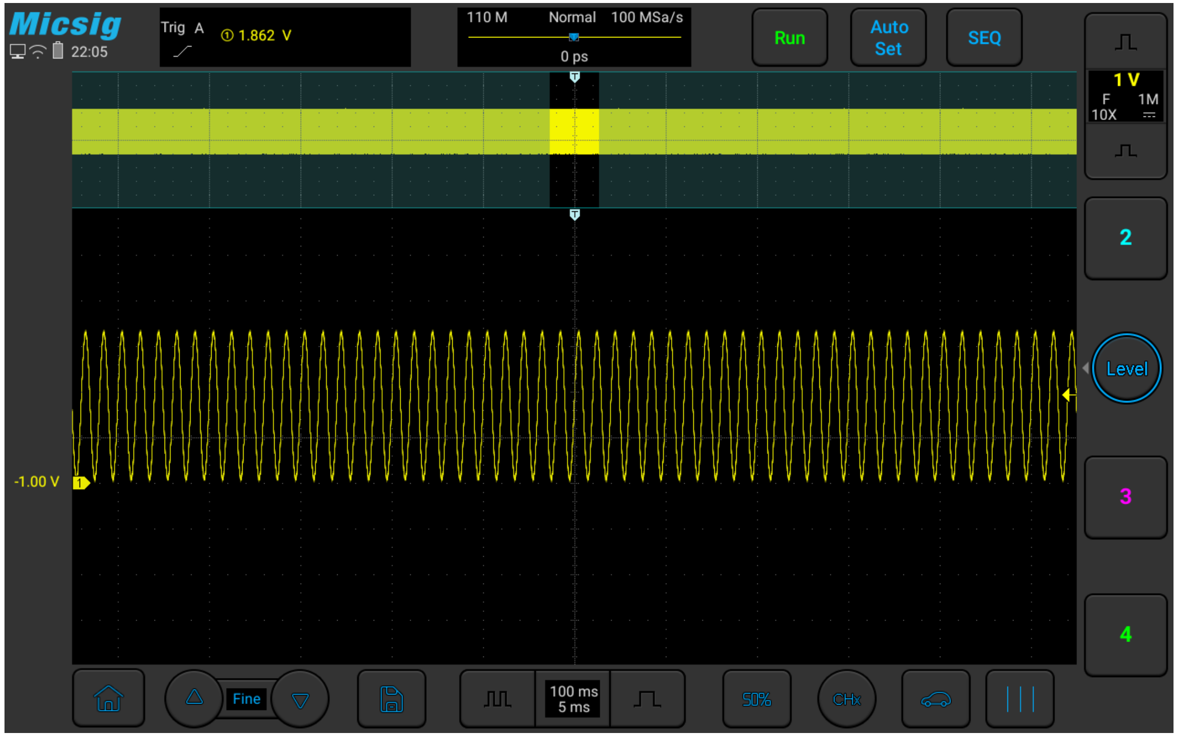
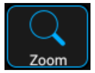


Figure 4-11 Zoom Interface

Zoom window view is the enlarged portion of the normal display window. You can use "Zoom" to view a portion of the normal window that is horizontally expanded to learn more about signal analysis.

Zoom on/off:

Open the pull-up menu and tap 

button to turn the zoom function on/off.

Zoom window is framed in a box on the normal window, and the other portion is covered by gray shade not displayed in the zoom window. This box shows the normal scan portion that was zoomed in the lower bottom.

Tap the time base button to adjust the time base of the zoom window. The size of the box in the normal window changes according to the time base of the zoom window.

Drag the waveform of the zoom window horizontally to adjust the waveform position. The box in the main window moves oppositely against the waveform; or directly drag the box in the normal window to quickly locate the waveform to be viewed.

Note:

1) The minimum time base is displayed in the normal window when the waveform in the screen is exactly within the memory depth. If the current time base is smaller than the minimum time base in the normal window at the current memory depth, when the zoom window is opened, the time base in the normal window is automatically set to the minimum time base in the normal window at the current memory depth.

2) The cursor, math waveform, and reference waveform are not displayed in the normal window, but can be displayed in the Zoom window.

3) If Roll mode is stopped, Zoom mode can be turned on, and tap “Run/Stop” to automatically turn off Zoom mode.

Chapter 5 Vertical System

This chapter contains the detailed information of the vertical system of the oscilloscope. You are recommended to read this chapter carefully to understand the set functions and operation of the vertical system of the ATO series oscilloscope.

- Open/close channel, set the current channel
- Adjust vertical sensitivity
- Adjust vertical position
- Open channel menu
- Set channel coupling
- Set bandwidth limit
- Waveform inversion
- Set probe type
- Set probe attenuation coefficient
- Vertical expansion reference

The figure below shows the "CH1 Channel Menu" displayed after opening the CH1 channel menu.

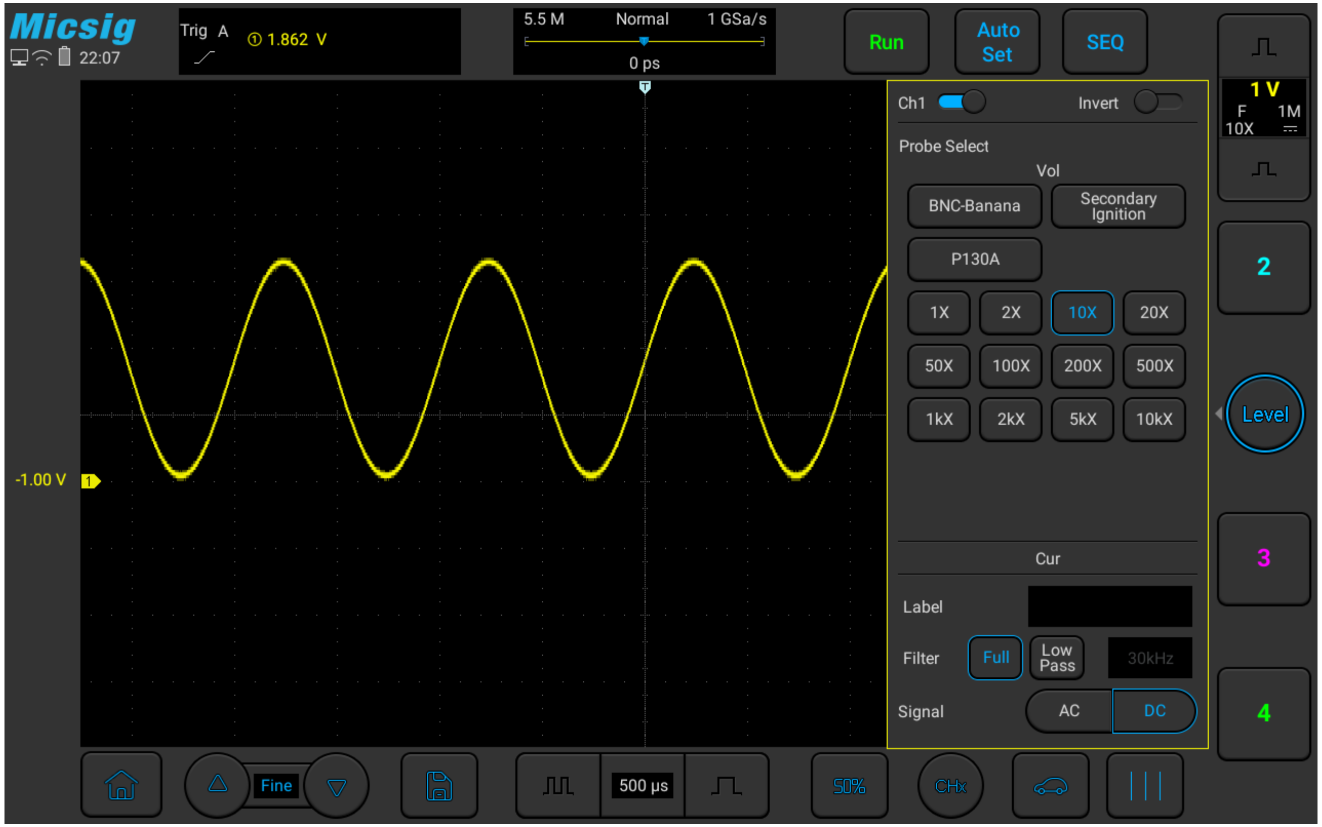


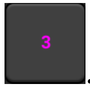
Figure 5-1 Channel Menu Display Interface

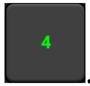
The ground level of each displayed analog channel signal is indicated by the channel indicator icon ① on the far left of the display screen.

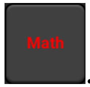
5.1 Open/Close Waveform (Channel, Math, Reference Waveforms)

The channel icons 

, 

, 

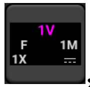
, 

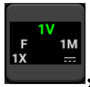
, 

, 

on the right side of the oscilloscope waveform display area (swipe up or down to switch to math channel and reference channel) correspond to the six channels of CH1, CH2, CH3, CH4, math function and reference channel. The channel icons in open state will shows like 

, 

, 

, 

, 

, 

. Swipe right to close the desired channel.

Current channel: The oscilloscope can display multiple waveforms at the same time, but only one waveform is preferentially displayed on the uppermost layer, and the channel that is preferentially displayed on the uppermost layer is called the current channel. The channel indicator for the current channel is solid, and the channel indicator for the non-current channel is hollow, as shown in Figure 5-2.

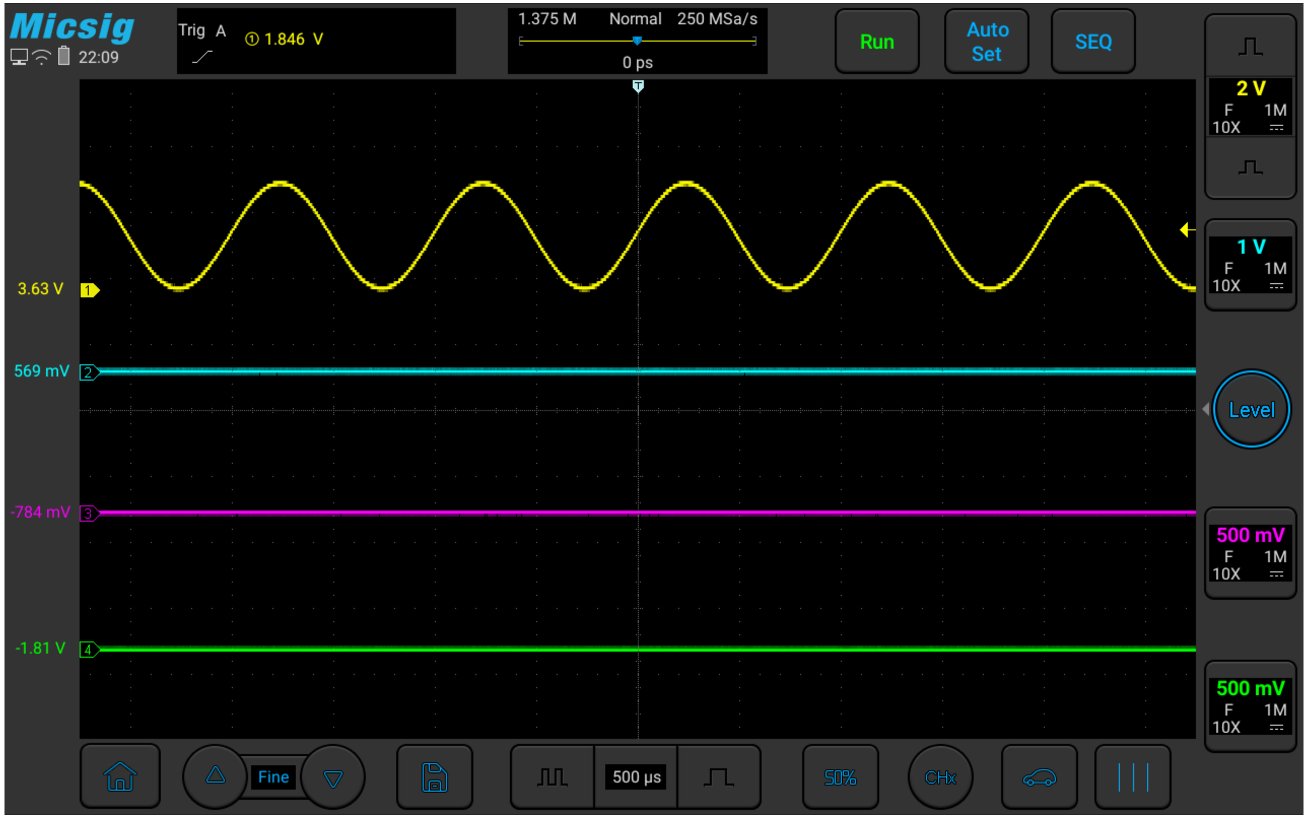


Figure 5-2 Current Channel and Non-Current Channel

The display content of the oscilloscope channel display interface includes the vertical scale, vertical scale sensitivity button, coupling mode, invert, bandwidth limitation of the channel, as shown in Figure 5-3.

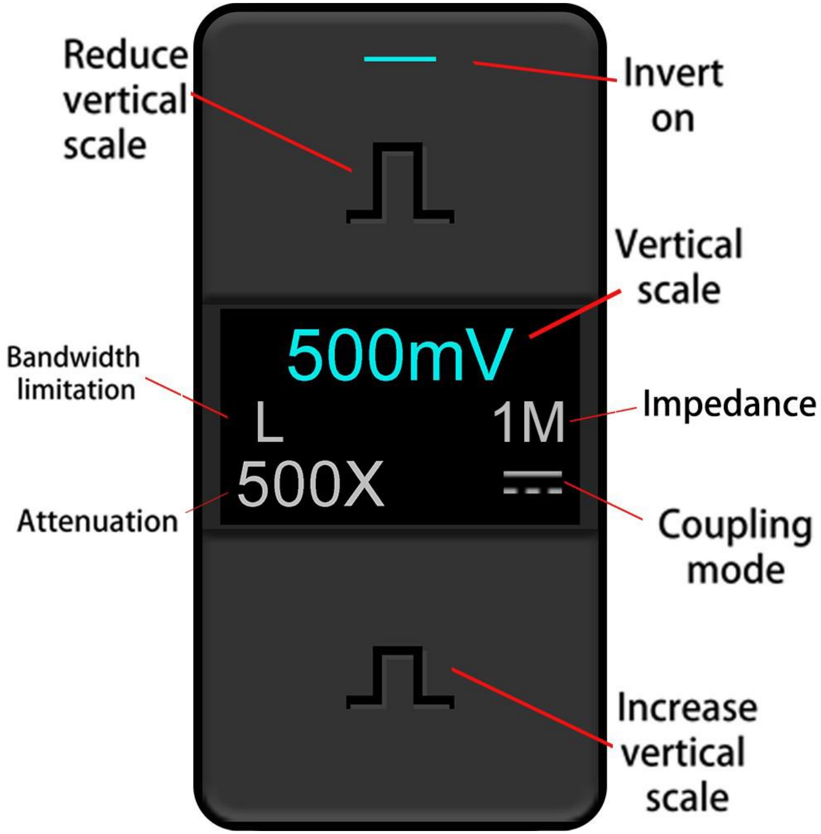


Figure 5-3 Channel Display Interface

When CH1 is on, but the state is not the current channel, tap CH1 waveform or vertical sensitivity or channel indicator ① or vertical sensitivity button or current channel selection button to set CH1 as the current channel, as shown in Figure 5-4.

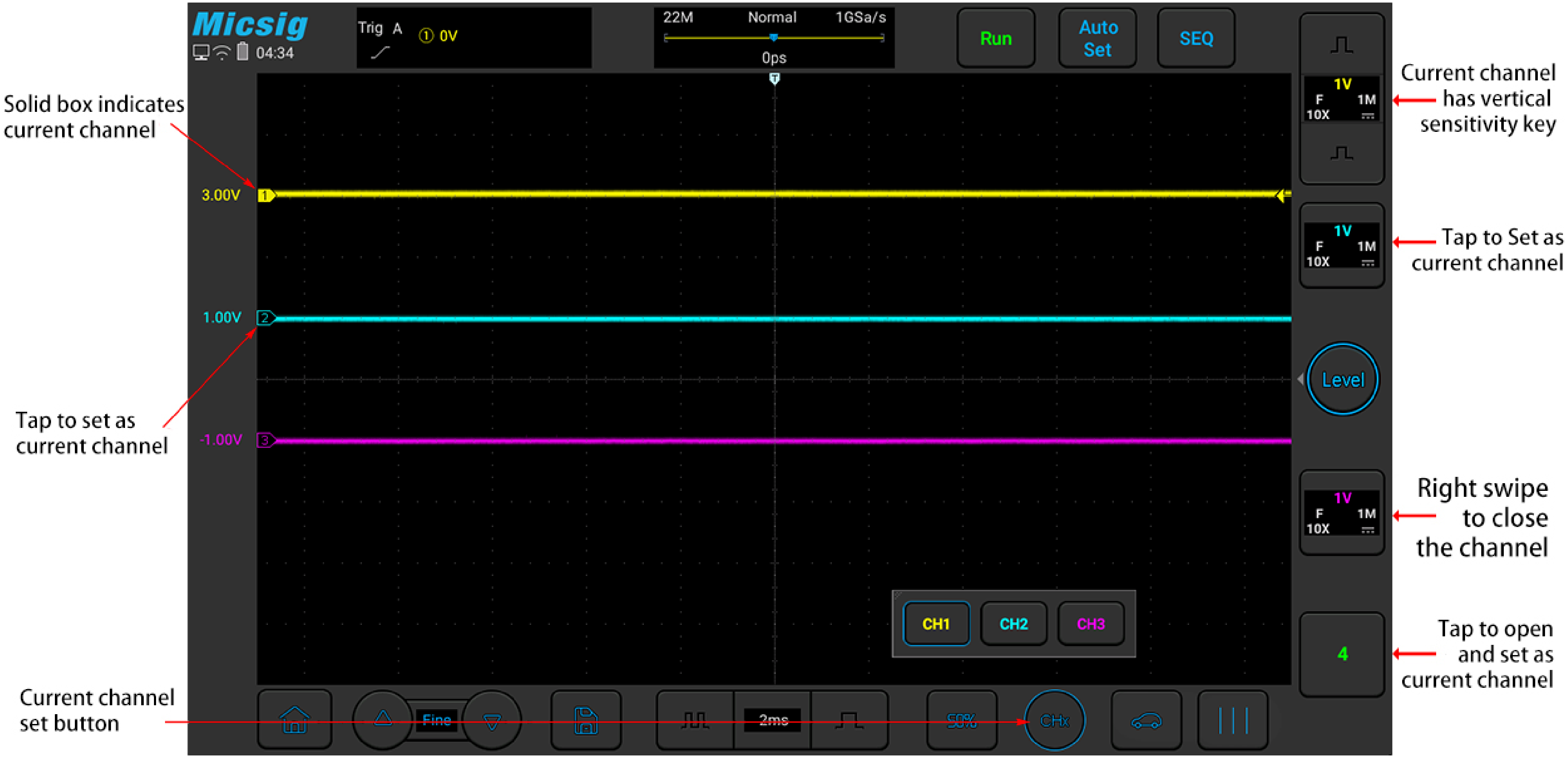


Figure 5-4 Channel Open, Close and Switching

Figure 5-5 Using the Current Channel Selection Button

Tap the current channel icon at the bottom of the screen to pop up the current channel switching menu and press the button to light it up, as shown in Figure 5-5. Tap the button in the menu to switch the current channel. When this function is opened:

a. the current channel may be switched in the channel switching menu;

b. the current channel menu can be moved anywhere on the screen;

c. only the open channel is displayed in the channel switching menu;

d. when the math or reference waveform is opened, the current channel switching menu is automatically opened.

5.2 Adjust Vertical Sensitivity

Tap the vertical sensitivity  or  buttons on the right side of the channel icon to adjust the vertical display of the waveform corresponding to the channel, so that the waveform is displayed on the screen at an appropriate size.

The vertical sensitivity scale (V/div) after each adjustment is displayed on the channel icon. For example, 

means that the current vertical sensitivity of CH1 is 1.0V/div.

The vertical sensitivity coefficient adjusts the vertical sensitivity of the analog channel in steps of 1-2-5 (the probe attenuation coefficient is 1X), and the vertical sensitivity range of 1:1 probe is 1mV/div-10V/div (optionally minimum at 500uV/div).

5.3 Adjust Vertical Position

The method of adjusting vertical position is as follows:

1) Coarse adjustment: In the waveform display area, hold the waveform and put one finger to slide up and down for changing the vertical position of the waveform.

2) Fine adjustment: Click the fine adjustment button in the lower left corner of the screen to fine adjust the vertical position of the waveform for the current channel.

5.4 Open Channel Menu

Right swipe the channel icon to open the desired channel menu.

The channel menu is shown in Figure 5-6. Channel waveform inversion, channel bandwidth limit, probe type, probe attenuation factor, channel coupling mode, channel on/off can be set in the vertical menu.

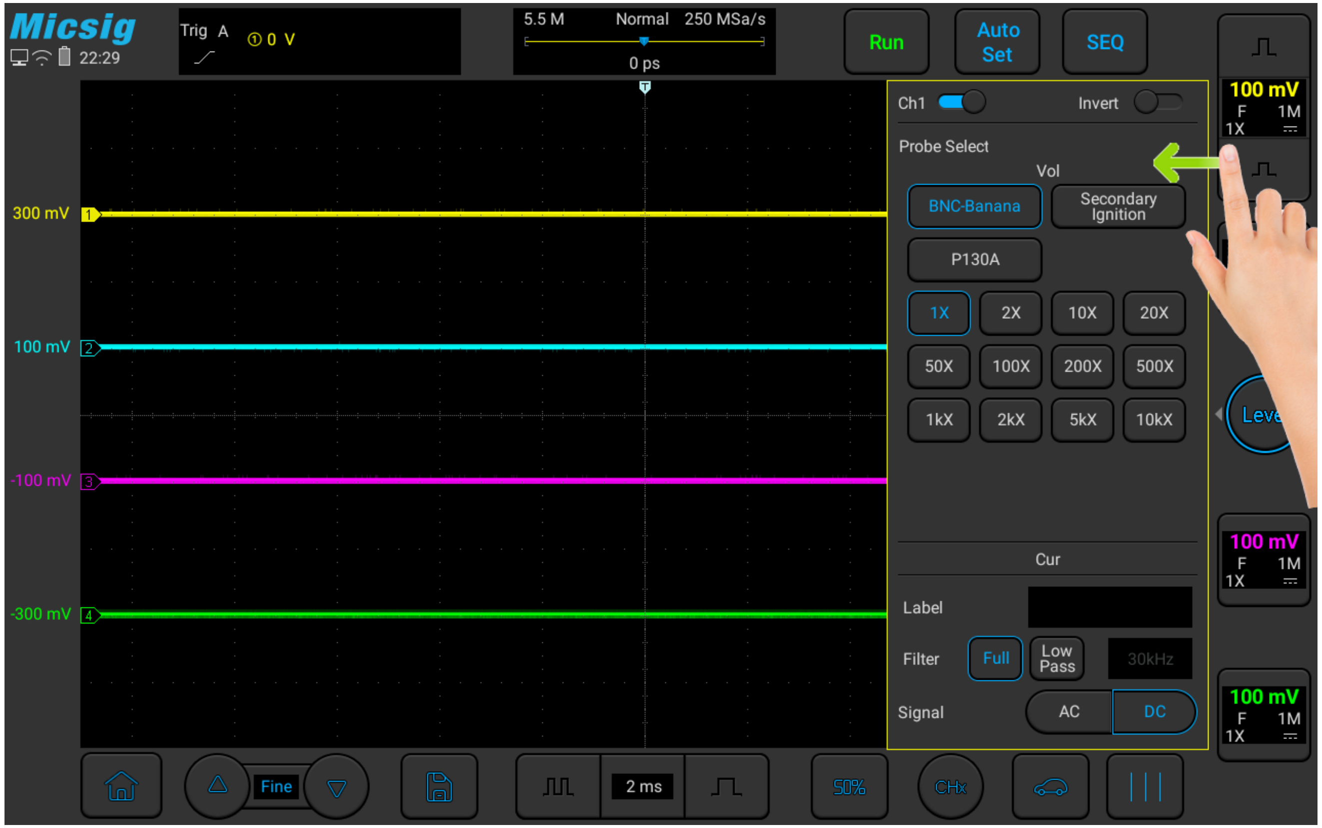


Figure 5-6 Channel menu

5.4.1 Set Channel Coupling

Tap the icon under “Signal” and select “DC”, “AC” channel coupling modes in the pop-up box.

DC: DC coupling. Both the DC component and the AC component of the measured signal can pass, and can be used to view waveforms as low as 0 Hz without large DC offset.

AC: AC coupling. Measured DC signal is blocked, and only the AC component can be allowed to pass, and used to view waveforms with large DC offsets.

The oscilloscope is connected to the square wave signal with a frequency of 1KHz, an amplitude of 2V and an offset of 1V. The waveforms of the channel couplings of DC, AC are shown in Figures 5-7, 5-8.

