Micsig

ATO1000 Series Automotive Oscilloscope

USER MANUAL

Shenzhen Micsig Instrument Co.,Ltd.

Version Info

Version	Date	Remarks
V1.0	2020.06	

Preface

Dear customers,

Congratulations! Thank you for buying Micsig instrument. Please read this manual carefully before use and particularly pay attention to the “Safety Precautions”.

If you have read this manual, please keep it properly for future reference.

The materials contained in this document are provided "as present" and are subject to change in future versions without notice.

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Chapter 1. Safety Precautions

1.1 Safety Precautions

The following safety precautions must be understood to avoid personal injury and prevent damage to this product or any products connected to it. To avoid possible safety hazards, it is essential to follow these precautions while using this product.

- **Only professionally trained personnel can operate the maintenance procedure.**
- **Avoid fire and personal injury.**
- **Use proper power cord.** Use only the power cord specified for this product and certified for the country/region of use.
- **Connect and disconnect probes properly.** Connect the instrument probe correctly, and its ground terminal is ground phase. Do not connect or disconnect probes or test leads while they are connected to a voltage source. Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement product.
- **Ground the product. To avoid electric shock, the instrument grounding conductor must be connected to earth ground**.
- **Observe all terminal ratings**. To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further information of ratings before making connections to the product.
- **User correct probes**. To avoid excessive electric shock, use only correct rated probes for any measurement.
- **Disconnect AC power**. The adapter can be disconnected from AC power and the user must be able to access the adapter at any time.
- **Do not operate without covers**. Do not operate the product with covers or panels removed.
- **Do not operate with suspected failures**. If you suspect that there is damage to this product, have it inspected by service personnel designated by Micsig.
- **Use adapter correctly.** Supply power or charge the equipment by power adapter designated by Micsig, and charge the battery according to the recommended charging cycle.
- **Avoid exposed circuitry.** Do not touch exposed connections and components when power is present.
- **Provide proper ventilation.**
- **Do not operate in wet/damp conditions.**
- **Do not operate in a flammable and explosive atmosphere.**
- **Keep product surfaces clean and dry.**
- **The disturbance test of all models complies with Class A standards, based on EN61326:1997+A1+A2+A3, but do not meet Class B standards.**

Measurement Category

ATO series oscilloscopes can be measured under measurement category I.

Measurement Category Definition

Measurement category I is for measurement on a circuit that is not directly connected to the mains power supply. For example, there is no circuit drawn from the main power source, or a circuit that has been drawn from the mains but has been specially protected (internal). In the latter case, the instantaneous stress will change; therefore, the user should understand the instantaneous endurance of the device.

Warning:

IEC measurement category. Under IEC category I installation conditions, the input terminal can be connected to a circuit terminal with a maximum line voltage of 300Vrms. To avoid the risk of electric shock, please do not connect the input terminal to a circuit whose line voltage exceeds 300Vrms. The transient overvoltage exists in a circuit isolated from the main power supply. TO1000 series digital oscilloscopes are designed to safely withstand occasional transient overvoltages up to 1000Vpk. Do not use this equipment to measure in a circuit where the instantaneous overvoltage exceeds this value.

1.2 Safety Terms and Symbols

Terms in the manual

These terms may appear in this manual:

⚠**Warning.** *Warning statements indicate conditions or practices that could result in injury or loss of life.*

⚠**Caution.** *Caution statements indicate 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 this product or other properties.

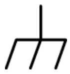
Symbols on the product

The following symbols may appear on the product:

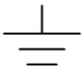
Hazardous Voltage

Caution Refer to Manual

Protective Ground Terminal



Chassis Ground



Measurement Ground Terminal

Please read the following safety precautions to avoid personal injury and prevent damage to this product or any products connected to it. To avoid possible hazards, this product can only be used within the specified scope.

⚠Warning

If the instrument input port is connected to a circuit with the peak voltage higher than 42V or the power exceeding 4800VA, to avoid electric shock or fire:

- *User only insulated voltage probes supplied with the instrument, or the equivalent product indicated in the schedule.*
- *Before use, inspect voltage probes, test leads, and accessories for mechanical damage and replace when damaged.*
- *Remove voltage probes and accessories not in use.*
- *Plug the battery charger into the AC outlet before connecting it to the instrument.*

Chapter 2. Quick Start Guide of Oscilloscope

This chapter contains oscilloscope inspection and some related operations. It is recommended that you read this chapter carefully in order to understand the appearance, power on and off, oscilloscope settings and related calibration requirements of the ATO series oscilloscope.

- Inspect package contents
- Use bracket
- Rear panel & side panel
- Front panel
- Power on/off the oscilloscope
- Understand the oscilloscope display interface
- Introduction to basic operations of oscilloscope
- Mouse operation
- Connect probe to the oscilloscope
- Use auto
- Use factory settings
- Use auto-calibration
- Passive probe compensation
- Modify the language

2.1 Inspect Package Contents

When you open package after receipt, please check the instrument according to the following steps.

1) Inspect if there is any damage caused by transportation

If the package or foam is found to be severely damaged, please retain it until the instrument and accessories pass the electrical and mechanical properties test.

2) Inspect the accessories

A detailed description is given in "Annex C" of this manual. You can refer it to check if the accessories are complete. If the accessories are missing or damaged, please contact Micsig's agent or local office.

3) Inspect the instrument

If any damage to oscilloscope is found by the appearance inspection or it fails to pass the performance test, please contact Micsig's agent or local office. If the instrument is damaged due to transportation, please retain the package and contact the transportation company or Micsig's agent, and Micsig will make arrangement.

2.2 Use the Bracket

Put the front panel of the oscilloscope flatly on the table. Use your two index fingers to hold the underside of the bracket and open the bracket by slightly upwards force, as shown in Figure 2-1.

Figure 2-1 Open Bracket

2.3 Rear panel & side panel

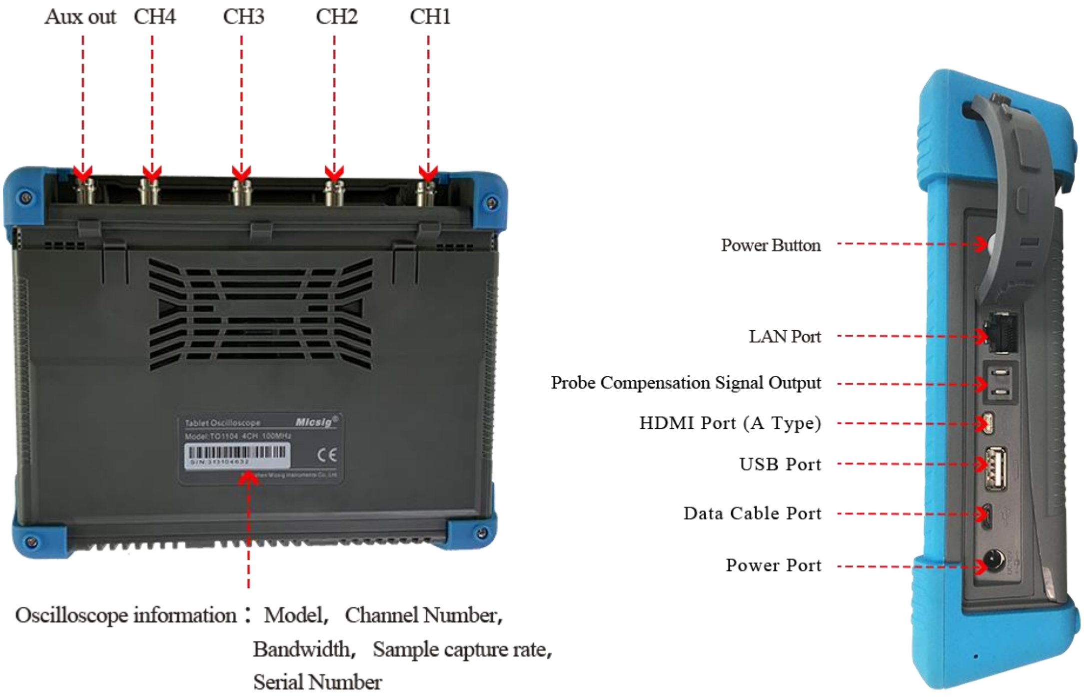


Figure 2-2 Rear panel & side Panel

2.4 Front Panel

Figure 2-3 Front Panel of Tablet Oscilloscope

Touch button	Description
Run Stop	**Run/Stop:** Touch to start/Stop acquisition
Single SEQ	**Single SEQ:** Touch to trigger on a single waveform
Auto	**Auto:** Automatically adjust the vertical scale factor, vertical position and horizontal time base to achieve the best display state of the waveform
50%	**50%:** Touch to set: ● The channel zero point quickly returns to the center of the screen ● The trigger position quickly returns to the center of the screen ● Trigger level quickly returns to the center of waveform ● The cursor automatically adjusts to the center of the screen on both sides, horizontal or vertical
Measure	**Measure:** Touch to turn on / off measurement menu
Trigger	**Trigger:** Touch to turn on / off trigger menu
	Home: Touch to return to the homepage

Table 2-1 Description of Oscilloscope Front Panel

2.5 Power on/off the Oscilloscope

Power on/off the oscilloscope

First time start

- Connect power adapter to the oscilloscope, and the oscilloscope should not be pressed on the adapter cable.
- Press the power button to start the instrument.

Power on

- Press the power button to start the instrument while ensuring it is connected to a power supply.

Power off

- Press the power button , go to power-off interface, and click to turn off the instrument.
- Long press the power button for forced power-off of the instrument.

⚠ **Caution**: Forced power-off may result in loss of unsaved data, please use with caution.

2.6 Understand the Oscilloscope Display Interface

This part briefly introduces and describes the user interface of the ATO series oscilloscope. After reading this part, you will be familiar with the contents of the display interface of the oscilloscope in the shortest time. The specific settings and adjustments are described in detail in the following chapters. The following items may appear on the screen at a given time, but not all items are visible. The oscilloscope interface is shown in Figure 2-4.

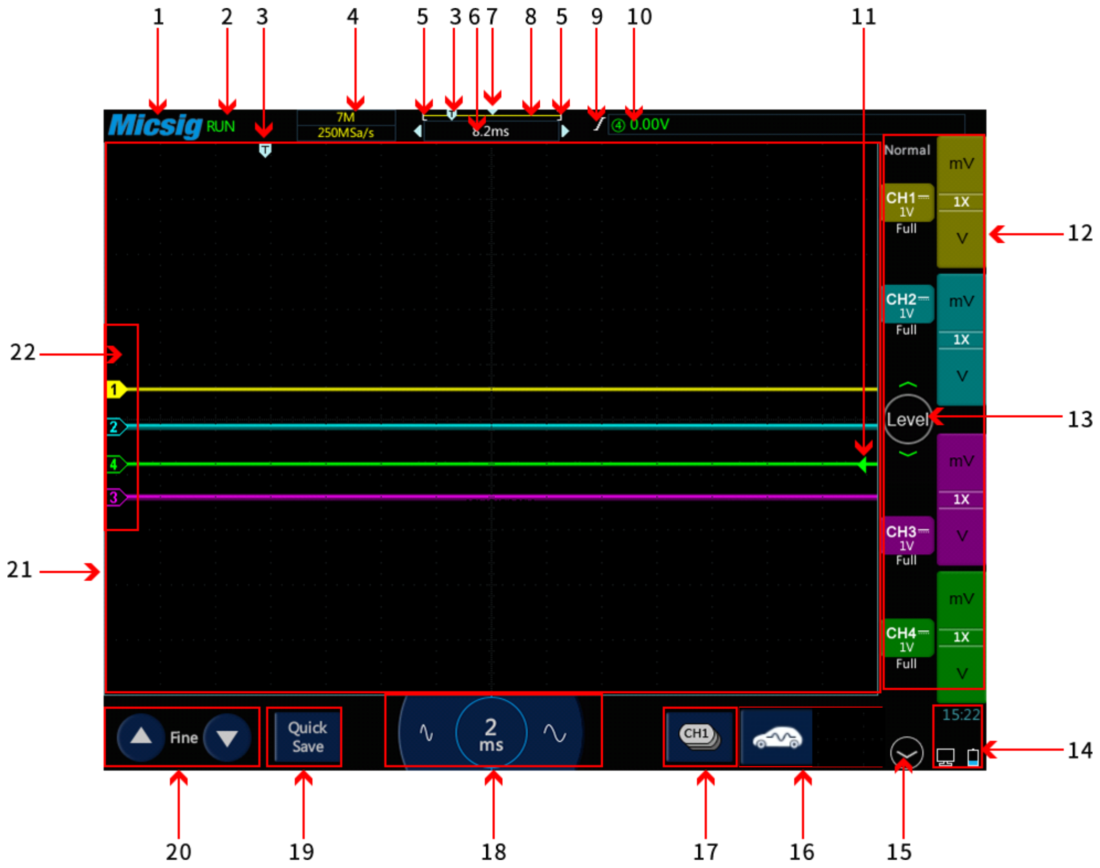


Figure 2-4 Oscilloscope Interface Display

No.	Description
1	Micsig logo
2	Oscilloscope status, including RUN, STOP, WAIT, AUTO
3	Trigger point
4	Sampling rate, memory depth
5	The area in "[]" indicates the position of waveform displayed on the screen throughout the memory depth
6	Delay time, the time at which the center line of the waveform display area is relative to the trigger point
7	Center line of waveform display area

No.	Description
8	Memory depth indicatrix
9	Current trigger type indication
10	Current trigger source, trigger level
11	Trigger level indicator
12	CH1、CH2、CH3、CH4 cchannel icons and vertical sensitivity icon. Tap the channel icons to open channels and corresponding channel menu, or close channels, operate in a loop; Tap mV or V to adjust the vertical sensitivity of channels; Display the vertical sensitivity of channels; Display the sampling mode
13	Trigger level adjustment, press on the button to modify the trigger level through upward and downward movements
14	Display areas of USB-PC connection, USB connection, battery level, time etc.
15	Switch to MATH and REF channel
16	Automotive diagnostic software presets
17	Current channel selection. Click to pop up the current channel switching menu to switch the current channel.
18	Horizontal time base control icon. Tap the left/right time base buttons to adjust the horizontal time base of the waveform. Tap the time base to turn on the time base knob and turn the knob to adjust the time base.
19	Quick save. Tap to quickly save the waveform as a reference waveform.
20	Fine adjustment button. Tap the button to finely adjust the last operation, including waveform position, trigger level position, trigger point and cursor position.
21	Waveform display area displays information such as waveforms, cursors, and related waveform measurements.
22	Channel indicator can indicate the zero-level position of the open channel.

Table 2-1 Description of Oscilloscope Display Interface

2.7 Introduction Basic Operations of Touch Screen

The tBook mini Series oscilloscope operates mainly by tap, swipe, single-finger drag, and multi-finger drag.

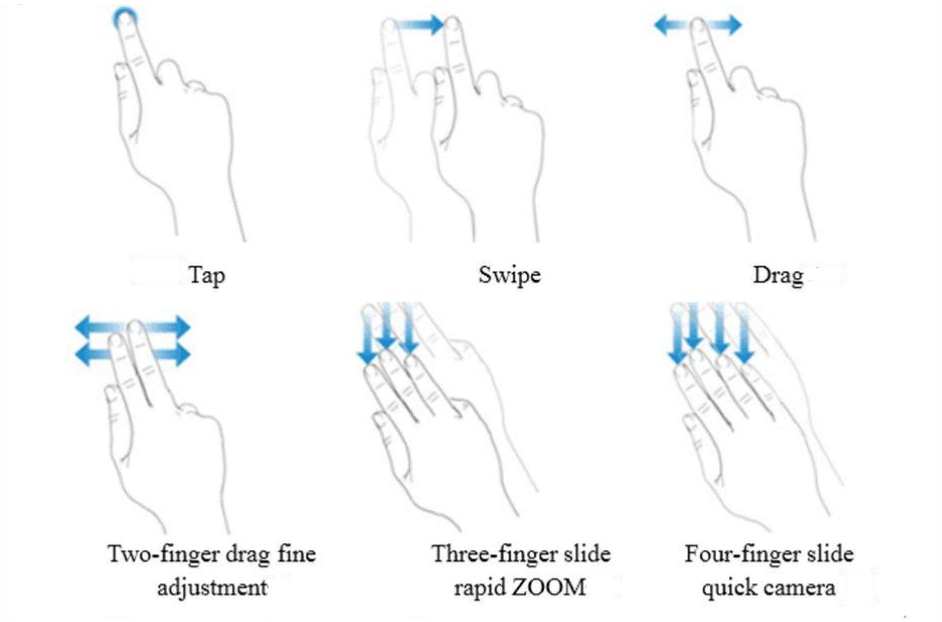


Figure 2-5 Basic Operations of tBook mini series Oscilloscope

Tap

Tap button on the touch screen to activate the corresponding menu and function. Tap any blank space on the screen to exit the menu.

Swipe

Single-finger swipe: to open/close menus, including main menu, shortcut menu button and other channel menu operations. For example, the main menu is opened as shown in Figure 2-6. The closing method is the opposite of the opening method.

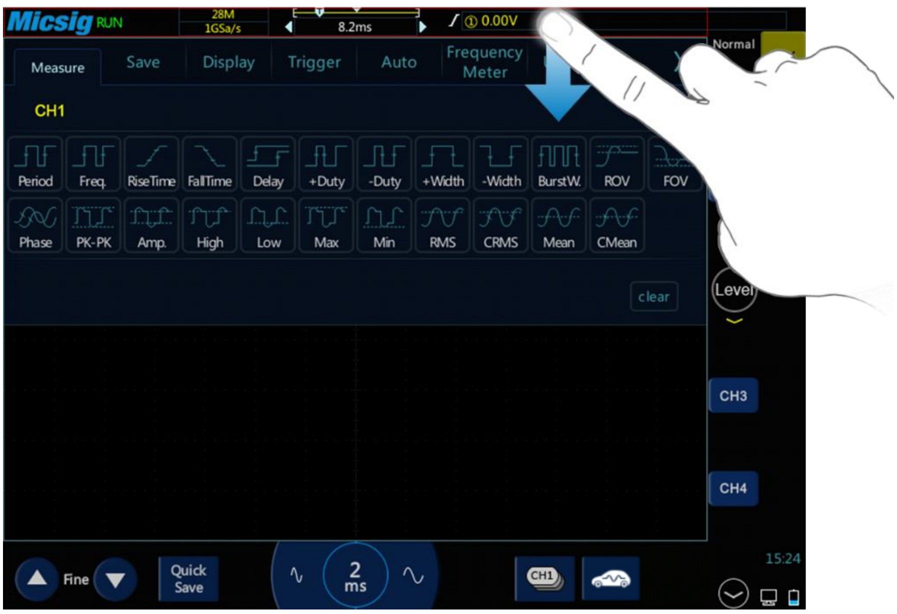


Figure 2-6 Slide out of Main Menu

Tap the options in the main menu to enter the corresponding submenu.

The opening methods of channel menu and math menu are slightly different from that of the main menu. Tap the channel icon and math icon to open the corresponding menu.

Three-finger slide: to quickly turn on/off Zoom. Refer to "3.5 Zoom Mode" for details.

Four-fingers slide: for quick screen capture. Refer to "7.1 Screen Capture Function" for details.

Single-finger drag: For coarse adjustments of vertical position, trigger point, trigger level, cursor, etc. of the waveform. Refer to "3.1 Horizontal Move Waveform" and "4.3 Adjust Vertical Position" for details.

2.8 Mouse Operation

Connect the mouse to the "USB Host" interface, then operate the oscilloscope with the mouse. The menu will pop up with the right mouse button. The left mouse button has the same function as the finger touch, and the horizontal time base can be adjusted by rolling the mouse wheel. The right mouse button menu is shown in Figure 2-7.

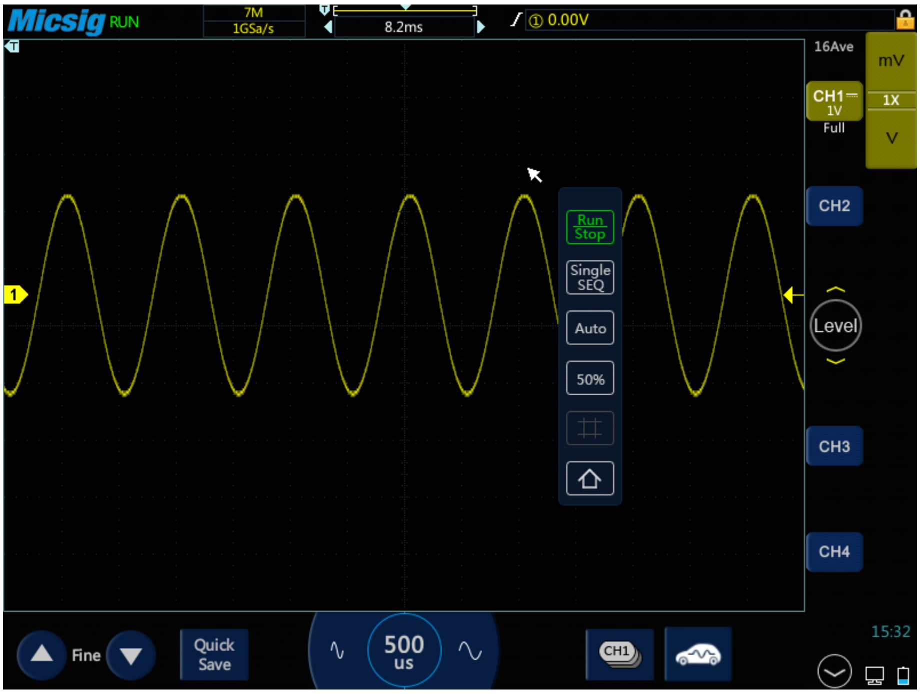


Figure 2-7 Mouse Cursor

Note: The touch operation cannot be used normally after the mouse is connected (unless it is unlocked, see 12.9 Shut down, lock screen and unlock for details)

2.9 Connect Probe to the Oscilloscope

1) Connect the probe to the oscilloscope channel BNC connector.

2) Connect the retractable tip on the probe to the circuit point or measured equipment. Be sure to connect the probe ground wire to the ground point of the circuit.

⚠ **Maximum input voltage of the analog input**

Category I 300Vrms, 400Vpk.

2.10 Use Auto

Once the oscilloscope is properly connected and a valid signal is input, tap the Auto Set button [Auto] to quickly configure the oscilloscope to be the best display effects for the input signal.

Auto is divided into **Auto Set** and **Auto Range**. It is defaulted as Auto Set.6

Auto Set — Single-time auto, and each time press "Auto", the screen displays "Auto" in the upper left corner. The oscilloscope can automatically adjust the vertical scale, horizontal scale and trigger setting according to the amplitude and frequency of signals, adjust the waveform to the appropriate size and display the input signal. After adjustments, exit from the auto set, the "Auto" in the upper left corner disappears.

Channels may be automatically opened. Any channel greater or less than the threshold level can be opened or closed automatically according to the set threshold level. The threshold level can be settable.

Source can be automatically triggered, and the triggered source channel can be automatically set to select priority to the current signal or to the maximum signal.

Open the main menu. Tap "Auto" to open the auto set menu, including channel open/close setting, threshold voltage setting and trigger source setting.

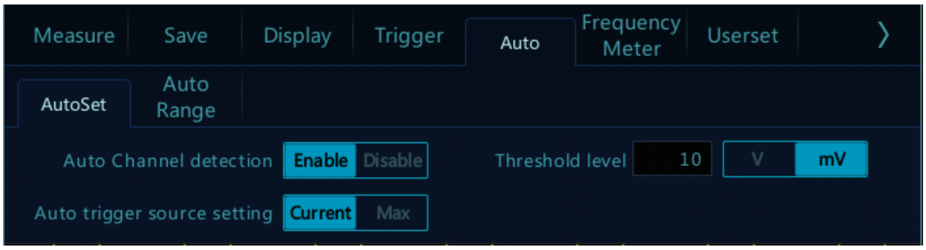


Figure 2-8 Open Auto Set

Automatic configuration includes: single channel and multiple channels; automatic adjustment of the horizontal time base, vertical sensitivity and trigger level of signal; the oscilloscope waveform is inverted off, the bandwidth limit sets to full bandwidth, it sets as DC coupling mode, the sampling mode is normal; the trigger type is set to edge trigger and the trigger mode is automatic.

Note: The application of Auto Set requires that the frequency of measured signal is no less than 20Hz, the duty ratio is greater than 1% and the amplitude is at least 2mVpp. If these parameter ranges are exceeded, Auto Set will fail.

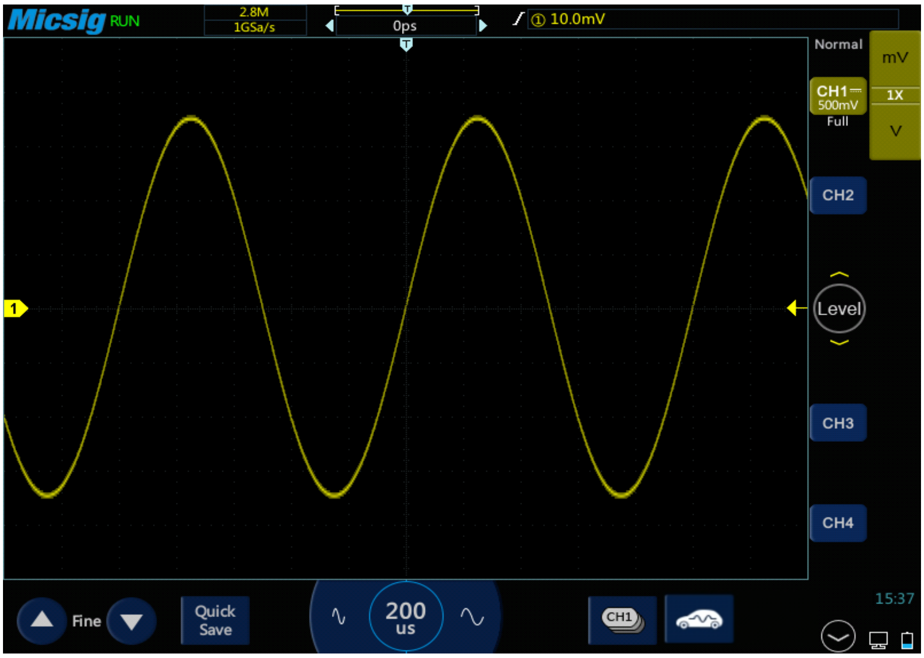


Figure 2-9 Auto Set Waveform

Auto Range - Continuously automatic, the oscilloscope continuously adjusts the vertical scale, horizontal time base and trigger level in a real-time manner according to the magnitude and frequency of signal. It is defaulted as off and needs to be opened in the menu. This function is mutually exclusive with "Auto Set".

Open the main menu and tap "Auto" to open the auto range menu for the corresponding settings. When the oscilloscope auto range function is turned on, the oscilloscope will automatically set various parameters, including: vertical scale, horizontal time base, trigger level, etc. When the signal is connected, these parameters will automatically change, and the signal does not need to be operated again after the change. The oscilloscope will automatically recognize and make the appropriate changes.

- Auto range: Turn the auto range function on or off
- Vertical scale: Turn on the vertical scale automatic adjustment function;
- Horizontal time base: Turn on the horizontal time base automatic adjustment function;
- Trigger level: Turns on the auto-adjust trigger level function.

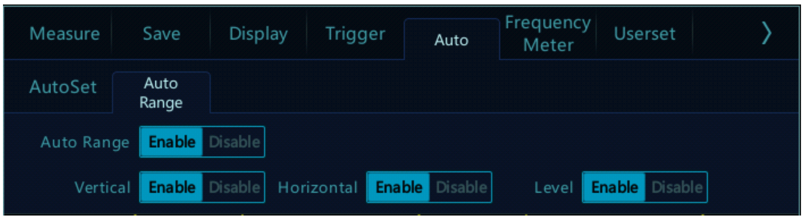


Figure 2-10 Open Auto Range

Auto Range is usually more useful than Auto Set under the following situations:

1) It can analyze signals subject to dynamic changes.

2) It can quickly view several continuous signals without adjusting the oscilloscope. This function is very useful if you need to use two probes at the same time, or if you can only use the probe with one hand because the other hand is full.

3) Control the automatic adjustment setting of the oscilloscope.

2.11 Load Factory Settings

Open the main menu, tap "User Settings" to enter the user setting page. Tap "Factory Settings" and the dialog box for loading factory settings will pop-up. Press "OK" and load the factory settings. The dialog box for loading factory settings is shown in Figure 2-11.

Figure 2-11 Load Factory Settings

2.12 Use Auto-calibration

Open the main menu, tap "User Settings" to enter the user setting page. Tap "Auto Calibration" to enter the auto-calibration mode. When the auto-calibration function is active, the upper left corner of the screen displays "Calibrating" in red, and after calibrating is finished, the word in red disappears. When the temperature changes largely, the auto-calibration function can make the oscilloscope maintain the highest accuracy of measurement.

- Auto-calibration should be done without probe.
- Auto-calibration process takes about two minutes.
- If the temperature changes above 10°C, we recommended users perform the auto-calibration.

2.13 Passive Probe Compensation

Before connecting to any channels, users should make a probe compensation to ensure the probe match the input channel. The probe without compensation will lead to larger measurement errors or mistakes. Probe compensation can optimize the signal path and make measurement more accurate. If the temperature changes 10°C or above, this program must run to ensure the measurement accuracy.

Probe compensation may be conducted in the following steps:

1) First, connect the oscilloscope probe to CH1. If a hook head is used, make sure that it is in good connection with the probe.

2) Connect the probe to the calibration output signal terminal and connect the probe ground to the ground terminal. As shown in Figure 2-12.

Figure 2-12 Probe Connection

3) Open the channel (if the channel is closed).

4) Adjust the oscilloscope channel attenuation coefficient to match the probe attenuation ratio.

5) Tap Auto button or manually adjust the waveform vertical sensitivity and horizontal time base. Observe the shape of the waveform, see Figure 2-13.

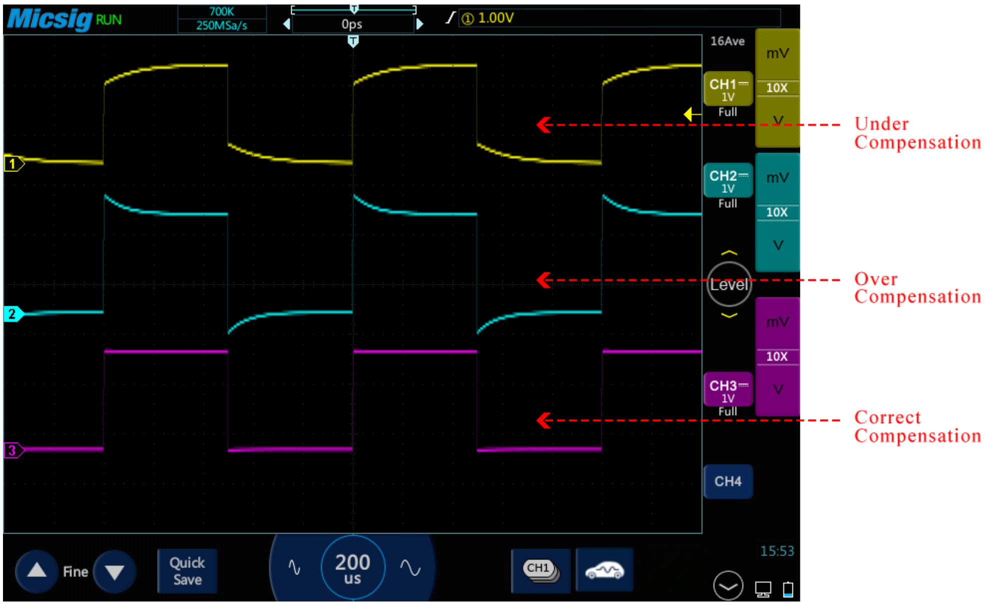


Figure 2-13 Probe Compensation

If the waveform on the screen is shown as "under-compensation" or "over-compensation", please adjust the trimmer capacitor until the waveform shown on the screen as "correct-compensation". The probe adjustment is shown in Figure 2-14.

Figure 2-14 Probe Adjustment

The safety ring on the probe provides a safe operating range. Fingers should not exceed the safety ring when using the probe, so as to avoid electric shock.

6) Connect the probe to all other oscilloscope channels (Ch2 of a 2-channel oscilloscope, or Ch 2, 3 and 4 of a 4-channel oscilloscope).

7) Repeat this step for each channel.

⚠**Warning**

- *Ensure the wire insulation is in good condition to avoid probe electric shock while measuring high voltage.*
- *Keep your fingers behind the probe safety ring to prevent electric shock.*
- *When the probe is connected a voltage source, do not touch metal parts of the probe-head to prevent electric shock.*
- *Before any measurement, please correctly connect the probe ground end.*

2.15 Modify the Language

To modify the display language, please refer to "11.4 Settings - Language".

Chapter 3 Automotive Test

This chapter contains most of the test applications of ATO automotive oscilloscopes in automotive circuits. The purpose is to help users quickly troubleshoot and locate automotive electronics faults. It is recommended that you read this chapter carefully to understand the general operation and use of automotive oscilloscopes.

3.1 Charging/Start Circuit

All electrical equipment of the car is powered by a power system composed of an on-board generator and a battery. In this power system, the generator supplies power to the electrical equipment and charges the battery when the generator is working normally. When the power generated by the generator is less than the power consumed by the on-board electrical equipment, the battery participates in power supply to make up for its deficiency. When the engine is working normally, it is necessary to ensure sufficient charging time for the battery to ensure that it does not lose power. When the generator is working normally, whether to charge the battery can be indicated from the charging indicator on the instrument panel. Due to the large speed range of the engine, the generator must be equipped with a voltage regulator to ensure that its rated voltage is not affected by the speed and current. The power supply when the engine starts is completely provided by the battery, so the battery must ensure that there is enough capacity to start the engine smoothly. The ATO1000 series car-specific oscilloscope can test the charging circuit and the starting circuit to test whether the charging/starting circuit of the car is working properly. The specific operations are as follows:：

Click the icon  in the lower right corner of the oscilloscope to display the screen shown in Figure 3-1：

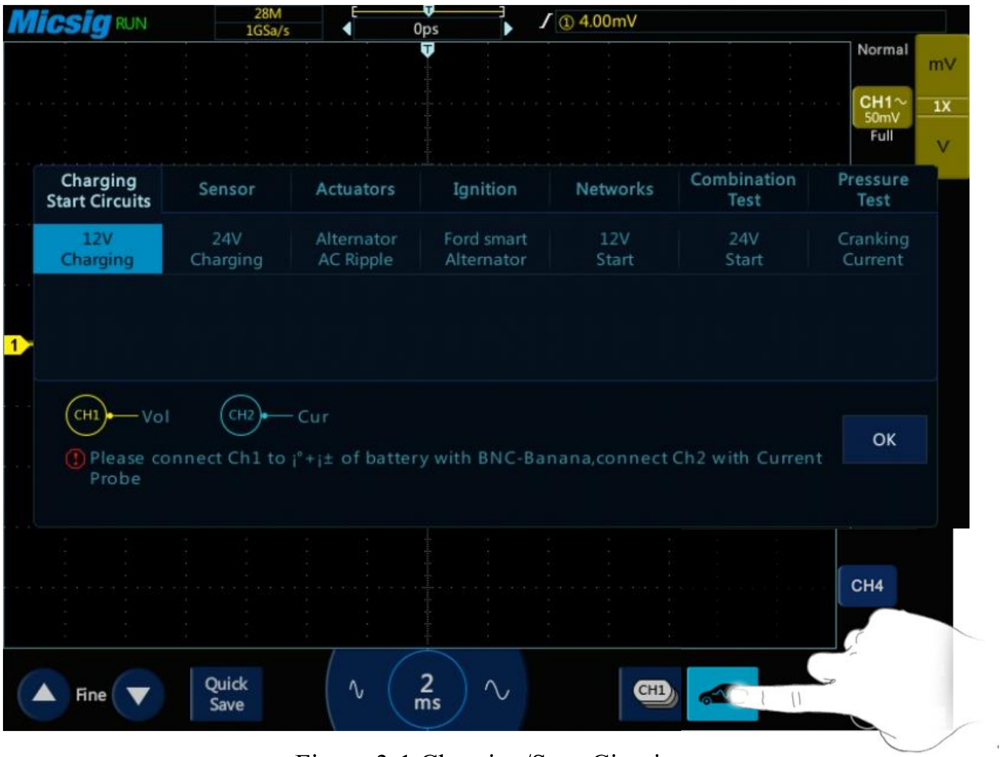


Figure 3-1 Charging/Start Circuits

3.1.1 12V Charging

12V charging is suitable for gasoline vehicles. Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, and the other end is connected to the positive and negative electrodes of the battery using two large alligator clips (the red wire is connected to the red clip to the positive electrode, and the black wire is connected to the black clip. negative electrode). If you need to measure current, please use a current clamp of 600A and above, connect the BNC of the current clamp to channel 2, turn on the switch of the current clamp, and clamp the current clamp to the output power line of the generator.

The alternator provides power to the vehicle. There is little difference between different manufacturers. The charging voltage is generally between 13.5V and 15.0V. It is not good if it is too large or too small. The output current of the generators of different models of different manufacturers is not the same, so it needs to be estimated according to the vehicle.

Note: The generator adopts AC power generation. The voltage is converted to DC through multiple rectifier diodes. The voltage can be measured by a multimeter. However, when the diodes are damaged, the multimeter displays the correct readings, and the waveform can be judged by an oscilloscope.

The specific operation is shown in Figure 3-2:

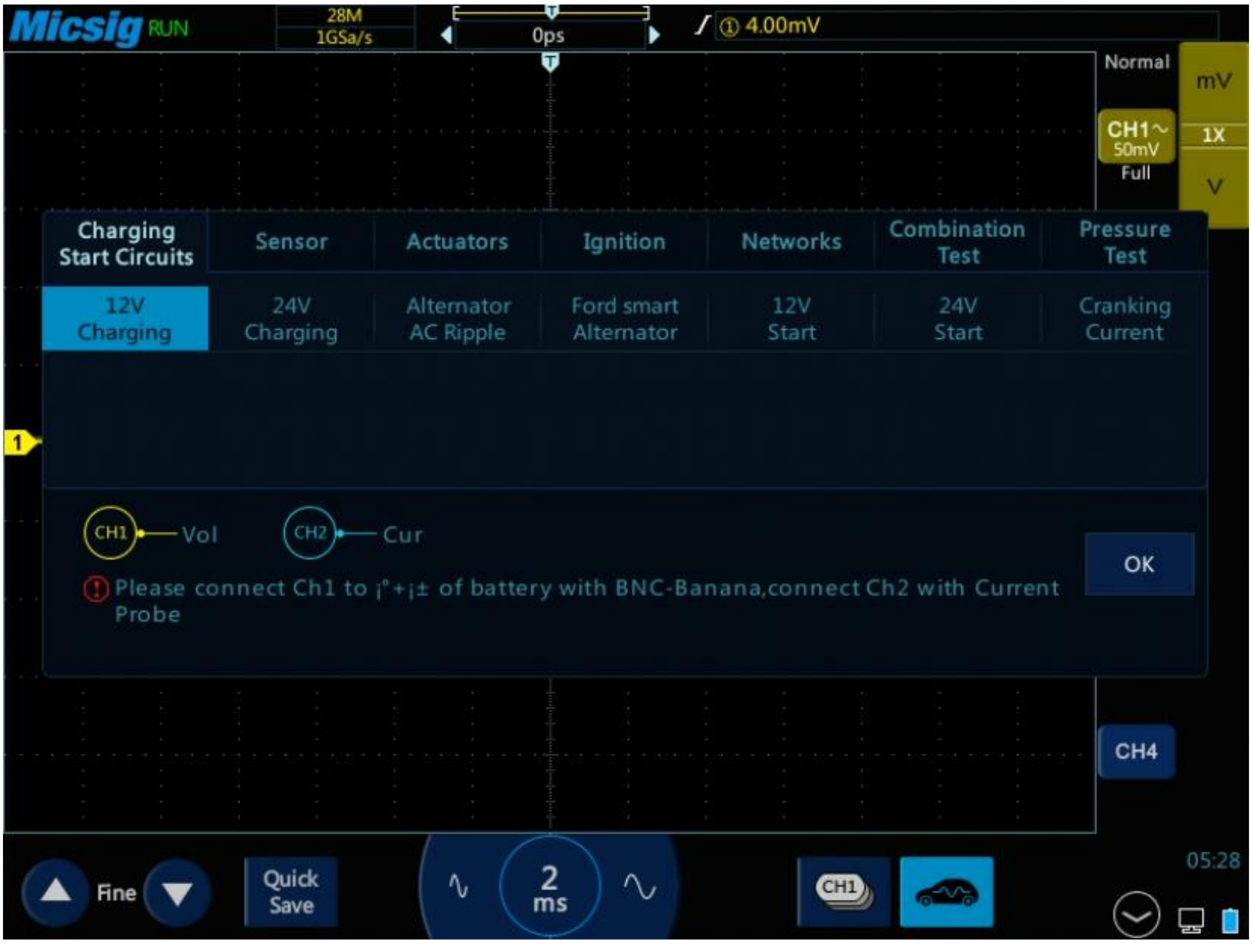


Figure 3-2 12V Charging

3.1.2 24V Charging

24V charging is suitable for diesel vehicles. The operation process is the same as that of 12V charging. The reference voltage is 26.5V~30V. It can be tested with an oscilloscope. The specific operation is shown in Figure 3-3:

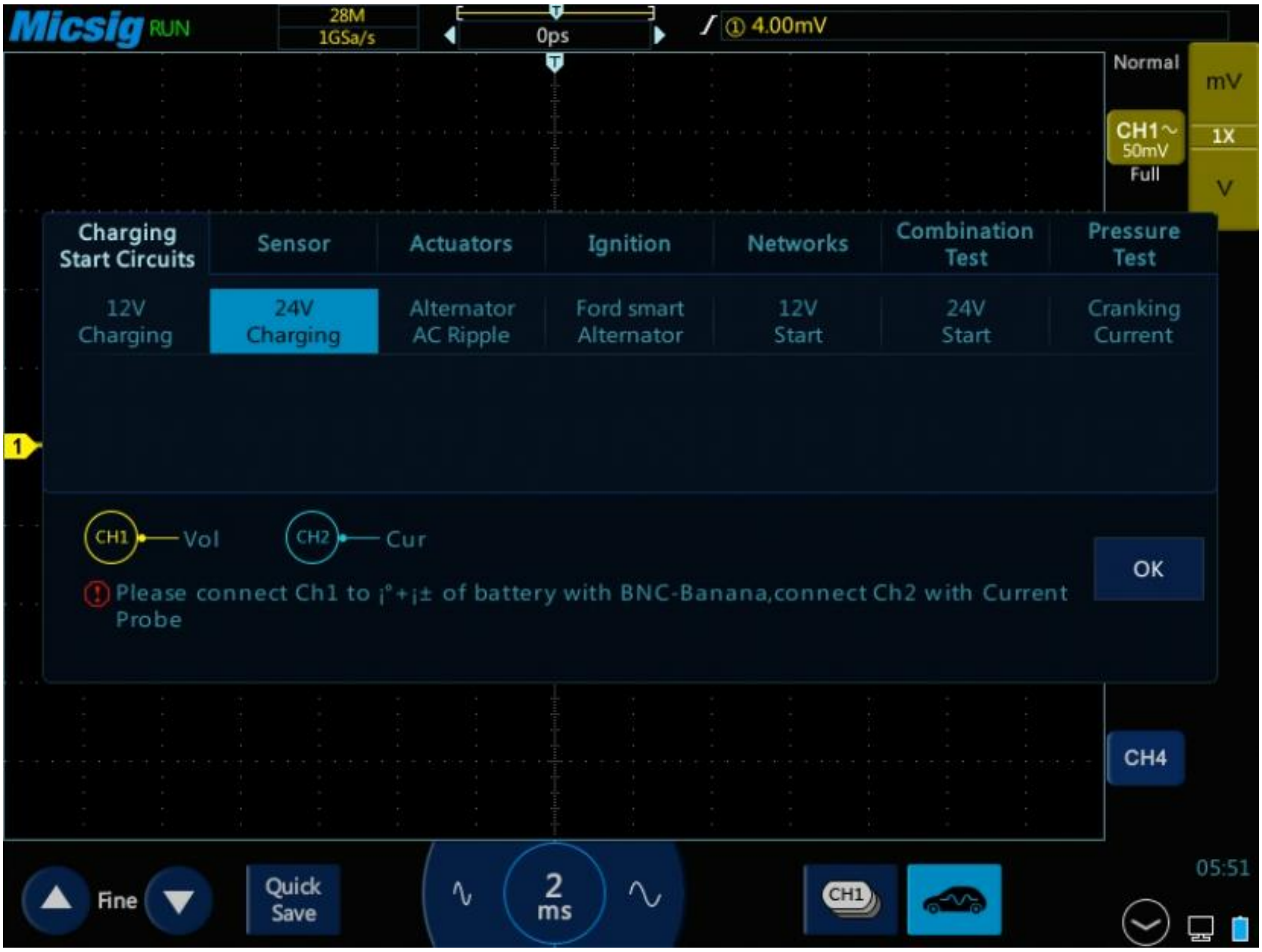


Figure 3-3 24V Charging

3.1.3 Alternator AC Ripple

The ATO oscilloscope can test the charging ripple and assist the user to determine whether the charging process is normal. Use a BNC to banana cable, one end is connected to the oscilloscope channel 1, and the other end is clamped between the positive and negative electrodes of the battery (the red wire is connected to the red clip) Connect the positive pole, and connect the black wire to the black clip to the negative pole). Start the vehicle and start the test. At this time, the oscilloscope is coupled to AC, and what is displayed is not the true voltage value. It is based on the DC waveform and the difference relative to the DC voltage.

As shown in Figure 3-4 below:

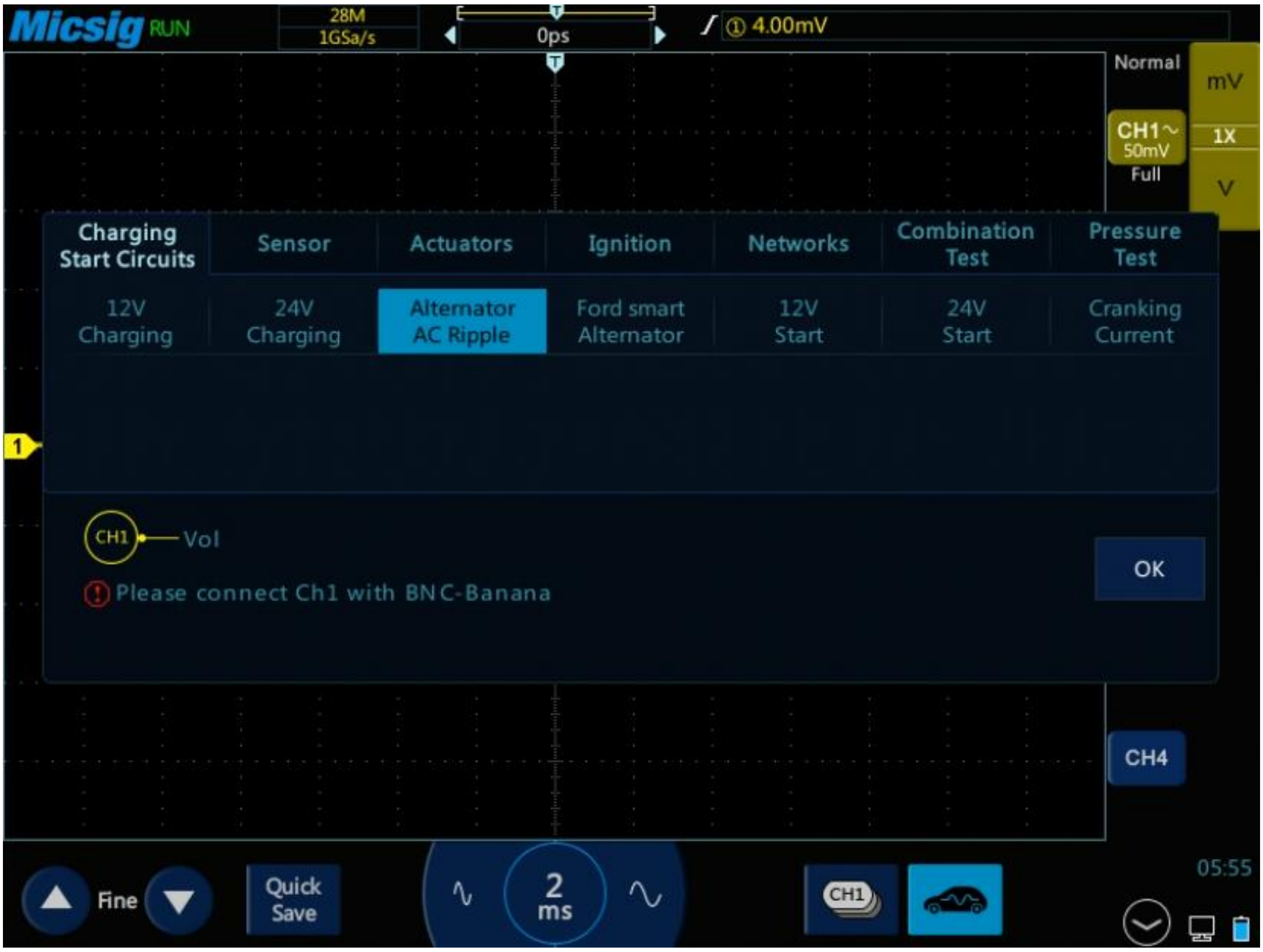


Figure 3-4 Charging Ripple

3.1.4 Ford Focus Smart Generator

Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, connect the black plug to the black alligator clip to ground (battery negative), and use a needle to connect the red connector to the engine ECM to generator output control line. Use BNC to banana cable, one end Connect to channel 2 of the oscilloscope, the other black plug is connected to the black alligator clip to ground (the negative electrode of the battery), and the red connector is connected to the feedback of the generator to the engine ECM with a stinger.

Use a current clamp of 600A and above, connect the BNC of the current clamp to channel 3, turn on the switch of the current clamp, and clamp the current clamp to the output power line of the generator.

Start the vehicle and start the test. Among them, the control signal of ECM to the generator on channel 1 is square wave/pulse width modulation signal/LIN line; the feedback signal of the generator on channel 2 is square wave/pulse width modulation signal, which is displayed on channel 3. Is the output current of the generator.

Use the ATO oscilloscope to test the Focus smart generator, the specific operation is shown in Figure 3-5:

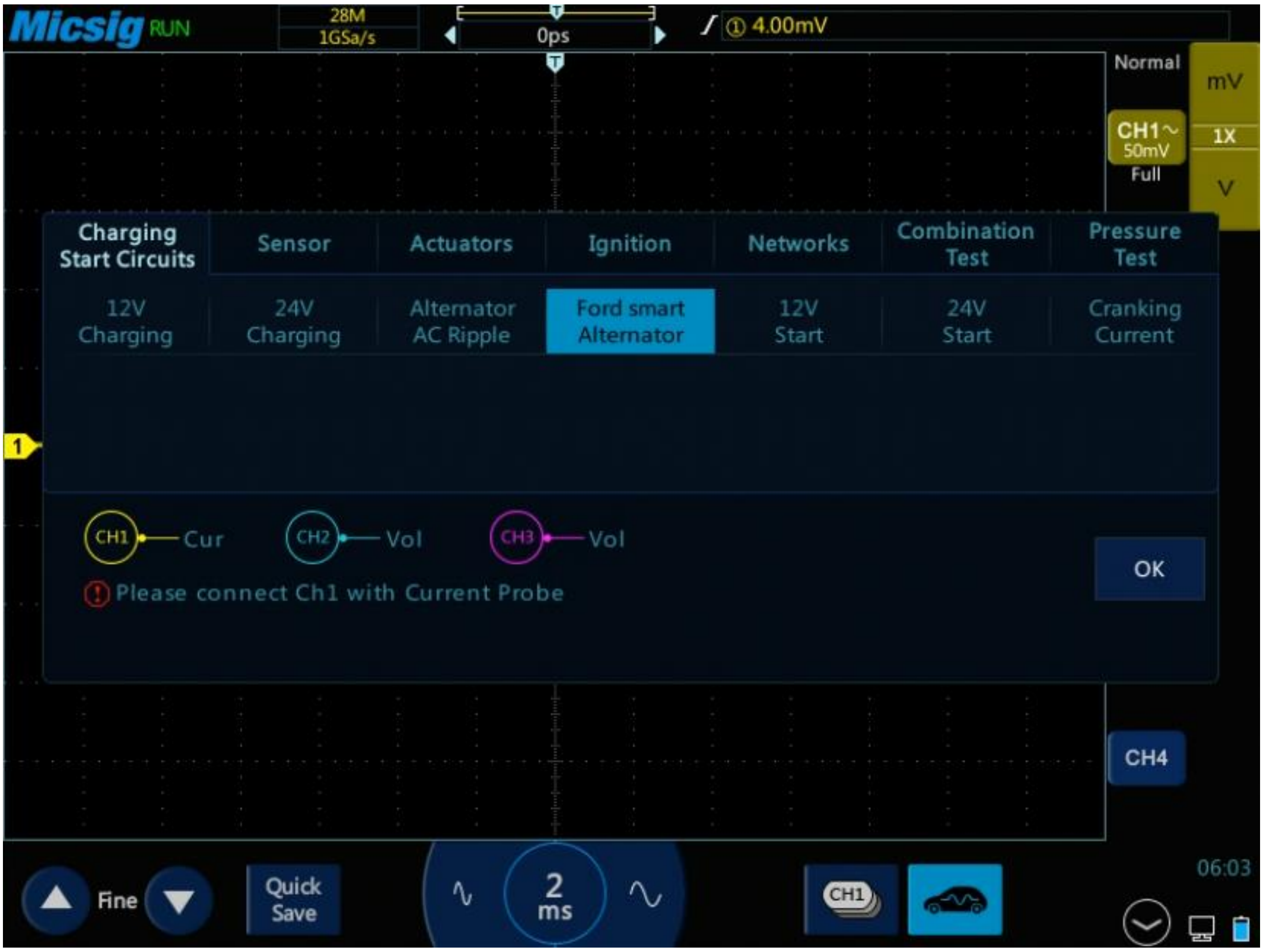


Figure 3-5 Ford Focus Smart Generator

3.1.5 12V Start

Use the ATO oscilloscope to test the start of the gasoline car, the purpose is to test whether the performance of the battery is maintained in the normal range. Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, and use two large alligator clips to clamp the positive and negative poles of the battery (the red wire connects to the red clamp to the positive pole, and the black wire to the black clamp to the negative pole). Use a current clamp above 600A, connect the BNC of the current clamp to channel 2, turn on the switch of the current clamp, and clamp the current clamp to the positive or negative power line of the battery. You need to clamp the entire positive or negative line. Stay, pay attention to the positive and negative polarity (positive current flows from the positive to the negative of the battery). The specific operation is shown in Figure 3-6:

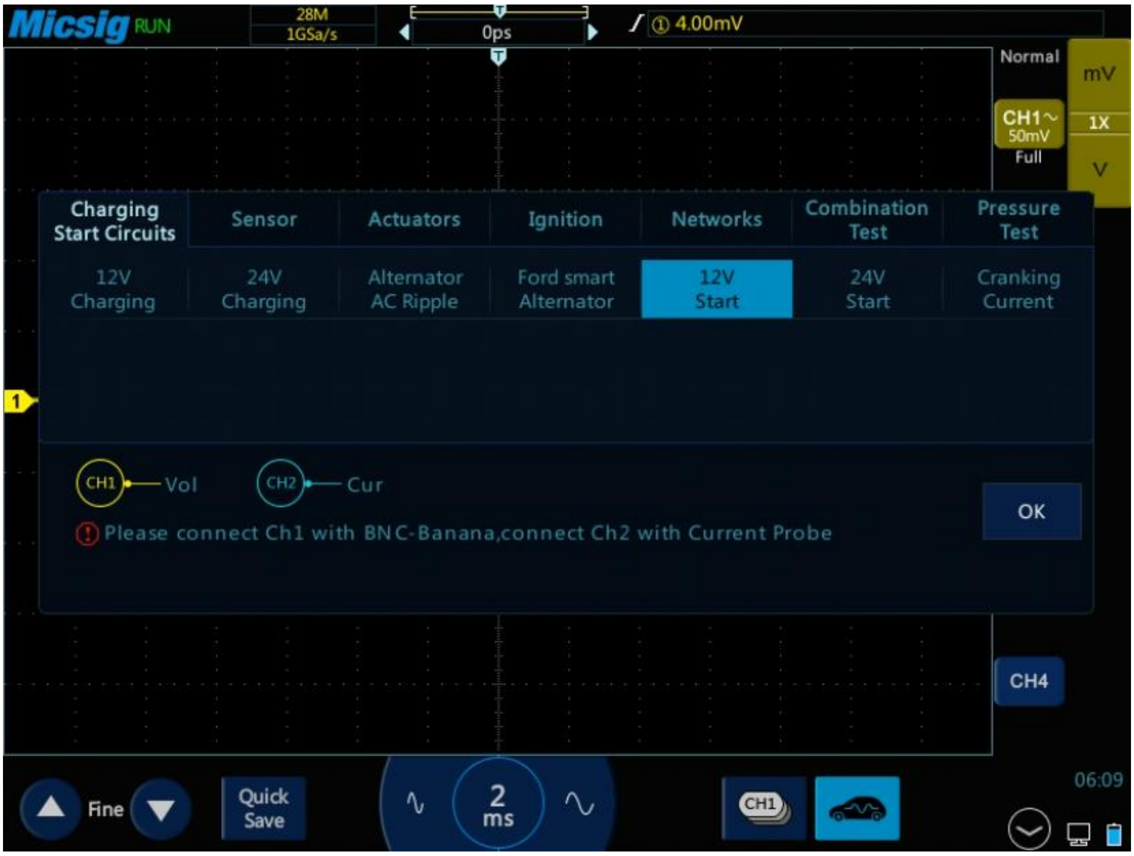


Figure 3-6 12V Start

The following figure is the actual measurement diagram of the starting voltage and current of Mazda in a certain year:

Figure 3-7 Starting voltage and current

3.1.6 24V Start

Use the ATO oscilloscope to test the starting process of the diesel vehicle, the purpose is to test whether the performance of the battery is maintained in the normal range, the operation process is the same as the 12V start. The specific operation is shown in Figure 3-8:

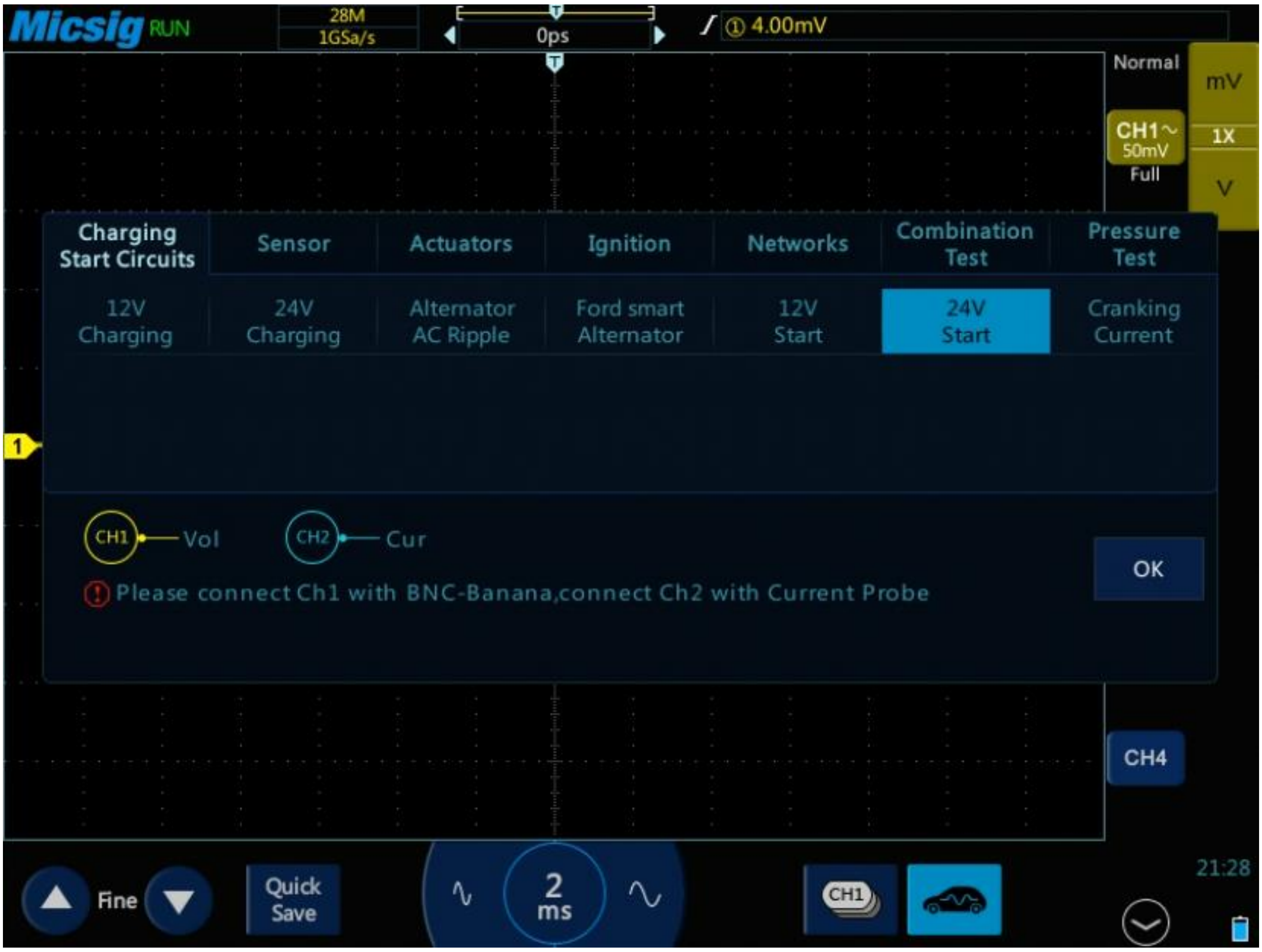


Figure 3-8 24V Start

3.1.7 Cranking Current

Use an ATO oscilloscope with a current probe to conduct a current test on the starting process of the car (automobile or diesel car), observe whether the current waveform is normal, use a current clamp of 600A or above, and connect the BNC of the current clamp to channel 2. On, turn on the switch of the current clamp and clamp the current clamp to the positive or negative power line of the battery. You need to clamp the entire positive or negative line. Pay attention to the positive and negative polarity (positive current flows from the positive electrode of the battery to the negative electrode).

