Micsig®

Automotive Oscilloscope

VATO Series

USER MANUAL

Shenzhen Micsig Technology Co., Ltd.

Version Info

Version	Date	Remarks
V1.0	2024.01	

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 information contained herein are furnished in an “as-is” state, and may be subject to change in future versions without notice.

The standard applicable for this product: GB/T15289-2013.

Table of Contents

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

The VATO series oscilloscope is intended to be used for measurements in Measurement Category I.

Measurement Category Definition

Measurement category I is for measurements performed on circuits not directly connected to the 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 user must understand the transient withstand capability of the equipment.

Warning

IEC Measurement Category. Under IEC Category I mounting conditions, the input terminal can be connected to the circuit terminal with a maximum line voltage of 300Vrms. To avoid the risk of electric shock, the input terminal should not be connected to the circuit with a line voltage greater than 300Vrms. Instantaneous overvoltage is present in circuits that are isolated from the mains supply. The VATO series digital oscilloscope is designed to safely withstand sporadic transient overvoltage up to 1000Vpk. Do not use this equipment for any measurements in circuits 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

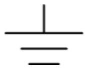
The following symbols may appear on the product:

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 checks and operations of the oscilloscope. You are recommended to read them carefully to understand appearance, power on/off, settings and related calibration requirements of the VATO series oscilloscope.

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 B" 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 Front Panel

Figure 2-1 Front Panel

The front panel includes the power on lock, power button, DC power port, Type-C interface, probe compensation signal output, and cable clamp.

2.3 Rear Panel

Figure 2-2 rear panel

The rear panel contains four analog channels Ch1 – Ch4

2.4 Power on/off the Oscilloscope

Power on/off the oscilloscope

Power on

- Make sure the machine is powered by power and the POWER LOCK switch is on the left side. Press the power button to turn on the instrument.

Power off

- Long press the power button for forced power-off of the instrument.

Power-off lock

- Turn the power-off lock switch to OFF(right), the oscilloscope cannot be turned on.

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

2.5 Connect the oscilloscope

Connect to smartphone/tablet

1. If the oscilloscope is powered by a power supply, please plug the adapter into the power socket first, and then connect the DC end to the oscilloscope (if you are using battery power, you can ignore this step)

2. Use the provided Type-C data cable to connect the oscilloscope to a smartphone/tablet running Android 7 or above.

3. Go to Micsig official website (https://www.micsig.com.cn/VATO/) to download the apk file, transfer it to the device, open and install it

4. After completing the installation, open the software and grant permission to the floating window. The power button of the oscilloscope will appear blue and flash, indicating that the connection is successful.

5. Connect the probe to the oscilloscope channel BNC connector, and then connect the retractable hook on the end of the probe to the circuit point to be measured or the device under test. Be sure to connect the probe ground lead to the ground point of the circuit.

Connect to PC

Since the emulator cannot recognize USB, VATO needs to install a virtual environment to connect to the computer. You can use Vmware or VirtualBox virtual machine software to install Android 7 or above systems. Here we take the Genymotion emulator and VirtualBox virtual machine software as an example:

1. Go to the Genymotion simulator website https://www.genymotion.com/download/ to download Genymotion with VirtualBox

2. After the installation is completed, select and install the Android system suitable for your computer configuration in the Genymotion emulator.

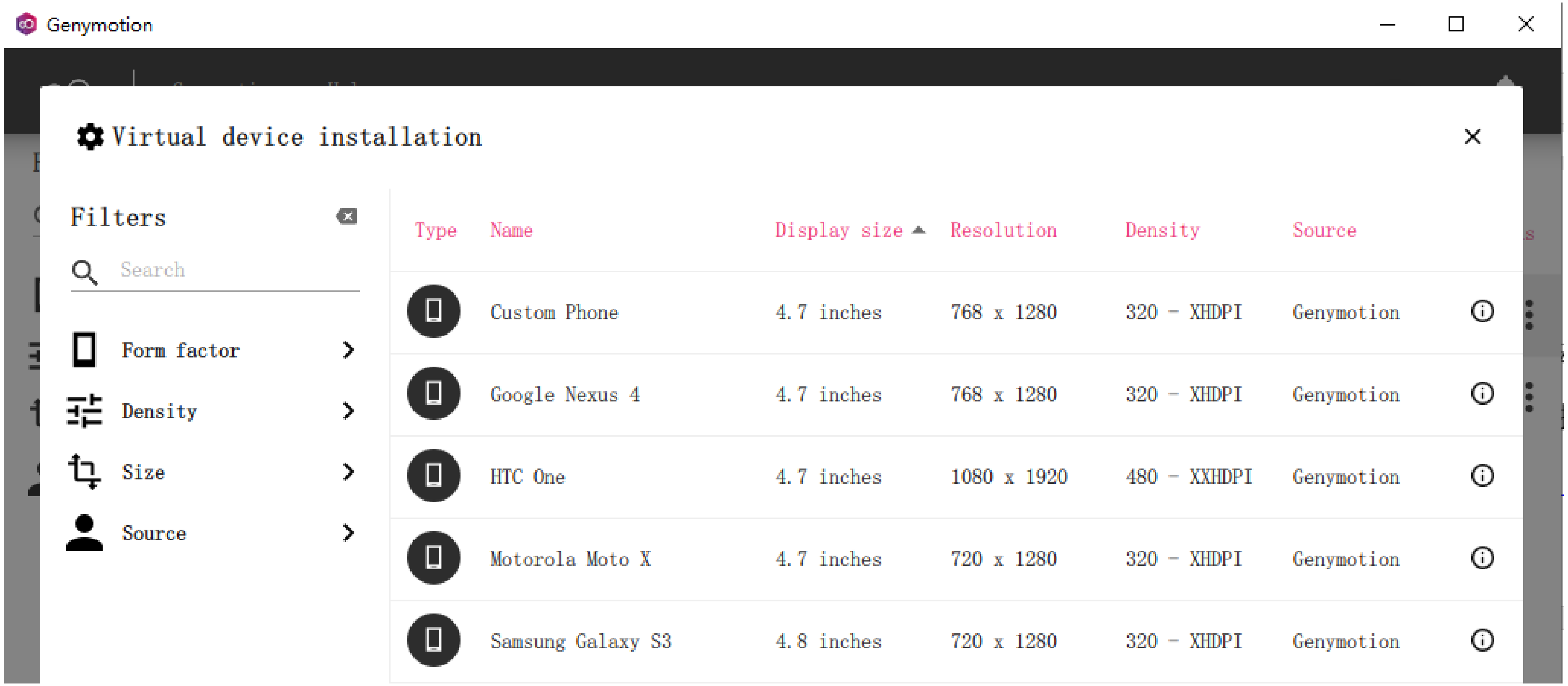


Figure 2-3 Android virtual device installation

3. Connect the oscilloscope to the computer, open VirtualBox and enter settings, USB devices, click Add USB, find Cypress, add and confirm

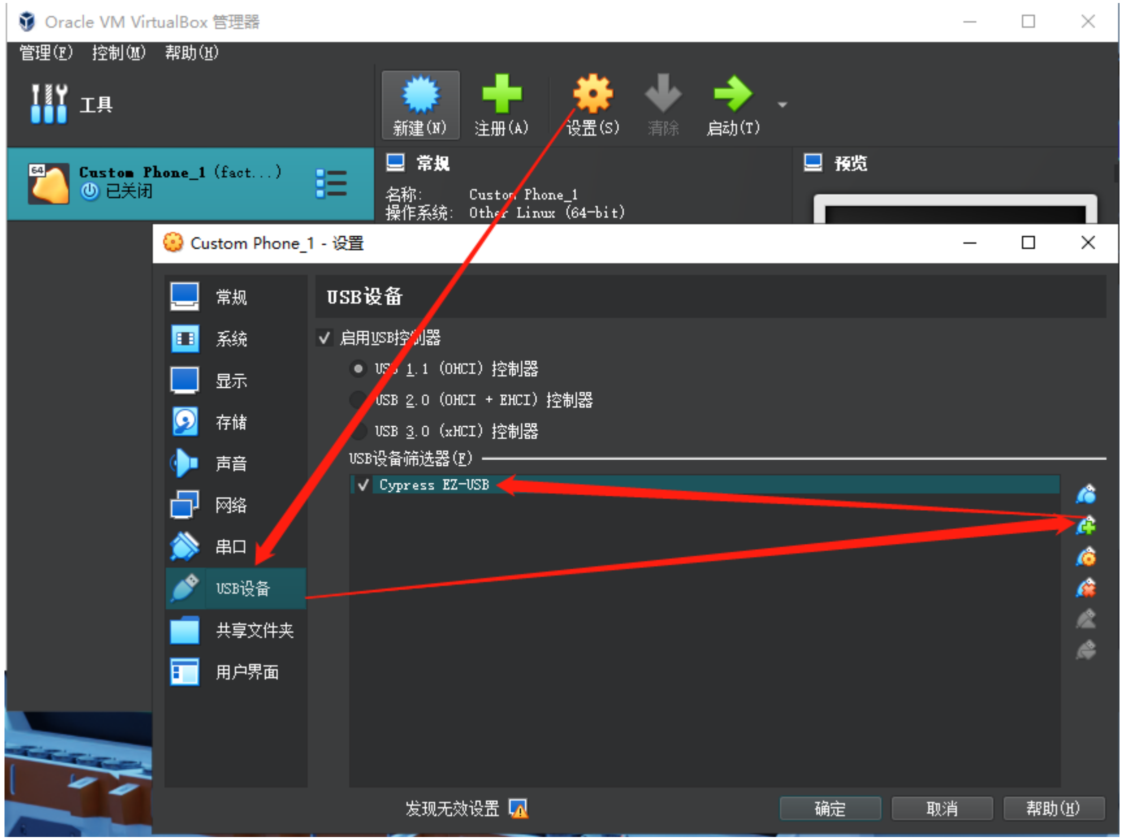


Figure 2-4 Setting USB device

4. Start the Android system installed on Genymotion, and drag the apk file downloaded from the Micsig official website (https://www.micsig.com.cn/VATO/) into the Android desktop for installation. After completing the

installation, open the software and grant floating window permissions. The power button of the oscilloscope turns blue and flashes, indicating that the connection is successful.

Figure 2-5 Oscilloscope connected successfully

⚠ **Maximum input voltage for analog input**

Class I 300Vrms, 400Vpk.

2.6 Understand the Oscilloscope Display Interface

This section provides a brief introduction and description of the VATO series oscilloscope user's interface. After reading this section, you can be familiar with the oscilloscope display interface content within the shortest possible time. The specific settings and adjustments will be detailed in subsequent chapters and sections. 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 2-6.

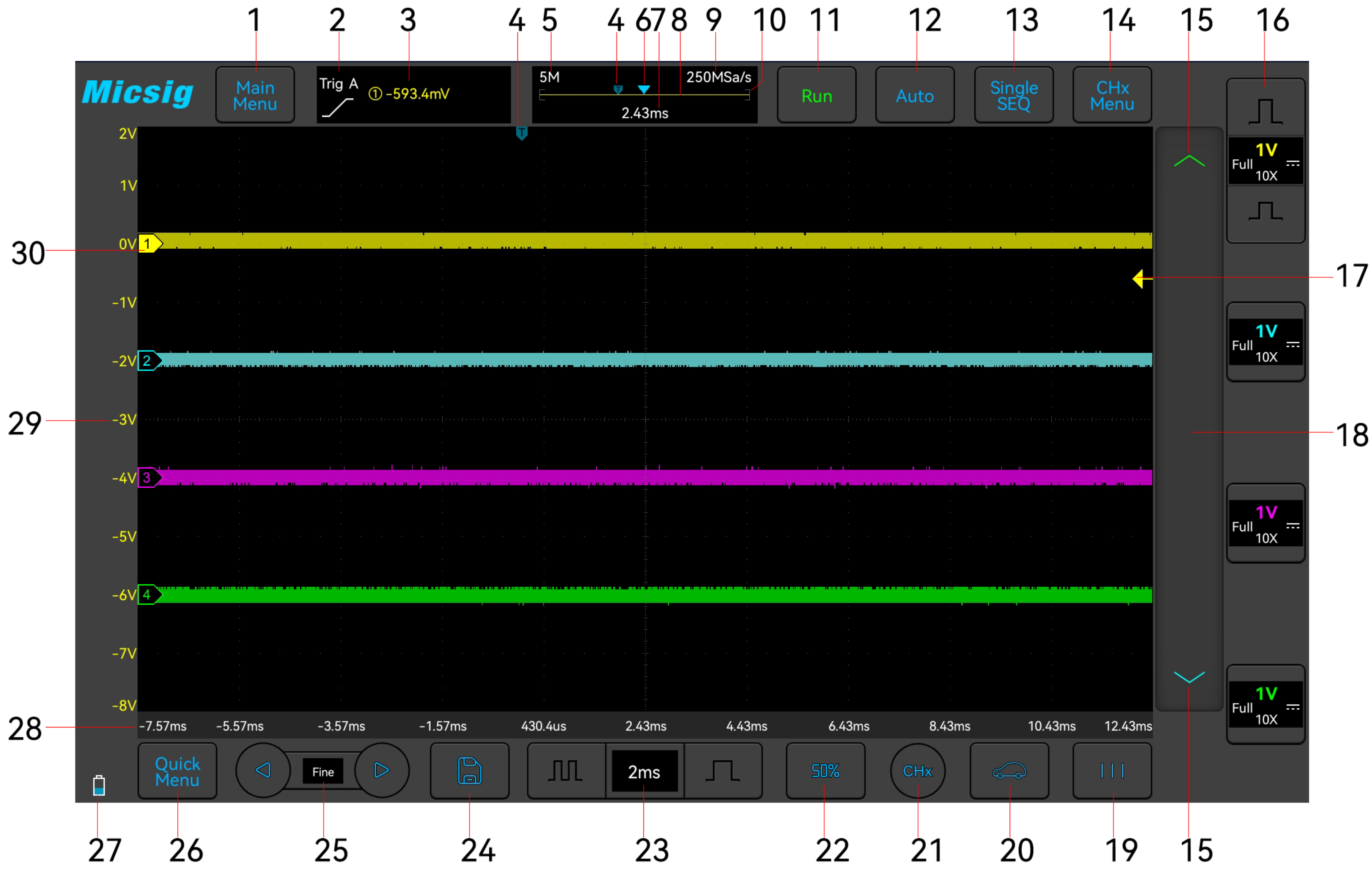


Figure 2-6 Oscilloscope Interface Display

No.	Description
1	Click to open the top main menu, including measurement, save, display, trigger, user settings, about
2	The current trigger type and current trigger mode are displayed. A means Auto, N means Normal
3	Current trigger source, trigger level value
4	Trigger position
5	Current record length
6	Waveform display area center indication
7	Delay time, the time at which the center line of the waveform display area is relative to the trigger point
8	Memory depth indicatrix
9	Current sample rate
10	The area in “[]” indicates the position of waveform displayed on the screen throughout the memory depth

No.	Description
11	Oscilloscope status includes running, stop, and waiting. Tap to switch to stop.
12	Automatically set, tap to enter the auto state, and the oscilloscope will automatically adjust the waveform to a suitable display mode.
13	Single trigger, tap for single trigger
14	Click to open the channel menu of the current channel
15	Click to switch the current trigger source
16	The relevant information display area of each channel includes channel switch status, vertical sensitivity, coupling mode, phase inversion, attenuation ratio, and bandwidth limit. Swipe left on the corresponding channel to open the channel menu corresponding to the channel, click or to adjust the vertical sensitivity of the channel
17	Trigger level indicator
18	Trigger level adjustment, drag up and down to adjust the trigger level

No.	Description
19	Phase scale to help measure timing of cyclic waveforms
20	The car repair soft bag has a variety of built-in car WeChat measurement items and can complete oscilloscope settings with one click.
21	The current channel is forced to be selected. After clicking, the current channel switching menu pops up to switch the current channel.
22	50% key: The channel zero point can be quickly returned to the center of the screen; the trigger position can be quickly returned to the center of the screen; the trigger level can be quickly Return to the center of the waveform; the cursor quickly returns to the center of the upper, lower, left and right sides of the screen
23	Horizontal time base control icon. Tap the left/right button of the time base to adjust the horizontal time base of the waveform. Tap the time base to open the time base matrix. Tap to select the required time base.
24	Fast storage. Tap to quickly save the currently opened channel waveform as a reference waveform

No.	Description
25	Fine adjustment buttons. Tap the fine-tuning button to fine-tune the waveform position, trigger level position, trigger position, and cursor position.
26	Click to open the bottom shortcut menu, including ZOOM, full measurement, and cursor
27	Oscilloscope battery power display area
28	Horizontal time scale
29	Vertical direction voltage (current) scale
30	Channel Indicator: The displayed ground level of each analog channel signal, identified by the channel indicator icon 1 on the left side of the display

Table 2-1 Description of Oscilloscope Display Interface

2.7 Introduction Basic Operations of Touch Screen

The VATO series oscilloscope operates mainly by tap, swipe, single-finger drag.

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 2-7. The closing method is the opposite of the opening method.

Figure 2-7 Close the channel menu

Single-finger drag

For coarse adjustments of vertical position, trigger point, trigger level, cursor, etc. of the waveform. Refer to “4.1 Horizontal Move Waveform” and “5.3 Adjust Vertical Position” for details.

2.8 Use Auto

After correctly connecting the oscilloscope and inputting a valid signal, tap the Auto Setup button. Auto Setup can quickly automatically configure the oscilloscope to display the best effect on the input signal. When the oscilloscope enters the automatic state, the automatic button will turn green.

Each time you press "Auto", the oscilloscope can automatically adjust the vertical scale, horizontal scale and trigger settings according to the amplitude and frequency of the signal, adjust the waveform to an appropriate size, and display the input signal. After the adjustment is completed, exit Auto and the Auto button changes to blue.

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.

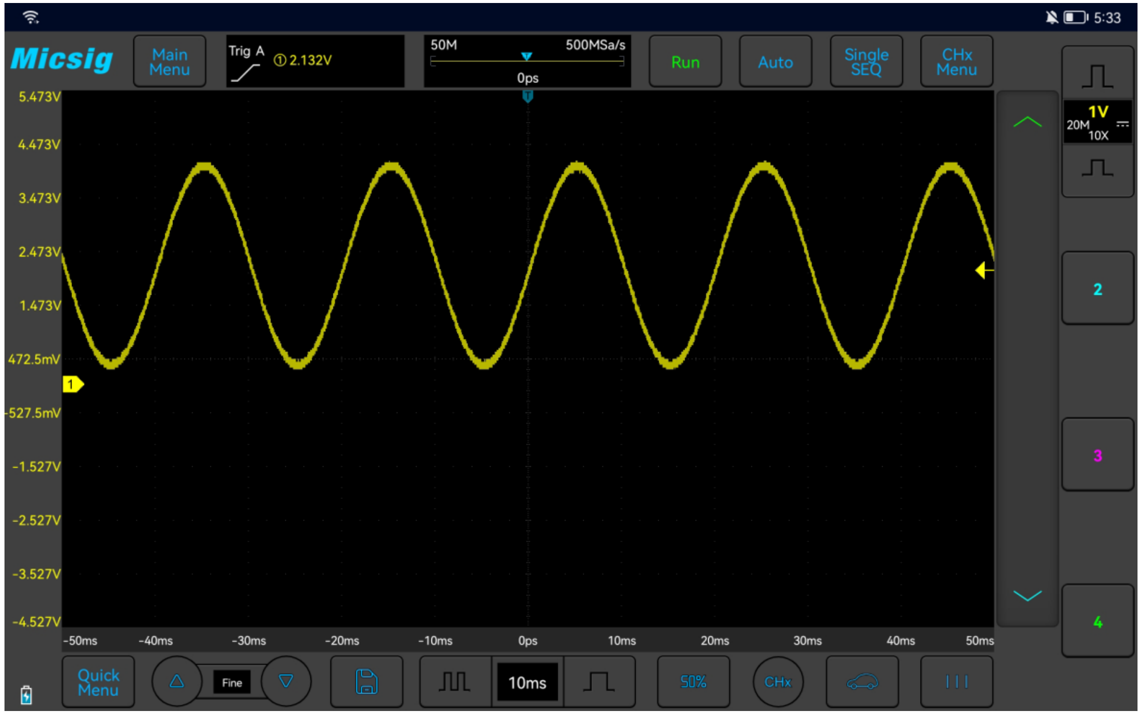


Figure 2-8 Open Auto Set

2.9 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 2-9.

Figure 2-9 Load Factory Settings

2.10 Use Auto-calibration

Open the main menu, tap “Userset” to enter the user setting page. Tap “Self Adjust” 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℃, we recommended users perform the auto-calibration.

2.11 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℃ 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 2-10.

Figure 2-10 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 2-11.