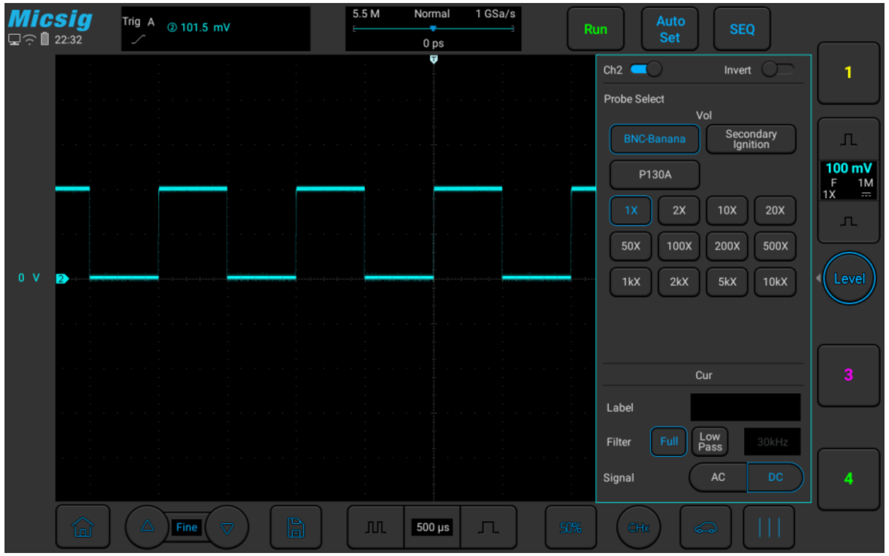


Figure 5-7 DC Coupling

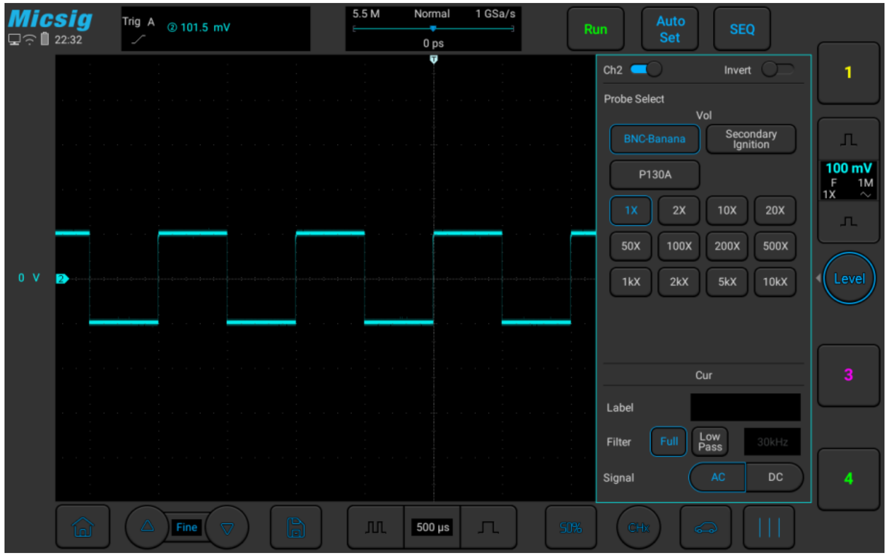


Figure 5-8 AC Coupling

Note: This setting is only valid for the current channel. To switch from the current channel, just tap the channel icon, channel indicator icon or horizontal position pointed by the channel indicator icon for direct switching. You do not need to exit the menu.

5.4.2 Set Bandwidth Limit

Open the channel menu, find the “Bandwidth” selection box in the channel menu, set bandwidth limit, high-pass filtering and low-pass filtering as needed.

Full Bandwidth: Allows signals of all frequencies to pass.

Low pass: Only signals below the currently set frequency upper limit are allowed to pass. (with the settings same as High Pass)

Low-pass filtering can be set within the frequency range of 30kHz-100MHz.

The difference in bandwidth limitation can be visualized by the waveform. The full bandwidth is shown in Figure 5-9, the low pass is shown in Figure 5-10.

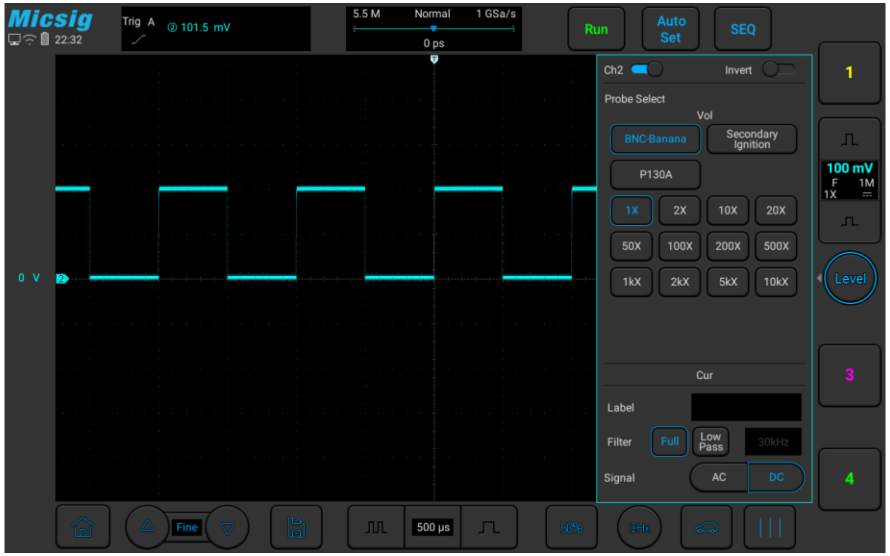


Figure 5-9 Full Bandwidth

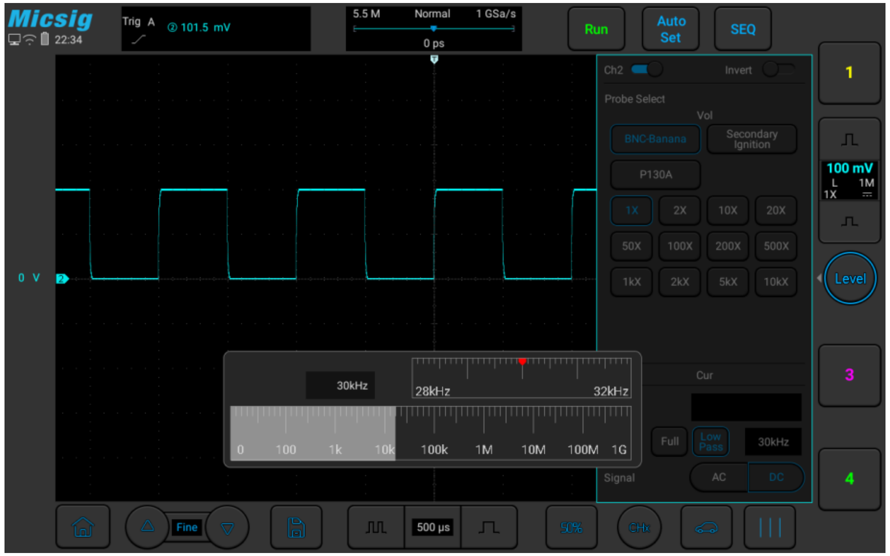


Figure 5-10 Low Pass

5.4.3 Waveform Inversion

After selecting "Invert", the voltage value of the displayed waveform is inverted. Inversion affects the way the channel is displayed. When using a basic trigger, you need to adjust the trigger level to keep the waveform stable.

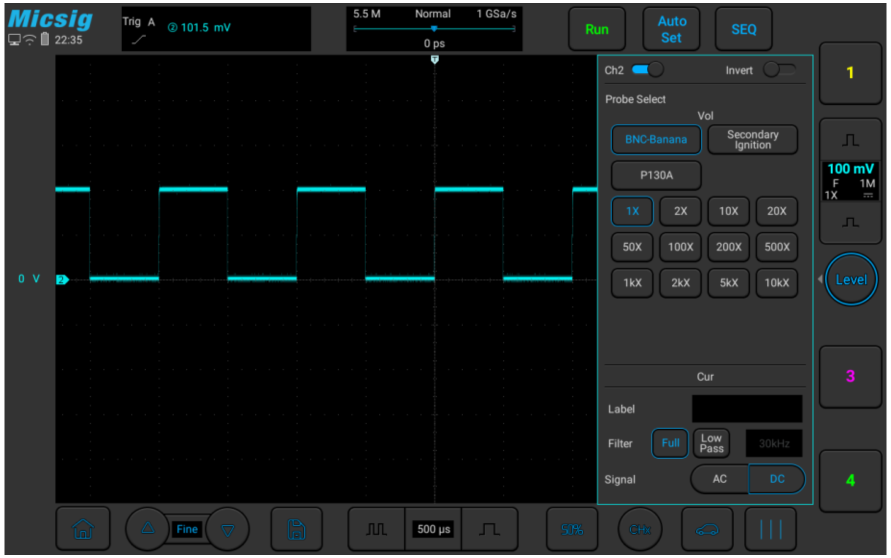


Figure 5-11 Before Inversion

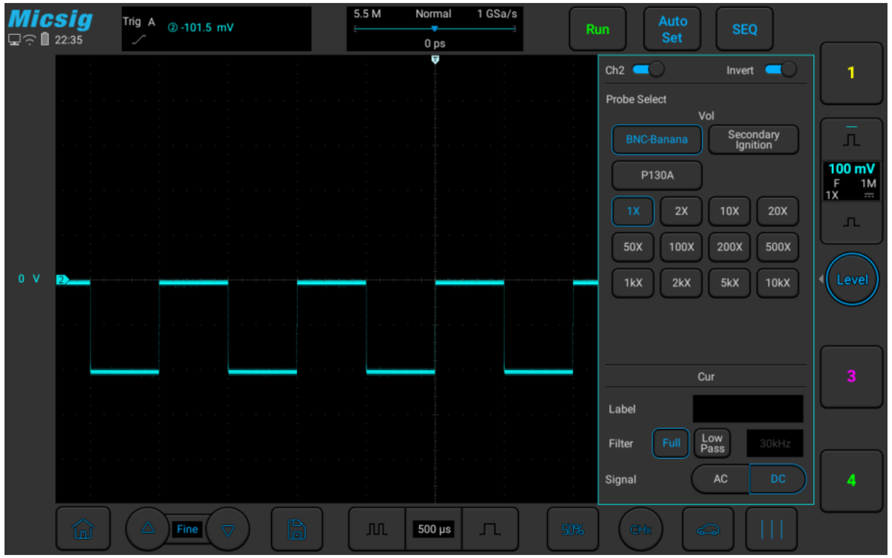


Figure 5-12 After Inversion

5.4.4 Set Probe Type

Probe types are divided into voltage probe and current probe.

Probe type adjustment steps:

Open the channel menu, find the “Probe Type” checkbox in the channel menu, then select:

- Vol - corresponding the voltage probe.
- Cur - corresponding the current probe.

5.4.5 Set Probe Attenuation Coefficient

When measuring with a probe, the correct measurement result can only be obtained by setting the correct probe attenuation ratio. In order to match the actual probe attenuation ratio, it is necessary to adjust the channel attenuation factor correspondingly under the channel menu. When probe attenuation ratio is changed, the corresponding attenuation ratio must be set on the channel menu to ensure the correctness of the waveform amplitude and measurement result displayed by the oscilloscope.

Probe attenuation ratio and menu attenuation ratio are shown in the table below:

Probe attenuation ratio / Menu attenuation ratio			
1:1	1x	200:1	200x
2:1	2x	500:1	500x
10:1	10x	1000:1	1kx
20:1	20x	2000:1	2kx
50:1	50x	5000:1	5kx
100:1	100x	10000:1	10kx

Table 5-1 Probe Attenuation Ratio Correspondence Table

5.4.6 Labels

Labels can be added to each analog channel as needed, and the added label is displayed behind the channel indicator.

Channel labels can be selected: none, custom, preset (including CAN_H, CAN_L, Flexray_H, Flexray_L).

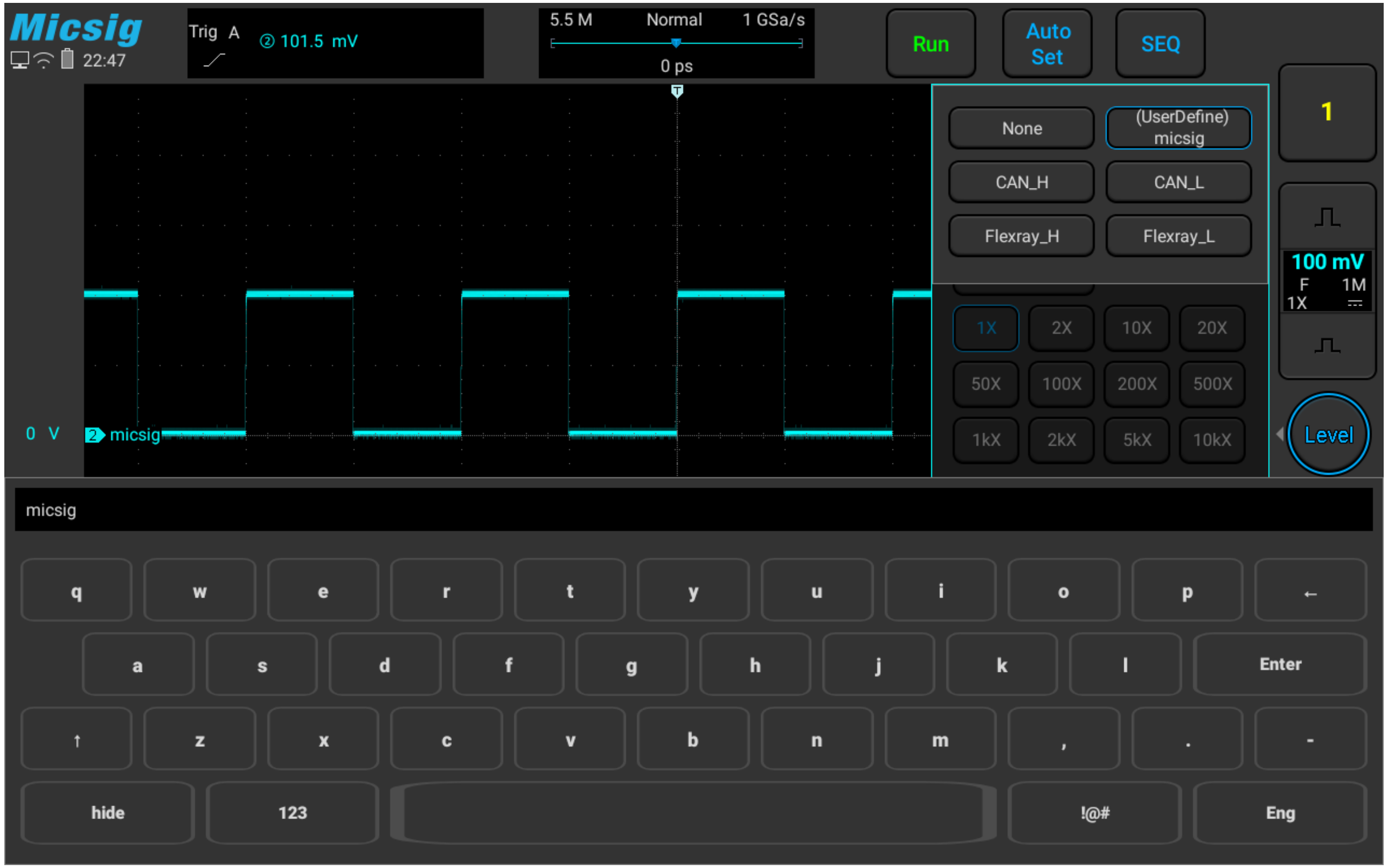


Figure 5-13 Label

Note: Customization supports up to 32 characters.

Chapter 6 Trigger System

This chapter contains the detailed information of the trigger system of the oscilloscope. You are recommended to read this chapter carefully to understand the set functions and operation of the trigger system of the ATO series oscilloscope.

- Trigger and trigger adjustment
- Edge trigger
- Pulse width trigger
- Logic trigger
- Nth edge trigger
- Runt trigger
- Slope trigger
- Time out trigger
- Video trigger
- Serial bus trigger

6.1 Trigger and Trigger Adjustment

What is Trigger?

The oscilloscope can capture a waveform only when it meets a preset condition first. This action of capturing the waveform according to the condition is **Trigger**. The so-called capture waveform is that the oscilloscope grabs a signal and displays it. **If it is not triggered, there is no waveform display**.

What can Trigger be used for?

(1) The oscilloscope can stably display a periodic signal.

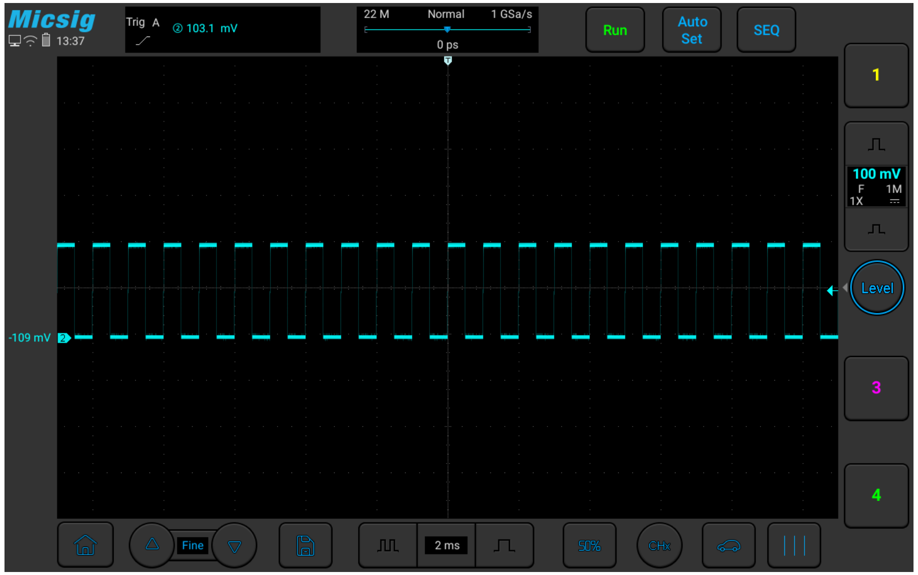


Figure 6-1 Stably Displayed Periodic Signal

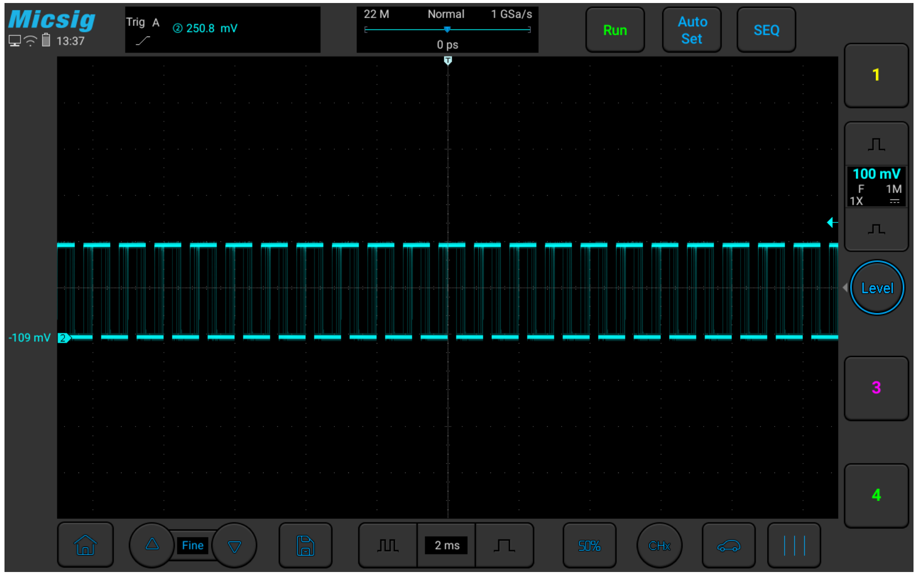


Figure 6-2 Non-Stably Displayed Periodic Signal

(2) Grab the segment you want to observe from a fast and complex signal

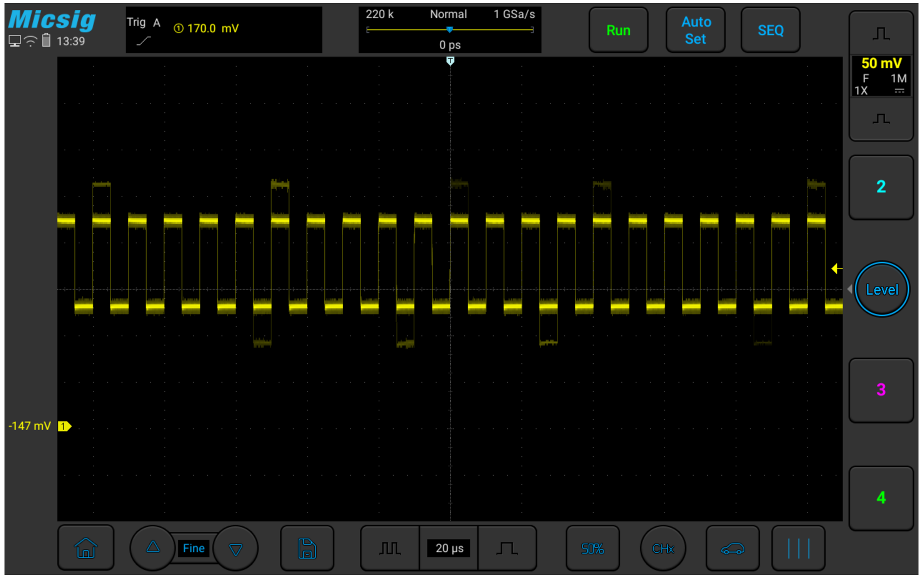


Figure 6-3 Abnormal Signal in Periodic Signals

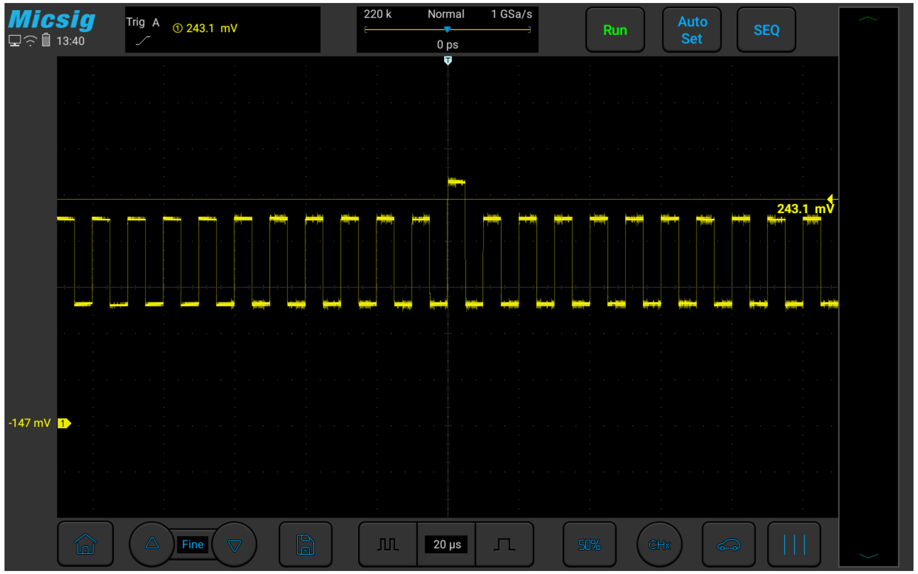


Figure 6-4 Abnormal Signal Captured by Setting Trigger Level

What is Forced Trigger?

When the oscilloscope does not meet the trigger condition, the artificial or automatic oscilloscope trigger is the forced trigger. It means that the oscilloscope only grabs a signal segment for display regardless of whether the condition is met or not.

Automatic forced trigger is set in the menu. In the trigger settings, there is usually a trigger mode option, which can be set as “Normal” or “Auto”. Normal trigger means trigger after meeting the set condition. Automatic trigger is a kind of forced trigger. The oscilloscope will be force triggered if it does not trigger for a certain period of time.

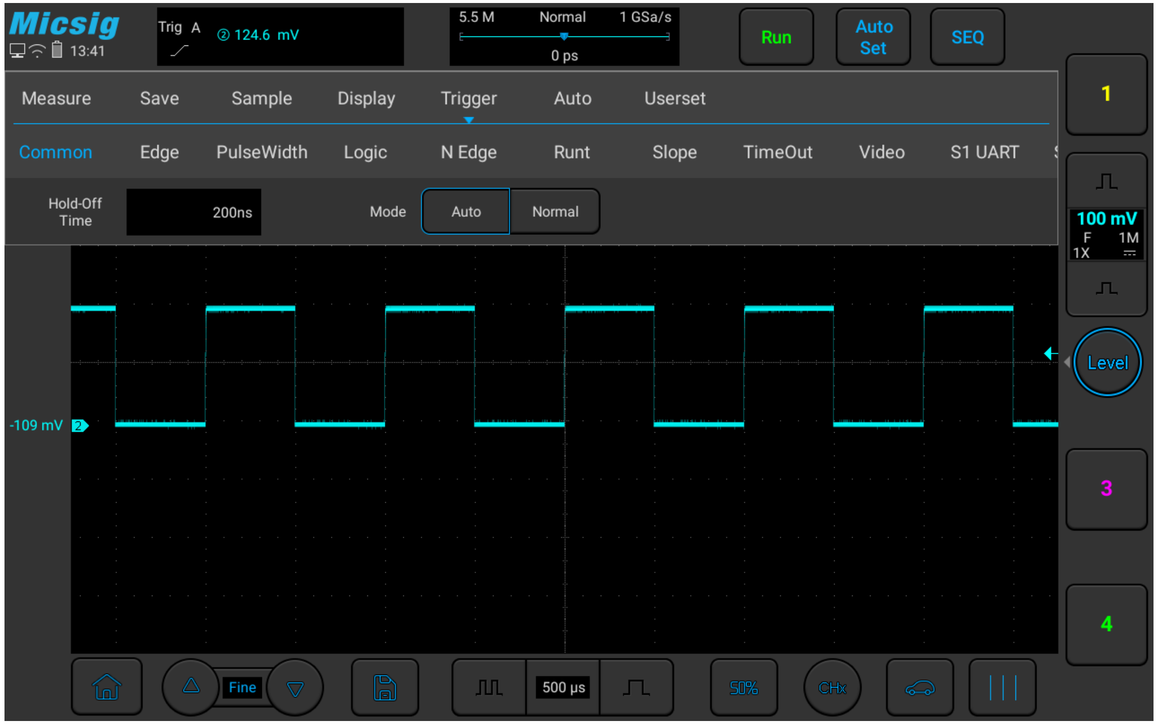


Figure 6-5 Oscilloscope Trigger Mode Setting

If a signal feature is not understood, the oscilloscope should be set as "**Auto**" mode, which can ensure that the oscilloscope can also display the waveform when other trigger settings are not correct. Although the waveform is not necessarily stable, it can provide the intuitive judgment for our further adjustment of the oscilloscope. The signal in Figure 2-10 is the result of forced trigger in "**Auto**" mode.