The specific operation is shown in Figure 3-9:

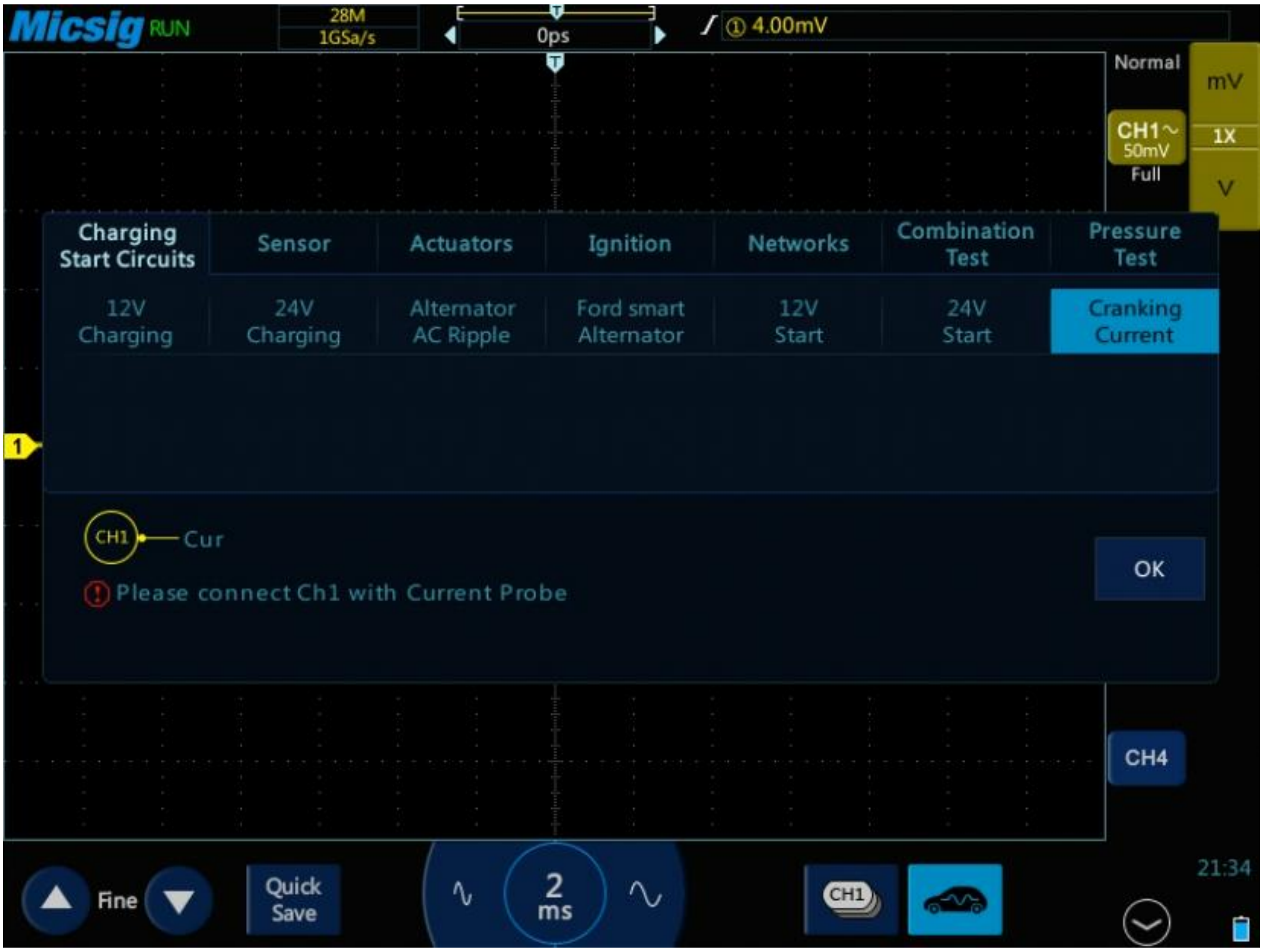


Figure 3-9 Cranking Current

3. 2 Sensor Tests

The sensor is an electronic signal conversion device that converts non-electrical information into voltage signals and reports various information about changes in the working environment to the car computer. For example, the air flow meter installed between the air filter and the throttle valve can measure the value of the air flow that is sucked into the engine through the throttle valve. It converts the air flow value into a voltage signal and sends it to the engine ECU (control computer).), the control computer adjusts the corresponding fuel injection volume according to the change of air flow to achieve the goal of the best combustion ratio. Another example is a vehicle speed sensor. Its function is to convert the vehicle speed into a voltage signal and send it to the trip computer. The trip computer controls the shift timing to achieve upshift or downshift.

With the continuous development of cars in the direction of intelligence and new energy, the number of sensors on the car body has shown a trend of sharp increase, and there are nearly 100 sensors on the mid-to-high-end cars of the company. The ATO series special oscilloscope can directly measure the signal waveform of the sensor. By comparing with the standard waveform during normal operation, it is easy to find whether the sensor is normal. The ATO series oscilloscope can test the following types of sensors. The purpose is to compare the real-time waveforms with the standard waveforms to help users find problems. The following are expanded and explained separately:

3.2.1 ABS

The ABS wheel speed sensor is divided into analog and digital. The analog sensor has 2 signal terminals, the signal is a sine wave, and the frequency of the sine wave represents the speed. Digital sensors generally have 3 terminals, power, signal, and ground; the signal line needs to be tested, the signal is a square wave pulse, and the square wave frequency represents the speed.

When testing, use BNC to banana cable, the BNC head is connected to the oscilloscope, and the banana head is connected to the sensor or the ECM pin to test 1/2/4 signals at the same time. Shown as Figure 3-10:

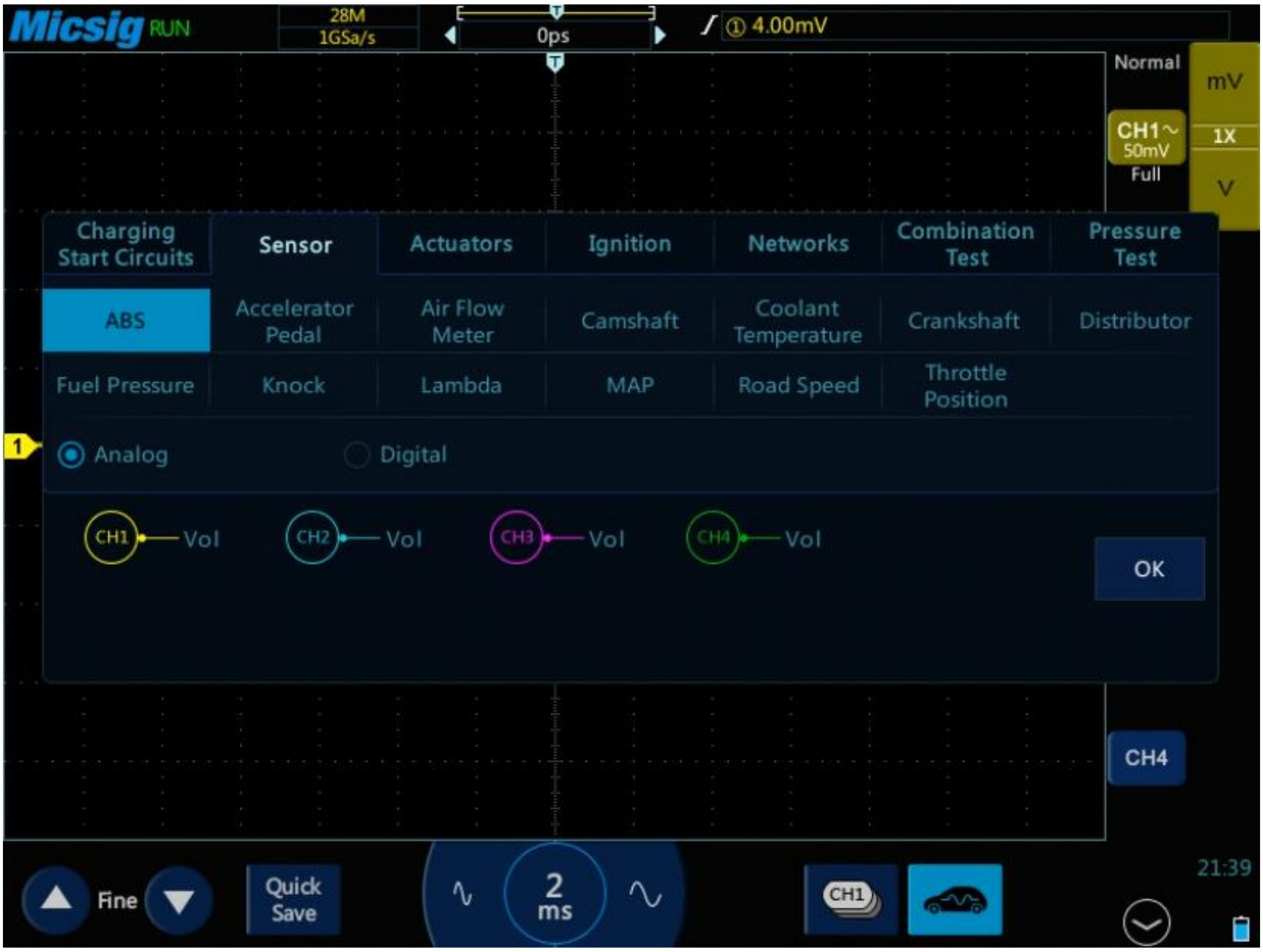


Figure 3-10 ABS Wheel Speed Sensor

3.2.2 Accelerator pedal

The accelerator pedal is the signal of the automobile accelerator. There are generally 2 groups, each pair of 3 wires, power, signal, and ground. Divided into analog/analog and analog/digital. Analog/analog signal is two analog signals, usually there are two ways, one is deviation signal: one signal is from 0.3V→4.8V, which rises as the accelerator pedal is depressed, and the other is 4.8V→0.3V, with Depress the accelerator pedal and descend. The other is the same direction signal, but the voltage is different, one is 0.5V→2.5V, the other is 1V→4.5V; (the voltage range is for reference only, the voltage range may be slightly different for different models, but the trend is the same).

Use ATO oscilloscope to test the accelerator pedal sensor, the specific operation is shown in Figure 3-11:

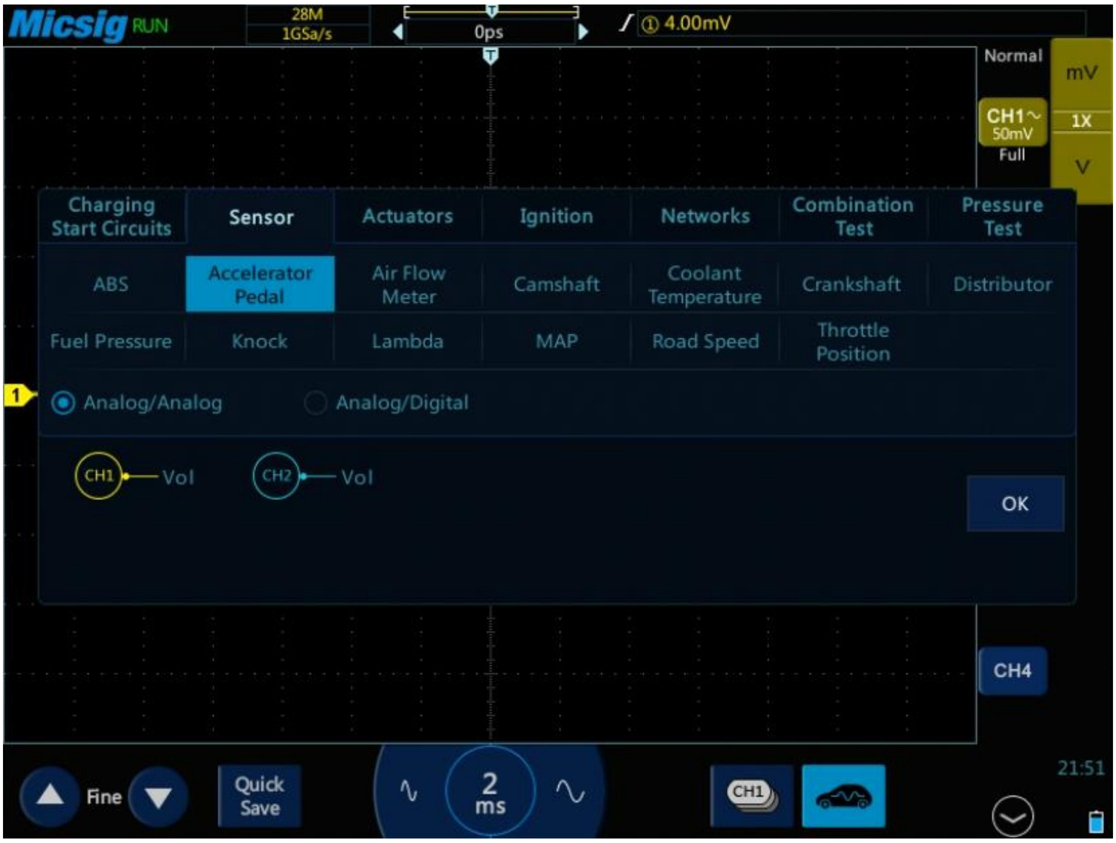
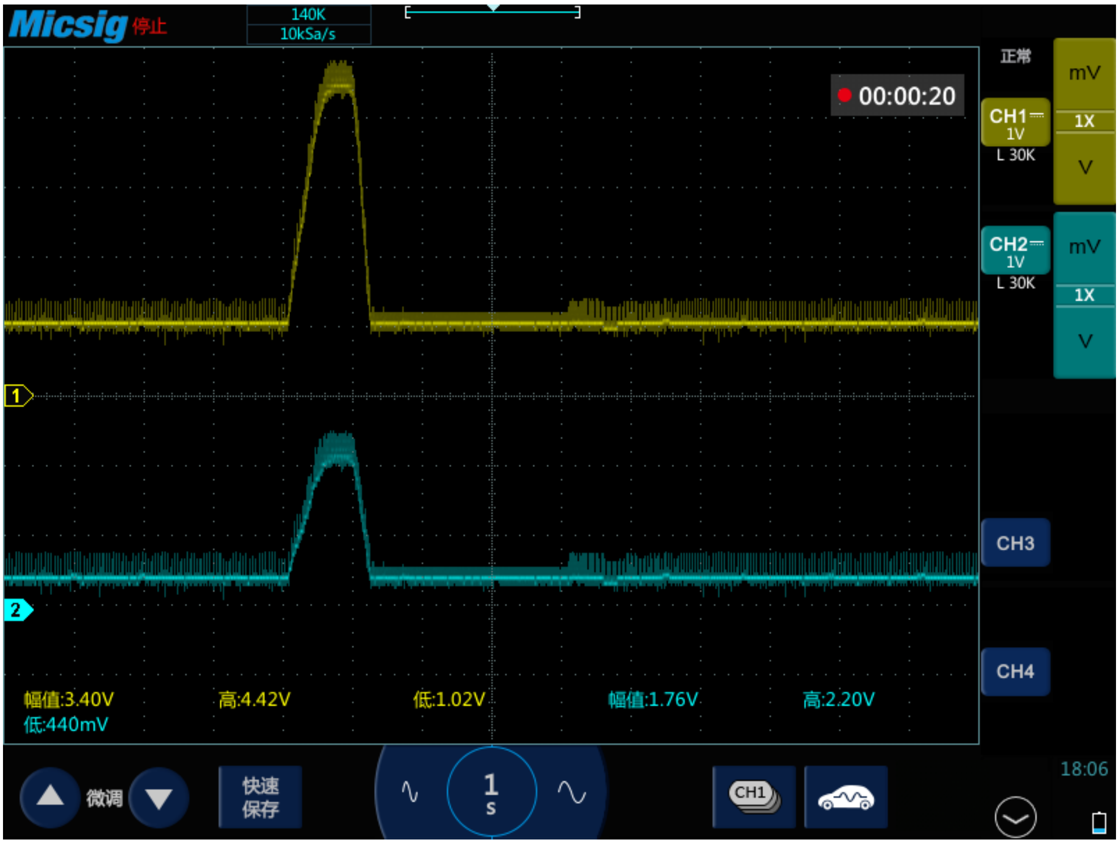


Figure 3-11 Accelerator Pedal

The following picture is the actual measurement diagram of the accelerator pedal sensor of a certain model:



3.2.3 Air Flow Meter

Air flow meters generally have vane type, hot wire type, digital type, etc.; among them: vane type and hot wire type are both analog output, and the output voltage is proportional to the air flow, generally 0.5V~4.5V, but the non-linear ratio, It needs to be corrected in the ECM; the general output voltage is about 1V at idling speed, and the voltage rises rapidly during acceleration, reaching a voltage of 4V~4.5V. After stopping the acceleration, it will return to the idling voltage; the output shows 0V or 5V is not normal.

The digital type has a digital circuit inside the sensor. The output signal is a square wave. The frequency is used to represent the air flow. A higher frequency means a higher air intake. Use a BNC to banana cable and connect one end to channel 1 of the oscilloscope. The black plug on the other end is grounded, and the red connector is connected to the signal wire of the air flow sensor with a needle. Start the vehicle, quickly depress the accelerator pedal and release it to test, you can view the waveform.

Use the ATO oscilloscope to test the throttle air flowmeter sensor (the air flowmeter is divided into three types: analog, digital, and hot wire, please test according to different types), the specific operation is shown in Figure 3-12:

Figure 3-12 Air flow meter

3.2.4 Camshaft

The camshaft sensor is generally used for timing, and is often tested in conjunction with the crankshaft sensor to determine the timing of the vehicle. There are one or two camshaft sensors in the common car models, and the use of four is relatively small. Common camshaft sensors are Hall type/induction type/AC excitation type;

Hall sensor output is square wave, high voltage can be 5V or 12V; generally 3-wire, power, signal, ground; inductive sensor output is a sine wave signal or square wave signal, generally 2-wire; AC excitation The output of the type sensor is multiple sine waves (there is a missing piece at the end of the camshaft, so that the signal changes, and the position of the No. 1 cylinder is judged at the missing place), generally 2-wire.

Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector uses a needle to connect the signal line of the camshaft sensor.
Shown in Figure 3-13:

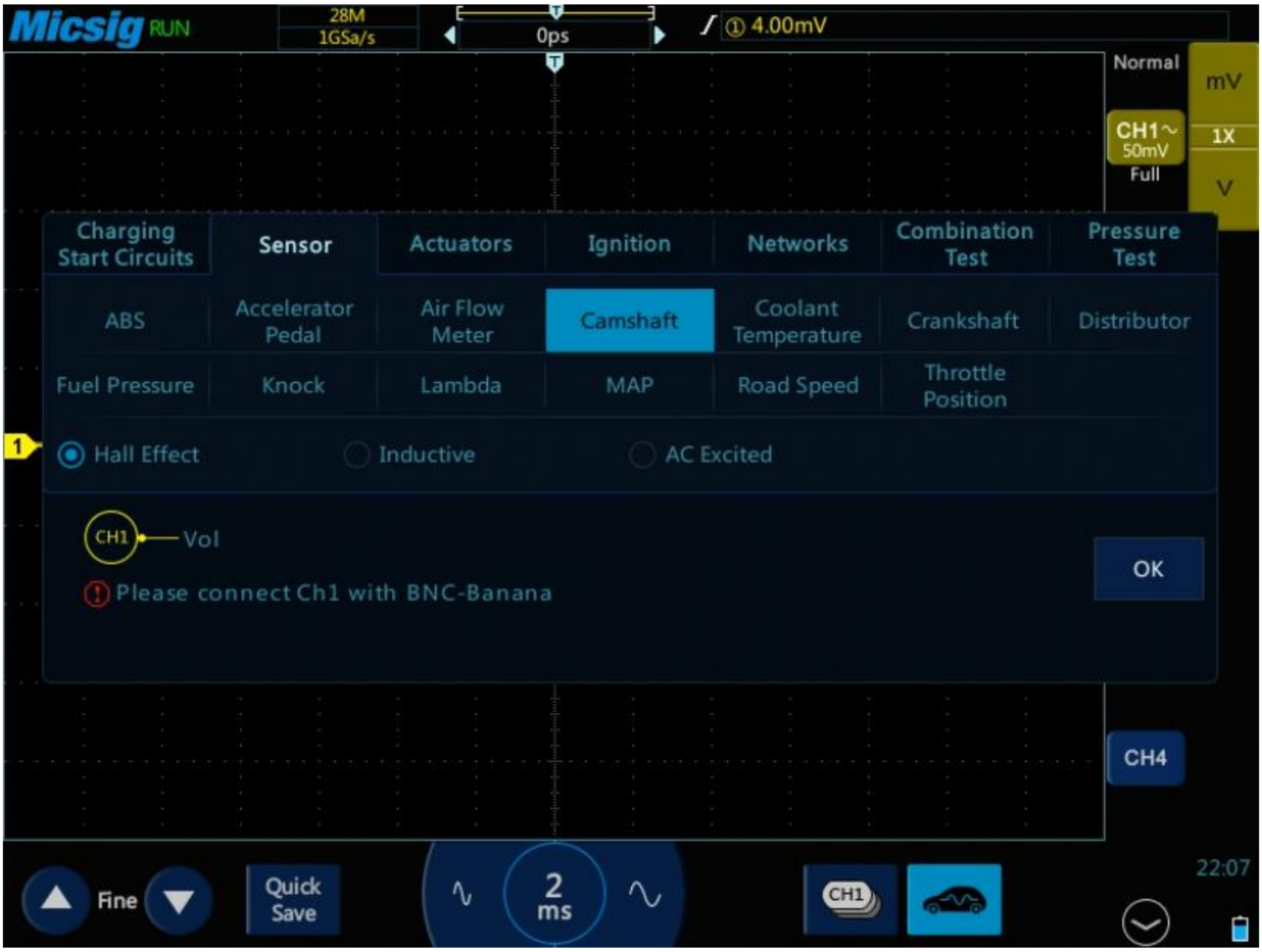


Figure 3-13 Camshaft

The following figure is the actual measurement diagram of the camshaft position sensor (Hall type) of a certain model:

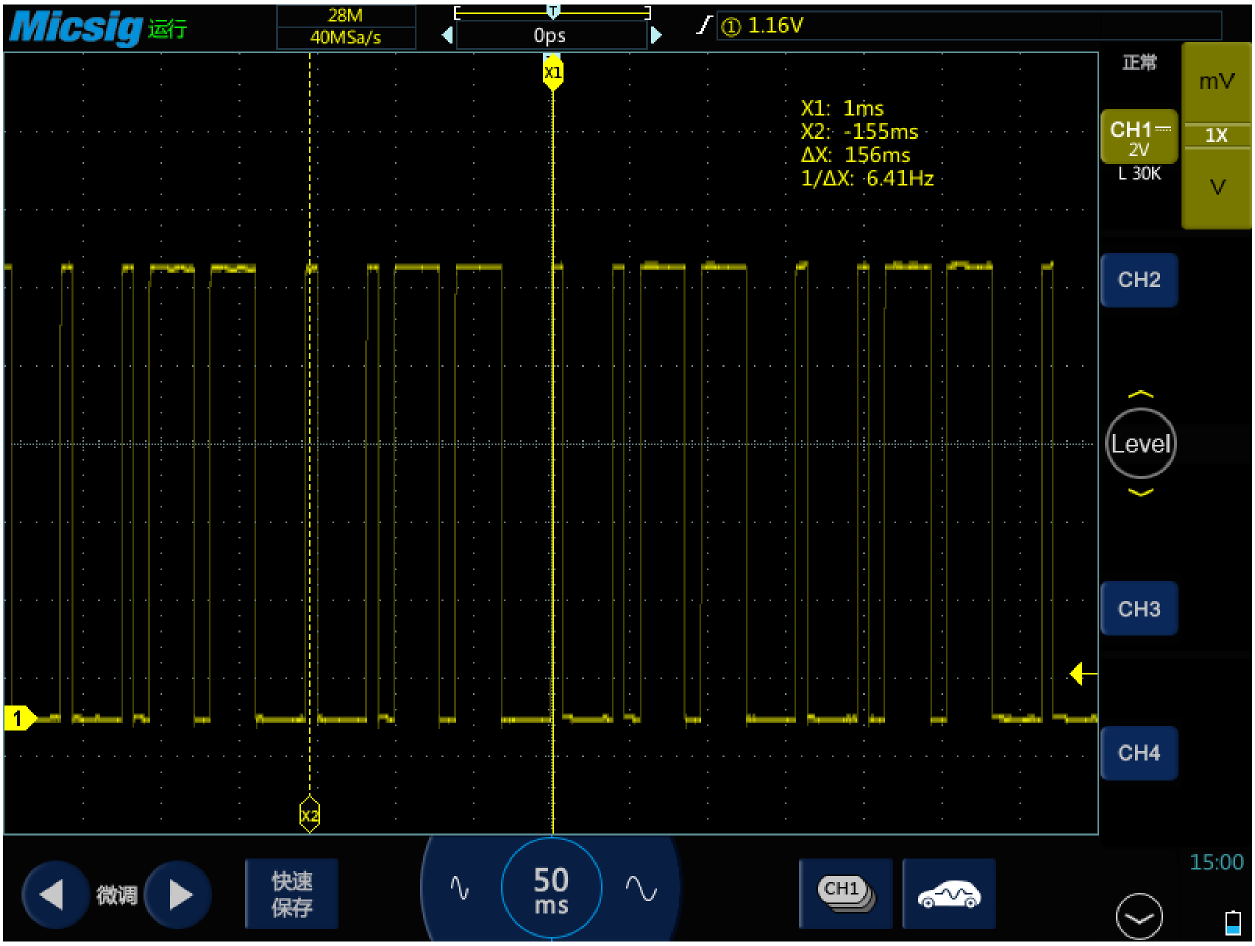


Figure 3-14 Camshaft position sensor (Hall type)

3.2.5 Coolant Temperature

The coolant temperature sensor is usually called a water temperature sensor. Generally, it contains a thermistor. As the temperature increases, the resistance becomes smaller, which causes the output voltage to change, and the water temperature changes slowly, so the voltage also changes slowly. Different models have different performances, and the output voltage can increase with the water temperature, it can also decrease with the water temperature.

However, there is a special sensor called the Vauxhaus sensor. The output voltage of this sensor is 3-4V when the vehicle is cold. As the vehicle starts, the temperature rises and the voltage gradually decreases. It is generally 1V during normal operation, but with As the vehicle temperature rises, when the vehicle temperature reaches 40-50 degrees, the ECM will switch the voltage to make the sensor voltage rise rapidly to 3-4V, so as to achieve more accurate voltage output at high temperatures.

Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with the black plug, and the red connector is connected to the signal wire of the coolant sensor (the ground wire of the coolant) with a needle probe.

Use ATO oscilloscope to test the coolant temperature sensor, the specific operation is shown in Figure 3-15:

Figure 3-15 Coolant Temperature

3.2.6 Crankshaft

The crankshaft sensor is installed in many places, which can be near the front pulley or on the rear flywheel. The ECM judges the precise position of the engine based on its output signal. Usually there are induction type and Hall type: the induction type output is usually a sine wave, there are missing teeth on the disk, and the sine wave will be missing in the missing teeth; this kind of sensor is generally 2-wire; the Hall type output is usually a square wave . Generally 3-wire, power, signal, and ground. Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with the black plug, and the red connector is connected to the signal line of the camshaft sensor with a needle.

Use the ATO oscilloscope to test the crankshaft position sensor, the specific operation is shown in Figure 3-16:

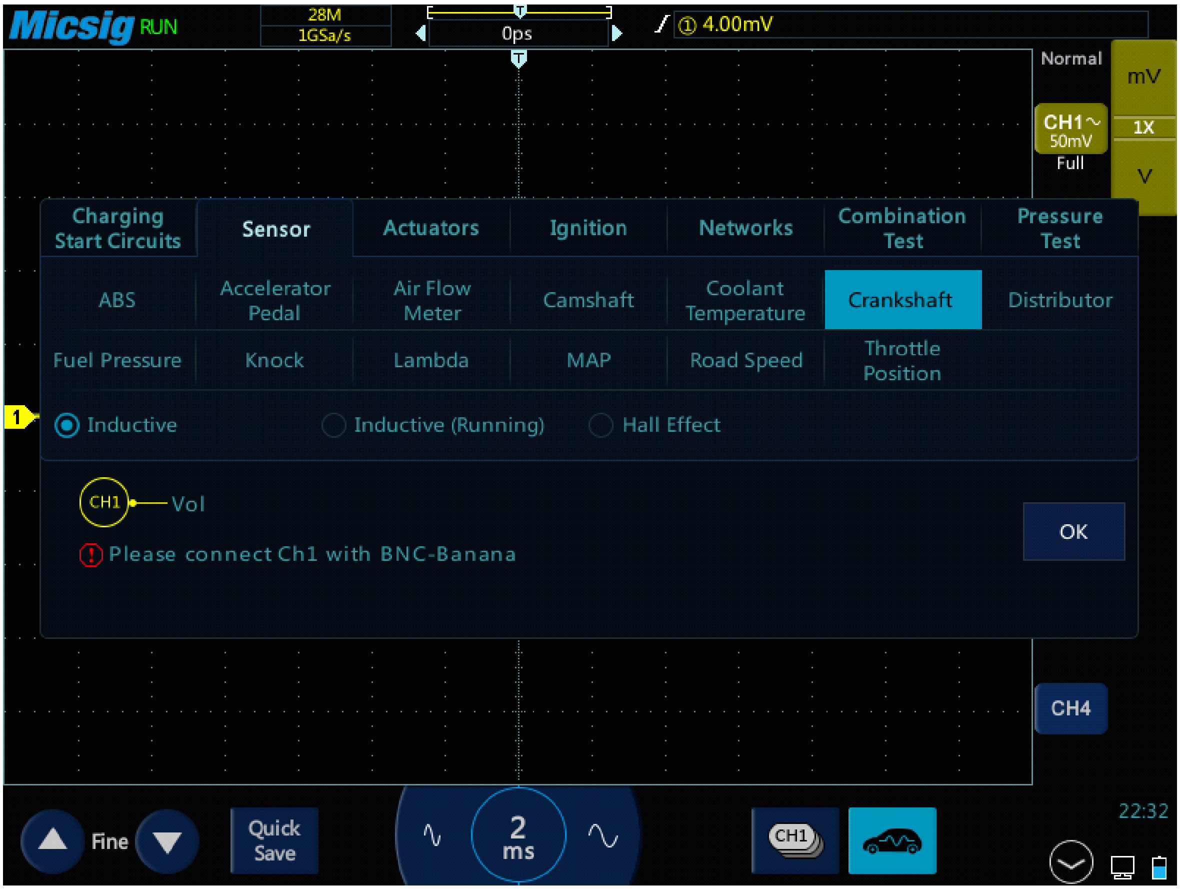
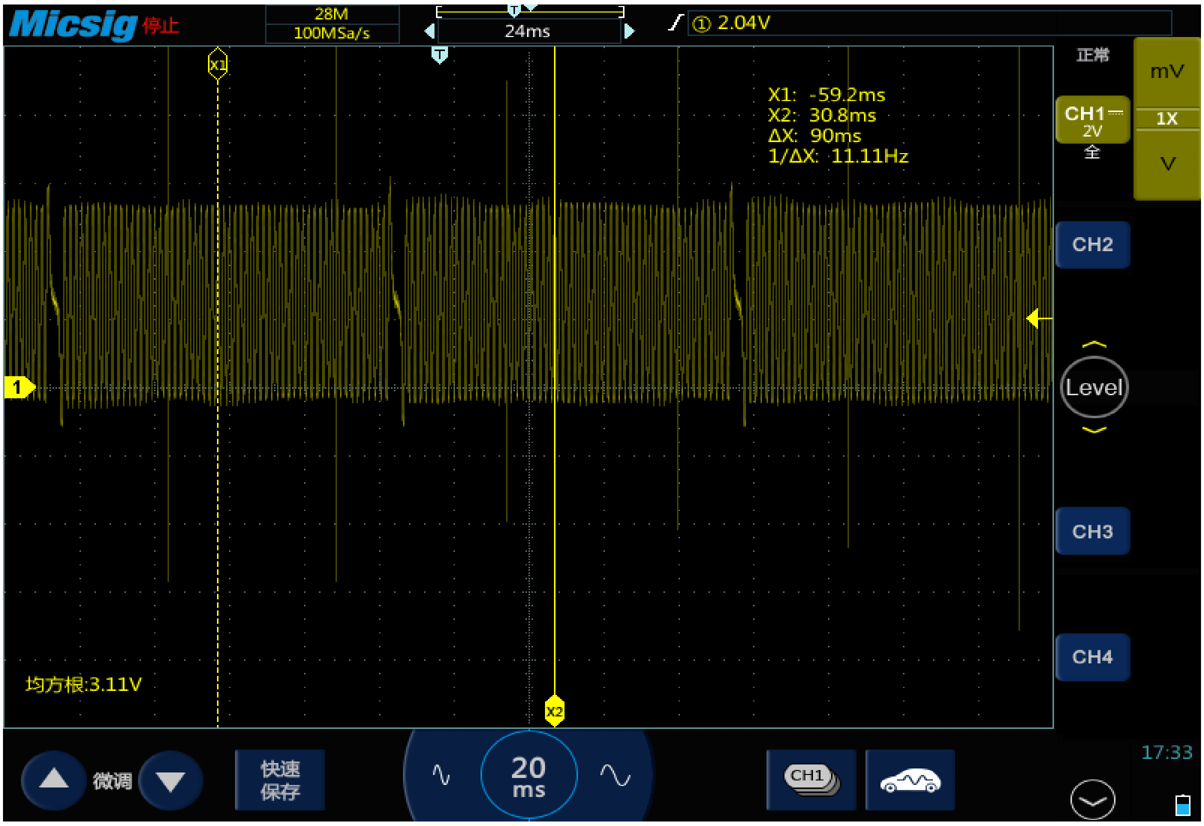


Figure 3-16 Crankshaft position sensor

The figure below is the actual measurement of the crankshaft position sensor (inductive) of a certain model:



3.2.7 Distributor

Distributor appears on models with high-voltage cables, and distribute the generated high voltages to spark plugs in sequence. Distributors generally have Hall type and induction type. Hall type is generally 3-wire, voltage, signal, and ground. The output is square wave. Inductive type is generally 2-wire. The output is sensing signal; use BNC to banana cable, one end is connected to channel 1 of the oscilloscope, and the other end is black The plug is grounded, and the red connector is connected to the signal line of the distributor with a needle.

Use the ATO oscilloscope to test the distributor sensor (divided into two types: Hall effect and induction). The specific operation is shown in Figure 3-17:

Figure 3-17 Distributor

3.2.8 Fuel pressure

Fuel pressure signals generally appear on high-pressure fuel rails or sensors or common rail diesel vehicles, and the pressure is relatively high. Generally, the fuel pressure is proportional to the output voltage, and the voltage increases with the angle of the accelerator pedal (no-load and full-load will affect the voltage rise time).

Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector uses a needle to connect the signal line of fuel pressure.

Use ATO oscilloscope to test the fuel pressure sensor, the specific operation is shown in Figure 3-18:

Figure 3-18 Fuel Pressure Sensor Test

3.2.9 Knock

The knock sensor is a passive device, generally 2-wire, signal and ground, no external power supply is required, and a signal will be generated when it is subjected to vibration. It can also be removed for testing. The signal can be generated by tapping, and the signal amplitude generally does not exceed 5V; if the sensor is removed and then reinstalled, please be careful not to cause excessive torque to avoid damage to the sensor.

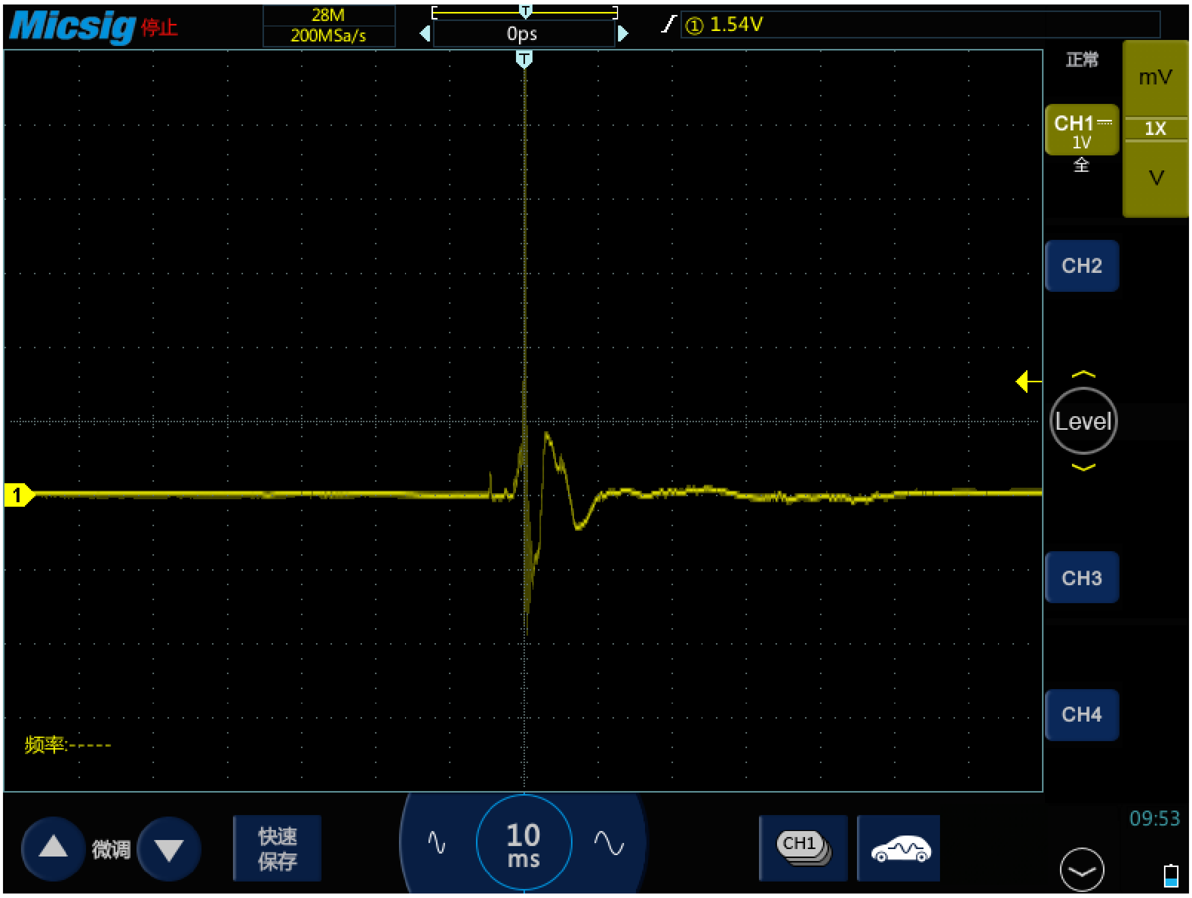
There may be several reasons for knocking: the ignition angle is too advanced, too much carbon deposits in the combustion chamber, the engine temperature is too high, the air-fuel ratio is too lean, the fuel is not clean enough, and the fuel octane number is too low.

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

Use ATO oscilloscope to test the knock sensor, the specific operation is shown in Figure 3-19:

Figure 3-19 Knock Sensor test

The following picture is the actual measurement diagram of the knock sensor of a certain model:



3.2.10 Lambda

The Lambda, or Oxygen Sensor is generally installed on the exhaust pipe, before the catalytic converter. It is a feedback sensor used to sense the oxygen content in the exhaust gas, so that the ECM can judge the combustion situation in the combustion chamber and adjust the fuel supply of the engine.

There are several types of oxygen sensors: titanium oxygen, zirconium oxygen, and front & rear dual oxygen sensors; the signal switching frequency is about 1 Hz, and it can only work when the temperature is normal. The voltage is high when the mixture is thick, and the voltage is low when the mixture is thin.

Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with the black plug, and the red connector is connected to the signal line (pre-oxygen) of the oxygen sensor with a needle. Use a BNC to banana cable, connect one end to channel 2 of the oscilloscope, ground the black plug on the other end, and use a needle to connect the red connector to the signal line of the oxygen sensor (rear oxygen, if there is no rear oxygen sensor, no test is required). If you want to measure current, connect the BNC end of the current clamp to channel 3 of the oscilloscope, and clamp the clamp on the heating wire.

Use ATO oscilloscope to test the oxygen sensor, the specific operation is shown in Figure 3-20:

Figure 3-20 Lambda (oxygen sensor) test

The following picture is the actual measurement diagram of a certain model of oxygen sensor:

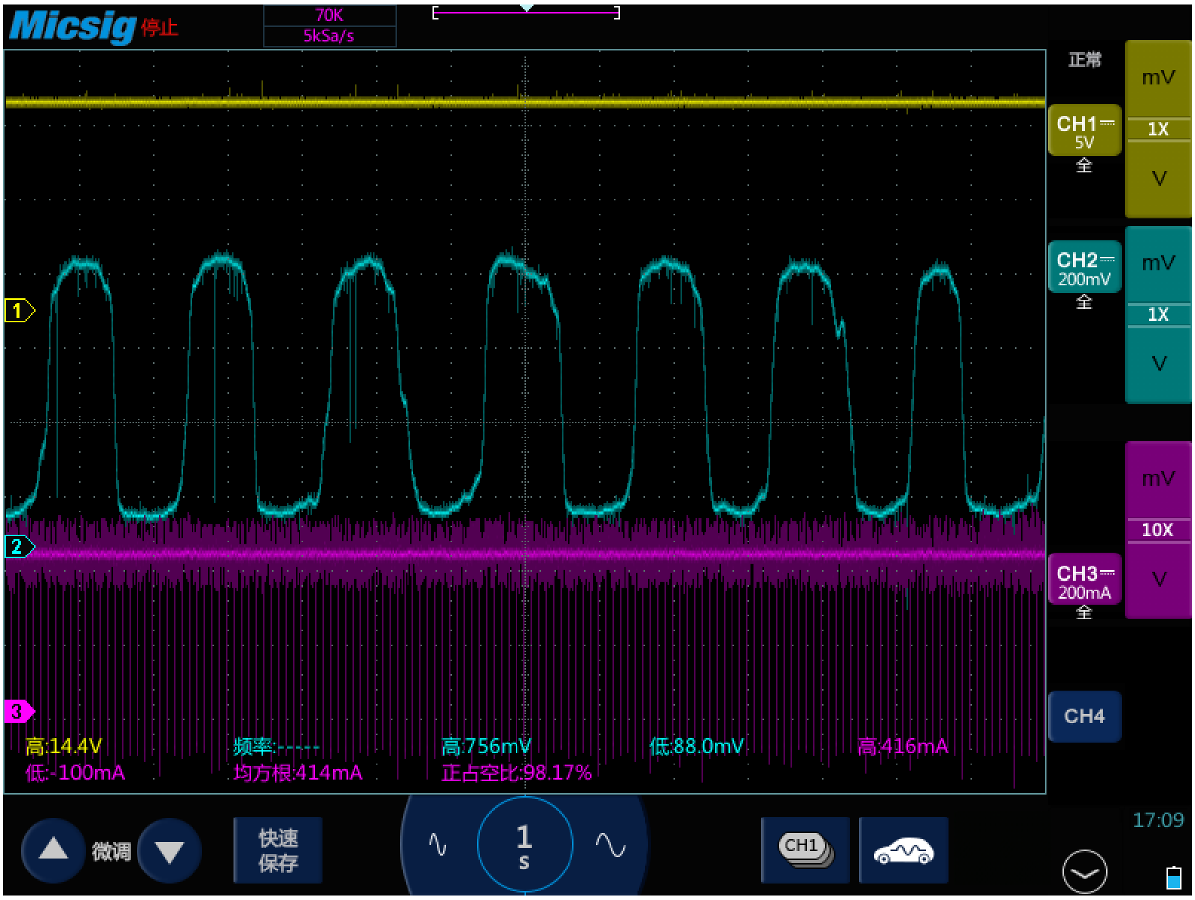


Figure 3-21 Lambda (Oxygen Sensor) diagram

3.2.11 MAP

The MAP, or Intake Pressure sensor is used to sense the pressure of the intake manifold and send it to the ECM to determine the fuel supply, vacuum (or light load), and ignition timing advance angle. There are two kinds of analog and digital, usually there are 3 wires, power, signal, ground, or together with other devices.

For the analog signal of a gasoline engine, when the throttle is closed or the engine is turned off, the output voltage is 0, and the output is generally about 1V at idling speed (it may be slightly higher or lower). After quickly depressing the accelerator, the throttle opens and the voltage rises rapidly. Achieve above 4.5V.

For the analog signal of the diesel engine, the voltage is between 1.5-2.0V at idling speed. After stepping on the accelerator, the voltage can be seen to rise, which can reach 4.0V.

Use ATO oscilloscope to test the intake pressure sensor, the specific operation is shown in Figure 3-22 below:

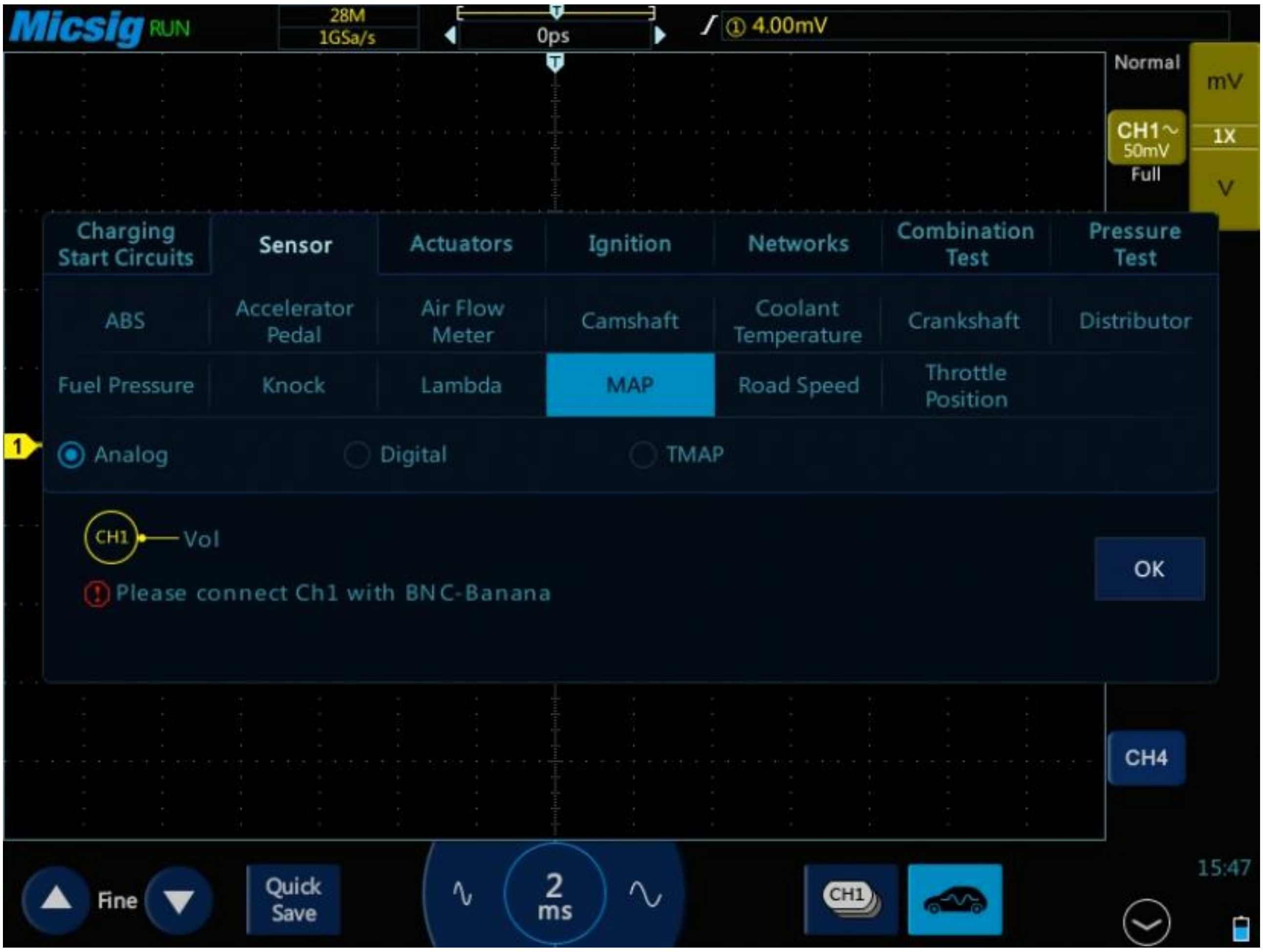


Figure 3-22 MAP (intake pressure sensor)

3.2.12 Road Speed

The speed sensor is generally installed on the drive output shaft of the speedometer of the gearbox or near the back of the head of the speedometer, to provide information for the ECM and monitor power. Usually is Hall type, there are 3 wires: power, signal, and ground, output square wave signal (some models will be analog, 2 wires, output inductive signal, sine wave). Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector is connected to the signal line of the vehicle speed sensor with a needle. Lift the vehicle as a whole or lift the driving wheels or connect the signal to a road test, start the vehicle, put in gear to rotate the wheels, and observe the waveform. The frequency of the square wave increases with the increase of vehicle speed.

Use ATO oscilloscope to test the vehicle speed sensor, the specific operation is shown in Figure 3-23:

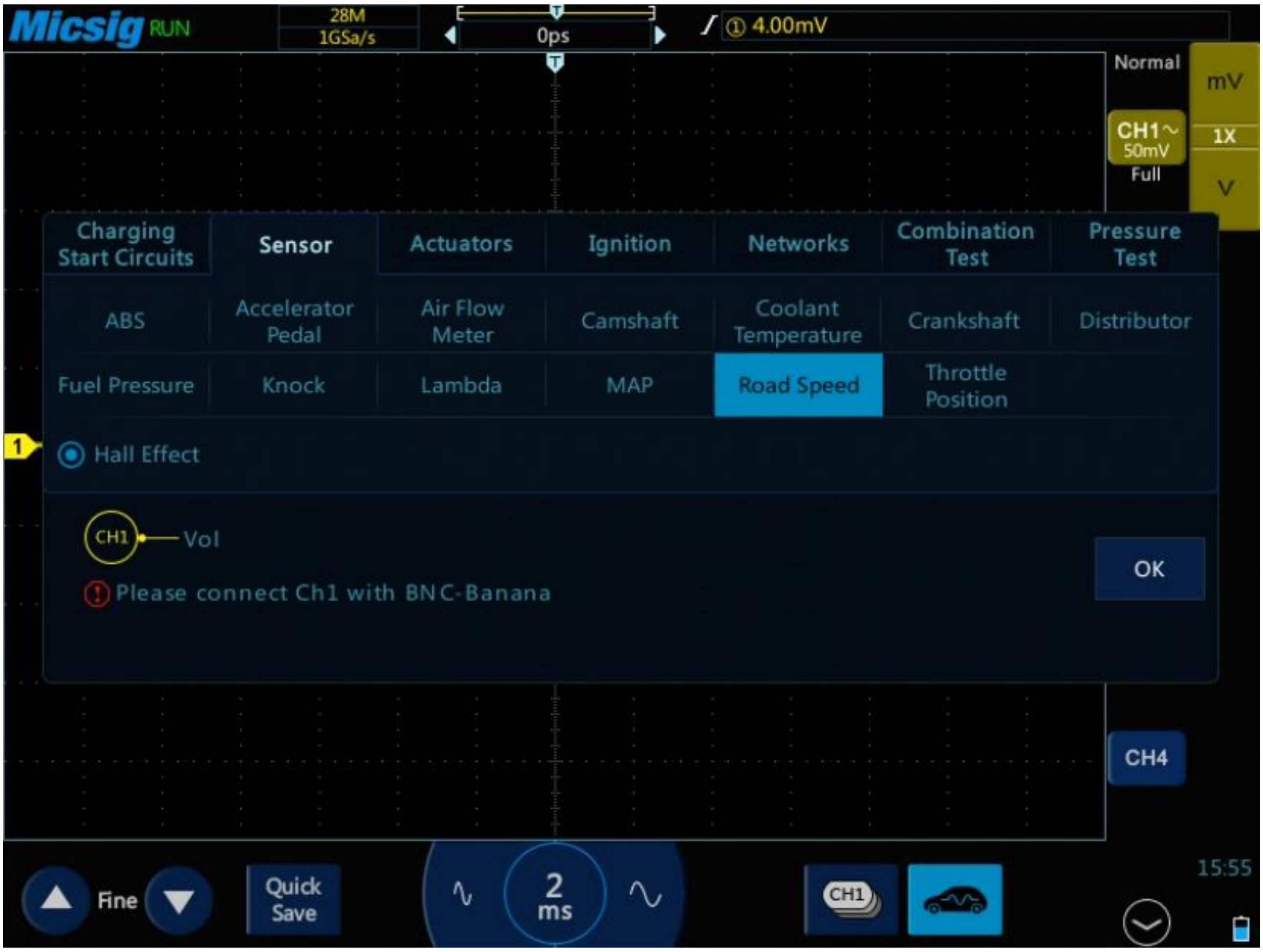


Figure 3-23 Vehicle speed sensor test

3.2.13 Throttle Position

The throttle position sensor is installed on the drive shaft of the throttle butterfly plate to sense the opening of the throttle and provide a basis for ECM to judge the intake. There are analog output and throttle switch output.

Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector uses a needle to connect the signal line of the throttle position sensor or the throttle switch signal 1.
Use a BNC to banana cable, connect one end to channel 2 of the oscilloscope, the other end of the black plug is grounded, and the red connector uses a needle to connect the signal line of the throttle position sensor, or the throttle switch signal 2. (if it is a throttle switch, you need to connect this test lead).

Use ATO oscilloscope to test the vehicle speed sensor, the specific operation is shown in Figure 3-24:

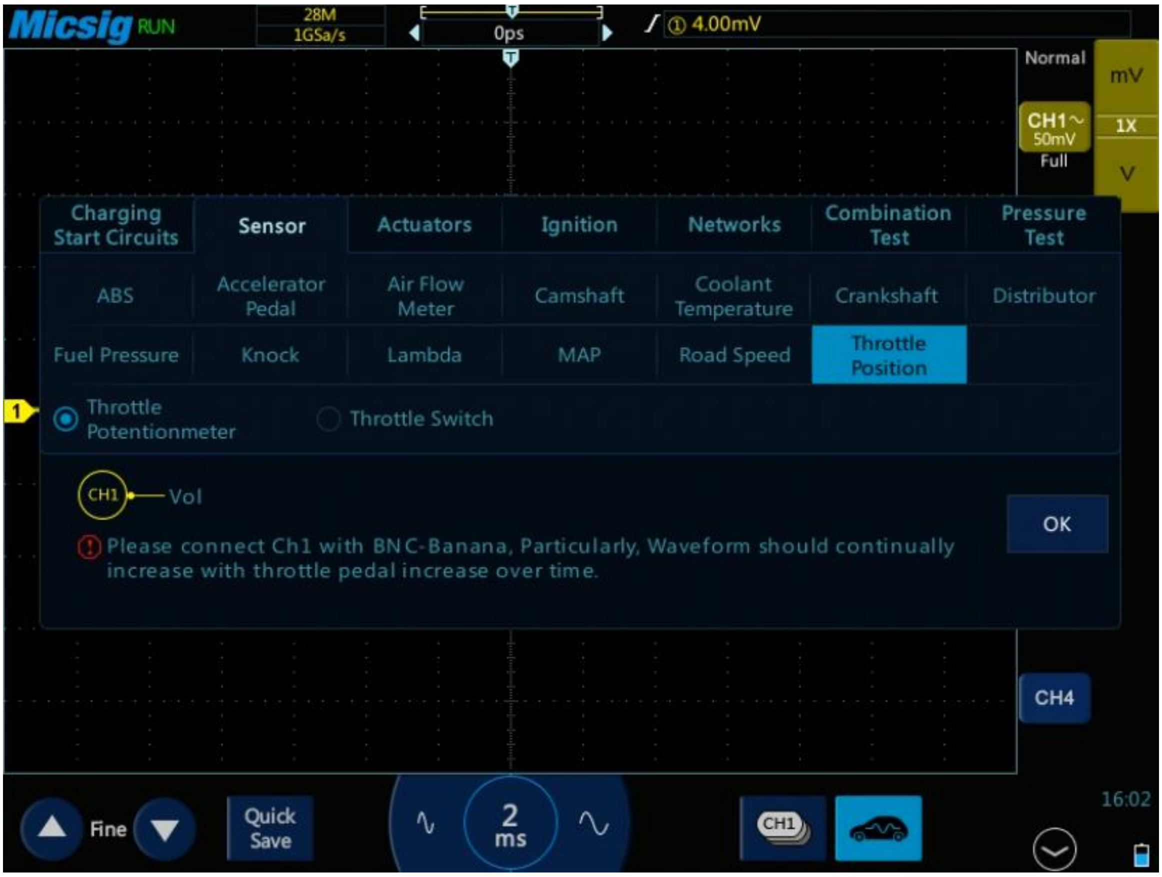


Figure 3-24 Throttle Position Sensor test

The following figure is the actual measurement diagram of the throttle position sensor of a certain model:

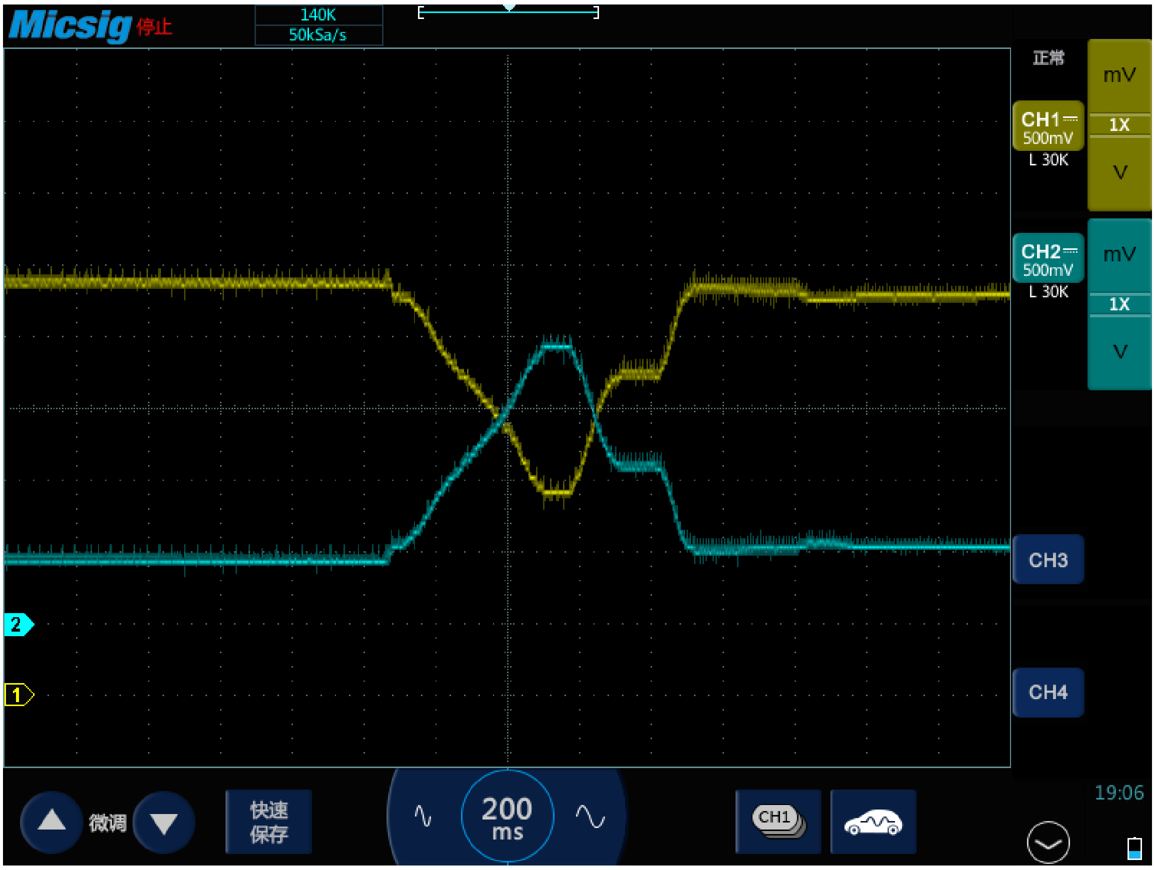


Figure 3-25 Throttle Position Sensor Diagram

3. 3 Actuators

3.3.1 Carbon canister solenoid valve

The carbon canister is generally installed in the engine compartment and connected to the fuel tank through a pipe to collect the vaporized oil and gas in the fuel tank, so as to prevent the oil and gas from being discharged into the air and causing pollution. Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector is connected to the ground wire of the canister solenoid valve with a needle tip.

Use ATO oscilloscope to test the vehicle speed sensor, the specific operation is shown in Figure 3-26:

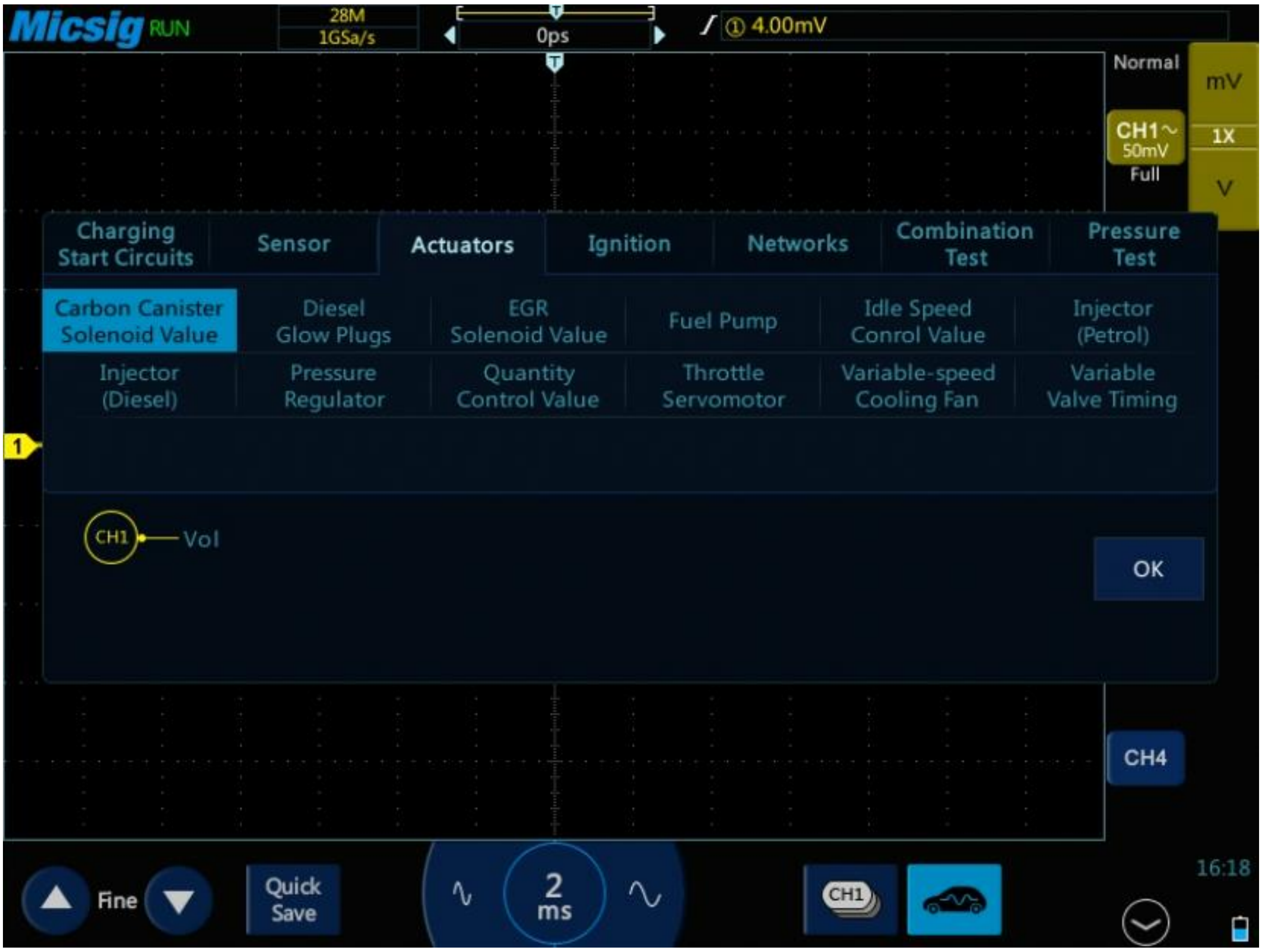


Figure 3-26 Carbon canister solenoid valve test

The following figure is the actual measurement of the Carbon canister solenoid valve of a Audi A6 model in a certain year:

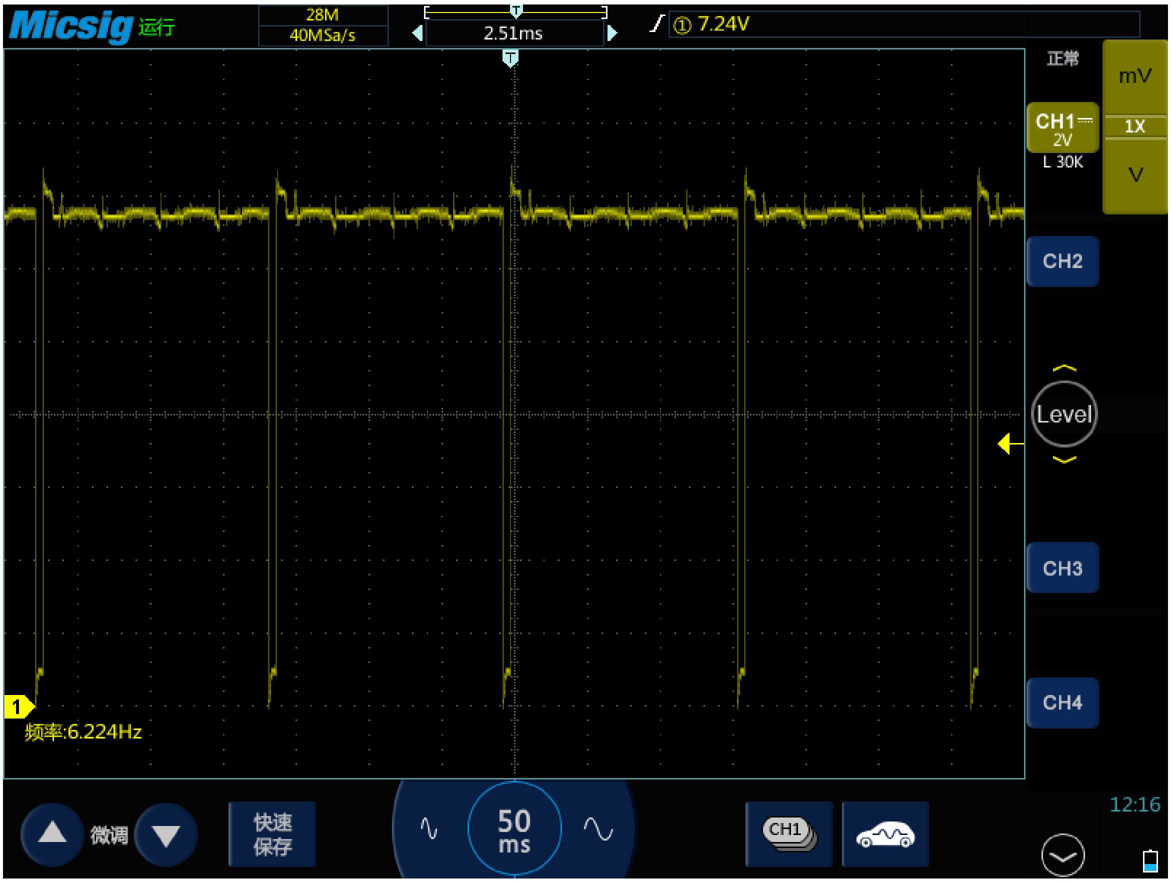


Figure 3-27 Audi A6 Carbon canister solenoid valve signal

3.3.2 Disel Glow Plugs

When the engine or the weather is relatively cold, it will affect the combustion of diesel fuel, so the glow plug is required to heat the cylinder before starting. Diesel engine glow plugs generally have one for each cylinder, connected in series, powered by a battery, and controlled by a relay to open and close.

When the ambient temperature is low or the engine temperature is relatively low, when starting the vehicle, the glow plug will be turned on first, and after the preheating light goes out, the vehicle can be started to make the engine idling.

Use a current clamp, connect one end to channel 1 of the oscilloscope, and clamp the other end to the power cord of the glow plug. Pay attention to the direction of the current.

ATO oscilloscope can be used to test the diesel engine glow plug (according to the type of glow plug, there are two types: glow plug and single glow plug).

The specific operation is shown in Figure 3-28 below:

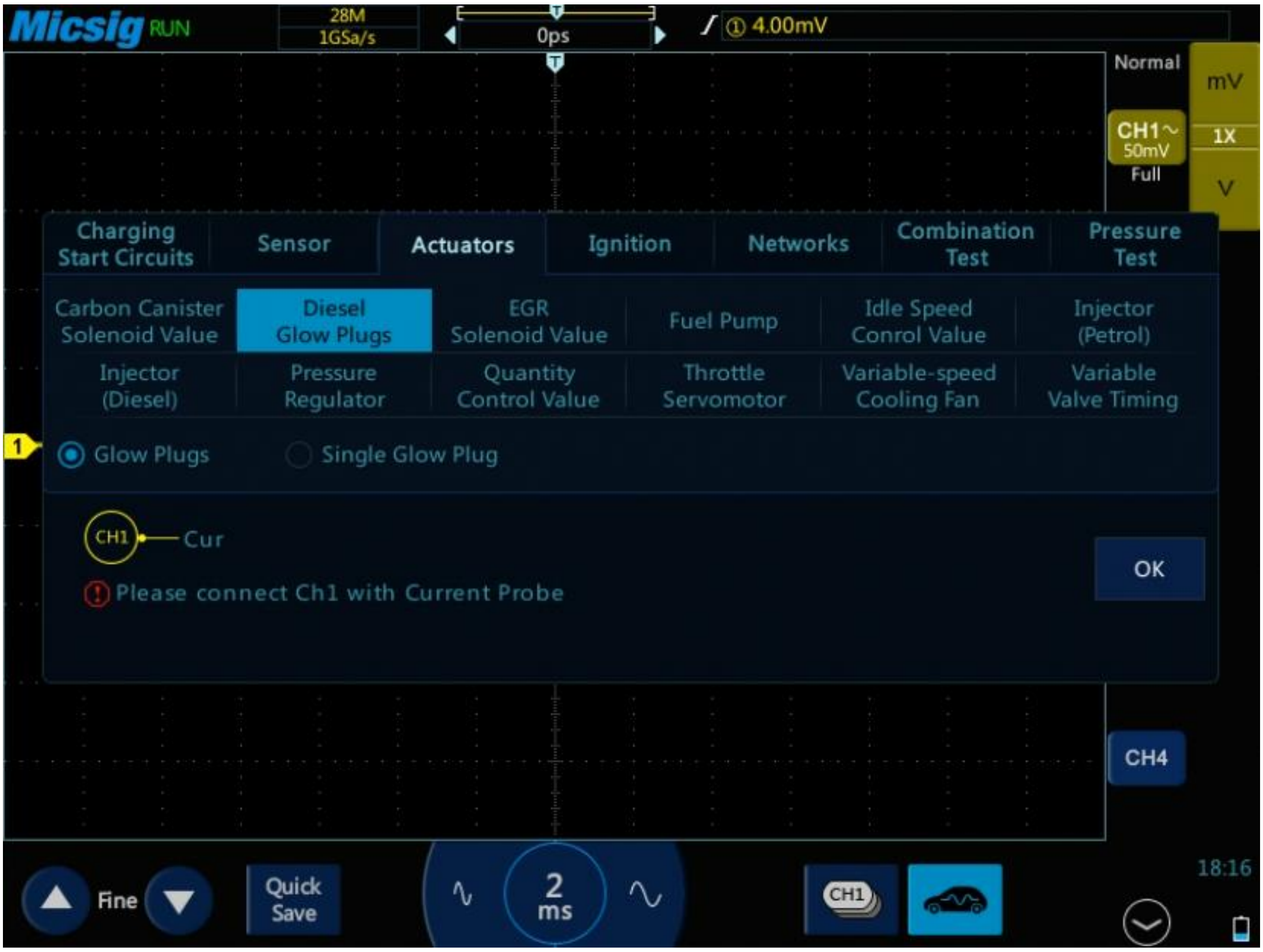


Figure 3-28 Disel Glow Plugs

3.3.3 EGR Solenoid Valve

The EGR solenoid valve is an abandoned recirculation solenoid valve. After opening, a part of the exhaust gas will be sucked into the intake manifold again to reduce the combustion temperature, so as to reduce the emission of nitrogen oxides in the exhaust gas and achieve the goal of environmental protection. Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with the black plug, and the red connector is connected to the ground wire of the EGR solenoid valve with a needle.

Use ATO oscilloscope to test the EGR solenoid valve, the specific operation is shown in Figure 3-29:

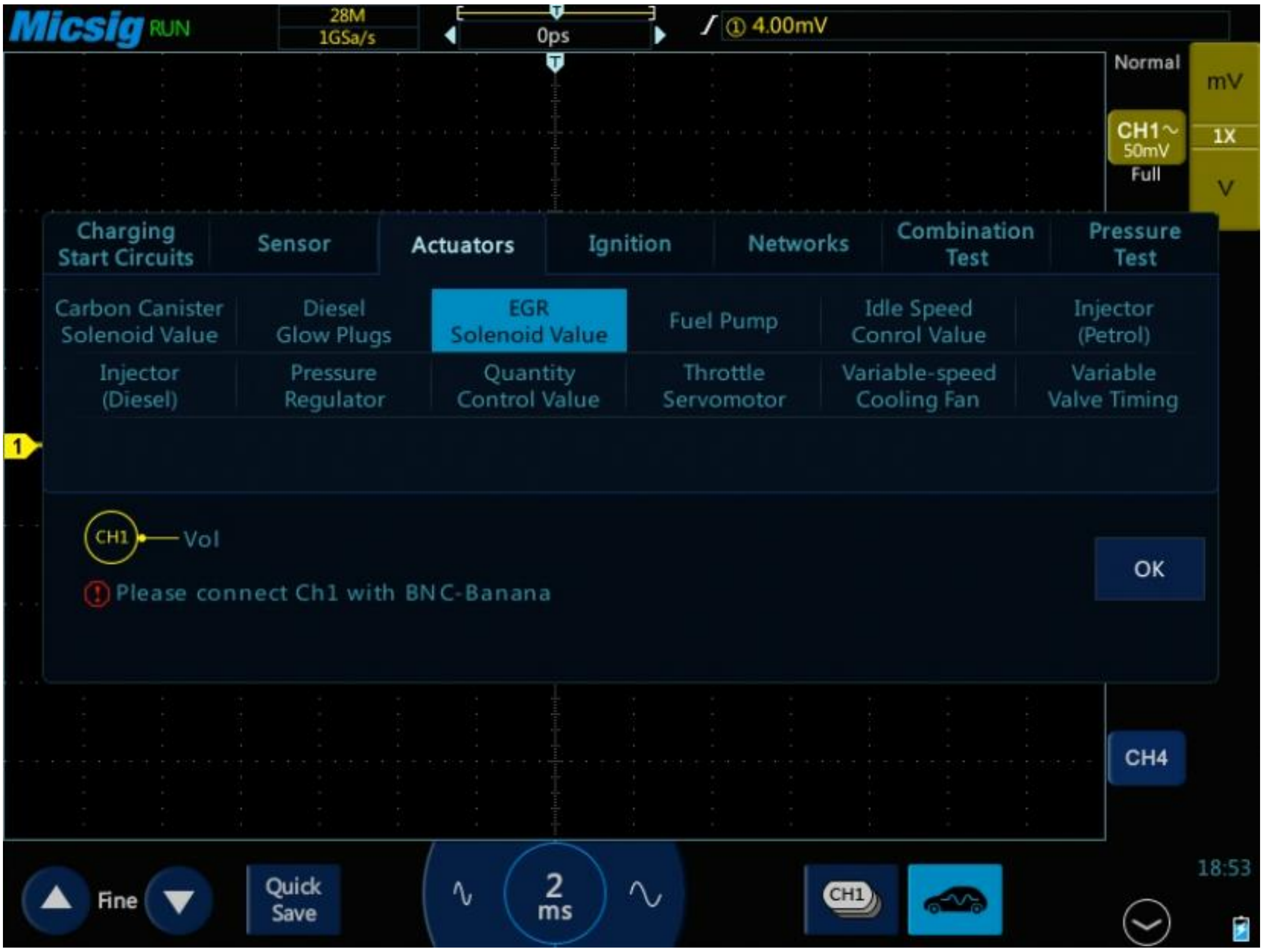


Figure 3-29 EGR solenoid valve test

3.3.4 Fuel Pump

The fuel in the fuel tank can be pumped and pressurized through the fuel pump, usually there are 6-8 sectors. Under the same condition of the engine, a good fuel pump has the same and uniform current change in each sector.

Use a current clamp, connect one end to channel 1 of the oscilloscope, and clamp the other end to the power line of the fuel pump. Pay attention to the direction of the current. (You can also use the corresponding fuse, replace it with a extension cord and clamp on the cord of the current clamp).

Use ATO oscilloscope to test the electronic fuel pump, the specific operation is shown in Figure 3-30 below:

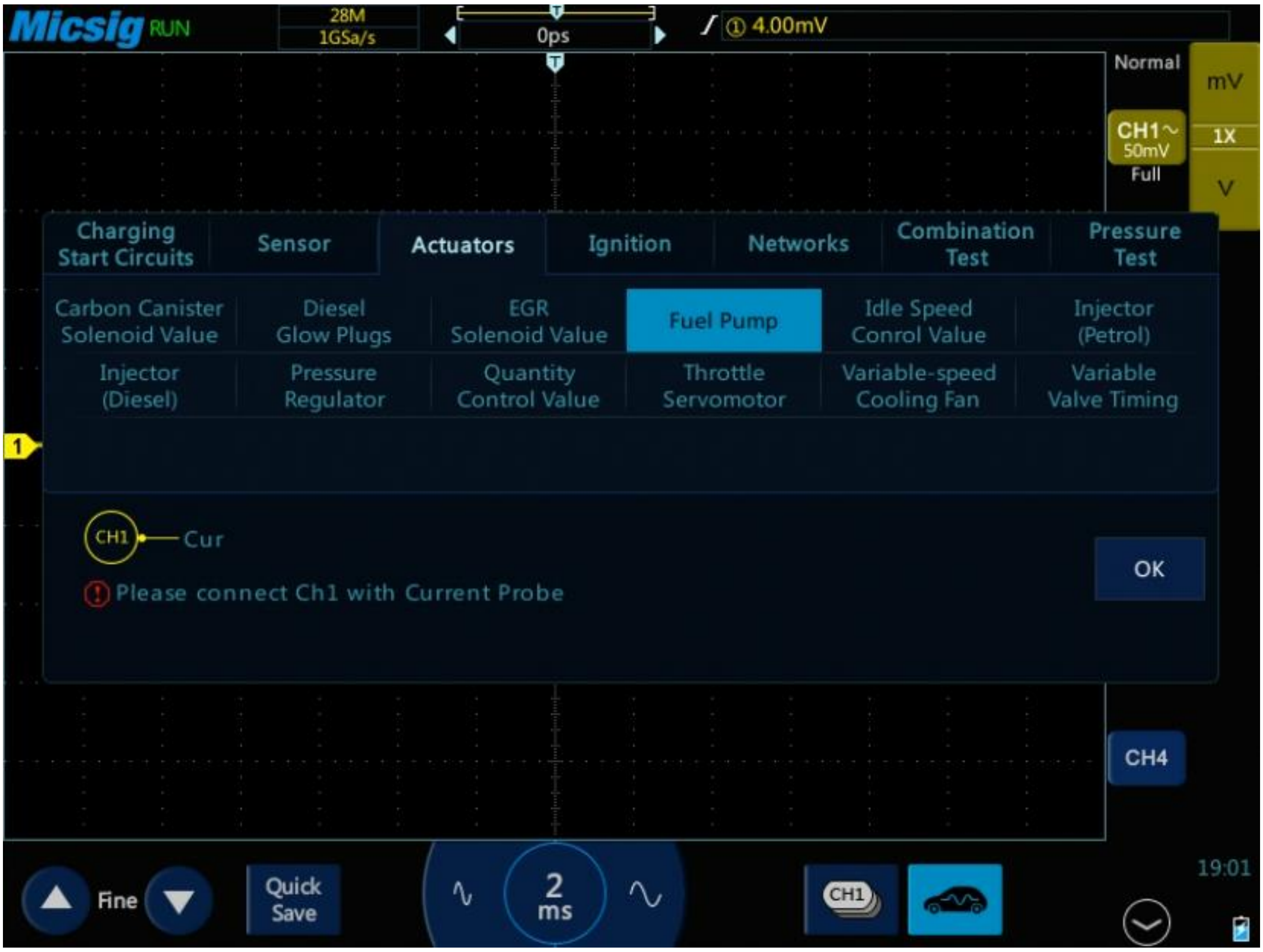


Figure 3-30 Electronic fuel pump test

3.3.5 Idle speed control valve

The idle speed control valve adjusts the throttle position or forms an air bypass around the engine according to the load conditions of the engine and the engine temperature to deliver controllable airflow to the air duct to adjust the engine idle speed. For gasoline vehicles, generally when the engine is cold started , The engine speed will rise rapidly to about 1200 rpm. When the engine reaches the normal operating temperature, the idle speed will gradually decrease, and finally stabilize at the preset value.

Use ATO oscilloscope to test the idle speed control valve, the specific operation is as shown in Figure 3-31:

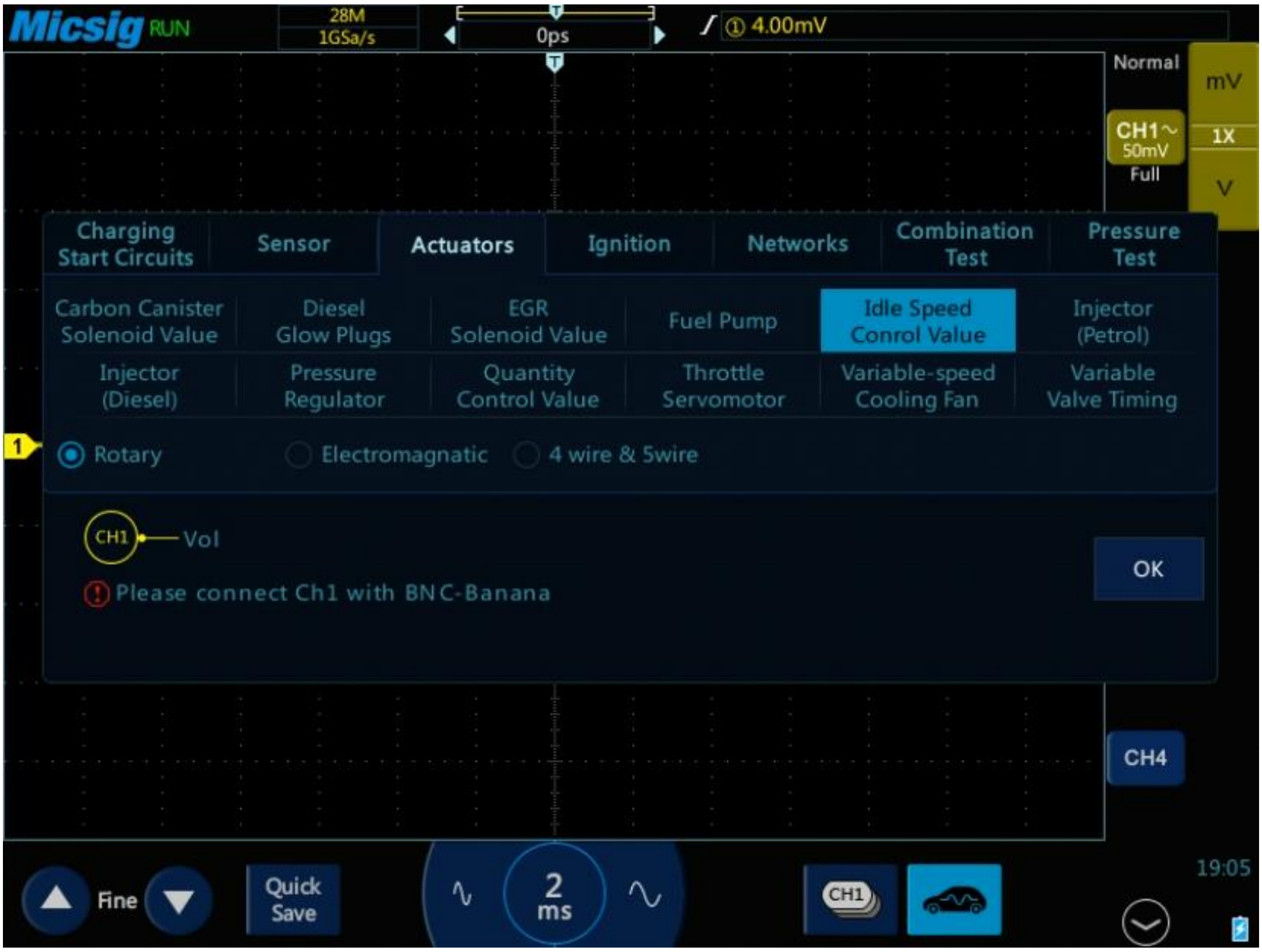


Figure 3-31 Idle speed control valve test

3.3.6 Injector (gasoline engine)

The fuel injector is an electromechanical device, which is supplied by a common rail fuel pipe and controlled by the ECM to start and stop time of fuel injection. Generally, it is a 2-wire device, the power supply voltage is 12V, and the ECM controls the grounding. Limited by cost, some vehicles are equipped with single-point fuel injectors. The single-point fuel injection pressure is low and the airflow from intake pipe can make a mist of fuel for better combustion.

Use ATO oscilloscope to test the fuel injector, the specific operation is shown in Figure 3-32:

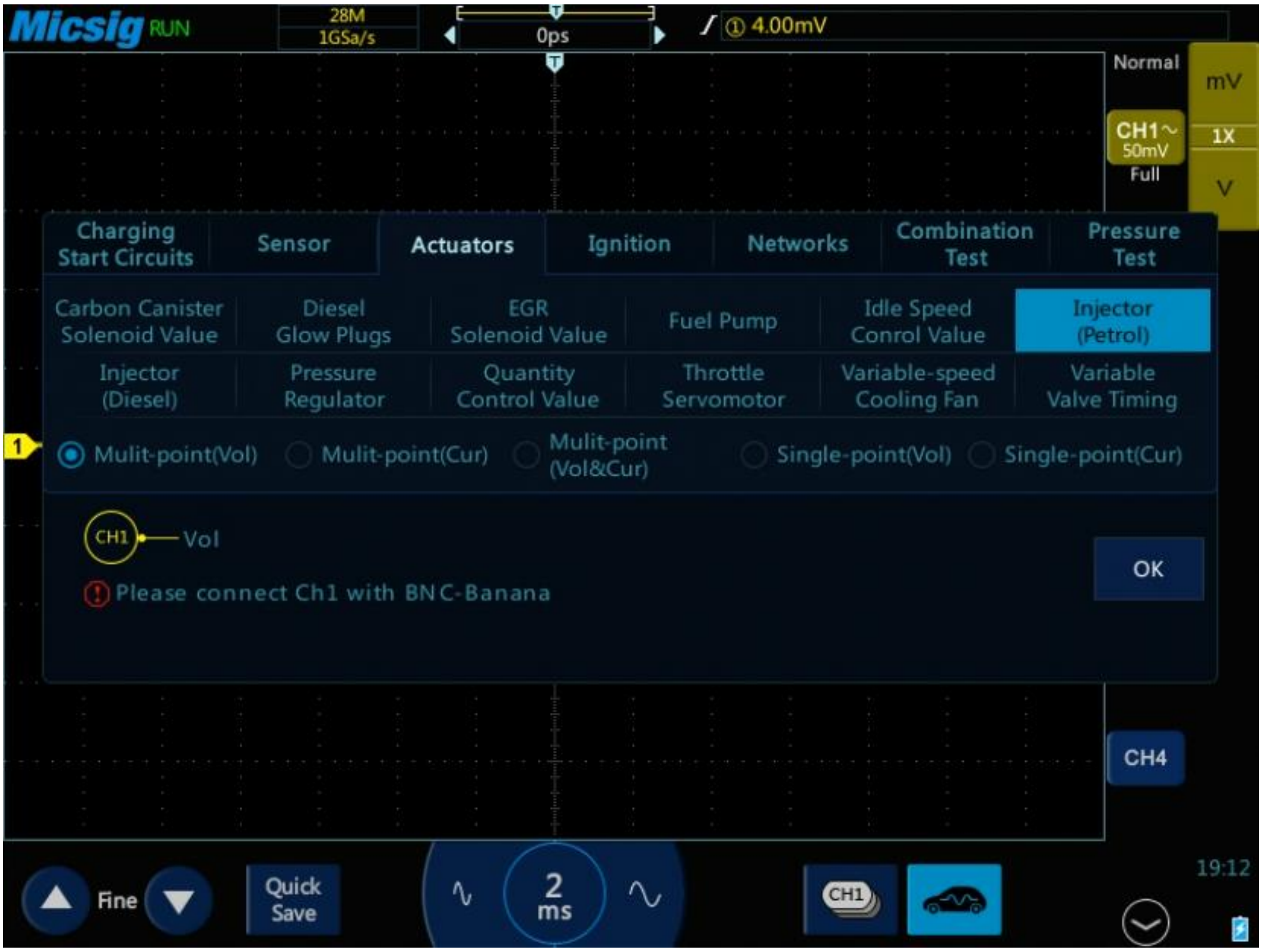


Figure 3-32 Injector (Petrol) Test

3.3.7 Injector (Diesel)

Most diesel engines use common rail fuel injection, fuel injection time is affected by the oil pressure. Low pressure at low speed, injection time is longer, less injection volume; High pressure at high speed, injection time is short, volume is large. There are mainly Bosch common rail injectors, Delphi injectors, CDi version 3 system injectors, piezoelectric injectors, Volkswagen Audi's PD system, Volkswagen Audi's piezoelectric PD, etc. on the market.

Use ATO oscilloscope to test the fuel injector (diesel engine), the specific operation is shown in Figure 3-33:

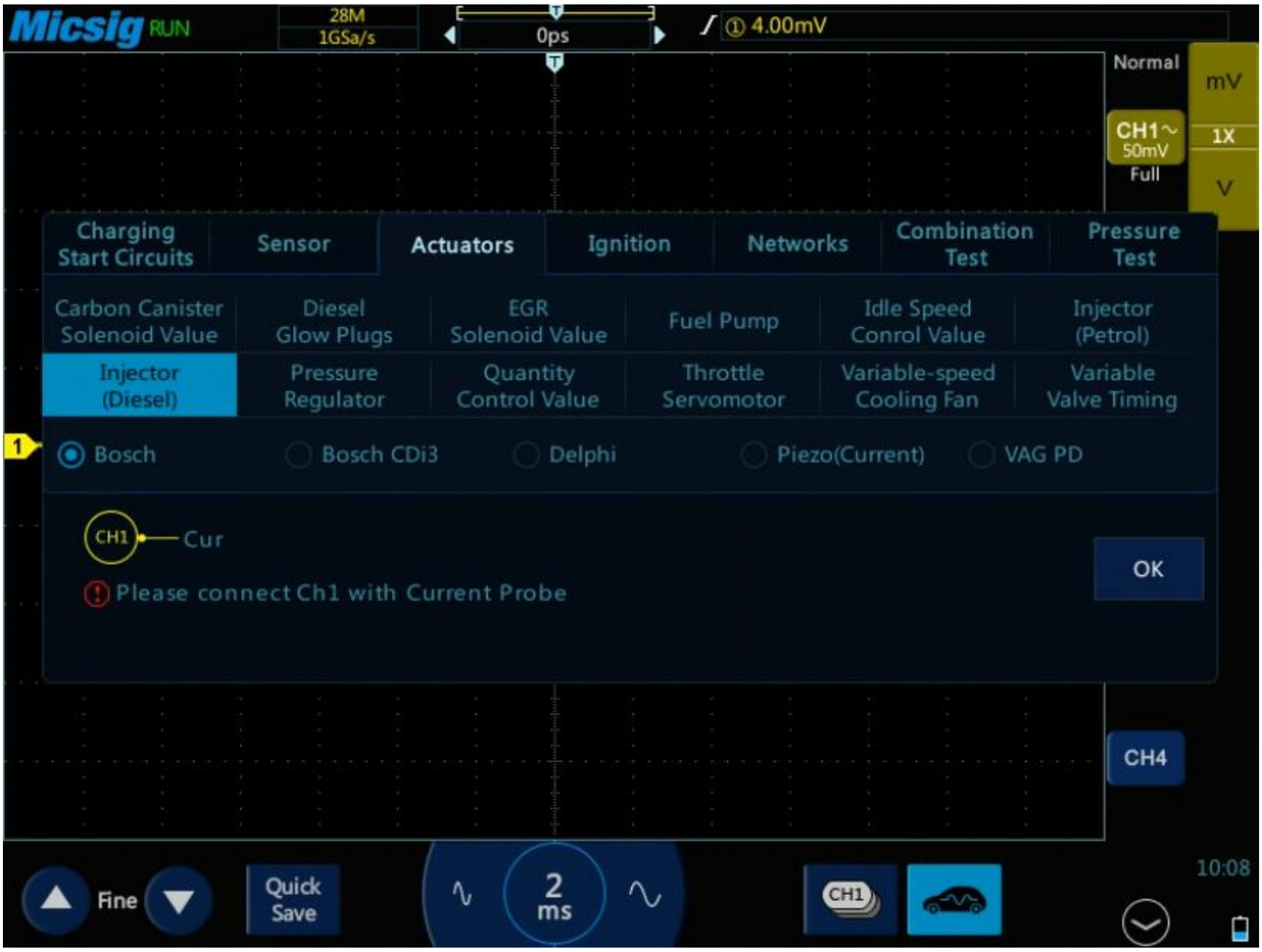


Figure 3-33 injector (diesel engine) test

3.3.8 Pressure regulator

The pressure regulator is a valve controlled by a square wave duty cycle. It is installed on the high-pressure fuel pump or on the common rail pipe and controls the common rail pressure together with the flow control valve. The pressure relief valve simply controls the amount of high-pressure oil entering the oil return system, thereby increasing or decreasing the fuel pressure of the common rail pipe. Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector is pierced into the end of the pressure regulator signal line with a needle probe.

Use ATO oscilloscope to test the pressure regulator, the specific operation is shown in Figure 3-34:

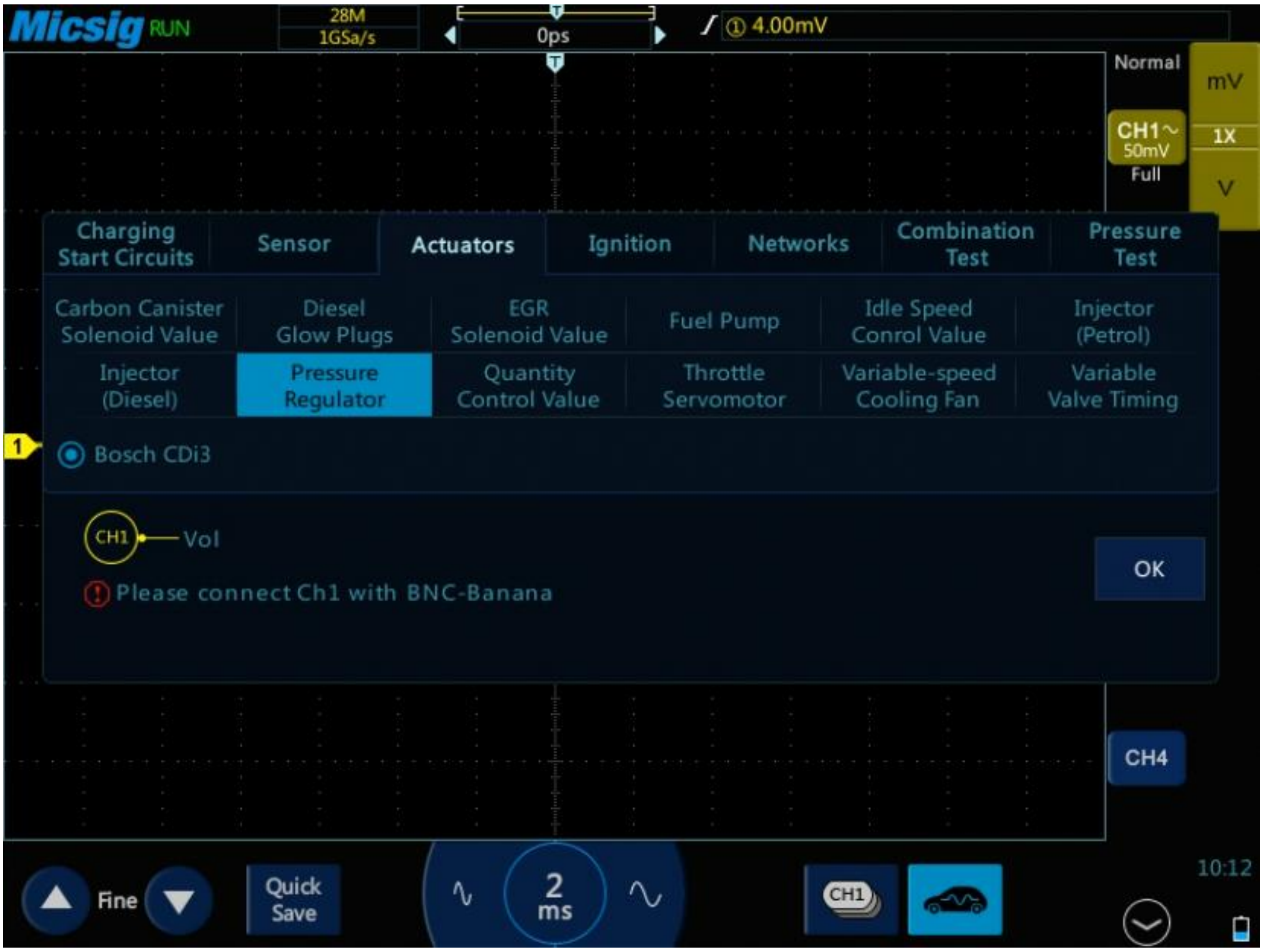


Figure 3-34 Pressure Regulator test

3.3.9 Quantity (Flow) control valve

The flow control valve, also known as the flow regulator and the fuel inlet metering valve, is used to measure the flow of fuel from the low pressure or lift pump into the high-pressure fuel pump. The more fuel enters the piston chamber of the high-pressure fuel pump, the higher the pressure, which increases the pressure in the common rail fuel pipe; on the contrary, the lower the pressure. Generally, two wires, signal (power) and ground.

Use ATO oscilloscope to test the flow control valve, the specific operation is shown in Figure 3-35:

Figure 3-35 Quantity (Flow) control valve test

3.3.10 Throttle Servo Motor

Throttle servo motor are commonly used in electronically controlled engines, and throttle butterfly valves are usually used. The ECM controls the throttle servo motor according to the accelerator pedal signal to realize the throttle opening control, which is then monitored by the throttle position sensor and transmits the signal back to the ECM to achieve closed-loop control.

Use ATO oscilloscope to test the throttle servo motor, the specific operation is shown in Figure 3-36:

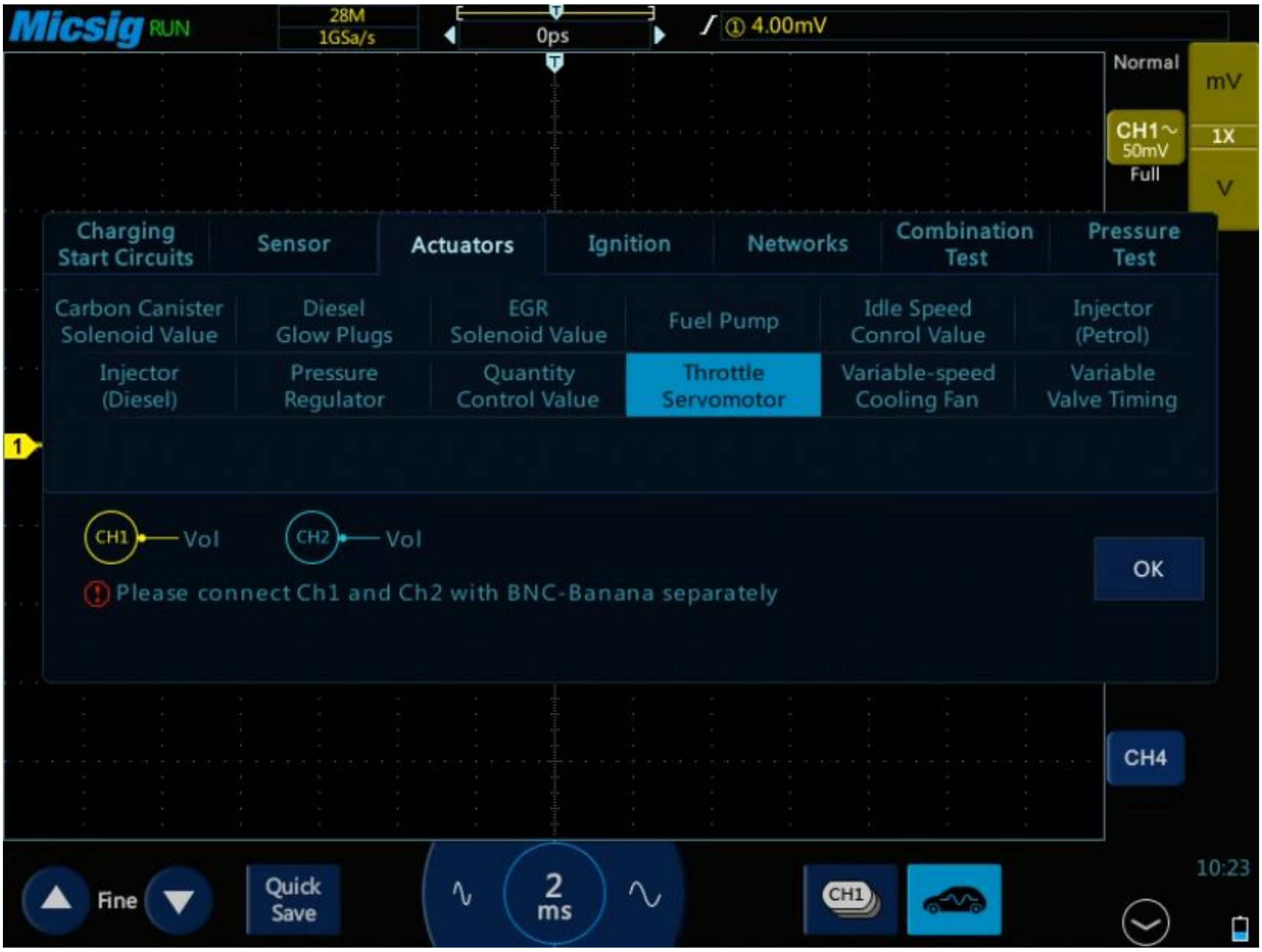


Figure 3-36 Throttle servo motor test

3.3.11 Variable speed cooling fan

At present, most cars' fans are variable-speed, and the speed of the fan can be adjusted according to different working conditions and temperatures.

Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, ground the other end of the black plug, and use a needle to pierce the red connector into the signal wire of the fan terminal; use a current clamp, connect one end to channel 2 of the oscilloscope, and clamp the other end to it Pay attention to the direction of the current on the fan's power cord. (If you need to test the current, connect a current clamp).

Use ATO oscilloscope to test the cooling fan, the specific operation is shown in Figure 3-37:

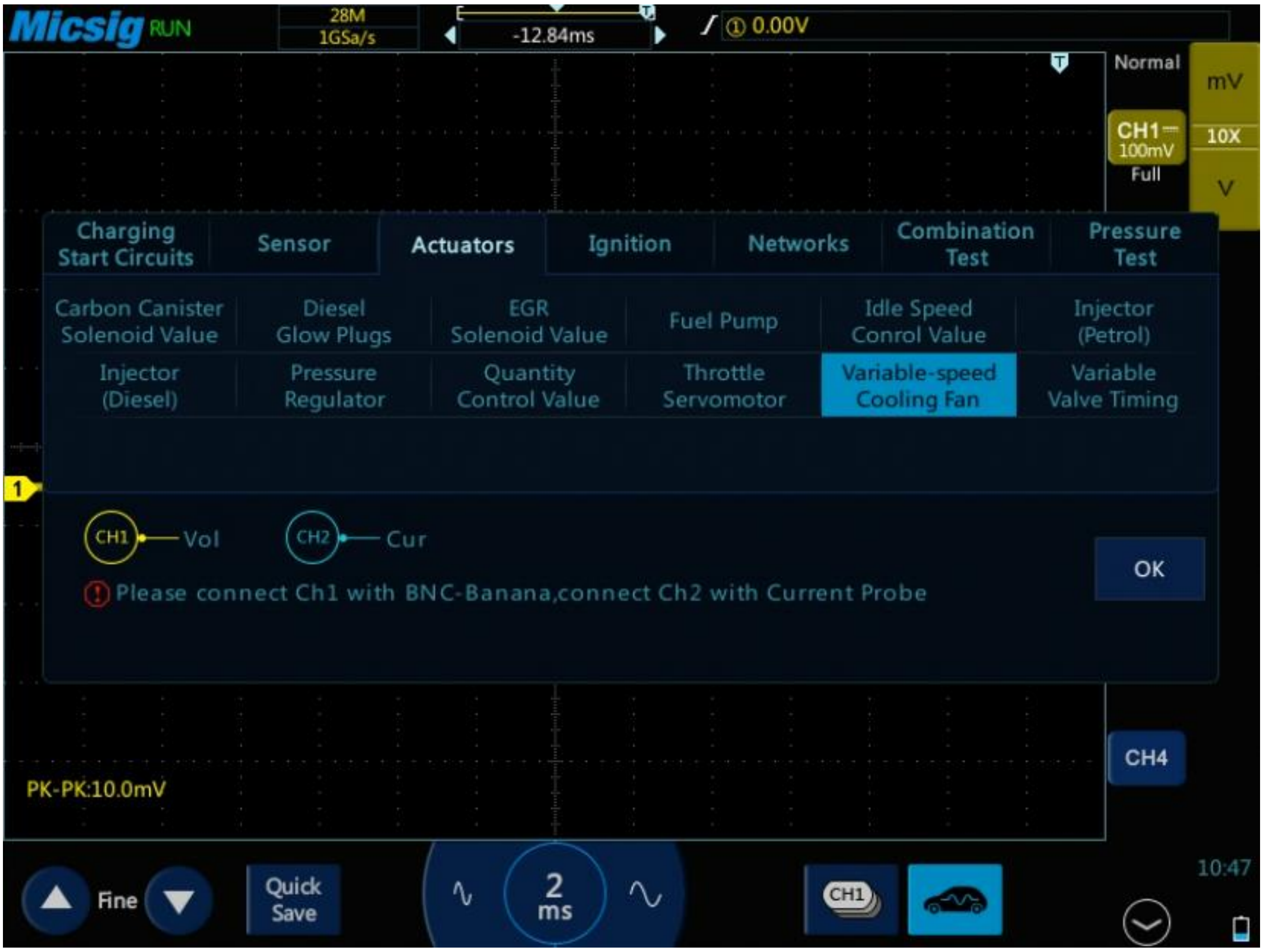


Figure 3-37 Variable-speed Cooling fan test

The following picture is the actual measurement diagram of the cooling fan of a certain model:

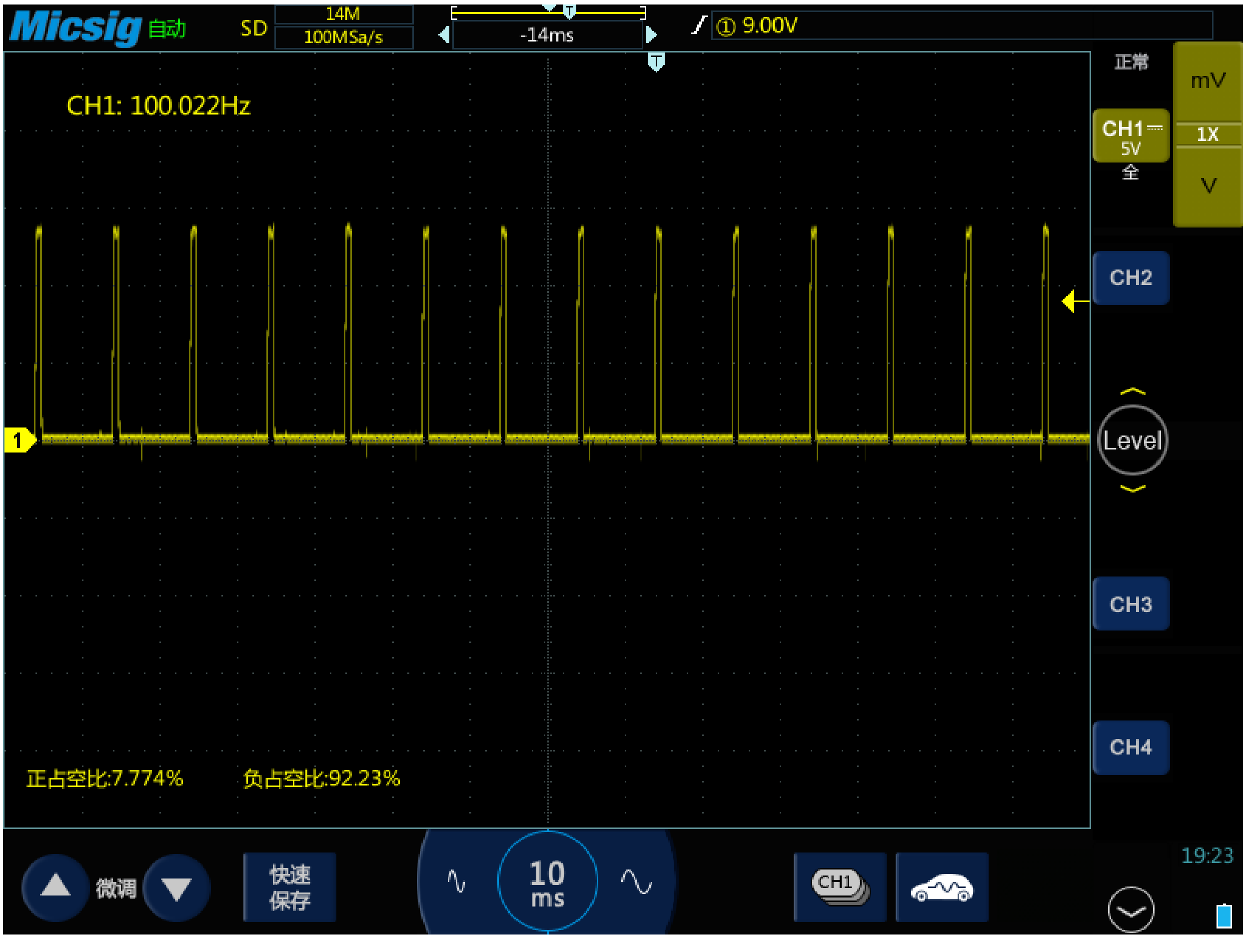


Figure 3-38 Cooling fan measurement diagram

3.3.12 Variable valve timing

Variable valve timing is achieved by adjusting the phase of the engine cam so that the intake air volume changes with the change of engine speed, so as to achieve the best combustion efficiency and improve fuel economy. Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector is pierced into the variable valve timing signal line with a needle tip.

Use the ATO oscilloscope to test the variable valve timing (divided into single and double timing), the specific operation is shown in Figure 3-39:

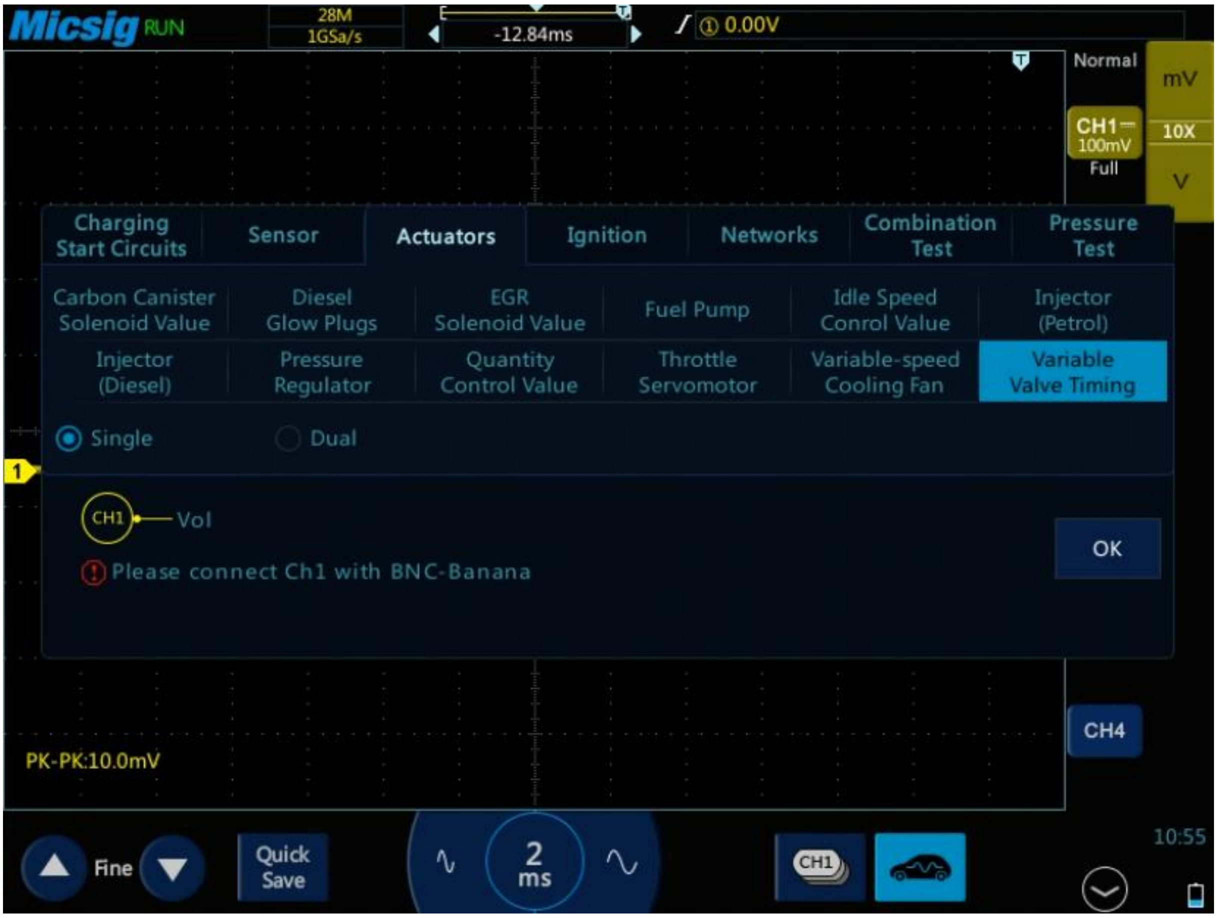
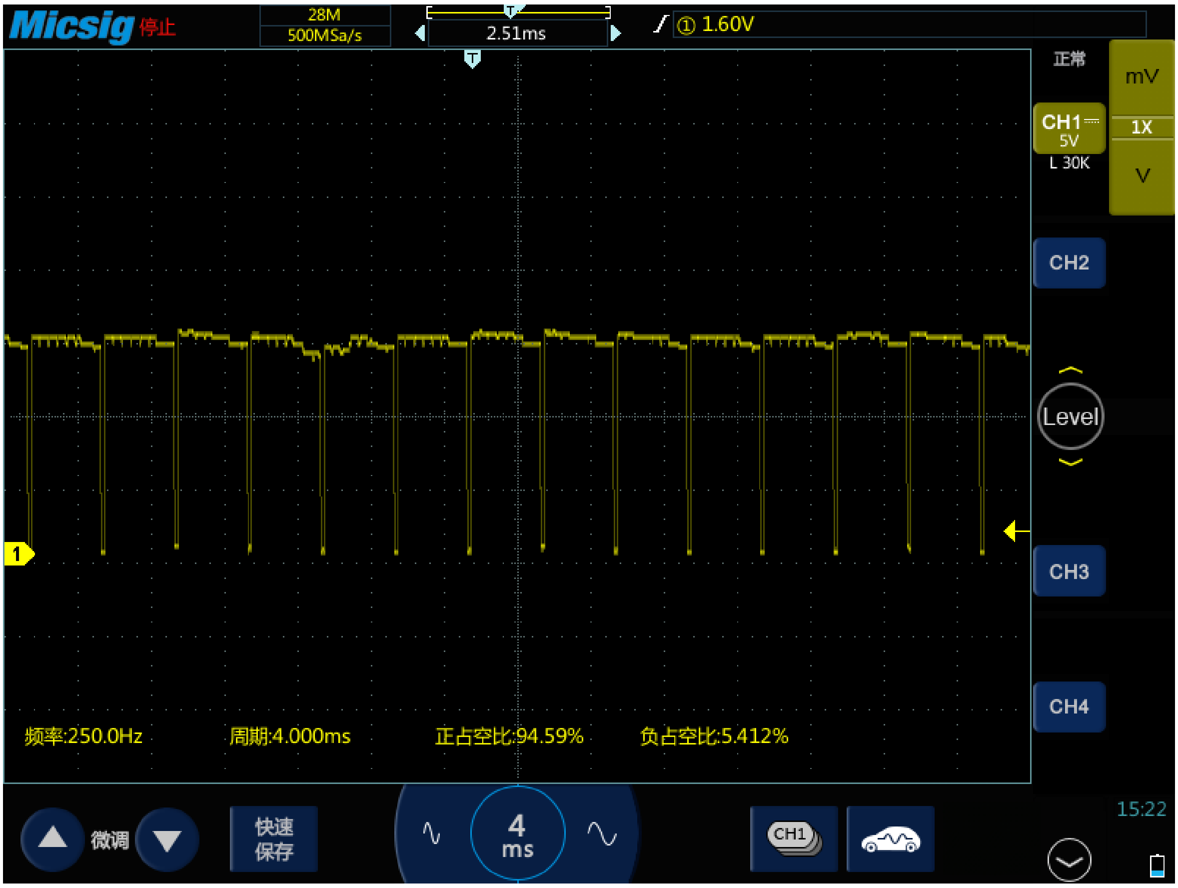


Figure 3-39 Variable valve timing test

The following picture is the actual measurement diagram of the Variable valve timing of a certain model:



3. 4 Ignition Tests

⚠ Special Attention! During the secondary ignition test, because the test voltage is about 40K volts, the secondary ignition probe must be used for operation. It is strictly forbidden to use the ordinary probe, otherwise it is very likely to cause personal safety injury and instrument damage.

3.4.1 Primary

The ignition system of a gasoline car usually consists of a primary coil, a secondary coil and a spark plug. There are traditional ignition systems and electronic ignition systems. Currently, most car models already use electronic ignition systems. The primary circuit has developed from the basic contact type and capacitive type to the system with no distributor and one coil per cylinder that is commonly used today.

Use a P130A probe, connect one end to channel 1 of the oscilloscope, and connect the other end to the ground with the black clip. Use a stinger to pierce the ground wire of the primary coil and hook the probe to the metal needle of the stinger; use a current clamp to connect the other end to channel 2 of the oscilloscope. Clamp the other end on the power cord of the primary coil, pay attention to the direction of the current (if you need to test the current, connect a current clamp).

Use the ATO oscilloscope to test the primary ignition coil (the voltage, current, voltage + current, signal can be tested separately to help users troubleshoot possible faults), the specific operation is shown in Figure 3-40:

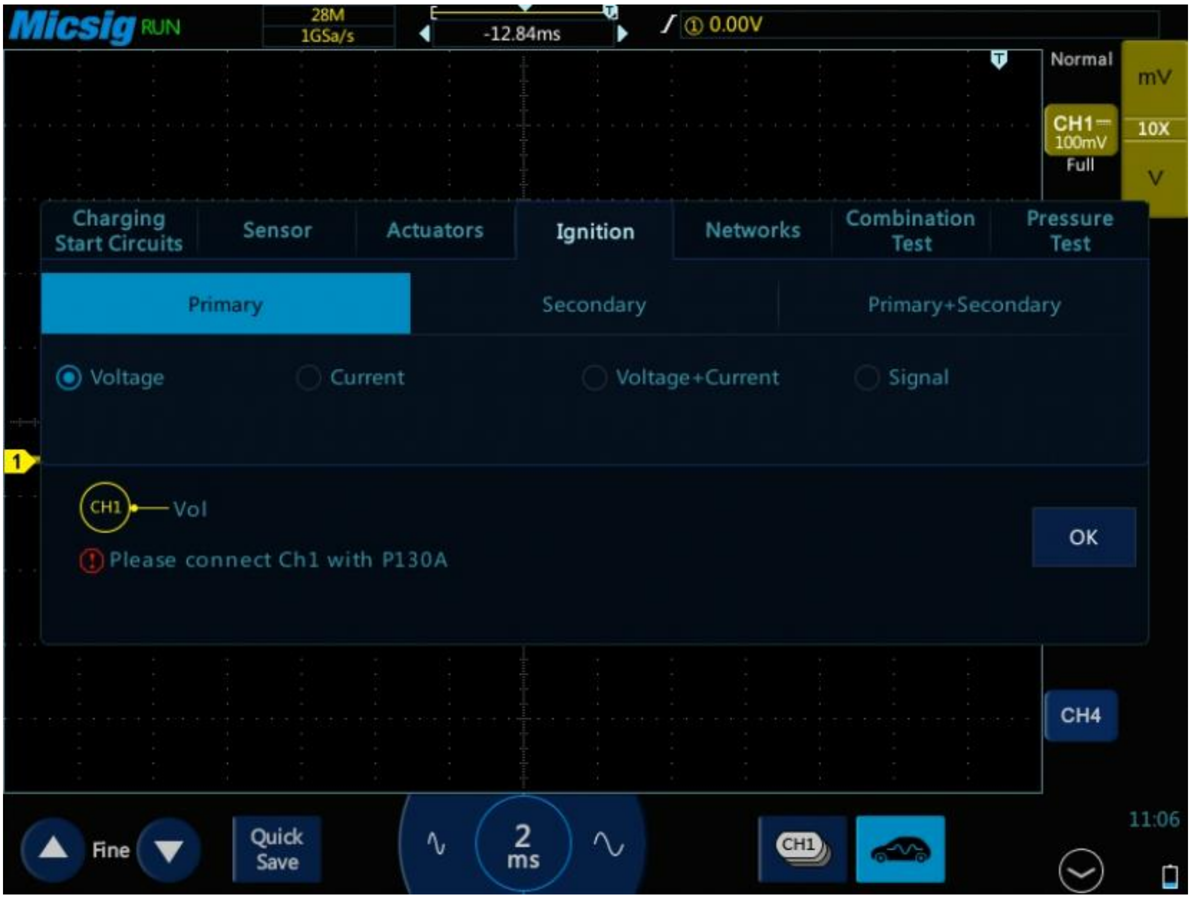


Figure 3-40 Primary ignition

The figure below is the actual measurement of the primary ignition of a certain model:

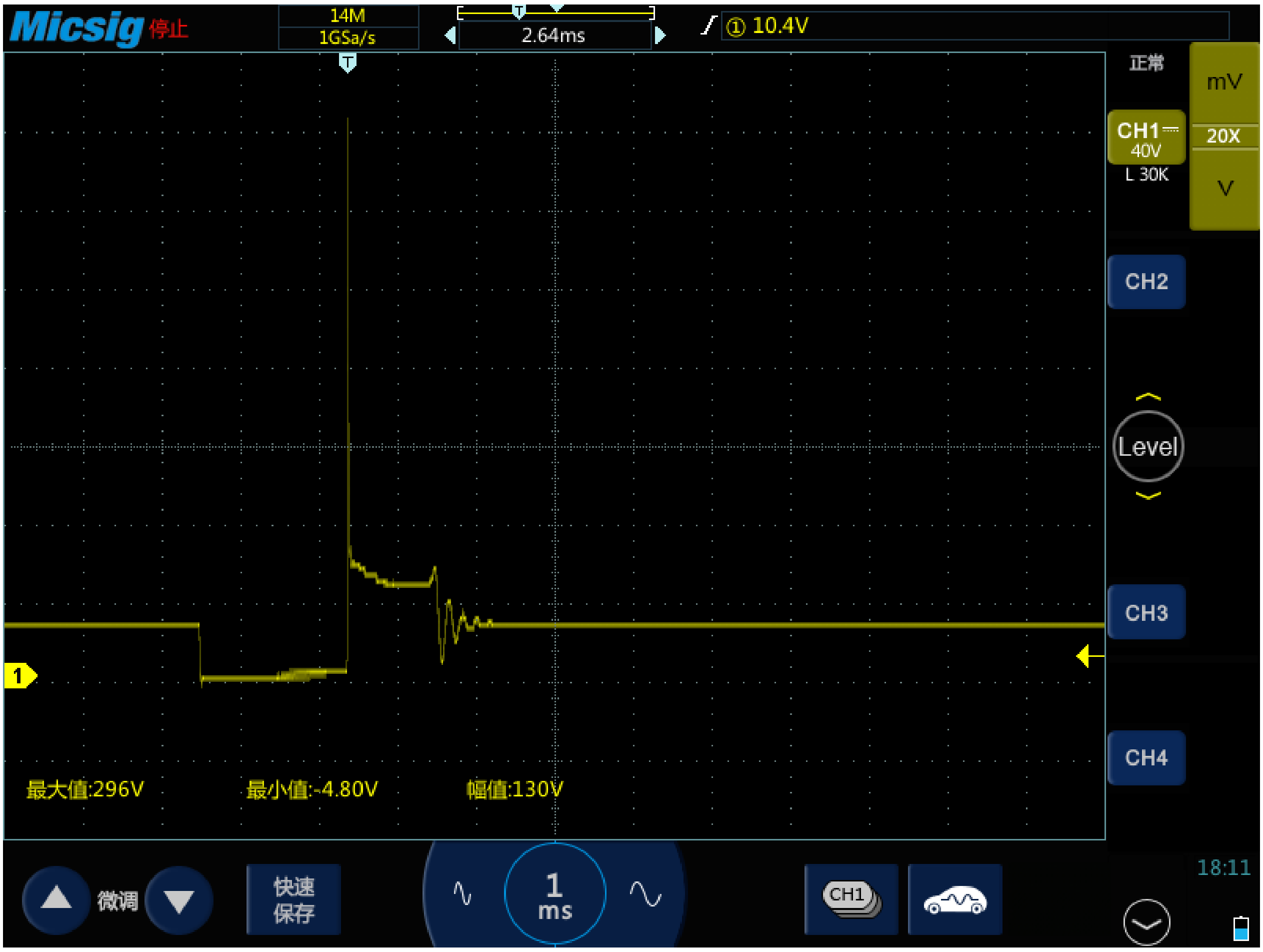


Figure 3-41 Primary ignition actual test

3.4.2 Secondary

The secondary coil has more coil turns than the primary coil, and can generate a high voltage of up to 40kv, which can cause the spark plug to break down and ignite. There are several types: distributor ignition system, distributorless ignition system/invalid spark, COP independent ignition, multi-COP integrated unit ignition.