When we set a specific trigger condition for a specific signal, especially when the time interval for satisfying the trigger condition is long, we need to set the trigger mode to "**Normal**" so as to prevent the oscilloscope from automatic forced trigger.

Figure 6-6 shows a conceptual demonstration of the acquisition memory. In order to understand the trigger event, the acquisition memory can be divided into pre-trigger and post-trigger buffers. The position of the trigger event in the acquisition memory is defined by the time reference point and trigger position (horizontal delay) settings.

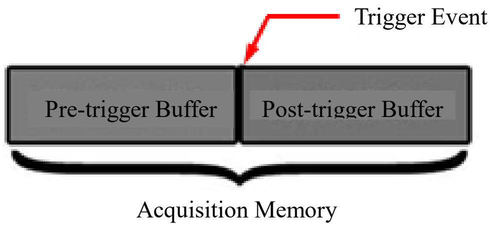


Figure 6-6 Conceptual Demonstration of Acquisition Memory

All events displayed to the left of the trigger point ⛉ occur before trigger. These events are called pre-trigger messages that show events before the trigger point. All events to the right of the trigger point is called post-trigger messages. The number of delay ranges available (pre-trigger and post-trigger messages) depends on the selected time base and memory depth.

Adjust trigger position (horizontal delay)

Fingers swipe left and right in the waveform display area, the trigger point will move horizontally, the horizontal delay time changes, and the delay time is displayed at the top center of the screen, that is, the distance between the trigger point and the center line of the waveform display area is displayed.

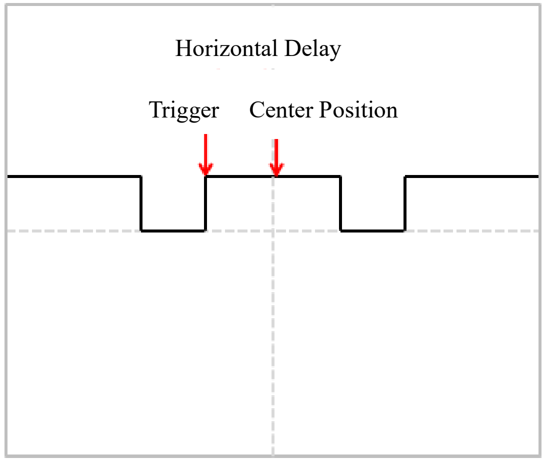


Figure 6-7 Horizontal Delay

When the trigger point is located on the left side to the center line of the waveform display area, the delay time is displayed as a positive value; When the trigger point is located on the right side to the time reference point , and the delay time is displayed as a negative value; the trigger point overlaps with the center line of the waveform display area, and the delay time is zero.

Trigger level

Trigger level is the signal voltage corresponding to the set trigger point. When the trigger level is changed, a horizontal line will appear temporarily on the screen to tell you the level position (the specific value of the trigger level is displayed in the upper right corner of the screen), then the horizontal line disappears, the trigger level is indicated by a small arrow and the indication icon can be dragged to adjust the trigger level value. The trigger level is shown in Figure 6-8 (the arrow indicates the trigger level line).

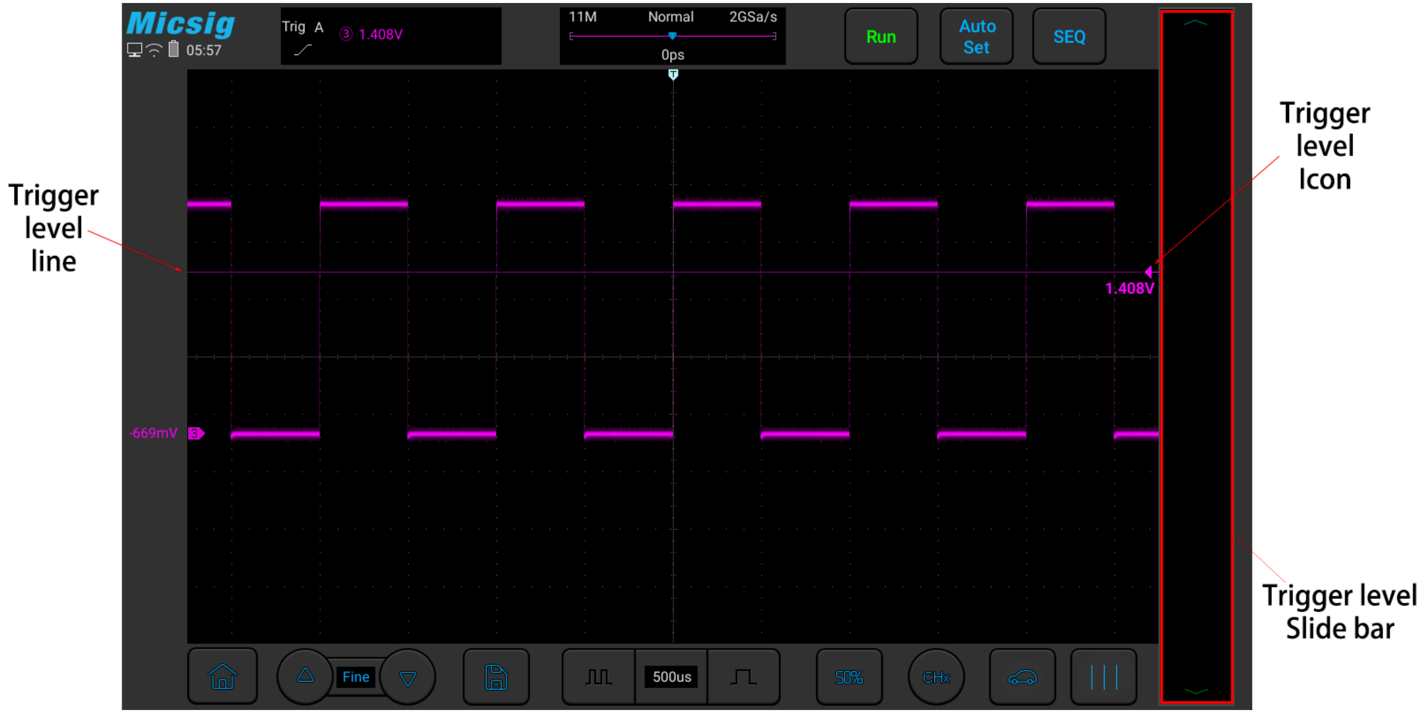


Figure 6-8 Trigger Level

Adjust trigger level

The trigger level can be coarsely adjusted and finely adjusted.

Coarse adjustment: Slide up and down in the trigger level adjustment area.

Fine adjustment: Tap the fine adjustment button in the lower left corner of the screen for fine adjustment of the trigger level.

Trigger setting shortcut

Left swipe from trigger level slide bar to open trigger setting shortcut, which includes trigger source, trigger mode etc.

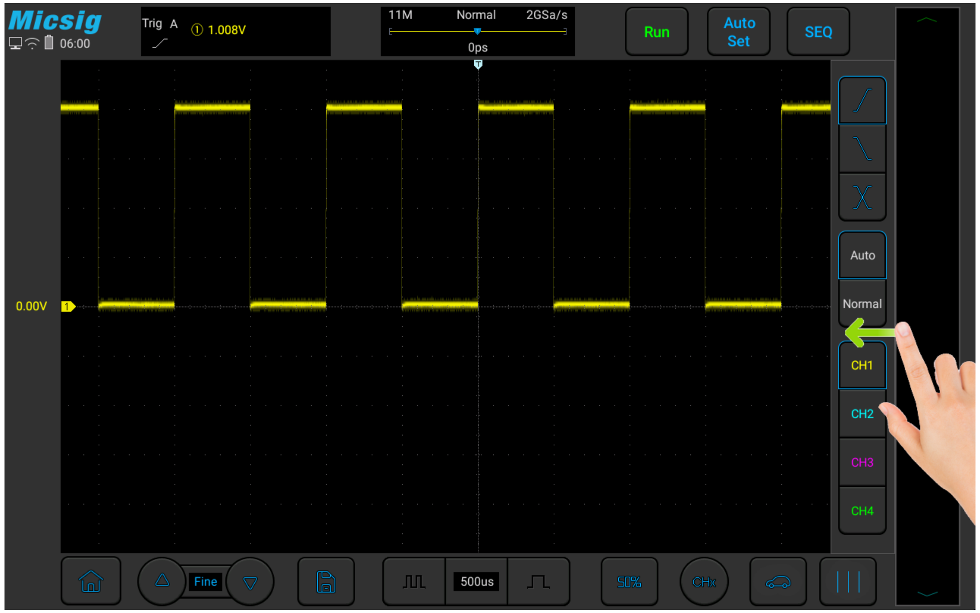


Figure 6-9 Trigger setting shortcut

Set trigger hold-off time

The trigger hold-off time can set up the waiting time of the oscilloscope after the trigger and before the trigger circuit is reconnected. During hold-off time, the oscilloscope does not re-trigger until the end of the hold-off time, and the hold-off time can be used to stably trigger complex waveforms. The trigger hold-off time ranges from 200ns~10s.

The hold-off may be used to trigger on repetitive waveforms with multiple edges (or other events) between waveform repetitions. If the shortest time between triggers is known, the hold-off may also be used to trigger on the first edge.

For example, to obtain stable trigger on the repetitive pulse trigger shown below, set the hold-off time to a value >200ns but <600ns.

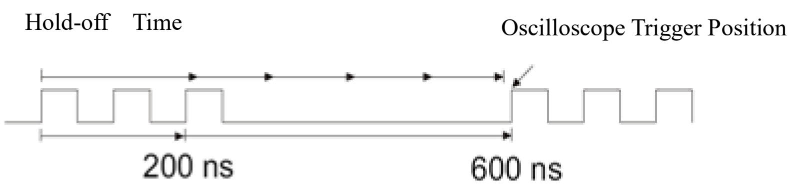


Figure 6-10 Trigger Hold-Off Time

Set trigger hold-off time:

1) Tap "Trigger" on the main menu to open the trigger menu. Under "Common", tap the box after "Rejection Time" to open the hold-off time adjustment interface. The trigger time is displayed on the upper left, the fine adjustment time scale is displayed on the upper right, and the coarse time scale is displayed below, as shown in Figure 6-11.

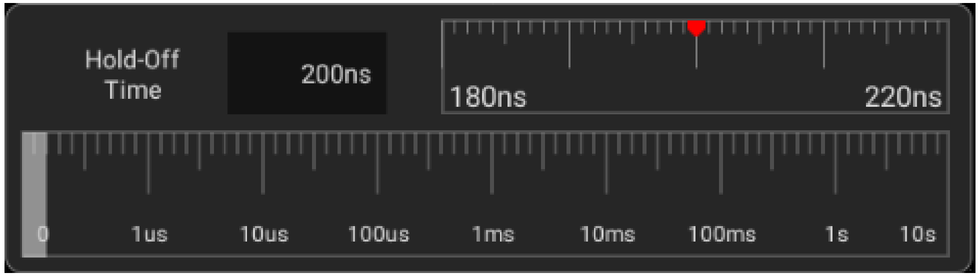


Figure 6-11 Trigger Hold-Off Time Set Interface

2) When adjusting the time, drag or tap the coarse adjustment scale for coarse adjustment, and then drag the fine adjustment scale for fine adjustment of the hold-off time.

Trigger hold-off operation prompt

It is typically used for complex waveforms. The correct rejection setting is usually slightly smaller than one repetition of the waveform. Setting the hold-off time to this time can become the only trigger point for the repetitive waveform.

Changing the time base setting will not affect the trigger hold-off time.

Using Zoom function, you can tap “Run/Stop” to stop, then horizontally move and zoom the data to find the position where the waveform is repeated. Use the cursor to measure this time and then set the hold-off time.

- Use “SEQ” button for single acquisition

Usually when performing a single acquisition, you must initiate some operations on the measured equipment, and the oscilloscope is not desired to trigger automatically before these operations. The trigger condition indicator WAIT is displayed in the upper left corner of the screen before starting operations in the circuit (this means the pre-trigger buffer is filled).

6.2 Edge Trigger

When the edge of trigger signal reaches a certain trigger level, the set signal is triggered and generated. Trigger occurs on either edge of the rising edge (indicating icon at the top of the screen), falling edge () or dual edge (), and the trigger level can be set to change the vertical position of the trigger point on the trigger edge, namely the intersection point of the trigger level line and the signal edge. The stable waveform can be obtained by correctly setting the edge trigger coupling mode. Edge trigger menu is shown in the table below:

Trigger Option	Setting	Description
Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source

Slope	Rising edge	Set signal trigger on the rising edge
	Falling edge	Set signal trigger on the falling edge
	Dual edge	Set signal trigger on either rising edge or falling edge
Coupling	DC	AC and DC components getting through trigger signals
	AC	Filter out the DC component of trigger signals
	HF rejection	Suppress signals above 50KHz in trigger signals
	LF rejection	Suppresses signals below 50KHz in trigger signals
	Noise rejection	Low-sensitivity DC coupling to suppress high-frequency noise in trigger signals

Set CH1 rising edge trigger and coupling as DC with operation steps as follows:

1) Tap “Trigger” on the main menu to open the trigger menu, select edge trigger in the trigger type, and set edge trigger as follows, as shown in Figure 6-12:

- Trigger source: CH1;

- Trigger coupling mode: DC;
- Trigger edge: rising.

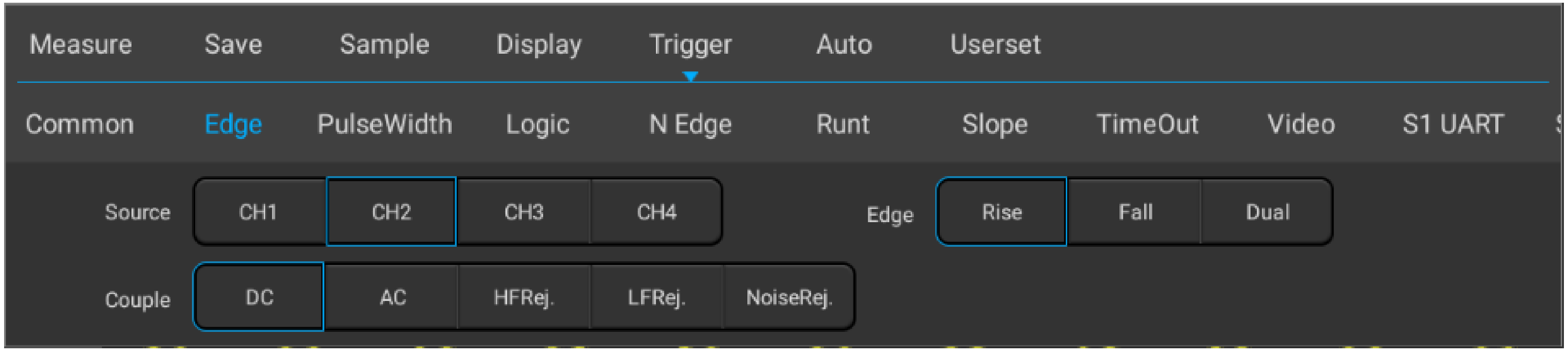


Figure 6-12 Edge Trigger Setting Menu

2) Adjust the trigger level to ensure that the waveform can be triggered stably, for example, the trigger level is set to 1V.

Trigger coupling description

When the edge trigger setup menu is opened, the trigger coupling option is displayed below the menu. Trigger coupling includes DC, AC, HFRei., LFRej., NoiseRej, see Figure 6-13:

Figure 6-13 Trigger Coupling Menu

1) DC coupling - allows DC and AC signals to enter the trigger path.

2) AC coupling - removes any DC offset voltage from the trigger waveform.

   When the waveform has a large DC offset, stable edge triggering can be achieved using AC coupling.

3) HFRej. (High Frequency Rejection Coupling) - removes high frequency components from the trigger waveform, using high frequency rejection to remove high frequency noises or noises from fast system clocks, from trigger paths such as AM or FM radio stations.

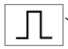
4) LFRej. (Low Frequency Rejection Coupling) - removes any unnecessary low frequency components from the trigger waveform, for example, power line frequencies that can interfere with correct trigger.

When there is low frequency noise in the waveform, stable edge triggering can be obtained using LF rejection coupling.

5) NoiseRej. (Noise Rejection Coupling) - Noise rejection can add extra hysteresis to the trigger circuit. By increasing the trigger hysteresis band, the possibility of noise triggering can be reduced. But it also reduces the trigger sensitivity, so triggering the oscilloscope requires a slightly larger signal.

Note: Trigger coupling is independent of channel coupling.

6.3 Pulse Width Trigger

The trigger happens when the trigger signal pulse width (8ns~10s, the trigger type indication icon at the top of the screen is ) reaches the set condition and the signal voltage reaches the set trigger level. Pulse width trigger menu is shown in the following table:

Trigger Option	Setting	Description
Trigger Source	CH1	Set CH1 as trigger signal source

Trigger Option	Setting	Description
	CH2	Set CH2 as trigger signal source
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Polarity	Positive	Trigger on setting the positive pulse width of signals
	Negative	Trigger on setting the negative pulse width of signals
Trigger Condition	$<$T	Trigger when the signal pulse width is smaller than pulse width T
	$>$T	Trigger when the signal pulse width is greater than pulse width T
	$=$T	Trigger when the signal pulse width is equal to pulse width T
	$\neq$T	Trigger when the signal pulse width is not equal to pulse width T
Trigger Pulse Width	8ns~10s	Set the trigger pulse width

Notes: Conditions of greater than, smaller than, equal to or not equal to indicating that the error is 6%.

Trigger steps of positive polarity pulse width: (taking CH1 as an example)

1) Tap “Trigger” on the main menu to open the trigger menu, select the pulse width trigger in the trigger type, and set the pulse width trigger as follows, as shown in Figure 6-14:

- Trigger source: CH1;
- Trigger pulse polarity: positive;
- Trigger level: 1V
- Trigger condition and pulse width time: “greater than”, the adjustment time is 180us.

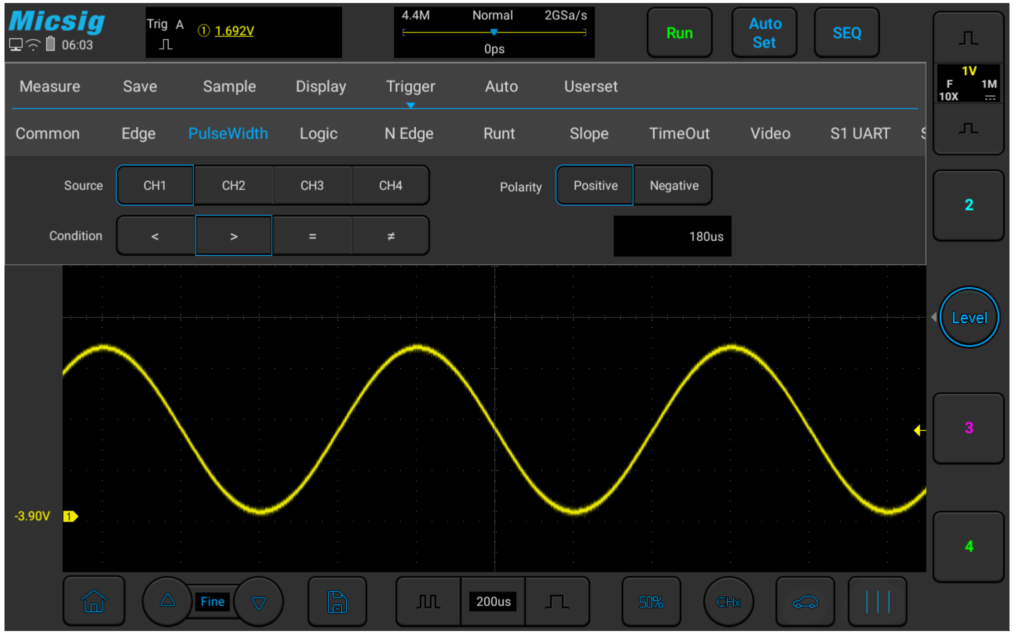


Figure 6-14 Pulse Width Trigger Setting Menu

Pulse width trigger setting description:

1) Pulse polarity selection

The selected pulse polarity icon is displayed in the upper right corner of the display screen. The positive pulse is higher than current trigger level (CH1 positive pulse indication icon ① 1.00V), and the negative pulse is lower than current trigger level (CH1 negative pulse indication icon ① 1.00V). When triggered on positive polarity pulse, if the restrictions are true, the trigger will happen on the high-to-low transition of the pulse; when triggered on negative polarity pulse, if the restrictions are true, the trigger will happen on the low-to-high transition. (Figure 6-15 Negative Pulse Level Flip)

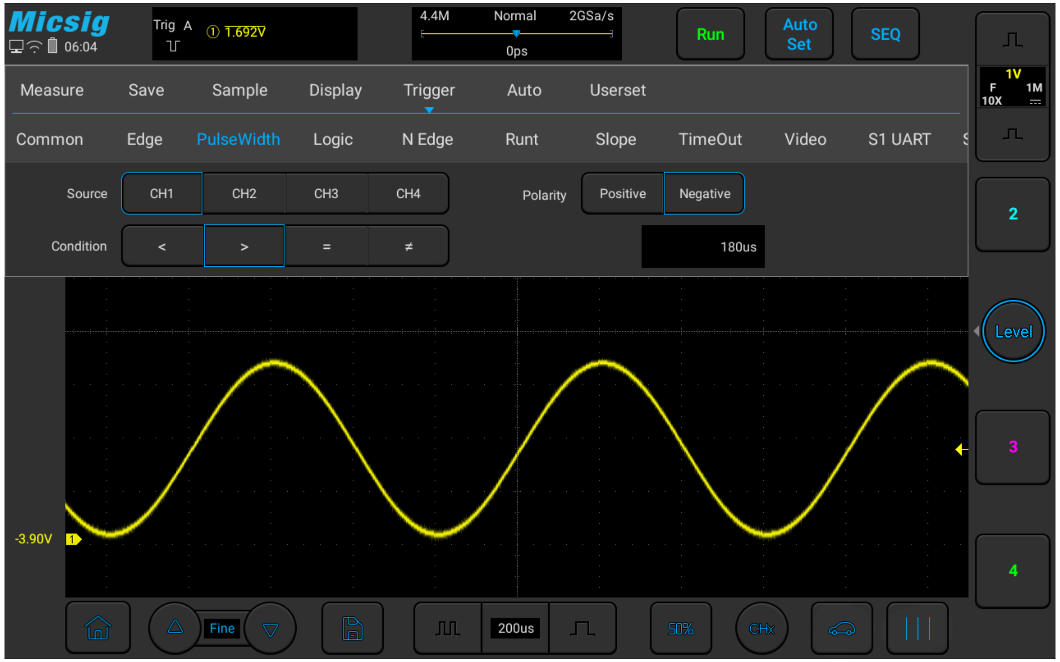


Figure 6-15 Negative Polarity Pulse Level Flip

2) Trigger condition and pulse width time setting

Time restrictions that can set in the trigger condition: <, >, =, ≠.

- Smaller than the time value (<)

  For example, for positive pulse, if it is set as T<80ns, the trigger will happen stably only when the pulse width is smaller than 80ns (Figure 6-16 Trigger Time T<80ns).

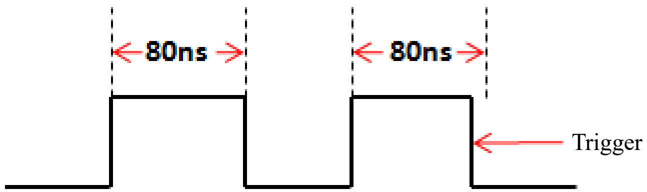


Figure 6-16 Trigger Time T<80ns

- Greater than the time value (>)

  For example, for positive pulse, if it is set as T>80ns, the trigger will happen stably only when the pulse width is greater than 80ns (Figure 6-17 Trigger Time T>80ns).

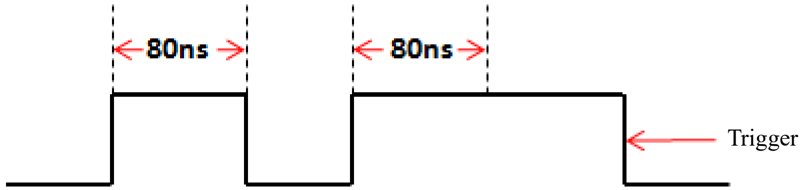


Figure 6-17 Trigger Time T>80ns

- Equal to the time value (=)

  For example, for positive pulse, if it is set as T=80ns, the trigger will happen stably only when the pulse width is equal to 80ns (Figure 6-18 Trigger Time T=80ns).

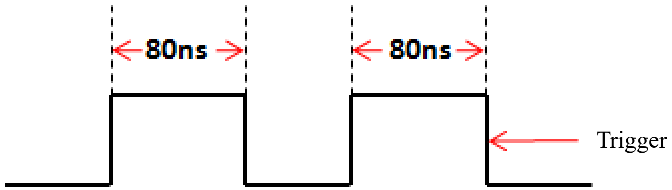


Figure 6-18 Trigger Time T=80ns

- Not equal to the time value (≠)

For example, for positive pulse, if it is set as T≠80ns, the trigger will happen stably only when the pulse width is not equal to 80ns (Figure 6-19 Trigger Time T≠80ns).

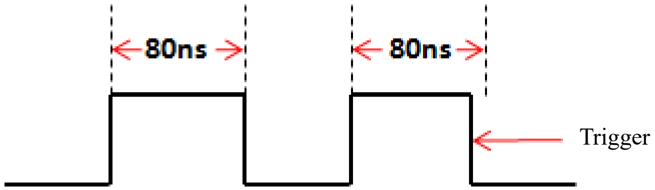
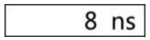


Figure 6-19 Trigger Time T≠80ns

The trigger pulse width time can be set as 8ns~10s.

Tap the pulse width time setting box  to pop up the time adjustment interface (as shown in Figure 6-20), and adjust the pulse width time. Adjust the pulse width time by adjusting or dragging the time scale.