Use the ATO oscilloscope to test the secondary ignition coil (⚠ must use the secondary ignition probe) [the voltage (KV), coil output voltage, and voltage (mv) can be tested separately to help users troubleshoot possible faults]. The specific operations are as follows Figure 3-42:

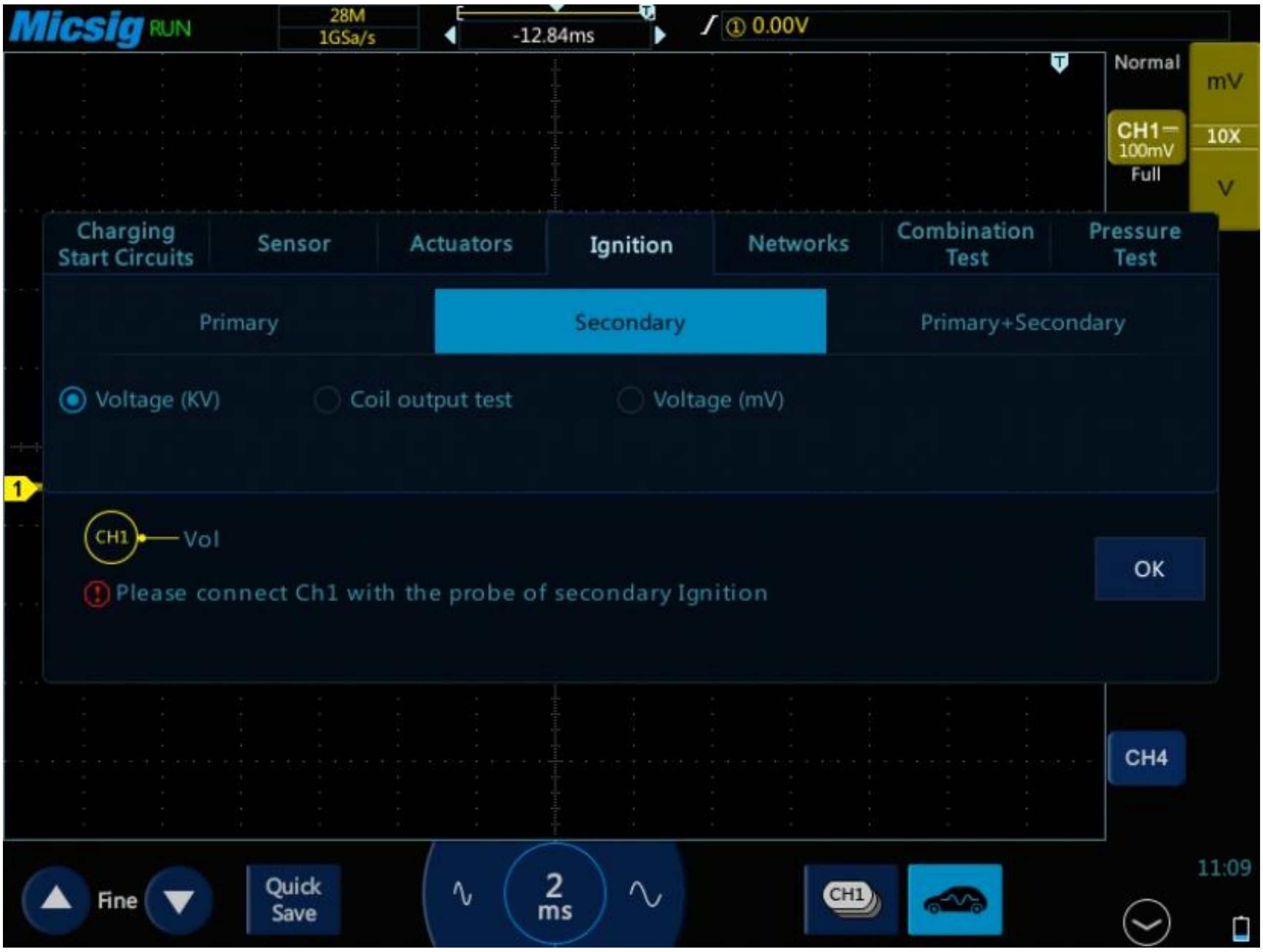


Figure 3-42 Secondary ignition test

3.4.3 Primary + Secondary

When measuring the primary and secondary waveforms at the same time, please use the P130A probe, one end is connected to channel 1 of the oscilloscope, the black clip on the other end is grounded, pierce the needle into the ground wire of the primary coil, and the probe is hooked to the metal needle; use a suitable secondary ignition probe to connect one end to channel 2 of the oscilloscope, and test the other end according to different engine ignition types.

Use ATO oscilloscope to simultaneously test the three indicators of the secondary ignition coil【Synchronize voltage test of the primary and the secondary coil, Primary coil voltage and current, and the voltage of the secondary coil (⚠ use the secondary ignition probe)】, the specific operation is shown in the Figure 3-43:

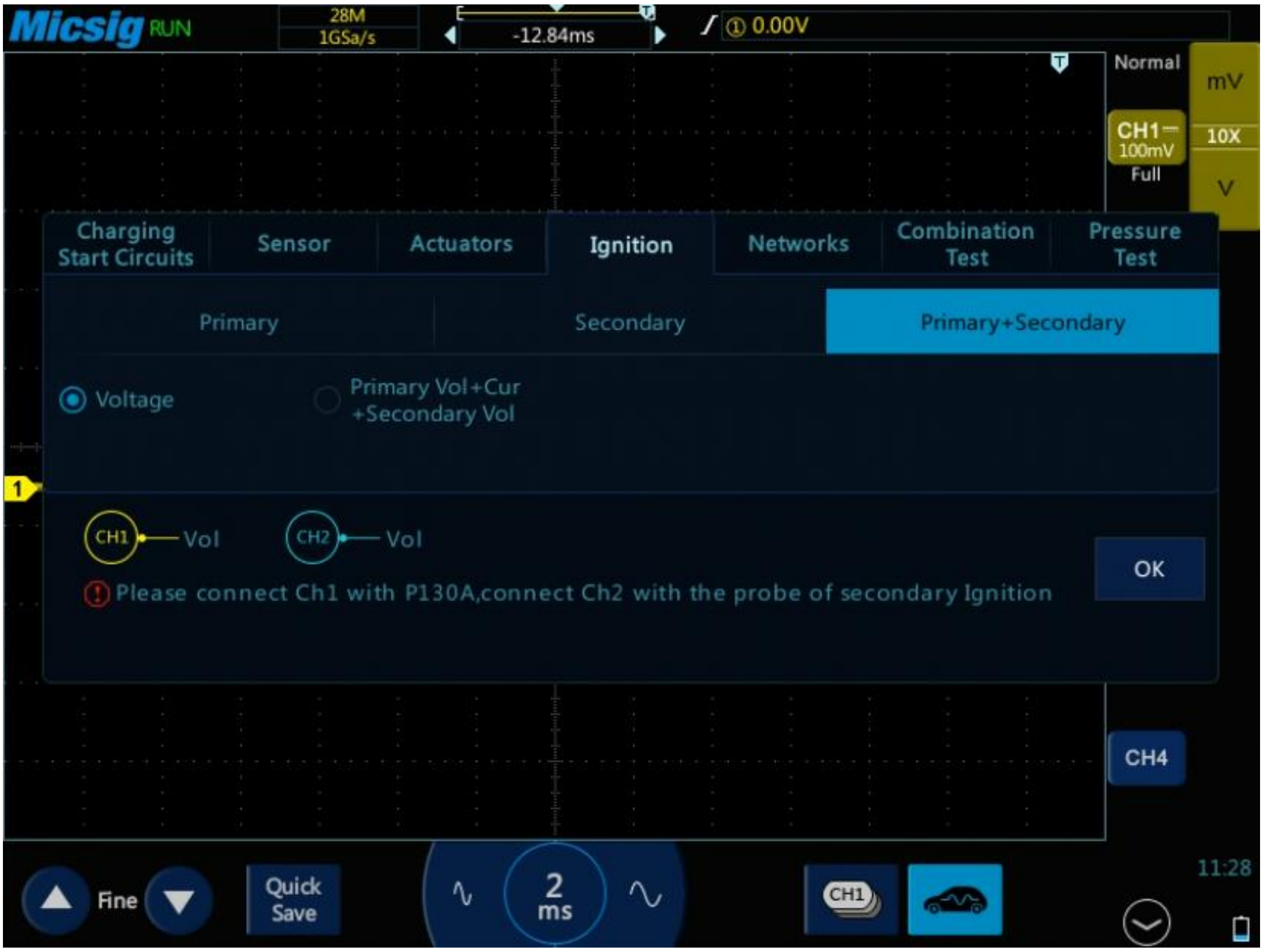


Figure 3-43: Primary + Scondary ignition test

The following figure is the actual measurement of the primary and secondary ignition of the BMW 5 Series N20 engine:

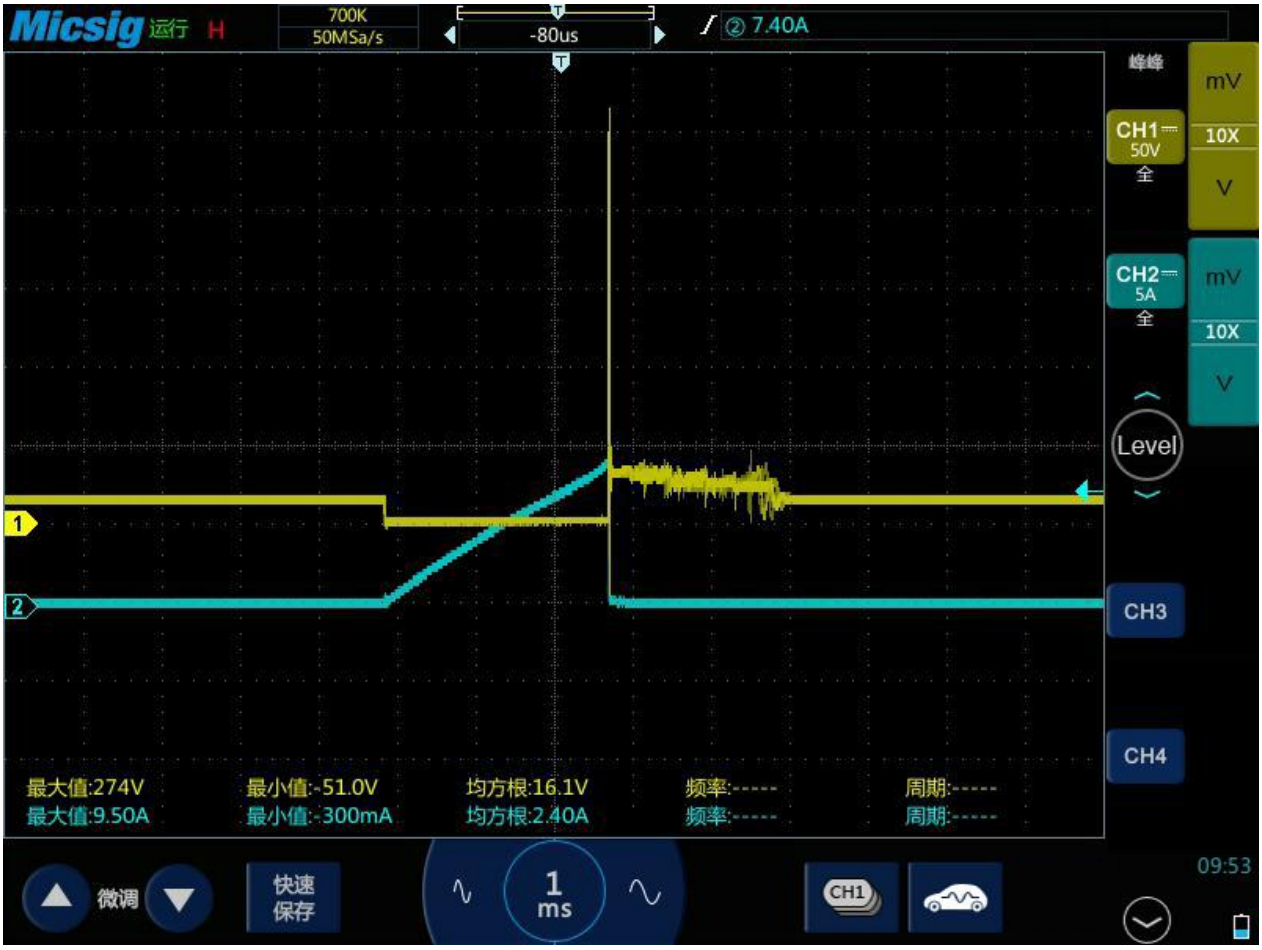


Figure 3-44 BMW 5 Series N20 Primary + Secondary ignition signal

3. 5 Networks

3.5.1 CAN High & CAN Low

CAN bus is a communication system, which is widely used in modern vehicles. A car may have 2 to 3 CAN bus networks, both high-speed and low-speed. The general high-speed transmission rate is 500k, which is usually used for power transmission. The low-speed rate is 250k, which is usually used for meter transmission. Each CAN bus network can connect multiple types of multiple devices, replacing the traditional multi-wire harness cable, significantly reducing weight and increasing reliability.

The CAN bus has 2 wires, CAN high and CAN low, and the signals are in a differential relationship. The CAN bus is divided into idle and transmission states. When idle, CAN high and CAN low are both 2.5V. When transmitting signals, the high level of CAN high is 3.5V, and the low level is 2.5V; the high level of CAN low is 2.5 V, the low level is 1.5V. Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector is pierced into the CAN high wire of the plug with a needle; use a BNC to banana cable, one end is connected to channel 2 of the oscilloscope, and the other end is grounded, and the red connector is pierced into the CAN low wire of the plug with a needle tip.

The specific CAN high and CAN low can be found in the technical manual of the vehicle.

Use ATO oscilloscope to test the CAN bus, the specific operation is shown in Figure 3-45:

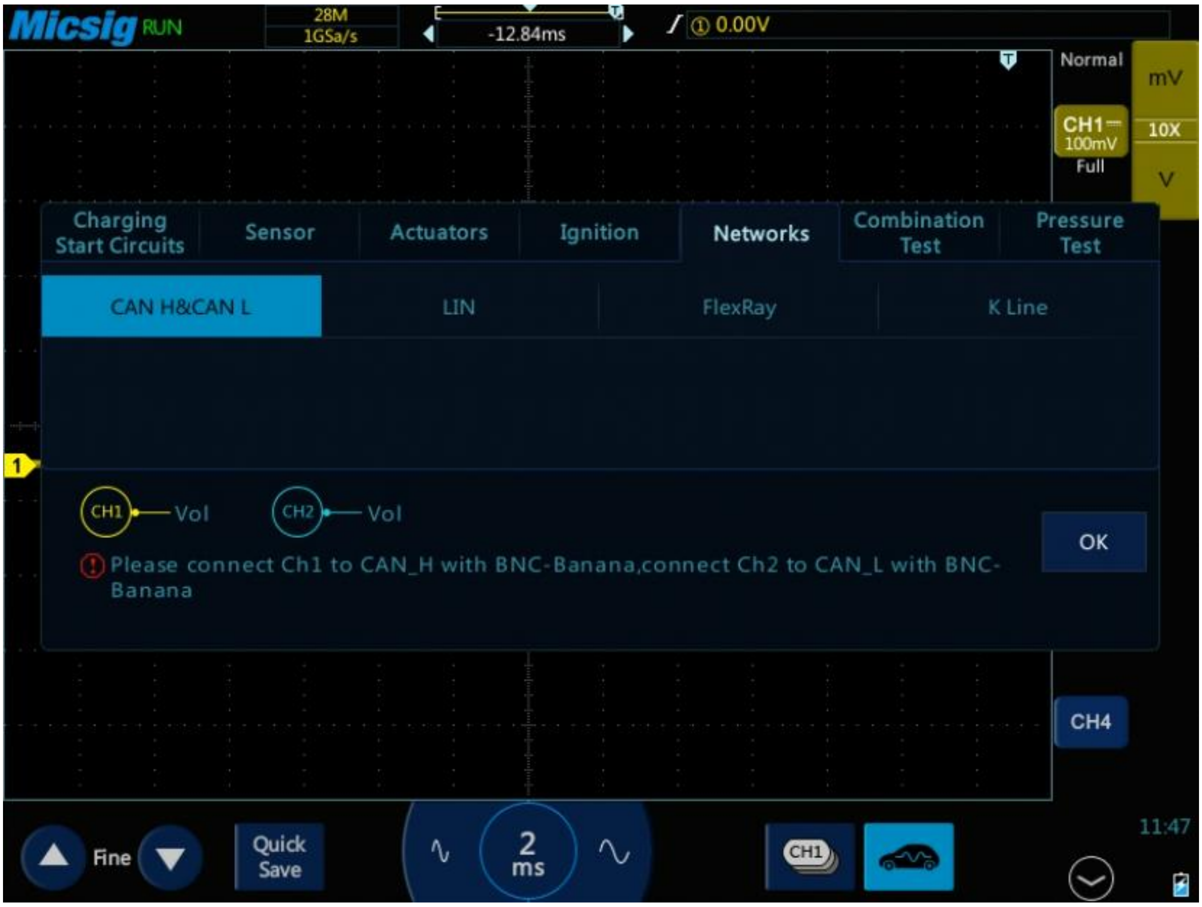
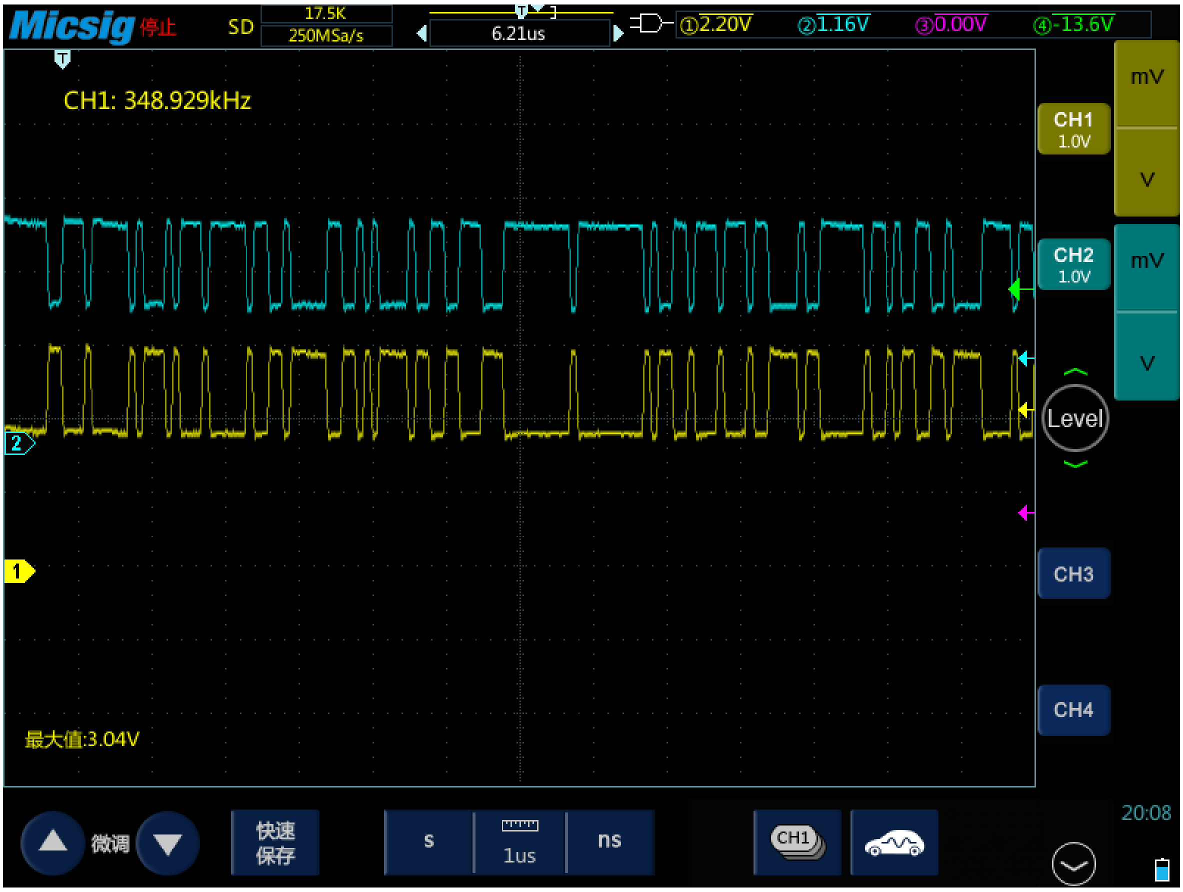


Figure 3-45 CAN BUS Test

The figure below is the actual measurement of the CAN bus of a certain model:



3.5.2 LIN Bus

The LIN protocol is short for Local Interconnect Network.
The Lin bus communication is very common in automobiles, it is low speed, there are multiple control devices mounted on a network. It can contril non-safety-critical and low-speed devices on vehicles, such as wipers, windows, mirrors, air conditioners, electronic seats, etc. LIN is single-wired, has high level and low level when transmitting data, the high level is 12V, and the low level is 0V. The LIN bus generally has a sync header followed by data. If there is only a signal from the sync header, it means that the device has not responded.
Use the ATO oscilloscope to test the LIN bus, the specific operation is shown in Figure 3-46:

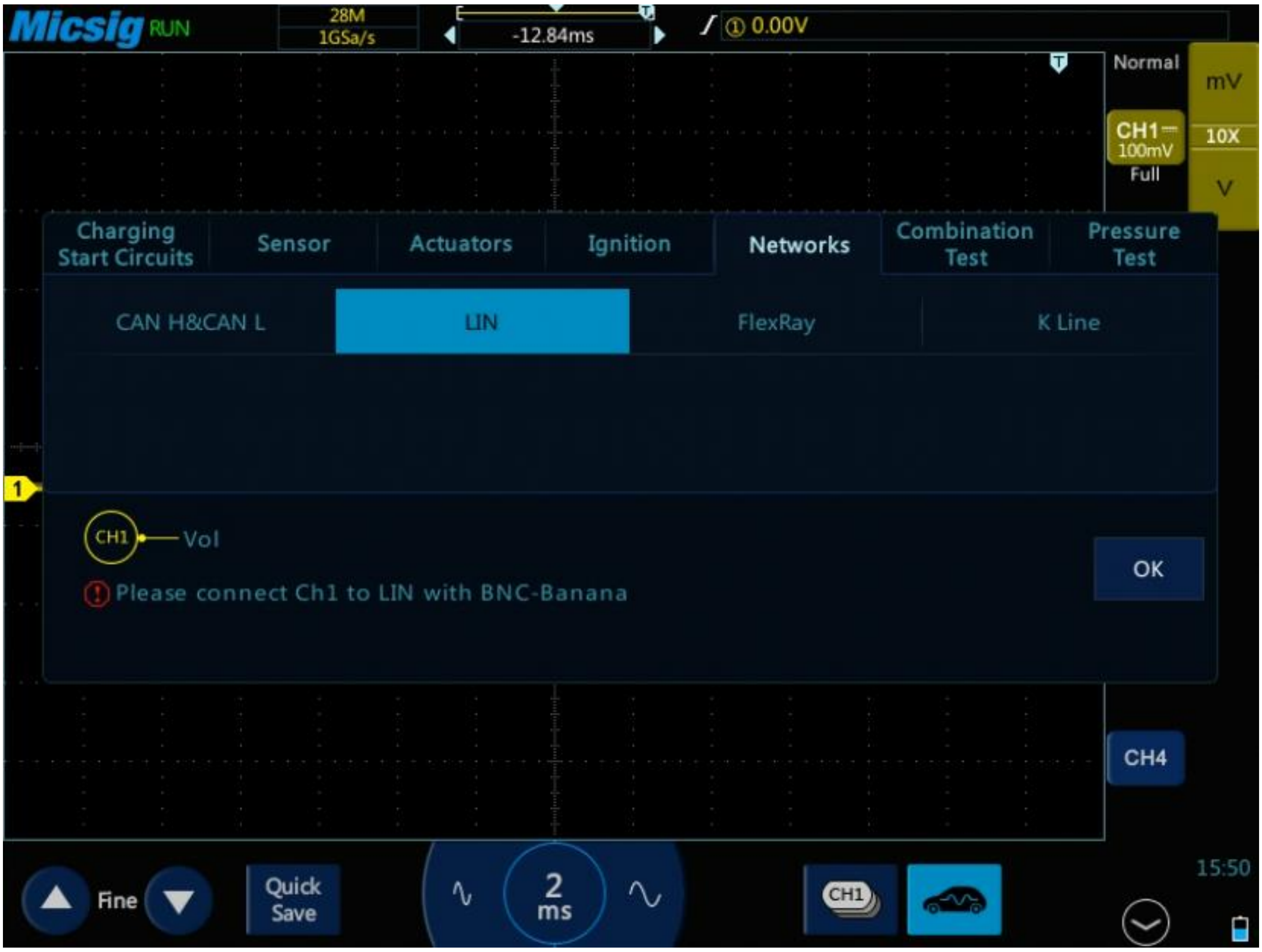


Figure 3-46 Lin bus test

The following picture is the actual measurement of Audi A6 LIN bus in a certain year:

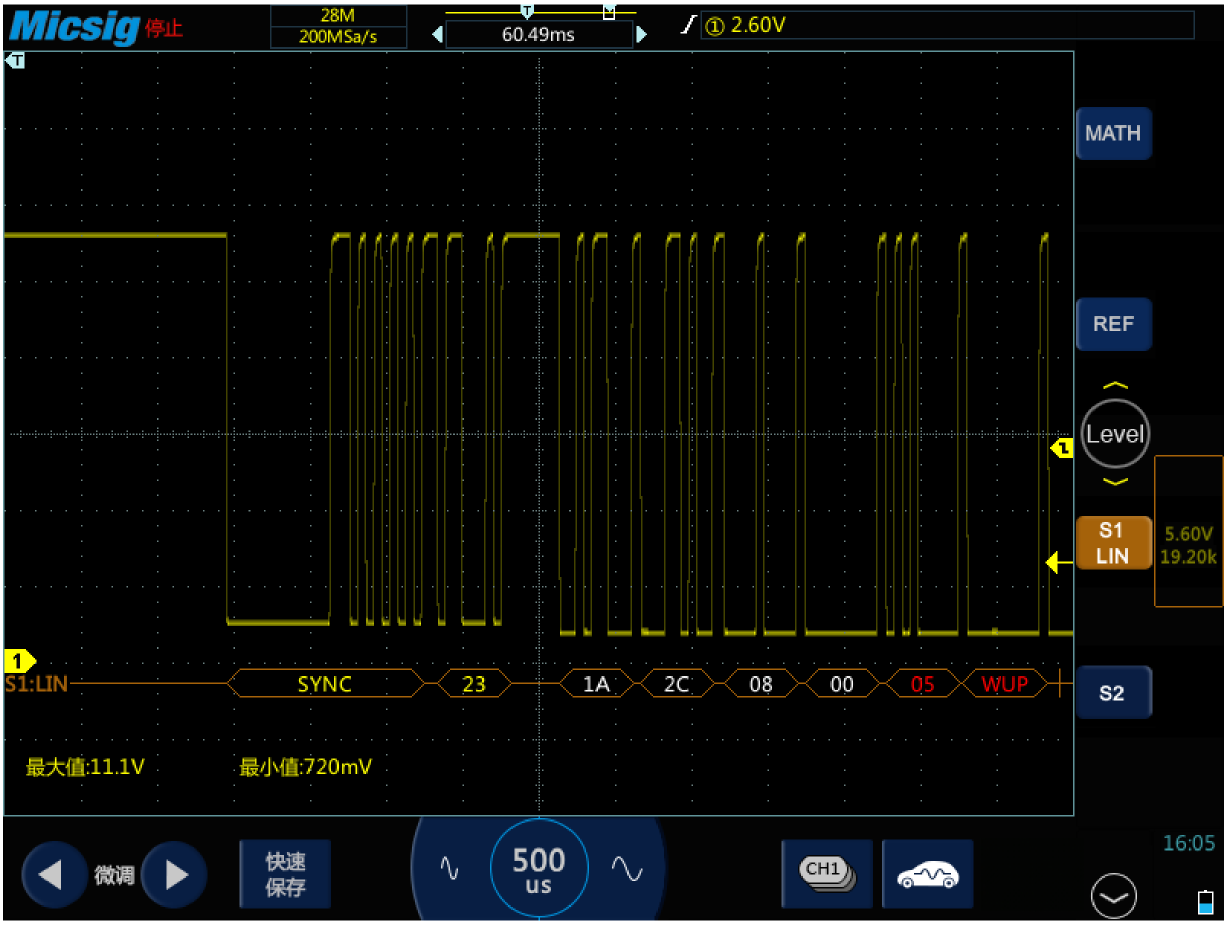


Figure 3-47 Audi A6 LIN bus measurement

3.5.3 FlexRay Bus

With the increase of car transmission content, the Flexray bus with faster transmission speed has been developed, and the transmission rate can reach 10Mbps. It has the advantages of high speed, determinability, and fault tolerance. It can work with CAN, LIN and other buses.

The Flexray bus still has 2 lines and the waveform is in a differential pattern. When idle, the voltage of the two wires is 2.5V; when transmitting data, both wires will have a voltage of 1V up and down, and the voltages on the two wires are opposite.

Use the P130A probe, one end is connected to channel 1 of the oscilloscope, and the other end is grounded with the black clip. Use a piercing needle to pierce the easy-to-test Flexray bus positive plug, and hook the probe to the metal needle of the puncture needle. Use the P130A probe, connect one end to channel 2 of the oscilloscope, and the black clip on the other end to ground. Use a needle to pierce the easy-to-test Flexray bus negative plug, and hook the probe to the metal needle of the needle.

The specific Flexray bus measurement location can be found in the vehicle's technical manual.

Use the ATO oscilloscope to test the FlexRay bus, the specific operation is shown in Figure 3-48:

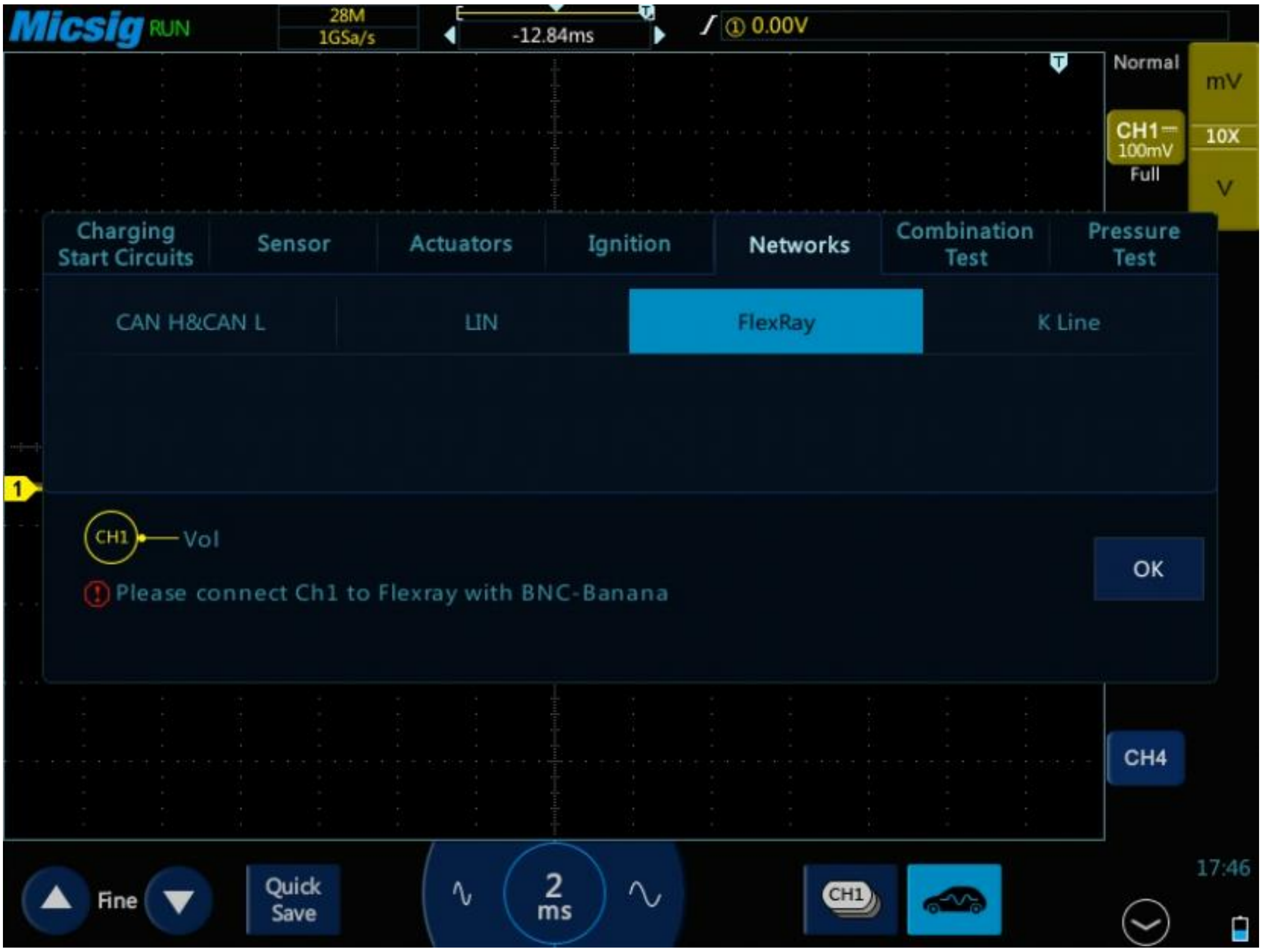


Figure 3-48: FlexRay bus test

3.5.4 K line

The K line is a special line for data transmission between the car control unit and the diagnostic instrument, and the transmission rate is low. In general, K-Line is very different from CAN Bus and most communication networks. For example, the CAN Bus network does not have a central or master ECM: all ECMs are equal because they can send and receive information along the network. The K line has only one line, and the information is transmitted in binary format and the pulse voltage signal is transmitted. Divided into 0 and 1, 0 is high level, 12V or above, 1 is low level, voltage is 0V.

Use the ATO oscilloscope to test the K line, the specific operation is shown in Figure 3-49 below:

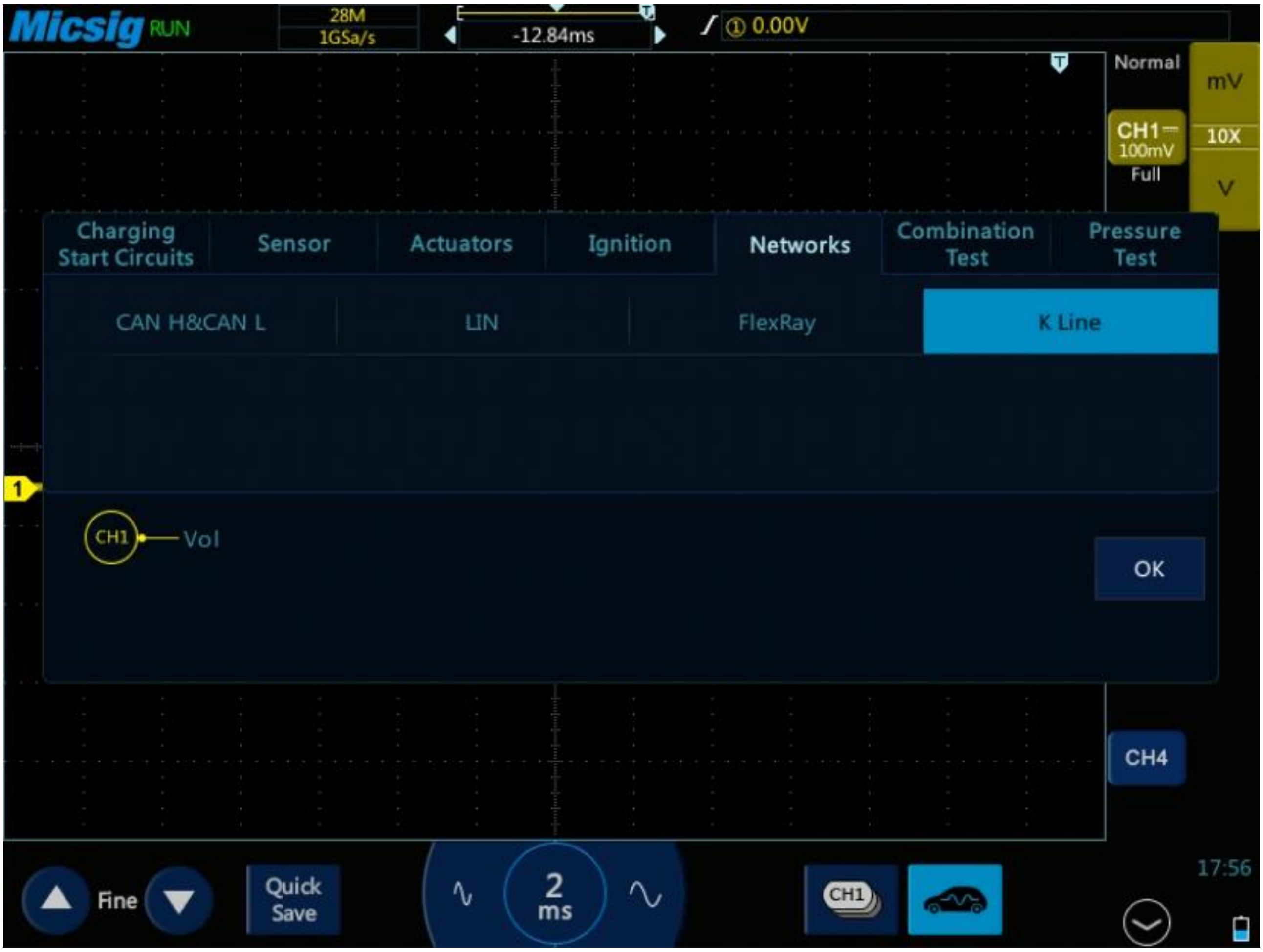


Figure 3-49 K line test

3. 6 Combination Tests

The electronic faults of automobiles are sometimes more complicated. We need to use an ATO oscilloscope to perform combination testing, compare several waveforms that collected, and help users judge the fault by observing and analyzing the timing relationship and quantitative relationship between the waveforms. , The ATO is a powerful tool to solve such complex problems.

3.6.1 Crankshaft + Camshaft

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, and the other black end is grounded, the red connector is pierced into the signal line of the camshaft sensor with a needle probe.
Use ATO oscilloscope to perform combined test on crankshaft + camshaft, the specific operation is shown in Figure 3-50:

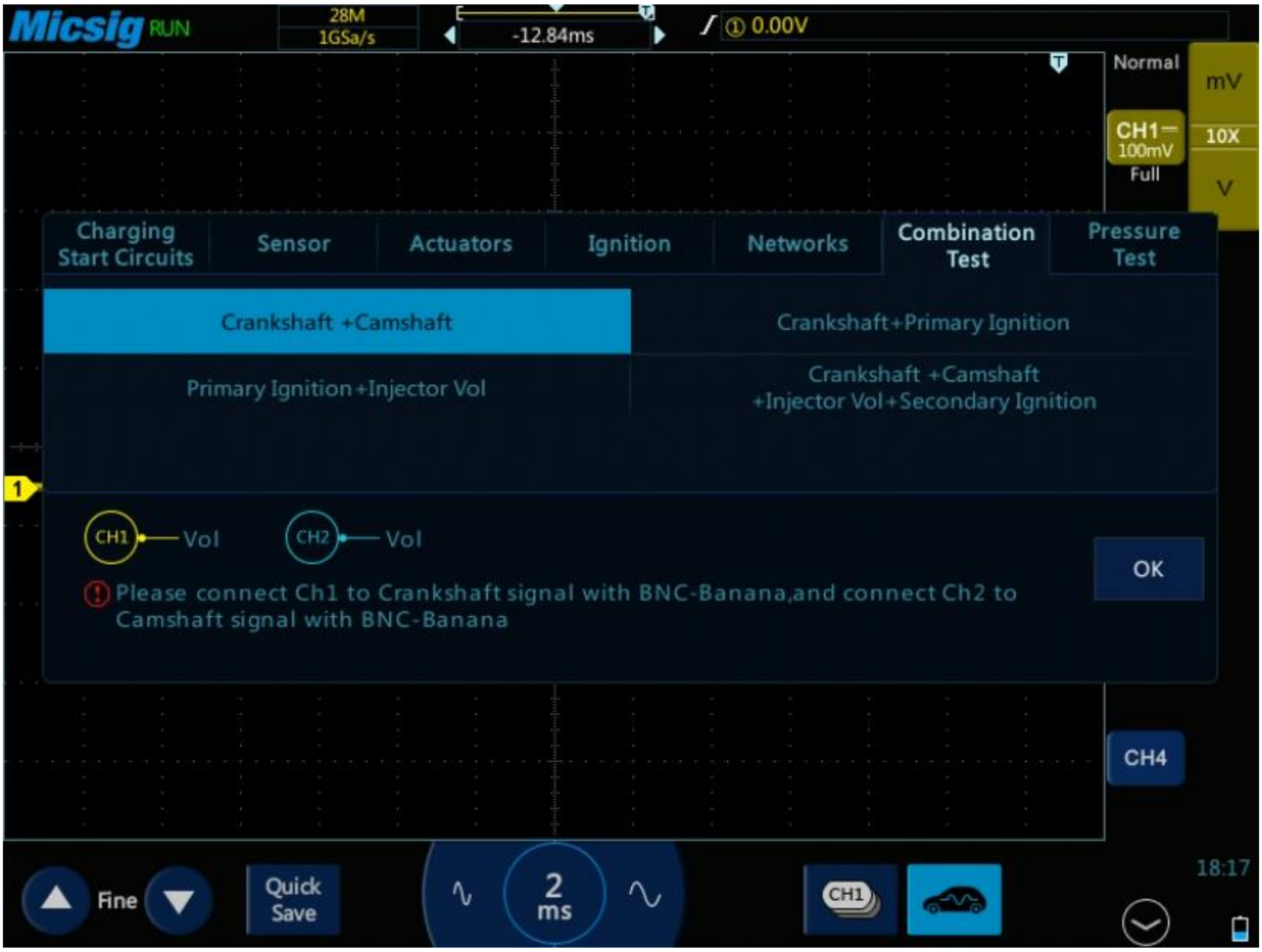


Figure 3-50 Crankshaft + Camshaft Combination Test

3.6.2 Crankshaft + Primary ignition

Measure the crankshaft and primary ignition at the same time, you can check whether the ignition advance angle is normal, and look for the cause of misfire at high engine speed. Check whether the crankshaft signal is normal or whether the primary ignition voltage and closing time are reached.

Use a P130A probe, one end is connected to channel 1 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 P130A probe, connect one end to channel 2 of the oscilloscope, and the black clip on the other end to ground. Use a needle to pierce the ground wire of the primary coil, and hook the probe to the metal needle of the needle;

Use ATO oscilloscope to perform combined test on crankshaft + primary ignition, the specific operation is shown in Figure 3-51:

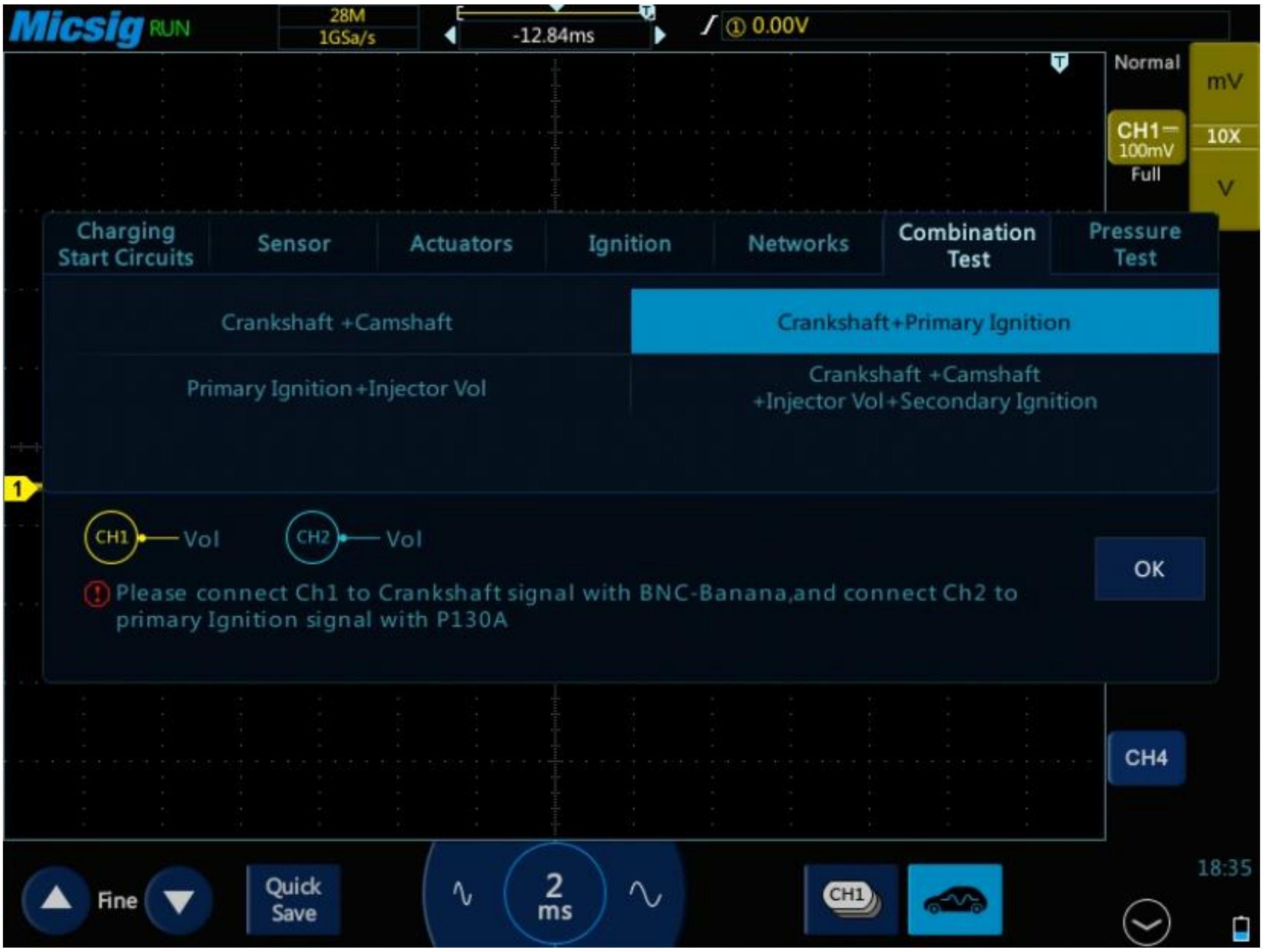


Figure 3-51 Crankshaft + Primary ignition test

3.6.3 Primary ignition + Injector voltage

If there is a problem with the startup or it is suddenly off, it may be necessary to test the primary ignition and the fuel injector at the same time. If the primary ignition fails, no fuel injector signal will be generated.

Use a P130A probe, one end is connected to channel 1 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 the P130A probe, one end is connected to channel 2 of the oscilloscope, and the other end is grounded with the black clip. Use a puncture needle to pierce the ground wire of the primary coil, and hook the probe to the metal needle of the puncture needle.

Use the ATO oscilloscope to perform a combined test on the primary ignition + injector voltage, the specific operation is shown in Figure 3-52:

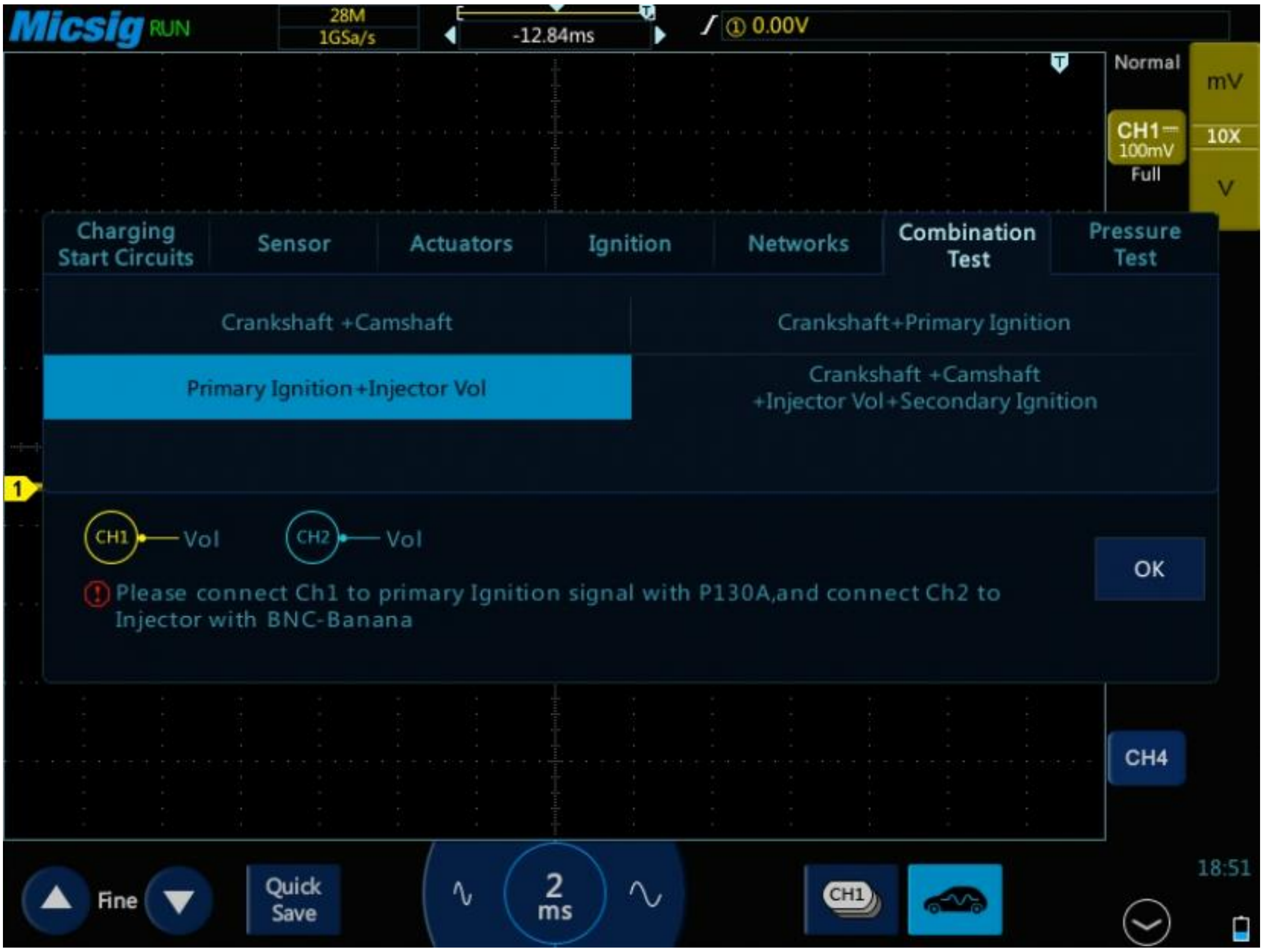


Figure 3-52 Primary ignition + Injector voltage

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.

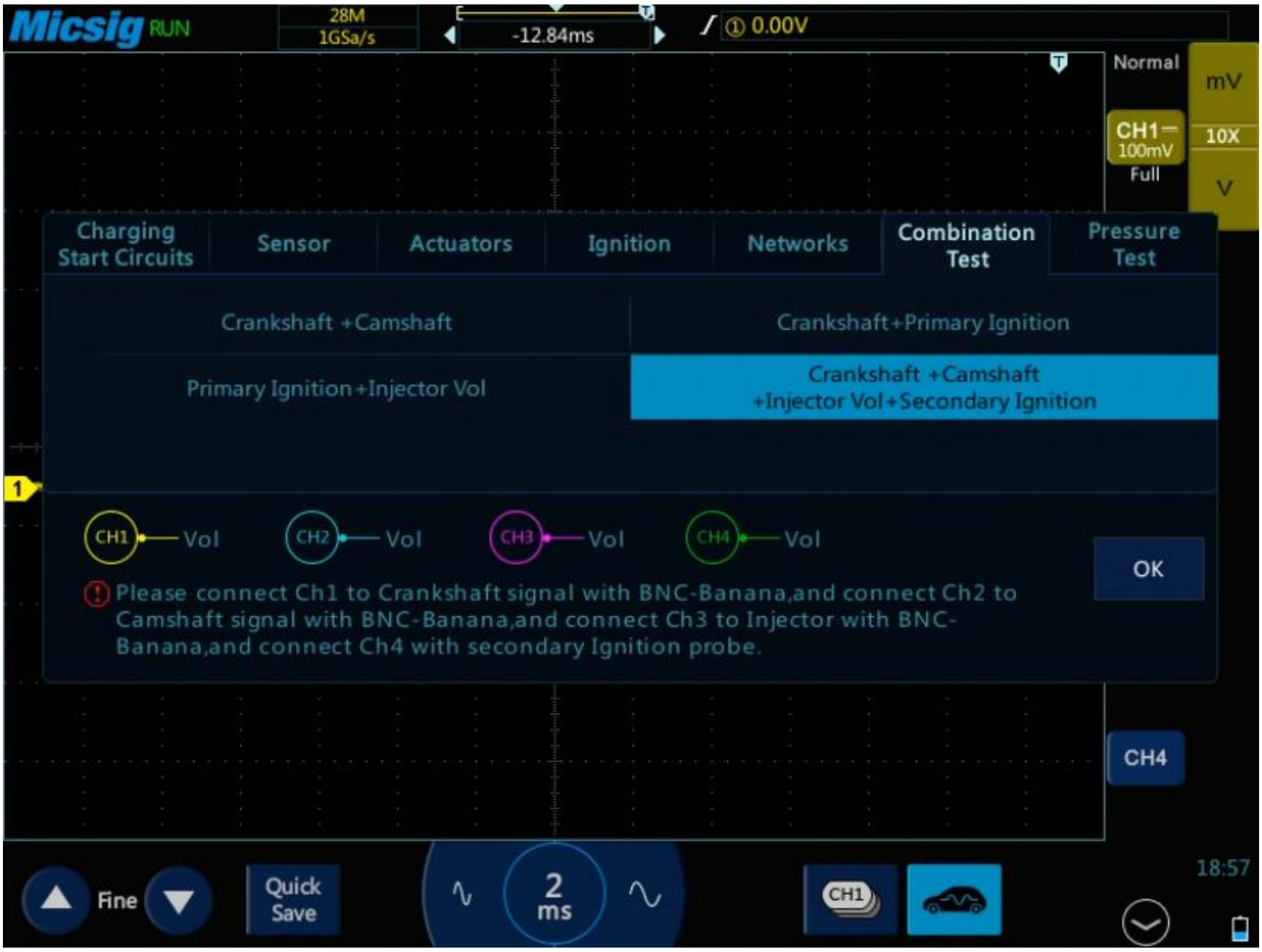


Figure 3-53 Combination test of Crankshaft + Camshaft + Injector + Secondary ignition

3. 7 Pressure Test

When the engine is started, the gas and liquid in the intake manifold, exhaust tail pipe, cylinder, and crankcase will generate pressure. The pressure can be converted into a voltage signal by the pressure probe. Therefore, the ATO oscilloscope can be tested by the pressure probe. The pressure values are all within a certain range when working normally. When the values are abnormal, it can help users to troubleshoot.