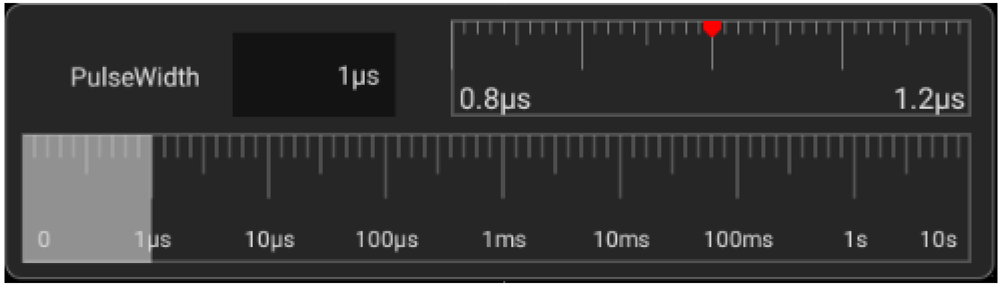


Figure 6-20 Pulse Width Time Adjustment Interface

6.4 Logic Trigger

Trigger happens when the level between analog channels satisfies a certain logical operation (AND, OR, NAND, NOR) and the signal voltage reaches the set trigger level and the trigger logic width (8ns~10s). Logic trigger menu descriptions are shown in the table below:

Trigger Option	**Setting**		**Description**
Trigger Source	CH1	High	Set CH1 as high
		Low	Set CH1 as low
		None	Set CH1 as none
	CH2	High	Set CH2 as high
		Low	Set CH2 as low
		None	Set CH2 as none
	CH3	High	Set CH3 as high

		Low	Set CH3 as low
		None	Set CH3 as none
	CH4	High	Set CH4 as high
		Low	Set CH4 as low
		None	Set CH4 as none
Trigger Logic	AND		Select the logic of trigger source as “AND”
	OR		Select the logic of trigger source as “OR”
	NAND		Select the logic of trigger source as “NAND”
	NOR		Select the logic of trigger source as “NOR”
Trigger Condition	Change to true value		Trigger when the logic changes to true value
	Change to false value		Trigger when the logic changes to false value
	<, >, =, ≠T		If logic status for hold time as <, >, =, ≠T, then trigger
Logic Time	8ns~10ns		Set trigger logic time

Notes: Conditions of greater than, smaller than, equal to or not equal to indicating that the error is 6%.

Logic trigger operation steps between channels:

1) Tap “Trigger” on the main menu to open the trigger menu, select logic trigger in the trigger type, and set the logic trigger as follows, as shown in Figure 6-21:

- Logic levels: CH1, CH3: High; CH2, CH4: Low; (without reference to the channel of logic operation, the level selection is None to avoid interference to the logic operation);
- Logic gate: AND;
- Condition: <;
- Logic time: 400ns.

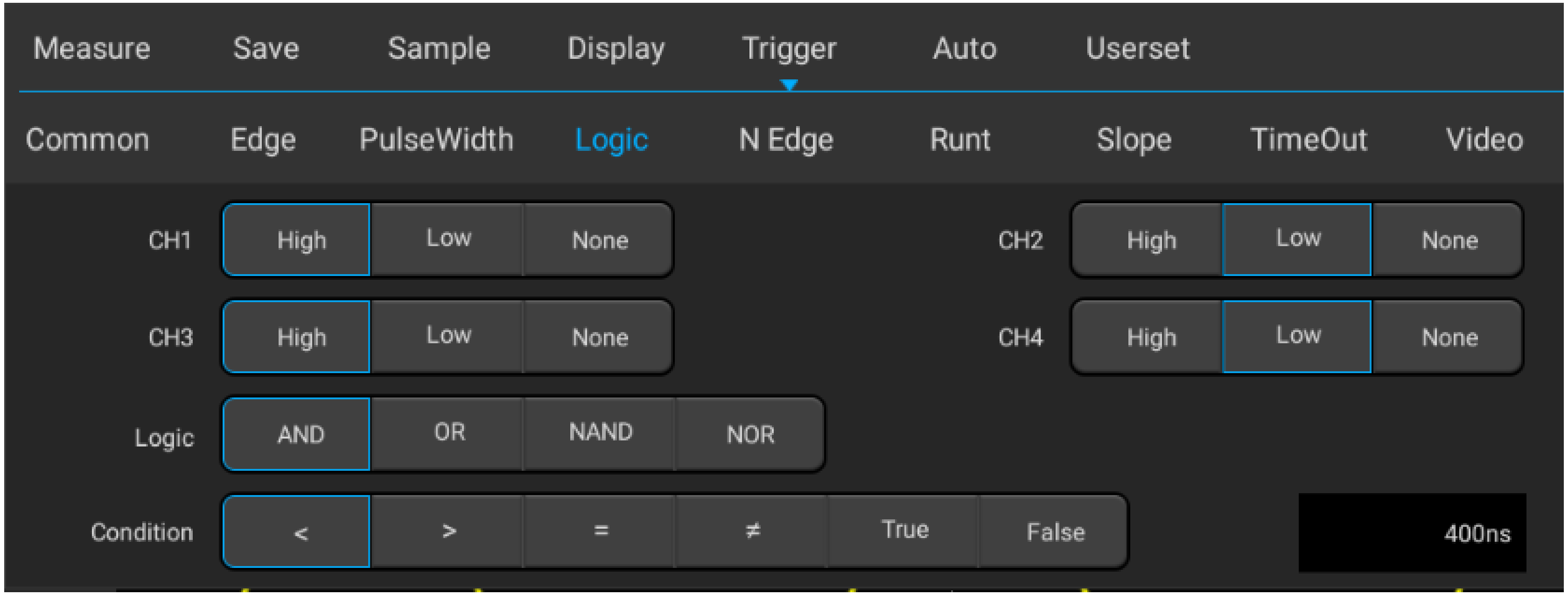


Figure 6-21 Logic Trigger Setting Menu

Logic trigger setting description:

Logic level setting

After trigger source, select High, Low and None for the channel. The corresponding trigger level value is displayed in the upper right corner of the display screen.

High: means a value higher than the current trigger level, and the icon indication is "0.0V".

Low: means a value lower than the current trigger level, and the icon indication is "0.0V".

None: This channel is invalid.

Switch the trigger level channel: Tap the trigger level slide bar arrow or use trigger setting shortcut

Logic conditions

1) True: Trigger when the logic changes to true value

2) False: Trigger when the logic changes to false value

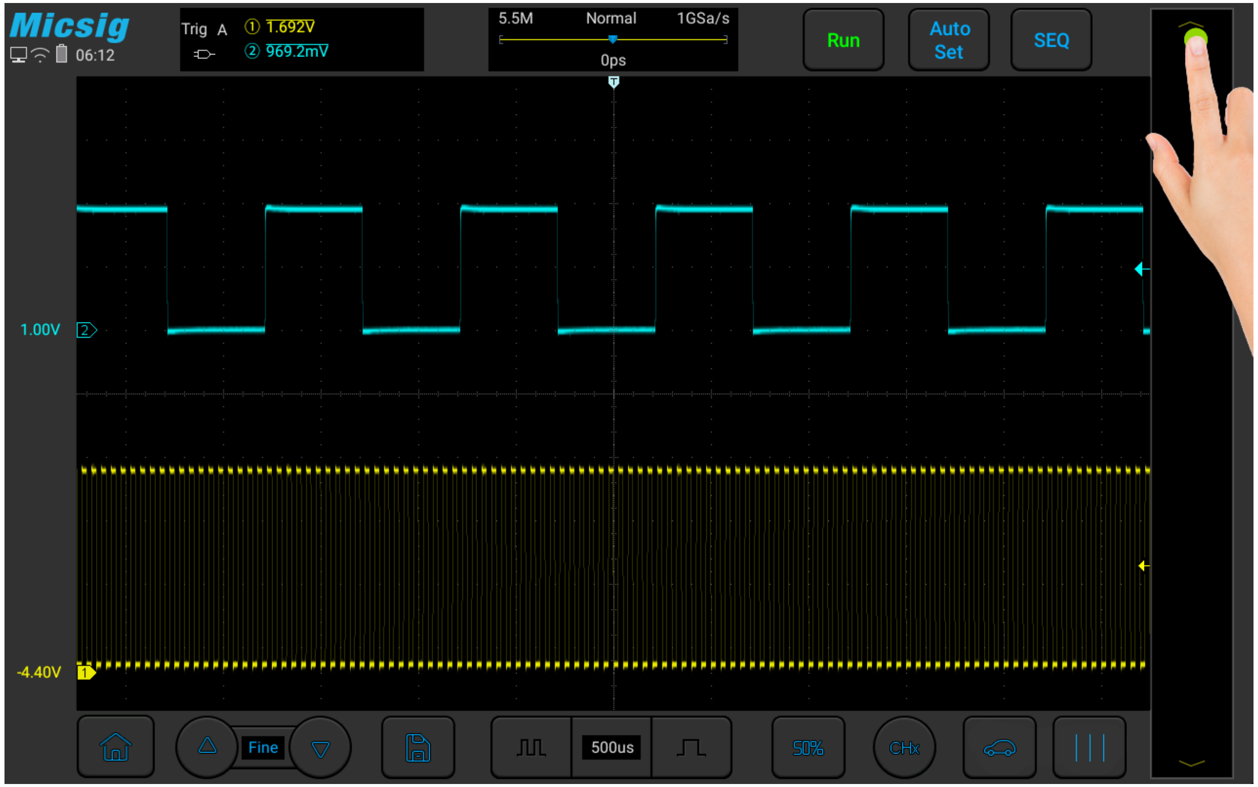


Figure 6-22 Trigger Level Adjustment

Trigger pulse width time can be set as 8ns~10s.

Tap the time setting box (400ns) to pop up the time adjustment interface and adjust the logic time. Please refer to the Pulse Width Adjustment section for details.

6.5 Nth Edge Trigger

When the trigger signal is triggered on the Nth edge after the specified idle time, it is Nth edge trigger. Menu descriptions of the Nth edge trigger are shown in the table below:

Trigger Option	Setting	Description
Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Time	8ns~10s	Idle time
Edge	Rising edge	Set signal trigger on the rising edge
	Falling edge	Set signal trigger on the falling edge
Nth Edge	1~65535	Set trigger on Nth edge after idle time

Set CH1 to trigger on the 5th rising edge after 500us. The steps are as follows:

1) Tap “Trigger” on the main menu to open the trigger menu, select Nth edge trigger in the trigger type, and set the Nth edge trigger as follows, as shown in Figure 6-23:

- Trigger source: CH1;
- Time: 10ms;
- Edge signal: rising;
- Nth edge: 99

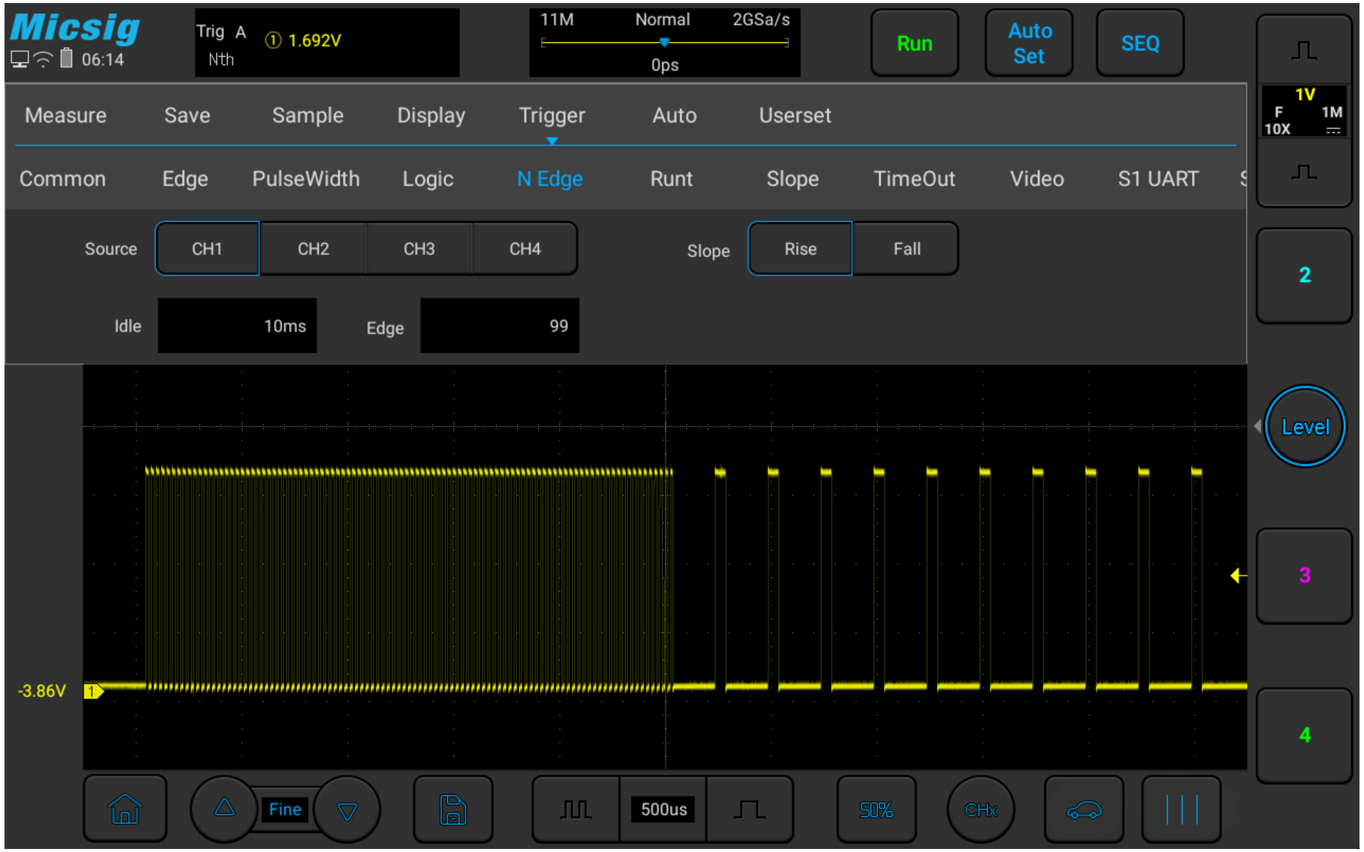


Figure 6-23 Nth Edge Trigger Menu

2) Adjust the trigger level to ensure that the waveform can be triggered stably, for example the trigger level is set to 1.44V.

6.6 Runt Trigger

By setting the high and low thresholds, trigger on a pulse that cross one threshold but fail to cross a second threshold. There are two types available: positive short pulse and negative short pulse.

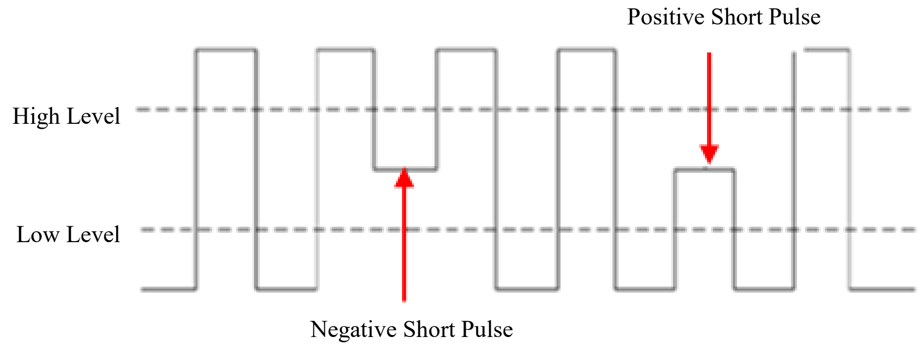


Figure 6-24 Runt Trigger

Runt trigger menu descriptions are shown in the table below:

Trigger Option	Setting	Description
Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source

Trigger Option	Setting	Description
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Polarity	Positive	Set signal to trigger on positive runt pulse
	Negative	Set signal to trigger on negative runt pulse
	Any	Set signal to trigger on either positive or negative runt pulse
Trigger Condition	<T	Trigger when the signal pulse width is smaller than pulse width T
	>T	Trigger when the signal pulse width is greater than pulse width T
	<>T	Trigger when the signal pulse width is greater than lower limit T1 and smaller than upper limit T2
	None	No trigger restrictions for runt pulse trigger
Trigger Pulse Width	8ns~10s	Set the trigger pulse width

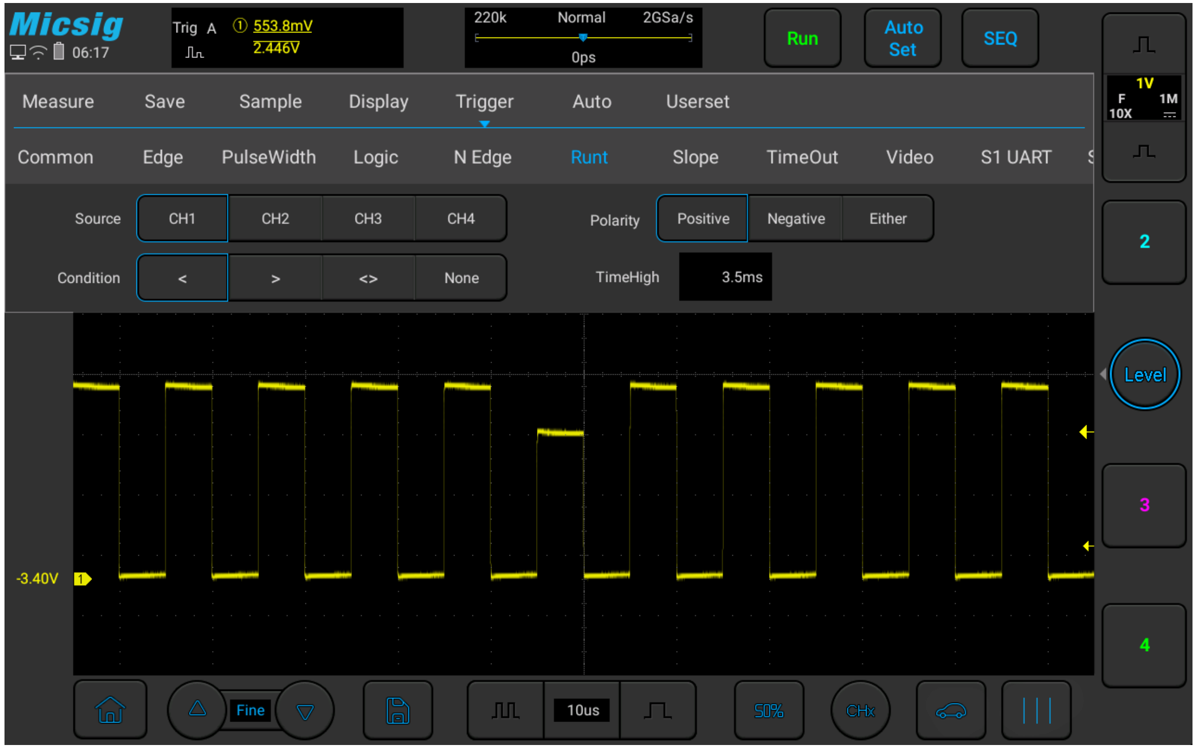


Figure 6-25 Runt Trigger Setting Menu

6.7 Slope Trigger

Slope Trigger means trigger when the waveform reaches a set time condition from one level to another.

Positive slope time: Time takes for the waveform to go from low to high.

Negative slope time: Time takes for the waveform to go from high to low.

As shown in Figure 6-26

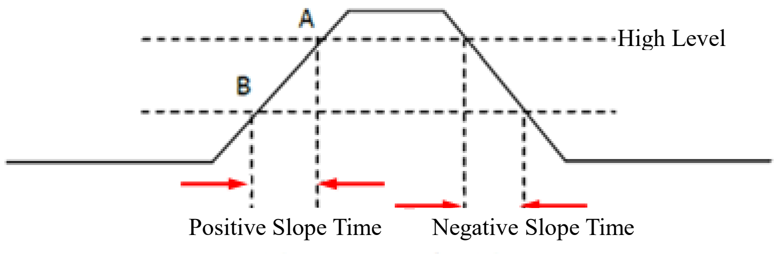
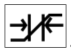


Figure 6-26 Positive/Negative Slope Time

When the trigger signal slope has the hold time (8ns~10s), the trigger type on the top of the screen is only the icon , and trigger happens when the set condition is reached. Slope trigger is suitable for observing sawtooth or triangular waves. The slope trigger menu descriptions are shown in the table below:

Trigger Option	Setting	Description
Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source

Trigger Option	Setting	Description
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Edge	Rising	Set trigger on positive signal slope
	Falling	Set trigger on negative signal slope
	Any	Set trigger on detecting a signal slope change
Trigger Condition	<T	Trigger when the signal slope hold time is smaller than T
	>T	Trigger when the signal slope hold time is greater than T
	<>T	Trigger when the signal slope hold time is smaller than upper limit T1 and greater than lower limit T2
Time	8ns~10s	Set the trigger signal slope hold time

Set CH1 slope status as rise and hold time less than 1ms. The steps are as follows:

1) Tap "Trigger" on the main menu to open the trigger menu, select the slope trigger in the trigger type, and set the slope trigger as follows, as shown in Figure 6-27:

- Trigger source: CH1;
- Edge: Rise;
- Slope hold time: 1us;

2) Adjust trigger level, adjust High or Low trigger level, click arrow at both ends of the chute Switch the trigger level between High and Low.

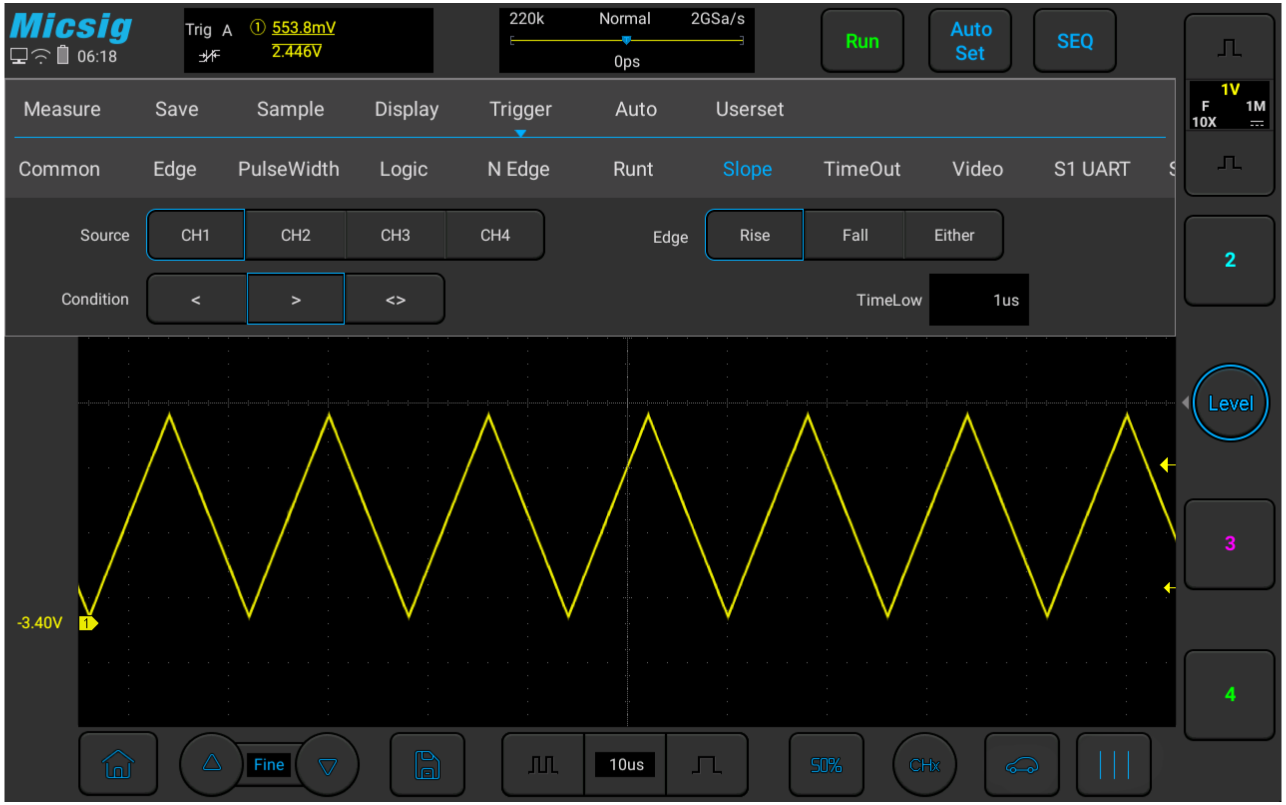


Figure 6-27 Slope Trigger Setting Menu

The slope hold time can be set as 8ns~10s.

Note: A stable trigger waveform can only be obtained by selecting the channel to which signals are connected as trigger source.

6.8 Timeout Trigger

Timeout trigger happens when the time from the intersection of signal and trigger level and above (or below) the trigger level reaches the set time, as shown in Figure 6-28:

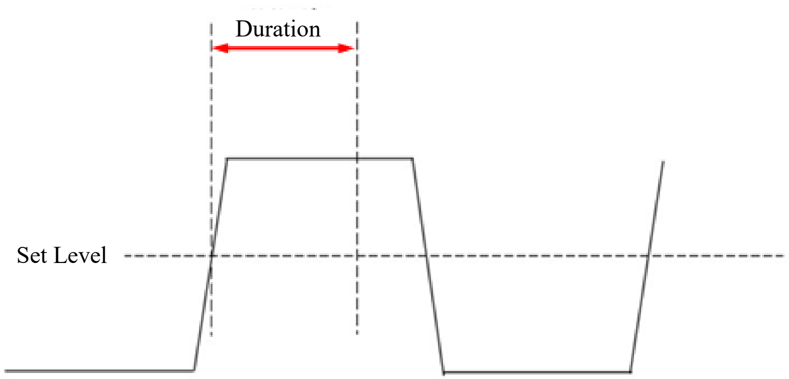


Figure 6-28 Timeout Trigger Schematics

Timeout trigger menu descriptions are shown in the table below:

Trigger Option	Setting	Description

Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Polarity	Positive	Select to count time when the rising edge of input signal gets through the trigger level
	Negative	Select to count time when the falling edge of input signal gets through the trigger level
	Any	Select to count time when the rising edge or falling edge of input signal gets through the trigger level
Time	8ns~10s	Timeout time

Set the polarity of CH1 trigger signal to be positive and the timeout time as 15us. The steps are as follows:

1) Tap “Trigger” on the main menu to open the trigger menu, select timeout trigger in the trigger type, and set the timeout trigger as follows, as shown in Figure 6-29:

- Trigger source: CH1;
- Edge: positive;
- Timeout time: 8ns;

2) Adjust the trigger level to ensure that the waveform can be triggered stably.

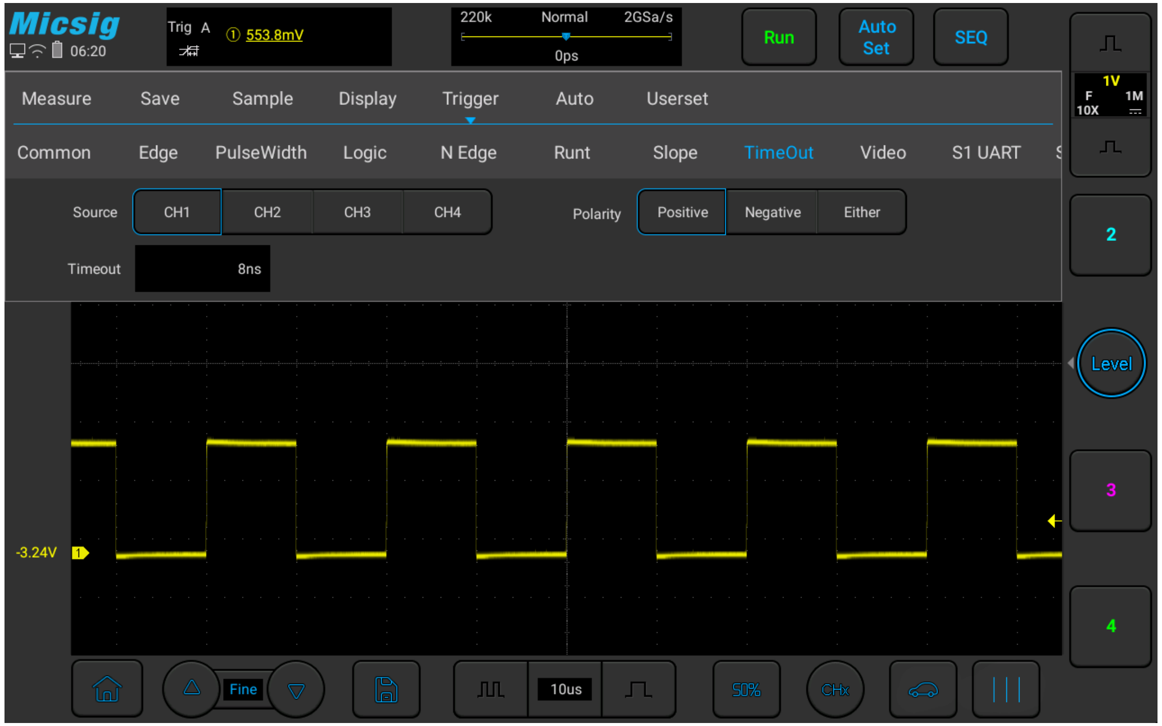


Figure 6-29 Time-out Trigger

6.9 Video Trigger

The triggering method for video signals depends on video formats. Generally, there are PAL/625, SECAM, NTSC/525, 720P, 1080I and 1080P formats. The video trigger can be triggered at different voltage scales, and the appropriate voltage scale can be adjusted as needed to observe the waveform. The video trigger menu descriptions are shown in the table below:

Trigger Option	**Setting**	**Description**
Trigger Source	CH1	Set CH1 as trigger signal source
	CH2	Set CH2 as trigger signal source
	CH3	Set CH3 as trigger signal source
	CH4	Set CH4 as trigger signal source
Polarity	Positive	Set signal positive polarity trigger
	Negative	Set signal negative polarity trigger
Video Standard	625/PAL	Based on PAL signal trigger
	SECAM	Based on SECAM signal trigger

	525/NTSC	Based on NTSC signal trigger
	720P	Base on 720P(50Hz, 60Hz) signal trigger
	1080I	Base on 1080I(50Hz, 60Hz) signal trigger
	1080P	Base on 1080P (24Hz, 25Hz, 30Hz, 50Hz, 60Hz) signal trigger
Line		Trigger lines
Trigger	Odd fields	Trigger on the rising edge of the first tooth pulse in odd fields
	Even fields	Trigger on the rising edge of the first tooth pulse in even fields
	All fields	Trigger on the rising edge of the first tooth pulse found
	All lines	Trigger on all horizontal sync pulses

	Lines	625 line (PAL,SECAM)	Trigger on a specified line in odd or even fields
		263 odd line 262 even line (NTSC)	
		750 line (720P)	
		1125 line (1080I,1080P)	

Set CH1 as trigger channel, positive polarity, NTSC standard video, all fields trigger, and the steps are as follows:

Tap "Trigger" on the main menu to open the trigger menu, select the video trigger in the trigger type, and set the video trigger as follows, as shown in Figure 6-30:

- Trigger source: CH1;
- Polarity: positive;

- Standard: 525/NTSC;
- Trigger: Odd fields

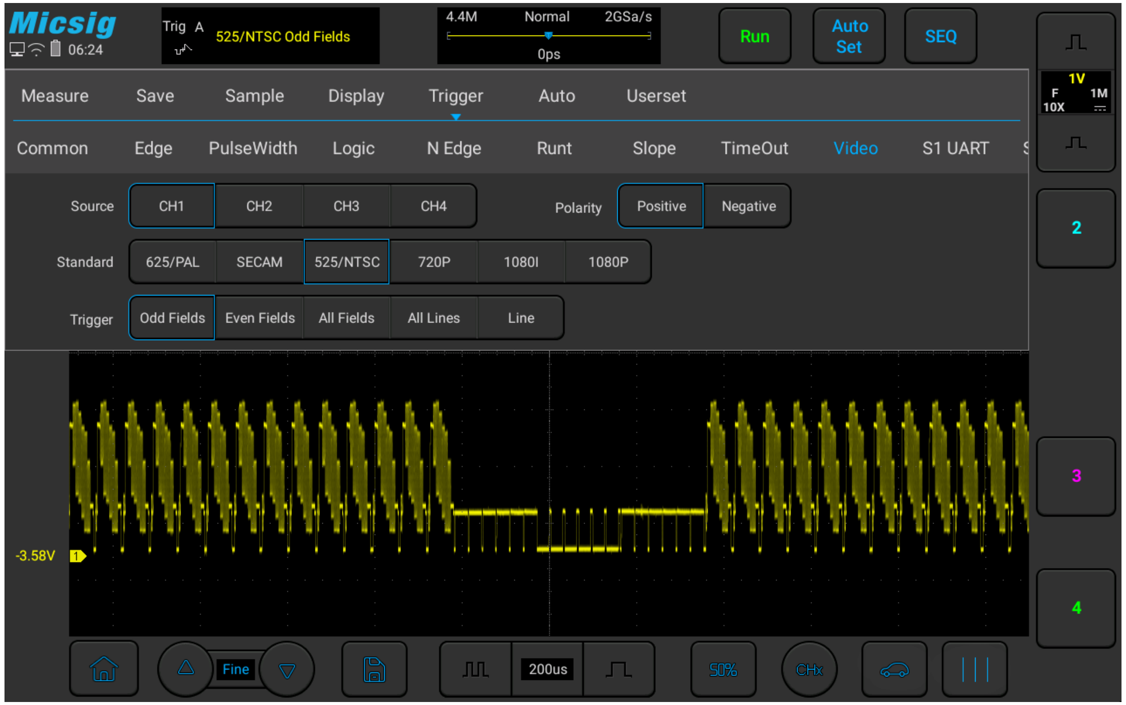


Figure 6-30 Video Trigger

Prompts:

- In order to better observe the waveform details in the video signal, first set the memory depth to be larger.

- During the trigger debugging of the video signal, since the digital oscilloscope has multi-level gray scale display function, different brightness can reflect the frequency of different parts of the signal. Experienced users can quickly judge the quality of the signal during the debugging process and find abnormal conditions.

6.10 Serial Bus Trigger

Please refer to Chapter 12 Serial Bus Trigger and Decode (Optional)

Chapter 7 Analysis System

This chapter contains the detailed information of the analysis system of the oscilloscope. You are recommended to read this chapter carefully to understand the set functions and operation of the analysis system of the ATO series oscilloscope.

- Automatic measurement
- Frequency meter measurement
- Cursor
- Phase Rulers

7.1 Automatic Measurement

Measurement setting

Slide down from top, open the main menu, tap “Measure” to enter the measurement menu. There are 23 measurement items on the measurement menu. Measurement menu, selected measurement item display and measurement item display are shown in Figure 7-1:

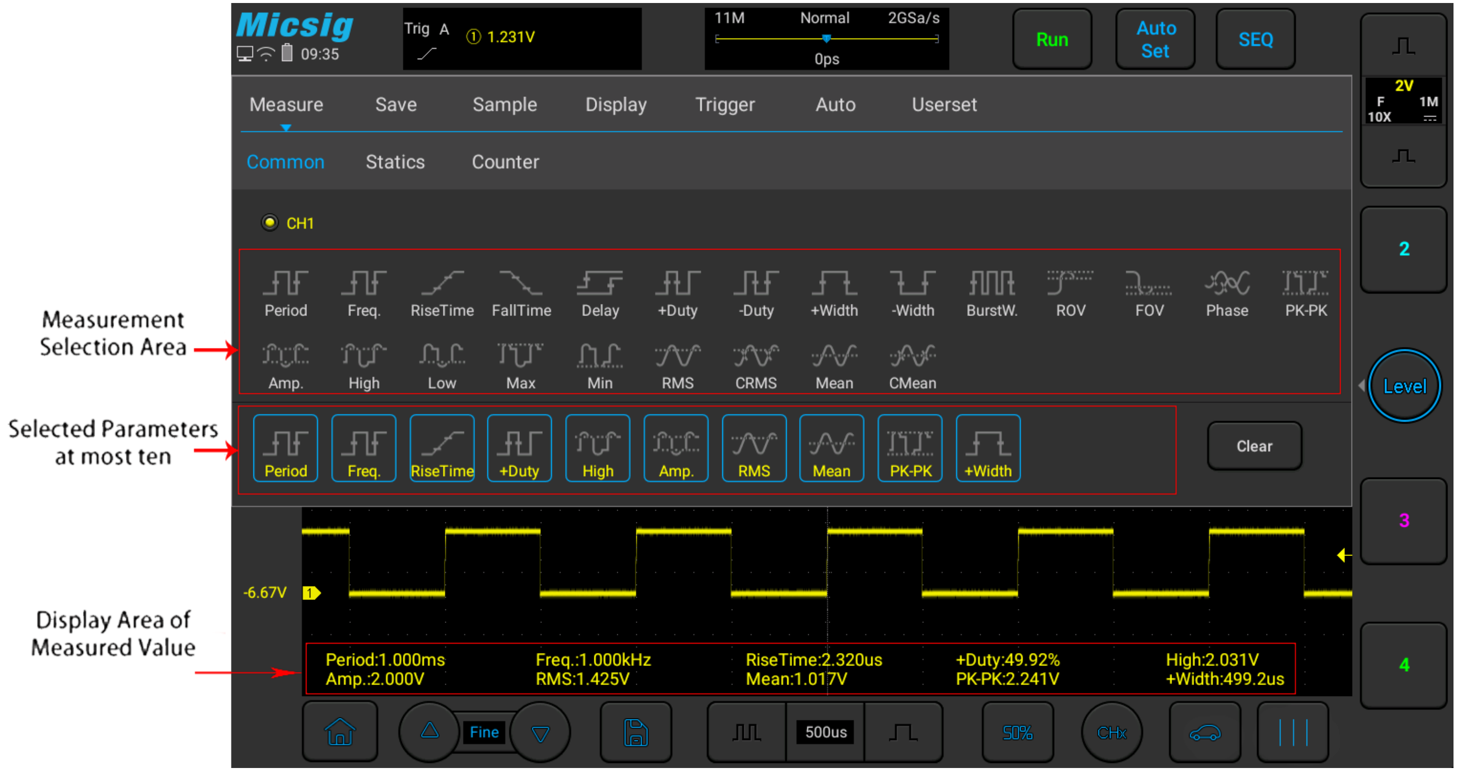
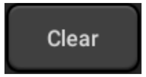


Figure 7-1 Automatic Measurement Menu

Automatic measurement

1) Select channel: Select the channel to be measured above the measurement menu.

2) Select measurement: Select the desired measurement item on the measurement menu. The selected measurement item is displayed in the "Selected Parameters" display area below.

3) Cancel measurement item: In the "Selected Parameters" display area below measurement menu, tap the measurement item to be cleared; or tap 

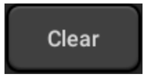
button to clear all measurement items.

Note:

Measurements and math functions will be recalculated when moving/zooming and opening/closing channels.

Oscilloscope has an automatic measurement memory function. Shutdown and restart will not automatically clear added automatic measurement options.

All measurements

Slide from bottom, open the **pull-up menu**, see Figure 7-2, click 

to open all measurement items, display the current channel measurement value. Switch the current channel to open all the measurement items of other channels, as shown in Figure 7-3; click again to turn off all measurements.

Figure 7-2 Pull-up Menu

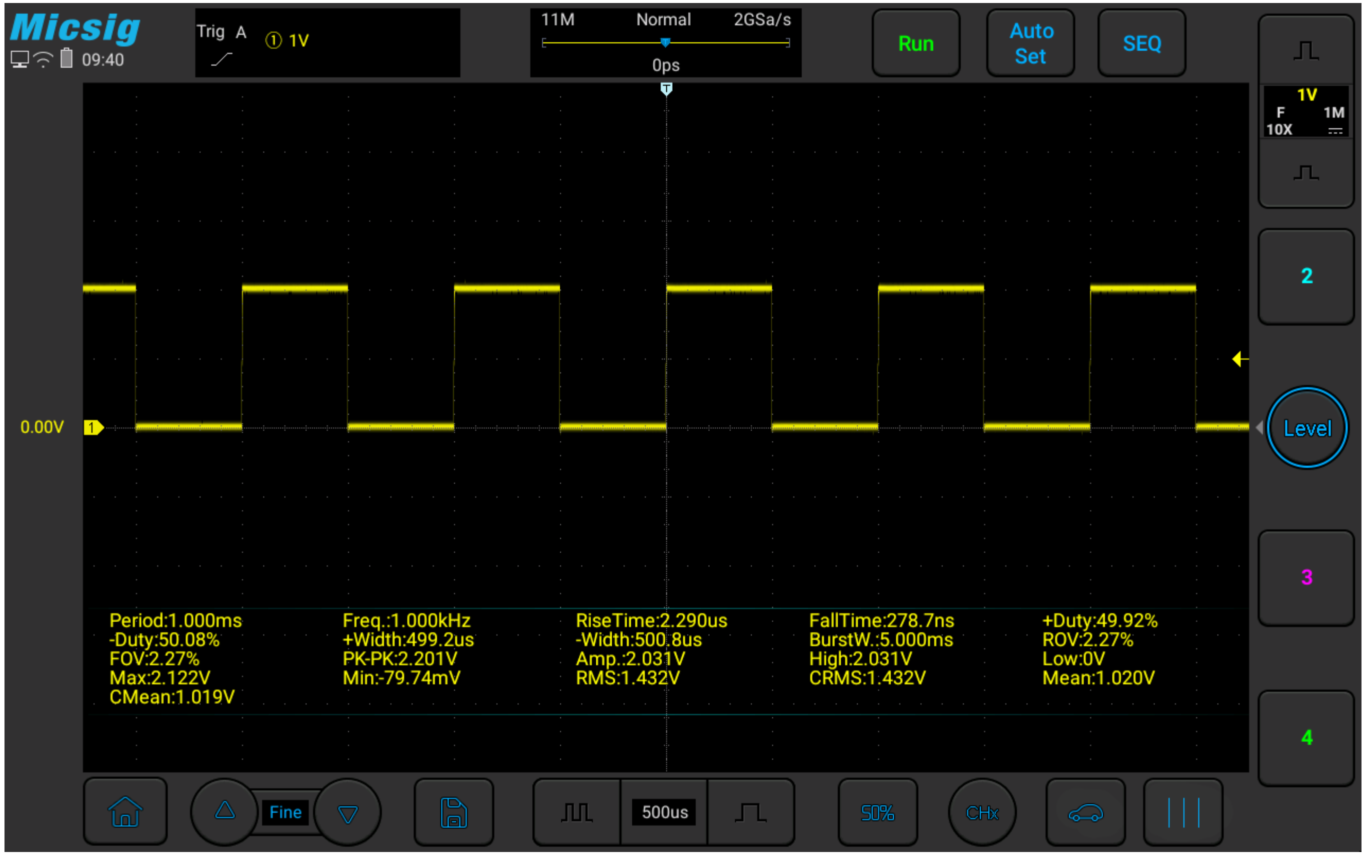


Figure 7-3 All Measurements

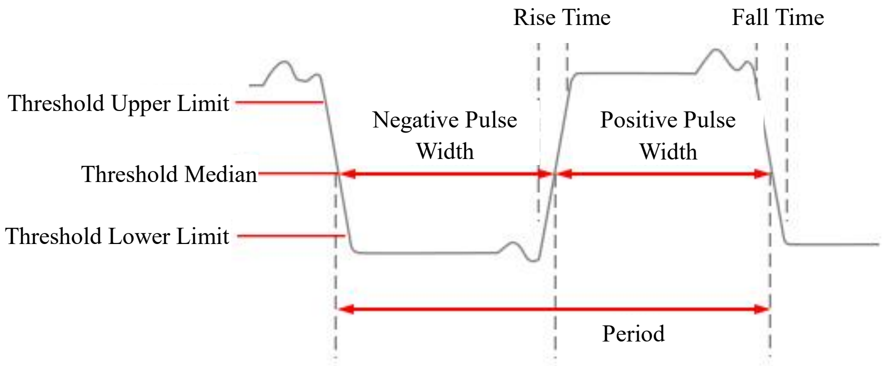


Figure 7-4 Time Parameter

Period

Time of the first complete signal cycle in the waveform

Frequency

Reciprocal to the cycle time

Rise time

Time required for the first rising edge of the waveform to rise from the amplitude of 10% to 90%

Fall time

Time required for the first falling edge of the waveform to rise from the amplitude of 10% to 90%

Delay

Time delay between rising or falling edges of channels may be measured, and there are nine effective measurement combinations

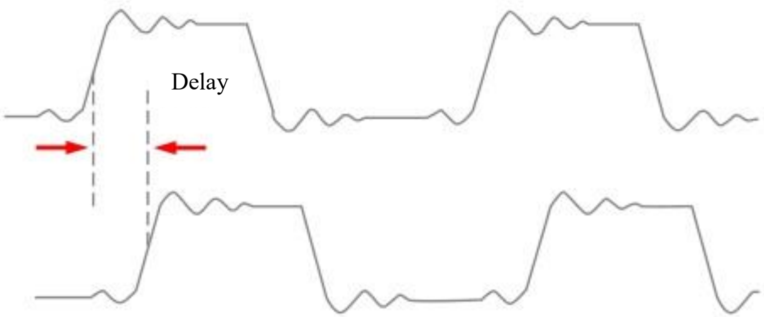


Figure 7-5 Delay Measurement Schematics

1) Open the automatic measurement menu and tap Delay to pop up the phase selection menu.

2) The left channel is defaulted as the current channel, and other channels can be selected by the channel area that has been opened (except the reference channel); there are four edge selections: first rising edge, first falling edge, last rising edge, last falling edge .

3) The right channel is a contrast delay channel, which can be selected between each channel and math channel. There are four edge selections: first rising edge, first falling edge, last rising edge, and last falling edge.

4) Tap ok button to confirm.

Positive duty cycle

Measured value of the first cycle in the waveform

Positive duty cycle = (waveform positive pulse width / period) * 100%

Negative duty cycle

Measured value of the first cycle in the waveform

Negative duty cycle = (waveform negative pulse width / period) * 100%

Positive pulse width

Measured value of the first positive pulse in the waveform, taking the time between two 50% amplitude points

Negative pulse width

Measured value of the first negative pulse in the waveform, taking the time between two 50% amplitude points

Burst width

Duration of a burst measured over the entire waveform

Overshoot

Positive overshoot

Positive overshoot =[(max - high) / amplitude]*100%

Negative overshoot

Negative overshoot =[(low - min) / amplitude]*100%

Phase

Timing measurement. The amount of time that one waveform leads or lags another waveform, expressed in degrees where 360°comprises one waveform cycle.

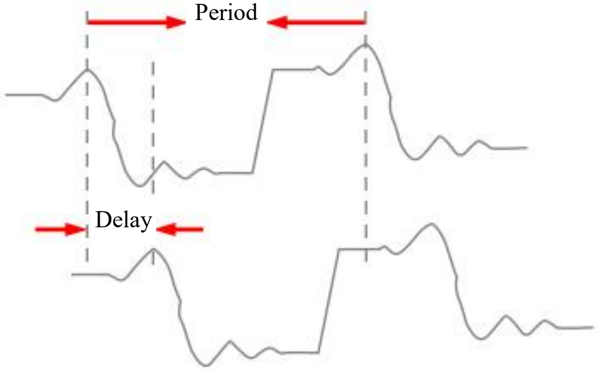


Figure 7-6 Phase Measurement Schematics

Peak-peak

In the entire waveform measurement, peak-peak = max - min

Amplitude

In the entire waveform measurement, amplitude = high (100%) - low (0%)

The figure below shows voltage measurement points.

The channel probe type setting is used to set the measurement unit for each input channel to Volts or Amperes.

Refer to "5.4.4 Set Probe Type".

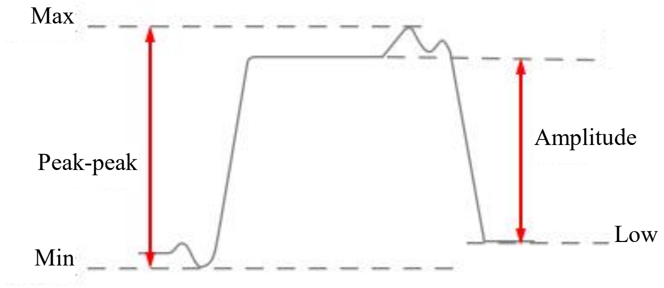


Figure 7-7 Voltage Measurement

High

Take 100% in the entire waveform, and calculated using either the min/max or histogram method.

Low

Take 0% in the entire waveform, and calculated using either the min/max or histogram method.

Max

Highest positive peak measured over the entire waveform

Min

Highest negative peak measured over the entire waveform

RMS

True root mean square value over the entire waveform

C RMS

True root mean square value of the first cycle in the waveform

Mean

Arithmetic mean over the entire waveform

C mean

Arithmetic mean over the first cycle in the waveform

Note:

If the waveform required for measurement is not fully displayed on the screen, “Forward Clipping” or “Negative Clipping” is displayed at the position of the measured value.

When the math function is operated, if source channel waveform is fully displayed, and the math waveform appears to be off the screen, the measured value of math waveform will not be influenced.

If source channel is clipped, the measured value of math waveform is the source channel value during screen wave clipping.

Statistics

Swipe down from the top to open the main menu, tap "Measure", then select "Statistics" to enter the statistics menu. The oscilloscope supports statistics and displays the current value of multiple measurement results, including Mean, Max, Min, Deviation, and Count. The number of counts can be up to 10,000 times. Click the "Reset" button to clear the historical data of all measurement items and perform statistics again, as shown in Figure 7-8:

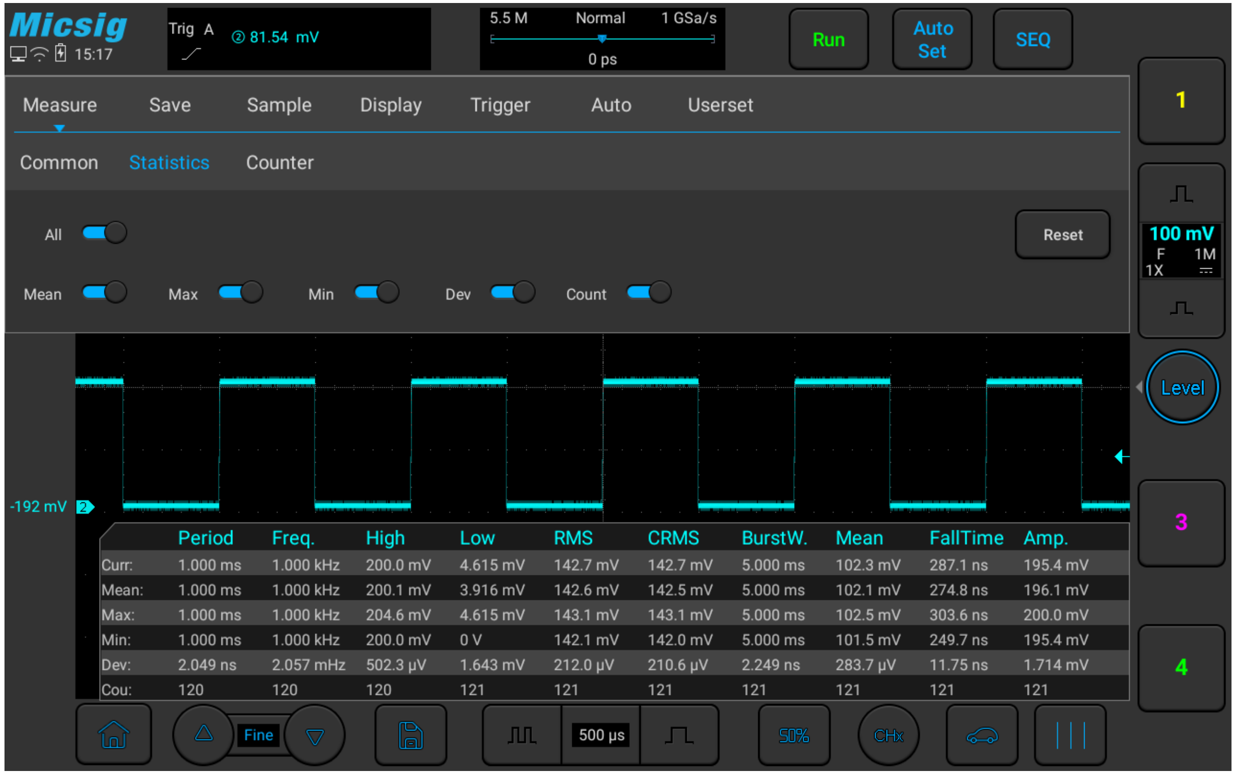


Figure 7-8 Frequency Meter Measurement Menu Open

7.2 Frequency Meter Measurement

Open the main menu, tap Measure and Counter to enter the hardware frequency meter setting menu, and select the channel to be measured, as shown in Figure 7-9. The measured value is displayed in the upper left corner of the screen, as shown in Figure 7-10.