3.7.1 Intake Manifold

Use ATO oscilloscope to test the pressure and voltage of the intake manifold under the five operating conditions of the engine, show as below Figure 3-54:

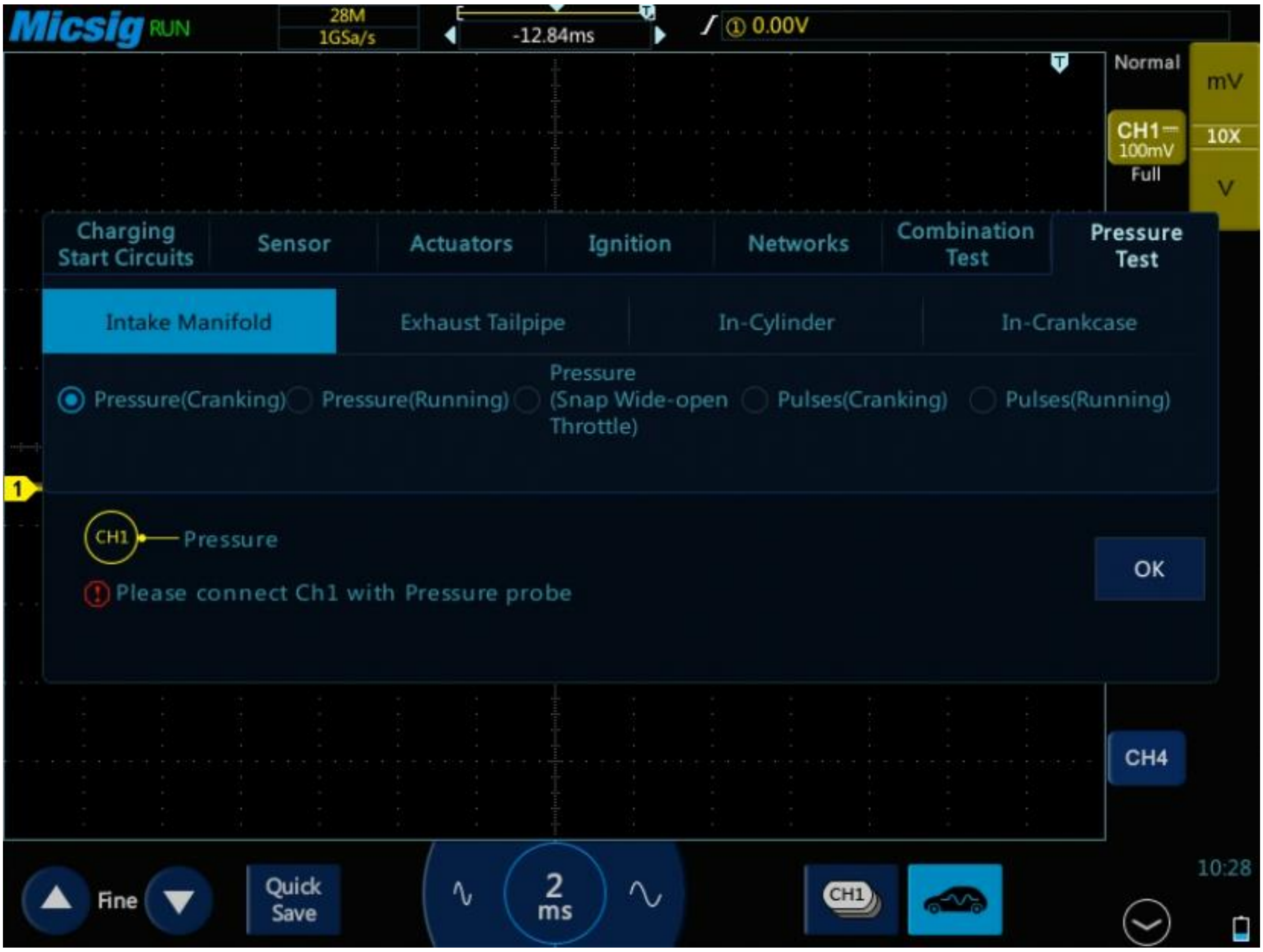


Figure 3-54 Intake Manifold test

3.7.2 Exhaust Tailpipe

Use ATO oscilloscope to test the exhaust tailpipe pressure and voltage under the two operating conditions of the engine, show as below Figure 3-55:

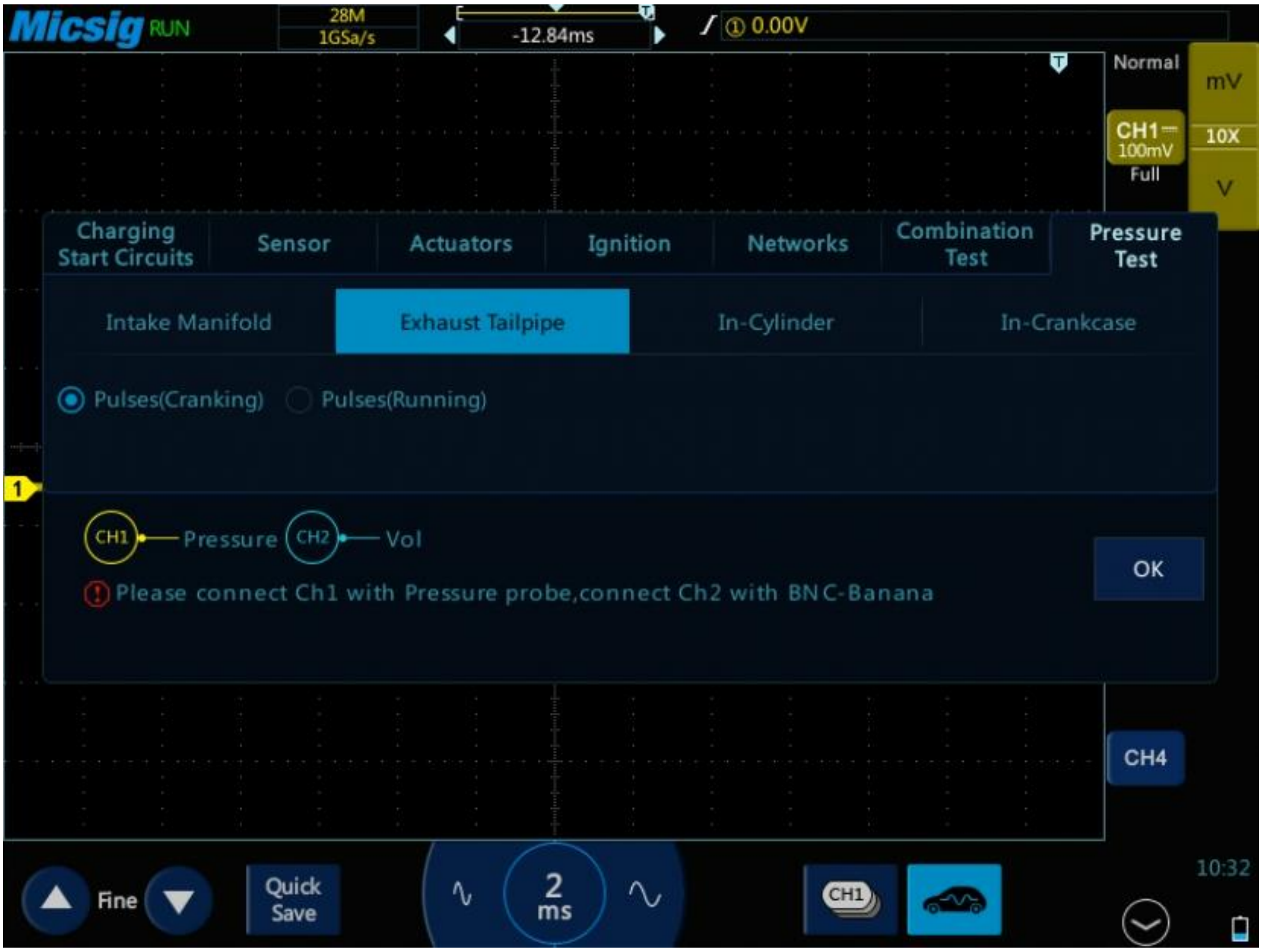


Figure 3-55 Exhaust Tailpipe Test

3.7.3 In-Cylinder

Use ATO oscilloscope to test the pressure of the cylinder of the engine under 3 working conditions, show as below Figure 3-56:

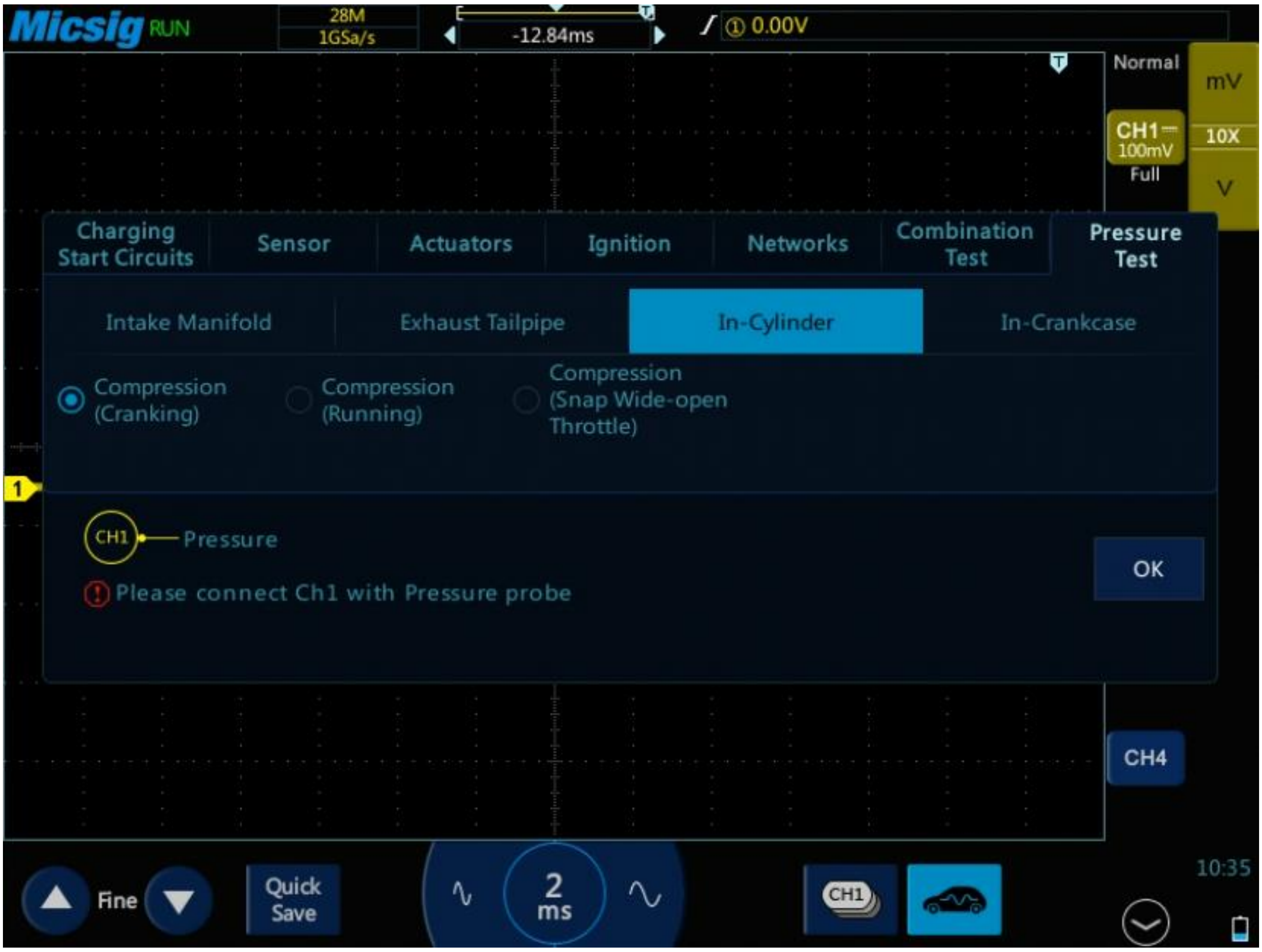


Figure 3-56 In-Cylinder Test

The figure below is the actual cylinder pressure of Mazda 6 in a certain year:

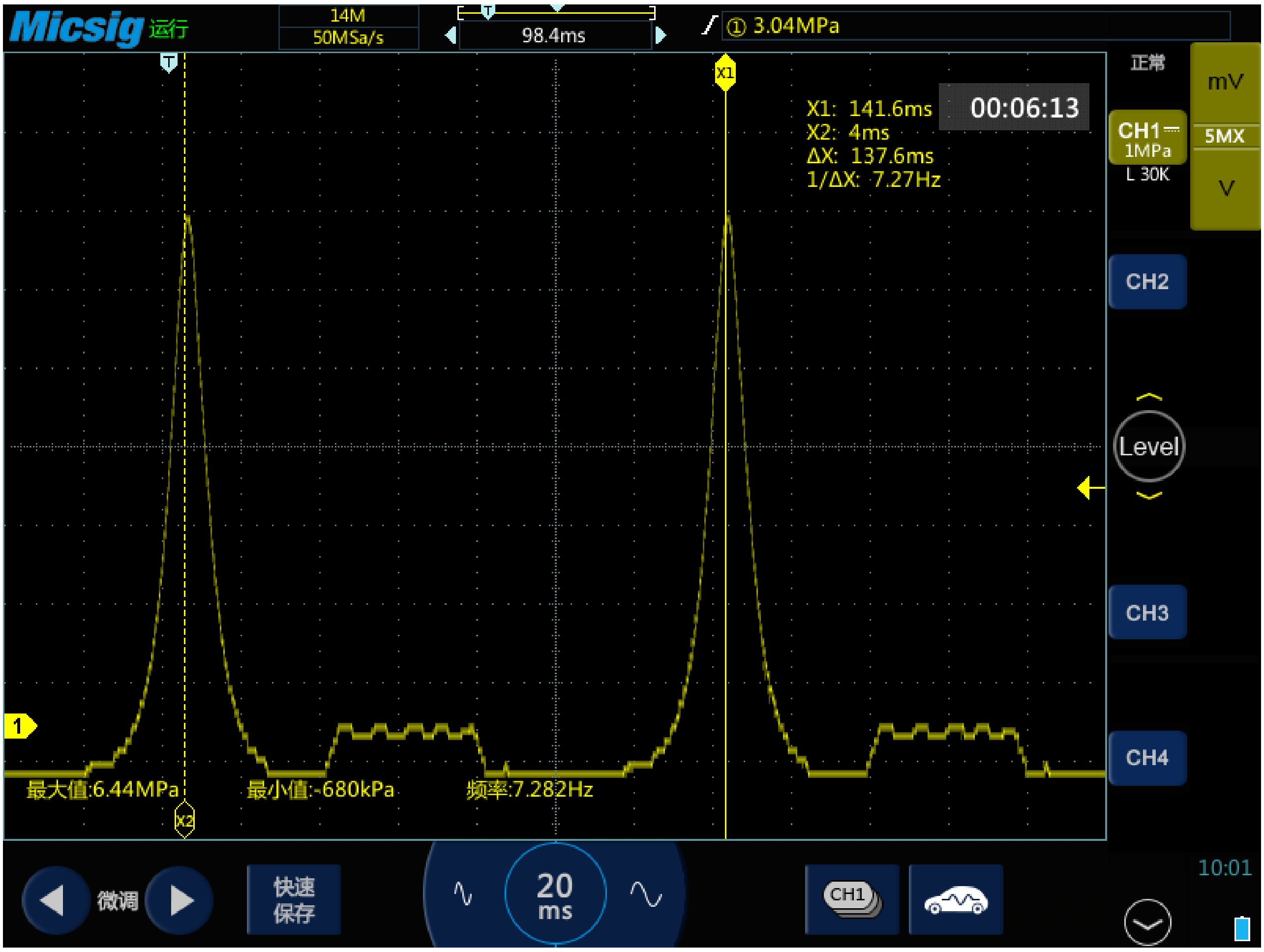


Figure 3-57 Mazda 6 Cylinder internal pressure measurement

3.7.4 In-Crankcase

Use ATO oscilloscope to test the pressure and voltage of the crankcase under two working conditions. The specific operation is shown in Figure 3-58:

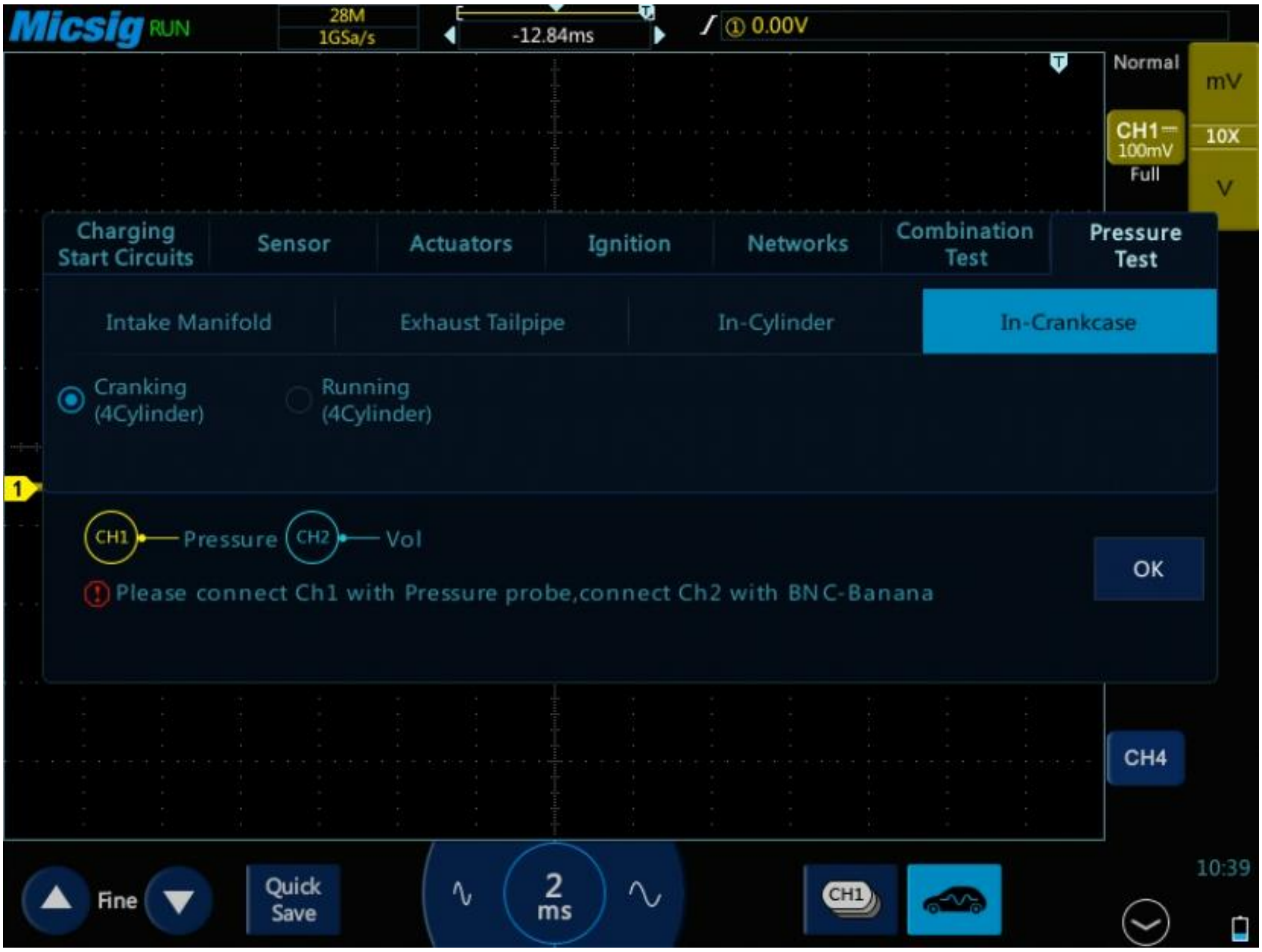


Figure 3-58 Crankcase Pressure and Voltage test

Chapter 4 Horizontal System

This chapter contains detailed information on the oscilloscope horizontal system. It is recommended that you read this chapter carefully in order to understand the setting function and operation of the horizontal system of the ATO oscilloscope.

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

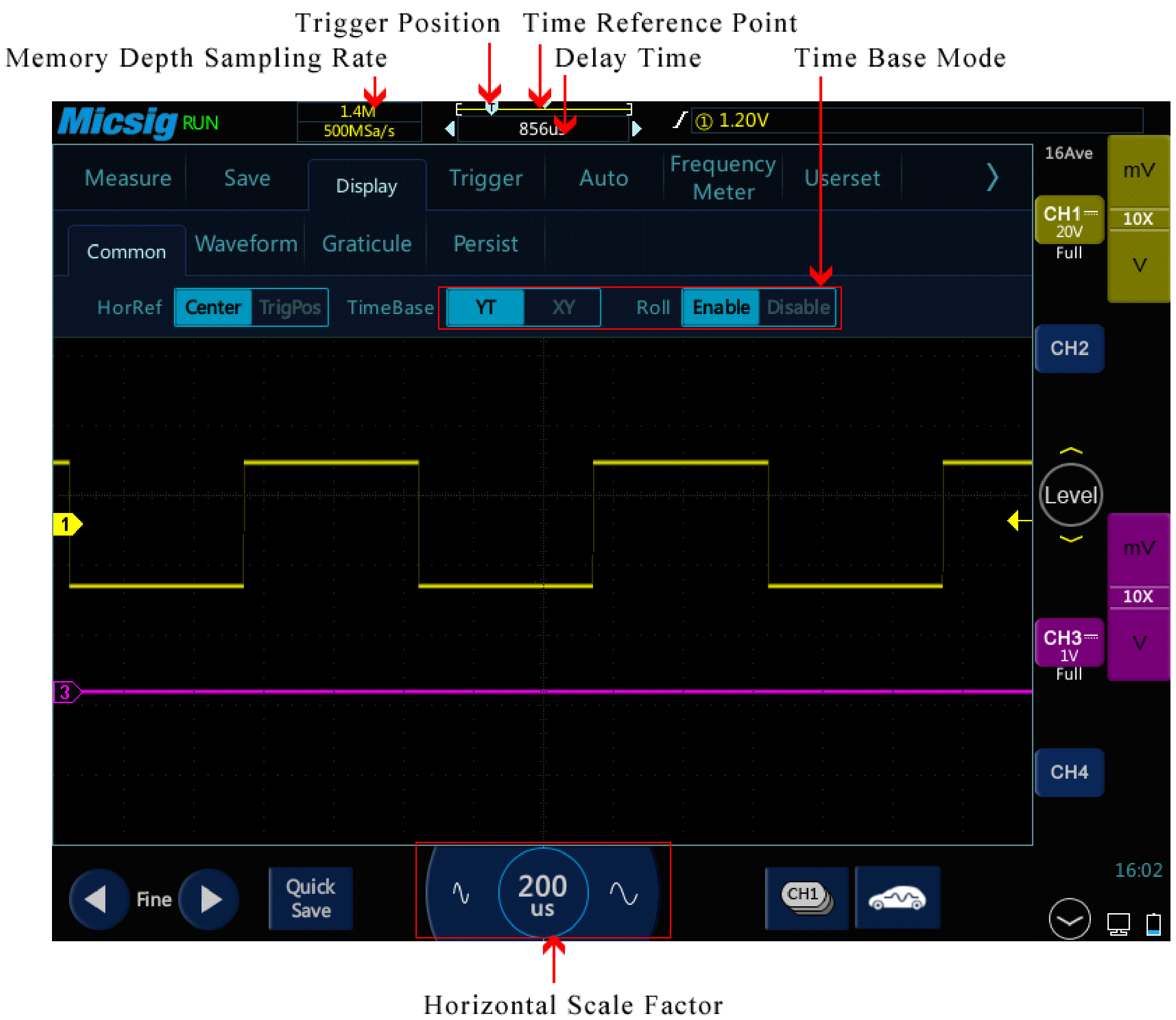


Figure 4-1 Horizontal system

4.1 Moving 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.

After moving the channel left and right, tap the 

key and select "time base" to quickly move the trigger position of the current channel to the center position in the horizontal direction.

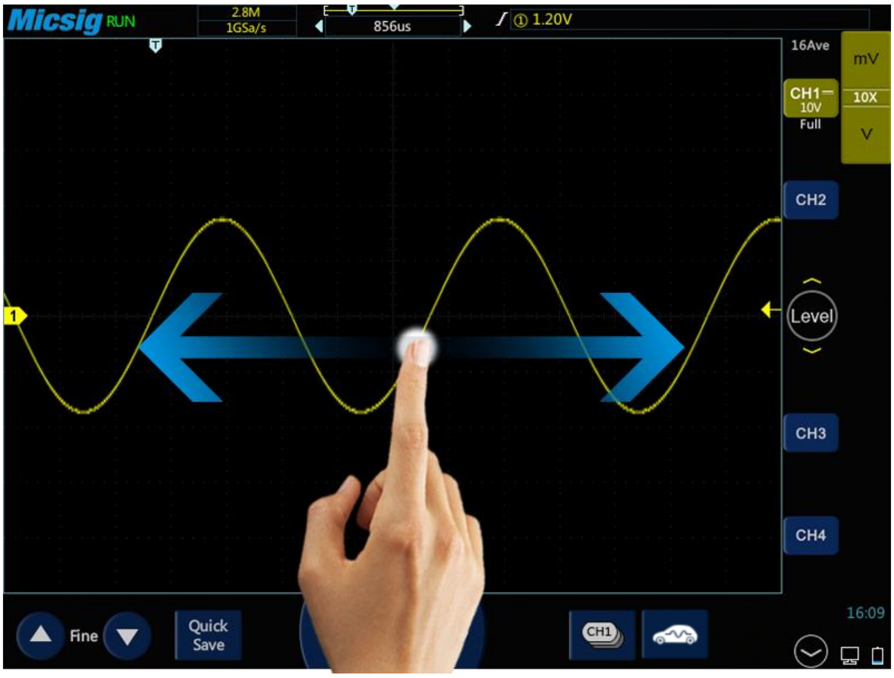
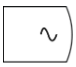


Figure 4-2 Move the Waveform Horizontally on the Screen

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.

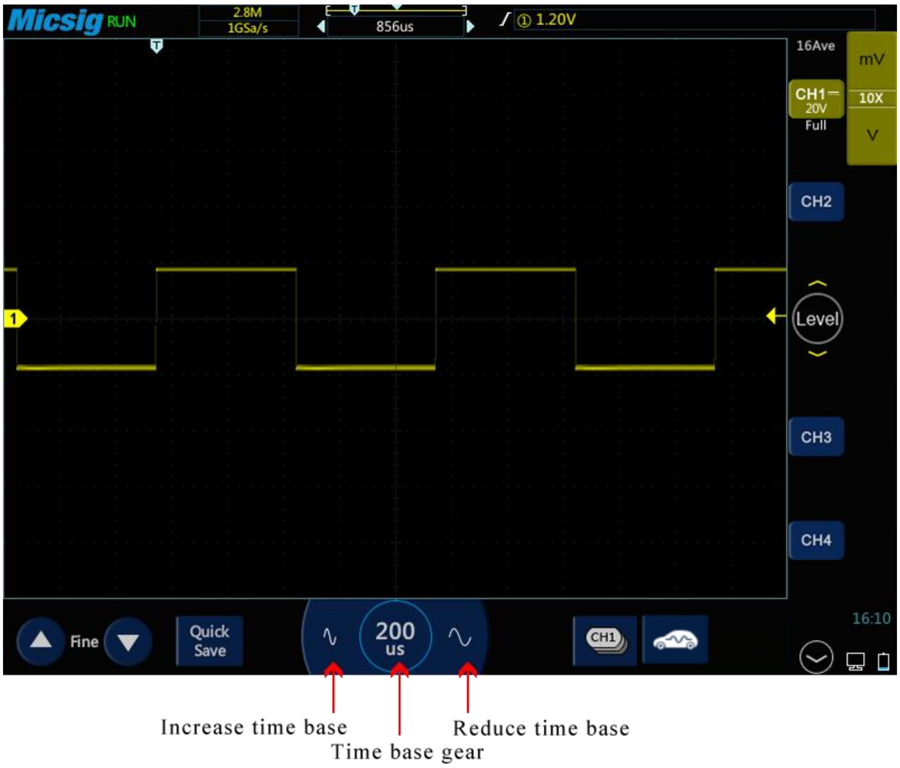


Figure 4-3 Adjust the Horizontal Time Base

Method 2: Time Base Knob

Tap 200 us to turn on the time base knob (see Figure 4-4 horizontal time base knob), and then turn the knob to adjust the appropriate time base. The time base shown on the left is the currently selected time base.

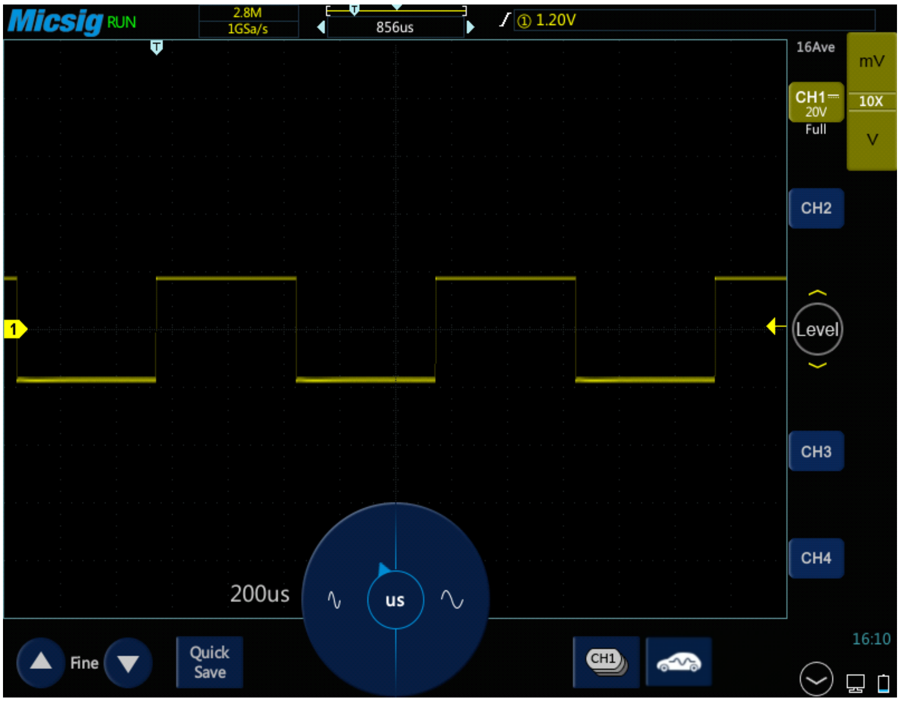


Figure 4-4 Horizontal Time Base Knob

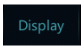
Method 3: Double-tap

Double tap on the screen with one finger to enlarge the waveform horizontally with the double-tap point as the center. Each time you double-tap, the horizontal time base decreases by one gear.

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 "4.1 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 

, then select the desired time base mode. The time base mode is divided into YT, ROLL, and XY.

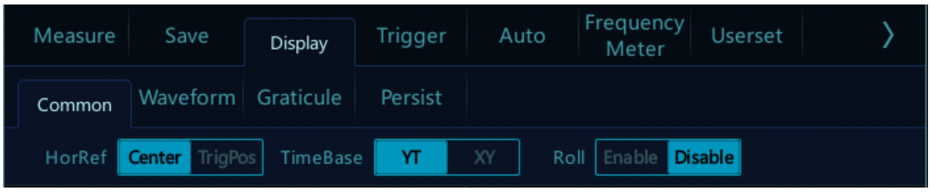


Figure 4-5 Display Mode

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.

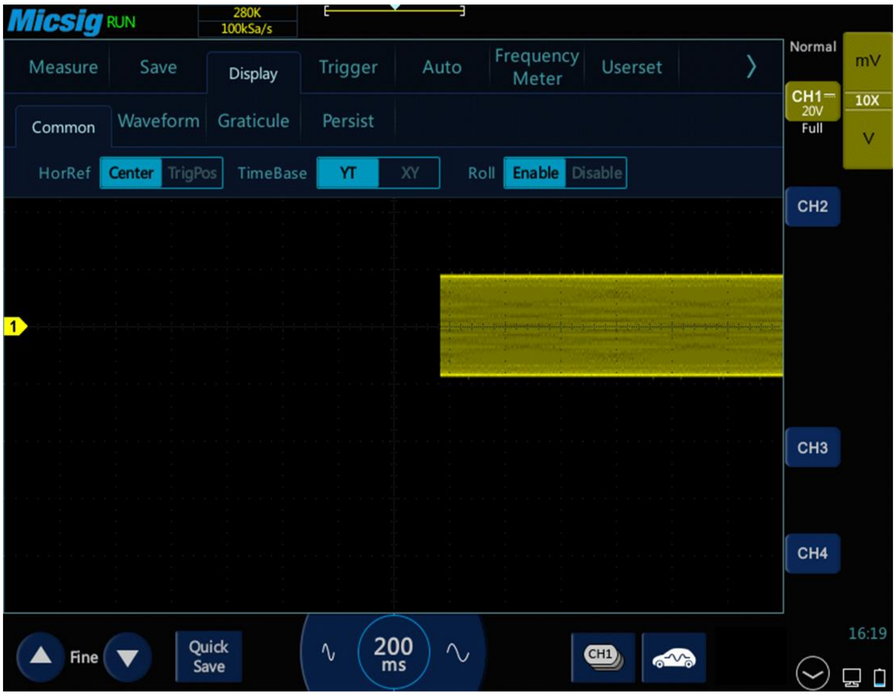


Figure 4-6 ROLL Mode

In ROLL mode, press Run/Stop to stop waveform display; press Run/Stop again to clear waveform display and restart acquisition; press Single 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 Display. In the “General” 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.

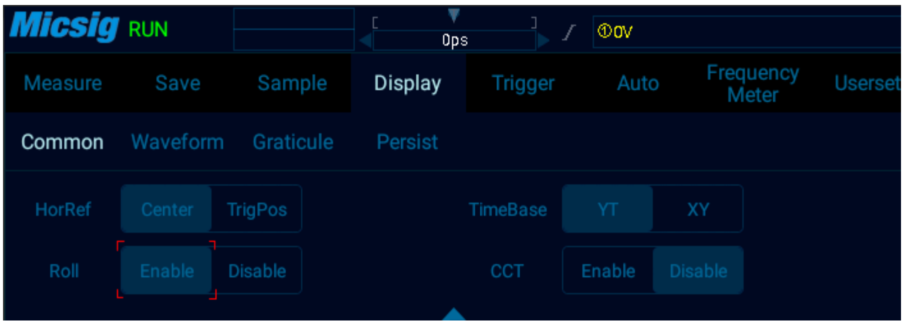


Figure 4-7 Roll Mode On/Off

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.

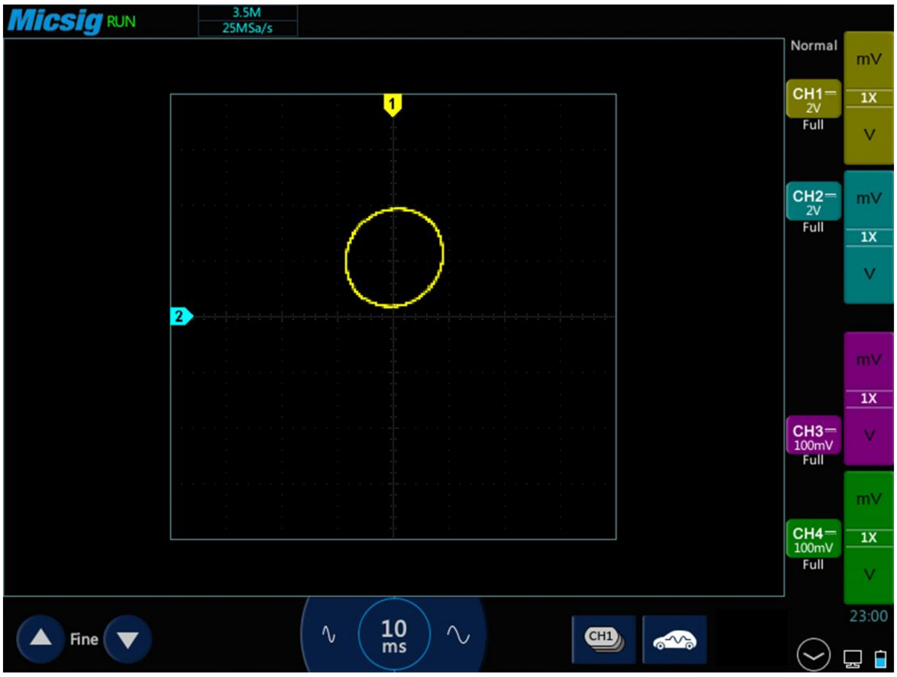


Figure 4-8 XY Mode

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):

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

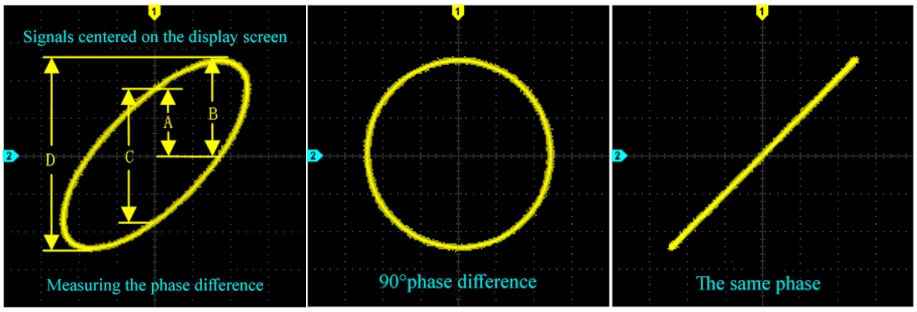


Figure 4-9 XY Time Base Mode Signal, Center on the Display Screen

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.

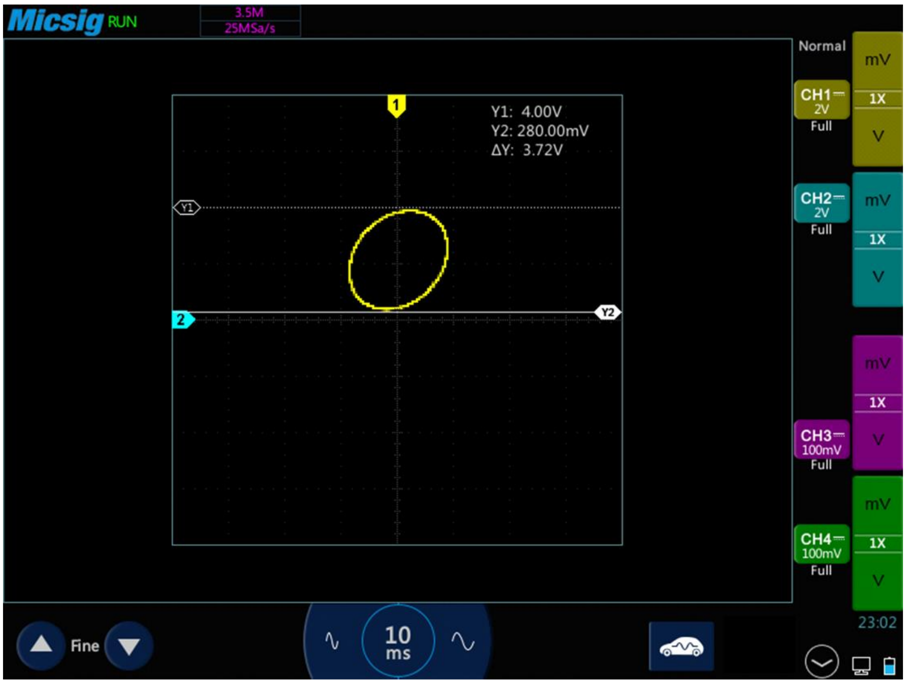


Figure 4-10 Phase Difference Measurement and Using the Cursor

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

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

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.

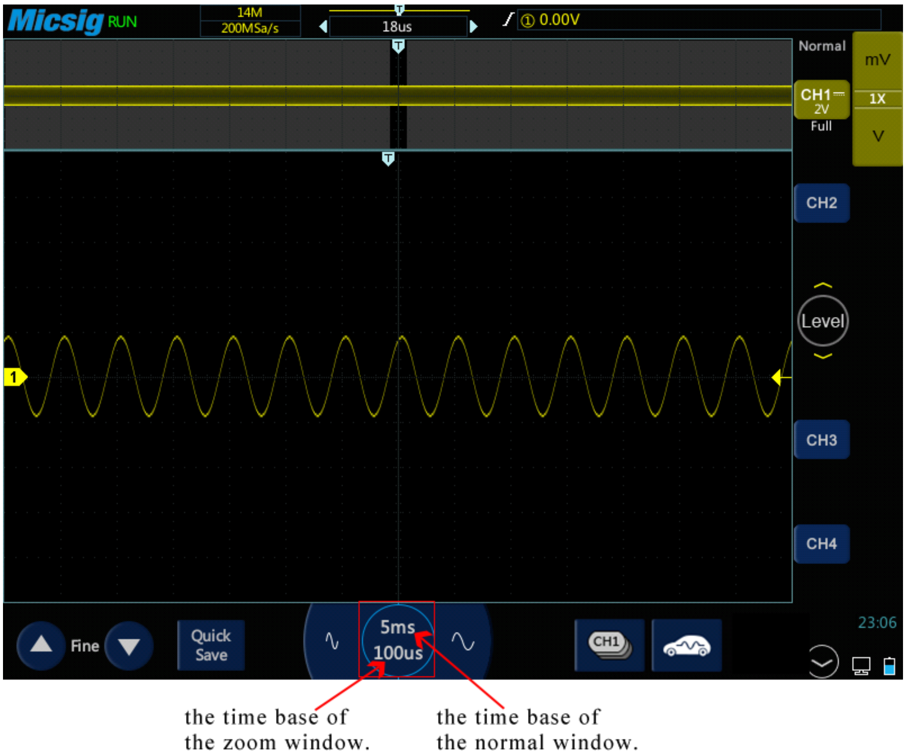


Figure 4-11 Zoom Interface

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:

1) Open the pull-up menu and tap  button to turn the zoom function on/off.

2) Put three fingers on the touch screen at the same time, slide down to open zoom mode; slide up to turn off zoom mode. Figure 4-12 shows the operation:

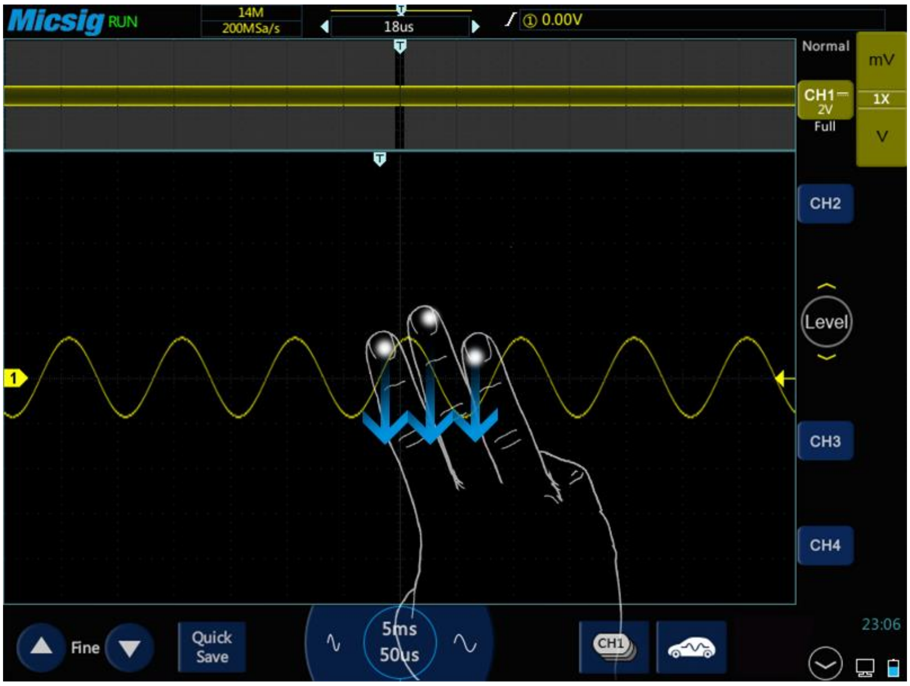


Figure 4-12 Open Zoom Function by Three Fingers Sliding Down

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.**

4) **When high refresh is turned on and stopped, it is forbidden to enter zoom mode.**

Chapter 5 Vertical System

This chapter contains detailed information about the vertical system of the oscilloscope. It is recommended that you read this chapter carefully in order to understand the setting function and operation of the vertical system of the ATO oscilloscope.

- Open/close channel (analog channel, math function), set the current channel
- Adjust vertical sensitivity
- Adjust vertical position
- Open channel menu
- Measured signal
- Set bandwidth filter
- Waveform invert
- Set probe type
- Set probe attenuation coefficient

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

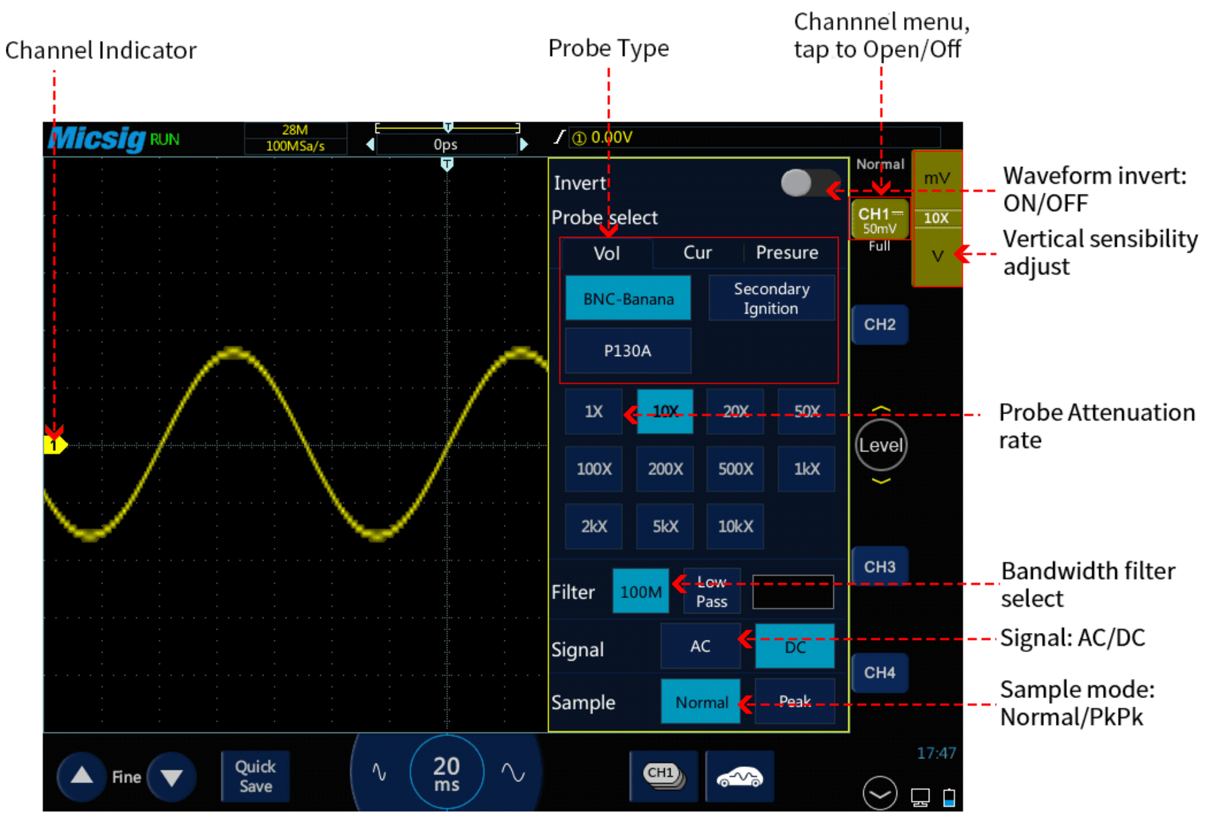


Figure 5-1 Channel Menu Display Interface

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

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

The channel icons CH1 1.0V, CH2 1.0V, CH3 1.0V, CH4 1.0V, MATH, REF on the right side of the oscilloscope waveform display area (tap  to switch to math channel and reference channel) correspond to the six channels of CH1, CH2, CH3, CH4, math function and reference channel. Click these six soft keys can cyclically realize the functions: open the channel, open the channel menu, and close the 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.

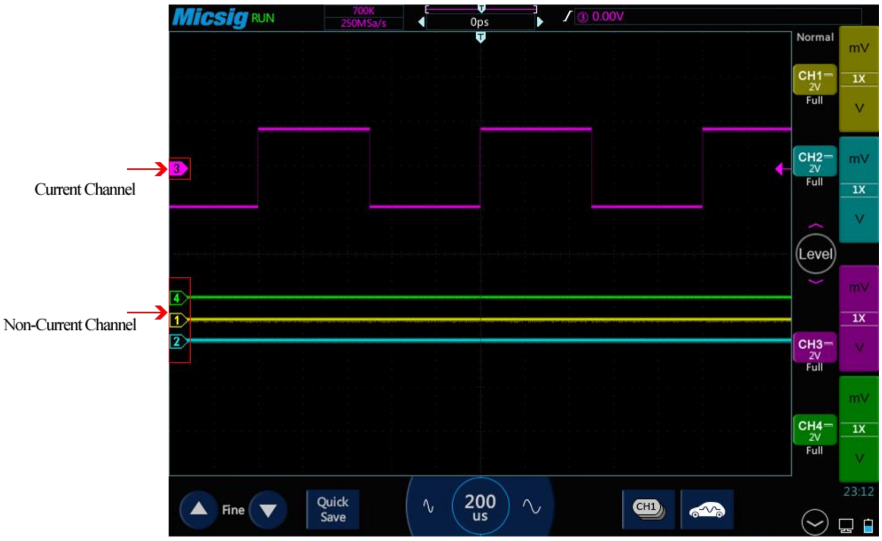


Figure 5-2 Current Channel and Non-Current Channel

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

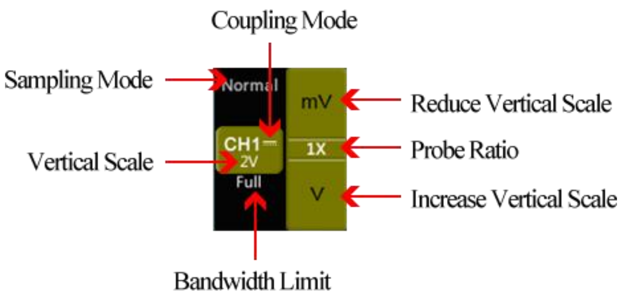


Figure 5-3 Channel Display Interface

When CH1 is on, but the state is not the current channel, tap CH1 waveform or vertical sensitivity or channel indicator  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

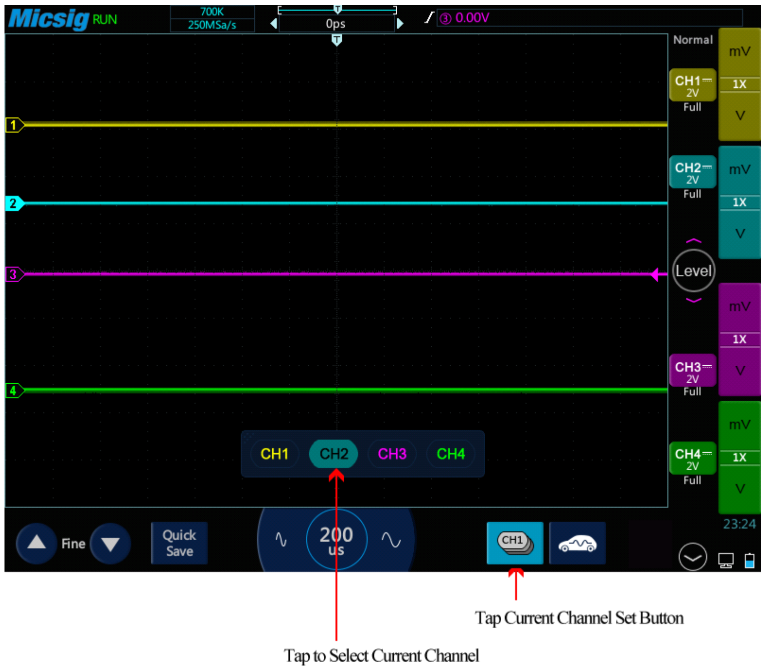


Figure 5-5 Using the Current Channel Selection Button

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 4-5. 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 mV or V 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, CH1 1.0V 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) Rough 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: After the waveform moves vertically, 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.
3) After moving the channel up and down, tap 50%, select the channel to be adjusted in the "vertical gear" item, and the grounding level of the channel can be moved to the center in the vertical direction of the screen.

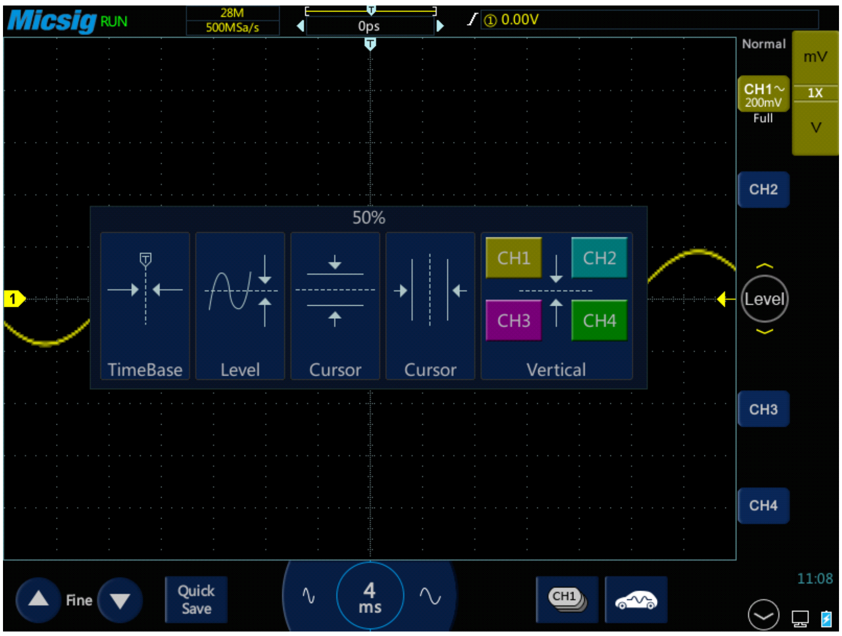


Figure 5-6 vertical position adjustment of waveform

5.4 Open Channel Menu

Tap the channel icon (channel is open) to open the channel menu.

The channel menu is shown in Figure 5-7. Channel waveform inversion, channel bandwidth limit, probe type, probe attenuation factor, channel coupling mode, and sampling mode can be set in the vertical menu.

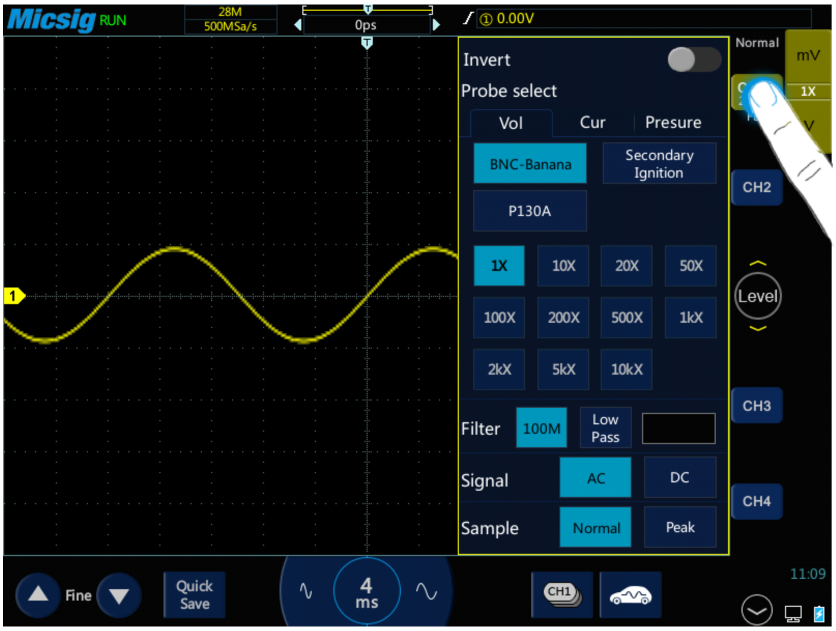


Figure 5-7 Channel Switching Icon and Menu

5.4.1 Measured Signal

Tap the icon on the right side of "Measured signal" to select two channel coupling modes, "DC" and "AC".

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 Figure 5-8, 5-9.

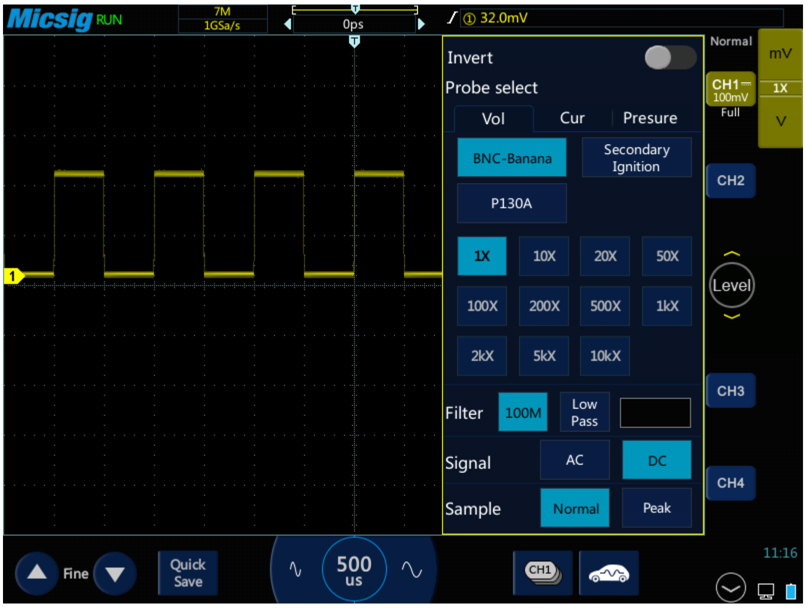


Figure 5-8 DC Coupling

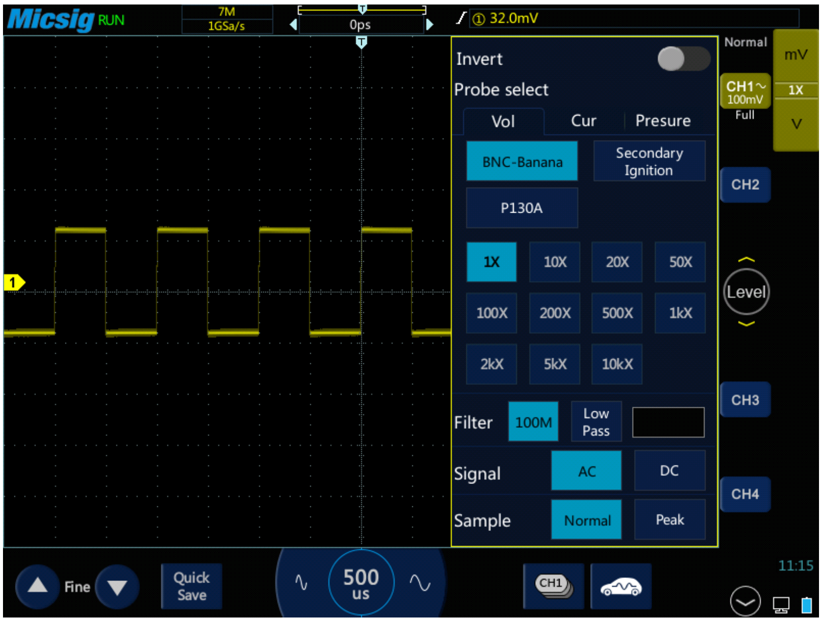


Figure 5-9 AC Coupling

Note: This setting is only valid for the current channel. To switch the current channel, just tap the channel icon, channel indicator icon or the horizontal position pointed to by the channel indicator icon to switch directly, without exiting the menu.

5.4.2 Filter

Open the channel menu, find the "bandwidth" selection box in the channel menu, and set the bandwidth limit, high-pass filter and low-pass filter as needed.

100M: Allow signals of all frequencies to pass.

Low Pass: Only allow signals that are lower than the upper limit of the current set frequency to pass.

The frequency range that can be set for the low-pass filter is 30kHz-100MHz.

The difference in bandwidth limitation can be visually expressed through the waveform. The 100M bandwidth is shown in Figure 5-10, and the low-pass bandwidth is shown in Figure 5-11.

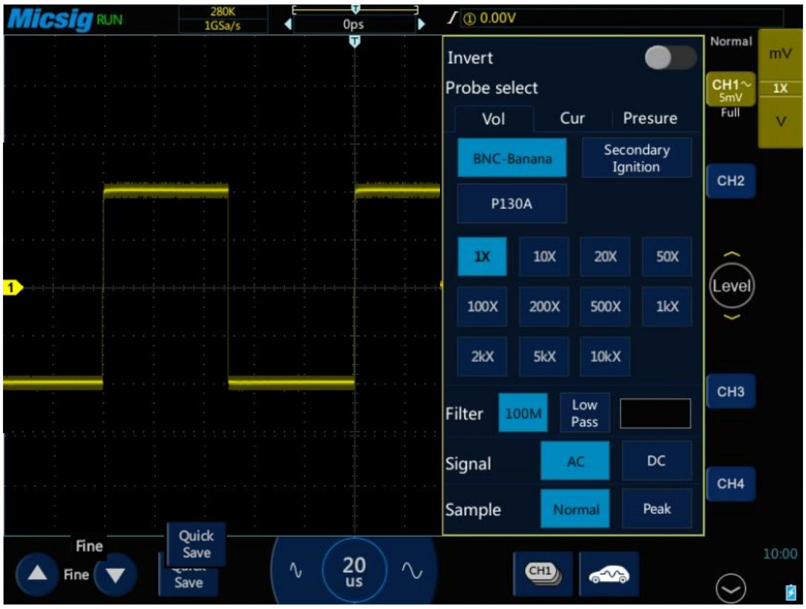


Figure 5-10 Full 100MHz filter

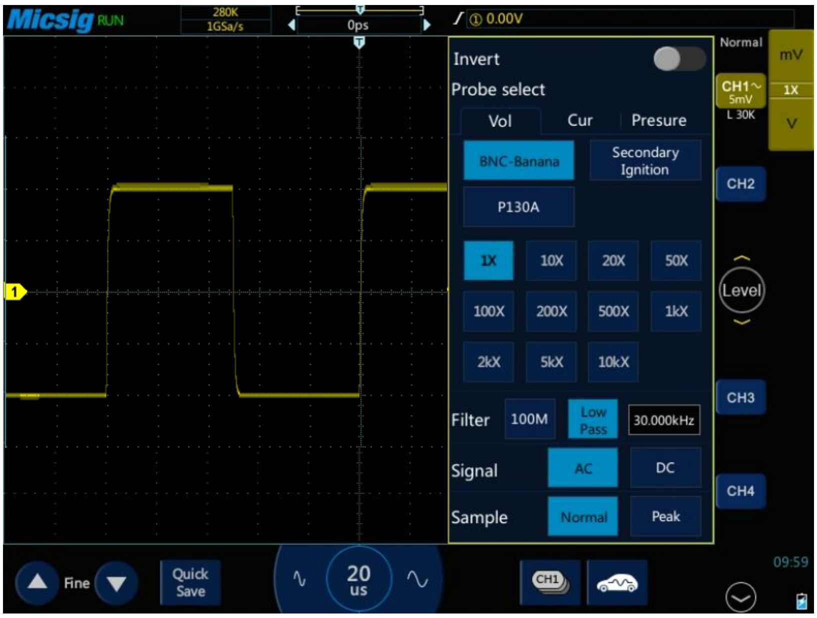


Figure 5-11 Low-pass filter

5.4.3 Waveform Invert

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 5-12 Before Invert

Figure 5-13 After Invert

5.4.4 Set Probe Type

Probe types are divided into Voltage, Current and Pressure.

Probe type adjustment steps:

Open channel menu and find the probe type "probe type" Vol, Cur, Presure, then select:

Figure 5-14 Voltage Probe

Figure 5-15 Current Probe

Figure 5-16 Pressure 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
0.001:1	1mx
0.002:1	2mx
0.005:1	5mx
0.01:1	10mx
0.02:1	20mx
0.05:1	50mx
0.1:1	100mx
0.2:1	200mx
0.5:1	500mx
1:1	1x
2:1	2x
5:1	5x
10:1	10x
20:1	20x
50:1	50x
100:1	100x
200:1	200x
500:1	500x
1000:1	1kx
2000:1	2kx
5000:1	5kx
10000:1	10kx

Table 5-17 Probe Attenuation Ratio Correspondence Table

Chapter 6 Trigger System

This chapter contains detailed information on the oscilloscope trigger system. It is recommended that you read this chapter carefully in order to understand the setting function and operation of the trigger system of the ATO 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.