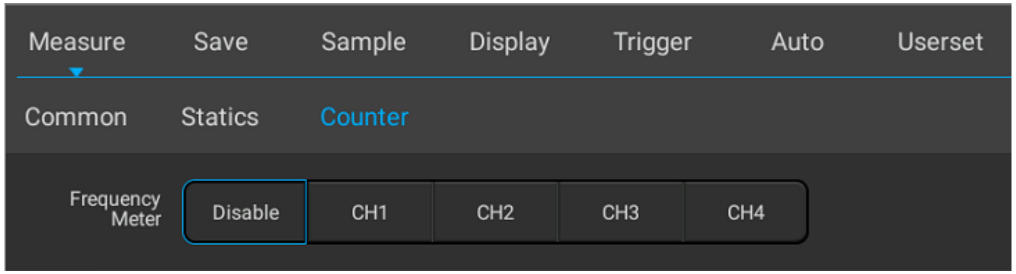


Figure 7-9 Frequency Meter Measurement Menu Open

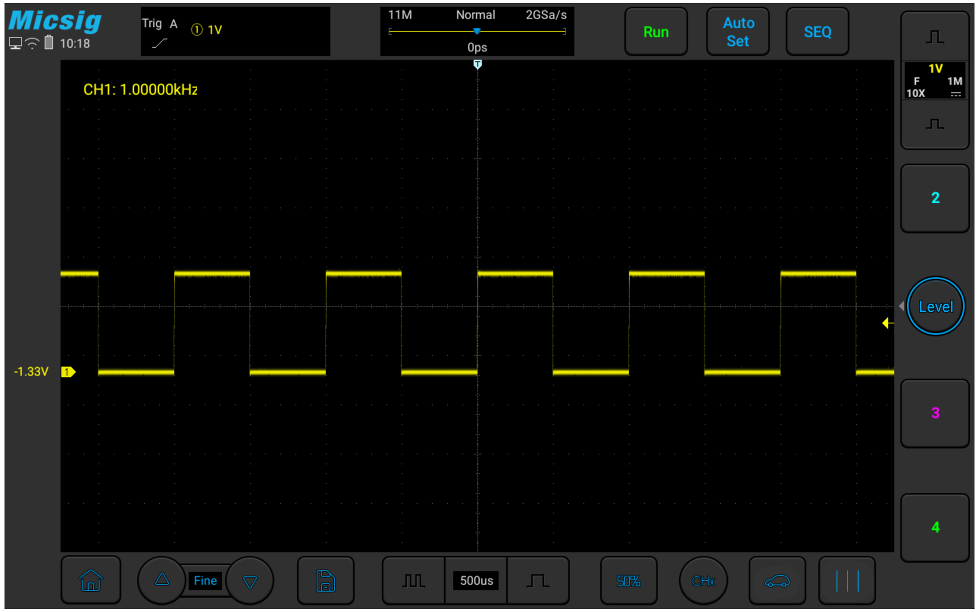


Figure 7-10 Frequency Meter Measurement

7.3 Cursor

Open cursor and place it on the measurement point to read the waveform measurement value. There are two types of cursors: horizontal cursor and vertical cursor. The horizontal cursor measures the vertical direction magnitude, and the vertical cursor measures the horizontal direction magnitude, as shown in Figure 7-11.

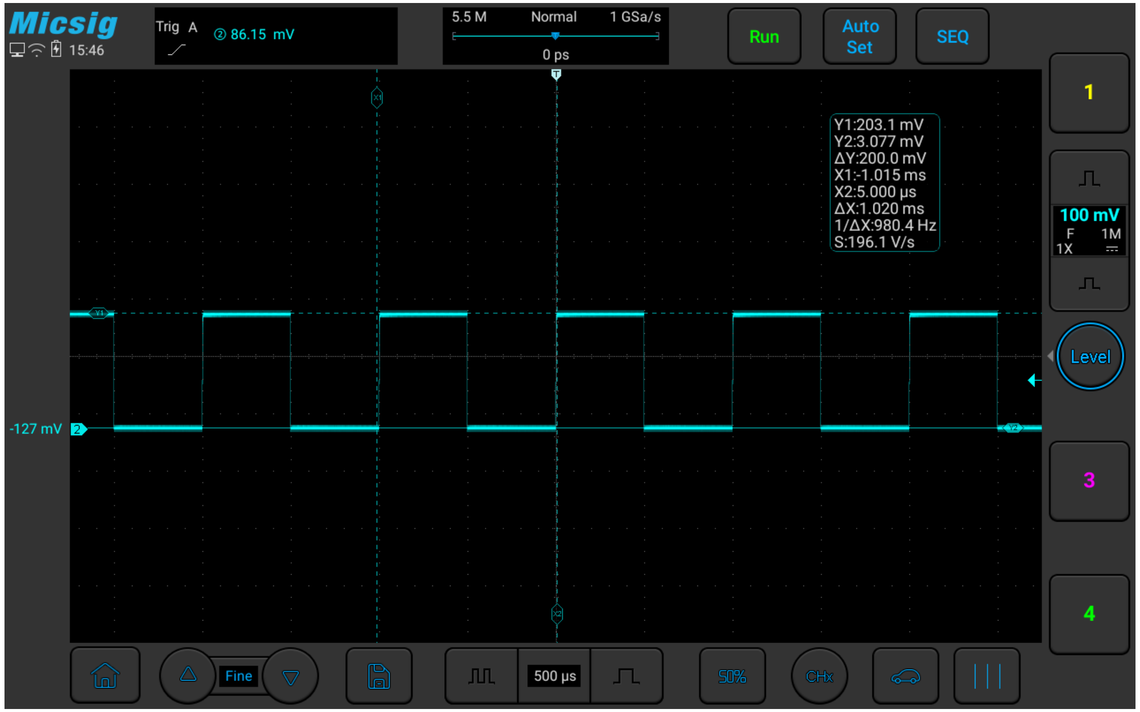


Figure 7-11 Cursor Measurement

Note:

△ reading: indicates the difference between two cursor positions.

Voltage readings after Y1, Y2: indicate the position of activated horizontal cursors relative to the zero potential.

Time readings after X1, X2: indicate the position of activated vertical cursors relative to the trigger point.

1/**△X: frequency**

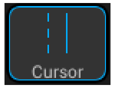
S reading. Indicates the quotient of △ (voltage difference) of horizontal cursors and Δ (time difference) of vertical cursors, that is, the slope of the intersection of the four cursors.

Vertical cursor on/off and activation

Vertical cursor on/off

Vertical cursor on: Open pull-up menu and tap cursor icon 

to open vertical cursors and the icon is on and activated.

Vertical cursor off: Open pull-up menu and tap cursor icon 

to turn off vertical cursors.

Tap the vertical cursor indicator line to switch the cursors.

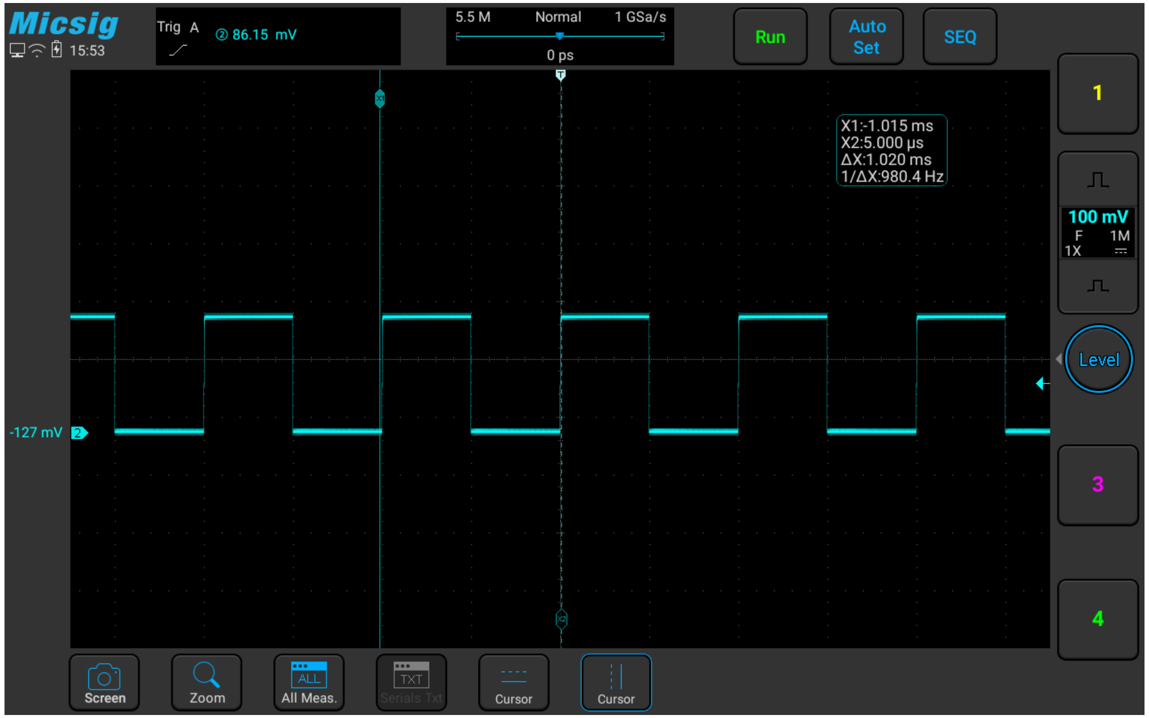


Figure 7-12 Open Cursor Selection Box and Close Cursor

Vertical cursor movement descriptions:

1) Use a single finger to press and hold the cursor indicator line on the screen to make coarse adjustment to the cursor; tap the fine adjustment button in the lower left corner of the screen to fine-adjust the cursor that has just been adjusted.

2) Cursor linkage: When the cursor is opened, two finger slide and enter the cursor linkage state.

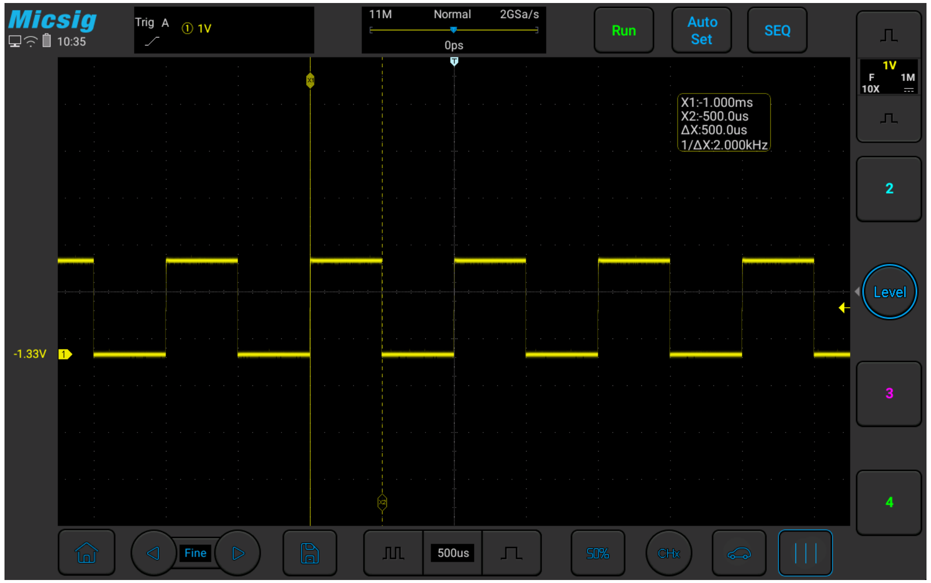
   Note: During the sliding process, the current operation is changed unless the initial two fingers leave the screen. If one finger leaves the screen and the other finger does not leave, the current linkage adjustment is continued.

Horizontal cursor on/off and activation

Horizontal cursor on/off, switching, activation and movement operations, similar to those of vertical cursors, will not be described in detail here, and please refer to vertical cursors for details.

Cursor test example

When vertical cursors are activated, the two cursors move together to check for pulse width changes in the pulse sequence.



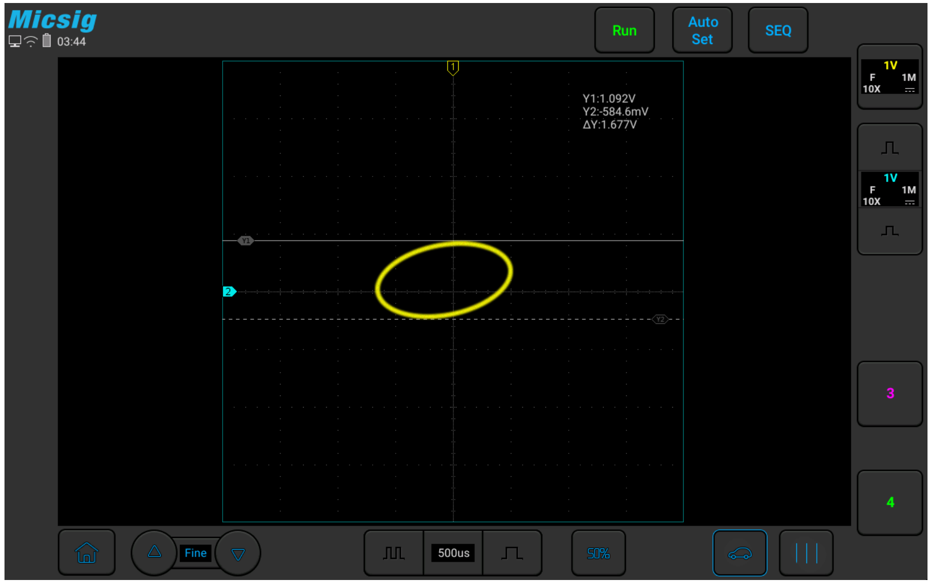


Figure 7-13 Cursor Measurement Pulse Width

Figure 7-14 In XY Mode, Cursor Measurement

In the XY horizontal mode, X cursor displays CH1 value (V or A), and Y cursor displays CH2 value (V or A).

7.4 Phase Rulers

The phase rulers help to measure the timing of a cyclic waveform on a scope view. Phase rulers measure relative to the start and end of a time interval that you specify. Phase ruler settings box include Number of cylinder & Angle. To use the phase rulers, drag the two phase ruler handles onto the waveform from their inactive position.

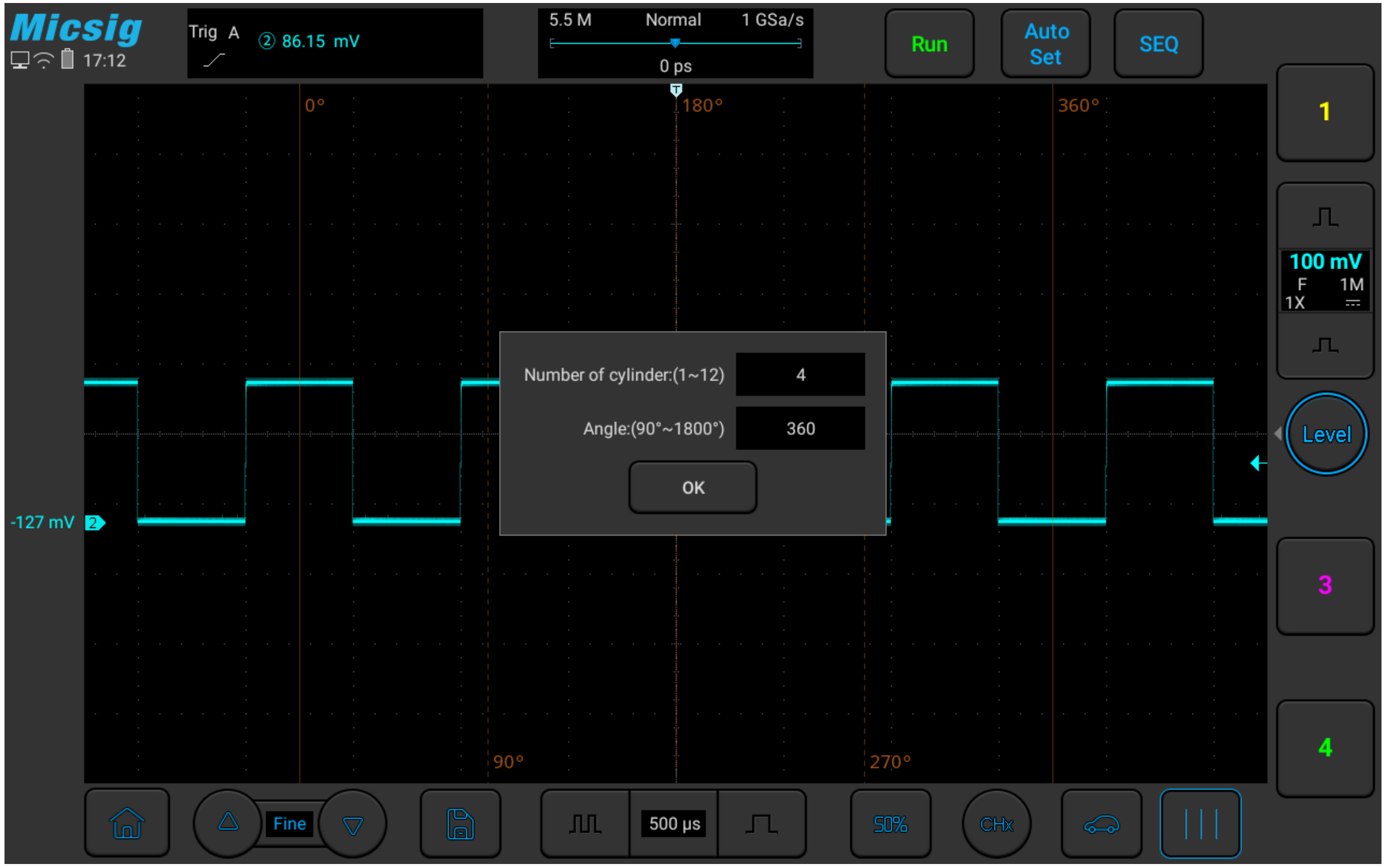


Figure 7-15 Phase Cursors

Chapter 8 Screen Capture, Memory Depth and Waveform Storage

This chapter contains the detailed information of the screen capture function and memory depth of the oscilloscope. You are recommended to read this chapter carefully to understand the storage system of the ATO series oscilloscope.

- Screen capture function
- Video recording
- Memory depth
- Waveform storage

8.1 Screen Capture Function

The screen capture function can locally store the display information on the current display screen in picture format.

Screen capture method: Slide upward from bottom to open pull-up menu. Tap the icon 

to have a screen capture in the oscilloscope application. Or pull down the menu in non-oscilloscope application interface twice and click the screen capture option to capture the screen content of the non-oscilloscope application.

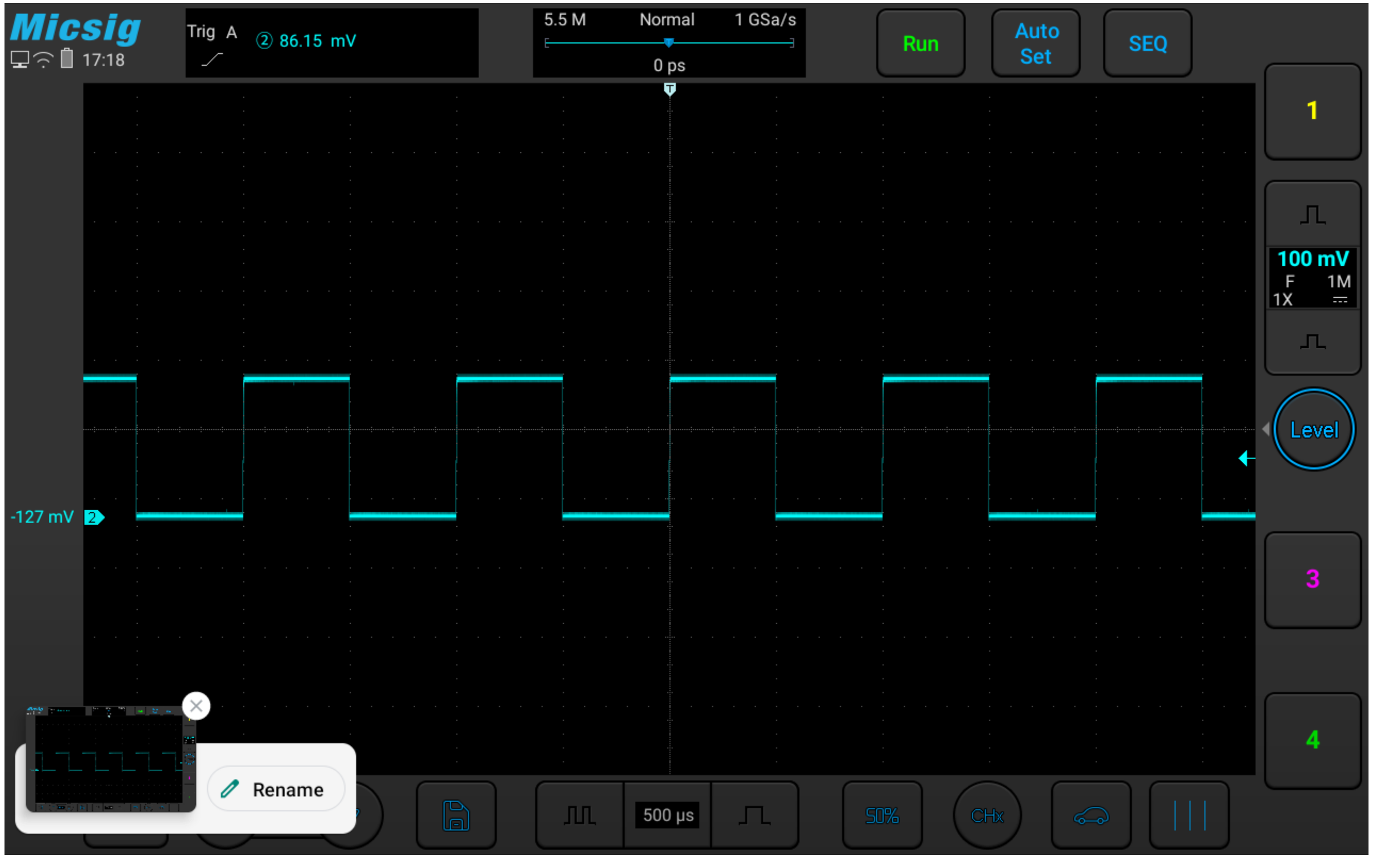


Figure 8-1 Screen Capture

Please refer to "13.7 Gallery" for details on viewing pictures.

Timestamp and InverseColor

Invert and time-stamp screenshots is possible in oscilloscope.

Open the main menu, tap Save and enter Picture menu, turn off/on Timestamp and InverseColor button as desired.

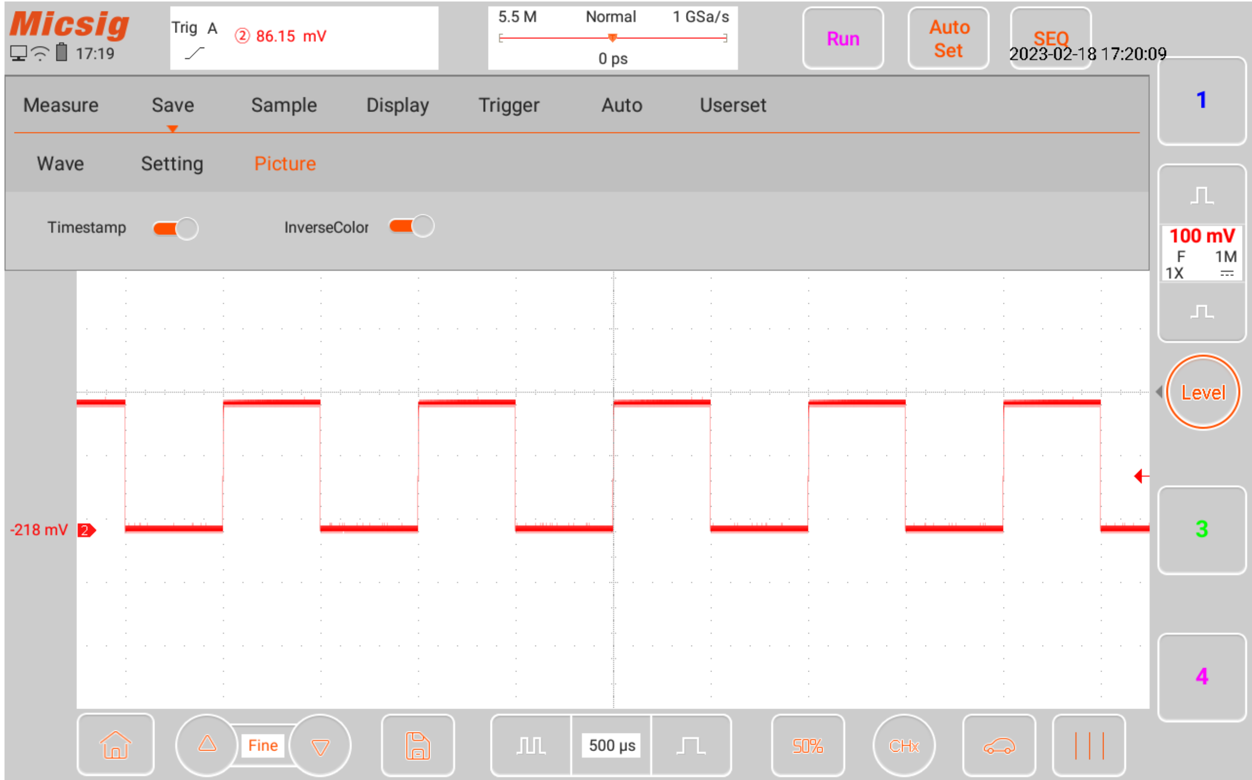


Figure 8-2 Timestamp & inverse color

8.2 Video Recording

The video recording function is similar to the screen capture function, and the display information of the current display screen can be stored locally in video format.

Video recording method is sliding down from top in non-oscilloscope application, open pull-down menu, tap the screen to start recording, and count down to three seconds to complete the video recording, as shown in Figure 8-3. You can cancel recording by pressing the triangular, circular or square button at the bottom of the screen before the countdown ends.

During video recording, you can end recording by tapping the video recording time at the top left of the screen. Or you can leave the oscilloscope application interface to open the pull-down menu, and click “Stop Recording” to end the video recording.

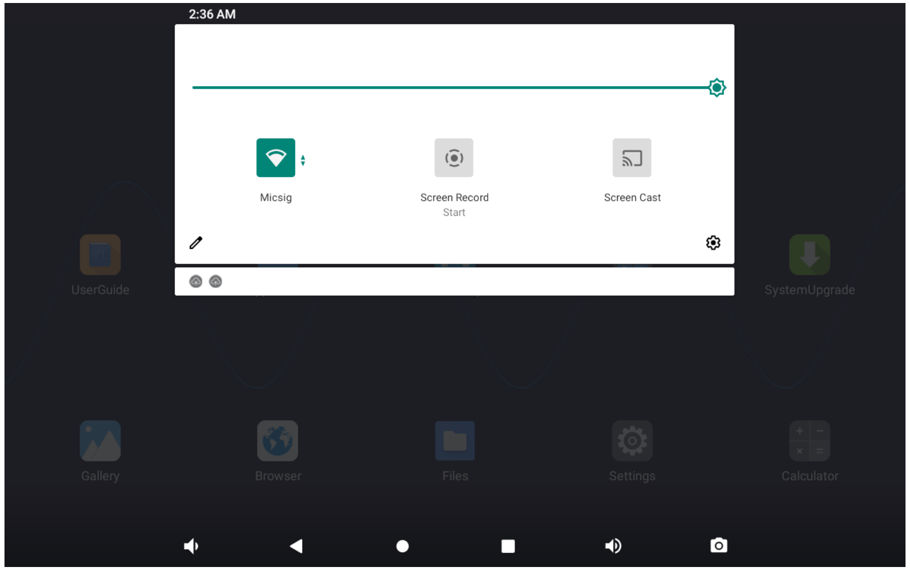


Figure 8-3 Video Recording Method

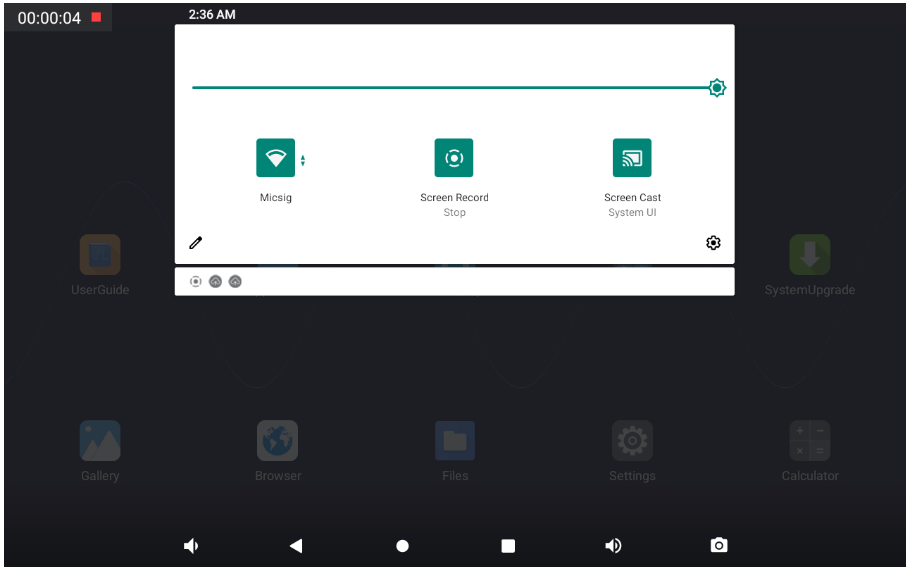


Figure 8-4 Video Recording

Please refer to "13.7 Gallery" for details of viewing videos.

8.3 Waveform Storage

The oscilloscope can save the analog channel or math channel waveform locally or in USB device. The file type can be WAV, CSV or BIN.

The oscilloscope provides four reference channels, which can be called to load WAV format files into the reference channel and open the reference channel to display the reference waveform.

Save reference file

Slide down from top, open main menu and tap "Save" to open the menu. Save the reference waveform interface of the specified channel as follows:

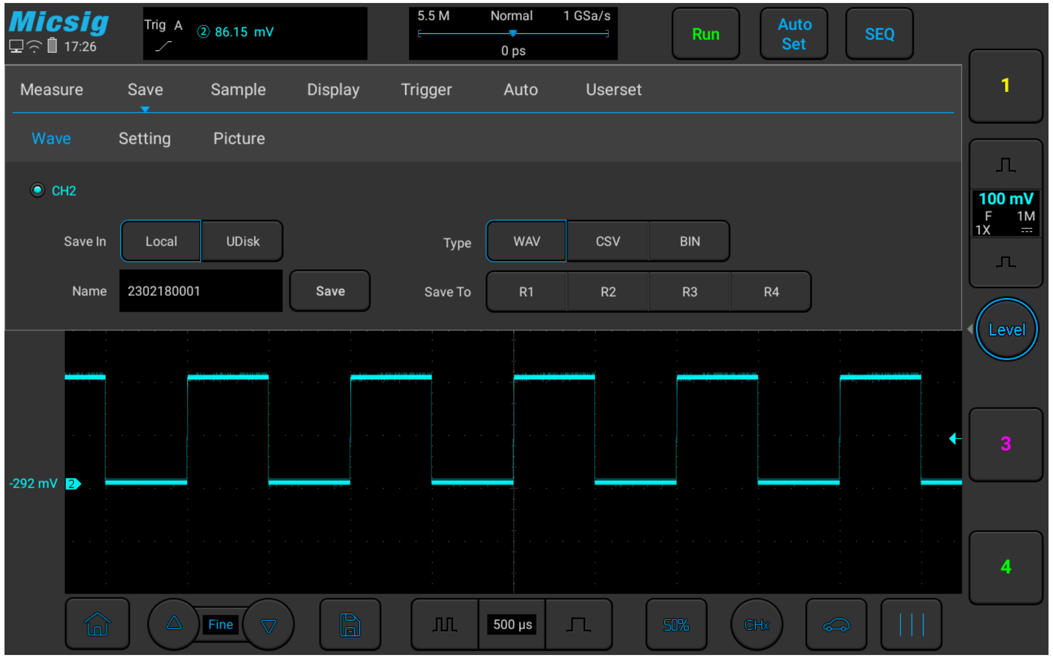


Figure 8-5 Save CH2 Reference Waveform Interface

Location: Stored locally and in USB device.

File types: WAV, CSV, and BIN.

File name: The initial file name is displayed as year + month + day + storage serial number. Press the file name box to pop up the virtual keyboard, tap “Backspace” to delete the file name, and use the virtual keyboard to rename the file.

Save: Tap to save the reference file and pop up the save success prompt. The most recently saved file will be displayed at the top of the called menu.

Save to: Tap the R* (R1, R2, R3, R4) button to save the current channel waveform directly to the corresponding reference channel, and the save success prompt will pop up.

Back: Tap to return to the previous level.

Method 1: Click the “save” button

In the Save Reference Waveform menu, select the channel waveform to be saved, select the file save location, file type and file name, and click the “save” button to save the reference waveform file.

Save the reference waveform by steps as follows:

1) The current channel is set to the channel to be saved, which can be analog channel, math channel or reference.

2) In the main menu, tap "Save" to enter the save menu.

3) In the Save menu, tap "Save" to open the Save Reference Waveform menu and make the following settings:

- Storage location: locally.
- Selecting the file type: WAV.
- Entering the file name: CH1.

4) Tap “Save” to save the reference file. The save success prompt box is popped up.

If the reference waveform file is to be saved in USB device, the oscilloscope must be connected to an external USB device. After connection, the reference waveform save location is preferentially set to the USB device.

There is no limit to the number of saved reference waveform files.

Method 2: Click R* button

In the Save Reference Waveform menu, tap R* (R1, R2, R3, R4) button to save the current channel waveform directly to the corresponding reference channel, and the save success prompt will pop up. The file name is displayed as Ref* in the reference channel (* is the corresponding reference channel name). Reference waveform files saved by this method will be overwritten after loading other reference waveforms and cannot be restored.

Method 3: Click "Quick Save" button

Tap  at bottom of the screen to save all channel waveforms as reference waveforms and capture the current screen. The file names are the default initial file names.

Management of reference files

In the file manager, open waveforms in the classification file to manage reference files by operations such as copy, cut, delete, rename, compress, etc., as shown in Figure 8-4. Select reference files and click trash button to delete them; click More at bottom of the screen, tap Rename to open soft keyboard and change the reference file name. Tap Compress to pop up the soft keyboard and enter the compressed file name to compress the file; when inserting the USB device, files on the oscilloscope can be moved to the USB device.

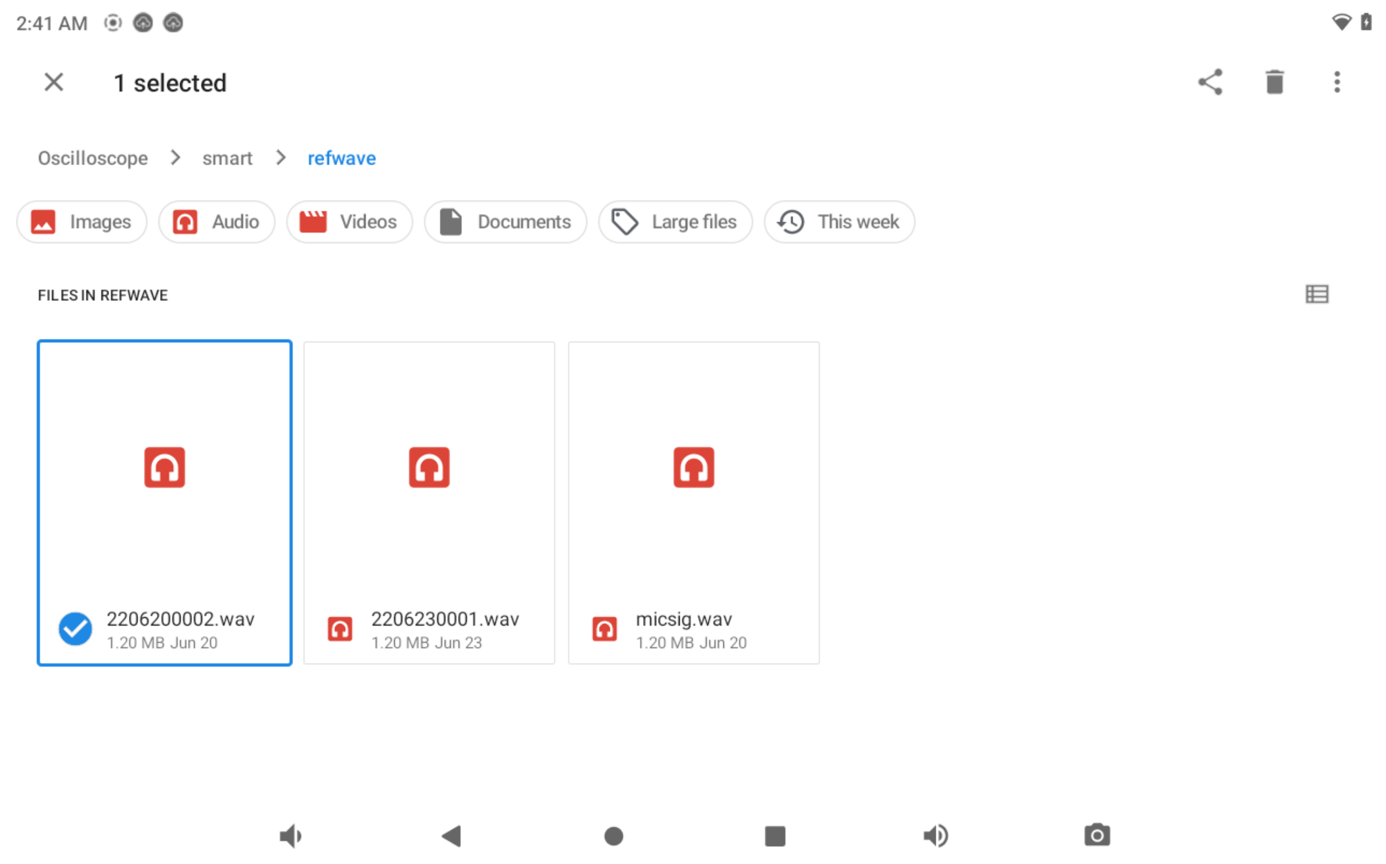


Figure 8-6 Delete Reference Files

CSV files

CSV file structure

CSV format contains the basic information of the saved data: save time, file name, data length, sampling interval, trigger time, source, vertical scale, vertical offset, vertical accuracy, horizontal time base, horizontal accuracy, probe multiples.

The data and length of CSV files can be saved up to 70K/35K depending on the single/dual channel while being saved. If the oscilloscope record length or the displayed data length is less than 70K/35K, the data length of CSV files changes either. For example, when the record length is set to 14/7/3.5K, there will be 7000 sample points in the dual channel CSV file.

Max and Min in CSV files

If running Min or Max measurements, Min and Max values displayed on the measurement results screen may not appear in CSV files.

Explanation: If the oscilloscope sampling rate is 1GSa/s, sampling will be once every 1ns. If the horizontal scaling is set to 10us/div, the data of 140us will be displayed (because there are 14 divisions on screen). To find the total number of samples, the oscilloscope will perform: 140us×1GSa/s=140K sampling, which require the oscilloscope to display 140K times of sampling using 600-pixel columns. The oscilloscope extracts 140K samples into 600-pixel columns, and this extraction will track Min and Max values of all points represented by any given column. These Min and Max values will be displayed in this screen column.

The similar process is applied to reduce sampled data and produce records that can be used to perform various analyses, such as measurements and CSV data. This analysis record (or measurement record) is much larger than 600 and may actually contain up to 60,000 points. However, once the number of points sampled exceeds 60,000, some extraction method is required. The extraction factor used to generate the CSV record is configured to provide the best estimate of all samples represented by each point in the record. Therefore, Min and Max values do not appear in CSV files.

8.4 Oscilloscope setting save

The oscilloscope supports saving up to 10 current settings and restoring them with one key.

Open the main menu, tap Save and enter Setting menu, as shown in Figure 8-7.

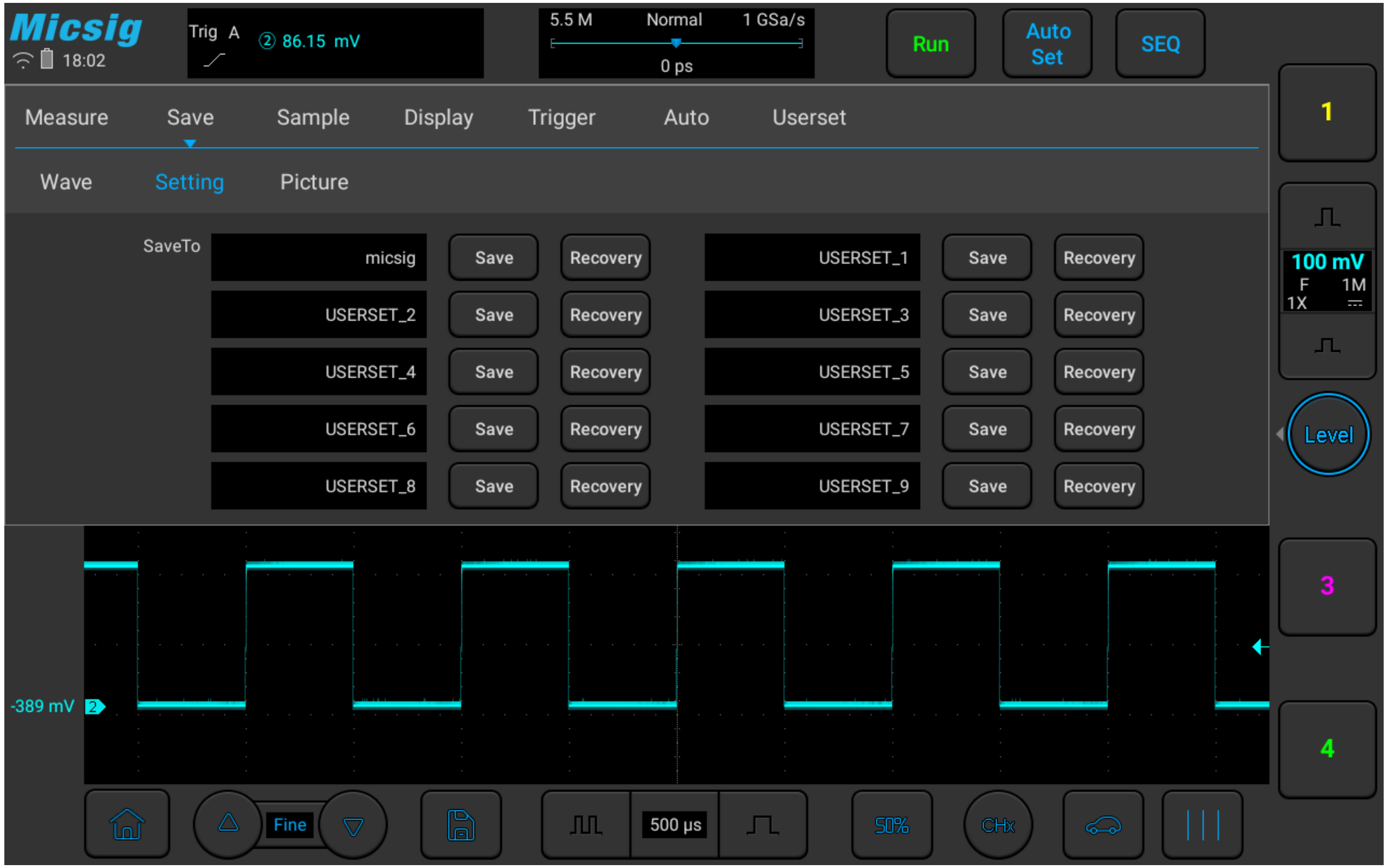


Figure 8-7 oscilloscope setting save

Tap the black box area to rename save settings, tap the Save button to store, the Recovery button to restore the settings.

Chapter 9 MATH and Reference

This chapter contains the detailed information of the MATH operation and reference channel of the oscilloscope. You are recommended to read this chapter carefully to understand the setting functions and operations of the MATH and reference channels of the ATO series oscilloscope.

- Dual waveform calculation
- FFT measurement
- Reference waveform call

9.1 Dual Waveform Calculation

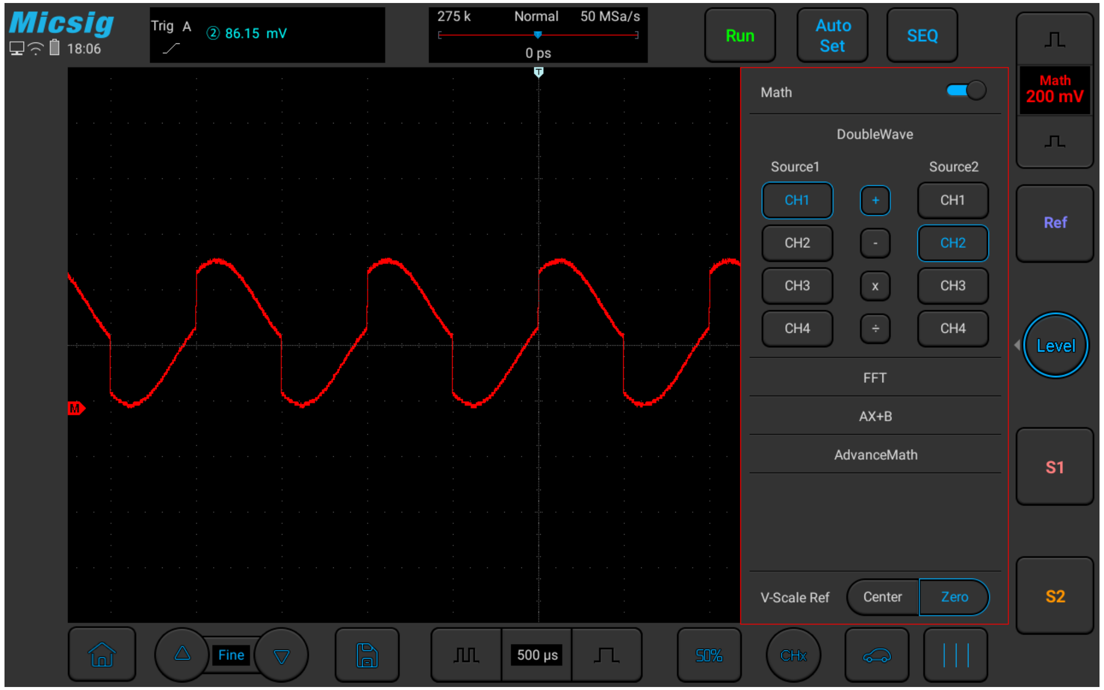


Figure 9-1 MATH Channel Waveform

Display math waveform

Swipe up or down at the channel selection area to enter the second channel selection area. Tap the soft key 

to open the math channel. After the math waveform is opened, the current channel selector is automatically opened.

Left swipe math channel icon to open the math channel menu. While opening math for the first time, the math operation is defaulted as the dual channel calculation.

Math operation prompt

If the analog channel or math function is clipped (not fully displayed on the screen), the resulting math function will also be clipped.

Once the math waveform is displayed, tap the channel icon to close the source channel for a better view of the math waveform.

The vertical sensitivity and offset of each channel participating in the math function can be adjusted to facilitate viewing and measuring of the math waveform.

The math function waveform can be measured using “Cursor” and “Measure”.

Adjust the math waveform

1) Press the math channel vertical sensitivity icon, directly tap the math waveform or math channel indication icon M, and set the math channel as the current channel.

2) For details of movement, vertical sensitivity adjustment, time base adjustment and vertical expansion reference of the math channel, please refer to "Chapter 4 Horizontal System" and "Chapter 5 Vertical System".

3) The vertical sensitivity, unit and time base corresponding to the math waveform are displayed in the channel area of the math channel. For details, see "2.7 Understand the Oscilloscope Display Interface".

Math waveform units

Use "Probe Type" on the channel menu to adjust the channel unit (refer to "6.4.4 Set Probe Type") and set the unit of each input channel to Volt or Ampere. The units of math function waveform include:

Math Function	Unit
＋/－	V, A, ?
×	VV, AA, W
÷	V/V, V/A, A/A, A/V

Table 9-1 List of Mathematical Units

Note: If the units of two operation source channels are different and the unit combination cannot be identified, the unit of math function will be displayed as? (undefined).

Math operators

Math operators perform arithmetic operations on the analog input channels.

Addition or subtraction

If addition or subtraction is selected, the values of function sources 1 and 2 will be added or subtracted point by point and the results will be displayed.

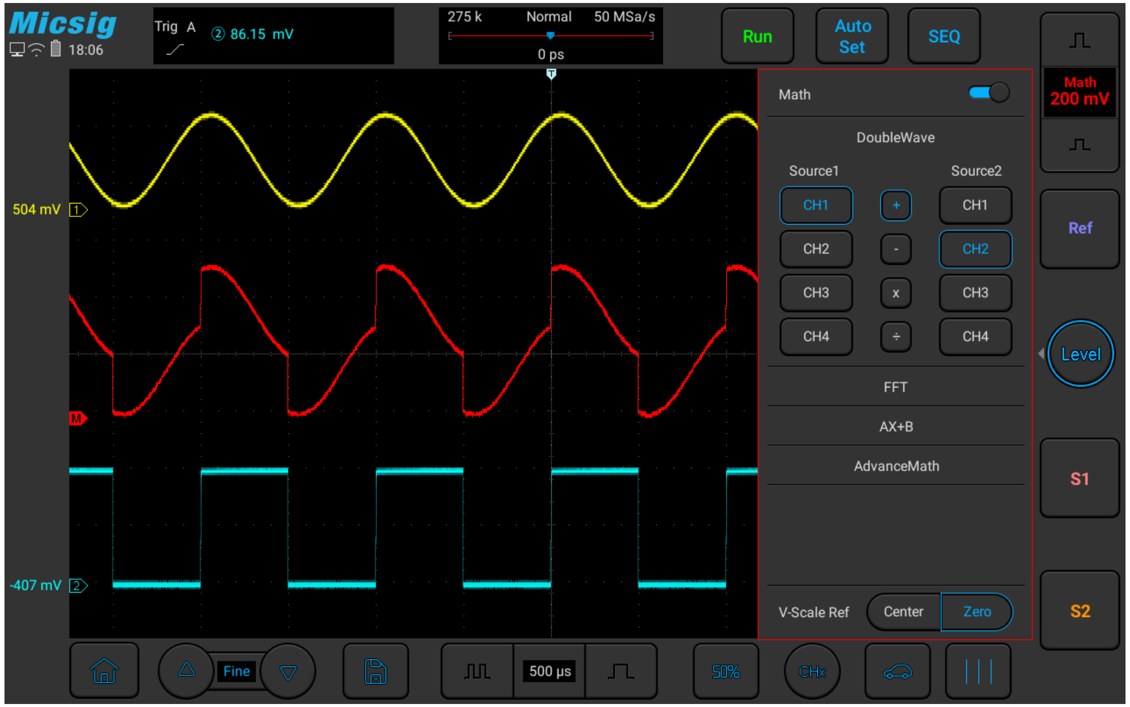


Figure 9-2 Mathematical Operation of CH1 adding CH2

Multiplication or division

When multiplication or division is selected, the values of function sources 1 and 2 values will be multiplied or divided point by point and the results will be displayed.