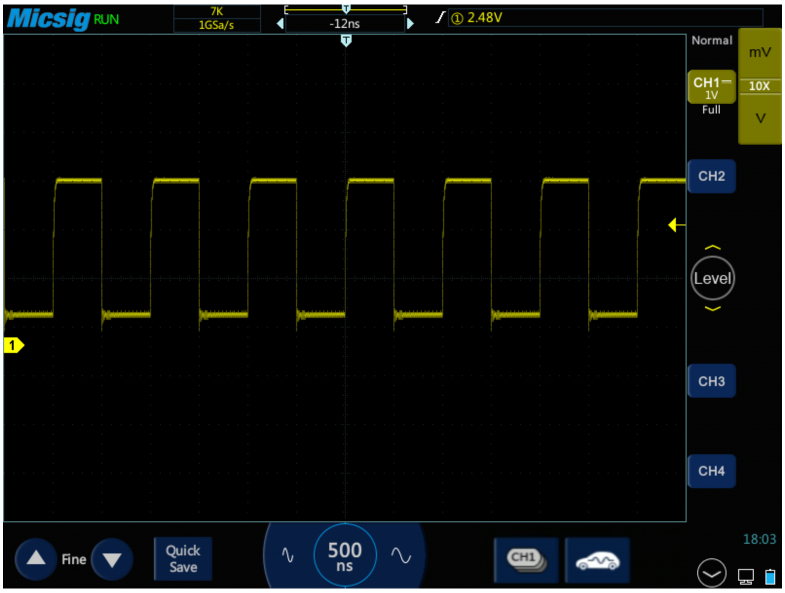


Figure 6-1 Stably display the periodic signals

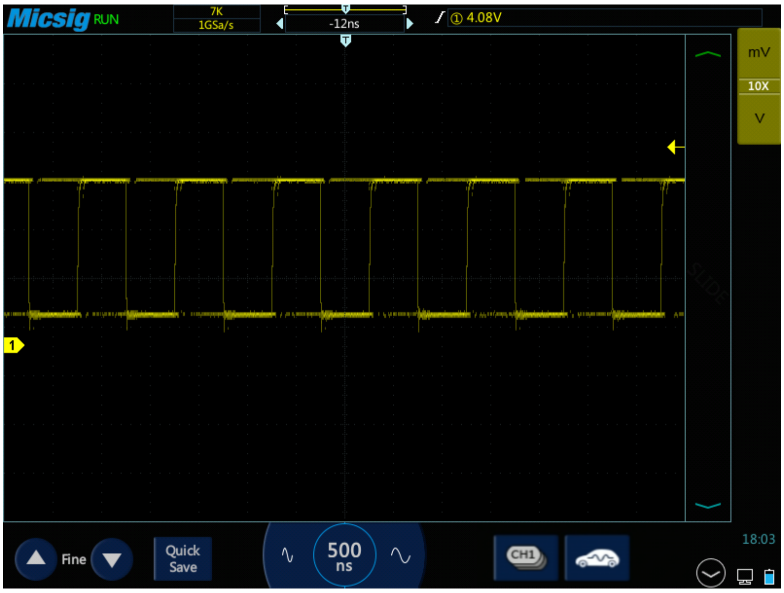


Figure 6-2 Non-Stably Displayed Periodic Signal

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

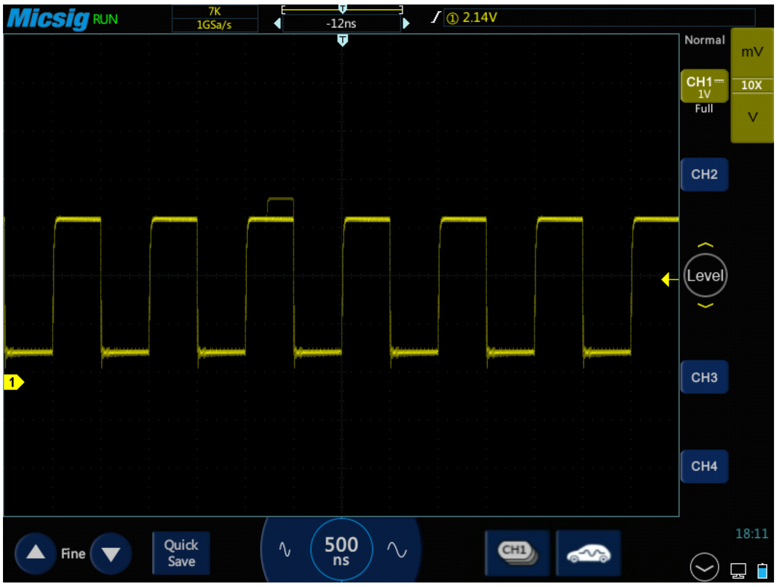


Figure 6-3 Abnormal Signal in Periodic Signals

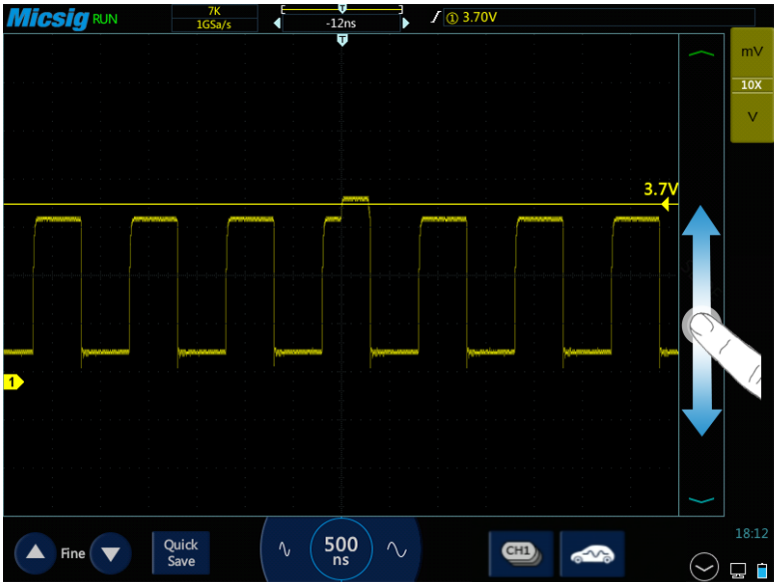


Figure 6-4 Abnormal Signal Captured by Setting Trigger Level

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 6-5 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.

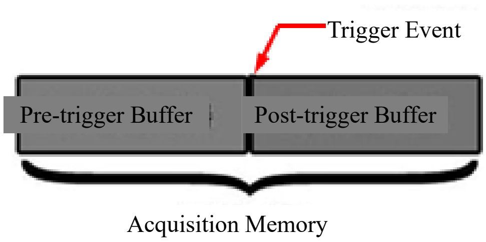


Figure 6-6 Conceptual Demonstration of Acquisition Memory

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.

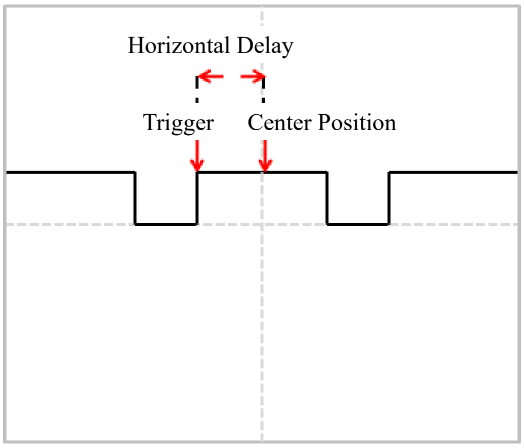


Figure 6-7 Horizontal Delay

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).

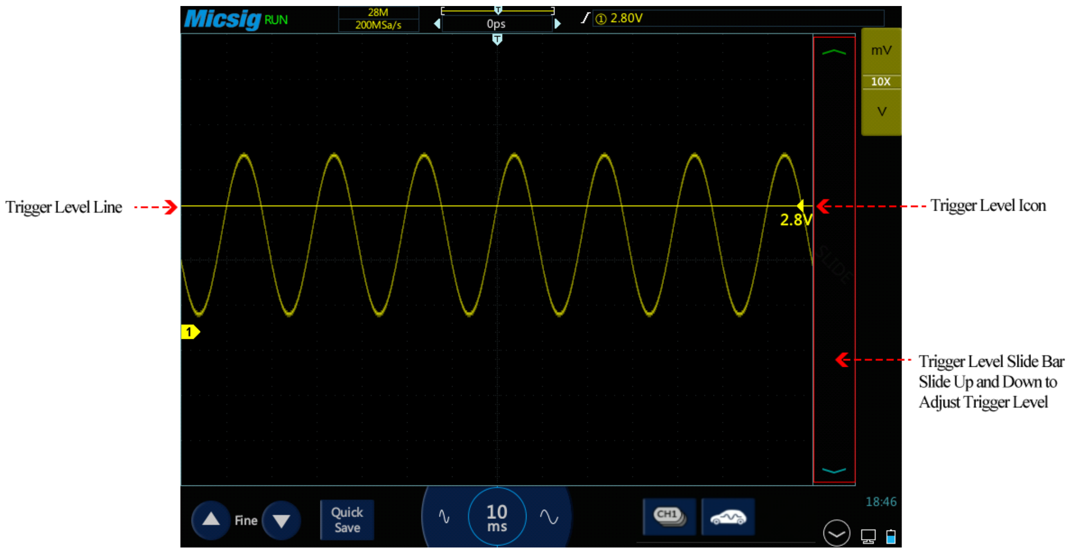


Figure 6-8 Trigger Level

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: After moving the trigger level, tap the fine adjustment button in the lower left corner of the screen for fine adjustment of the trigger level.

Note: Fine adjustment requires activation of the trigger level control function.

In addition, if the final operation of the oscilloscope is to adjust the trigger level, tap 

and select the "level" item to adjust the trigger level to 50% of the waveform amplitude of the trigger source channel.

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, 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 of >200ns but <600ns.

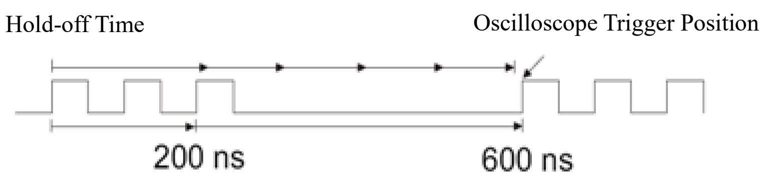


Figure 6-9 Trigger hold-off Time

Set trigger hold-off time:

1) Tap “Trigger” on the main menu to open the trigger menu. Under “Common”, tap the box after “hold-off Time” to open the hold-offtime 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 6-10.

Figure 6-10 Trigger Hold-off Time Setting

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-offtime.

Trigger hold-offoperation prompt

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

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

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-offtime.

- Use “SingleSEQ” 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 6-11:

- Trigger source: CH1;
- Trigger coupling mode: DC;
- Trigger edge: rising.

Figure 6-11 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, HFRej., LFRej., NoiseRej, see Figure 6-12:

Figure 6-12 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 Hold-off Coupling) - removes high frequency components from the trigger waveform, using high frequency hold-offto remove high frequency noises or noises from fast system clocks, from trigger paths such as AM or FM radio stations.

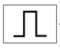
4) LFRej. (Low Frequency Hold-off Coupling) - removes any unnecessary low frequency components from the trigger waveform, for example, power line frequencies that can interfere with correct trigger.

   When there is low frequency noise in the waveform, stable edge triggering can be obtained using LF hold-offcoupling.

5) NoiseRej. (Noise Hold-off Coupling) - Noise hold-offcan 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 has nothing to do with 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
	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
	≠T	Trigger when the signal pulse width is not equal to pulse width T
Trigger Pulse Width	8ns~10s	Set the trigger pulse width

Note: The error of greater than, less than, equal to or not equal to the conditions is 6%.

Trigger steps of positive polarity pulse width: (CH1 as 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 5-13:

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

Figure 6-13 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 6-14 Negative Pulse Level Flip)

Figure 6-14 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 6-15 Trigger Time T<80ns).

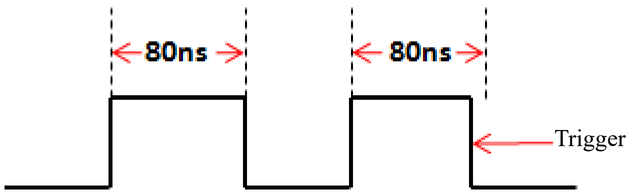


Figure 6-15 Trigger Time T<80ns

- 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 6-16 Trigger Time T>80ns).

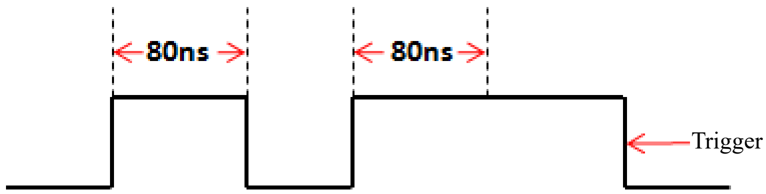


Figure 6-16 Trigger Time T>80ns

- 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 6-17 Trigger Time T=80ns).

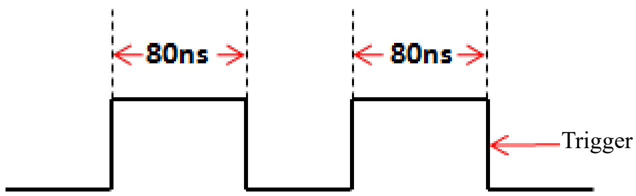


Figure 6-17 Trigger Time T=80ns

- 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 6-18 Trigger Time T≠80ns).

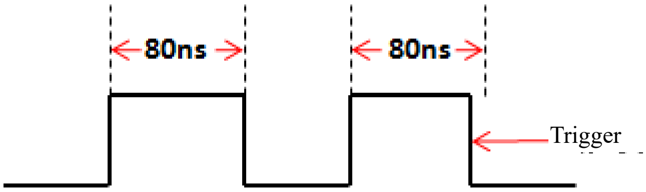


Figure 6-18 Trigger Time T≠80ns

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

Tap the pulse width time setting box 8 ns to pop up the time adjustment interface (as shown in Figure 6-19), and adjust the pulse width time. Adjust the pulse width time by adjusting or dragging the time scale.

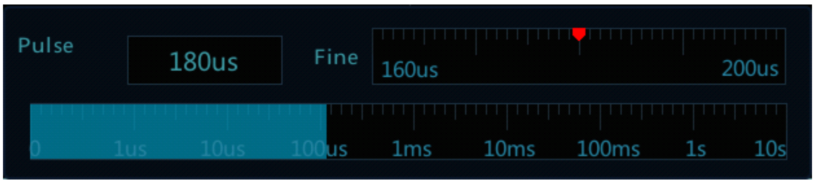


Figure 6-19 Pulse Width Time Adjustment Interface

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: The error of greater than, less than, equal to or not equal to the conditions 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 6-20:

- 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 6-20 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 value shown in the upper right corner.

Logic conditions

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

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

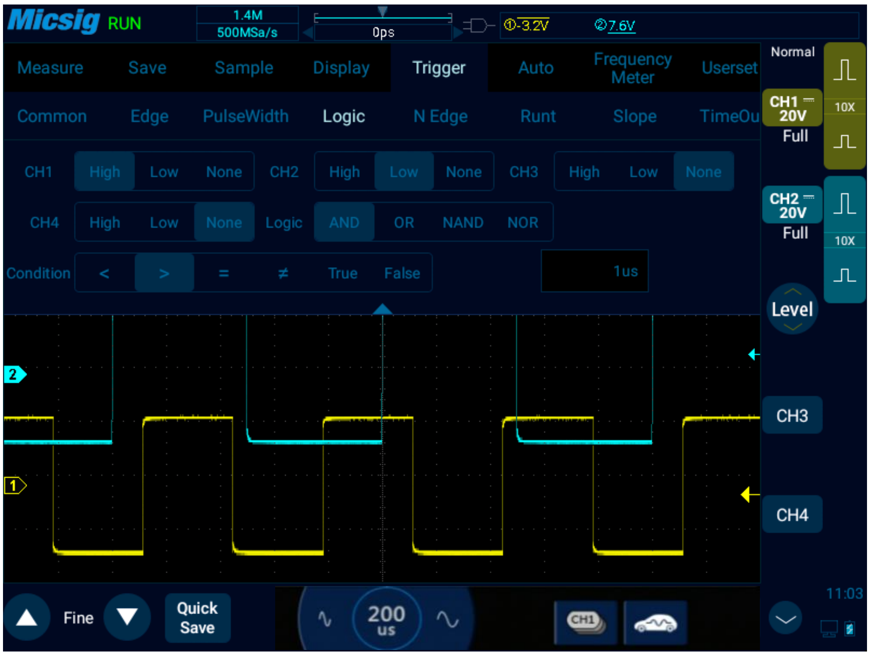


Figure 6-21 Logic Trigger

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

Trigger Option	Setting	Description
	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 6-22:

- Trigger source: CH1;
- Time: 10ms;
- Edge signal: rising;
- Nth edge: 3

Figure 6-22 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 -3.2V.

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.

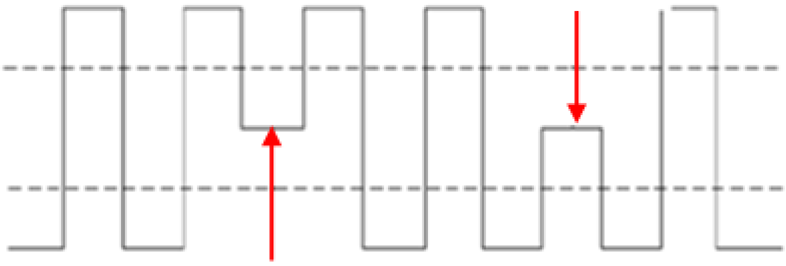


Figure 6-23 Runt Trigger

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
	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 6-24 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 6-25

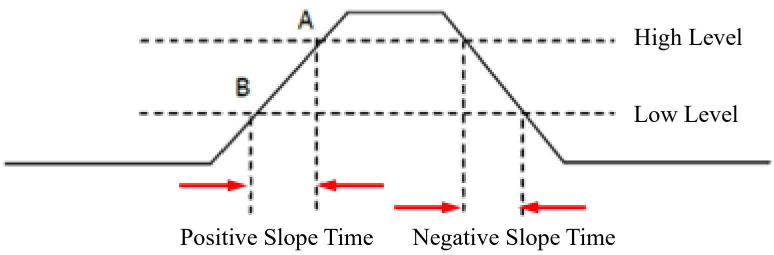


Figure 6-25 Positive/Negative Slope Time

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 6-26:
   - 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 6-26 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 6-27:

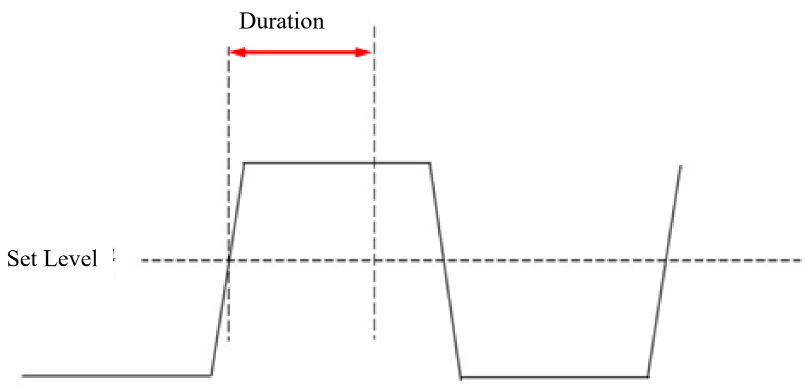


Figure 6-27 Timeout Trigger Schematics

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 6-28:

- Trigger source: CH1;

- Edge: positive;
- Timeout time: 8ns;

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

Figure 6-28 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

<table>
<tr><th>Trigger Option</th><th colspan="2">Setting</th><th>Description</th></tr>
<tr><td rowspan="4"></td><td colspan="2">525/NTSC</td><td>Based on NTSC signal trigger</td></tr>
<tr><td colspan="2">720P</td><td>Base on 720P(50Hz, 60Hz) signal trigger</td></tr>
<tr><td colspan="2">1080I</td><td>Base on 1080I(50Hz, 60Hz) signal trigger</td></tr>
<tr><td colspan="2">1080P</td><td>Base on 1080P (24Hz, 25Hz, 30Hz, 50Hz, 60Hz) signal trigger</td></tr>
<tr><td>Line</td><td colspan="2"></td><td>Trigger lines</td></tr>
<tr><td rowspan="8">Trigger</td><td colspan="2">Odd fields</td><td>Trigger on the rising edge of the first tooth pulse in odd fields</td></tr>
<tr><td colspan="2">Even fields</td><td>Trigger on the rising edge of the first tooth pulse in even fields</td></tr>
<tr><td colspan="2">All fields</td><td>Trigger on the rising edge of the first tooth pulse found</td></tr>
<tr><td colspan="2">All lines</td><td>Trigger on all horizontal sync pulses</td></tr>
<tr><td rowspan="4">Line</td><td>625 line (PAL,SECAM)</td><td rowspan="4">Trigger on a specified line in odd or even fields</td></tr>
<tr><td>263 odd line 262 even line (NTSC)</td></tr>
<tr><td>750 line (720P)</td></tr>
<tr><td>1125 line (1080I,1080P)</td></tr>
</table>

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

1) 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 5-29:
   - Trigger source: CH1;
   - Polarity: positive;
   - Standard: 525/NTSC;
   - Trigger: All fields
2) Adjust the trigger level to ensure that the waveform can be triggered stably.

Figure 6-29 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 14 Serial Bus Trigger and Decode (Optional)

Chapter 7 Analysis System

This chapter contains detailed information on the oscilloscope analysis system. It is recommended that you read this chapter carefully in order to understand the setting function and operation of the analysis system of the ATO oscilloscope.

- **Automatic measurement**
- **Frequency meter measurement**
- **Cursor**

7.1 Automatic Measurement

Measurement setting

Slide down from top, open the main menu, tap "Measure" or click Measure on the right side of the screen 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) Press Measure button on the key area to quickly close the measurement menu.
4) Cancel measurement item: In the "Selected Parameters" display area below measurement menu, tap the measurement item to be cleared; or tap clear 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.

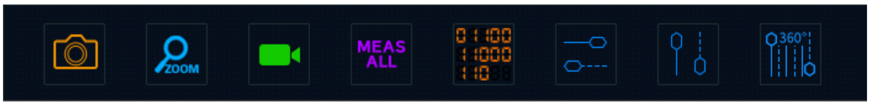


Figure 7-2 Pull-up Menu

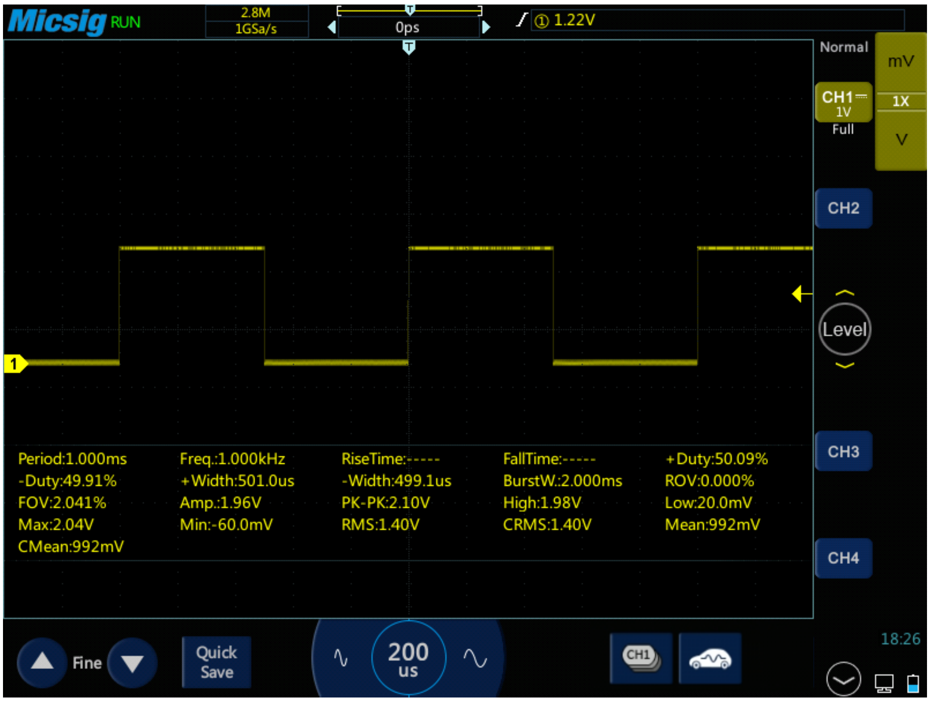


Figure 7-3 All Measurements

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

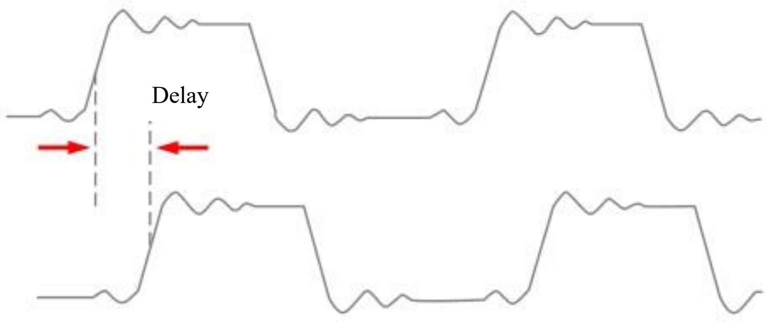


Figure 7-4 Delay Measurement Schematics

1) Open the automatic measurement menu and tap  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: FirstRise、FirstFall、LastRise、LastFall .
3) The right channel is a contrast delay channel, which can be selected between each channel and math channel. There are four edge selections: FirstRise、 FirstFall、 LastRise、 LastFall.
4) Tap  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.

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".

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.

7.2 Frequency Meter Measurement

Open the main menu, tap “Frequency Meter” to enter the hardware frequency meter setting menu, and select the channel to be measured, as shown in Figure 7-5. The measured value is displayed in the upper left corner of the screen, as shown in Figure 7-6.

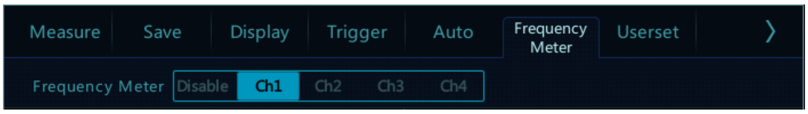


Figure 7-5 Frequency Meter Measurement Menu Open

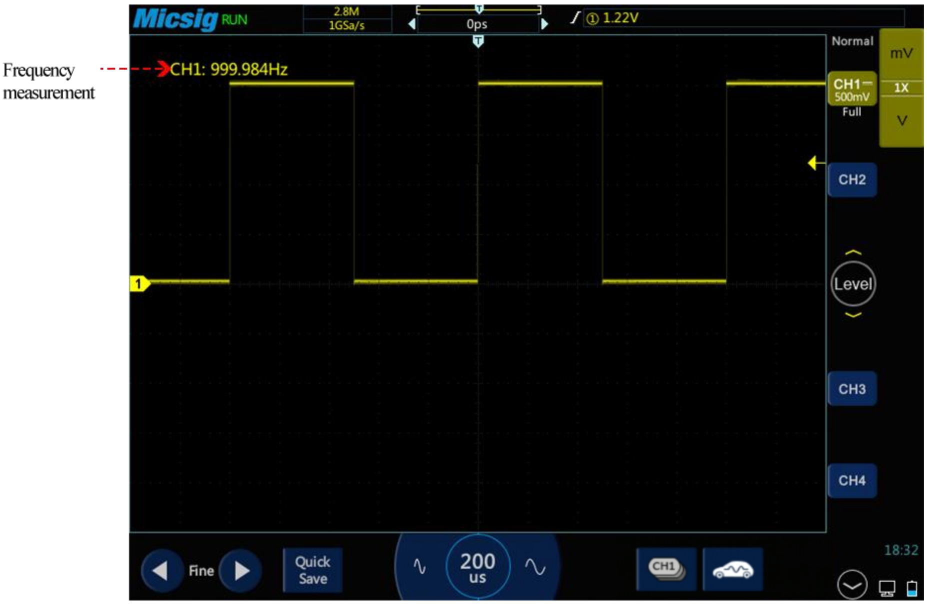


Figure 7-6 Frequency Meter Measurement

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 7-7.

Figure 7-7 Cursor Measurement Description

Note:

△ reading: indicates the difference between two cursor positions.

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

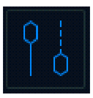
Time readings behind X1, X2: indicate the position of activated vertical cursors relative to the trigger point.

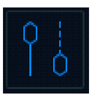
1/**△X: frequency**

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: Tap cursor icon  to open vertical cursors and the icon is on and activated.

Vertical cursor off: Tap cursor icon  to turn off vertical cursors.

Tap the vertical cursor indicator  (or ) to switch the cursors.

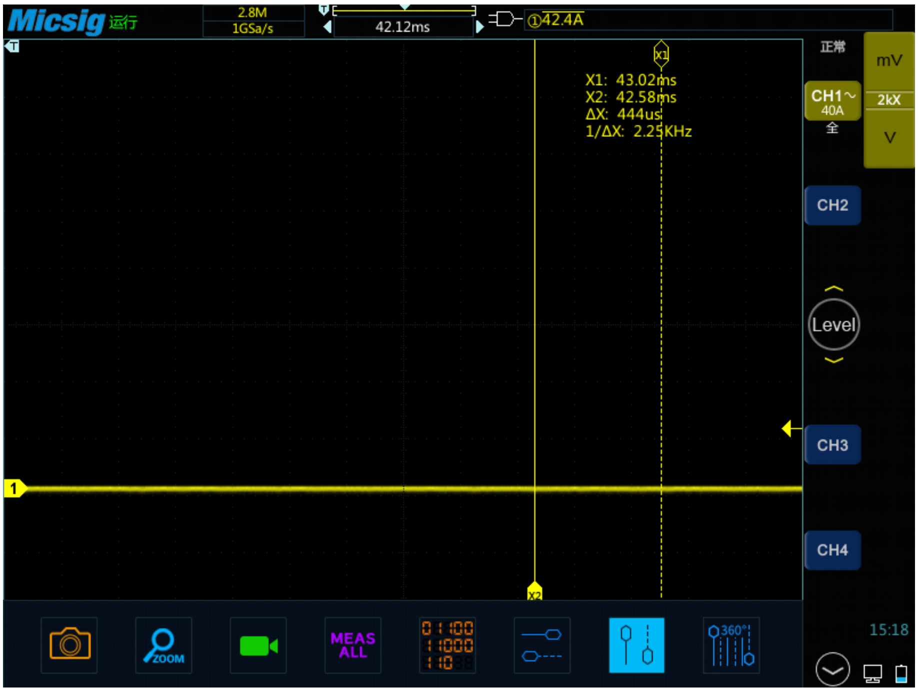


Figure 7-8 Open Cursor Selection Box and Close Cursor

Vertical cursor movement descriptions:

1) Use a single finger to press and hold the cursor indicator X1 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.

3) Open the cursor, tap 50%, select the "cursor" item, and the cursor will automatically adjust to the center position of the screen on both sides of the horizontal or vertical.

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.

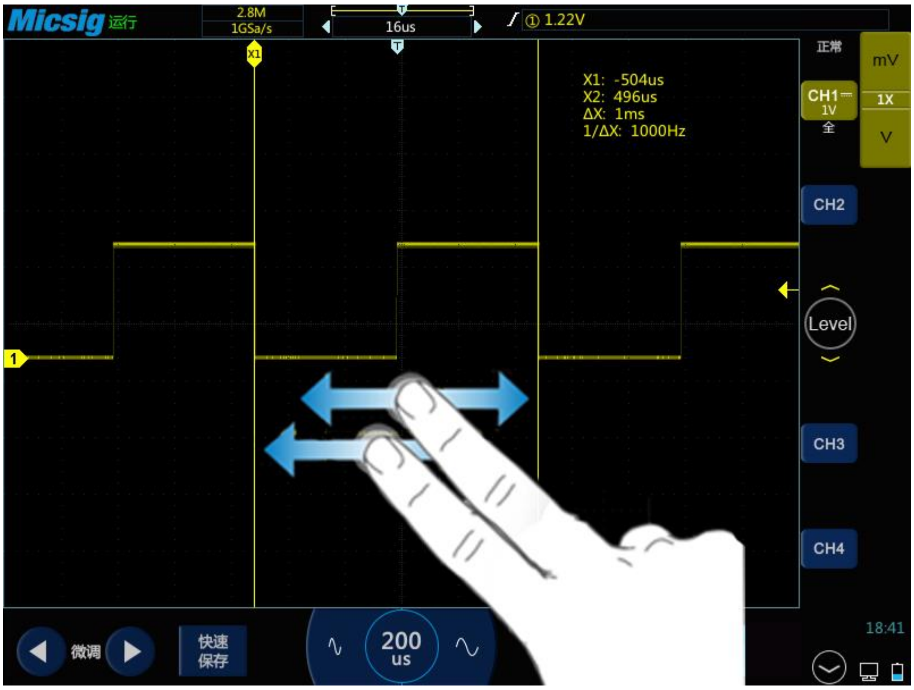


Figure 7-9 Cursor Measurement Pulse Width

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

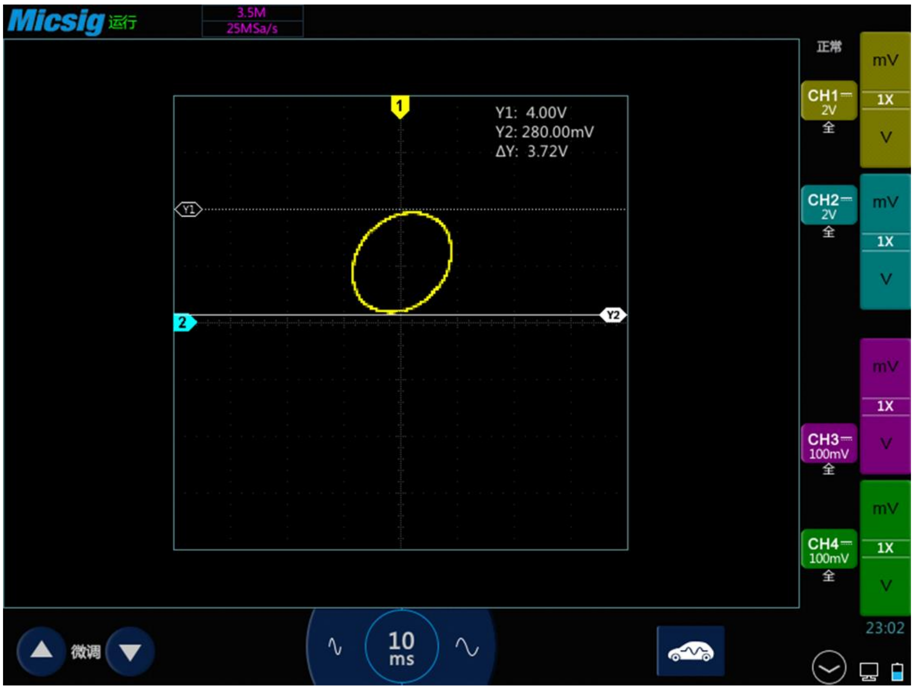


Figure 7-10 In XY Mode, Cursor Measurement

Chapter 8 Screen Capture, Memory Depth and Waveform Storage

This chapter contains detailed information about the oscilloscope's screen capture function and record length. It is recommended that you read this chapter carefully in order to understand the storage system of ATO oscilloscopes.

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

8.1 Screen Capture Function

The screen capture function can store the display information of the current display screen to the local or U disk in picture format. When the U disk is not inserted, the file is stored locally by default. When the U disk is inserted, the file is automatically stored in the U disk.

Screen capture method: slide upward from the bottom to open the pull-up menu. Tap the icon  to have a screen capture.

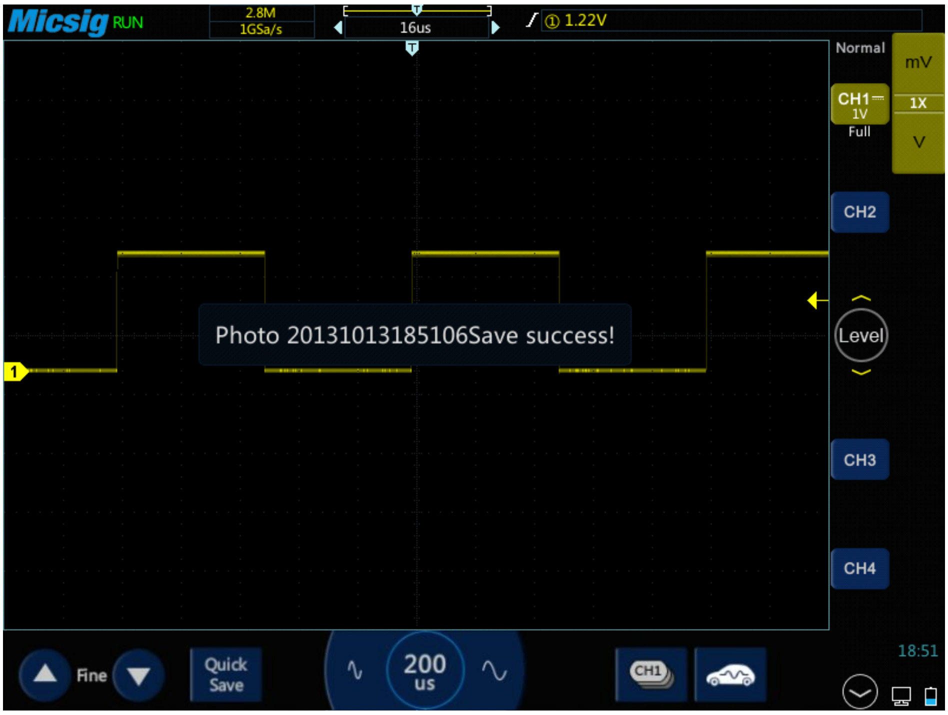


Figure 8-1 Screen Capture

Please refer to "12.6 Photo" for details on viewing pictures.

8.2 Video Recording

The video recording function is similar to the screen capture function, which can store the display information of the current display to the local or U disk in video format. When the U disk is not inserted, the file is stored locally by default. When the U disk is inserted, the file is automatically stored in the U disk.

Video recording method: slide up from the bottom to open the pull-up menu. Tap the icon  to record the video.

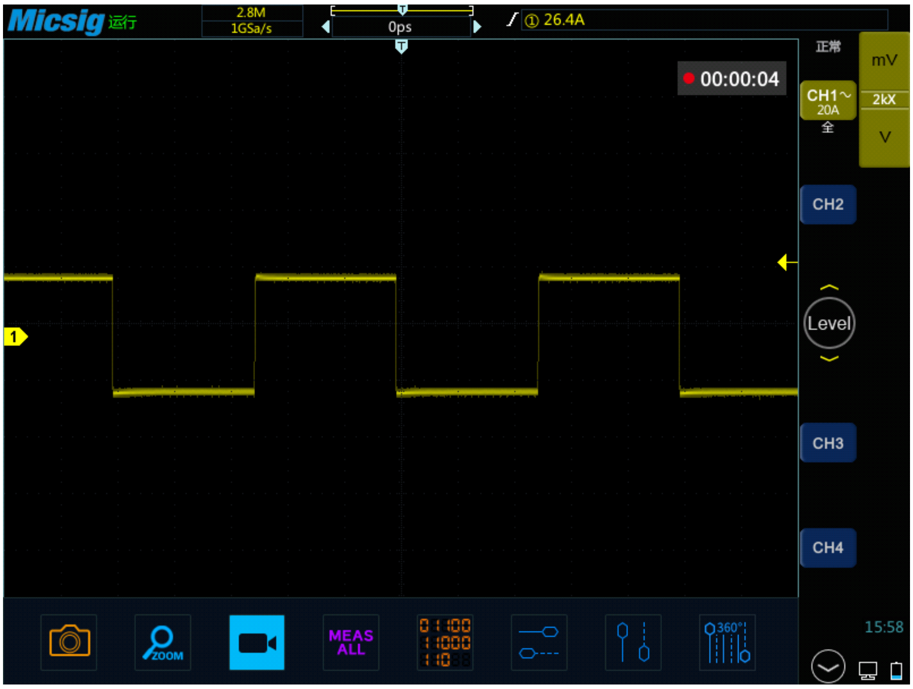


Figure 8-2 Video Recording

Please refer to "12.7 Video" 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 

to open the menu. Save the reference waveform interface of the specified channel as follows:

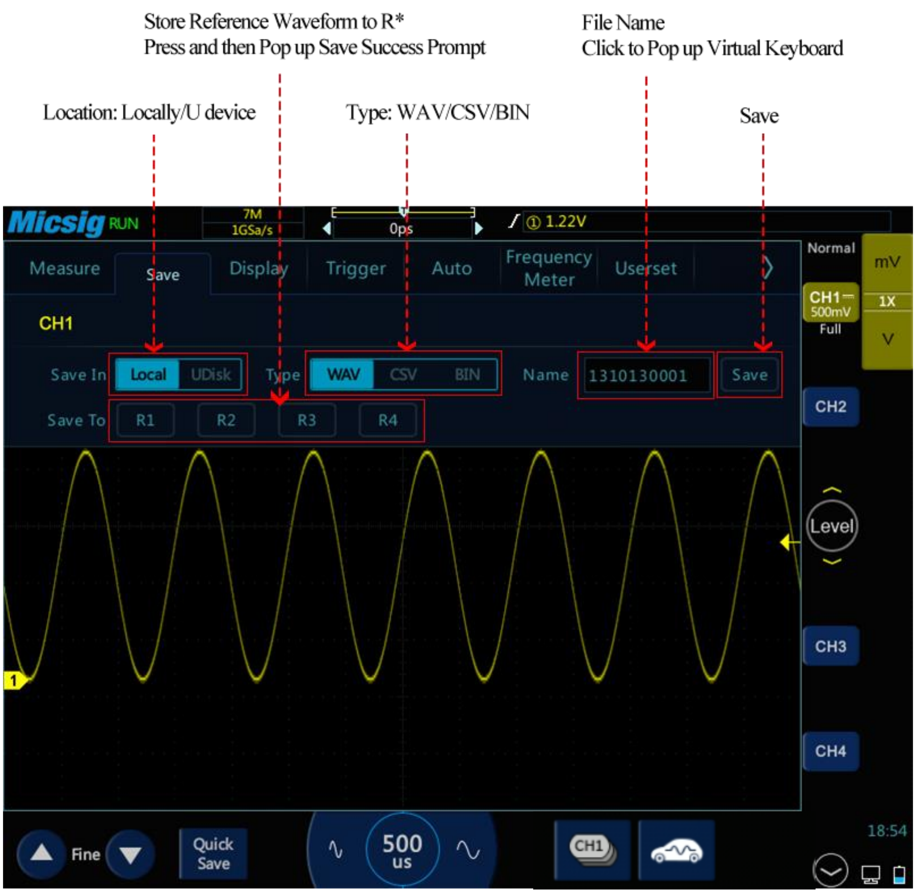


Figure 8-3 Save CH1 Reference Waveform Interface

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 

to enter the save menu.

3) In the Save menu, tap 

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

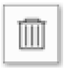
In the Save Reference Waveform menu, tap R* (R1, R2, R3, R4) button to save the current channel waveform directly to the corresponding reference channel, and the save success prompt will pop up. The file name is displayed as Ref* in the reference channel (* is the corresponding reference channel name). 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 directly save the waveform of the current channel (except the reference channel) as the reference waveform. The file name is the default initial file name.

Management of reference files

In the file manager, open the REF file menu, you can delete, rename and move the reference file. Select the reference file and click the button  on the right to delete the reference file; click rename to open the soft keyboard and change the name of the reference file; when inserting the U disk, the file on the oscilloscope can be moved to the U disk.

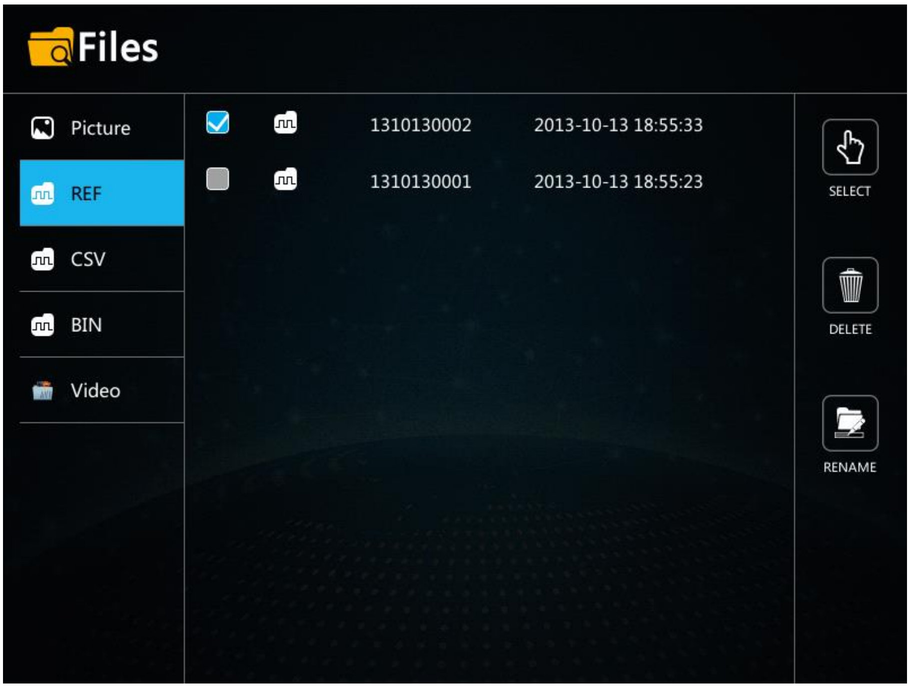


Figure 8-4 Delete Reference Files

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.

Chapter 9 MATH and Reference

This chapter contains detailed information on oscilloscope math operations and reference channels. It is recommended that you read this chapter carefully in order to understand the math and reference channel setting functions and operations of the ATO oscilloscope.

- **Dual waveform calculation**
- **FFT measurement**
- **Reference waveform call**

9.1 Dual Waveform Calculation

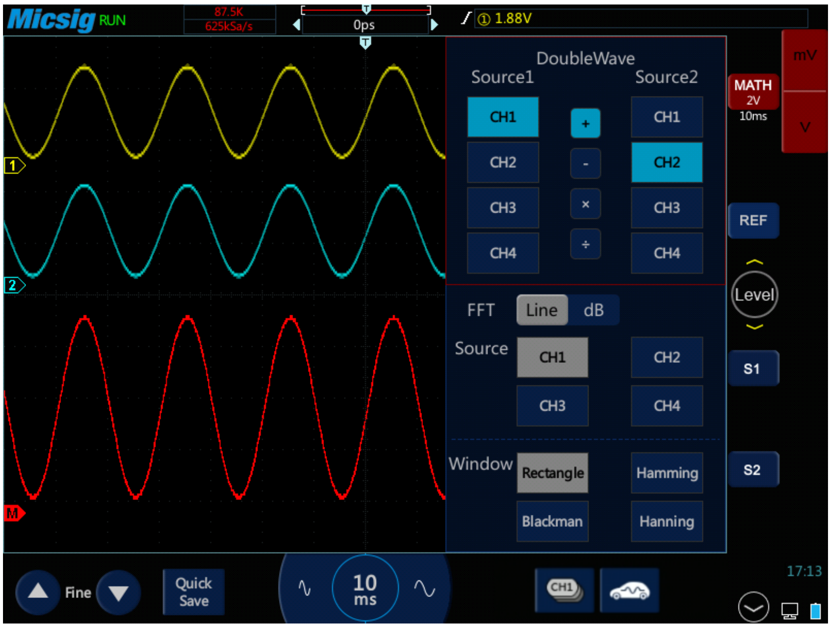


Figure 9-1 MATH Channel Waveform

Display math waveform

Tap on the lower right corner of the screen to enter the second channel selection area. Tap the soft key MATH to open the math channel. After the math waveform is opened, the current channel selector is automatically opened.

Tap the math channel icon, open the math channel, and tap again 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 and time base adjustment 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 "2.6 Understand the Oscilloscope Display Interface".

Math waveform units

Use "Probe Type" on the channel menu to adjust the channel unit (refer to "4.8 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.

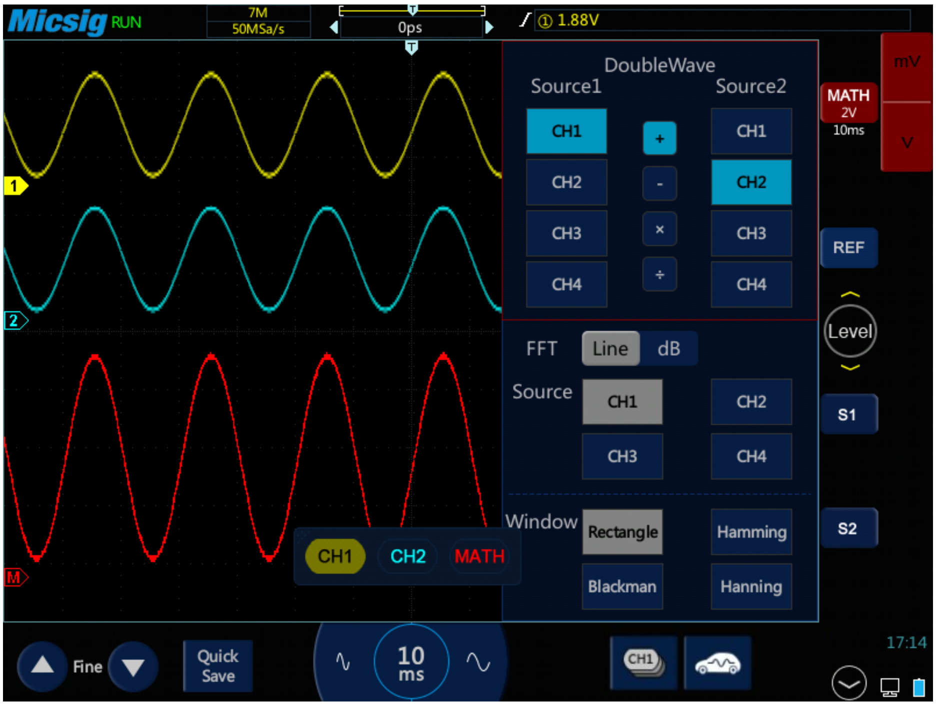


Figure 9-2 Mathematical Operation of CH1 adding CH2

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.

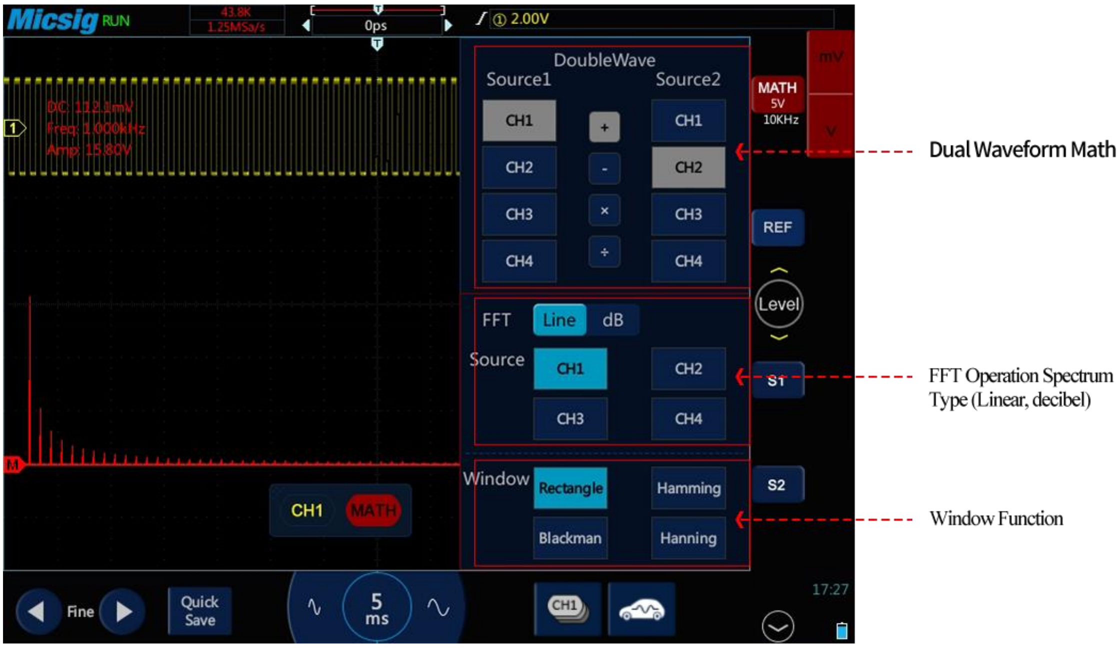


Figure 9-3 FFT Window

Open FFT

1) Tap on the lower right corner of the screen to enter the second channel selection area. Tap the soft key MATH to cycle through the math channel, open the math channel menu, and close the math channel.

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
- Move the channel horizontally, tap 50%, tap the "time base" item, and move the leftmost (0Hz) of the waveform to the horizontal 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 V or mV 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 Reference Waveform Call

Reference waveform call and close

Tap  in the bottom right corner of the screen to enter the second channel selection area. Tap REF button to open the reference menu, see Figure 9-5.

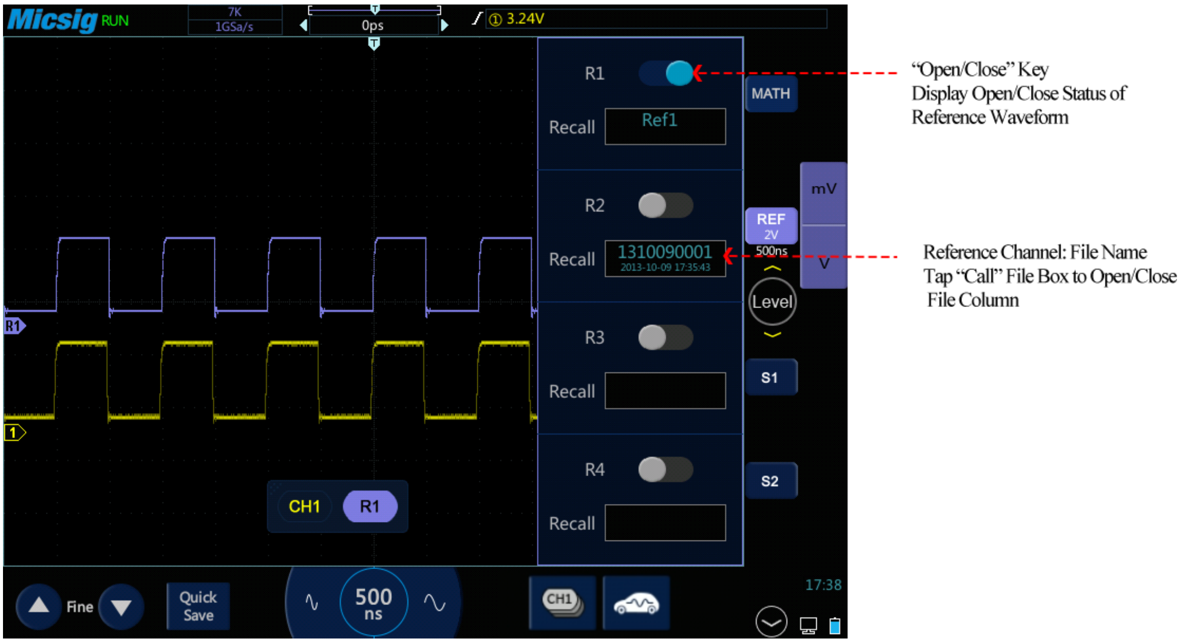


Figure 9-5 Reference Channel Menu

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) Tap REF to open the 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 REF 200mV 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 REF to open the reference channel of all loaded reference files; tap REF 200mV to close all currently opened reference waveforms. A single reference channel may also be opened with the Open/Close button.

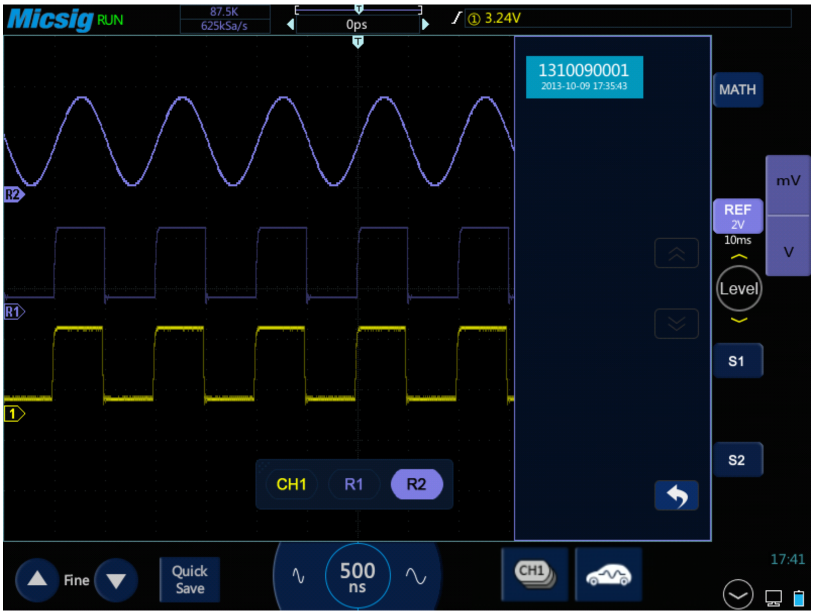


Figure 9-6 Restore Reference Waveform

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. When all reference waveform channels are closed, the reference waveform channel icon REF becomes gray.

3) Tap REF 200mV 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 and Function Buttons

This chapter contains detailed information on the oscilloscope display settings and function keys. It is recommended that you read this chapter carefully in order to understand the display and function key setting functions and operations of the ATO oscilloscope.

- Waveform setting
- Graticule setting
- Persistence setting
- Horizontal expansion center
- Time base mode selection
- Waveform refresh rate (high refresh mode)
- Run/Stop and Single SEQ
- Auto
- 50% function
- Measurement
- Trigger
- Home

In the main menu, tap 

button to enter display settings menu, as shown in Figure 9-1.

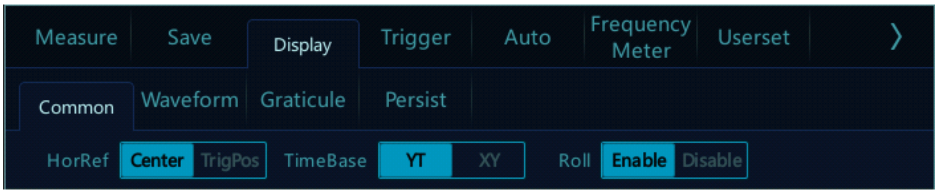


Figure 10-1 Display Settings and Function Buttons

10.1 Waveform Settings

Open the display menu, tap Waveform button to open the waveform display menu. This menu is used to set the display mode and brightness of waveform. The waveform display mode is divided into two types: dots and vectors. The waveform brightness percentage is adjustable, and the waveform display setting is shown in Figure 10-2.

Figure 10-2 Waveform Display Menu

10.2 Graticule Setting

Open the display menu and tap Graticule button to open the graticule setting menu (Figure 10-3). Graticule display mode includes: “Full”, “Grid”, “Retical” and “Frame”, and the brightness percentage is adjustable.

Figure10-3 Graticule Menu Display

10.3 Persistence Setting

Open the display menu and tap Persist key to open the persistence settings menu.

1) Persistence setting

In the persistence setting menu, select:

- **None:** None - no persistence.
- **Auto:** Auto — automatic persistence.
- **Normal:** Normal - set the persistence time — After selecting the variable persistence, tap the box on the right of “Adjust” to pop up the persistence time selection box (Figure 9-4) and set the persistence time. It can be set between 10ms and 10s.
- **∞:** Infinite persistence - never erase the results of previous acquisitions

  Infinite persistence can be used to measure noise and jitter, display the worst-case extremes of varying waveforms, find time violations, capture events that occur infrequently.

Figure 10-4 20MHz Sine Wave Variable Persistence 500ms

2) **Erase persistence**

To erase the previously acquired results from the display, tap Clear key or adjust the horizontal time base and vertical sensitivity. The oscilloscope will erase the persistence display and start the cumulative acquisition again.

10.4 Horizontal Expansion Center

Horizontal expansion is divided into two types: screen center and trigger position:

1) Screen center

Select Center to adjust the time base waveform to expand or contract toward both sides with the screen center as the base point, and the delay time does not change.

2) Trigger position

Select TrigPos to adjust the time base waveform to expand or contract toward both sides with the trigger position as the base point. The delay time varies with the horizontal time base.

10.5 Time Base Mode Selection

For details, please refer to "4.4 ROLL, XY" in Chapter 4.

10.6 Run/Stop and Single SEQ

Tap 

in the right function area to quickly freeze and capture the current signal waveform, tap again, and the waveform will continue to run; Tap 

to conduct single acquisition, and the oscilloscope will display the single acquisition waveform.

For details, please refer to "11.2 Run/Stop and Single SEQ Buttons" in Chapter 11.

10.7 Auto

Use 

on the right function key area to turn on the Auto set function. Each time you tap "Auto", the oscilloscope can recognize the type of input signal and adjust the control mode, It automatically adjusts the vertical scale, horizontal scale and trigger setting, and adjust the waveform to the best display state.

For details, please refer to "2.10 Use Auto" in Chapter 2.

10.8 Measurement

Tap 

in the right function area to open or close the automatic measurement menu.

For details, please refer to "7.1 Automatic Measurement" in Chapter 7.

10.9 Trigger

Tap 

in the right function area to quickly open or close the trigger menu.

For details, please refer to Chapter 5 Trigger System.

10.10 Home

Tap  in the right function area, switch to the oscilloscope homepage.

For details, please refer to Chapter 12 Homepage Functions.

Chapter 11 Sampling System

This chapter contains detailed information about the oscilloscope acquisition system. It is recommended that you read this chapter carefully in order to understand the setup and operation of the sampling system of the ATO oscilloscope.

- **Sampling overview**
- **Run, stop and single sequence acquisition (running control)**
- **Select sampling mode**
- **Record length and sampling rate**

11.1 Sampling Overview

To understand the sampling and sampling modes of the oscilloscope, you need to understand the sampling principle, aliasing, oscilloscope bandwidth and sampling rate, oscilloscope rise time, required oscilloscope bandwidth, and the influence of memory depth on the sampling rate.

Sampling principle

According to the Nyquist sampling principle, for a bandwidth-limited signal with the maximum frequency f_{MAX}, the equidistant sampling frequency f_S must be twice as large as the maximum frequency f_{MAX}, so that a unique signal can be reconstructed without aliasing.

$$f_{MAX} = \frac{f_S}{2} = \text{Nyquist frequency } (f_N) = \text{alias frequency}$$

Aliasing

Aliasing occurs when the signal is under sampled ($f_S<2f_{MAX}$). Aliasing is signal distortion caused by incorrectly reconstructing low frequencies from a small number of sampling points.

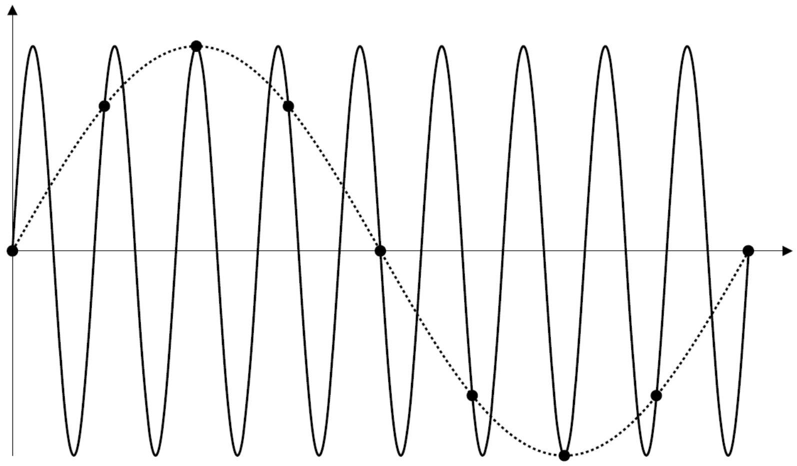


Figure 11-1 Aliasing

Oscilloscope bandwidth and sampling rate

The oscilloscope bandwidth usually refers to the lowest frequency at which the input signal sine wave is attenuated by 3dB (-30% amplitude error).

For oscilloscope bandwidth, according to the sampling principle, the required sampling rate is $f_S=2f_{BW}$. However, this principle assumes that there is no frequency component exceeding f_{MAX} (f_{BW} in this case) and requires a system with ideal brick-wall frequency response.

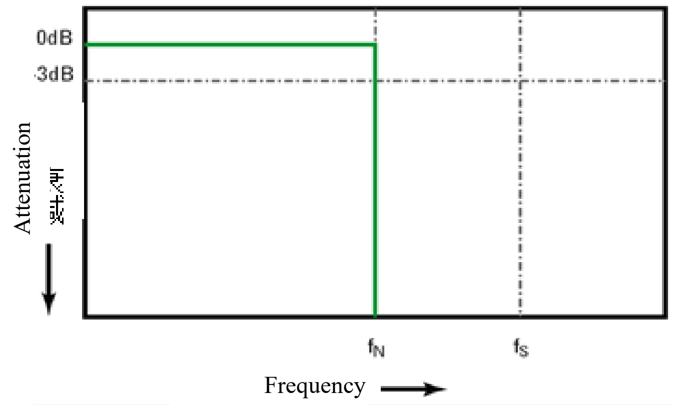


Figure 11-2 Theoretical Brick-Wall Frequency Response

However, digital signals have frequency components that exceed the fundamental frequency (the square wave consists of sine waves at fundamental frequency and an infinite number of odd harmonics), and for bandwidths of 500MHz and below, the oscilloscope typically has Gaussian frequency response.

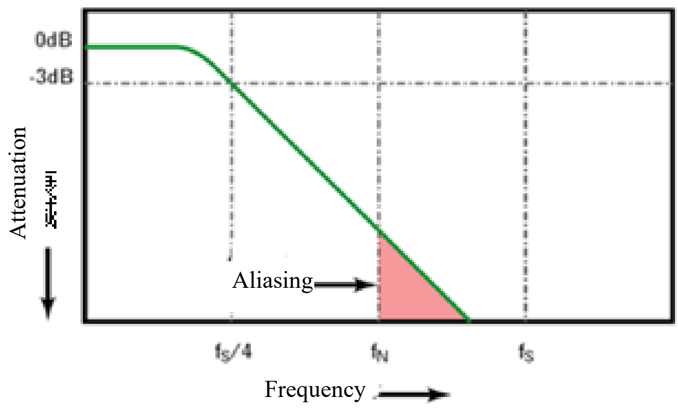


Figure 11-3 Sampling Rate and Oscilloscope Bandwidth

The oscilloscope bandwidth is limited to 1/4 sampling frequency and reduces the frequency response above the Nyquist frequency.

Therefore, in fact, the oscilloscope sampling rate should be 4 times or more of its bandwidth: $f_S \geq 4f_{BW}$. This can reduce aliasing and cause greater attenuation in the aliased frequency components.

Oscilloscope rise time

The oscilloscope rise time is closely related to its bandwidth. The rise time of an oscilloscope with Gaussian type frequency response is approximately $0.35/f_{BW}$ (based on the standard from 10% to 90%).

The oscilloscope rise time is not the fastest edge speed that an oscilloscope can accurately measure. It is the fastest edge speed that the oscilloscope can produce.

Desired oscilloscope bandwidth

The oscilloscope bandwidth required to accurately measure signal is primarily determined by the rise time of the signal rather than the frequency of the signal.

The following steps can be used to calculate the required oscilloscope bandwidth:

1) Determine the fastest edge speed.

   Rise time information is typically obtained from the published device specifications used in the design.

2) Calculate the maximum "actual" frequency component.

   According to Dr. Howard W. Johnson's book "*High-Speed Digital Design–A Handbook of Black Magic*", all fast edges have wirelessly continuous frequency components. However, there is a turning point (or "inflection point") in the fast edge spectrum at which frequency components above f_{knee} are negligible in determining the signal shape.

   f_{knee}=0.5/signal rise time (based on 10% - 90% threshold)

   f_{knee}=0.4/signal rise time (based on 20% - 80% threshold)

3) The multiplication factor for the desired accuracy is used to determine the required oscilloscope bandwidth.

Desired Accuracy	Desired Oscilloscope Bandwidth
20%	$f_{BW}=1.0xf_{knee}$
10%	$f_{BW}=1.3xf_{knee}$
3%	$f_{BW}=1.9xf_{knee}$

Table 11-1 Bandwidth Corresponding to Oscilloscope Measurement Accuracy

11.2 Run/Stop Key and Single SEQ Key

Use softkeys in the button area to start and stop the oscilloscope acquisition system: Run/Stop button Run Stop and Single Sequence Acquisition Single SEQ button.

- When the Run/Stop button Run Stop is displayed in green, it indicates that the oscilloscope is running, that is, it meets the trigger condition and data acquisition is being performed. The green "RUN" or "WAIT" is displayed in the upper left corner of the screen.

  To stop data collection, tap the Run/Stop button. After stopping, the screen displays the last acquired waveform.

- When the Run/Stop button Run Stop is displayed in red, it indicates that data acquisition has stopped. The red "STOP" is displayed in the upper left corner of the screen.

  To resume data acquisition, press the Run/Stop button again.

- To capture and display single acquisition (whether the oscilloscope is running or stopped), tap the single sequence key **Single SEQ** for a single acquisition.

11.3 Select Sampling Mode

Open the channel menu, tap the sampling mode option under “Sample”, and choose among the four sampling modes: normal, average, peak and envelope in the pop-up box.

The sampling modes of all channels are same. That is, if the sampling mode of any channel is changed, the sampling mode of all channels is changed at the same time.

Normal sampling mode

Oscilloscope samples signal through equivalent time intervals to build waveform. When the time base of 20 ns or faster is chosen, the oscilloscope automatically performs an interpolation algorithm that inserts difference point between sampling points.

This mode produces the best display effects for most waveforms.

Peak sampling mode

In peak sampling mode, when the horizontal time base setting is low, the minimum and maximum sample values are retained to capture rare events and narrow events (with any noise expanded). This mode will display all pulses that are at least as wide as the sampling period.

When the time base is set to 200ms and above, the oscilloscope will automatically exit the peak sampling mode and switch to the normal sampling mode.

Burr or narrow pulse capture

Burr is the rapid change in waveform that is usually narrower than waveform. Peak sampling mode can be used to view burr or narrow pulses more easily. In the peak sampling mode, narrow burr and transition edges are brighter than in those in the “normal” sampling mode, making them easier to see.

Applying the peak sampling mode can avoid signal aliasing but show more real noises.

Figure 11-4 Sine Wave with Burr, Normal Sampling Mode

Figure 11-5 Sine Wave with Burr, Peak Sampling Mode

Use Peak detection mode to find burrs

1) Connect signal to the oscilloscope to be stably displayed.

2) To find burr, select the peak sampling mode in Sampling Mode option in the Channel menu.

3) In the menu, tap “Display” → “Persistence”, then tap “∞” (infinite persistence). The oscilloscope will restart sampling data and display them on the screen.

4) Use the zoom mode to represent the characteristics of burr:

   a. Tap the “Zoom” button in the main menu to open the zoom window.

   b. To get a better resolution of burr, expand the time base to set the expanded portion of the normal window view around burr.

11.4 Record Length and Sampling Rate

The record length is the data volume for each captured waveform. For example, if the record length is 700K, it means that 700K sample points are captured by one trigger.

In the main menu, tap 

to enter the record length setting menu, which can be set by tapping the corresponding record length.

Figure 11-8 Record Length

In normal refresh mode, if it is a single channel, the record length can be set to 14k, 140k, 1.4M, 14M, 28M, Auto; if it is dual channel, the record length can be set to 7k, 70k, 0.7M, 7M, 14M, Auto; if it is three or four channels, the record length can be set to 3.5k, 35k, 0.35M, 3.5M, 7M, Auto.

Record length and Sampling rate

The record length is data volume collected per waveform capture. For example, if the record length is 0.7M, it means that 700K sample points are captured by one trigger.

The oscilloscope record length and sampling rate have the following relationship:

Sampling rate = Record length/Acquisition time

Generally, the oscilloscope acquisition time is exactly the display time on the current entire screen (current horizontal time base×14).

For example, if the oscilloscope has the memory depth of 700K, the sampling rate of 1GSa/s, and the horizontal time base of 50us/div, the acquisition time is 700us, which is 50us/div×14div.

However, when the fast time base (below 20 ns) or the record length is set to a fixed value, the oscilloscope acquisition time does not necessarily represent the display time on the current entire screen.

For example, if the oscilloscope has the memory depth of 700K, the sampling rate of 1GSa/s, and the horizontal time base of 20ns, the acquisition time is 700ns, which is 2.5 times of the current display time on the entire screen.

Or, if the memory depth is 140K (fixed value), the sampling rate is 1GSa/s, and the horizontal time base is 1us, the acquisition time is 140us, which is 10 times of the current display time on the entire screen.

For a single channel in a channel pair, the maximum sampling rate of the ATO series oscilloscope is 1GSa/s.

If any two channels are opened, the sampling rate of the two channels will halved. For example, when CH1 and CH3 are opened, the sampling rates of CH1 and CH3 are both 500 MSa/s.

If any three channels or all four channels are opened, the sampling rate per channel will become 1/4 of the maximum sampling rate. For example, when CH1, CH2 and CH3 are opened, the sampling rates of CH1, CH2 and CH3 are 250 MSa/s for each of them.

Chapter 12 Homepage Functions

This chapter contains the functions of the oscilloscope's homepage, and introduces the functions of the icons in the homepage and how to set them. It is recommended that you read this chapter carefully in order to understand the home page function of the ATO oscilloscope.

- Automotive
- Contact us
- File manager
- Settings
- Quickguide
- Photo
- Video
- Time
- Shutdown

The following figure shows the contents of the oscilloscope home page. See Figure 12-1.

Figure 12-1 Homepage

12.1 Oscilloscope (see Chapters 2~13)

12.2 Contact us

Tap  on the home page to find out the contact information of MICSIG.

12.3 File Manager

Tap  on the home page to enter the file manager interface. The file format includes picture, ref (reference waveform), CSV, bin and video. When the U disk is not inserted, the local file will be displayed; when the U disk is inserted, the "local" and "U disk" soft keys will appear. Tap to select and manage the files in the "local" or "U disk". The functions of naming, deleting and exporting can be realized.

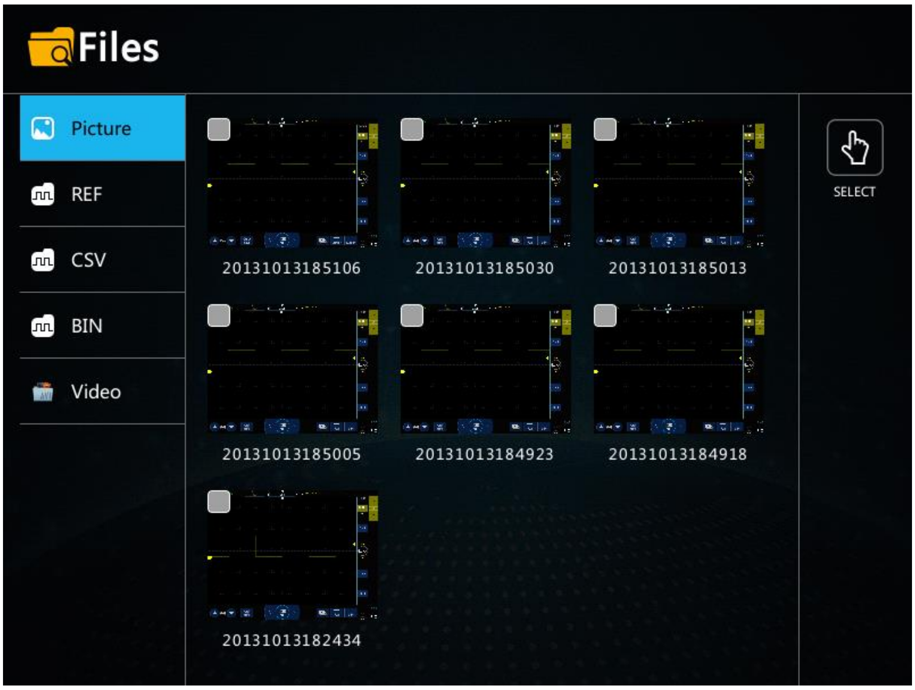


Figure 12-2 File Manager

Picture

Tap "picture" to open the picture list and enter the picture management interface.

Tap the picture. The picture is selected. Click again to cancel the selection. If you select a single picture file, you can delete and rename the picture file. When you insert a U disk, you can export the file to the U disk. If you select multiple picture files, you can delete the file. When you insert a U disk, you can export the file to the U disk.

Tap the "select all" button on the right, quickly select all picture files, click again to cancel the selection, delete the files in all selected status, and export the files to the U disk when inserting the U disk.

REF, CSV, BIN and Video files

File management is the same as picture file

12.4 Settings

Tap  in the homepage to enter the system setting interface. The setting interface includes brightness, SOUNDS, language, shutdown time, USB, LAN, WLAN, WLAN AP, upgrade and INFORMATION.
The system setting interface is shown in Figure 12-3.

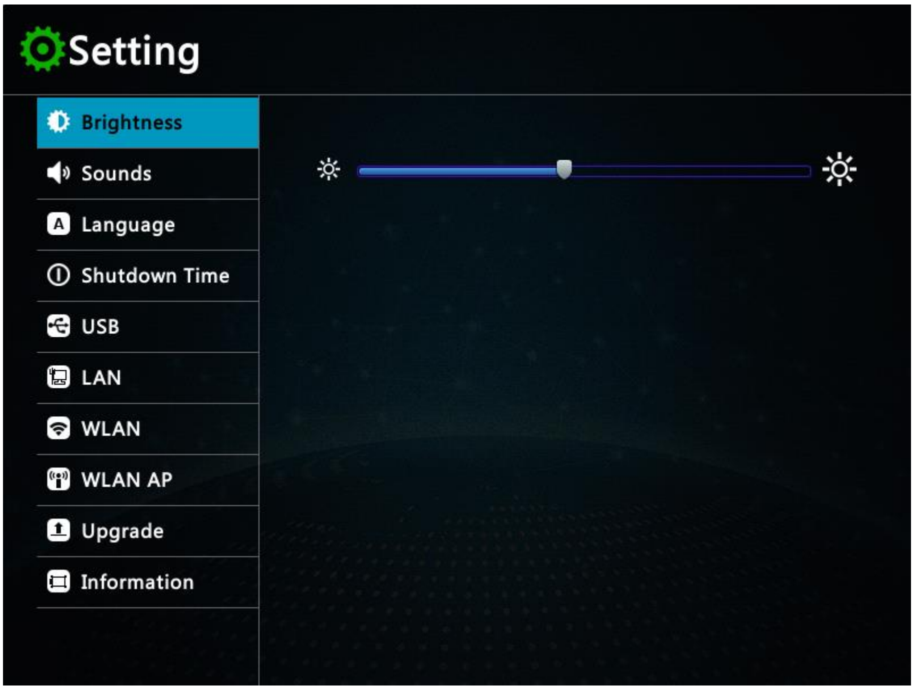


Figure 12-3 System setting interface

Brightness

Brightness adjustment method: adjust the brightness of the screen display, drag the "Brightness" display bar, and the screen brightness will change accordingly.

Sounds

Volume adjustment method: adjust the volume of the prompt tone, drag the "volume" display bar, and the soft key and power on music sound will change accordingly.

Language

The oscilloscope supports multi language display, including simplified Chinese and English.

Shutdown time

Tap the shutdown time display bar to set the shutdown time. If there is no operation within the set shutdown time, the oscilloscope will automatically shut down. If the oscilloscope is operated within the shutdown time, the system will start to calculate the shutdown time again, and will not shut down automatically until the requirements are met. Adjustment range of standby time: invalid, 1-60min.

USB

When the USB cable is used to connect the oscilloscope and PC for the first time, the PC will pop up the prompt of installing the driver. Only after the driver is installed correctly can the oscilloscope exchange information with the computer. After installing the driver, modify the USB connection mode to achieve different effects:

1) USB connection: after the USB connection is selected, the host computer software can be used to update the oscilloscope program and write the oscilloscope information.

2) USB storage device: the oscilloscope can be used as a USB storage device. After connecting with the computer,

the files in the oscilloscope can be viewed, modified, deleted, and stored in the oscilloscope at the same time.

LAN

The oscilloscope provides LAN port. Through wired connection, the oscilloscope can be connected to the network. After the LAN connection is set, the online upgrade can be carried out through the network, the internal files of the oscilloscope can be accessed through FTP, and the web interface of the oscilloscope can be accessed.

Establishing a LAN connection

Automatic configuration

Select "automatic" for IP acquisition mode. Oscilloscope automatically obtains IP address, subnet mask, gateway IP and DNS IP.

Manual configuration

Select "static" for IP acquisition mode. Click the IP address input box, pop up the virtual keyboard, and manually enter the IP address, subnet mask, gateway IP and DNS IP values.

Figure 12-4 LAN Connection Setting

WLAN connection

Tap WiFi icon to enter WLAN setting interface.

Figure 12-5 WLAN Connection Setting

Tap the upper right switch to turn on the WLAN function. The oscilloscope automatically scans the surrounding wireless network and displays the name of the surrounding wireless network according to the list.

Tap the wireless network you need to connect, and the password input box will pop up. After entering the password with the virtual keyboard, tap enter to connect, and the oscilloscope is connected to the wireless network.

Automatic configuration

Select "automatic" for IP acquisition mode. Oscilloscope automatically obtains IP address, subnet mask, gateway IP and DNS IP.

Manual configuration

The steps of network setting are:

1) Set the IP address. The IP address should be set in the same network segment as the current network and cannot be duplicate.

2) Set the subnet mask, which is generally the default and does not need to be set manually.

3) Set the gateway to be consistent with the routing gateway of the current network.

4) Set DNS to be consistent with the routing gateway of the current network.

WLAN AP

Tap the hotspot icon to enter the WLAN AP setting interface.

Tap the switch in the upper right corner to turn on the hotspot function.

Tap the hotspot name and password setting input box, use the virtual keyboard to enter the hotspot name and password for setting, and other devices can share the oscilloscope file by connecting the oscilloscope hotspot.

Figure 12-6 WLAN AP Setting

Upgrade

Tap the upgrade icon to enter the upgrade options interface, which supports multiple upgrade modes, including local upgrade, U-disk upgrade and online upgrade.

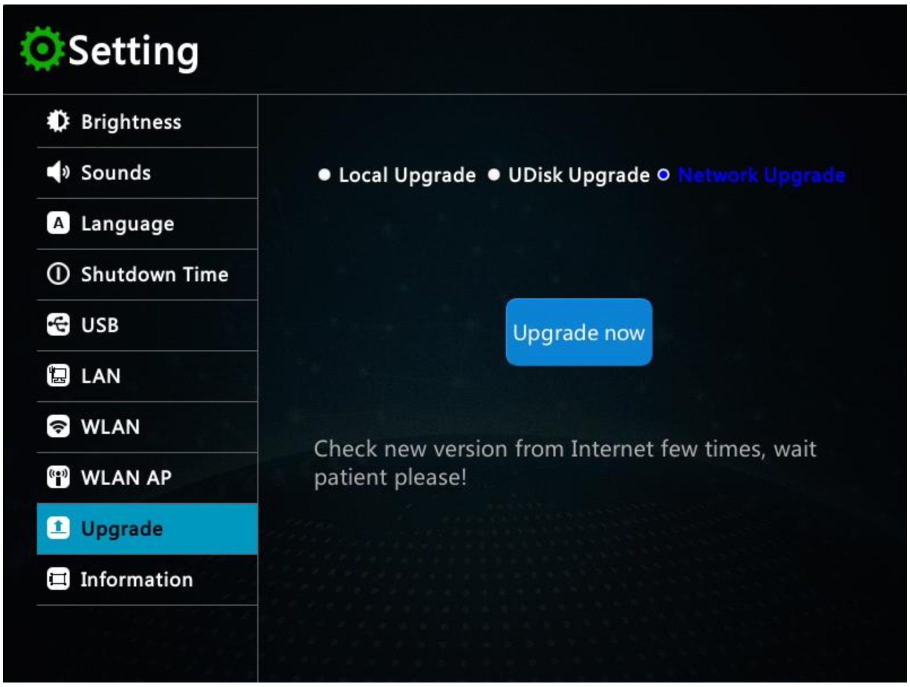


Figure 12-7 Upgrade

Local upgrade

1) Contact micsig company or download the relevant upgrade package from the website (the latest upgrade package download address: http://www.micsig.com/html/list_60.html).

2) Use USB cable to connect oscilloscope and PC.

3) In the setting and select USB option as USB storage device (refer to "USB option" in "setting") to store the

upgrade package in oscilloscope.
4) Change the USB option to USB connect.
5) Click "upgrade" in settings → upgrade to enter the upgrade interface, which is displayed as local upgrade.
6) Click "upgrade" to start the upgrade, and restart automatically after the upgrade.

U disk upgrade

1) Contact micsig company or download the relevant upgrade package from the website (the latest upgrade package download address: http://www.micsig.com/html/list_60.html).

2) Unzip the upgrade package and store it in the root directory of the U disk.

3) Connect the USB disk to the USB port of the oscilloscope. When the oscilloscope detects the upgrade program, the upgrade interface pops up.

4) Click "upgrade" in settings → upgrade to enter the upgrade interface, click "upgrade" to start the upgrade, and restart automatically after the upgrade.

Online upgrade

1) When connected to the Internet, click "upgrade now" to check the update;
2) Click download upgrade package;
3) Click "upgrade" to start the upgrade, and restart automatically after the upgrade.
Note:
1) In the upgrade interface, if you don't want to upgrade the program, you can click home or return to exit.
2) When upgrading the program, it is necessary to ensure that the oscilloscope has sufficient power; if the power is insufficient, a prompt box will pop up by taping Upgrade.

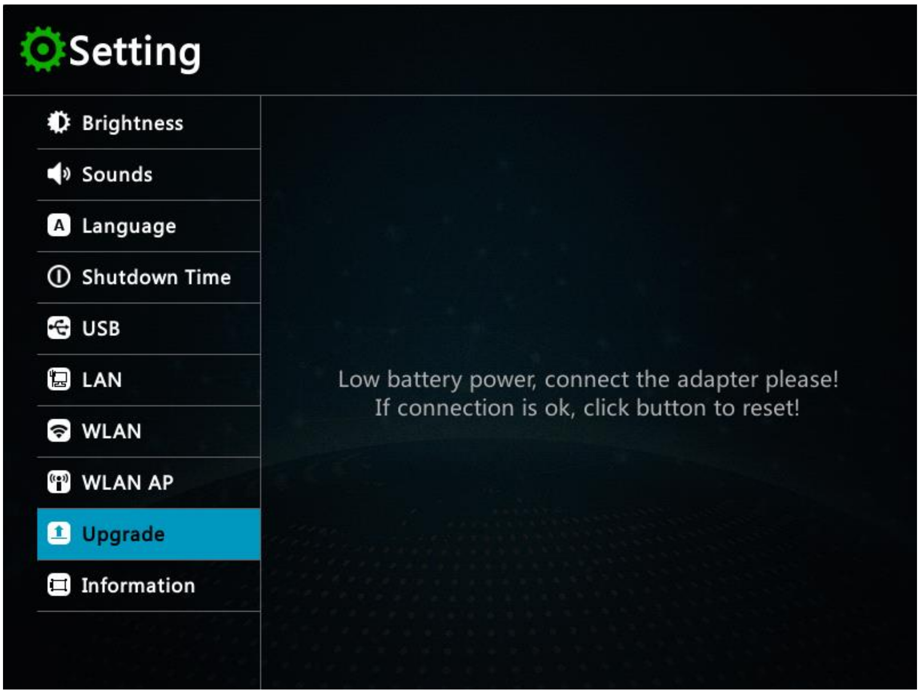


Figure 12-8 Low battery power

Information

In the information interface, you can view the machine model, bandwidth, serial number, version info, delivery date, installed option information, open the virtual keyboard, enter the license to open the corresponding option function. The installable options include: 28m storage depth, HDMI, automatic range, frequency meter, WLAN, etc.

If you need the optional function service, please contact Micsig to get license and enter the install option function at the license bar.

12.5 Quickguide

Tap  on the home interface to view the quick guide of the oscilloscope, and turn the page by sliding left and right.

Figure 12-9 Quick Guide

12.6 Photo

Tap  in the homepage interface to enter the picture viewing interface.

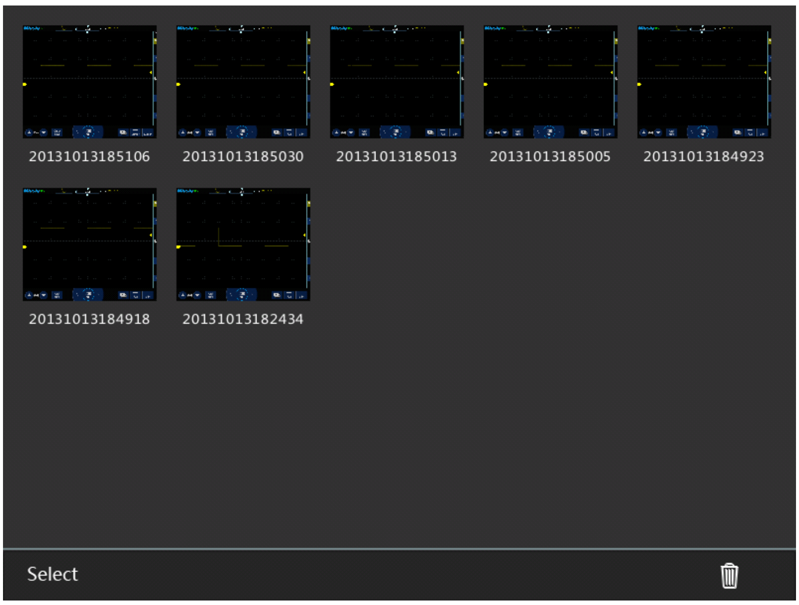


Figure 12-10 Picture Viewing Interface

In the picture viewing interface, the picture can be displayed in full screen. When the full screen is displayed, drag the picture left and right to view the previous and next picture. Tap the return key to exit the full screen display.

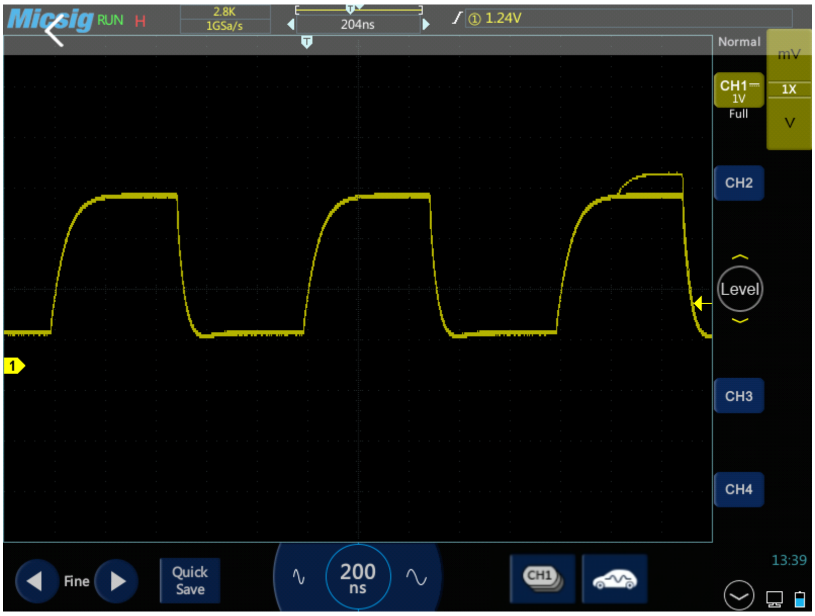


Figure 12-11 Picture Full Screen Viewing Interface

In the picture viewing interface, tap the "select" button at the bottom of the screen, click the picture to select the picture, and " √ " will be displayed on the left side of the picture, and click the trash can icon at the bottom right corner of the screen to delete the picture.

After the U disk is connected to the oscilloscope, if there are pictures in the U disk, the pictures in the U disk will be automatically displayed in the picture viewing interface.

12.7 Video

Tap  in the homepage interface to enter the video viewing interface.

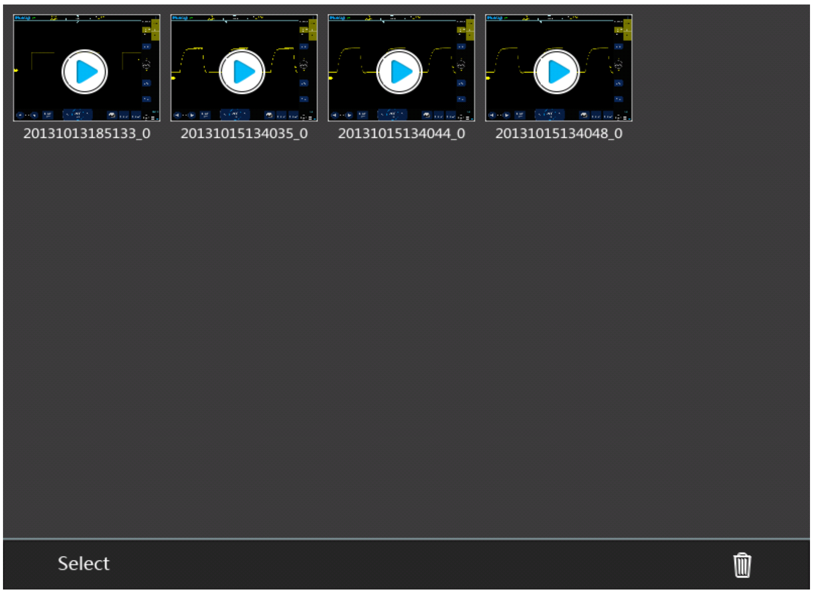


Figure 12-12 Video Viewing Interface

In the video viewing interface, tap the video to play back the selected video file, and tap the back button to exit the playback. During video playback, you can pause, and quickly switch to the previous video and the next video by shortcut keys.

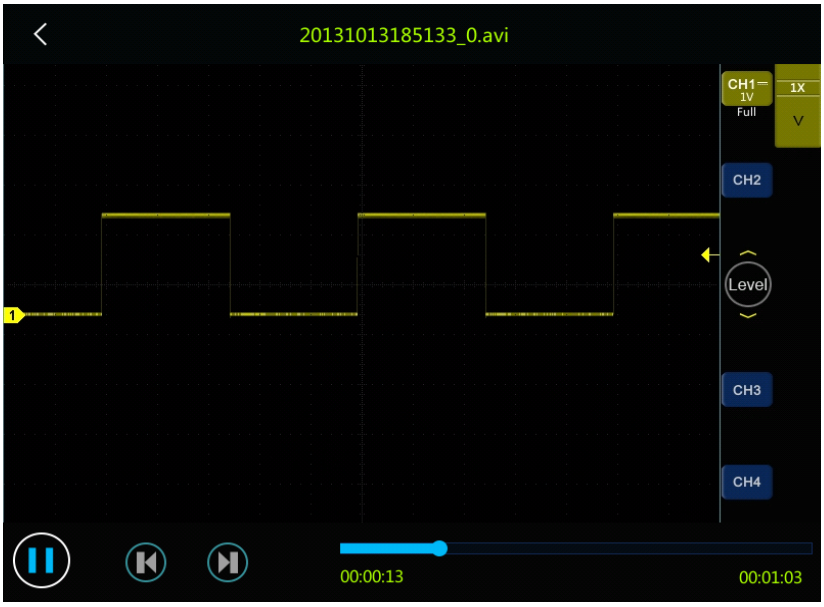
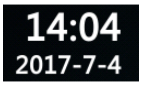


Figure 12-13 Video Playback Interface

In the video viewing interface, tap the "select" button at the bottom of the screen, click the video to select it, and " √ " will be displayed on the left side of the video, and click the trash can icon at the bottom right corner of the screen to delete the video.

After connecting the U disk to the oscilloscope, if there are videos in the U disk, the videos in the U disk will be automatically displayed in the video viewing interface.

12.8 Time

Click 

on the homepage to enter the system time setting interface. Click the time item to be adjusted and drag it up and down to adjust the time. After setting, the time displayed on the homepage and oscilloscope interface will be updated to the set time synchronously.

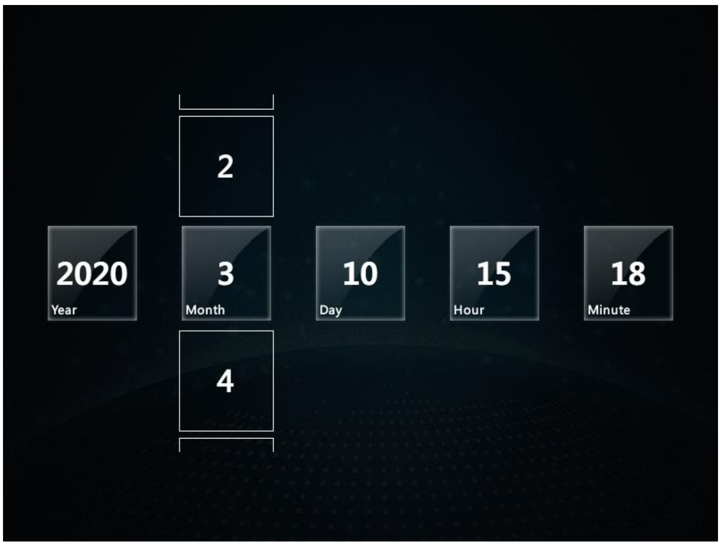


Figure 12-14 Time Setting

12.9 Shutdown、Lock Screen and Unlock

Press the side button  to enter the shutdown interface. Shutdown includes 4 options: shutdown, restart, screen lock or unlocking.

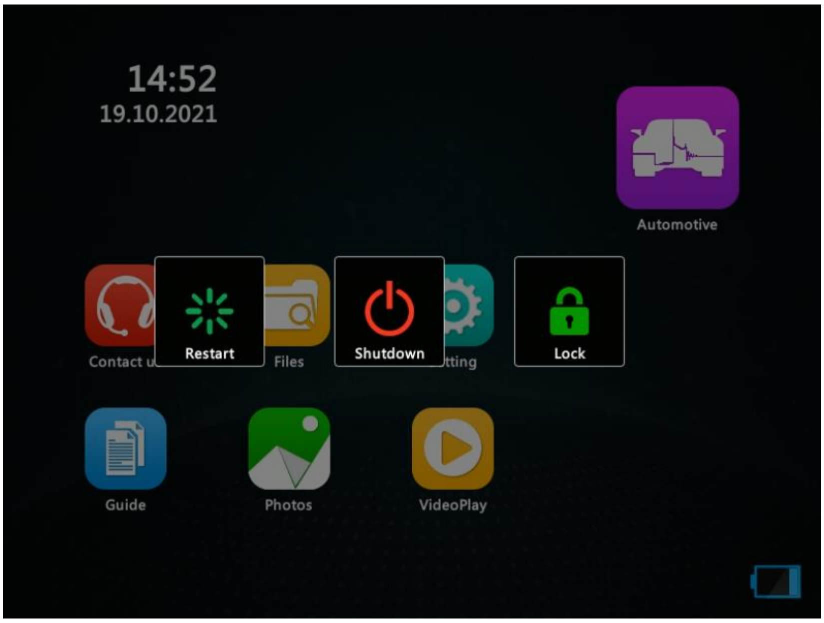


Figure 12-15 Shutdown Interface

Shut down: tap  to shutdown the oscilloscope.

Restart: click  to restart the oscilloscope.

Lock screen: tap , the oscilloscope screen will be locked, and the upper right corner of the screen is displayed . No other operation is allowed except shutdown, and restart. It will be displayed  when clicking, and disappear after 1 second.

When using the mouse, the screen will lock and the touch screen will fail unless it is unlocked.

Unlocking: After the screen is locked, click the power button on the right,  will appear, and then tap , the oscilloscope screen will be unlocked.

Figure 12-15 Locking Interface

Chapter 13 Serial Bus Trigger and Decode (Optional)

This chapter contains the detailed information of serial bus decoding. You are recommended to read this chapter carefully to understand the setting and operation of ATO series auto-scope bus trigger and decode.

This chapter mainly include the below contents:

- UART (RS232/RS422/RS485) bus trigger and decode
- LIN bus trigger and decode
- CAN bus trigger and decode
- SPI bus trigger and decode
- I^2C bus trigger and decode
- ARINC429 bus trigger and decode
- 1553B bus trigger and decode

Press in the lower right corner to switch to decode channels S1 S2, tap S1 or S2 to enable decoding, open bus configuration menu, select bus type, there are seven bus types: UART (RS232/RS422/RS485), LIN, CAN, SPI, I^2C, ARINC429, 1553B, where channels S1 and S2 can be used for decoding simultaneously. Open the trigger setting menu, choose an appropriate trigger type, the corresponding bus trigger type and trigger mode can be set when the bus trigger is selected, and the serial bus is displayed in graphic form.

In the serial bus decode mode, if it is screen rolling in other modes, the time base is automatically adjusted to 1ms when switching to serial decode (the maximum time base supported by the serial decode mode is 100ms); in Zoom mode, the enlarged signal can be decoded and displayed. The normal display window supports a maximum time base of 100ms. When decoding is enabled, clicking “AUTO” will set the trigger type to be the same as the decode channel bus type. The bus type selection menu is shown in Figure 13-1:

Figure 13-1 Bus Type Selection Menu

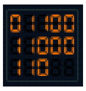
Open the pull-up menu and tap  key to open or close the text mode, as shown in Figure 13-2.

Figure 13-2 Bus Decode Text Mode

Description:

Two decode channels S1&S2 in the text interface must be configured identically to be opened, and each channel is displayed in chronological order with different colors;

S1/S2/S1&S2 are the channel configuration bus information, and X knob is rotated or the label is switched to change the bus channel;

Clicking save during the text acquisition process can save all currently acquired data. If the date volume is too large, “wait” will be displayed, and the save success prompt will be displayed.

Oscilloscope can be used as a USB storage device to view saved files on a computer, as shown in Figure 13-3:

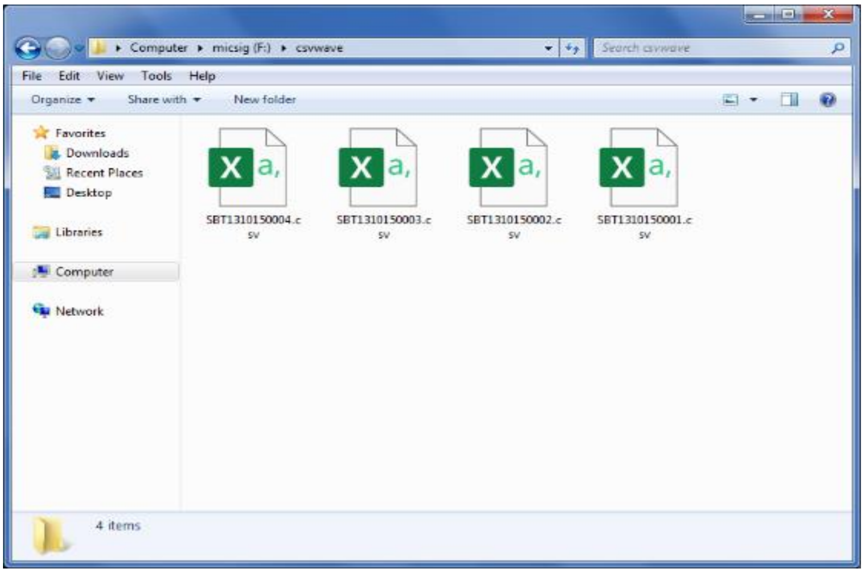


Figure 13-3 Bus Text Storage Files

13.1 UART (RS232/RS422/RS485) Bus Trigger and Decode

For correctly decoding UART(RS232/RS422/RS485) bus data and making trigger stable, the bus configuration, trigger mode setting and trigger level need to be adjusted.

- **Bus configuration**

  Tap S1 or S2 to open the bus configuration menu, as shown in Figure 13-4. The RX channel must be chosen and the following parameters must be set according to measured signals:

  Idle-level — Choose Idle Low or Idle High to match the idle state of measured equipment. For RS232, Idle Low may be chosen.

  Note: RS232 industry standard uses “negative logic”, namely high level is logic “0” and low level is logic “1”.

  Check — Choose odd, even or none depending on measured equipment.

  #Bits — Set the number of bits in UART word to match measured equipment (5-9 bits available).

  BaudRate — Choose the baud rate that matches signal in measured equipment.

  The baud rate can be set within the range from 1.2Kb/S to 8.000Mb/S.

  Display — Choose hexadecimal, binary or ASCII code display.

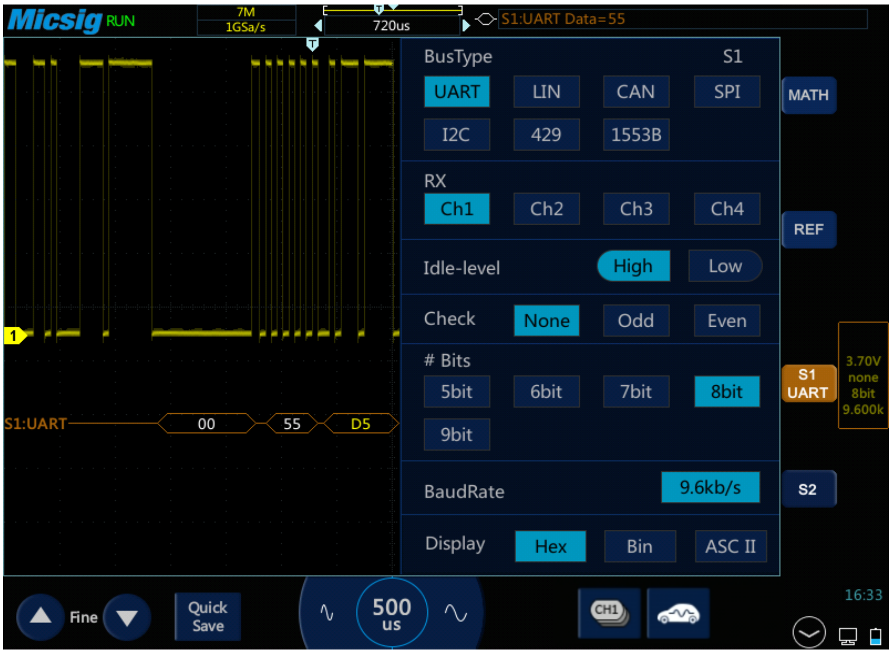


Figure 13-4 UART Bus Configuration Menu

When word is displayed in ASCII, 7-bit ASCII format is used. Valid ASCII characters are between 0x00 and 0x7F. To display in ASCII, at least 7 bits in the "#Bits" must be chosen. If ASCII is chosen and the data exceeds 0x7F, the data will be displayed in hexadecimal.

Click the baud rate setting box to open the baud rate selection column. If Custom is chosen, click to pop up the virtual soft keyboard, select the bit to be modified, enter value, and click "Enter" on the virtual soft keyboard to complete setting. The baud rate can be set from 1.2Kb/S to 8.000Mb/S. The virtual soft keyboard is shown in Figure 13-5:

Figure 13-5 Baud Rate Default Setting

Note: When there is parity bit, the data word length indicates the total length of data bit plus parity bit.

When there is no parity bit, the data word length is considered to be the length of data bit. For example, if the data word length is 8bit, when there is no parity bit, it means that the total length of data bits is 8bit; when there is parity bit, it means that the total length of data bits is 7bit, and there is parity bit of 1 bit.

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type; when choosing UART bus trigger, the trigger type, trigger relationship and trigger data need to be set, as shown in Figure 13-6:

Figure 13-6 Trigger Setting Menu

After selecting the trigger data, use the pop-up virtual keyboard to modify it, enter the value, and click “Enter” on the virtual soft keyboard to complete the setting.

UART trigger configuration menu description:

a) Start bit — trigger at the start bit of the measured signal;

b) Stop bit — trigger at the stop bit of the measured signal, no matter the measured signal uses 1, 1.5, or 2 stop bits or not, the trigger will occur at the first stop bit.

c) [data] — Trigger at the specified data bit, when measured signal data bits are effective as 5 to 8bits, select [data], and select the trigger relationship as” =“ “ >“ “ <“ “≠”, then select “Trigger Data”, press data on the touch screen, and use the pop-up virtual keyboard to modify;

d) [0:data] — the measured signal data bits is 9bits (the 9th bit is parity bit). Only when the 9th bit is 0, then trigger. The trigger relationship, trigger data configuration are the same as those of [data] trigger;

e) [1:data] — the measured signal data bits is 9bits (the 9th bit is parity bit). Only when the 9th bit is 1, then trigger. The trigger relationship, trigger data configuration are the same as those of [data] trigger;

f) [x:data] — the measured signal data bits is 9bits (the 9th bit is parity bit). No matter what the value of the 9th bit is, trigger at the designated data bit. The trigger relationship, trigger data configuration are the same as those of [data] trigger;

g) Parity Error — valid when there is parity check at parity bit, trigger while parity error.

- **UART serial decode**

The measured signal word length is 8bit; parity bit, none; baud rate, 19.2kb/s, hexadecimal; trigger mode as data bit:55; follow the steps as below:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

(2) Select the bus type as “UART”, click “Ch1”, “Idle High”, “Check None”, “8bit”, “19.20kb/s”, display “hexadecimal”, then close menu;

(3) Open the trigger mode setting menu, click “Data”, enter 55 manually, and press “enter” to confirm;

(4) Adjusting the threshold level according to the amplitude level of signal may make the signal to be stably triggered. The UART trigger graphic interface is shown in Figure 13-7:

Method 1: Click 

configuration information to open the decode channel threshold level adjustment box, and drag the adjustment box upward and downward to adjust the threshold level.

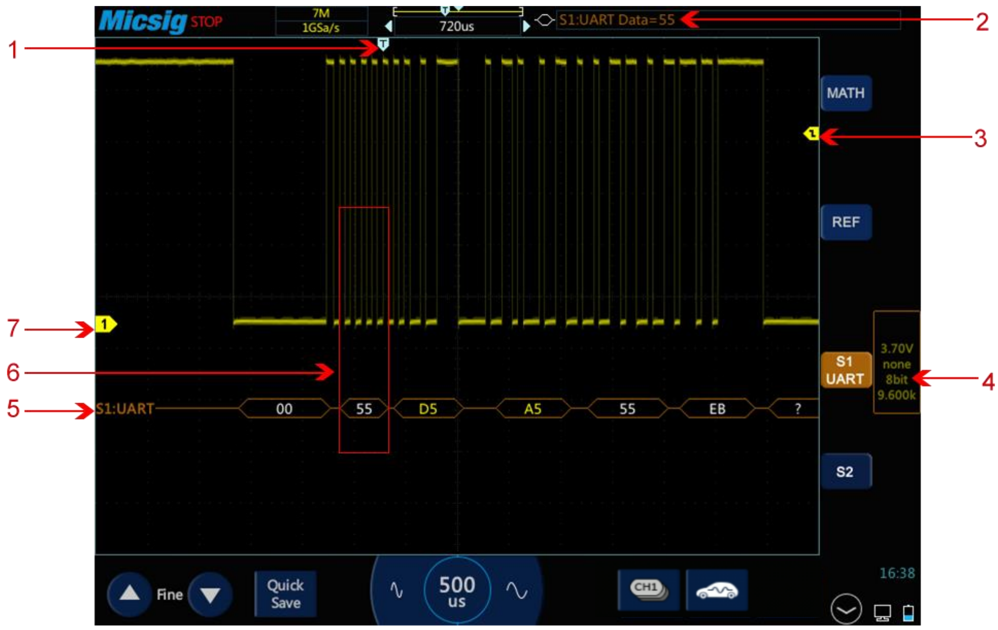


Figure 13-7 UART Graphic Interface

UART graphic interface description:

(1) Trigger position

(2) Trigger type

(3) Threshold level

(4) Configuration information

(5) Decode the data packet, detailed as follows

(6) Decode data and the corresponding waveform area

(7) Signal source Ch1

UART decode data packet description:

(1) Decode data packet displays real-time data about the bus activities;

(2) Decode data displays as hexadecimal system in white;

(3) When the word length is 5-8 bits, the decode data displays as two bits of hexadecimal; when the word length is 9 bits, the decode data displays as 3 bits of hexadecimal, and the 9th bit displays at the left side;

(4) When there is error in decode data, if the error is at stop bit, the data displays in yellow, if it is parity error, data displays in red;

(5) When “?” appears, the time base needs to be adjusted to view decode results.

Figure 13-8 UART Text Interface

UART text interface description, see Figure13-9:

(1) S1/S2/S1&S2 is channel configuration bus information.

(2) Area for decode data.

(3) ASCII code corresponding to the text data (when the data format is 9 bits and there is no parity bit, ASCII code corresponds to lower 8 bits of data on the left side).

(4) Counter: Calculates the total number of frames and the percentage of ERR (parity error and stop bit error) frames.

(5) Clear: Clear the counter data.

(6) Roller bar.

In the decode data area, the stop bit error data is displayed in yellow, and the decode error data is displayed in red;

13.2 LIN Bus Trigger and Decode

For correctly decoding LIN bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Press S1 or S2 to open the bus configuration menu, and the following need to be set according to measured signal:

Source — Select the signal source of decode.

Idle-level - high and low. Select whether to display high active or low active after the signal start bit of measured equipment.

BaudRate — Select the baud rate that matches the signal being measured, and it can be customized.

The setting method is the same as that of UART, and will not be repeated here. As shown in Figure 13-9:

Figure 13-9 LIN Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type. When the LIN bus trigger is selected, the trigger mode includes: Sync-Rising, Frame ID, ID + Data. See Figure 13-10:

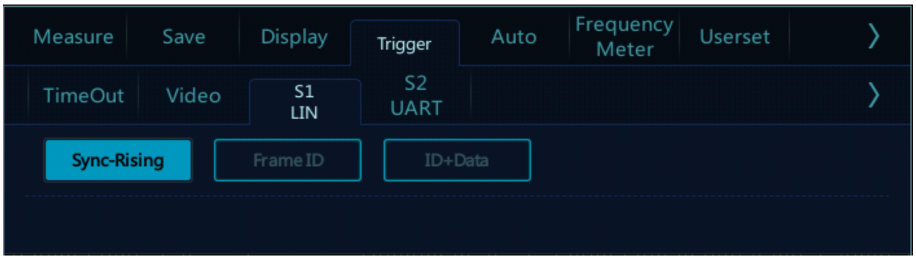


Figure 13-10 LIN Trigger Mode Configuration Menu

a) Sync-Rising – When the "Sync Interval" of LIN bus ends, the rising edge triggers.

b) Frame ID — Triggered when a frame with an ID equal to the set value is detected. Select "Frame ID", click data on the touch screen, and use the pop-up virtual keyboard to modify it.

c) ID + Data—triggered when a frame with ID and data equal to the set value is detected. After selecting "ID + Data", click ID or data, and set them.

- **LIN serial decode**

Ch1 is connected to measured signal. The idle level is high and the baud rate is 19.2 kb/s. The trigger mode is synchronous rising edge. Please follow these steps:

(1) Tap S1 to open the decode channel, and click again to open the bus configuration menu;

(2) Select the bus type as "LIN", click "Ch1", "Idle High", "19.20kb/s", and then close the menu;

(3) Open the trigger mode configuration menu and click "Sync-Rising";

(4) Click 

configuration information to open the decode channel threshold level adjustment box, and drag the adjustment box upward and downward to adjust the threshold level; adjust the threshold level according to the signal amplitude level to make the signal stably triggered. The LIN trigger graphic interface is shown in Figure 13-11:

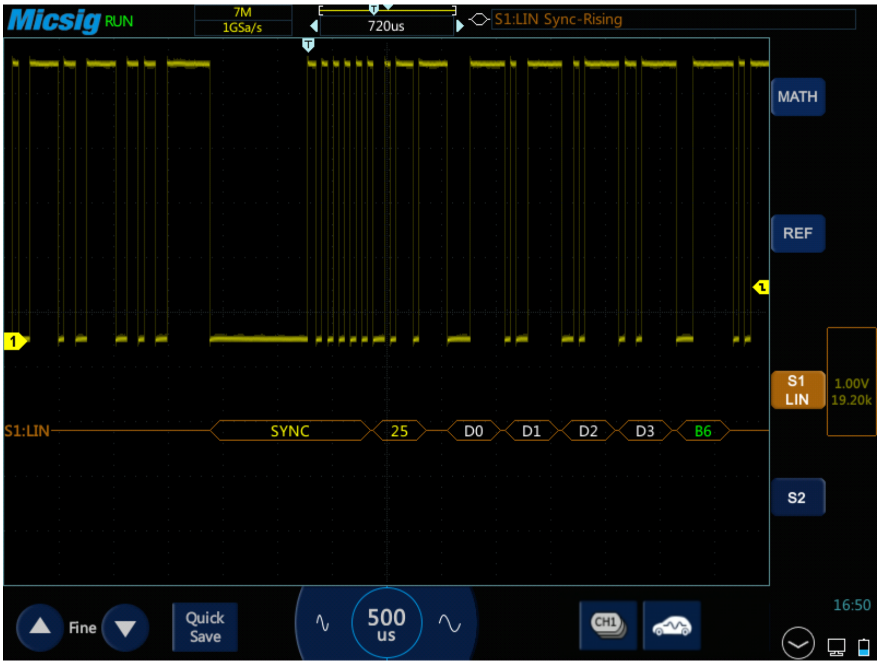


Figure 13-11 LIN Graphic Interface

LIN decode data packet description:

(1) Decode data packet displays real-time data about the bus activities.

(2) Decode data displays as hexadecimal system.

(3) “Frame ID” displays in yellow, “Data” displays in white, and “Parity sum” displays in green. If the parity sum has error, it is displayed in red “E”.

(4) When “?” appears, the time base needs to be adjusted to view decode results.

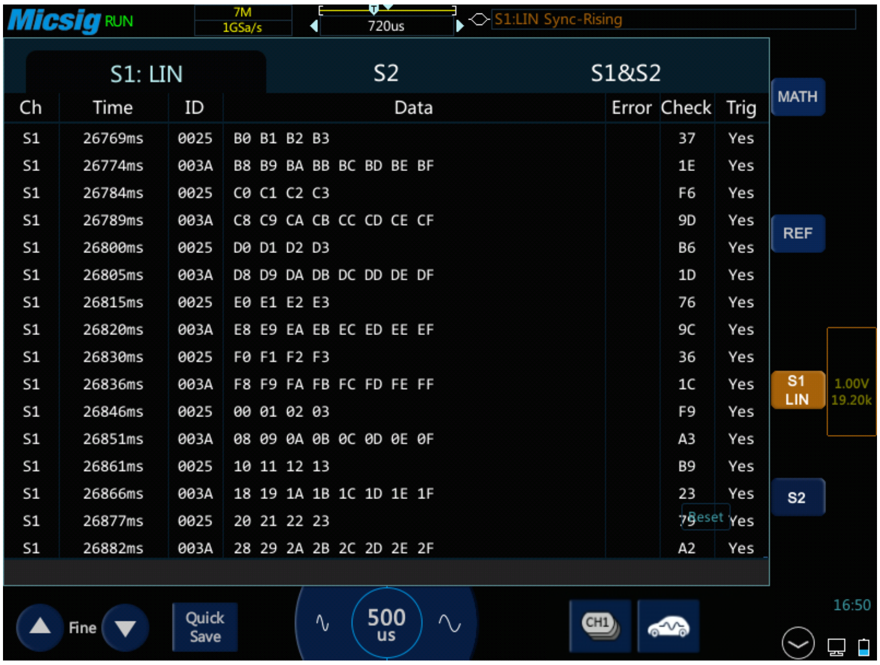


Figure 13-12 LIN Text Interface

LIN text interface description, as shown in Figure 13-12:

(1) "Ch": bus channel.

(2) "Time": Time intervals between the last frames to current frames.

(3) "ID": Frame ID value.

(4) "Data": Frame data.

(5) "Error Check": Frame parity sum, the sum of parity error displays in red.

(6) "Trigger": "Yes" means the frame reaches trigger condition.

(7) "Clear": Clear counter data.

13.3 CAN Bus Trigger and Decode

For correctly decoding CAN bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Tap S1 or S2 to open the bus configuration menu, the signal source needs to be set, and the signal type and baud rate are set according to measured signal; the setting method is the same as that of UART and will not be repeated here. See Figure 13-14:

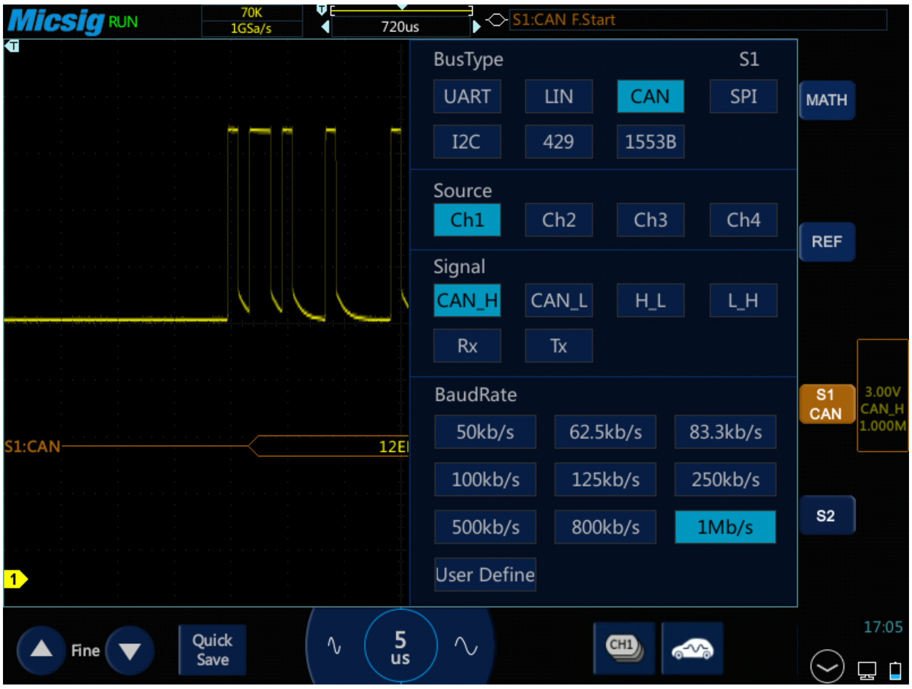


Figure 13-14 CAN Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type; when S1 CAN bus trigger is selected, as shown in Figure 13-15:

Figure 13-15 CAN Trigger Mode Configuration Menu

Trigger mode selection menu description:

a) F.start — trigger at the start of the frame;

b) Remote ID — setting the ID matches the remote frame trigger. After selecting the "Remote Frame ID", and then set the ID value at the bottom of the trigger data area

Operation description: Press the numbers on the touch screen and use the virtual keyboard to set;

c) Data ID — trigger on data frame that matches set ID. Data frame ID configuration mode is the same as the remote data frame ID configuration;

d) R/D ID — trigger on remote frame or data frame that matches set ID. Remote frame/data frame ID configuration is the same as the remote data frame ID configuration;

e) ID + data — trigger on data frame that matches set ID and data. The configuration method is the same as the remote frame ID configuration;

f) Wrong F. — trigger on CAN error frame;

g) All Error — trigger when there is any error in format or activity;

h) Ack Error — trigger on recessive (high) Ack position;

i) Over Load — trigger on CAN overload frame.

- **CAN serial decode**

Ch1 is connected to measured signal. The idle level is high and the baud rate is 1Mb/s; the Trigger mode is the frame start. Please follow these steps:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

(2) Select the bus type as "CAN", and then click "Ch1", "Idle High" and "1Mb/s". After setting, click the blank area to close the menu;

(3) Open the trigger mode configuration menu and click "F.Start";

(4) Adjust the threshold level according to the signal amplitude; the CAN trigger graphic interface is shown in Figure 13-16:

Figure 13-16 CAN Graphic Interface

CAN decode data packet description:

(1) Decode data packet displays real-time data about the bus activities.

(2) Decode data displays as hexadecimal system.

(3) “Frame ID” displays in yellow, “Data” displays in white, and “DLC” and “ CRC” codes display in green. If there is frame error, it is displayed in red “E”.

(4) When “?” appears, the time base needs to be adjusted to view decode results, and “!” indicates that the bus waveform corresponding to the decode data packet is incomplete and the data cannot be displayed correctly.

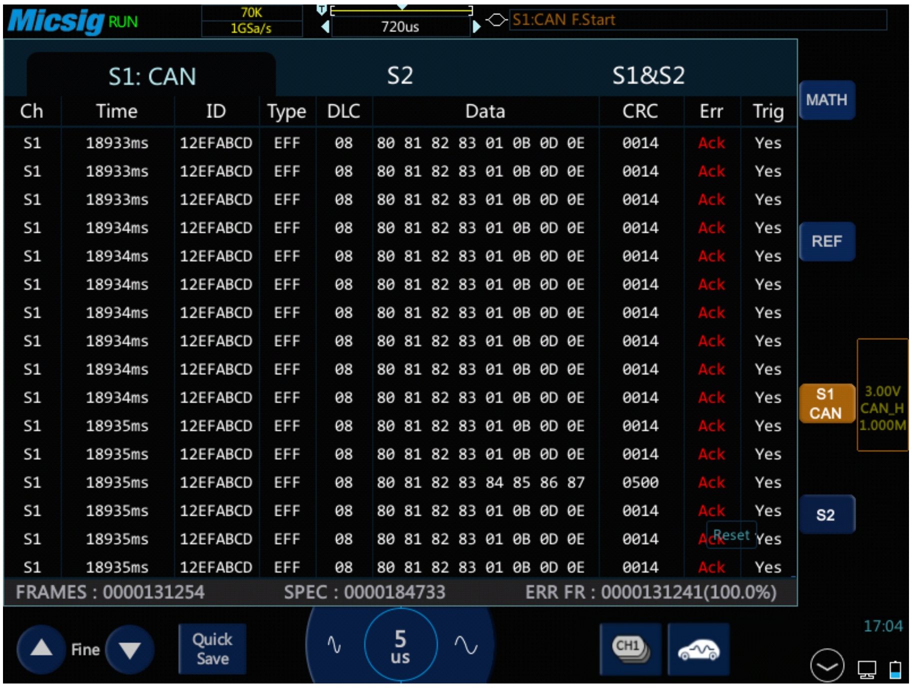


Figure 13-17 CAN Text Interface

CAN text interface description, as shown in Figure 13-17:

(1) “Ch”: bus channel.

(2) “Time”: Time intervals between the last frames to current frames.

(3) “ID”: CAN frame ID value displayed in hexadecimal, maximum 29 bits.

(4) “Type”: Frame type, “SFF” standard data frame, “SRF” standard remote frame, “EFF” extended data frame, “ERF” extended remote frame.

(5) “DLC”: Number of data bytes sent by this frame. This value can be ignored for remote frames.

(6) “Data”: Frame data.

(7) “CRC”: Frame CRC check code.

(8) “Err”: Response error, bit stuffing error, format error, CRC error.

(9) “Trig”: “Yes” means the frame reaches trigger condition.

(10) “Statistics”: counts the number of occurrences of frame type, data length, status, etc., and the percentage.