Multiplication is useful when viewing the power relationship, if one of the channels is proportional to the current.

9.2 FFT Measurement

FFT is used to calculate the Fast Fourier Transform using the analog input channel. FFT record specifies the digitization time of the source and converts it to the frequency domain. After selecting the FFT function, FFT spectrum is plotted as amplitude in V-Hz or dB-Hz on the oscilloscope display screen. The reading of the horizontal axis changes from time to frequency (Hz), while the unit of the vertical axis changes from volt to V or dB.

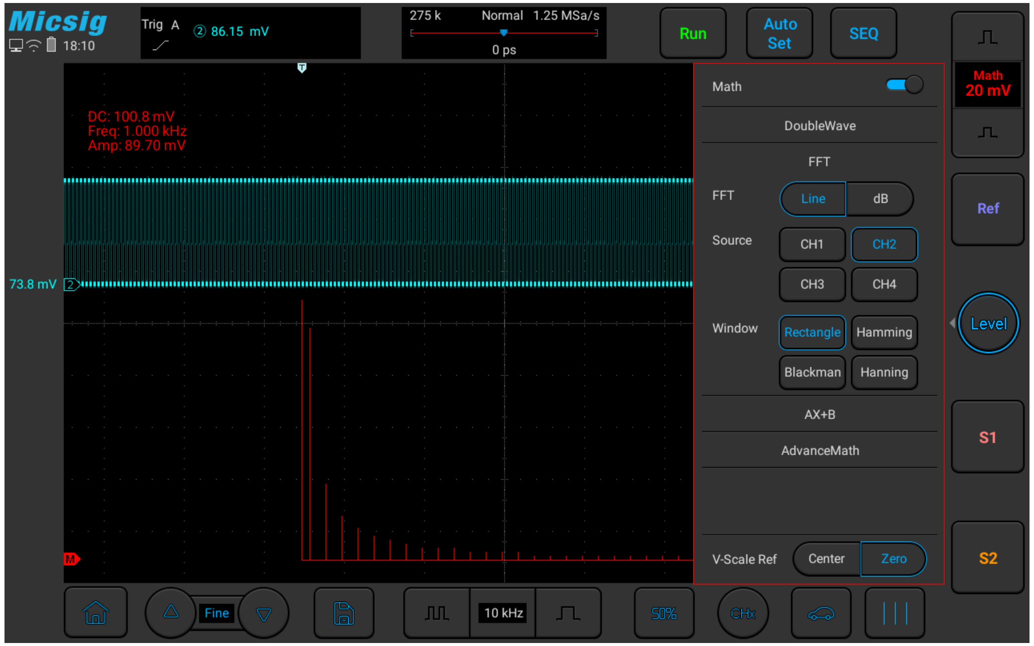


Figure 9-3 FFT Window

Open FFT

1) Swipe up or down at the channel selection area to enter the second channel selection area. Tap the soft key Math to open the math channel, left swipe to open math channel menu.

2) Tap FFT spectrum type "Line/Decibel" to open the FFT window (see Figure 9-3 FFT Window).

3) Tap the Operation Source box to select the channel for which FFT transform is required.

4) Tap the window box to select the window function applied to the FFT input signal.

Selection of window function

In the FFT transform, four different FFT windows can be selected.

Each window is alternatively used between frequency resolution and amplitude accuracy, and the appropriate window may be selected according to the characteristics of the following windows.

- **Rectangular window**

This is the best window type for resolution frequencies that are very close to the same value, but this type is the least effective at accurately measuring the amplitude of these frequencies. It is the best type of measuring the spectrum of non-repetitive signals and measuring the frequency component close to DC.

Use the “Rectangular” window to measure transients or bursts of signal levels before or after almost the same event. Moreover, this window can be used to measure equal-amplitude sine waves with very close frequencies and wideband random noises with relatively slow spectral variations.

- **Hamming window**

This is the best window type for resolution frequencies that are very close to the same value, and the amplitude accuracy is slightly better than the “Rectangular” window. The Hamming type has a slightly higher frequency resolution than the Hanning type.

Use Hamming to measure sinusoidal, periodic, and narrowband random noises. This window is used for measuring transients or bursts of signal levels before or after events with significant differences.

- **Hanning window**

  This is the best window type for measuring amplitude accuracy but less effective for resolving frequencies.

  Use Hanning to measure sinusoidal, periodic, and narrowband random noises. This window is used for measuring transients or bursts of signal levels before or after events with significant differences.

- **Blackman-Harris window**

  This is the best window type for measuring frequency amplitude, but worst for measuring the resolution frequency.

  Use the Blackman-Harris measurement to find the main single-signal frequency waveform for higher harmonics.

  Since the oscilloscope performs FFT transform on the finite-length time record, the FFT algorithm assumes that YT waveform is continuously repeated. Thus, when the period is integral, the amplitudes of YT waveform at the beginning and at the end are the same, and waveform will not interrupt. However, if the period of YT waveform is not integral, the waveform amplitudes at the beginning and at the end are different, resulting in high-frequency transient interruption at the junction. In the frequency domain, this effect is called leakage. Therefore, to avoid leakage, the original waveform is multiplied by a window function, forcing the values at the beginning and at the end to be zero.

Note: Signals with DC components or deviations can cause errors or deviations in the FFT waveform components. AC coupling can be selected to reduce DC components.

Spectrum type

Select Line, the vertical axis reads V or A; select dB, the vertical axis reads dB. When the spectrum is linear, the waveform is shown in Figure 9-4.

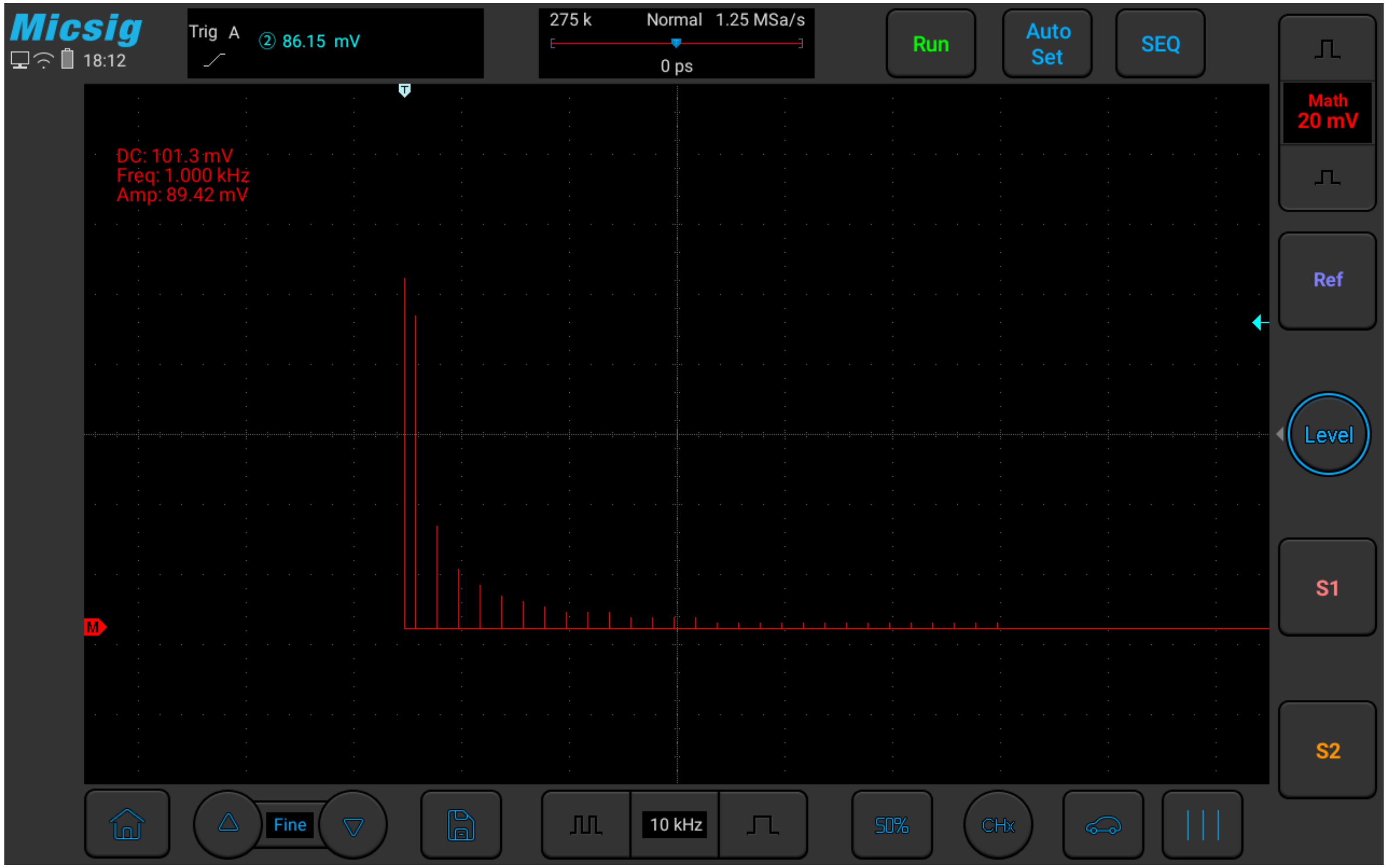


Figure 9-4 Spectrum Amplitude as V-Hz

Adjust FFT waveforms

Waveform position

- Select math channel as the current channel. After touching math waveform on the screen with one finger, adjust the waveform display position by dragging upward and downward, leftward and rightward, or tap the fine adjustment button in the lower left corner of the screen for fine adjustment
- Select math channel as the current channel and press the “position” knob in the horizontal button area to move the leftmost side of the waveform (0Hz) to the horizontal center of the screen.
- Select math channel as the current channel and press the “position” knob in the vertical button area to move the waveform to the vertical center of the screen.

Horizontal time base scale

Select math channel as the current channel, tap the time base adjustment button, and adjust the horizontal time base scale. The horizontal time base is stepped in 1-2-5, and the waveform changes either.

For FFT measurement, the reading of the horizontal axis changes from time to frequency (Hz), and it no longer shares the same time base with other analog channels. Therefore, before adjusting the horizontal frequency scale, the math channel must be set as the current channel.

Vertical sensitivity

Tap  or  on the right side of the screen to set the vertical sensitivity (V/div or dB/div) for the channel so that waveform is displayed on the screen at an appropriate size. The vertical sensitivity factor is stepped in 1-2-5 (using 1:1 probe).

Note: FFT waveform does not support automatic parameter measurement.

9.3 Advanced Math

ATO series oscilloscopes support user-defined editing formulas for waveform calculation. Support the input of functions, operators, channels, constants, variables, etc. The expression supports up to 36 characters.

Click the corresponding button to input and edit the waveform (please click in order, the ones that are grayed out cannot be clicked).

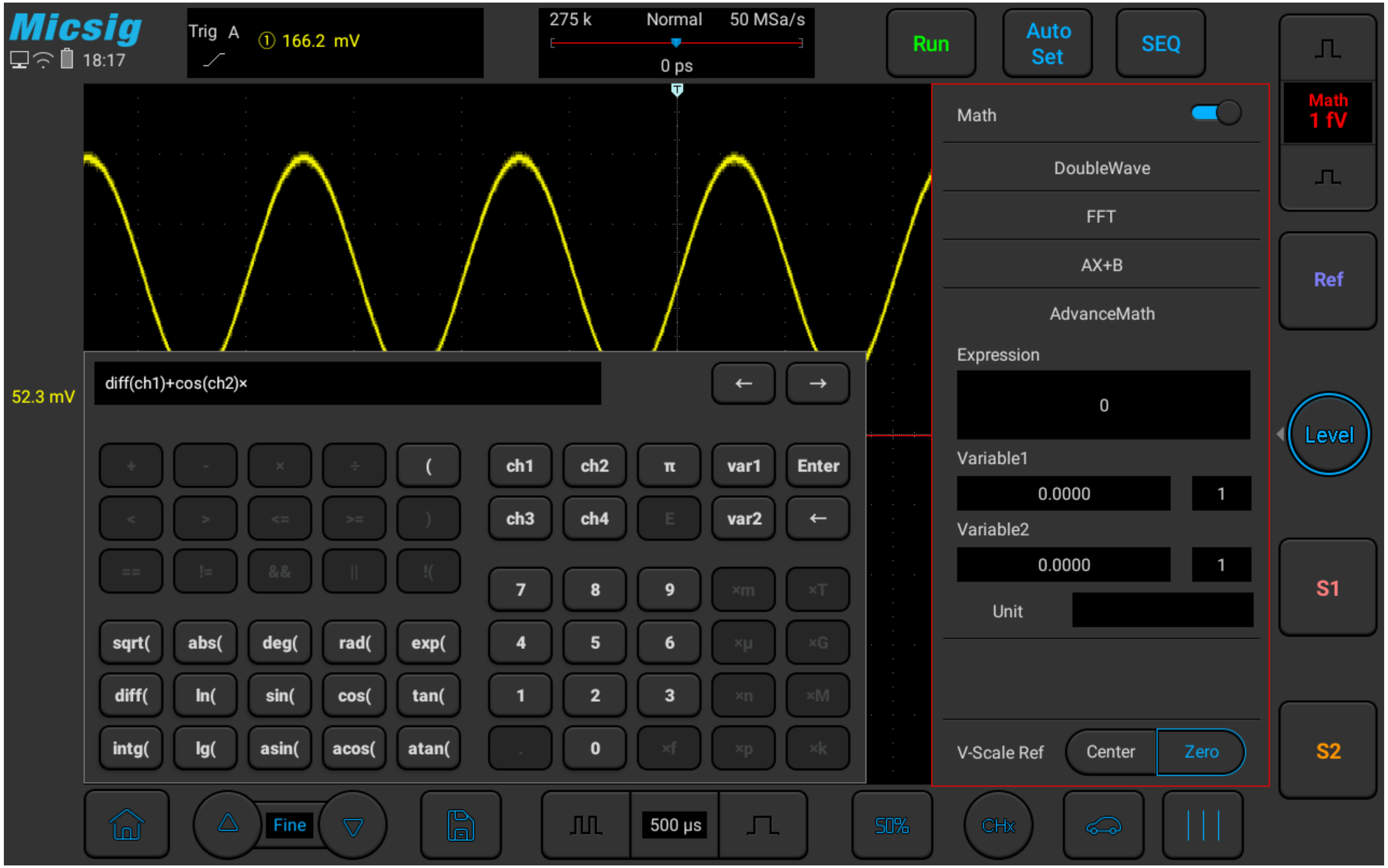


Figure 9-5 Advanced Math

Type	Description	Item	Remark
Function		Sqrt()、Abs()、Deg()、Rad()、Exp()、Diff()、ln()、Sine()、Cos()、Tan()、Intg()、Log()、arcsin()、arccos()、arctan()	Functions can be nested
Channel	Source	Ch1、Ch2、Ch3、Ch4	
Variable	Source	variable1、variable2	When a variable is written in the expression, the input box of the variable appears in the math menu, indicating that it can be input; for example, input 4.1235 -3 for variable 1, which means 4.1235×9^{-3}

			Variable value range -9.9999~9.9999, variable power range -9~9
Operator		+、-、*、/、==、!=、>、<、≥、≤、&&、||、!(	
symbol	brackets	(、)	
Value	Source	0、1、2、3、4、5、6、7、8、9、.、π、E	
	Source	10^{x}	
	Numerical unit	f、p、n、u、m、K、M、G、T	

Table 9-2 List of Advanced Math

9.4 Reference Waveform Call

Reference waveform call and close

Swipe up or down at the channel selection area to enter the second channel selection area. Left swipe 

button to open the reference menu, see Figure 9-5.

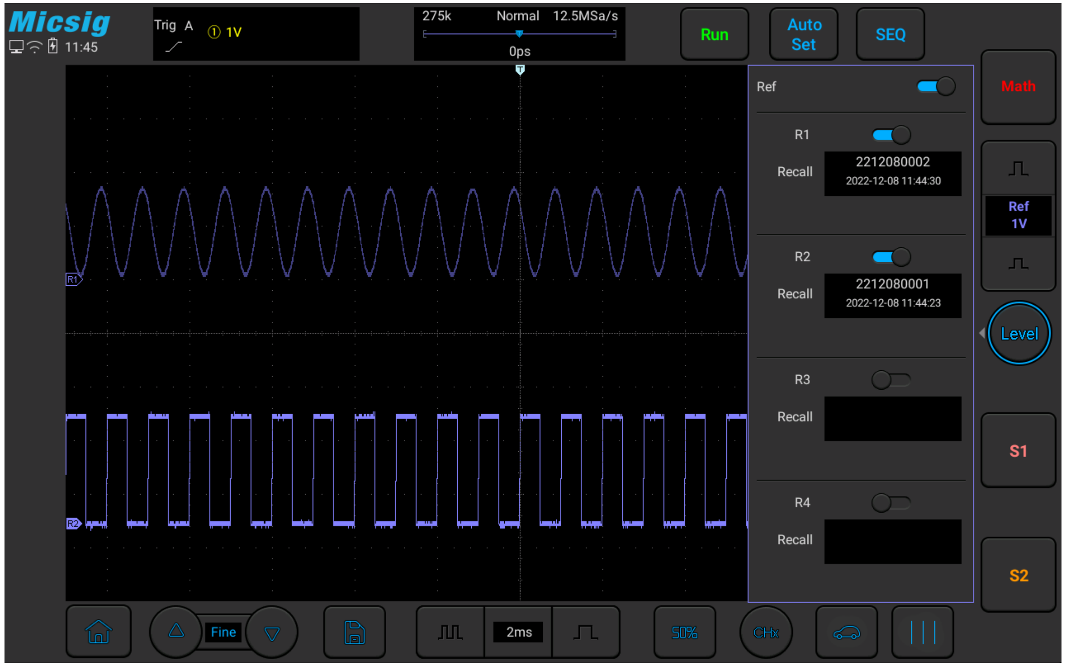


Figure 9-6 Reference Channel Menu

When there are already waveforms loaded into the reference channel, click “Open/Close” button to open or close the reference channel; the reference waveform is displayed in blue-violet, and the four stored waveforms can be displayed simultaneously, wherein the current reference waveform is brighter than non-current reference waveforms.

When there are no waveforms loaded into the reference channel, turn on the “Call” switch to call waveforms.

Take R1 as an example, with operation steps as follows:

1) Open reference menu.

2) Tap the “Call” file box under R1 to open the reference file column.

3) Click the name of the reference waveform file to be called. The file is loaded into R1 channel. Then, R1 channel is turned on as the current channel waveform, and the reference waveform channel icon 

is highlighted. The displayed state changes from “Close” to “Open”. As in Figure 9-6, the brighter reference waveform is shown as the current reference channel.

If there are already files loaded into the reference channel, tap 

to open the reference channel of all loaded reference files; Right swipe 

to close all currently opened reference waveforms. A single reference channel may also be opened with the Open/Close button.

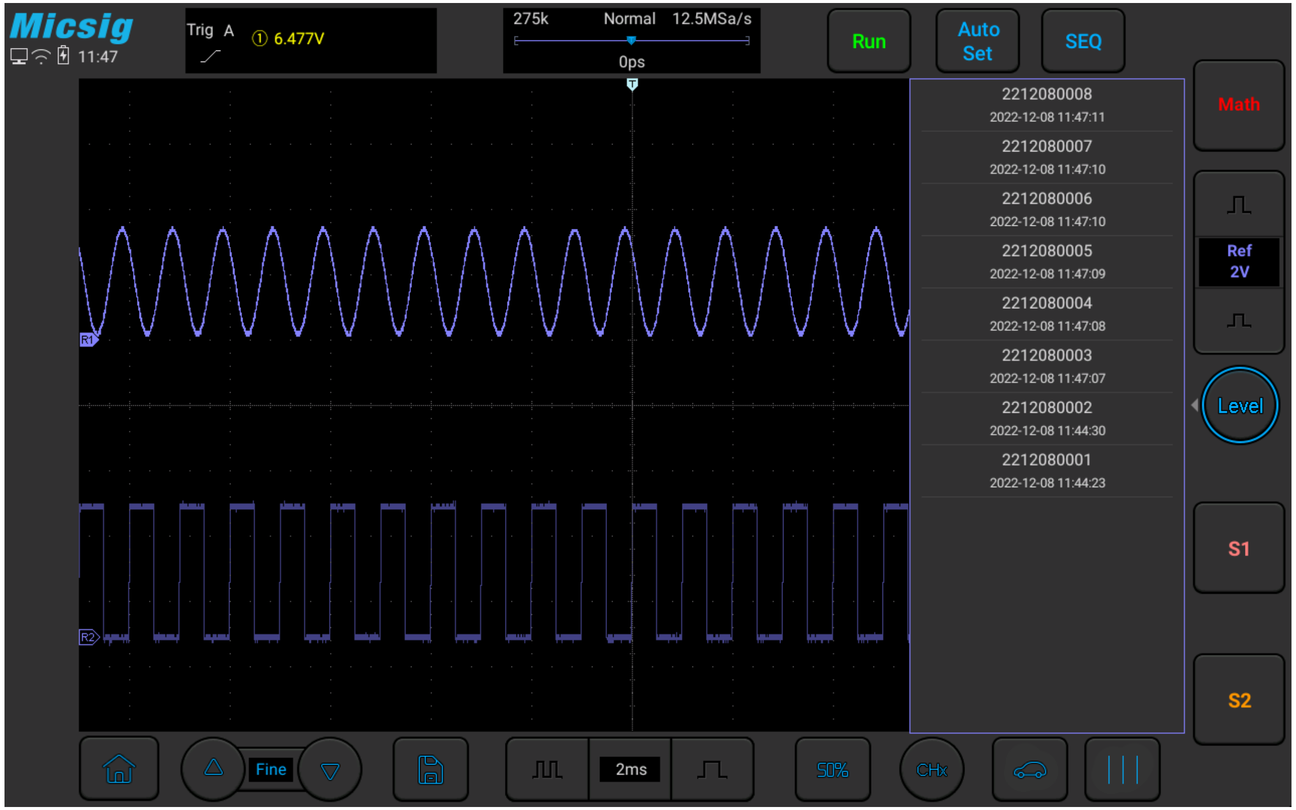


Figure 9-7 Restore Reference Waveform

Close the reference waveform:

1) In the reference menu, tap “Open/Close” button in R1 to close the reference waveform.

2) Repeat step 1 to close other reference channels.

3) Right swipe 

to turn off all reference waveforms.

Reference waveform movement and time base adjustment

The horizontal or vertical movement and zoom of reference waveforms are independent of analog channels, and the adjustments among different reference waveform channels are also independent of each other.

To adjust the reference waveform of a channel, first set the channel as the current channel, and then adjust the reference waveform by move or zoom (in accordance with the analog channel method).

The scale and time base of the current channel reference waveform are displayed on the reference button. After switching the current reference channel, the scale and time base on the reference button change with the change of current reference channel.

Chapter 10 Display Settings

This chapter contains the detailed information of the display settings and function buttons of the oscilloscope. You are recommended to read this chapter carefully to understand the display setting functions and operations of the ATO series oscilloscope.

- Waveform setting
- Graticule setting
- Color temperature setting
- Persistence setting
- Horizontal expansion center
- Time base mode selection

In the main menu, tap Display button to enter display settings menu, as shown in Figure 10-1.

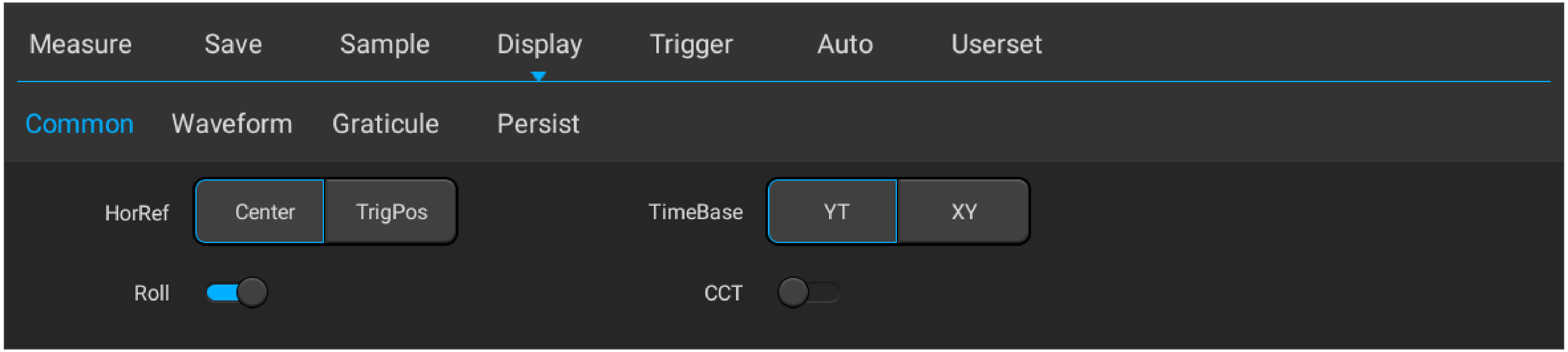


Figure 10-1 Display Settings and Function Buttons