13.4 SPI Bus Trigger and Decode

For correctly decoding SPI bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Tap S1 or S2 to open the bus configuration menu, the following need to be set:

Clock source, data source, chip select signal, and data bits, as shown in Figure 13-18:

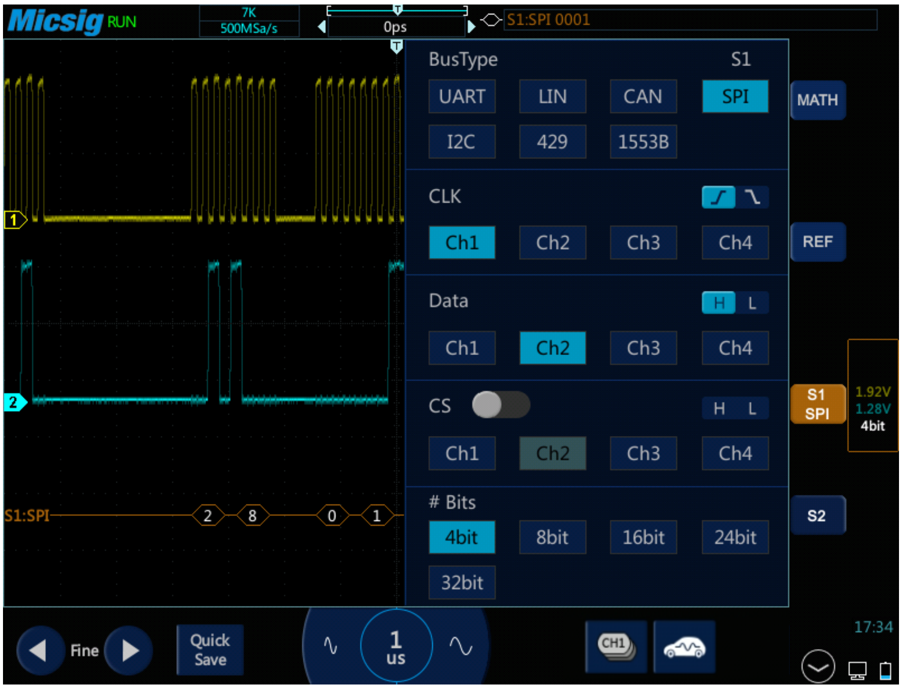


Figure 13-18 SPI Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type; when selecting the SPI bus trigger, as shown in Figure 13-19:

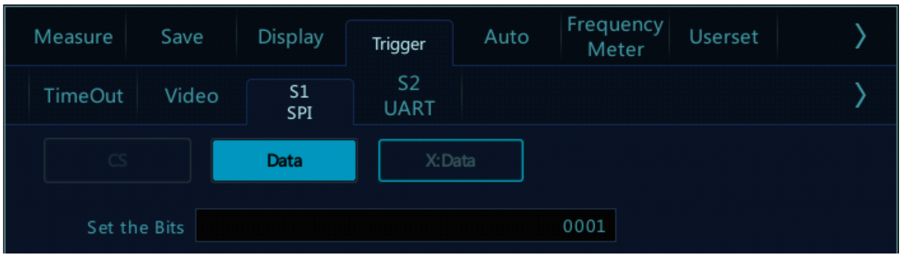


Figure 13-19 SPI Trigger Mode Configuration Menu

The operation method is the same as CAN frame ID to be matched in the configuration, and will not be repeated here.

Note: According to the data byte length set by bus decode, the value of the relevant bit within the byte length is set. Trigger when the corresponding bit on data bus matches the set value.

- **SPI serial bus**

The measured signal channel Ch1 is connected to CLK, Ch2 channel is connected to DATA, the bus idle state is high, the clock rising edge is sampled; the data word length is 4 bits; the CS chip select is off; the trigger mode matches the "Data" at 0001, please follow the steps below:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

(2) Select the bus type as "SPI", click clock as "Ch1" rising edge, the data is "Ch2" high level, and the data word length is "4bit";

(3) Open the trigger setting menu, click data on the touch screen, and use the virtual soft keyboard to set the data to be matched as "0001";

(4) Adjust the threshold levels of two channels according to signal amplitude; the SPI trigger graphic interface is shown in Figure 13-20:

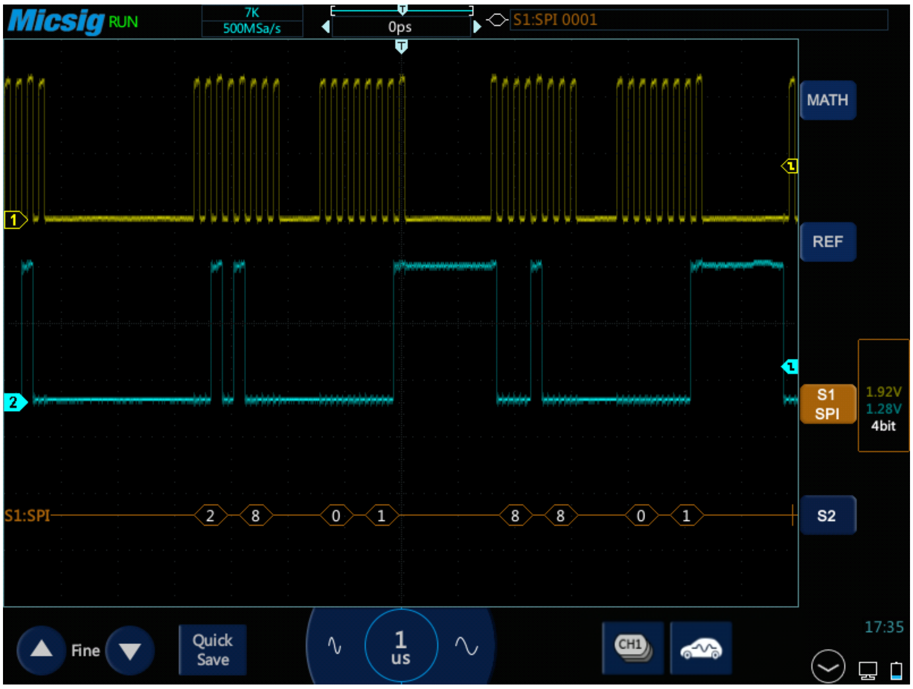


Figure 13-20 SPI Graphic Interface

SPI decode data packet description:

(1) Decode data packet displays real-time data about the bus activities.

(2) Decode data displays as hexadecimal system.

(3) Data displays in white.

(4) When "?" appears, the time base needs to be adjusted to view decode results.

Figure 13-21 SPI Text Interface

SPI text interface description, as shown in Figure 12-21:

(1) "Ch": bus channel.

(2) "Time": Time intervals between the last frames to current frames.

(3) "Data": According to the data word length setting, the decode data is displayed. For example, if the data word length is 8bit, only one byte displays in the data column; if the data word length is 16bit, 2 bytes display in the data column; if the data word length is 24bit, 3 bytes display; and if the data bits is 32bit, 4 bytes display.

(4) "Trig": "Yes" means the frame reaches trigger condition.

Note: "One frame" is measured by the set "data word length" and can meet 1 data bit code stream.

13.5 I2C Bus Trigger and Decode

For correctly decoding I2C bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Tap S1 or S2 to open the bus configuration menu, Bus configuration includes the serial clock (SCL) and the serial data (SDA) corresponding to the channel settings. See Figure 13-22:

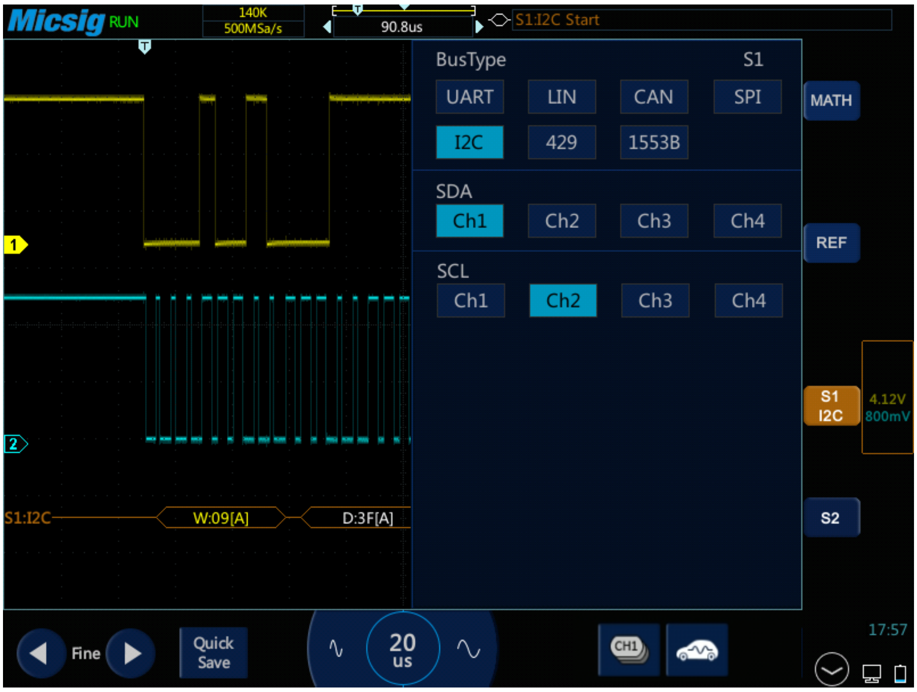


Figure 13-22 I2C Bus Configuration Menu

Notes: When SCL or SDA channel is set, the system will automatically set other channels.

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type. When the I2C bus trigger is selected, click the trigger type and relationship on the screen, as shown in Figure 13-23:

Figure 13-23 I^2C Trigger Mode Configuration Menu

Trigger mode menu description:

a) Start — trigger when SCL is high and SDA has a falling edge (includes restart).

b) Stop — trigger when SCL is high and SDA has a rising edge.

c) LostAck — Trigger when the bus Ack bit is high.

d) Restart — triggered when a new start condition occurs before the stop condition.

e) NoACKInAdr — trigger when the ack bit in the set address field is invalid (ignoring W/R bit), select "Address" in the trigger data, and use the pop-up virtual soft keyboard to modify it.

f) Frame 1 - Start + Address 7 + Read/Write + Acknowledge + Data; if all bits in the frame type match, trigger on read/write frames in 7-bit addressing mode on the 17th clock edge.

   Frame type 1 operation method: Select values after the address/data, click values after the address/data on the touch screen, and modify them on the pop-up virtual soft keyboard.

g) Frame 2 — Start + Address 7 + Read/Write + Acknowledge + Data 1 + Acknowledge + Data 2; trigger on read/write frames in 7-bit addressing mode on the 26th clock edge if all bits in the frame type match. The operation method of configuring frame type 2 is the same as frame type 1, and will not be repeated here.

h) RomData - When the read operation which contains 1010xxx control byte of the EEPROM appears on the bus and the Ack bit is correct, then the read data can be captured. If the captured data and the set data match the set relationship condition, trigger on the clock edge of Ack bit after the data byte. After selecting "EEPROM Data Read", click the relationship by "=" " >" "<" " ≠", and the setting method is the same as the address field.

i) 10WriteFrame - Trigger on 10-bit write frame on the 26th clock edge if all bits in the pattern match.

Trigger mode is start condition, SCL connect to Ch2, SDA connect to Ch1, follow these steps as below:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

(2) Select the bus type as "I2C", open the bus setting menu, and select the clock SCL as Ch2 channel;

(3) Open the trigger mode configuration menu and click "Start Condition" on the touch screen.

(4) Set the threshold level of two channels according to signal amplitude; I2C trigger graphic interface is shown in Figure 13-24:

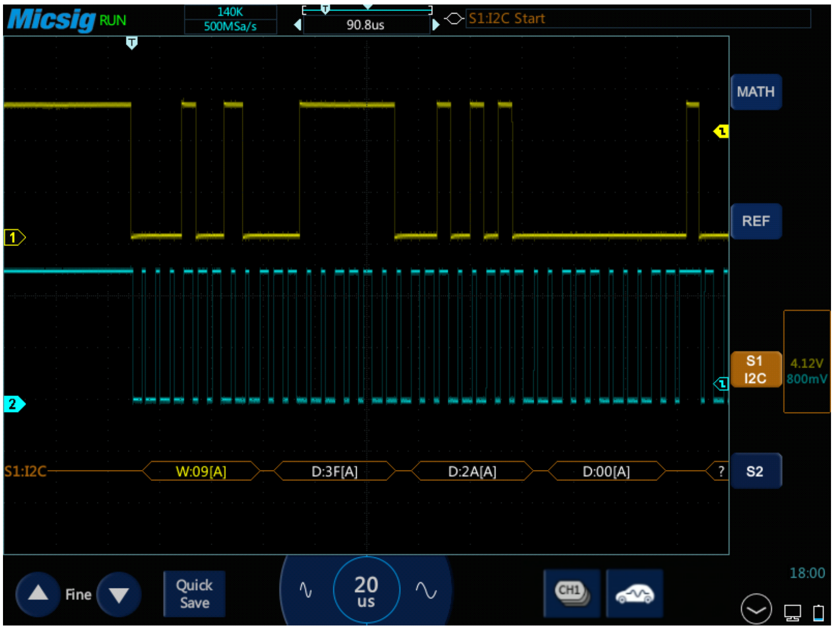


Figure 13-24 I^{2}C Graphic Interface

I2C decode data packet description:

(1) Decode data packet displays real-time data about the bus activities.

(2) Decode data displays as hexadecimal system.

(3) Address content display: Read address displays in green, write address displays in yellow, and data displays in white. "W" denotes write operation, "R" denotes read operation, "D" denotes decode data, and "~A" denotes no Ack bit.

(4) When "?" appears, the time base needs to be adjusted to view decode results.

Figure 13-25 I2C Text Interface

I2C text interface description, as shown in Figure 13-25:

(1) "Ch": bus channel.

(2) "Time": intervals between the last read/write operations to current read/write operations

(3) "Addr": in address bar, "R" means the read operation, and "W" means write operation

(4) "Data": data sent by one read and write operation is in the data bar.

(5) "Ack": in Ack bar, "X" means Ack bit lost.

(6) "Trigger": "Yes" means reach trigger condition.

(7) "Restart": "Yes" means reach restart condition.

13.6 ARINC429 Bus Trigger and Decode

For correctly decoding ARINC429 bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Tap S1 or S2 to open the bus configuration menu, the following needs to be set:

Data Source — Select channel for ARINC 429 signal.

Word format — Select ARINC 429 decode mode.

Bus Display — Set the format for ARINC 429 decode data.

Baud Rate — Set the speed of ARINC 429 signal.

As shown in Figure 13-26:

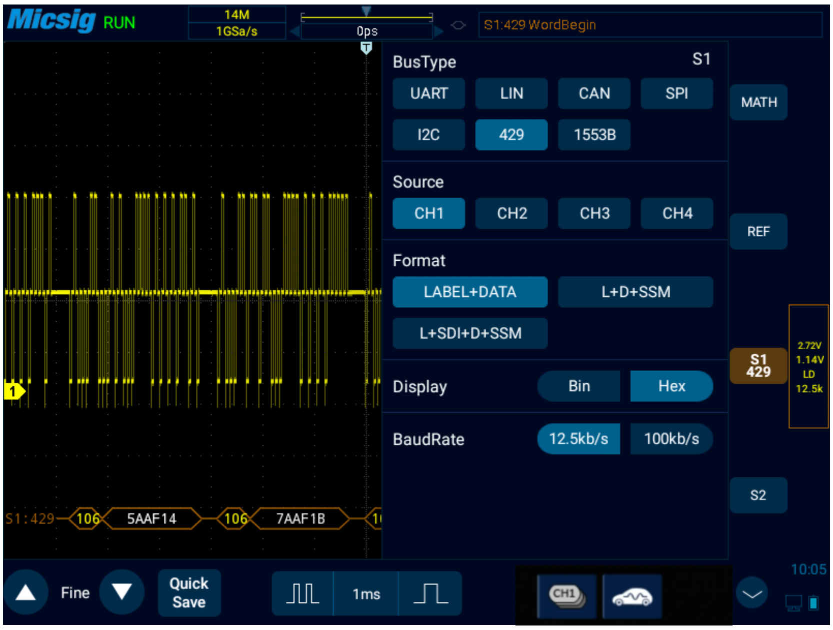


Figure 13-26 ARINC429 Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type; when the ARINC429 bus trigger is selected, click the trigger type and relationship on the screen, as shown in Figure 13-27:

Figure 13-27 ARINC429 Trigger Mode Configuration Menu

If LABEL, SDI (source identifier), DATA or SSM (symbol/status mark) trigger are used, after selecting trigger mode, use the pop-up virtual keyboard to modify it, enter the value, and click “Enter” on the virtual soft keyboard to complete the setting.

Trigger configuration menu description:

a) WordBegin: Trigger at the word start.

b) WordEnd: Trigger at the word stop.

c) Label: Label, triggered when the specified tag value occurs.

d) SDI: Source identifier, triggered on the specified source terminal.

e) Data: Trigger on the specified data.

f) SSM: Symbol/status mark, triggered on the specified symbol status matrix.

g) Label+SDI: Trigger on the specified label and the specified source terminal.

h) Label+Data: Trigger on the specified label and the specified data.

i) LABEL+SSM: Trigger on the specified label and the specified symbol status matrix.

j) Word Err - Triggered when a word error occurs.

k) Gap Err: Triggered when a gap error occurs.

l) Parity error: Triggered when a verification error occurs.

m) All Err: Triggered when any of the above errors occur.

n) All 0: Triggered when any bit with the value of zero occurs.

o) All 1 -: Triggered when any bit with the value of 1 appears.

- **ARINC 429 serial decode**

The measured signal source is CH1, the decode format is LABEL+DATA, the display is in hexadecimal, the baud rate is 12.5kb/s, and the trigger mode is LABEL, operate as follows:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

Select bus type “429”, source as “CH1”, decode format as “Label+Data”, display in “hexadecimal”, baud rate as 12.5kb/s.

(2) Open the trigger setting menu, select the trigger type as bus trigger, S1-ARINC429, the trigger mode is LABEL, and enter LABEL as “106” on virtual keyboard.

Adjust **High trigger threshold level** and **Low trigger threshold level** according to signal amplitude; and ARINC429 trigger graphic interface is shown in Figure 13-28:

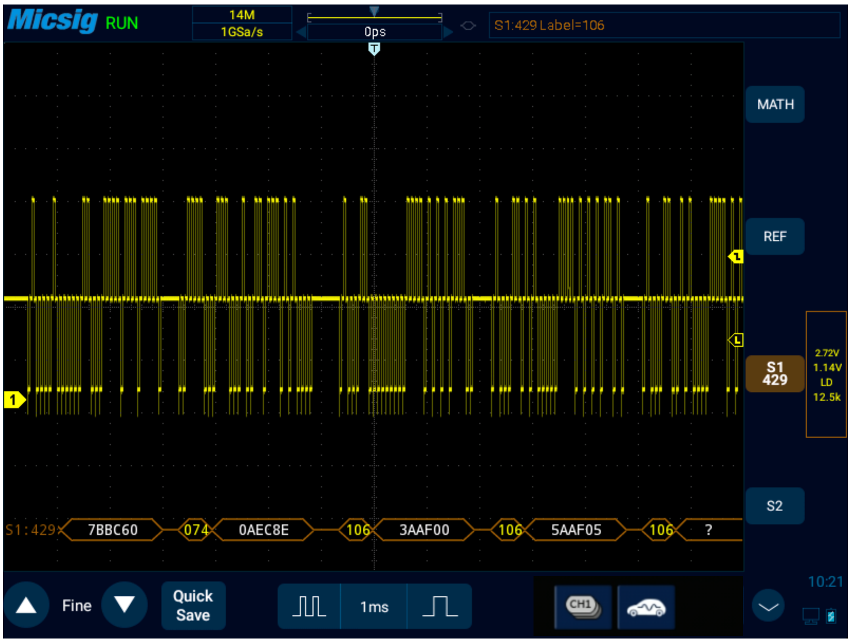


Figure 13-28 ARINC429 Graphic Interface

ARINC429 decode data packet description:

(1) Data packet, a total of 32bits, the data format is 8~1 (label bit, high bit first) +9~10(SD) +11~29 (data bit, low bit first) +30~31 (symbol status bit) +32 (parity bit)

(2) Label (8bits) - Displayed in octal: yellow

(3) SDI (2bits) - Displayed in binary: blue

(4) Data (19bits) - Displayed in selected numeration system: white, or red if there is parity error

(5) SSM (2bits) - Displayed in binary: green

Figure 13-29 ARINC429 Text Interface

ARINC429 text interface description, as shown in Figure 13-29:

(1) “Ch”: bus channel.

(2) “Time”: intervals between the last read/write operations to current read/write operations

(3) “LABLE”: label, information identifier, displayed in octal.

(4) “SDI”: source/target identifier, displayed in binary (displays XX if not identified separately).

(5) “Data”: content of the transmitted information, displayed in the selected numeration system.

(6) “SSM”: symbol/status matrix, displayed in binary (displays XX if not identified separately).

(7) “Error”: displays the frame error type (parity error Par, frame error Frm).

(8) “Trigger”: “Yes” means reach trigger condition.

13.7 1553B Bus Trigger and Decode

For correctly decoding 1553B bus data and making trigger stable, the bus configuration, trigger mode set and trigger level need to be adjusted.

- **Bus configuration**

Tap S1 or S2 to open the bus configuration menu, the data source and display hexadecimal need to be set, as shown in Figure 13-30:

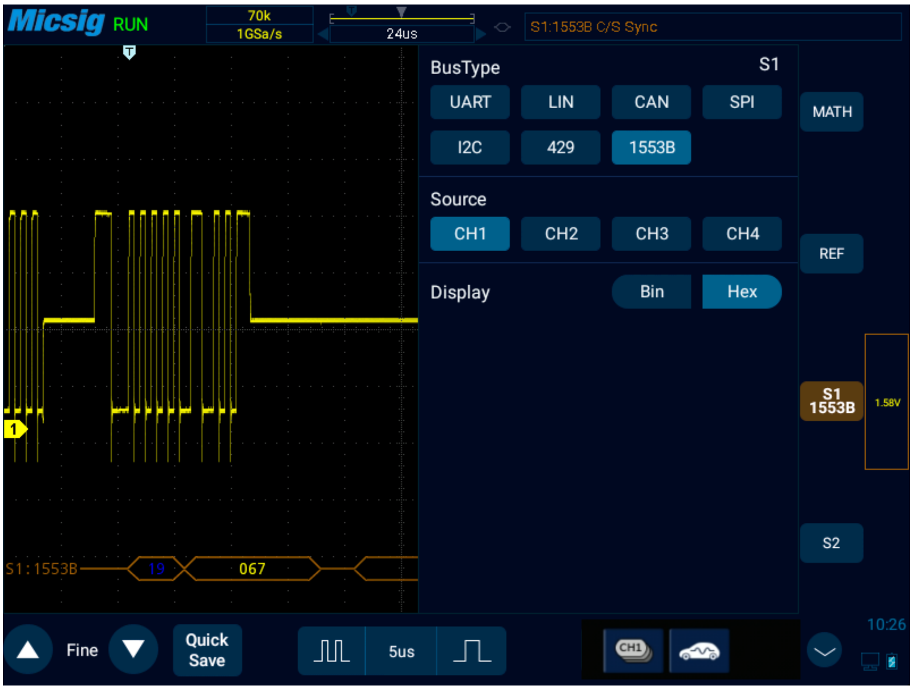


Figure 13-30 1553B Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type. When the trigger type is 1553B bus trigger, click the trigger type on the screen, as shown in Figure 13-31:

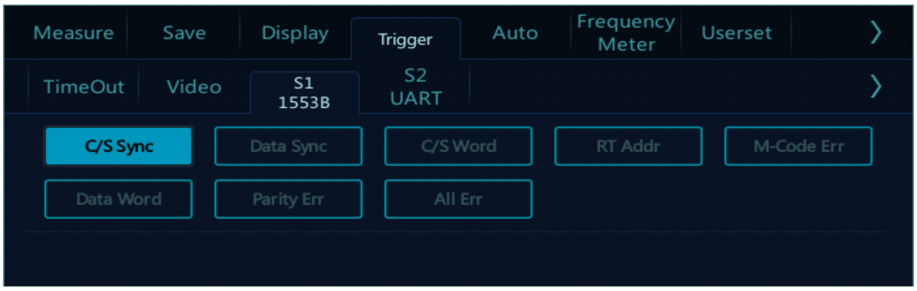


Figure 13-31 1553B Trigger Mode Configuration Menu

Trigger configuration menu description:

a) Command/status word sync header: Triggered at the beginning of the command/status word (at the end of valid C/S sync pulse).

b) Data word sync header: Triggered at the beginning of data word (at the end of valid data sync pulse).

c) Command/status word: Triggered when the specified command/status word is detected.

d) Remote terminal address: Triggered when RTA of command/status word matches the specified value.

e) If you select this option, RTA softkey will be available, allowing you to select the hexadecimal remote terminal address value to be triggered on it. If you select 0xXX (irrelevant), oscilloscope will trigger on any RTA.

f) Manchester coding error: Triggered when a Manchester coding error is detected.

g) Data word: Triggered when the specified data word is detected.

h) Odd parity error: Triggered when the odd parity bit is incorrect for data in the word.

i) All errors: Triggered when an error is detected.

- **1553B serial decode**

The measured signal source is CH1, the bus display is hexadecimal, the baud rate is 12.5kb/s, and the trigger mode is the command/status word sync header, and operate as follows:

(1) Tap S1 to open the decode channel, and click S1 again to open the bus configuration menu;

(2) Select the bus type as “1553B”, source as “CH1’, and display in “hexadecimal”.

(3) Open the trigger setting menu, select the trigger type as bus trigger, 1553B, and trigger mode as “command/status word sync header”.

Channel **threshold level** is adjusted according to signal amplitude. 1553B trigger graphic interface is shown in Figure 13-32:

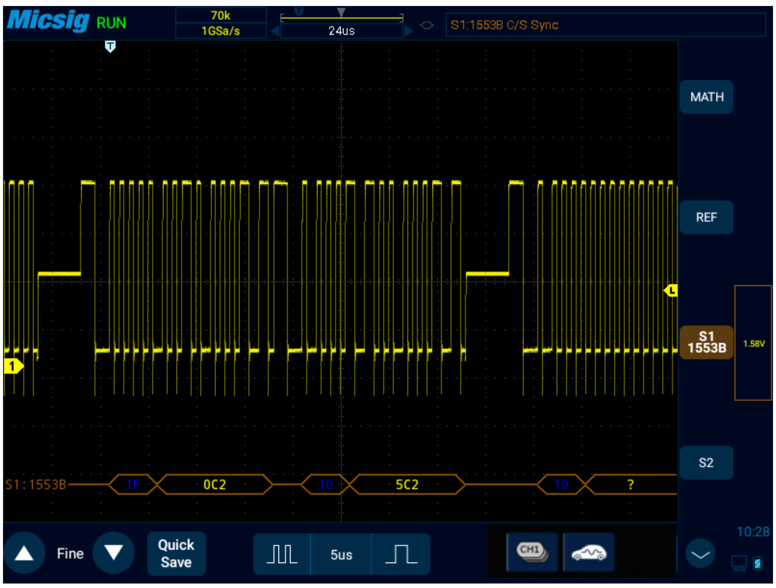


Figure 13-32 1553B Graphic Interface

1553B decode data packet description:

(1) Remote terminal address (5-bit data): blue

(2) The value of remaining 11 bits of the command/status word: yellow

(3) Decoded data: white

(4) If the command/status or data word has a parity error, its decoded text is displayed in red instead of green or white.

(5) The sync error is displayed together with the word “SYNC”.

Figure 13-33 1553B Text Interface

1553B text interface description, as shown in Figure 13-33:

(1) “Ch”: bus channel.

(2) “Time”: intervals between the last read/write operations to current read/write operations.

(3) “Type”: frame type (data frame DATA, command/status frame C/S, others N/A).

(4) “RAdr”: remote terminal address, displayed in the selected numeration system (N/A for no content display).

(5) “Data”: content of the transmitted information, displayed in the selected numeration system.

(6) “Trigger”: “Yes” means reach trigger condition.

(7) “Error”: displays the frame error type (parity error Par, Manchester coding error M-ch).

Chapter 14 Remote Control

This chapter mainly covers the application of the host computer, FTP and SCPI commands in order to understand the remote control function of the ATO oscilloscope.

- Host computer (PC)
- Remote control
- FTP
- SCPI commands

14.1 Host Computer (PC)

To control the instrument using the host computer software, you need to install the NI driver first (**when there is network connection, this may not be installed**), then the RemoteDisplay software is downloaded and installed. This software is suitable for Micsig ATO1000 Series oscilloscopes.

14.1.1 Installation of Host Computer Software

Note: The host computer software only supports Win7 or higher edition operating system. The computer needs to install NI-VISA driver first. (when there is network connection, only the host computer software specific for network connection should be installed, and no drive is needed).

The host computer download address http://www.micsig.com/html/list_64.html.

Driver download address http://www.ni.com/download/ni-visa-16.0/6184/en/..

Download the host computer software on official website of Micsig, open RemoteDisplaySetup.exe file, and complete the software installation.

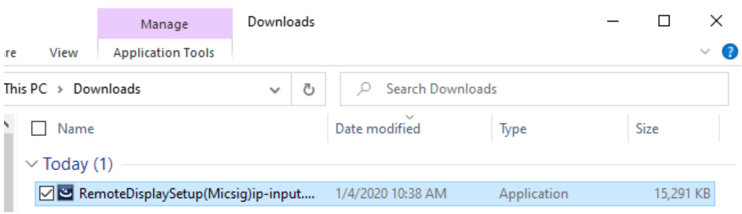


Figure 14-1 RemoteDisplay Software

14.1.2 Connection of Host Computer

USB connection: Connect USB Device to the computer and oscilloscope through USB data cable. After the computer recognizes the USB device, open the host computer, set the connection mode to USB 

, and display the device information in the device information display box in the lower right corner. This indicates that the oscilloscope has been found. Click to connect to the selected oscilloscope.

WIFI connection: Under the oscilloscope settings →WLAN menu, choose and connect the same WIFI with the computer to ensure that **the computer and the oscilloscope are in the same network**. Open the host computer, set the connection mode to Net 

, and display the device information in the device information display box in the lower right corner. This indicates that the oscilloscope has been found. Click to connect to the selected oscilloscope.

Enter IP connection: In case of network connection (WIFI or LAN), directly type oscilloscope IP to be connected in the oscilloscope device information display box in the lower right corner, and then click the oscilloscope connection status button, the host computer will be connected to the oscilloscope corresponding to the entered IP address.

14.1.3 Main Interface Introduction

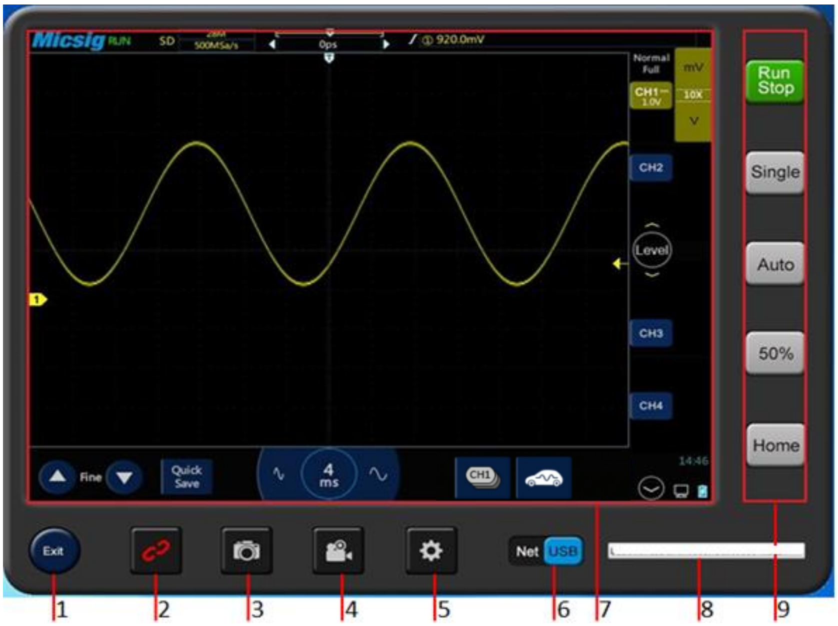
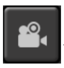


Figure 14-2 Host Computer Interface

1.Host computer on/off button	Click to exit the host computer software
2  Oscilloscope connection status button	The button has two states: Green: Connect to selected oscilloscope when clicked Red: Disconnect from oscilloscope when clicked
3.Quick camera button	Click to take photo quickly. Pictures are stored in the local directory C:\Users\Public\Pictures
4.Video record button	Click to open or close video record function. Videos are stored in local directory C:\Users\Public\Videos
5.Host computer storage button	Set photo taking and video recording storage locations
6.Select oscilloscope connection mode	USB and WIFI connections are available **Note: WIFI connection must ensure that oscilloscope and computer are in the same network**
7. Host computer display area	Synchronous display with oscilloscope
8. Oscilloscope information display	Display oscilloscope model, connection mode, SN, IP and other information, select the oscilloscope to be connected

9. Host computer waveform control area	Waveform control area button has the same function with that button on the oscilloscope

14.1.4 Operation Interface Introduction

The host computer and the oscilloscope are synchronously displayed, and the waveform operation mode and the menu opening and closing mode are the same as those on the oscilloscope; the left mouse button and the single finger operation mode are the same, and both of them can perform the operations of slide, click, drag, etc.; the biggest difference of host computer and oscilloscope is the scroll wheel operations, which can move waveform and cursor, adjust trigger level, and horizontal time base.

Scroll wheel operation introduction:

1. Operate the scroll wheel on the waveform display to move the **current** waveform;
2. After opening the cursor, operate the scroll wheel to move the **current** cursor;
3. Click the trigger level button, and operate the scroll wheel to adjust the trigger level.
4. Put the mouse in the time base adjustment area 

and adjust the horizontal time base by operating the scroll wheel;

14.1.5 Storage and View of Pictures and Videos

Storage setting of pictures and videos:

Open the host computer storage setting , set the storage location of pictures and videos, as shown in the figure below:

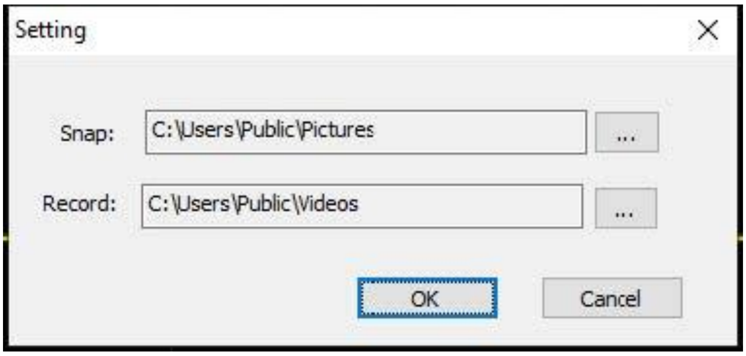


Figure 14-3 Host Computer Storage Setting

Pictures are stored in the local directory C:\Users\Public\Pictures by default. We can also store them under the directory defined by ourselves according to our own needs. For example, we store pictures in a “mini photo” directory under E-drive disk. We can set the video storage location in the same way, then click OK.

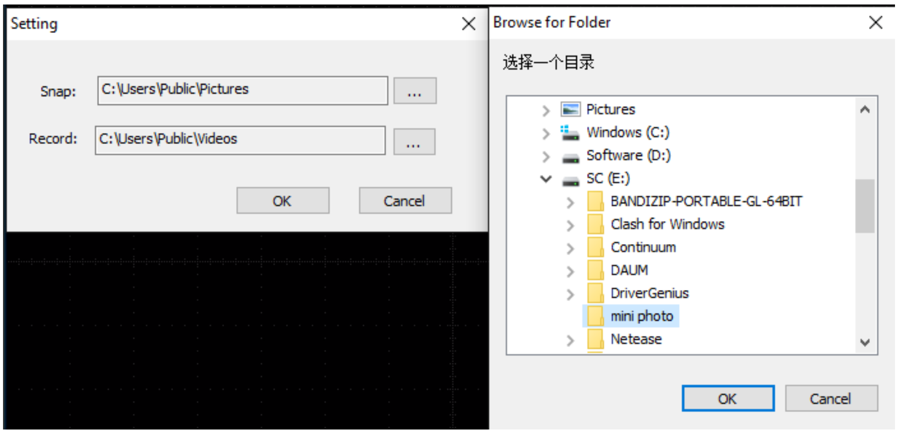


Figure 14-4 Change Storage Directory

View pictures and videos:

Open picture (video) storage directory to view pictures (videos) stored on the host computer.

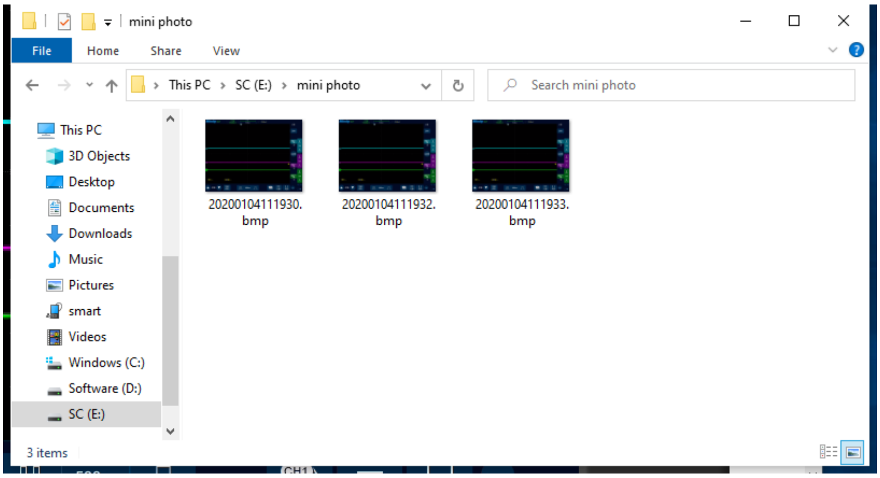


Figure 14-5 View Pictures

14.2 Mobile Remote Control

Micsig ATO1000 series oscilloscopes support remote control on mobile phone. You need to download Android app from the official website of Micsig (address: http://www.micsig.com/html/list_64.html) and install it. After App is successfully connected, Android device can be used to control the oscilloscope and display the oscilloscope interface in a real time manner.

Figure 14-6 Android APP

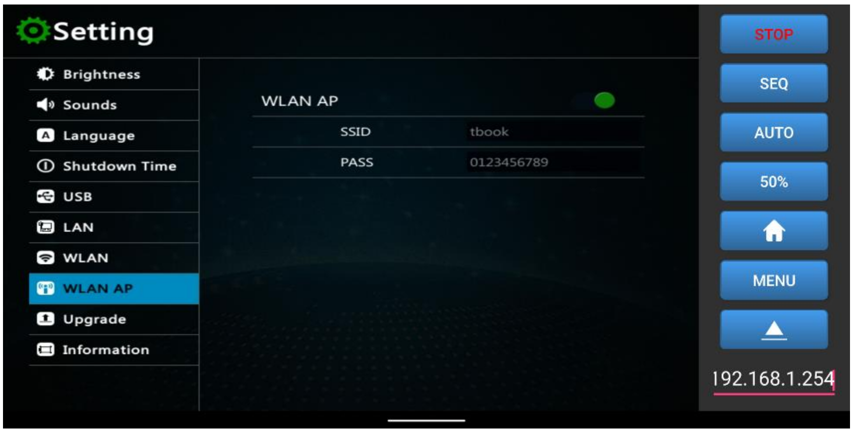


Figure 14-7 Successful Connection of Android APP

Android APP can be connected by two methods:

1. Use oscilloscope portable hotspot: Mobile phone can be connected to the hotspot of oscilloscope. Enter the oscilloscope IP 192.168.1.254 in the IP box at the lower right corner of the screen to connect successfully for control;

2. Connect mobile phone and oscilloscope to the network segment under the same router: view the IP address of the oscilloscope, and enters such IP address in the lower right corner of the mobile phone to connect successfully.

   The first connection method is recommended.

14.3 FTP

Through FTP, internal files of oscilloscope can be quickly viewed, called and managed from PC or mobile phone. The tBook mini series oscilloscopes can open FTP via WIFI, oscilloscope portable hotspot, LAN, etc.

WLAN

Turn on WLAN on oscilloscope (refer to 12.4 Settings - WLAN Connection), check and ensure that PC and oscilloscope are in the same network. Input the IP address (FTP:// IP address) displayed on the oscilloscope, and then connect.

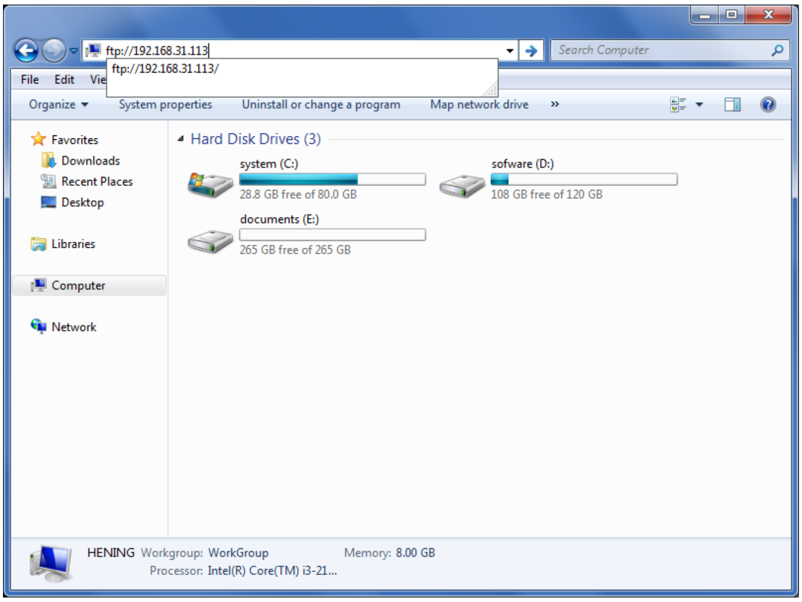


Figure 14-8 FTP Address Input

Enter the username and password of FTP server. The default username and the password are "ftp". Click Login, and view, call or manage files in the oscilloscope after successful login.

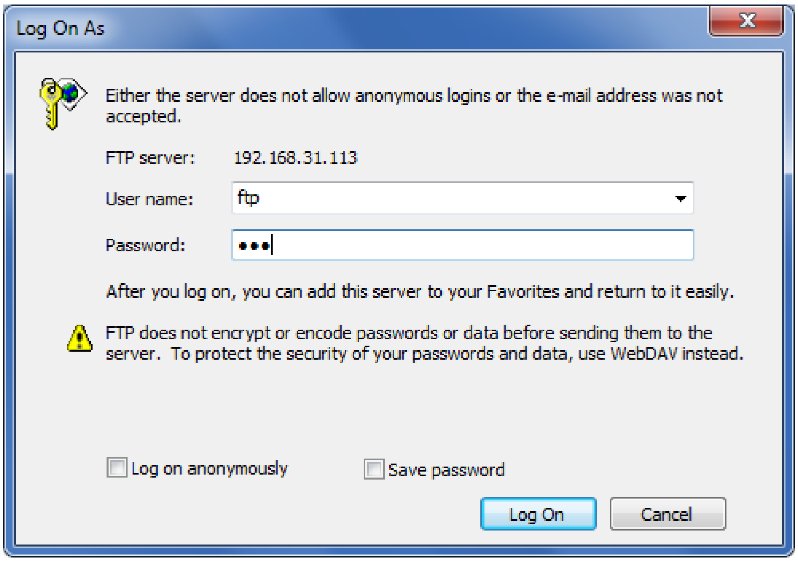


Figure 14-9 FTP Login

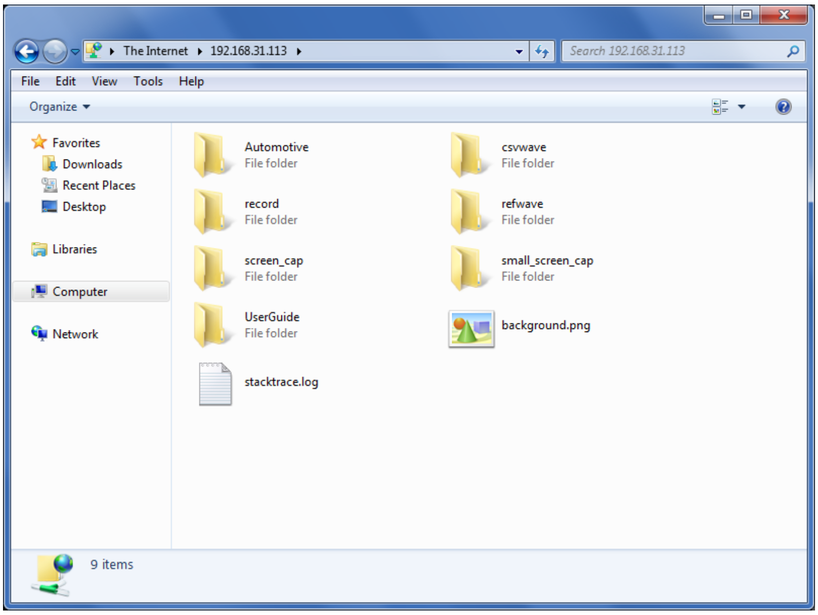


Figure 14-10 View Files

WLAN AP

Open the WLAN AP on oscilloscope (refer to [12.3 Settings - WLAN AP]), connect PC to theWLAN AP of oscilloscope, Enter oscilloscope IP address on PC (ftp://IP address), the default IP is 192.168.1.254. Then connect to FTP server and enter the username and password. The default username and the password are "ftp". Click Log in, and view, call or manage files in the oscilloscope after successful login.

Tip: The connection method is the same as WLAN connection.

LAN

Connect to the FTP function through LAN. For details, refer to WLAN connection and portable hotspot connection.

Mobile phone connection

To connect to FTP via mobile phone, download and install relevant file browser first, such as ES file browser. Check and make sure oscilloscope and mobile phone are connected to the same network. Enter oscilloscope IP address, account number and password through the ES browser. Click OK to log in, and then manage files on the oscilloscope.

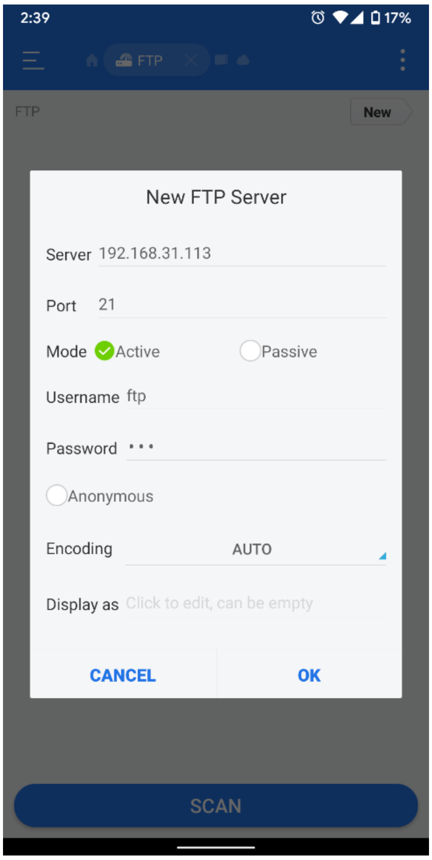


Figure 14-11 Mobile Phone Login

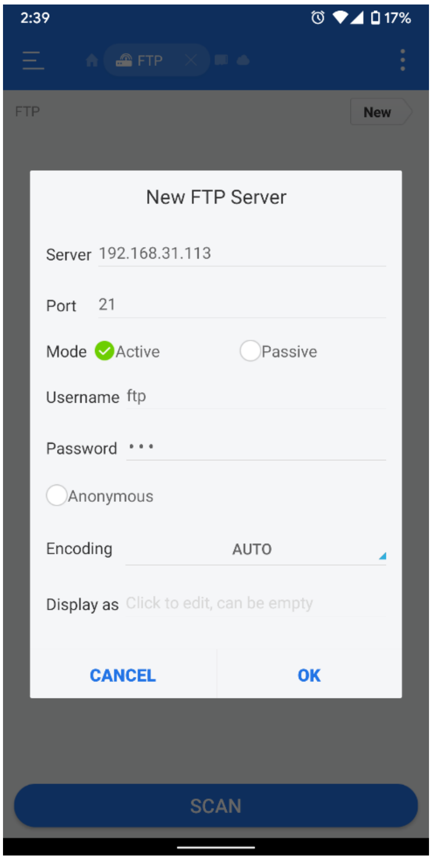


Figure 14-12 View Files

14.4 SCPI

SCPI is the abbreviation for Standard Commands for Programmable Instruments. SCPI is a standardized instrument programming language based on the existing standards IEEE 488.1 and IEEE 488.2, and observes floating-point arithmetic rules in IEEE754 standard, information exchange 7-bit code symbol in ISO646 (equivalent to ASCII programming) and other standards. SCPI commands show a tree hierarchy consisting of multiple subsystems, each of which is made up of a root keyword and one or several hierarchical keywords.

SCPI command can be used to programmatically control ATO1000 Series digital oscilloscopes via the USB interface. ATO1000 Series may communicate with computer through USB device.

Note: For more details, the ATO1000 series oscilloscope commands can be downloaded from the official website of Micsig.

Chapter 15 Reference

15.1 Measurement Category

Oscilloscope measurement category

ATO oscilloscope is mainly used for measurement 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.

Measurement category II is for measurements performed on circuits directly connected to the low voltage installation. Examples are measurements on household appliances, portable tools and similar equipment.

Measurement category III is for measurements performed in the building installation. Examples are measurements on distribution boards, circuit-breakers, wiring (including cables, bus-bars, junction boxes, switches, socket-outlets) in the fixed installation, and equipment for industrial use and some other equipment, for example, stationary motors with permanent connection to the fixed installation.

Measurement category IV is for measurements performed at the power source of the low-voltage installation. Examples are electricity meters and measurements on primary overcurrent protection devices and ripple control units.

Transient withstand capability

⚠ Maximum input voltage of the analog input

Category I 300Vrms, 400Vpk.

15.2 Environmental conditions

Environment	Both indoor and outdoor
Ambient tem.	0°C to +40°C when working; -30°C to +70°C when not working.
Humidity	Working: 50% to 95% RH at 40°C within 5 days. Non-working time: 90%RH at 65℃ within 24 hours
Altitude	Maximum operating altitude: 3,000 meters (9,842 feet)
Overvoltage cat.	This product should be powered by a mains power source that complies with overvoltage category II, which is a typical requirement for equipment connected via power cords and plugs.
Pollution degree	ATO series oscilloscopes can work in an environment with pollution degree 2 (or pollution degree 1).

Pollution degree category	Pollution degree 1: No pollution or only dry non-conductive pollution. This degree of pollution has no effect. For example: a clean room or a temperature-controlled office environment. Pollution degree 2: Usually refers to only dry, non-conductive pollution occurs. Sometimes temporary conduction due to condensation may occur. For example: general indoor environment. Pollution degree 3: Conductive pollution occurs, or dry non-conductive pollution, which becomes conductive due to condensation. For example: a sheltered outdoor environment. Pollution degree 4: Permanent conductive pollution caused by conductive dust, rain or snow. Such as outdoor places.

15.3 Software and Firmware Updates

Micsig often releases software and firmware updates for its products. To search for the firmware update for your oscilloscope, please download it from the website (download address of the latest upgrade package: http://www.micsig.com/html/list_60.html)

To view the currently installed software and firmware, click "setting" in "homepage" to display the software and firmware information of oscilloscope in the system.

Refer to "12.4 setting" for detailed software and firmware update steps.

Chapter 16 Troubleshooting

1. **If the oscilloscope does not start up at power on, please follow steps below:**
   - Check the power cord to verify whether it has been connected properly and whether the power supply is normal;
   - Check the power on/off buttons to ensure it has been pushed, and if you are using battery, check whether the battery is in good condition;
   - Restart the oscilloscope after the checks above;
   - Contact Micsig if the problem persists, and we will provide service to you.
2. **If acquired waveforms do not display on the screen when the signal source is connected, please follow the steps below:**
   - Check whether the probe is connected correctly in the BNC socket;
   - Check whether the probe is connected correctly in the signal source;
   - Check whether the trigger type is correctly selected;
   - Check whether trigger conditions are set correctly
   - Check whether signal source is working properly;
   - Check whether the channel is turned on;
   - Check whether the vertical scale factor is set correctly;
   - Check whether the instrument is in single-sequence waiting state for trigger
   - Tap 

 to resample signal.
3. **If the measured voltage amplitude is 10 times greater or smaller than the actual value:**
   - Check whether the set attenuation factor of the channel is consistent with the attenuation factor of the actually used probe.
4. **There is a waveform display, but cannot be stable:**
   - Check the trigger source on the trigger type menu to ensure that it is consistent with the actually used signal channel;
   - Check the trigger type: edge trigger is adopted for general signal, and video trigger mode for video signal. Only the correct trigger mode is used, the waveform can be displayed stably;
   - Check signal source noise. Set the trigger coupling mode to be high-frequency hold-offor low-frequency hold-offto filter out high frequency or low frequency noise interference
5. **A waveform is displayed but inconsistent with the input waveform:**

- Check whether the coupling mode setting in the channel menu is correct.

6. **If there is no display after pressing Run/Stop button:**
   - Check whether the trigger mode is "Normal", and whether the trigger level is beyond the scope of the waveform. Center the trigger level and set the trigger mode as "Auto".
   - Check whether the picture is displayed in full screen, and if so, exit the display.
7. **If the display becomes slower after setting average times of sampling:**
   - If the average times are above 32, it is normal for the general speed to become slow.
   - You can reduce the average times.
8. **Staircase waveform is displayed:**
   - This phenomenon is normal because the horizontal time base is too low, and the horizontal time base may be increased to raise the horizontal resolution, and then improve the display;
   - The display type may be "line". The connection between sampling points may lead to the display of staircase waveform. This problem can be solved by setting the display type as "point" display mode.
9. **There is persistence of vision in waveform display:**
   - This phenomenon is normal because the persistence time may be set too long, and the waveform persistence shows persistence of vision;
   - The reason may be that sampling mode is set to envelope of sampling, and the sampling mode can be modified to normal waveform for normal display
10. **During measurement, the measured value is displayed as -----:**
    - This phenomenon is normal. When the channel waveform displays beyond the waveform display area, the measured value is displayed as -----. If the channel vertical sensitivity or vertical position is adjusted, the measured value can be displayed correctly;
    - This phenomenon is normal. When there is no full-cycle waveform in the waveform display area, the measured value may be displayed as -----. If the time base is adjusted, the measured value will be displayed correctly.
    - This phenomenon is normal, and the measured value of the FFT waveform is displayed as -----.
11. **When viewing pictures, no pictures are displayed:**
    - Check whether the USB option in the settings is set as the USB storage device. If it is the USB storage device, please change to other options.
12. **The oscilloscope will be black if there is no operation for a period of time:**
    - Check whether the standby time setting in the setting is disabled; if it is not disabled, it will

automatically standby at the set time.

13. Oscilloscope will automatically shut down after no operation for a period of time:

- Check whether the shutdown time setting is Disabled; if it is not Disabled, it will automatically shut down when the set time is reached.

14. CSV files cannot be selected when loading reference:

- CSV files are not the supported format that can be loaded into reference channels.

15. Tap the button during the use of oscilloscope, there is no beep sound:

- Check whether the sound volume setting is correct.

16. Oscilloscope backlight has low brightness:

- Check whether the backlight settings are correct.

17. A waveform being moved changes abruptly:

- Check whether the picture is displayed in full screen.

18. Turn off the channel at Auto state:

- This phenomenon is normal. At Auto state, the channel with an amplitude less than 10mV will be turned off.

19. Function buttons are pressed without response:

- Check whether the picture is displayed in full screen.

Chapter 17 Services and Support

Service Commitments : Micsig guarantees that the products are manufactured and tested according to national standards or enterprise standards, no unqualified products will leave our factory and the first-class customer services are provided for all sold products. The warranty period for our products is three years since date of shipment, and three months for the sold spare parts and the product repair and maintenance. For the details of warranty service, please read the "Scope of Limited Warranty and Services" chapter. Micsig provides lifetime repair and maintenance services for products. In accordance with the relevant provisions of after-sale service of industrial products and the enterprise's own capacities, Micsig commit as follows:

Repair Commitments : Micsig commits to use the original factory parts for products returned by the user for repair (under warranty or not) and the commissioning and testing standards are identical with new products. Micsig the obligation to inform the customer, but without any other obligations for non-product defects or products with decreased performance not for objective reasons.

Service Time Commitments : Micsig will give a reply of the time and cost for repair within 3 working days after receiving the product returned by the user for repair. After the reply is confirmed, the repair period for a general fault is 5 working days and shall not exceed 10 working days for any special fault.

Contact us

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Annex

Annex A： Technical specifications

In addition to other notes, all technical specifications are applicable to all models of tbook Mini. To meet the technical specifications, two conditions must be met:

1. The oscilloscope must work continuously for more than 30 minutes within the specified operating temperature range.
2. If the operating temperature range reaches or exceeds 10 ℃, the system menu must be opened and the "self -Adjust" program must be executed.

All specifications are guaranteed except those marked "typical".

General specifications

Model——Bandwidth		ATO1102——100MHz AT01104——100MHz
BNC input maximum voltage		CAT I 300Vrms，400Vpk
Channel number		2 or 4 oscilloscope channels
Display		
Screen		8 "TFT led multi-point capacitive touch screen
Display resolution		800*600
Background light intensity, typical		250 candela/m^2
Communication		
Communication Interface		USB Micro USB WIFI/LAN Micro HDMI
Power Supply		
Adapter power supply voltage, frequency		100VAC to 240VAC、50Hz/60Hz
Adapter power supply		12VDC*4A
Battery	Standard lithium battery capacity Continuous working time, typical	7.4V 8000mAh 4.0~5.0hours
Environmental		
Temperature (working / storage)		0℃~+45℃ / -40℃~+60℃
Humidity (working / storage)		5%~85% / 5%~90%，25℃
Altitude (working / storage)		3000m/12000m
Cooling method		fan
Mechanical specifications		
	2 channels	4 channels

Dimension (h * w * d)	250mm*200mm*55mm	
Oscilloscope (mainbody)	1040g	1125g

Oscilloscope specifications

Sampling rate range		single channel 1GSa/s Double channel 500Msa/S Three / four channels 250Msa/S
Recording length		single channel 28/14m, double channel 14/7m, three/four channe l7/3.5m
Bandwidth limit		100MHz, low pass filter
Sampling		normal, peak,
Probe compensation frequency, typical		1KHz，square wave
Input		
Input coupling		DC, AC,
Input impedance		1m Ω± 1% in parallel with 14.5pf ± 3pf
Probe attenuation coefficient		1mx ~ 10kx in steps of 1 ~ 2 ~ 5
Differential delay, typical		< 40 PS between any two channels with the same scale and coupling
Horizantal		
Position range		-14grids~14ks
Scanning range（s/div）		2ns/div～1ks/div
Time base accuracy, typical		±20ppm
Vertical		
Vertical zoom range（V/div）		1mV/div～10V/div in steps of 1~2~5
Position range		±6 grids
Vertical resolution		8 bits
Rise time, typical		70MHz≤5ns
		100MHz≤3.5ns
DC gain accuracy, typical		≤±2.0%
Trigger		
Trigger sources		CH1、CH2、CH3、CH4
Trigger mode		auto, normal, single
Trigger type	edge	rising edge, falling edge and double edge
	Pulse width	condition: less than, greater than, equal to, not equal to Polarity: positive, negative
	Logical trigger	AND、OR、NAND、NOR
	N edge	rising edge, falling edge
	Runt	polarity: positive, negative, arbitrary

	Slope	rising edge, falling edge, arbitrary
	Timeout	positive, negative, arbitrary
	Video	Type: odd field, even field, all fields, all lines, lines System: PAL, NTSC, SECAM, 720P, 1080I, 1080P
	UART (RS232/RS422 /RS485)	Trigger on sending start bit, stop bit, data, 0 data, 1 data, X data, parity error within 10 Mb/s
	LIN（optional）	Trigger on synchronous rising edge, frame ID, frame ID and data within 100 kb/s (20 kb/s defined by LIN).
	CAN（optional）	Within 1 Mb/s CAN signal frame start, frame type (data, remote, error, overload), identifier (standard or extended), data, identifier and data, end of frame, missing ACK, or bit stuffing error. You can further specify the data to be used to trigger when ≤, <, =, >, ≥ or ≠ a special data value. The user-adjustable sampling point is set to 50% by default
	SPI（optional）	Trigger on SS activation, frame start, MOSI, MISO, or MOSI and MISO on the SPI bus within 50.0 Mb/s
	I2C（optional）	Trigger on start, repeated start, stop, lost ACK, address (7 or 10 bits), data, or address and data on the I2C bus within 10 Mb/s.
	ARINC429（optional）	
	1553B（optional）	
Trigger coupling mode		DC, AC, HF suppression, LF suppression, noise suppression
Trigger hold-off time range		200ns~10s
measurement		
Measurement type		cycle, frequency, rise time, fall time, positive duty ratio, negative duty ratio, delay, positive pulse width, negative pulse width, burst pulse width, positive overshoot, negative overshoot, phase, peak peak value, amplitude, high, low, maximum, minimum, average, cycle average, root mean square, cycle root mean square
Cursor type		horizontal cursor, vertical cursor, cross cursor
Math		

FFT	4 windows: Rectangle 、 Hanning 、 Hamming 、 Blackman
Double waveform	+, -, *, /
XY mode	
X-axis input / Y-axis input	Channel 1（CH1）/Channel 2（CH2）
Storage	
Waveform	Unlimited
Picture	Unlimited
User settings	10
Display	
Maximum refresh rate	130k/s
Persist	none，auto、100ms~10s、∞
Waveform display range	14*10 grids
Waveform display mode	point、line
Language	Chinese, English, etc.

Annex B: Maintenance of ATO oscilloscope

General maintenance

Do not put or leave the instrument in a place where the LCD display will be exposed to direct sunlight for long period.

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

Clean oscilloscope

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

- Use a soft cloth to remove floating dust on the outside of the oscilloscope and probes. Take care to avoid scratching the touch screen while cleaning.
- Use a soft cloth dampened with water to clean the oscilloscope while doing this please keep the power off. Wipe with a mild detergent and water. Do not use any corrosive chemical cleaning agent, in order to avoid damaging the oscilloscope or probe.
- Clean the ventilation hole with a soft brush to keep it unimpeded. Do not use any corrosive chemical cleaning agent, so as to avoid damage to the oscilloscope motherboard.
- If the fan needs to be cleaned, please consult the after-sales service personnel, so as to avoid damage to the oscilloscope.

⚠ Warning

Make sure the instrument is dry before recharging, to avoid electrical short circuit or personal injury caused by moisture.

Store oscilloscope

The lithium battery needs to be charged before storing the oscilloscope for a long period.

Battery charge

Upon delivery, the lithium battery may not be charged. It takes 6 hours to be fully charged (the oscilloscope is recommended to turn off to save the charging time). When running on battery power, the battery level indicator in the lower right corner of the screen will indicate the battery usage.

⚠**Caution:** In order to avoid charging battery from overheating, do not use beyond the permitted environmental temperature value given in the technical specification.

Annex C: Accessories

Standard accessories

1) 2 pcs for 10X standard probes (incl. grounding cap, grounding aligator clip, standard rubber plug)
2) Power adapter (12V DC, 4A)
3) Power cord
4) ATO calibration certificate
5) ATO packing list

Optional accessories

1) Oscilloscope suitcase/handbag
2) Battery
3) Carry strap belt
4) Secondary ignition probe