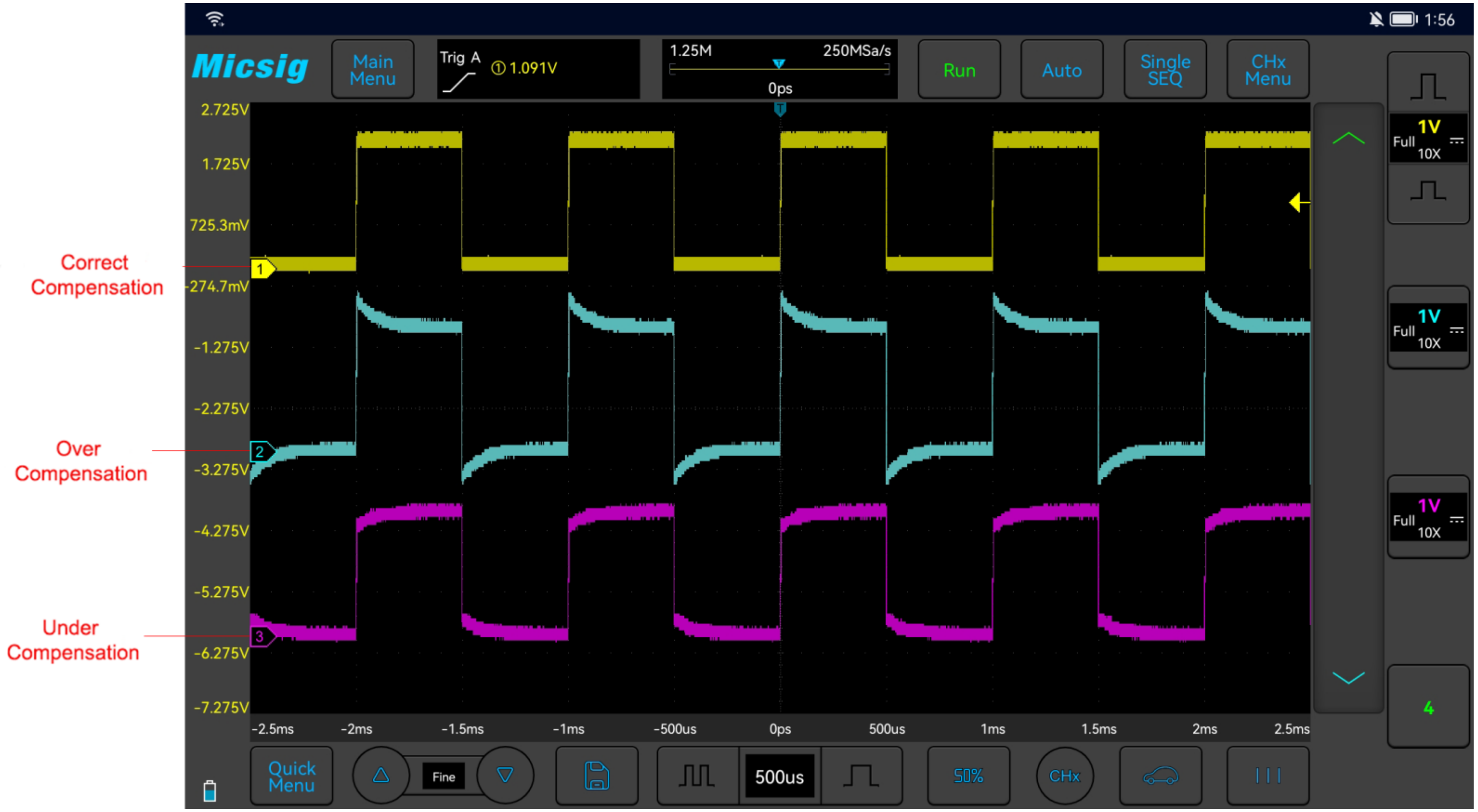


Figure 2-11 Probe Compensation

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 2-12.

Figure 2-12 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.*

2.12 Modify the Language

The language of the oscilloscope interface depends on the system language of the Android device. If you modify the language of the Android system, the oscilloscope will automatically switch to the corresponding language. Currently, it supports Simplified Chinese, Traditional Chinese, and English. For unsupported languages, it will switch to English by default.

Chapter 3 Automotive Test

This chapter contains most of the test applications of VATO 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 VATO 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 VATO 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 VATO 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 VATO 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:

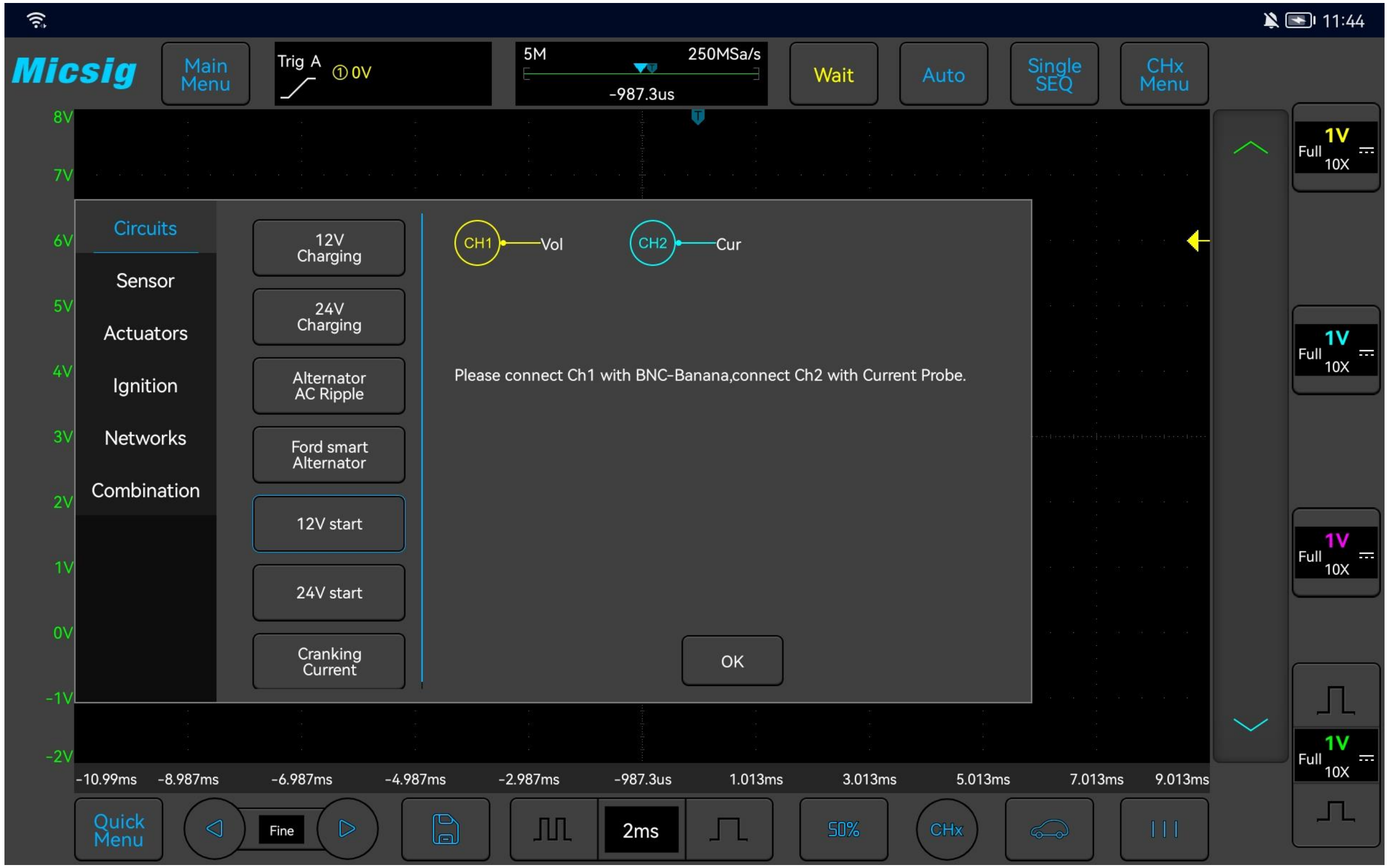


Figure 3-6 12V Start

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

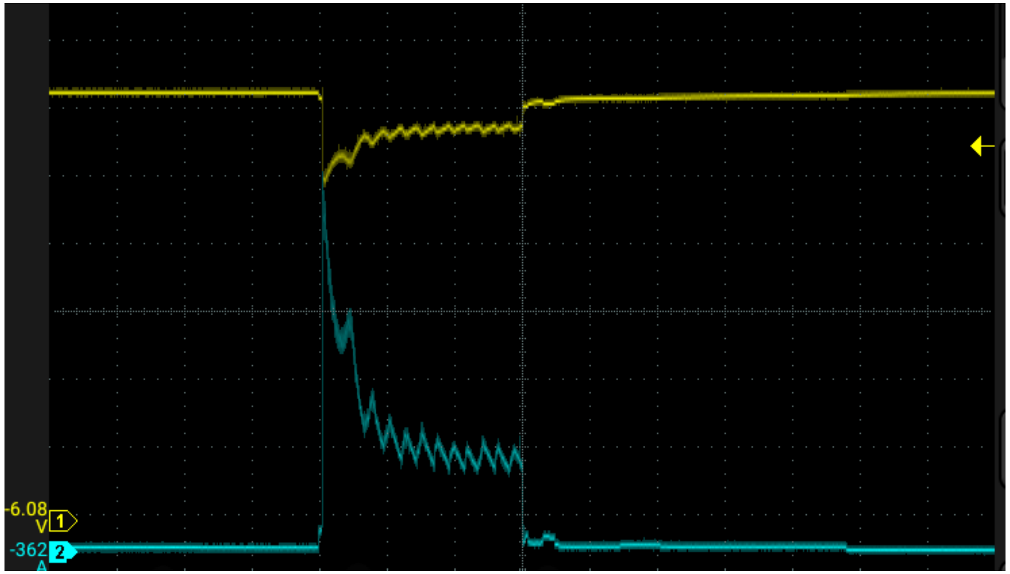


Figure 3-7 Starting voltage and current

3.1.6 24V Start

Use the VATO 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 VATO 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 VATO 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

VATO 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:

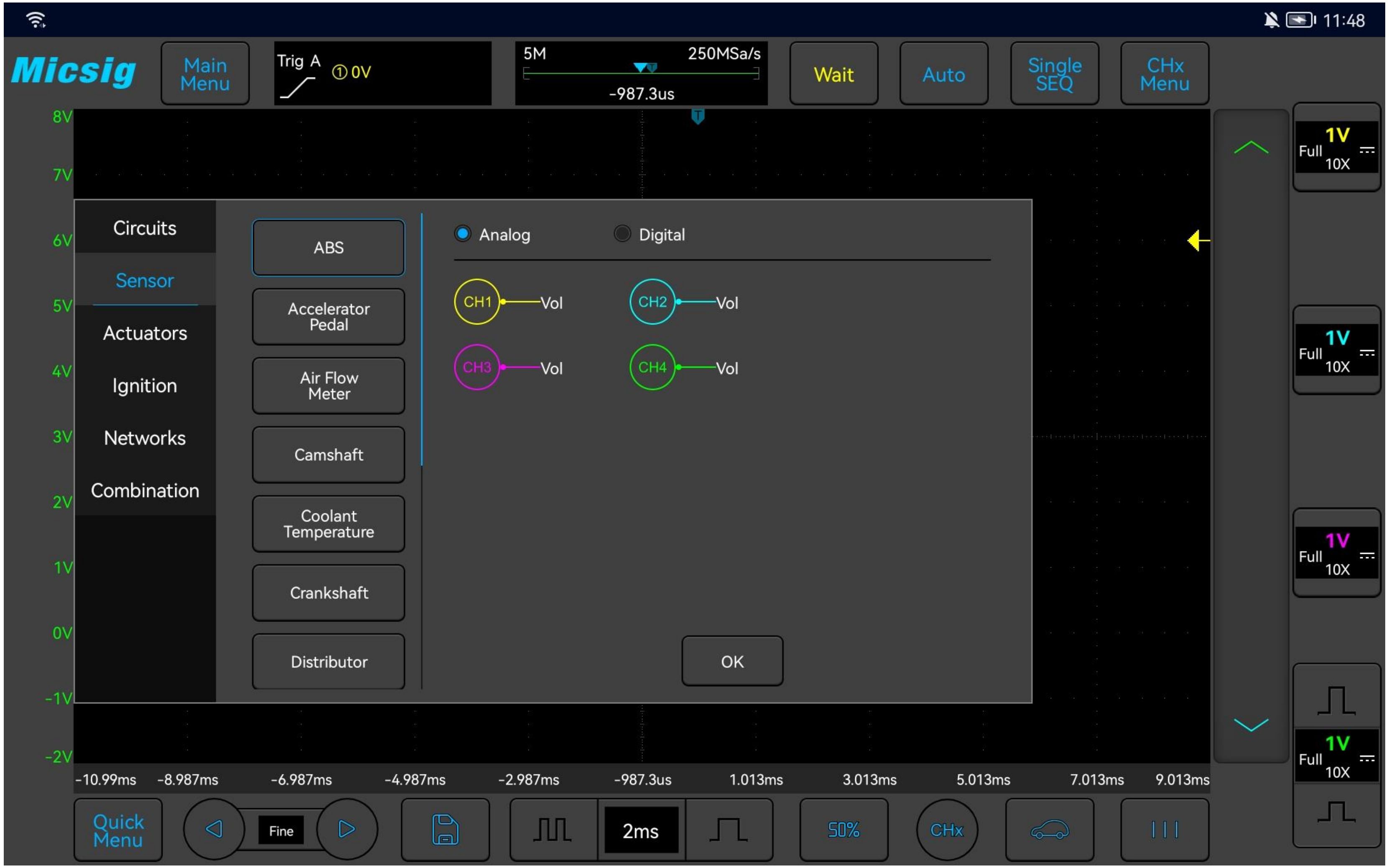


Figure 3-10 ABS Wheel Speed Sensor

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

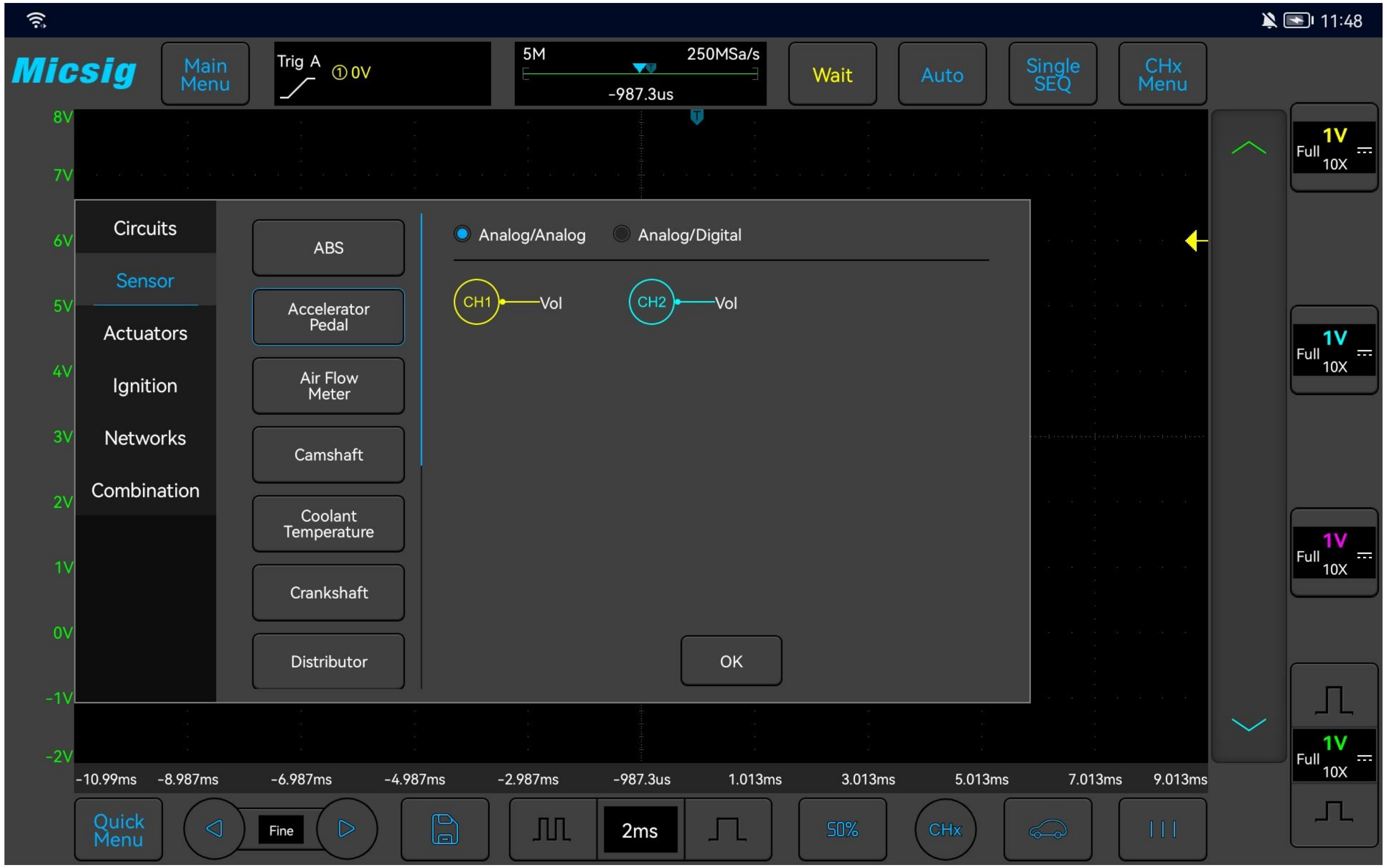


Figure 3-11 Accelerator Pedal

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

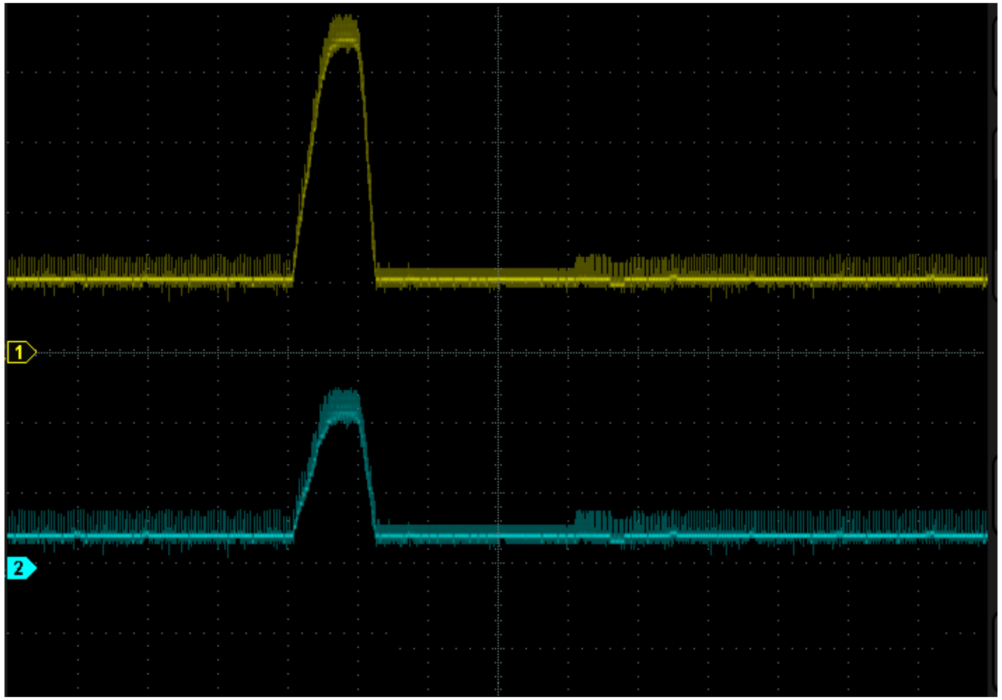


Figure 3-12 Actual measured waveform of accelerator pedal sensor

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 VATO 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 3-13:

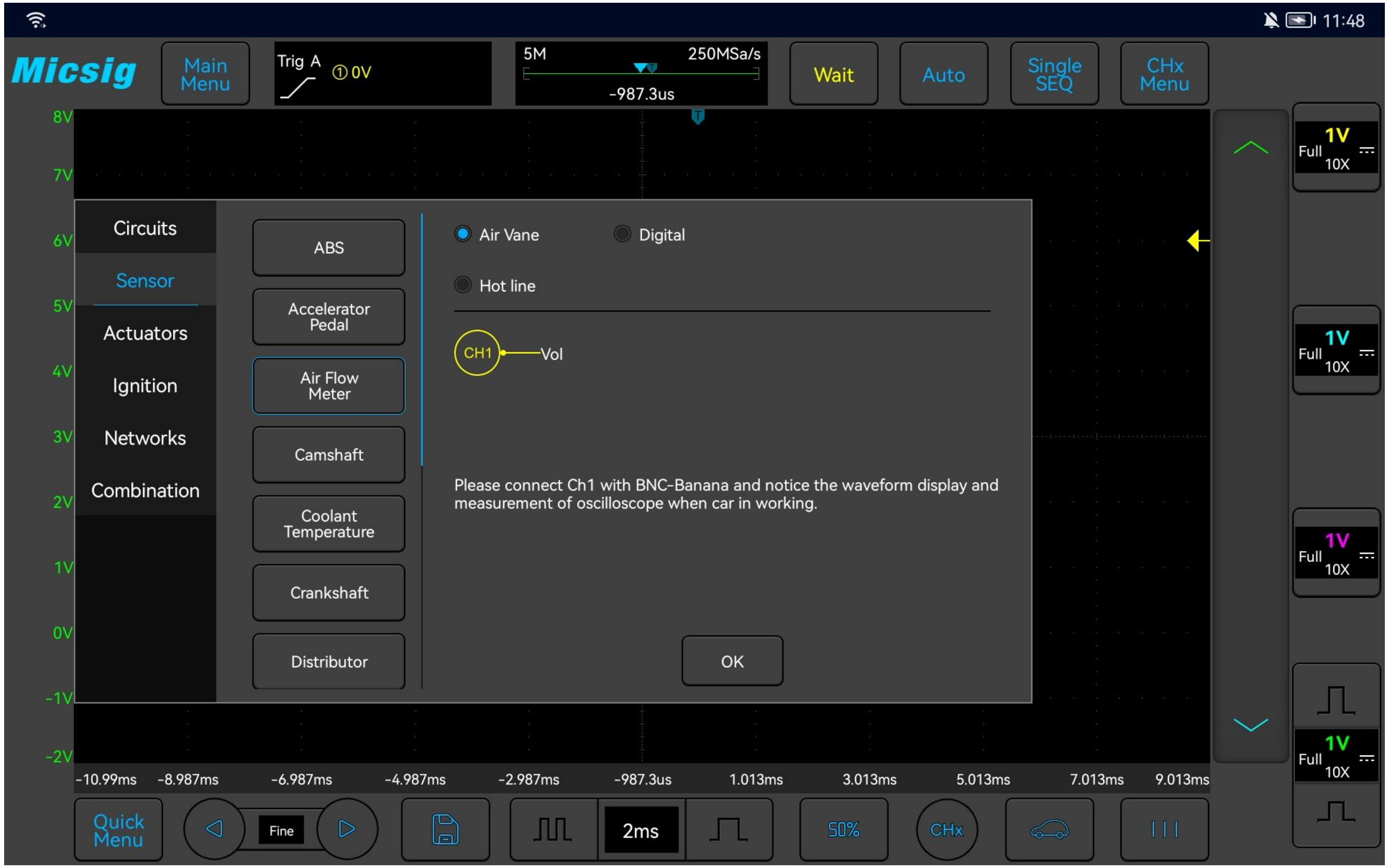


Figure 3-13 Air flow meter

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 3-14:

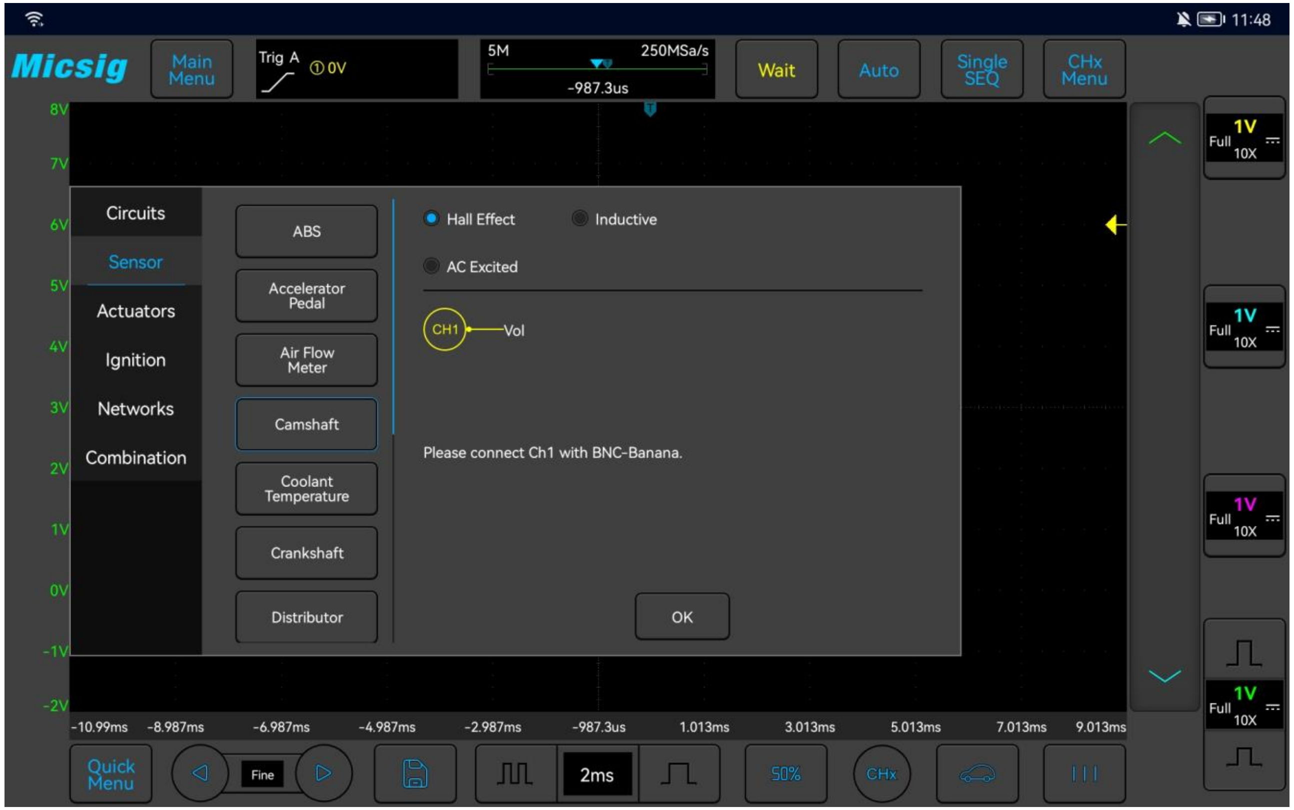


Figure 3-14 Camshaft

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

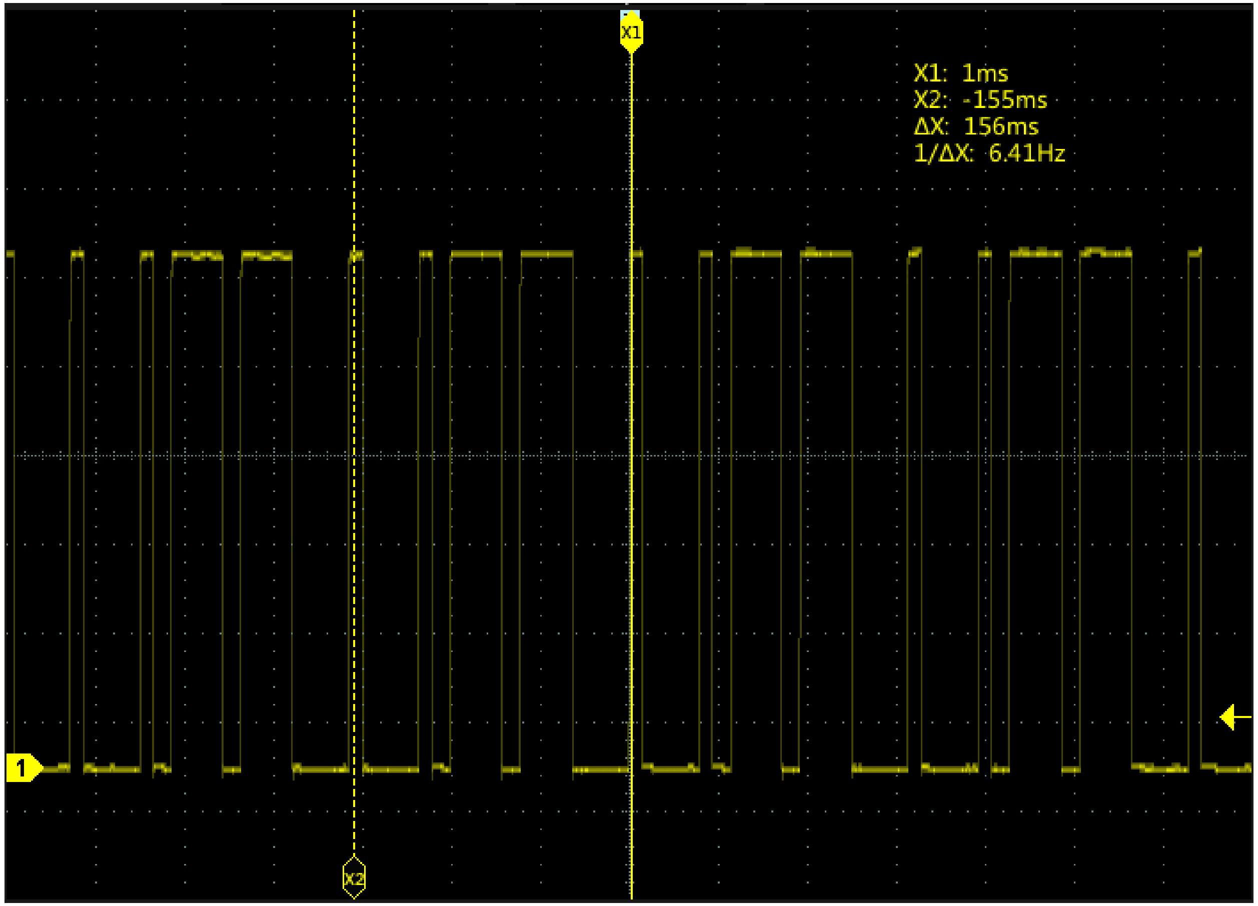


Figure 3-15 Camshaft position sensor (Hall type)

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 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 VATO oscilloscope to test the coolant temperature sensor, the specific operation is shown in Figure 3-16:

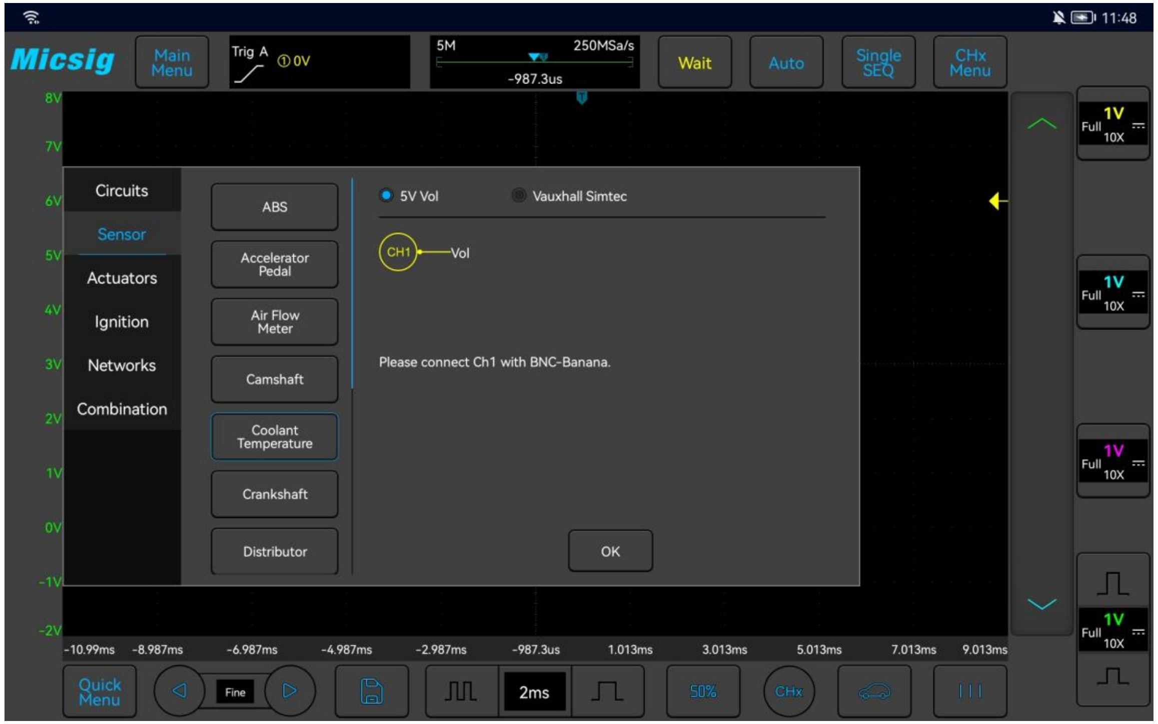


Figure 3-16 Coolant Temperature

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 VATO oscilloscope to test the crankshaft position sensor, the specific operation is shown in Figure 3-17:

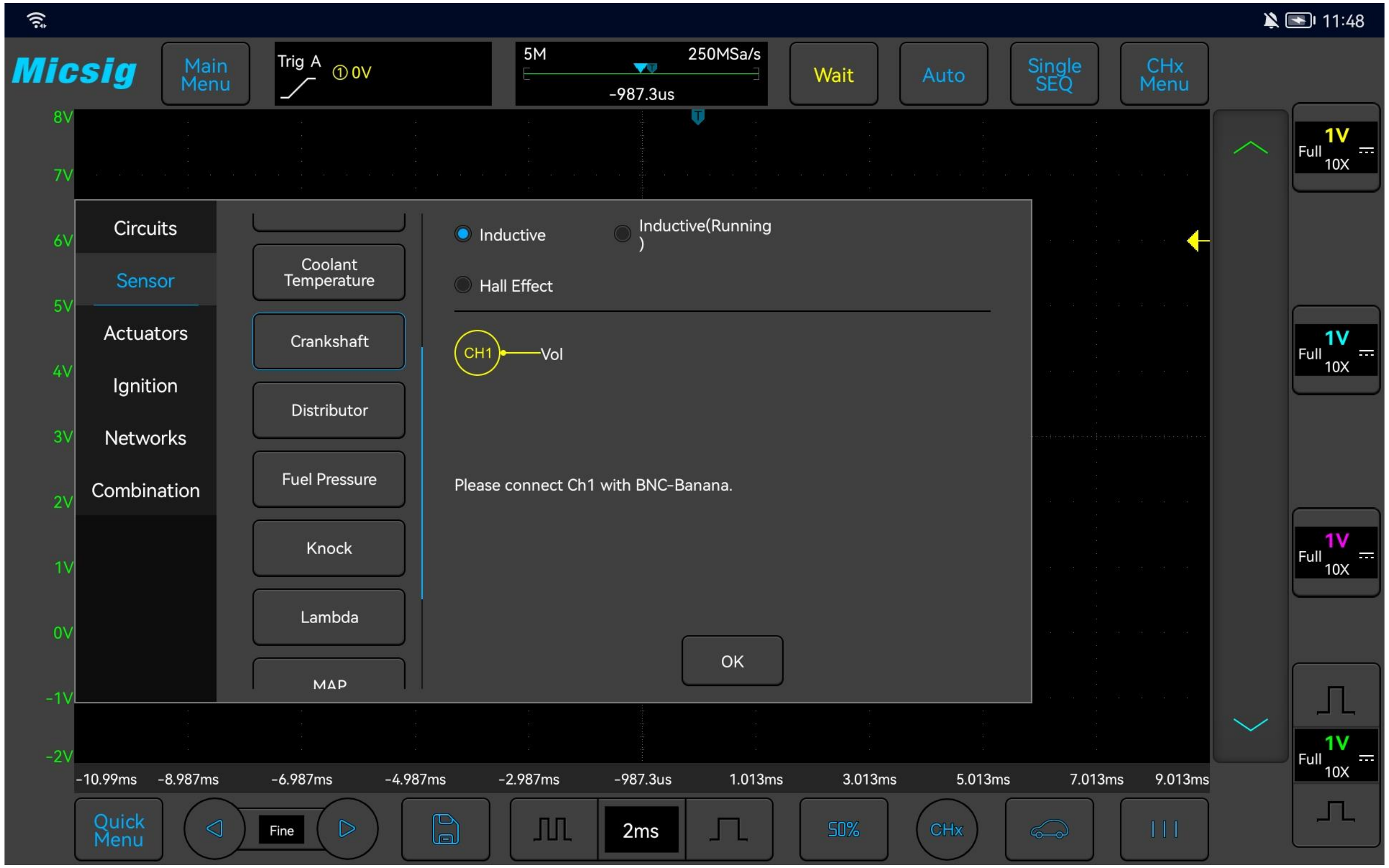


Figure 3-17 Crankshaft position sensor

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

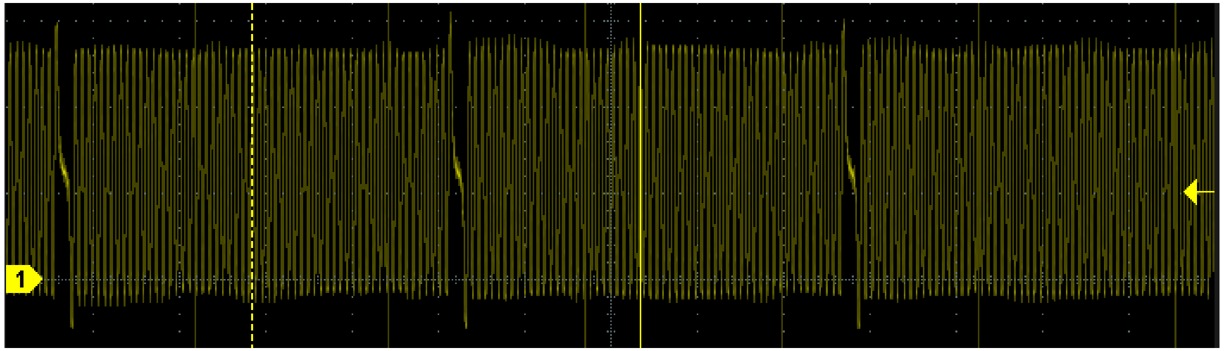


Figure 3-18 Actual measurement diagram of crankshaft position sensor (inductive type)

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 VATO oscilloscope to test the distributor sensor (divided into two types: Hall effect and induction). The specific operation is shown in Figure 3-19:

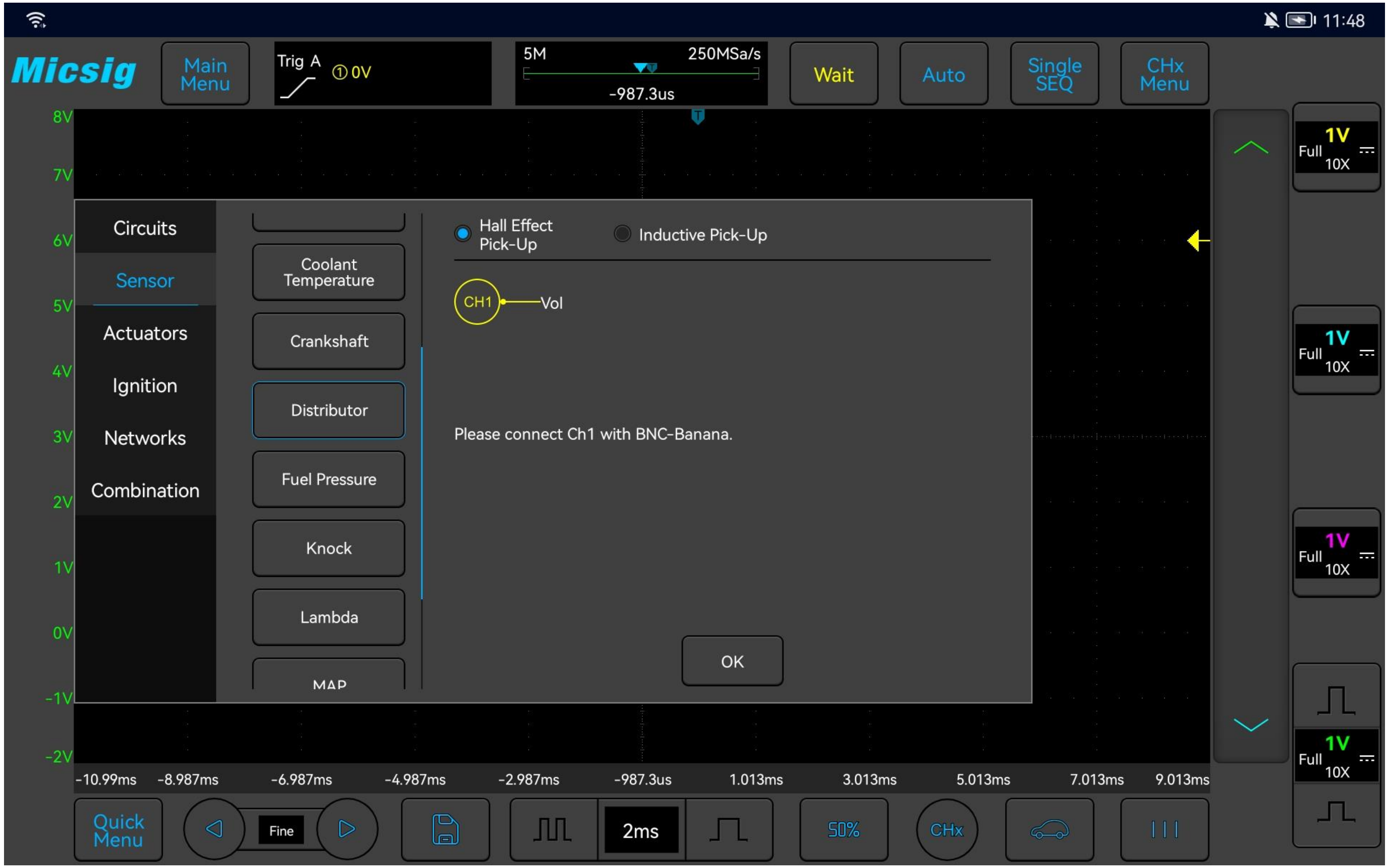


Figure 3-19 Distributor

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 VATO oscilloscope to test the fuel pressure sensor, the specific operation is shown in Figure 3-20:

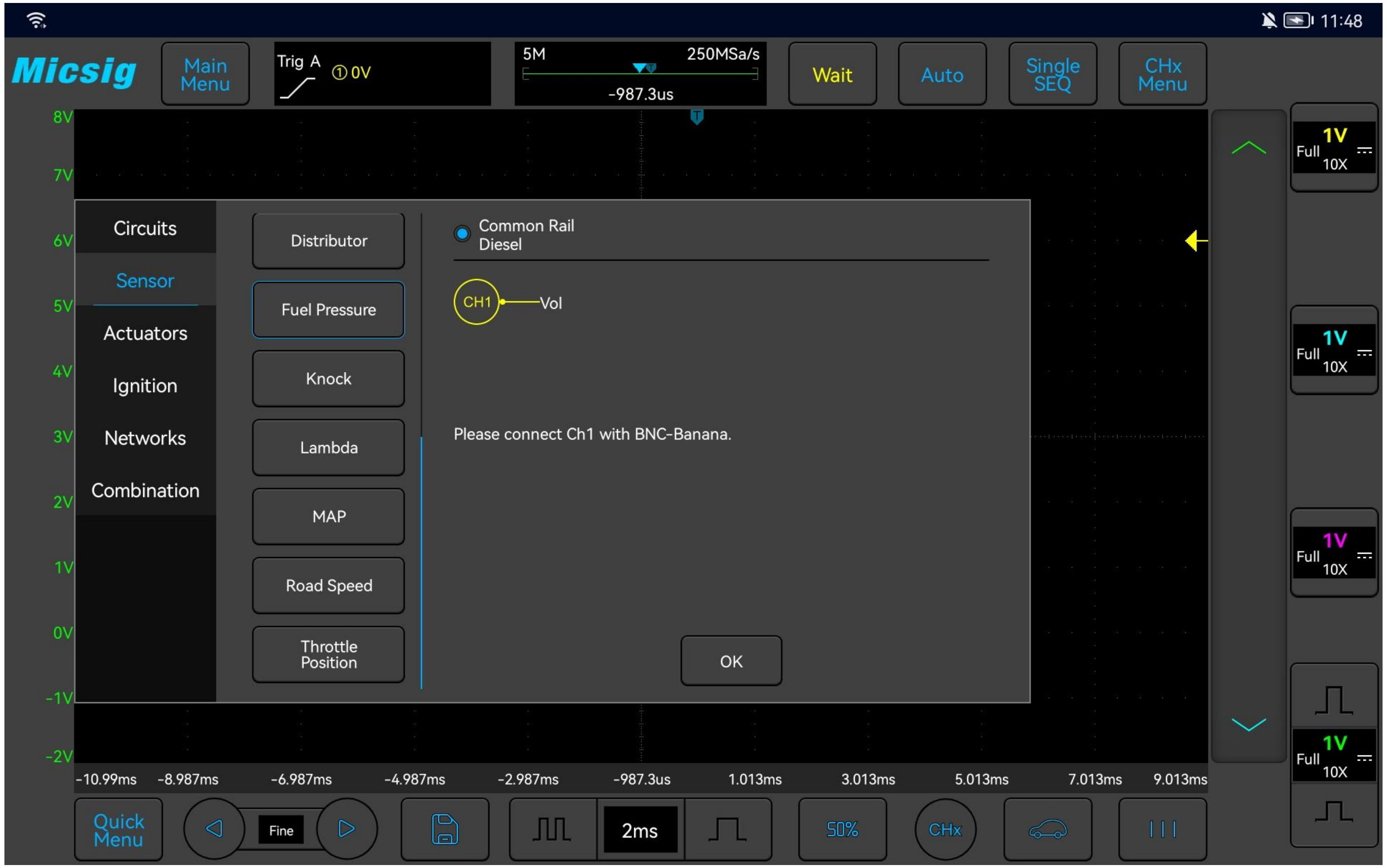


Figure 3-20 Fuel Pressure Sensor Test

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 VATO oscilloscope to test the knock sensor, the specific operation is shown in Figure 3-21:

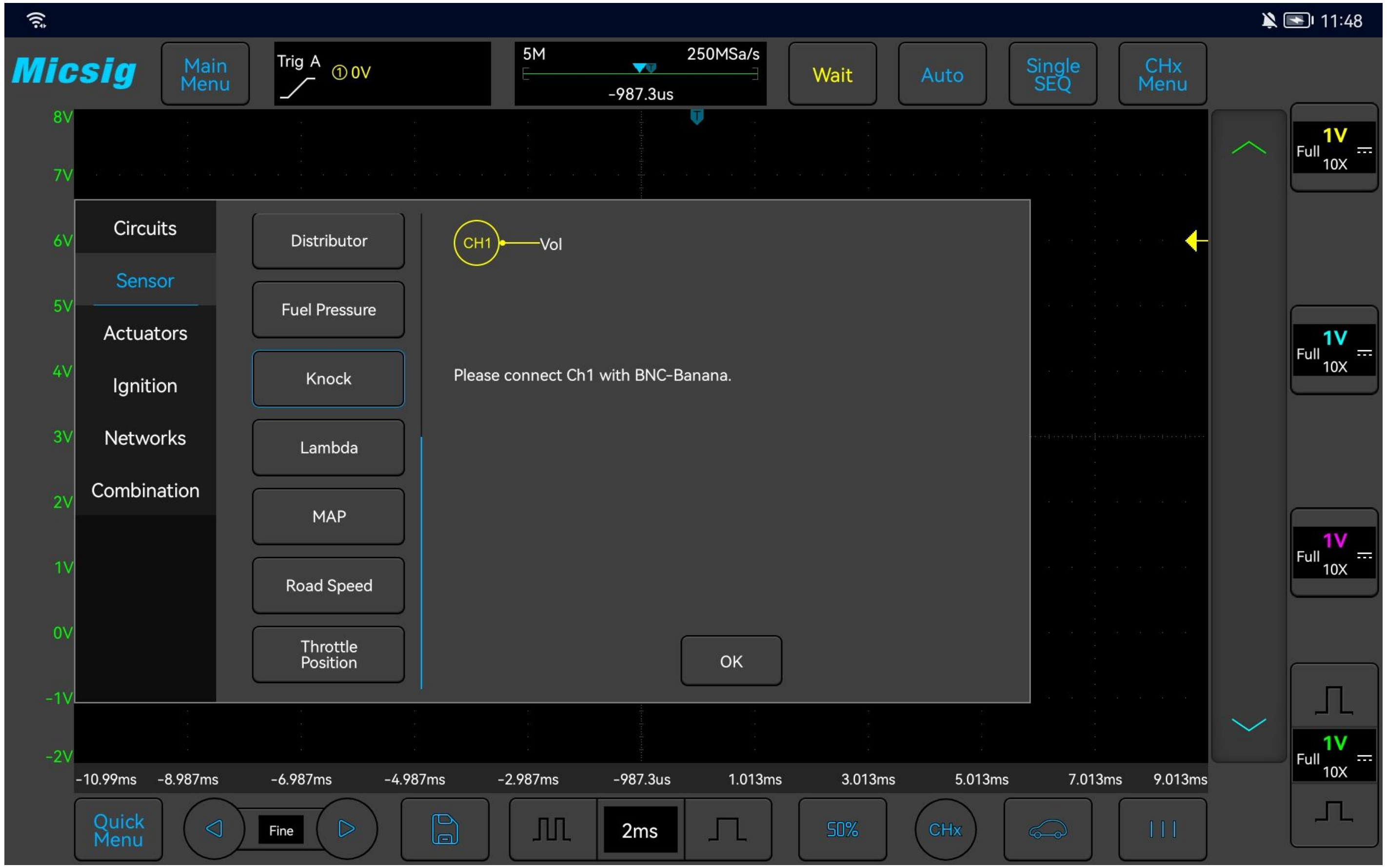


Figure 3-21 Knock Sensor test

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

Figure 3-22 Actual measurement chart of knock sensor

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 VATO oscilloscope to test the oxygen sensor, the specific operation is shown in Figure 3-23:

Figure 3-23 Lambda (oxygen sensor) test

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

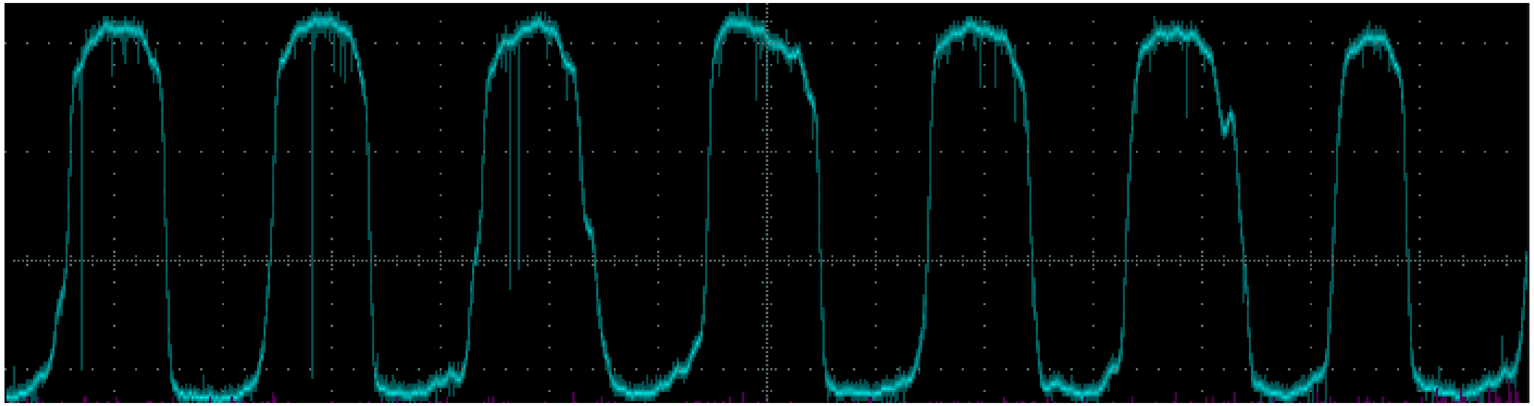


Figure 3-24 Lambda (Oxygen Sensor) diagram

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 VATO oscilloscope to test the intake pressure sensor, the specific operation is shown in Figure 3-25 below:

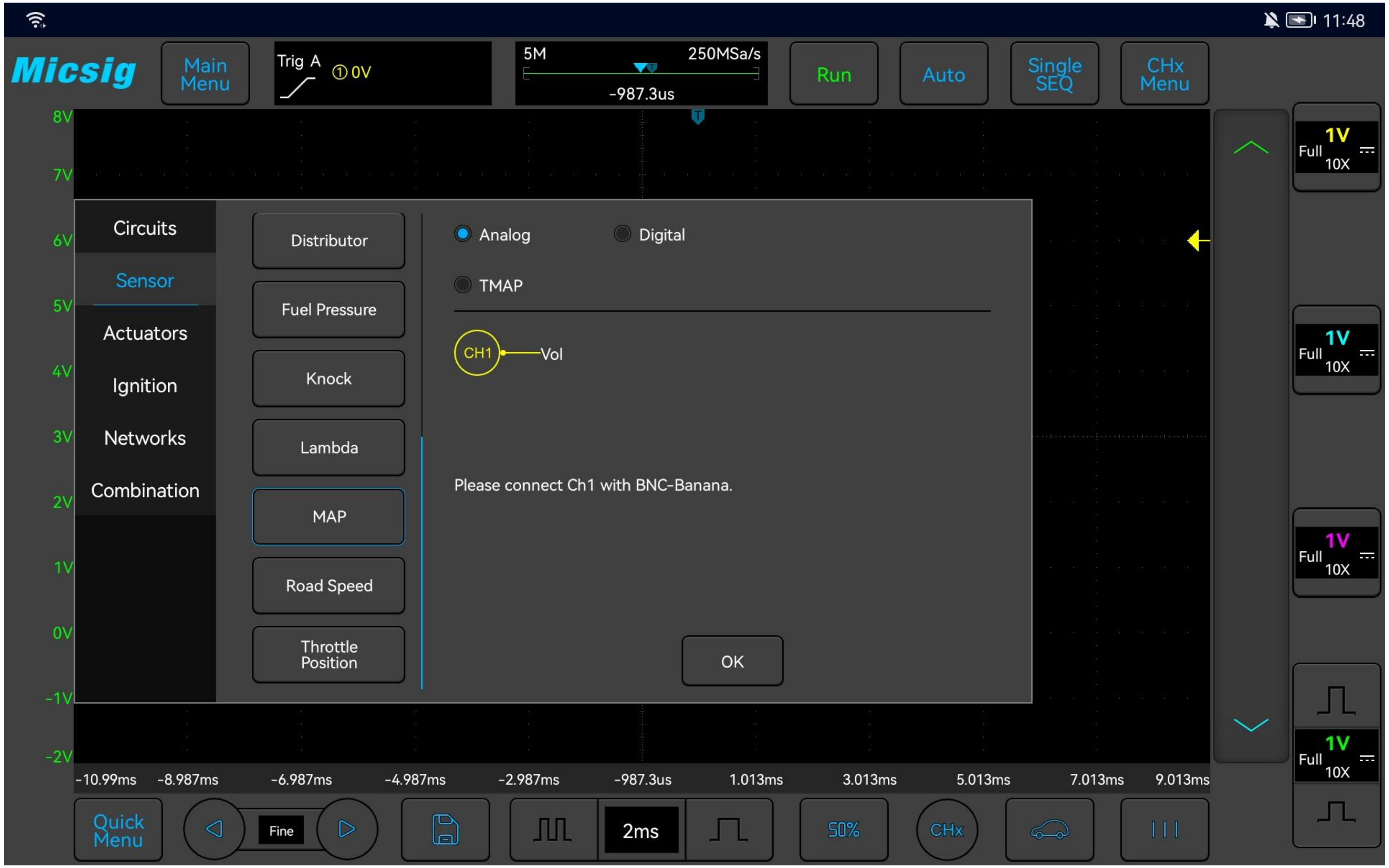


Figure 3-25 MAP (intake pressure sensor)

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

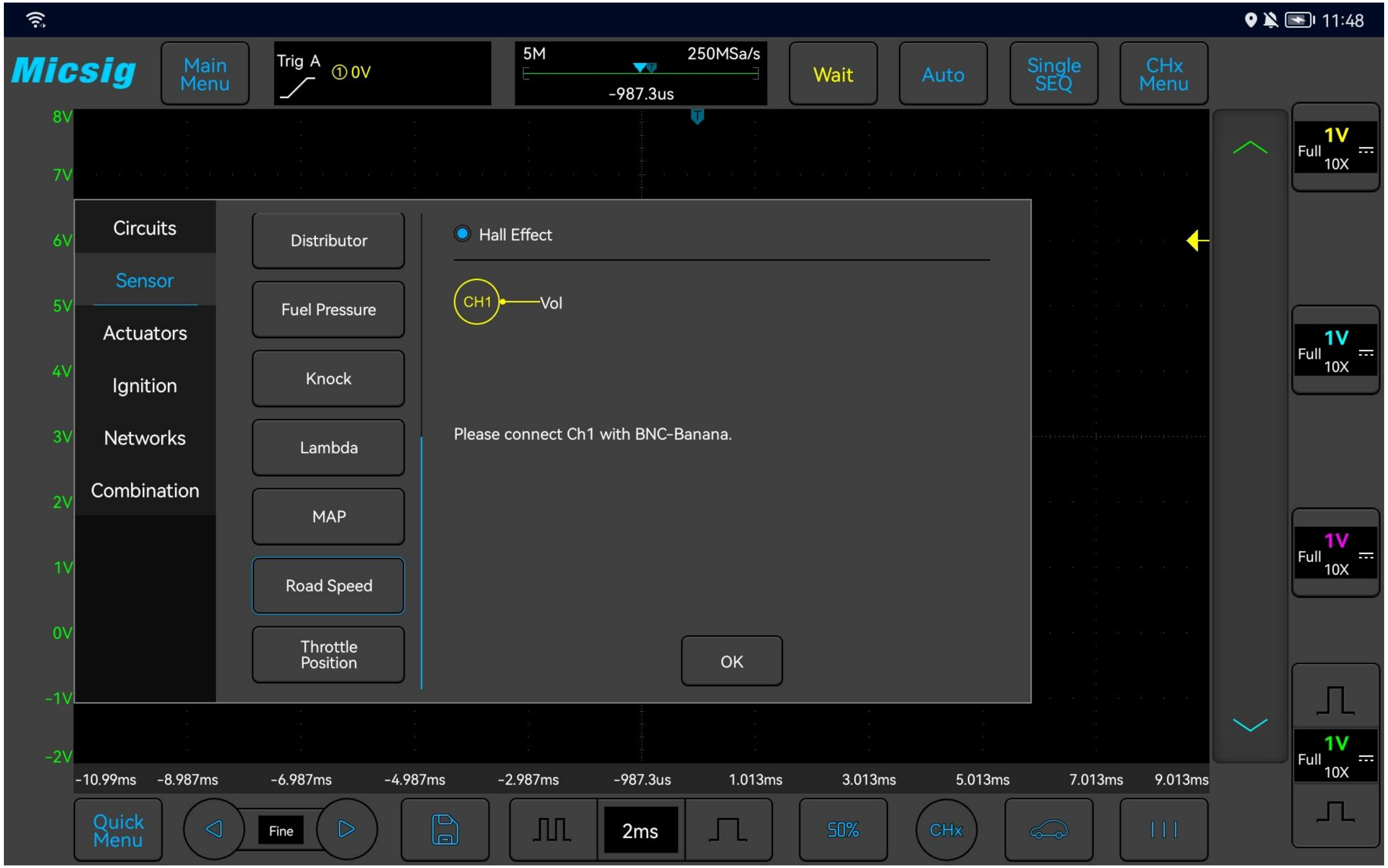


Figure 3-26 Vehicle speed sensor test

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 VATO oscilloscope to test the vehicle speed sensor, the specific operation is shown in Figure 3-27:

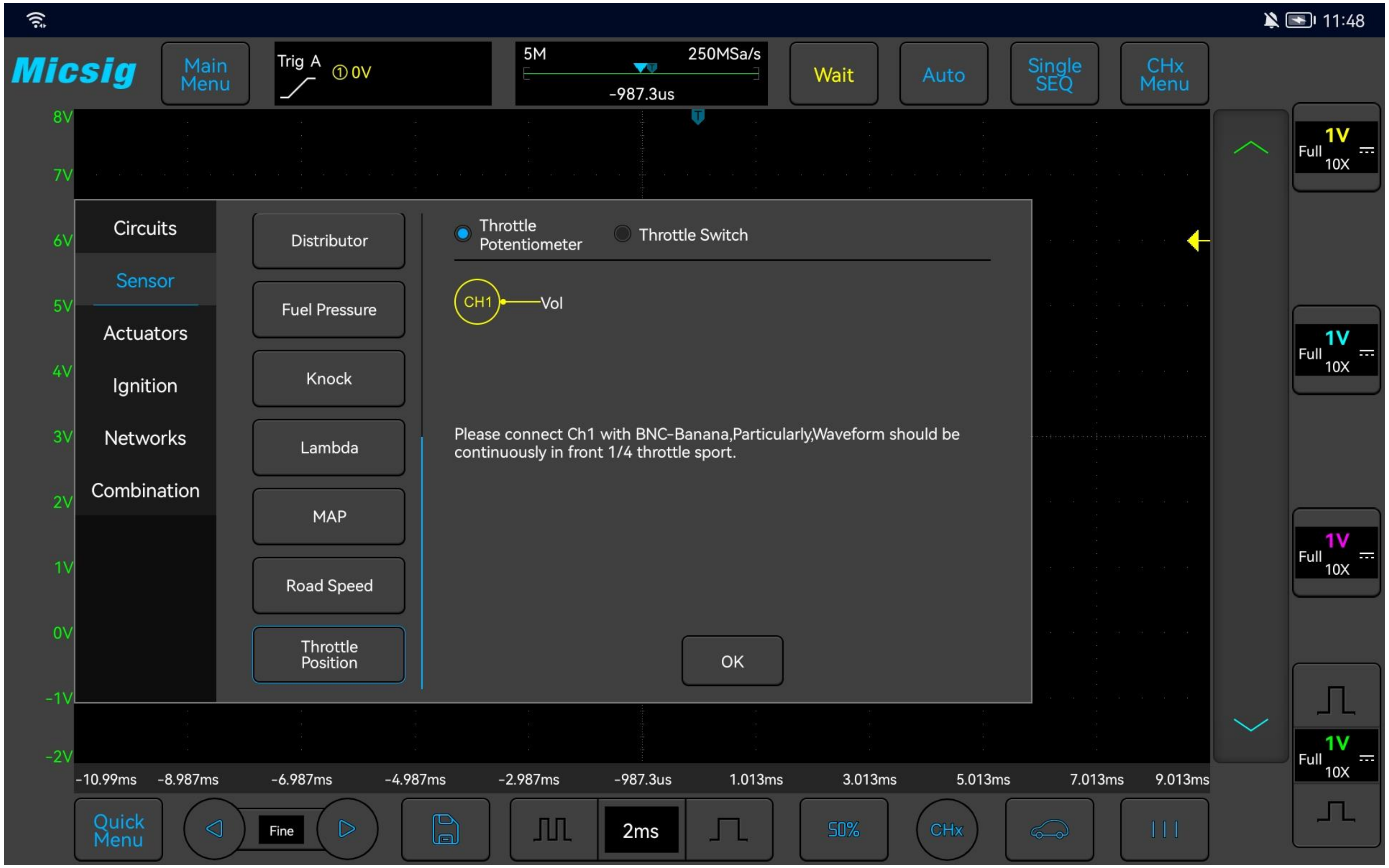


Figure 3-27 Throttle Position Sensor test

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

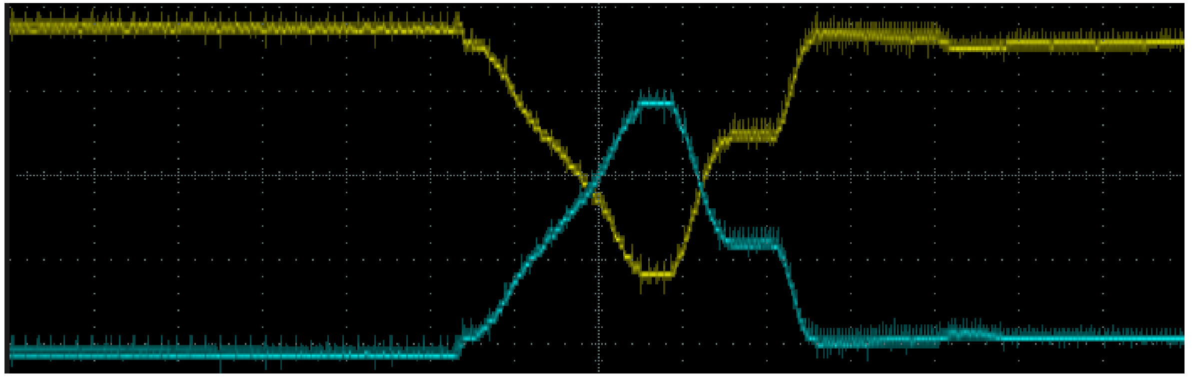


Figure 3-28 Throttle Position Sensor Diagram

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 VATO oscilloscope to test the vehicle speed sensor, the specific operation is shown in Figure 3-29:

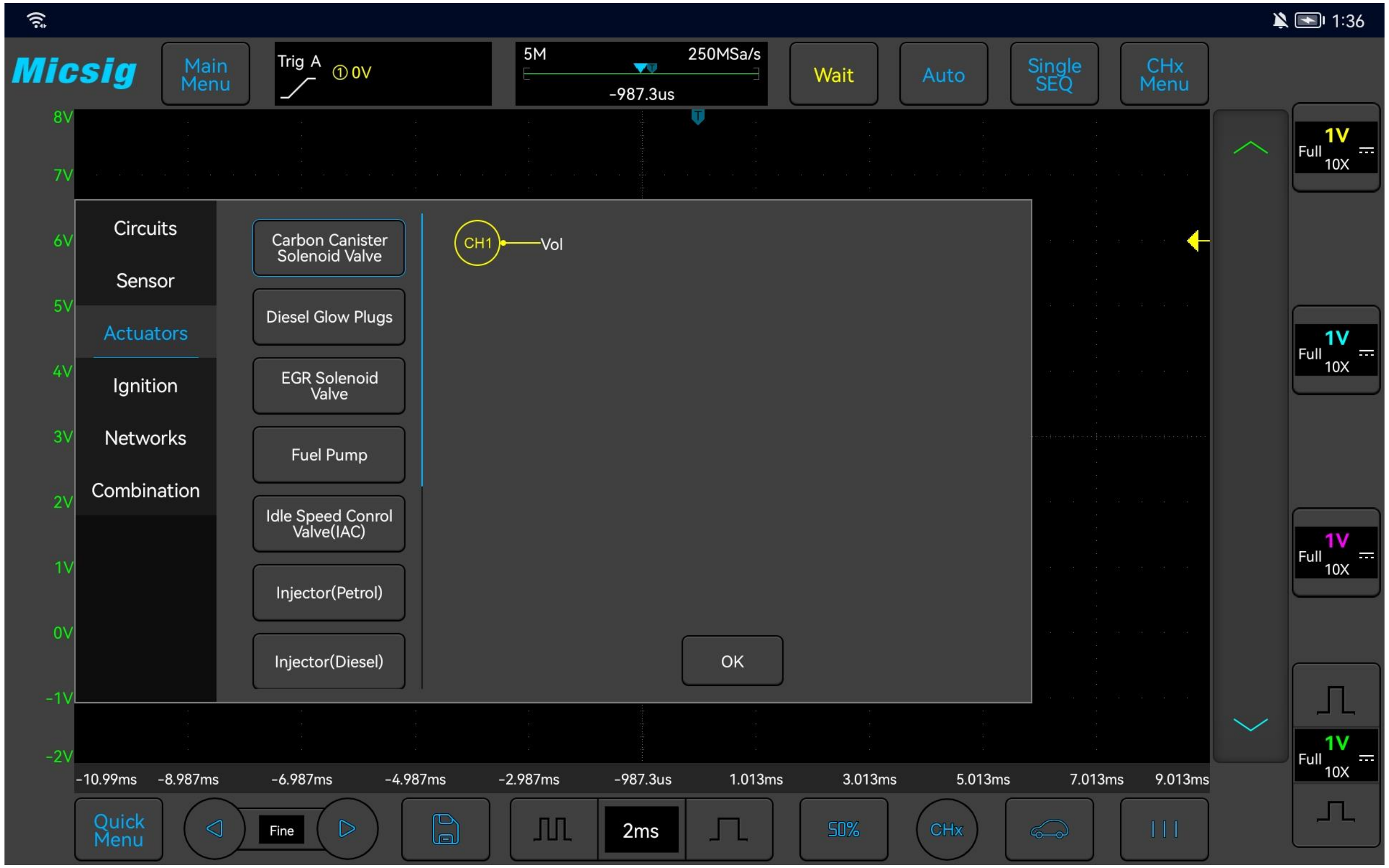


Figure 3-29 Carbon canister solenoid valve test

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

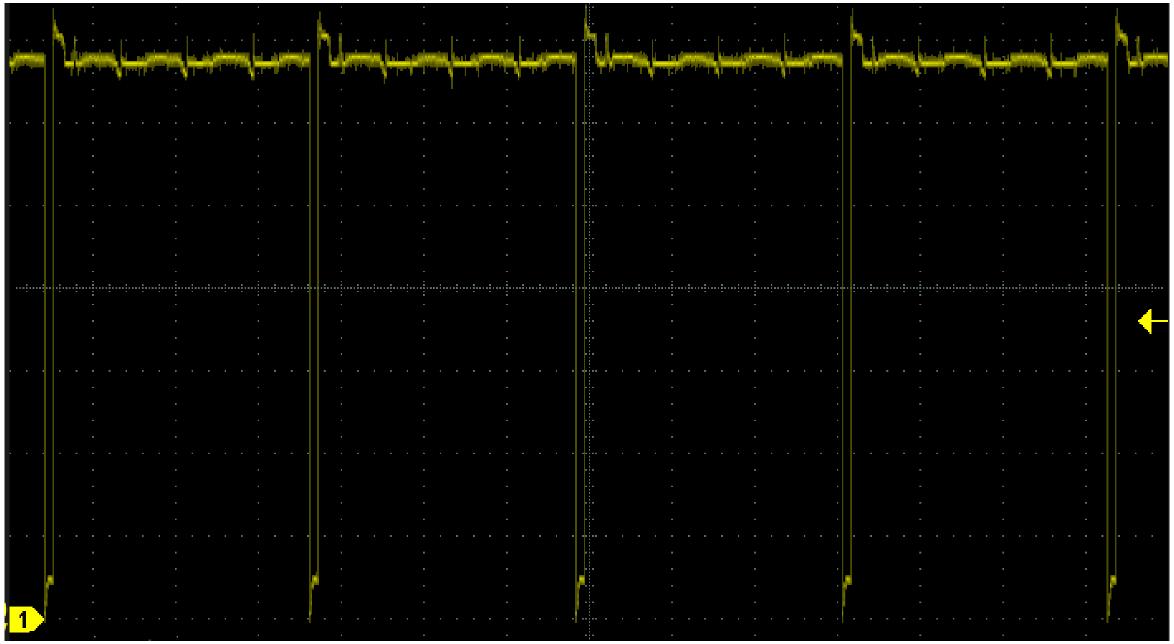


Figure 3-30 Audi A6 Carbon canister solenoid valve signal

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.

VATO 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 3-31 below:

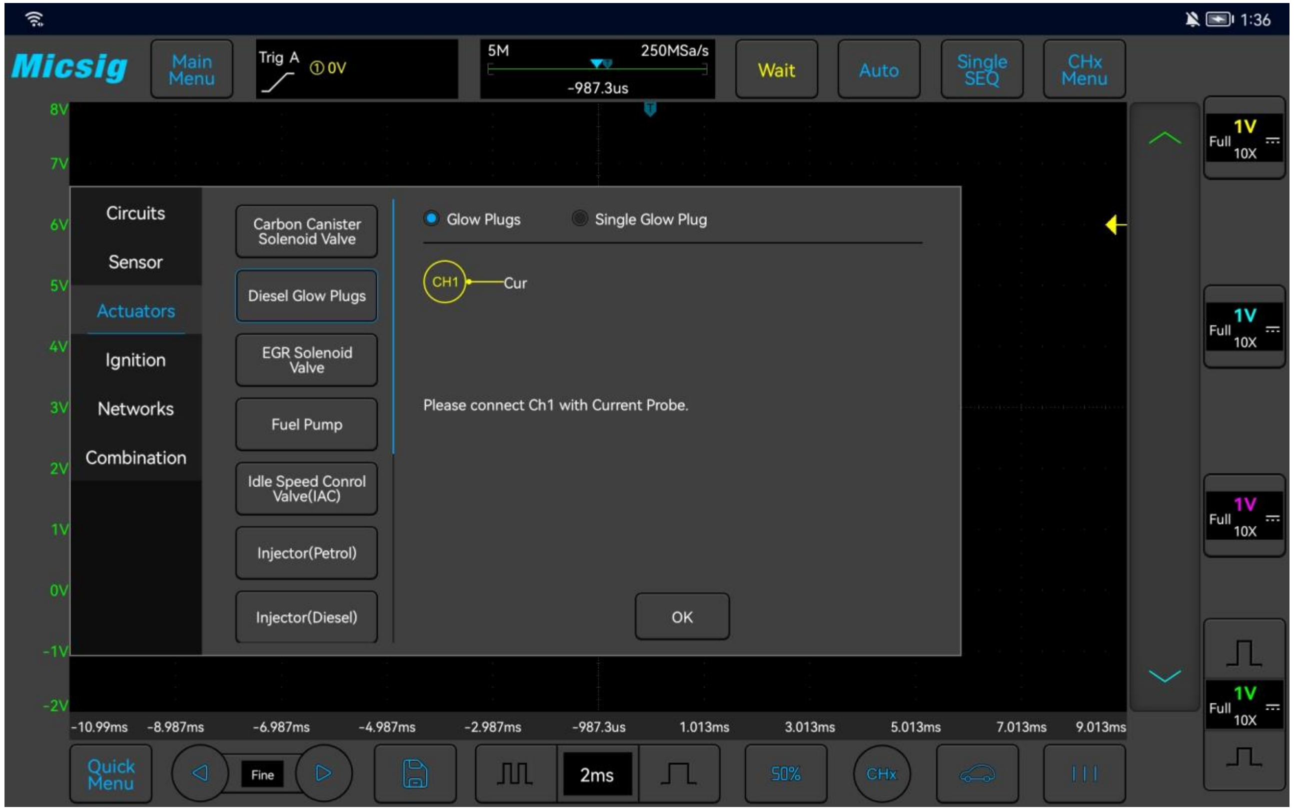


Figure 3-31 Disel Glow Plugs

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 VATO oscilloscope to test the EGR solenoid valve, the specific operation is shown in Figure 3-32:

Figure 3-32 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 VATO oscilloscope to test the electronic fuel pump, the specific operation is shown in Figure 3-33 below:

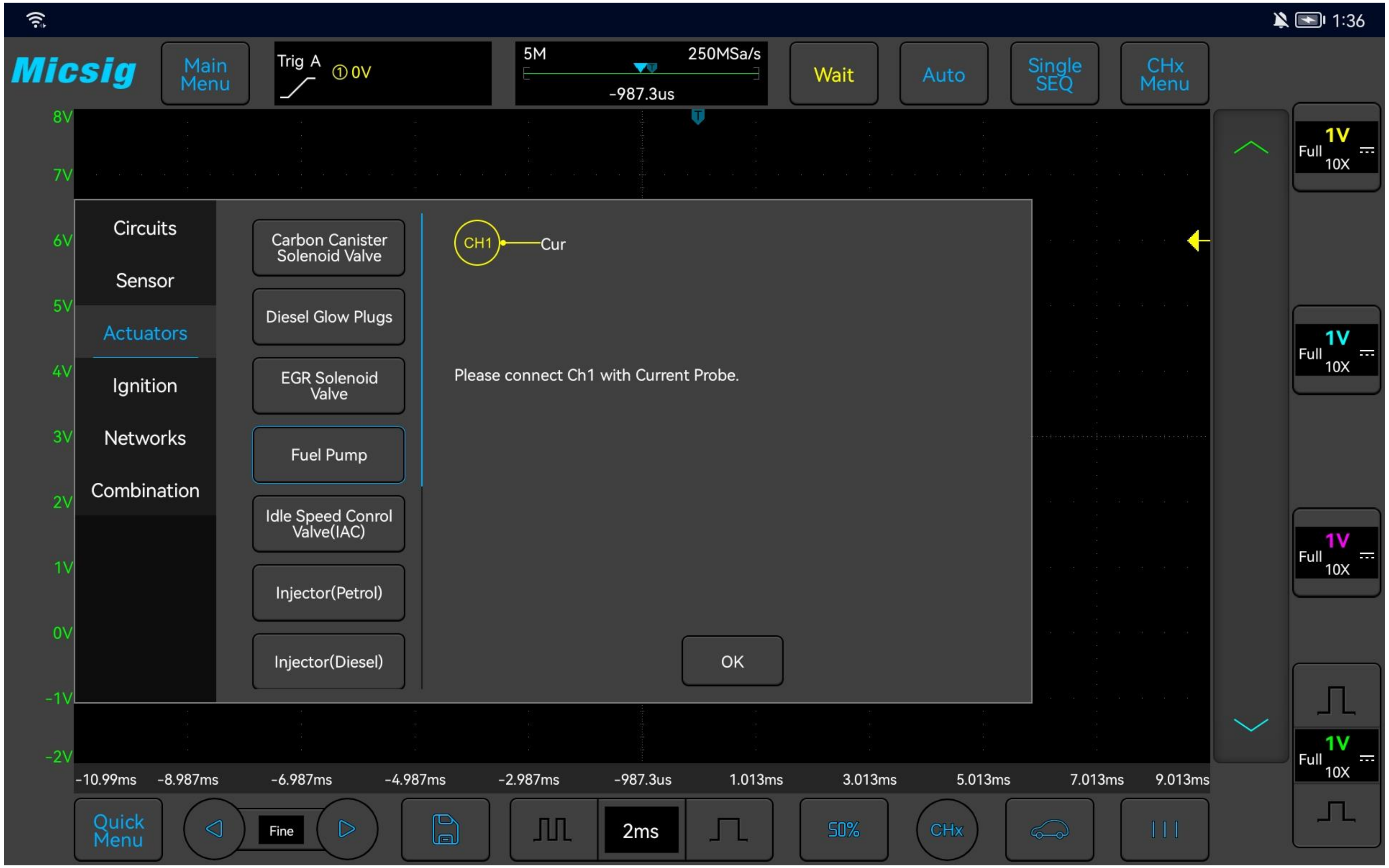


Figure 3-33 Electronic fuel pump test

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 VATO oscilloscope to test the idle speed control valve, the specific operation is as shown in Figure 3-34:

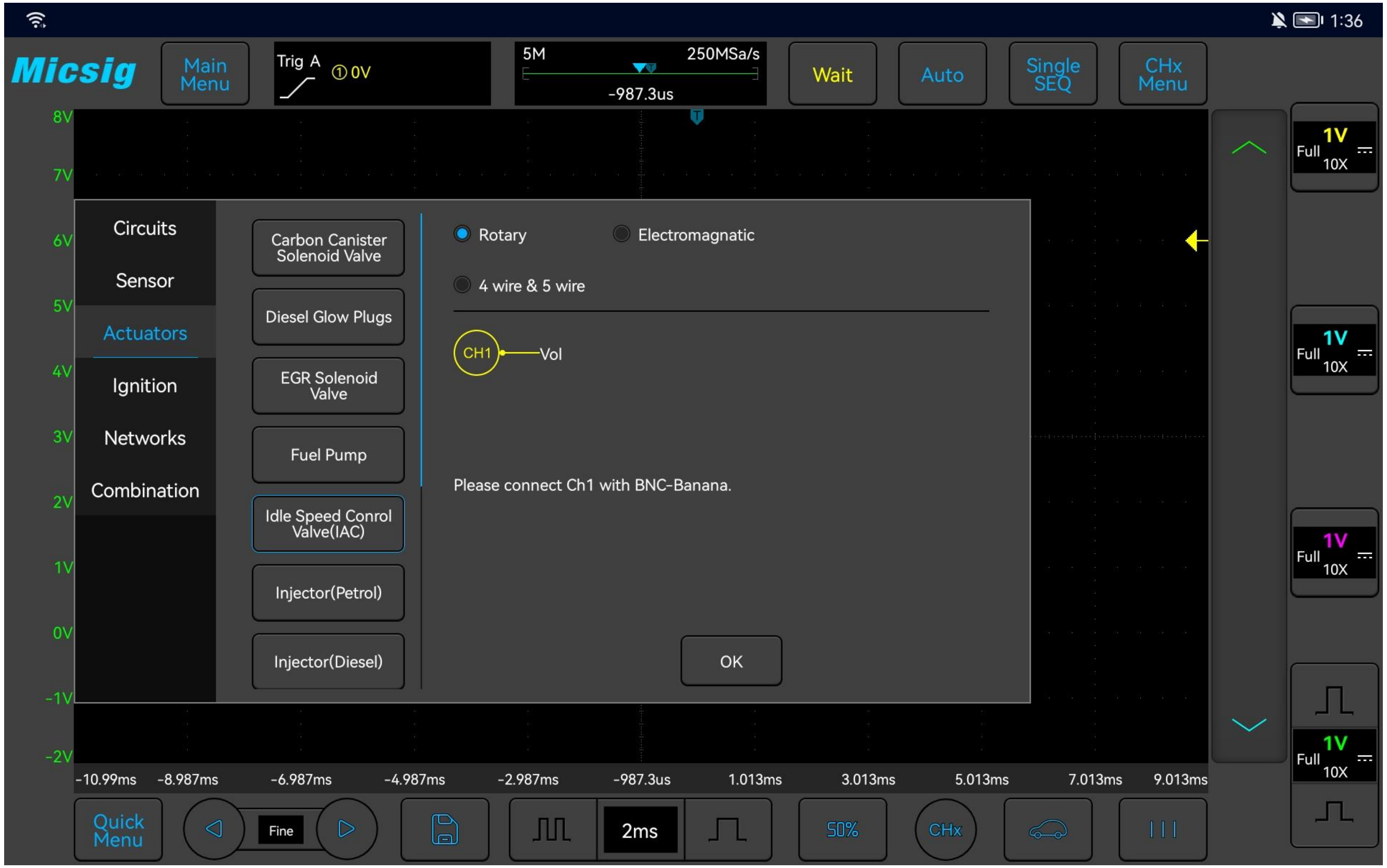


Figure 3-34 Idle speed control valve test

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 VATO oscilloscope to test the fuel injector, the specific operation is shown in Figure 3-35:

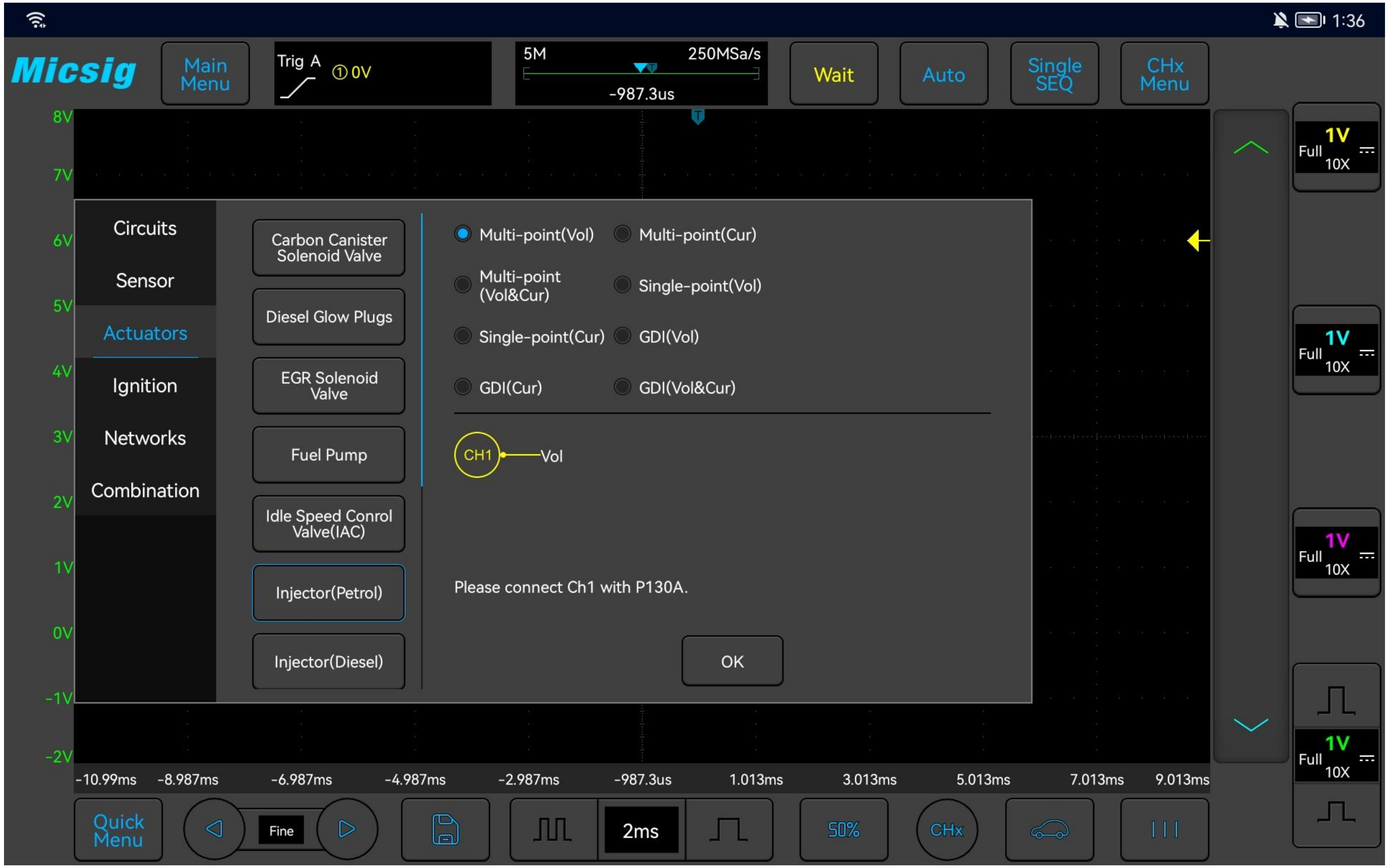


Figure 3-35 Injector (Petrol) Test

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 VATO oscilloscope to test the fuel injector (diesel engine), the specific operation is shown in Figure 3-36:

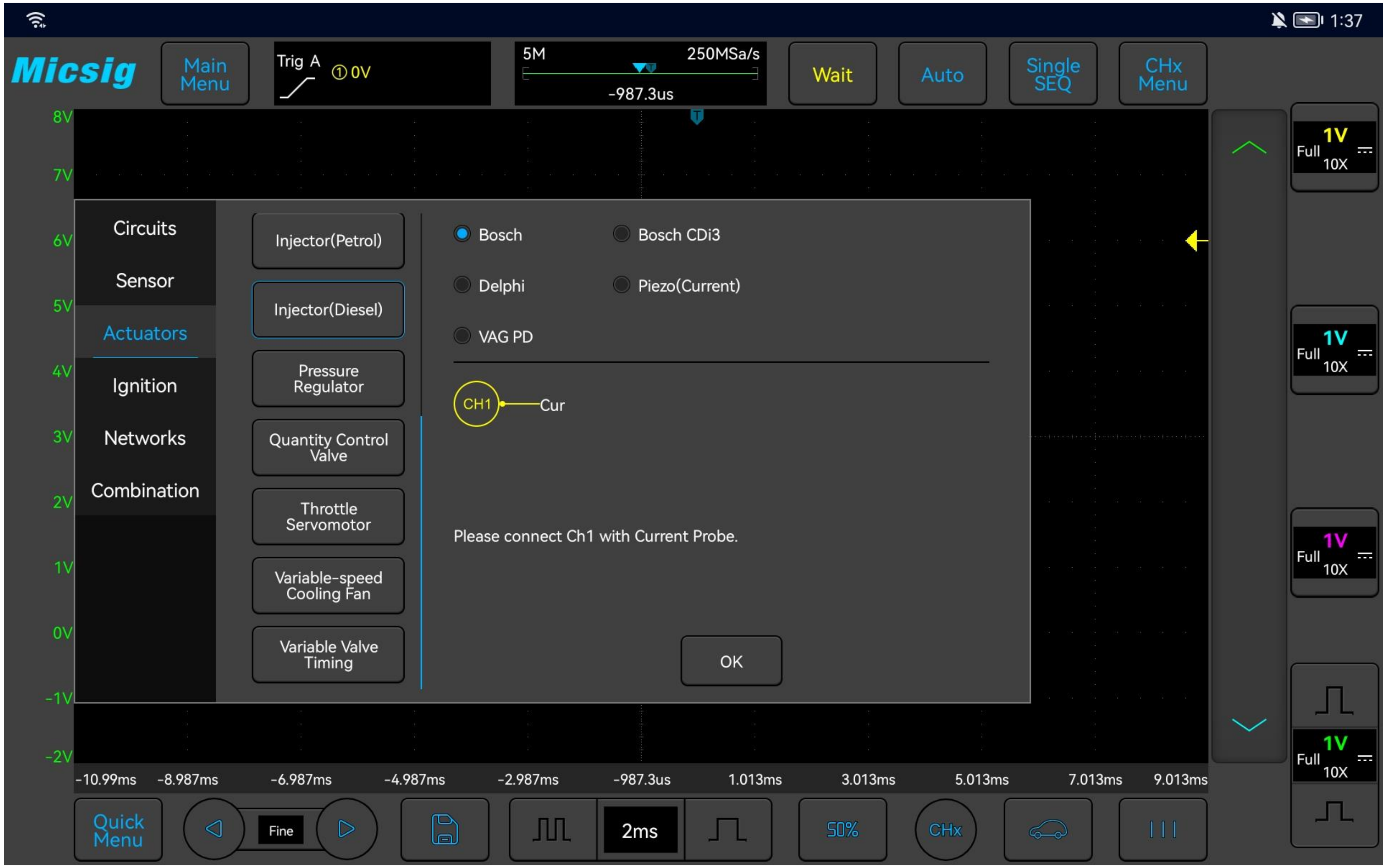


Figure 3-36 injector (diesel engine) test

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 VATO oscilloscope to test the pressure regulator, the specific operation is shown in Figure 3-37:

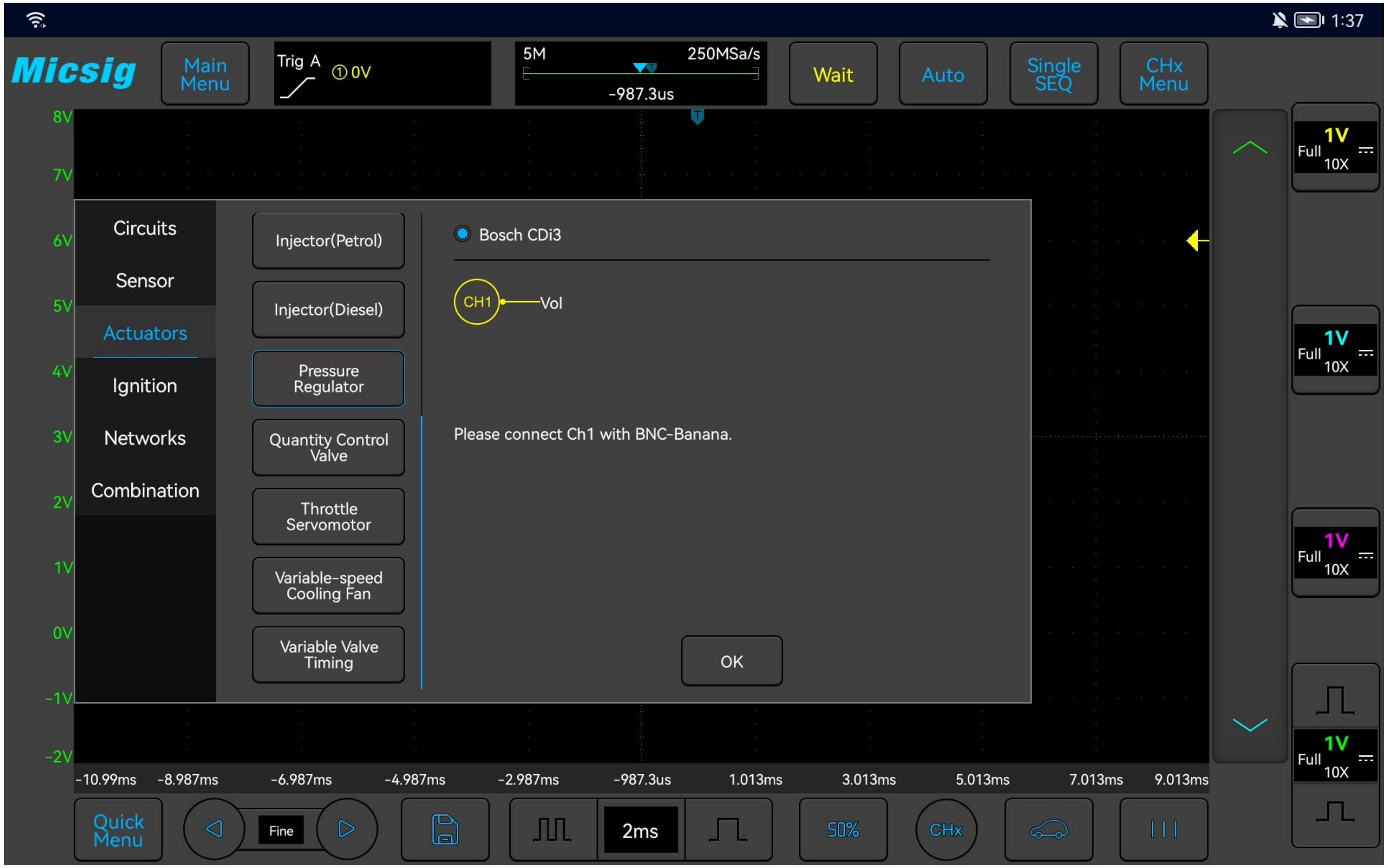


Figure 3-37 Pressure Regulator test

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 VATO oscilloscope to test the flow control valve, the specific operation is shown in Figure 3-38:

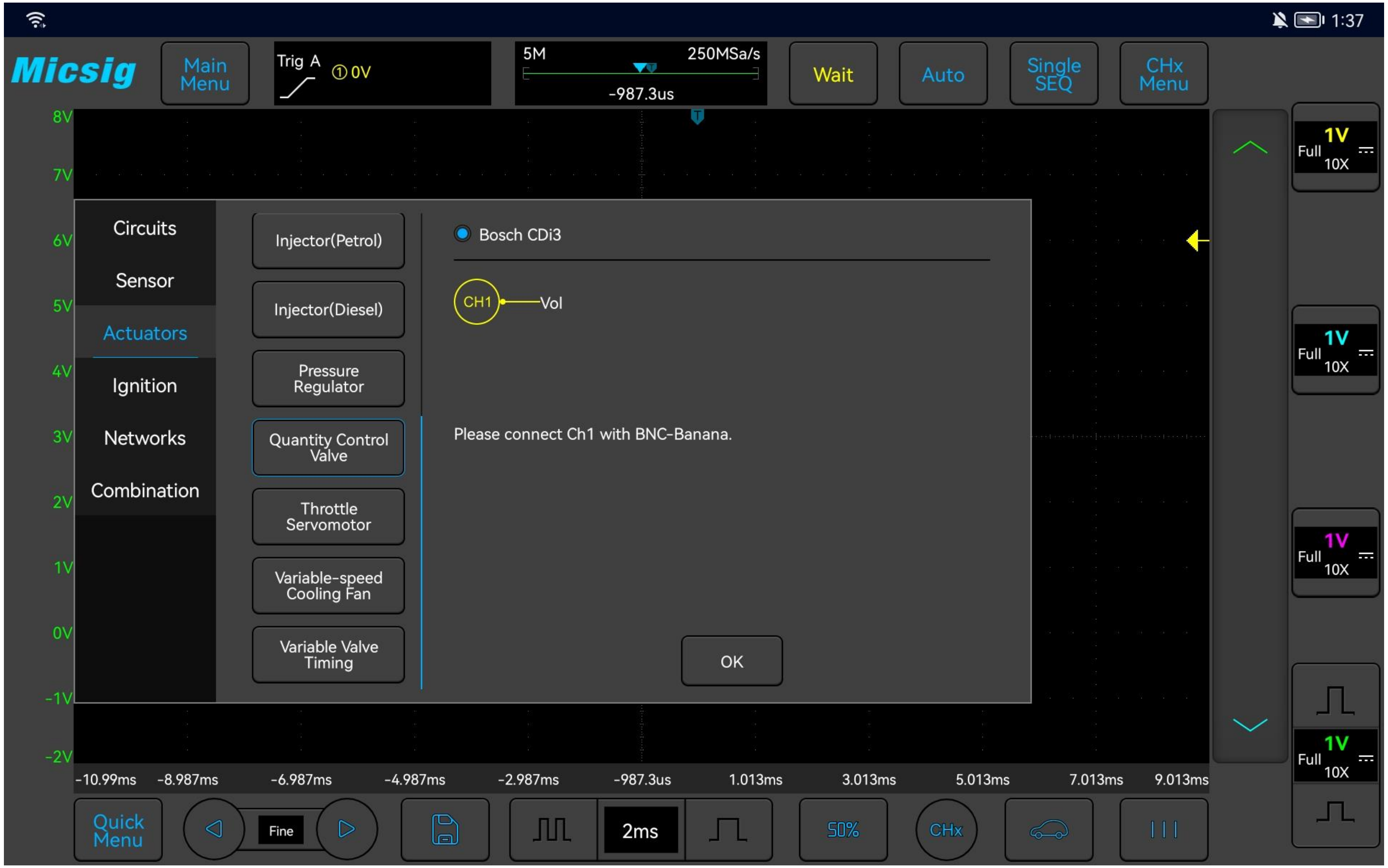


Figure 3-38 Quantity (Flow) control valve test

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 VATO oscilloscope to test the throttle servo motor, the specific operation is shown in Figure 3-39:

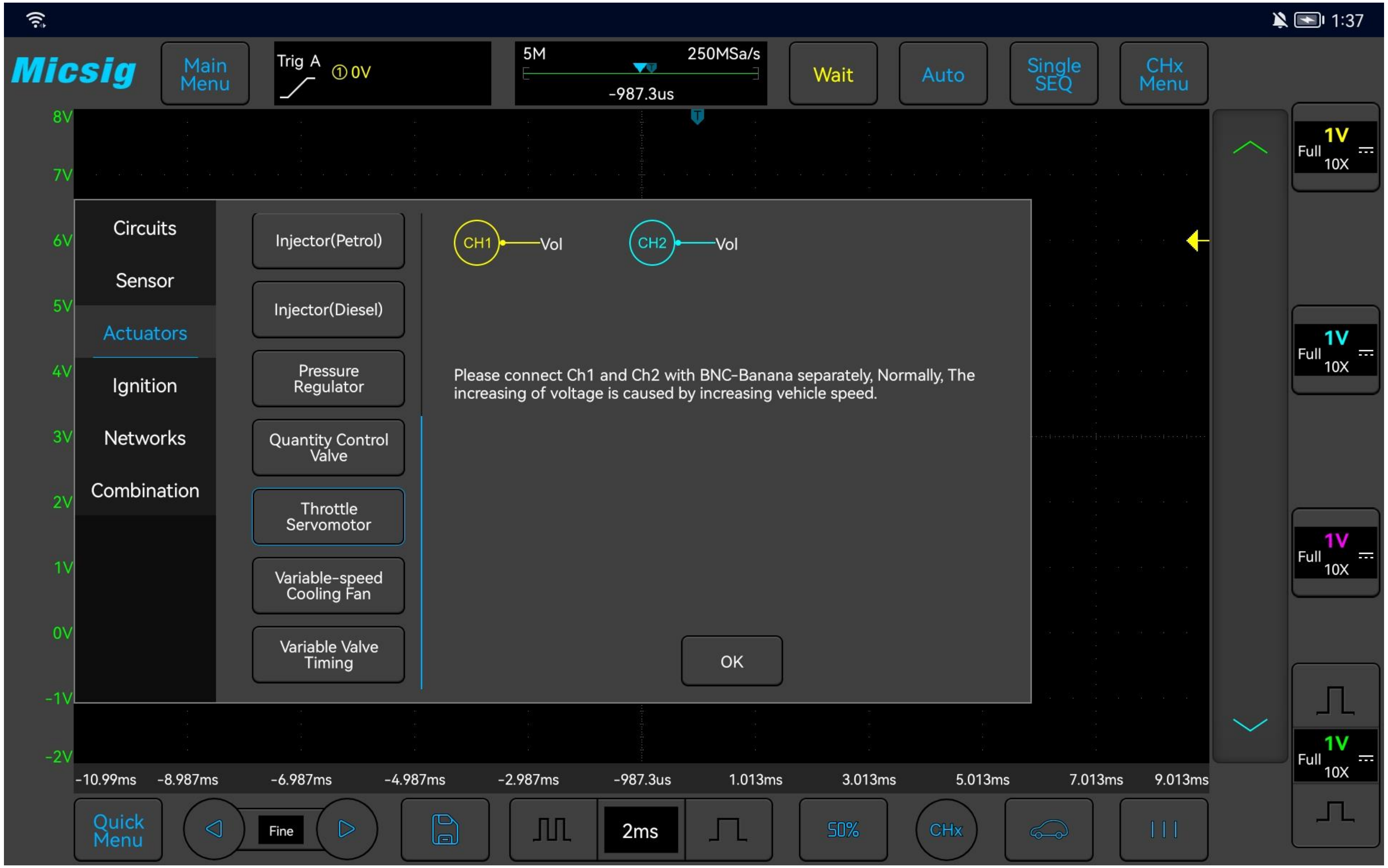


Figure 3-39 Throttle servo motor test

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 VATO oscilloscope to test the cooling fan, the specific operation is shown in Figure 3-40:

Figure 3-40 Variable-speed Cooling fan test

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

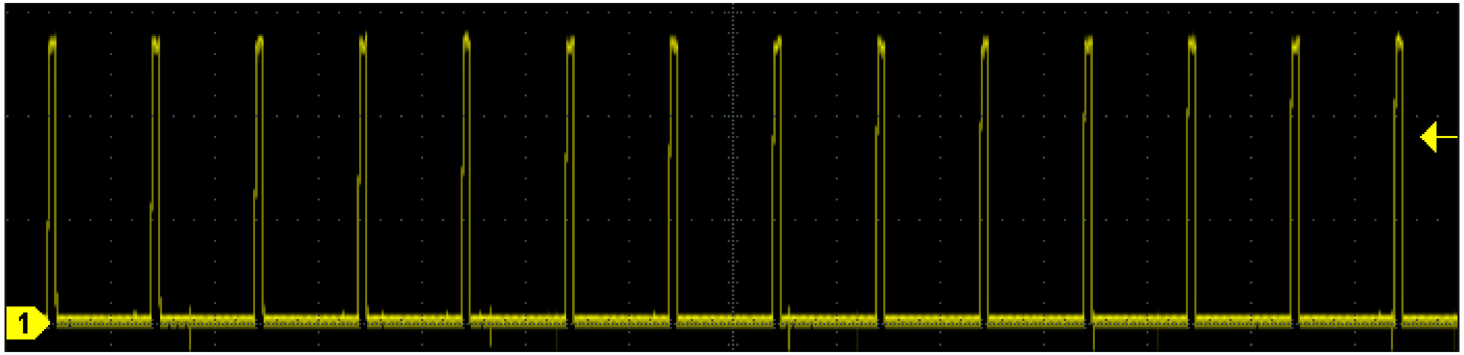


Figure 3-41 Cooling fan measurement diagram

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 VATO oscilloscope to test the variable valve timing (divided into single and double timing), the specific operation is shown in Figure 3-42:

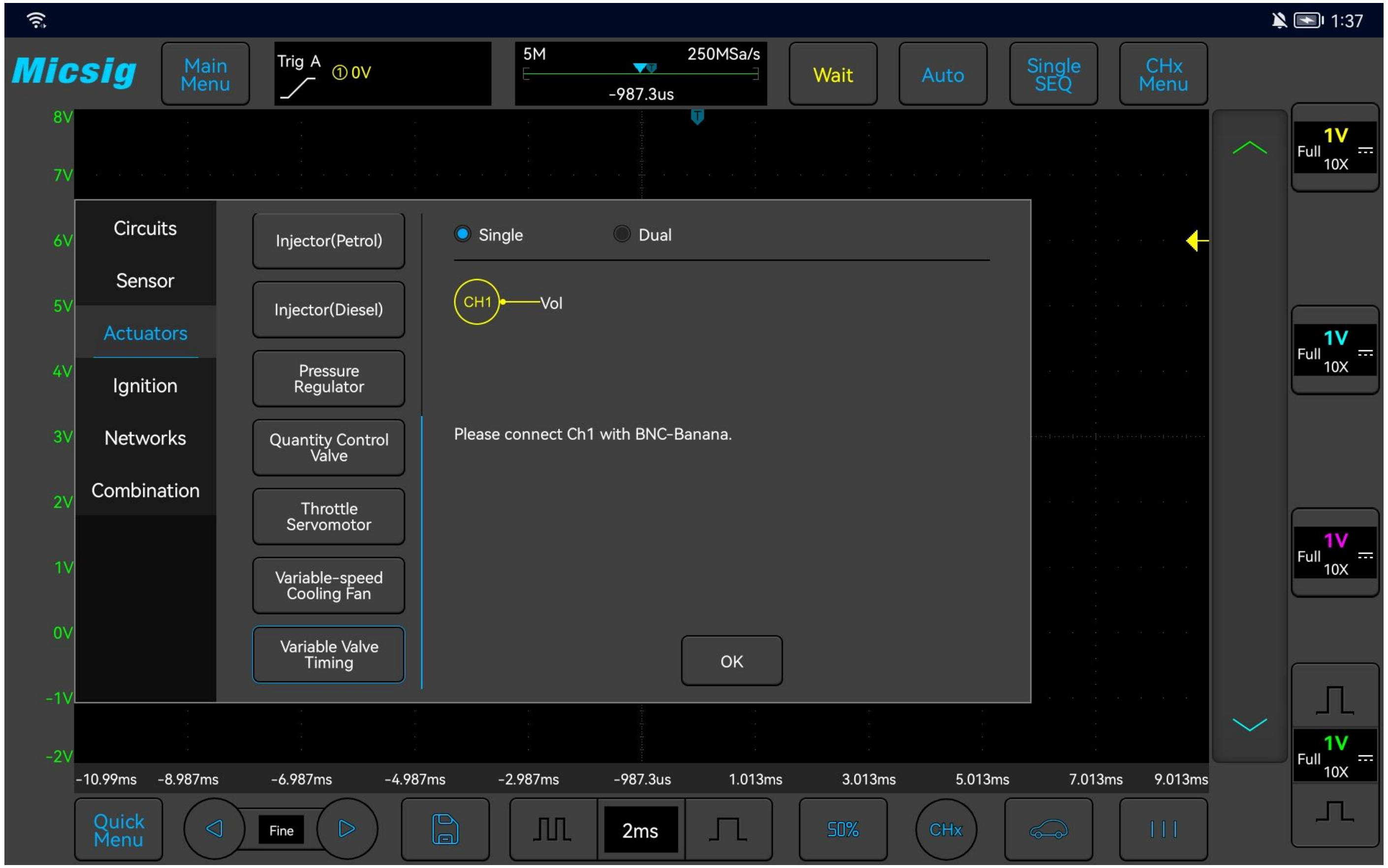


Figure 3-42 Variable valve timing test

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

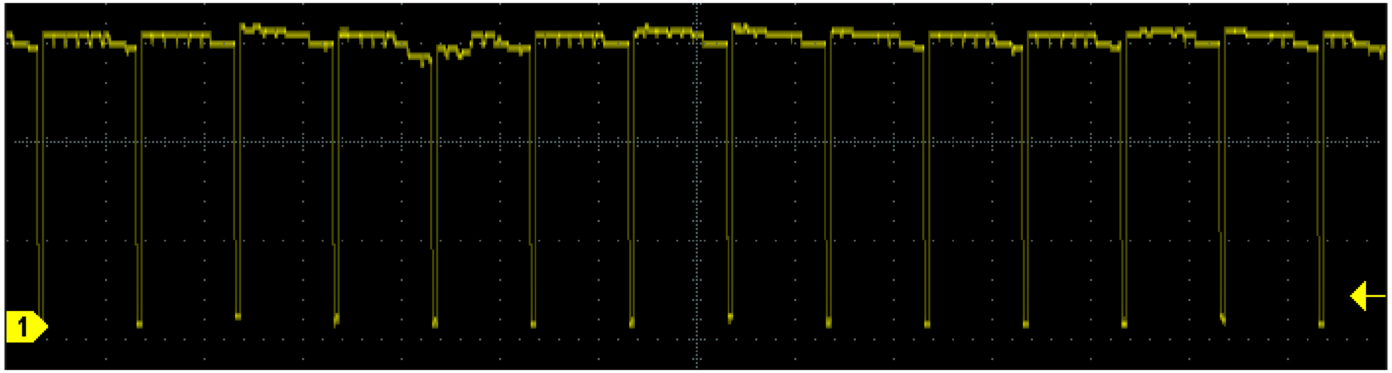


Figure 3-43 Actual measurement chart of variable valve timing

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 VATO 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 3-44:

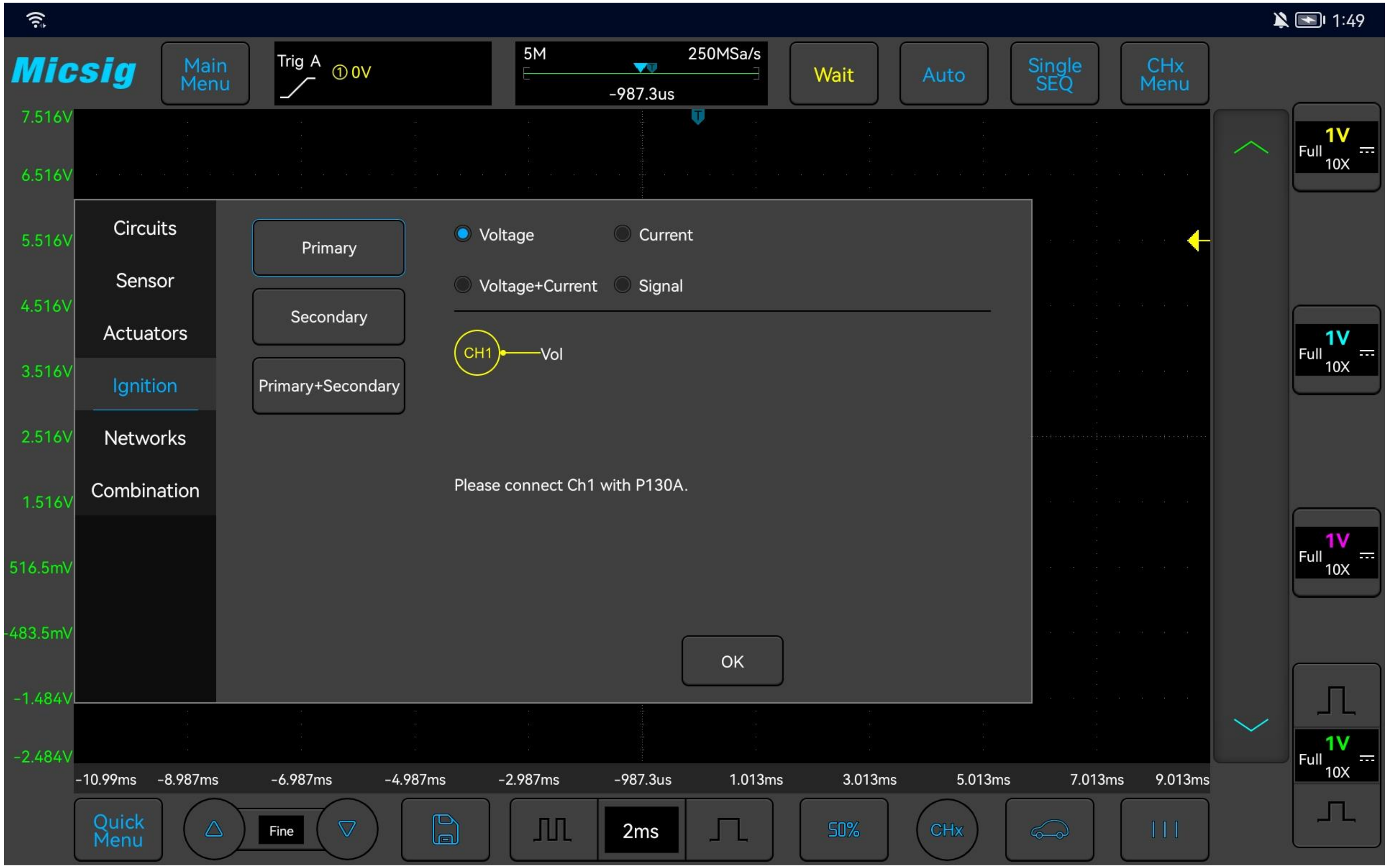


Figure 3-44 Primary ignition

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

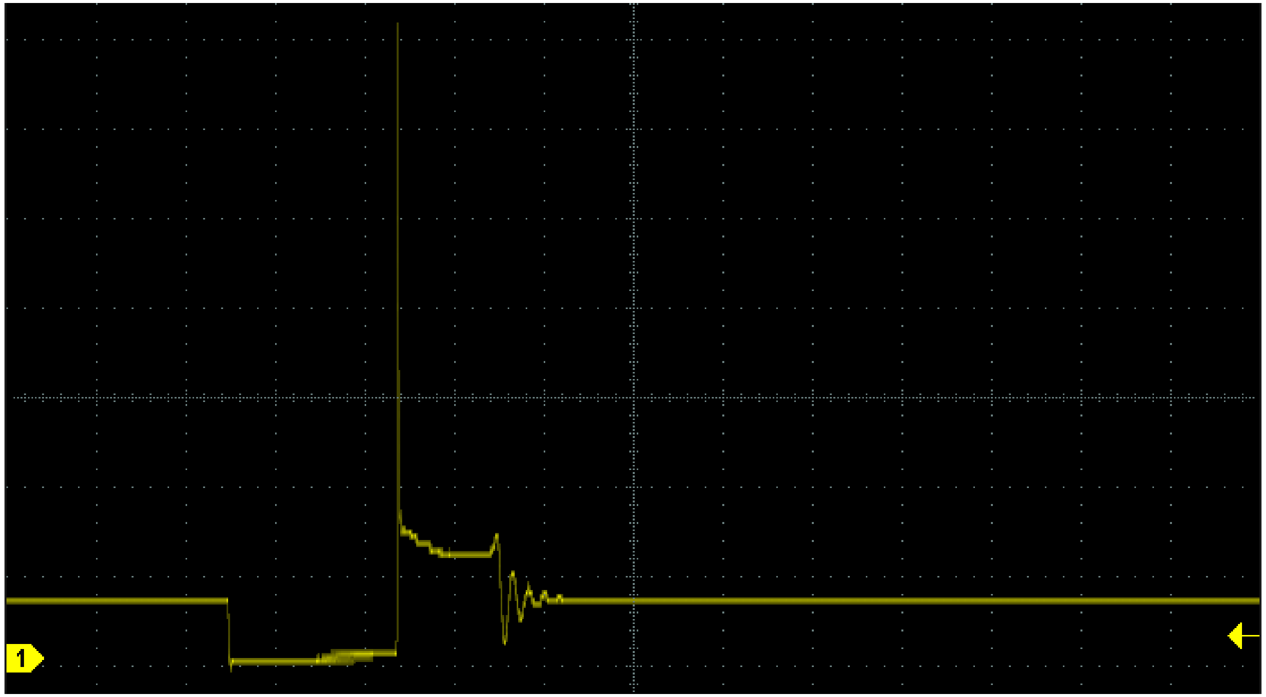


Figure 3-45 Primary ignition actual test

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 VATO 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 3-46:

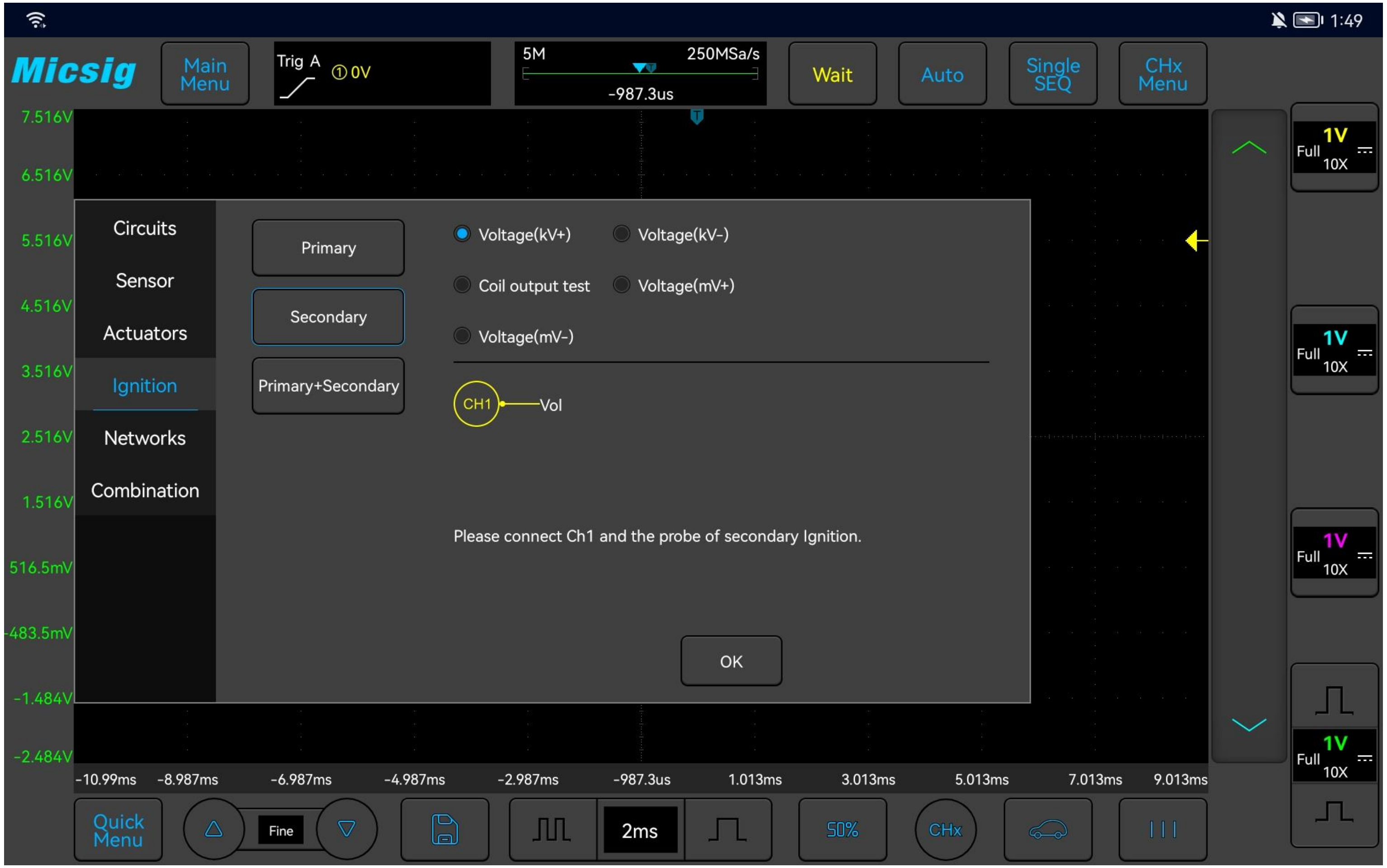


Figure 3-46 Secondary ignition test

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 VATO 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 3-47:

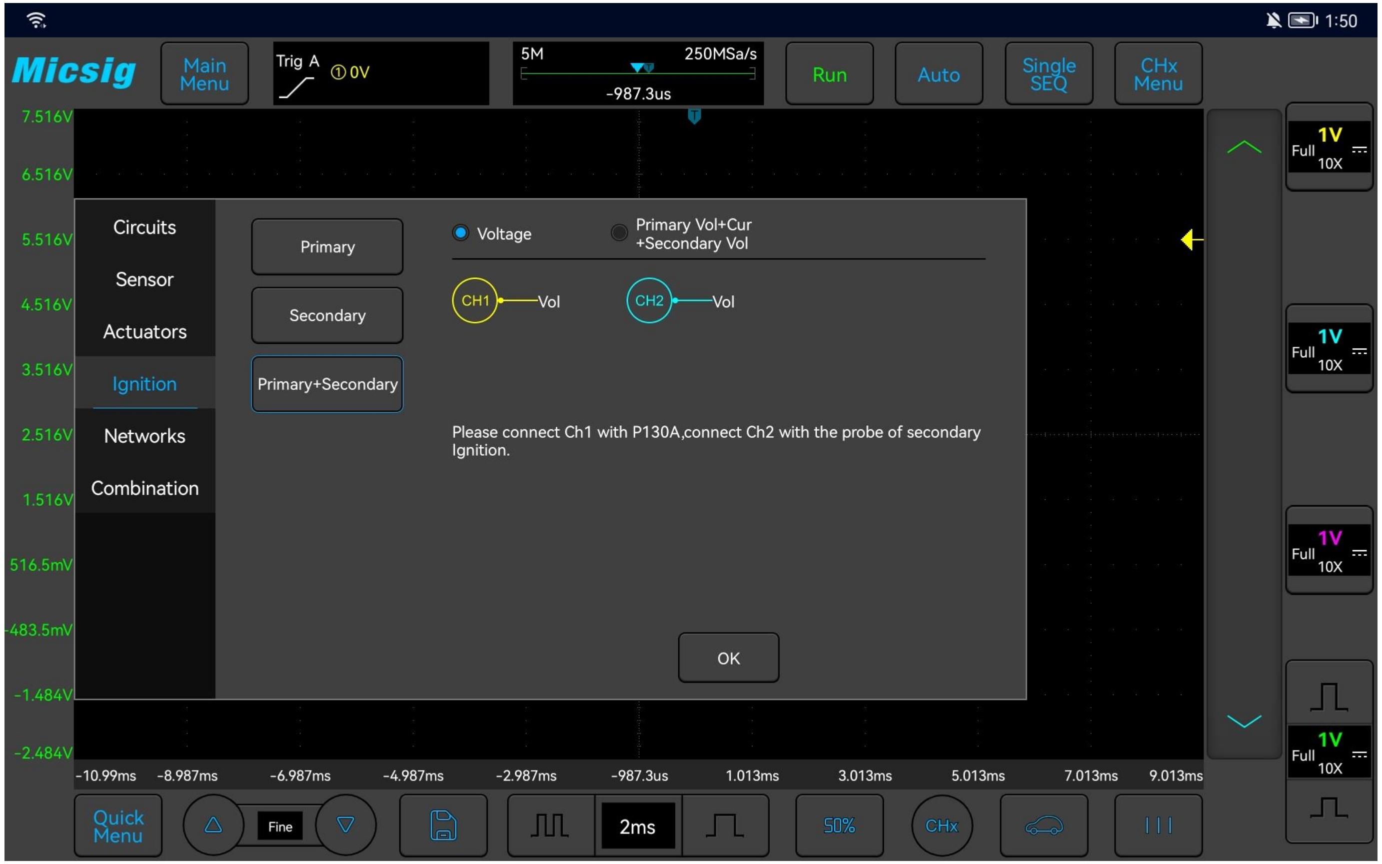


Figure 3-47: Primary + Scondary ignition test

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

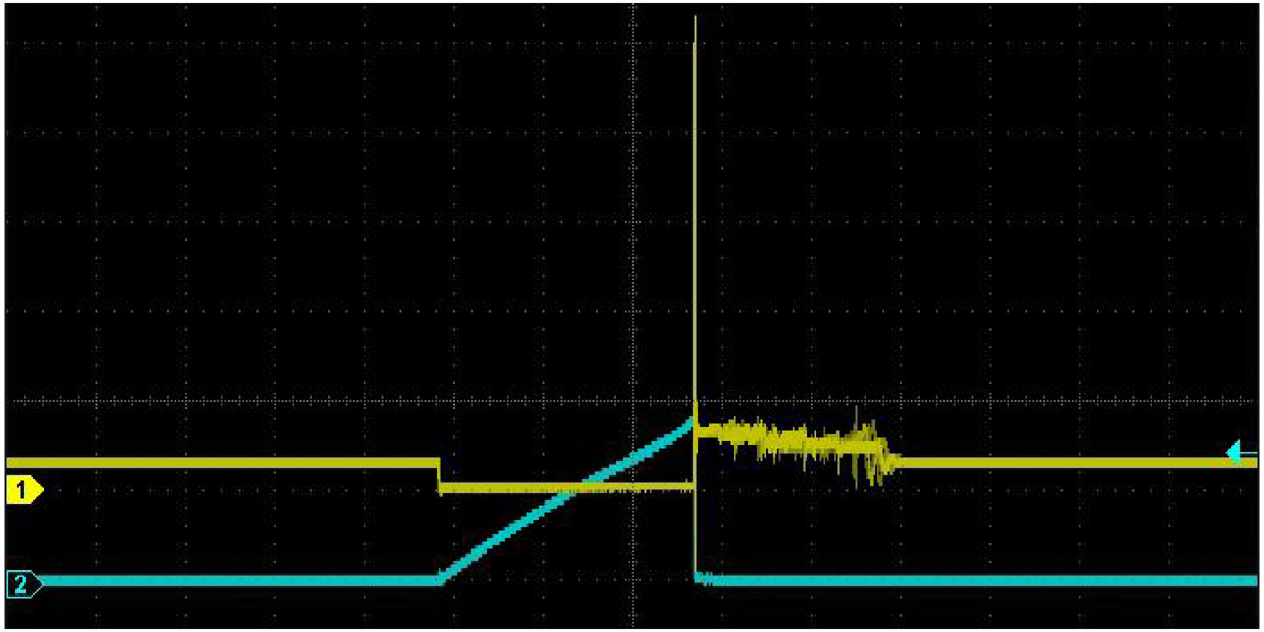


Figure 3-48 BMW 5 Series N20 Primary + Secondary ignition signal

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 VATO oscilloscope to test the CAN bus, the specific operation is shown in Figure 3-49:

Figure 3-49 CAN BUS Test

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

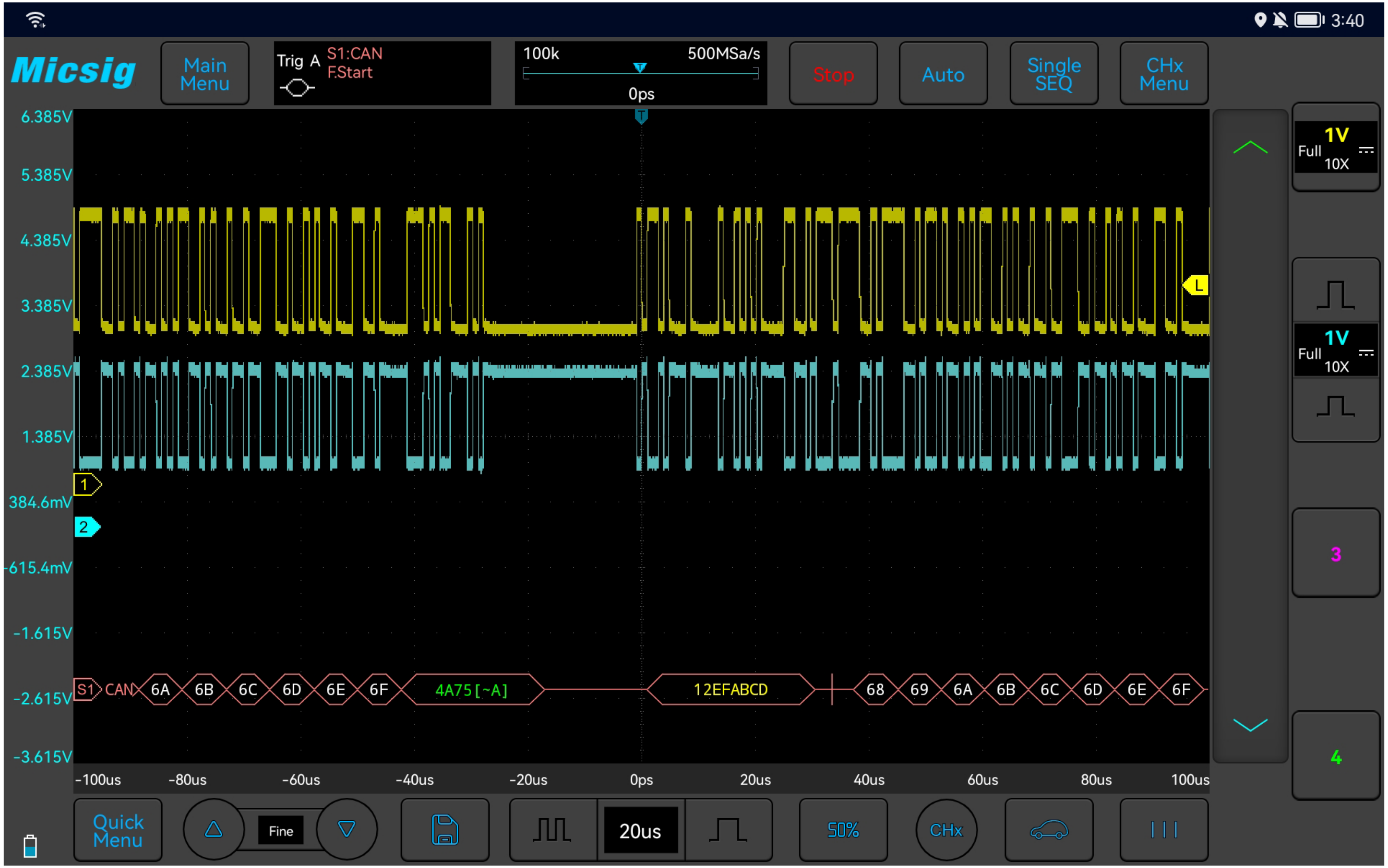


Figure 3-50 CAN bus measurement diagram

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 VATO oscilloscope to test the LIN bus, the specific operation is shown in Figure 3-51:

Figure 3-51 Lin bus test

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

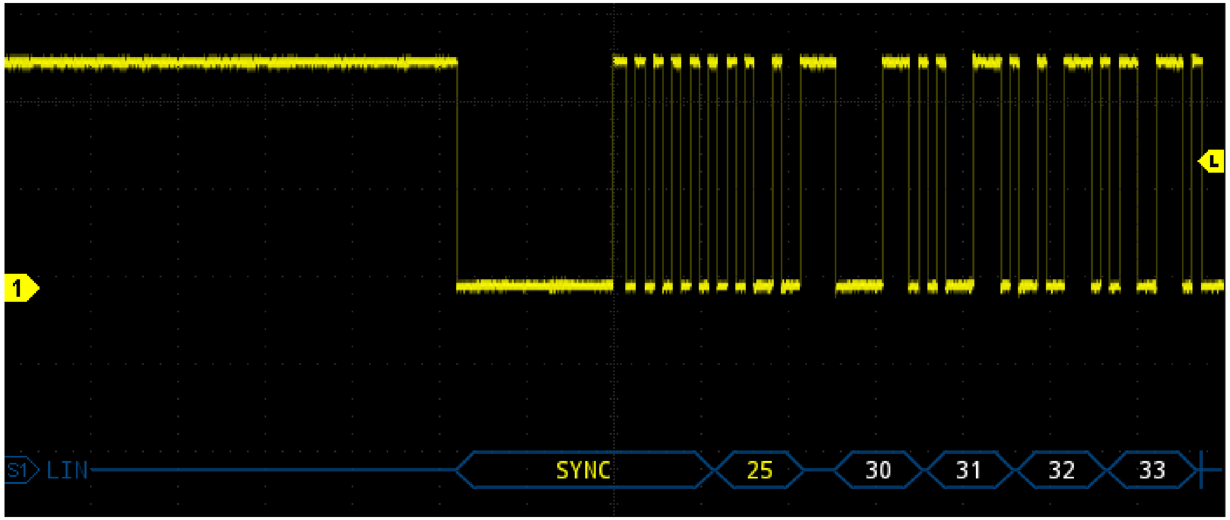


Figure 3-52 Audi A6 LIN bus measurement

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 VATO oscilloscope to test the FlexRay bus, the specific operation is shown in Figure 3-53:

Figure 3-53: 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 VATO oscilloscope to test the K line, the specific operation is shown in Figure 3-54 below:

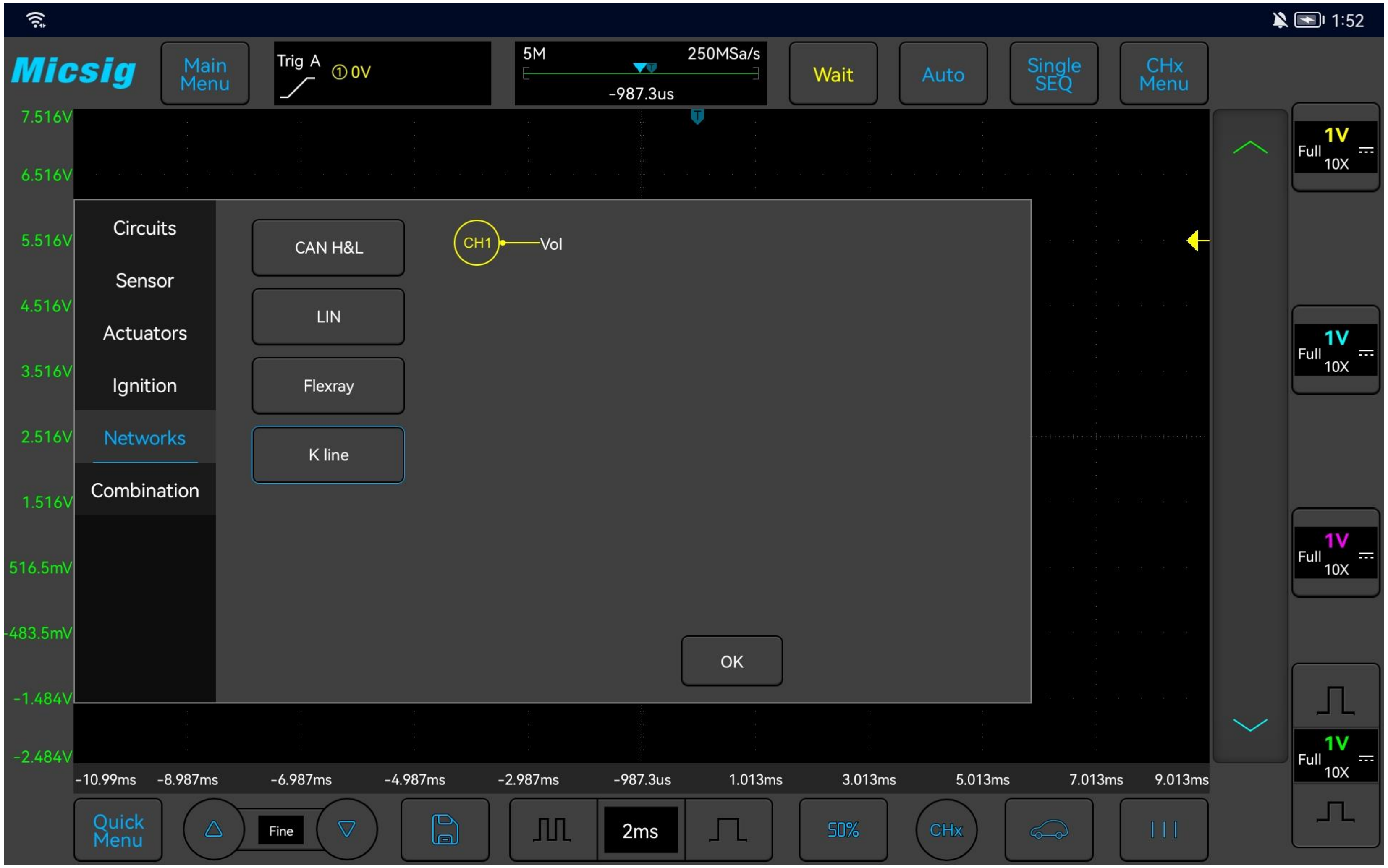


Figure 3-54 K line test

3. 6 Combination Tests

The electronic faults of automobiles are sometimes more complicated. We need to use an VATO 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 VATO 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 VATO oscilloscope to perform combined test on crankshaft + camshaft, the specific operation is shown in Figure 3-55:

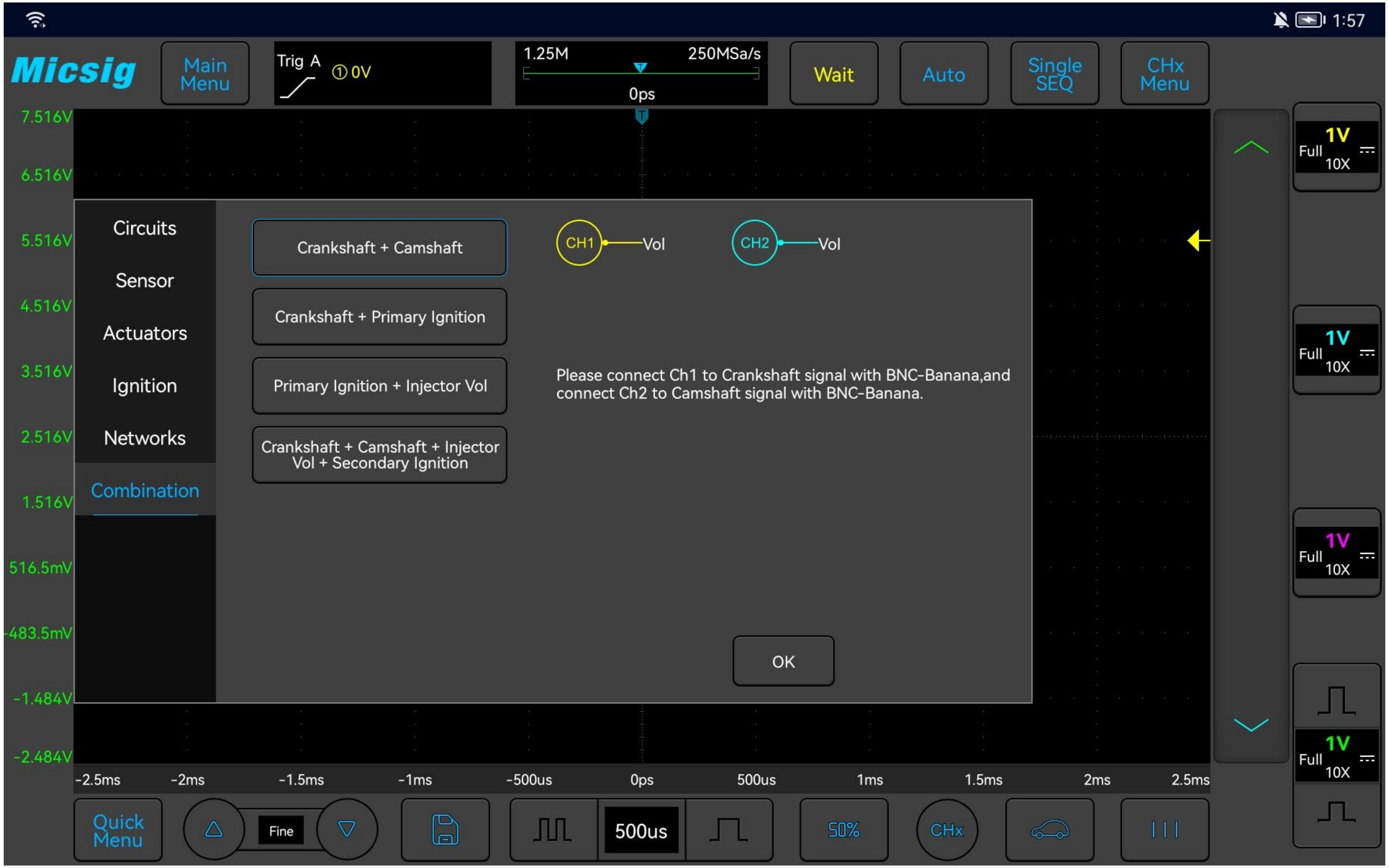


Figure 3-55 Crankshaft + Camshaft Combination Test

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 VATO oscilloscope to perform combined test on crankshaft + primary ignition, the specific operation is shown in Figure 3-56:

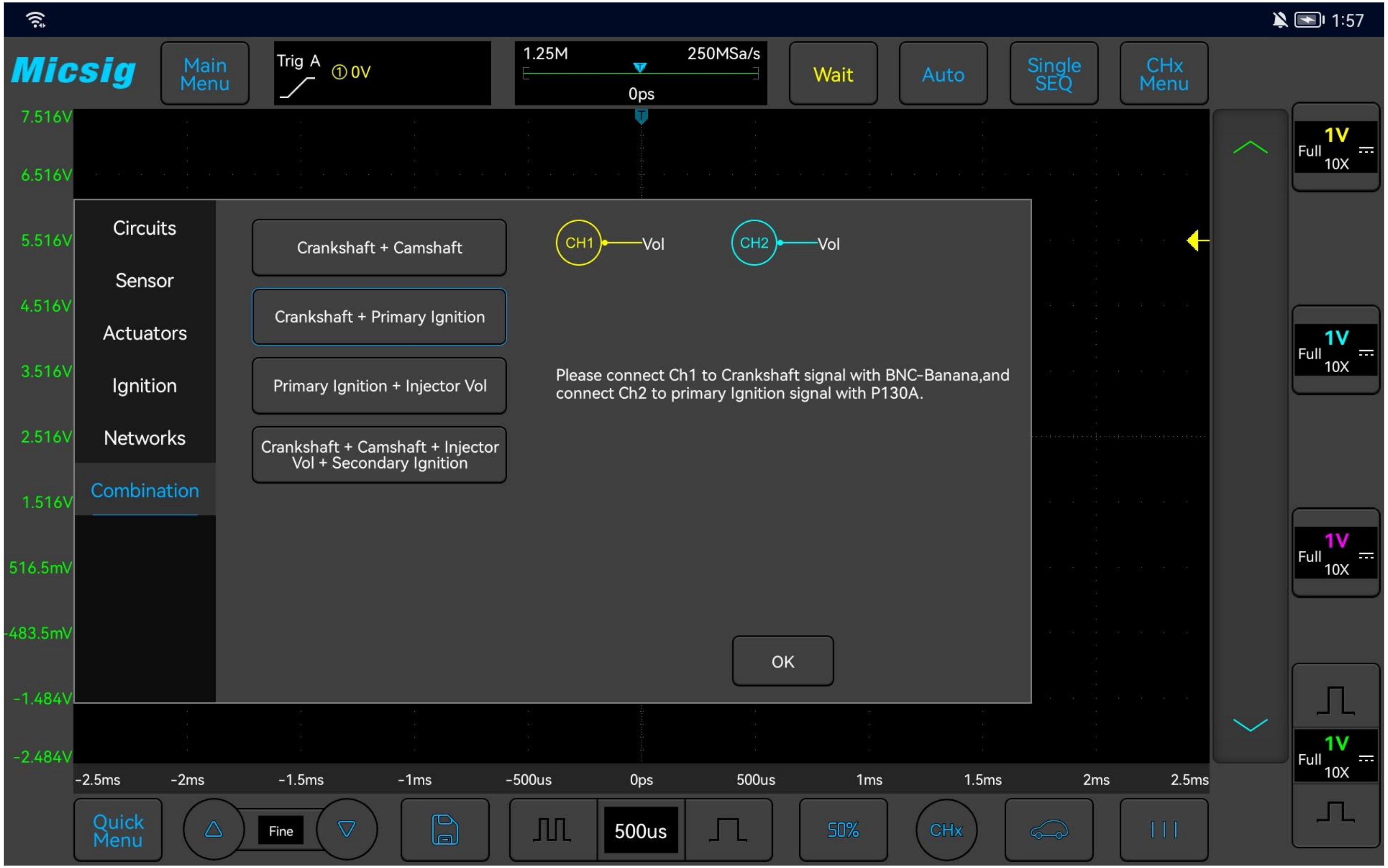


Figure 3-56 Crankshaft + Primary ignition test

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 VATO oscilloscope to perform a combined test on the primary ignition + injector voltage, the specific operation is shown in Figure 3-57:

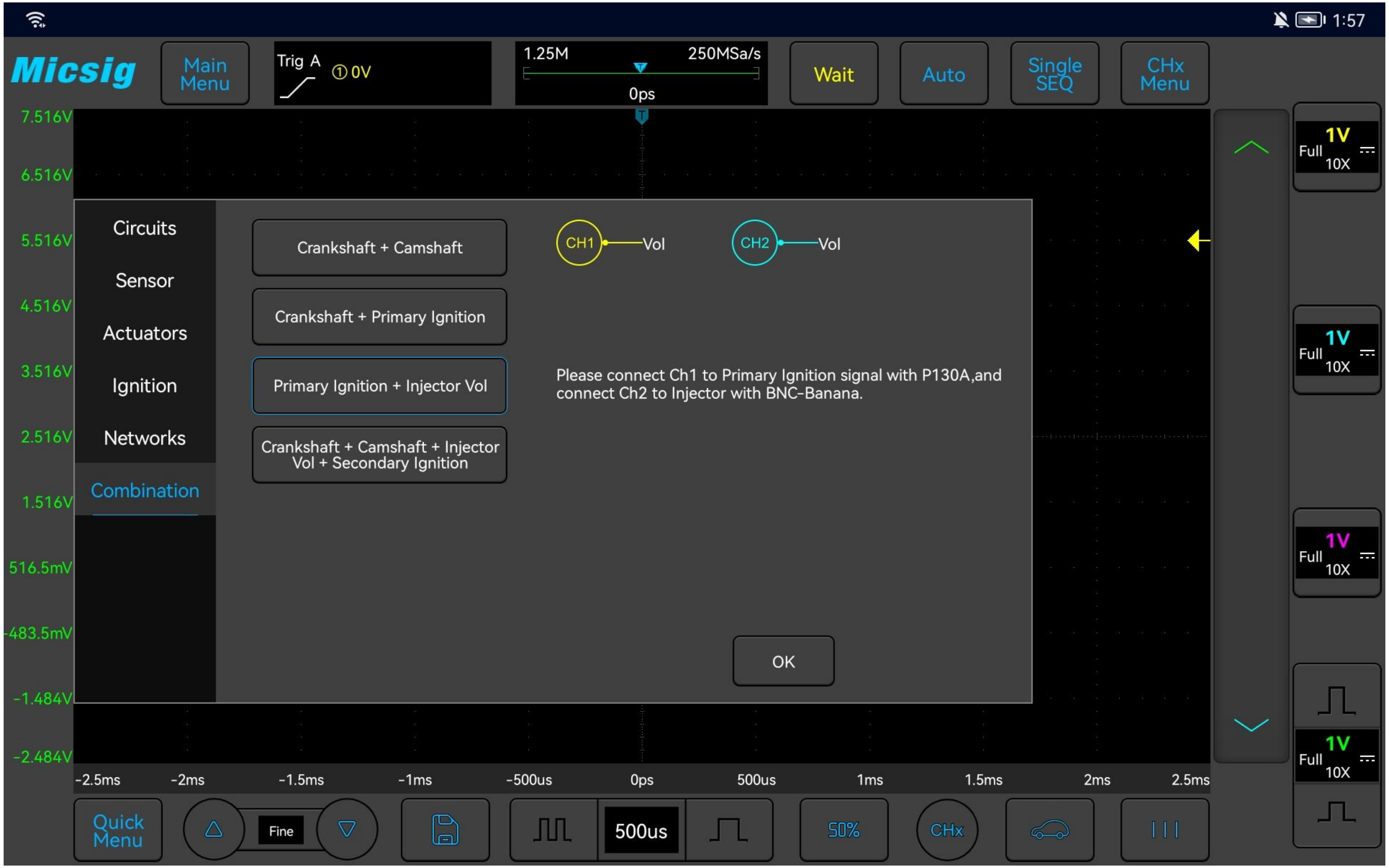


Figure 3-57 Primary ignition + Injector voltage

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.

VATO oscilloscope can be used to perform combined test on crankshaft + camshaft + fuel injector + secondary ignition. The specific operation is shown in Figure 3-58.

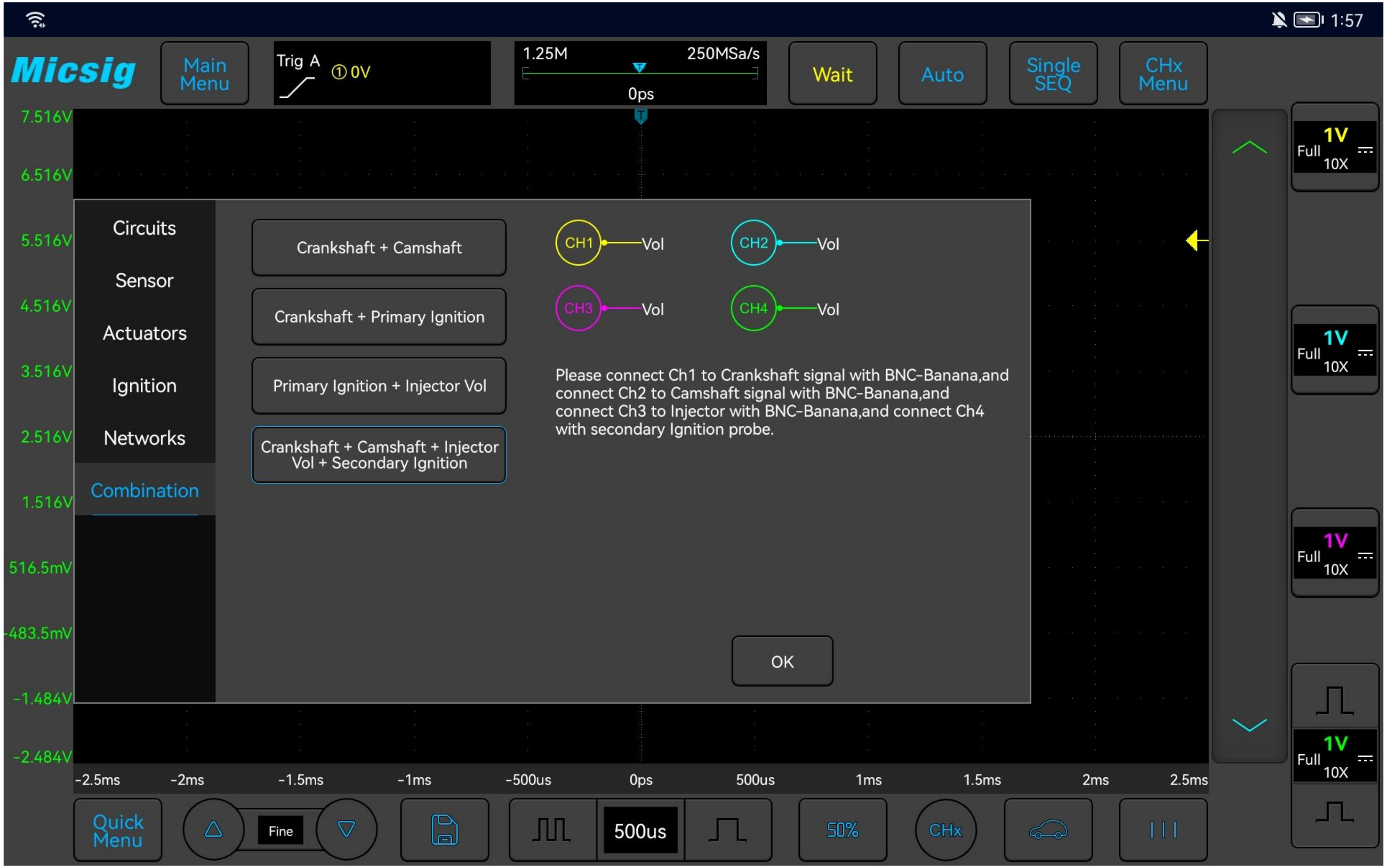


Figure 3-58 Combination test of Crankshaft + Camshaft + Injector + Secondary ignition

Chapter 4 Horizontal System

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

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

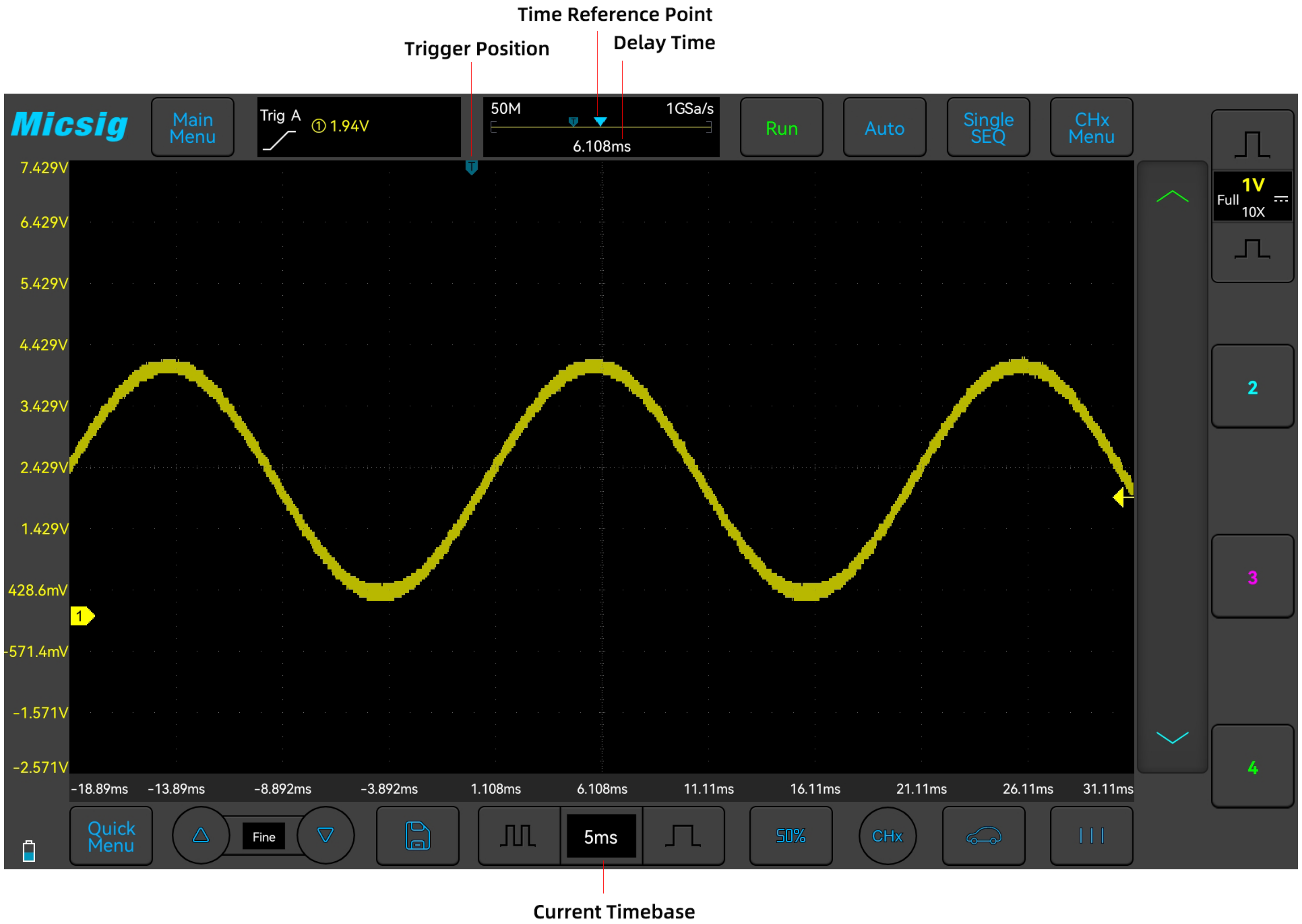


Figure 4-1 Horizontal system

4.1 Move the Waveform Horizontally

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

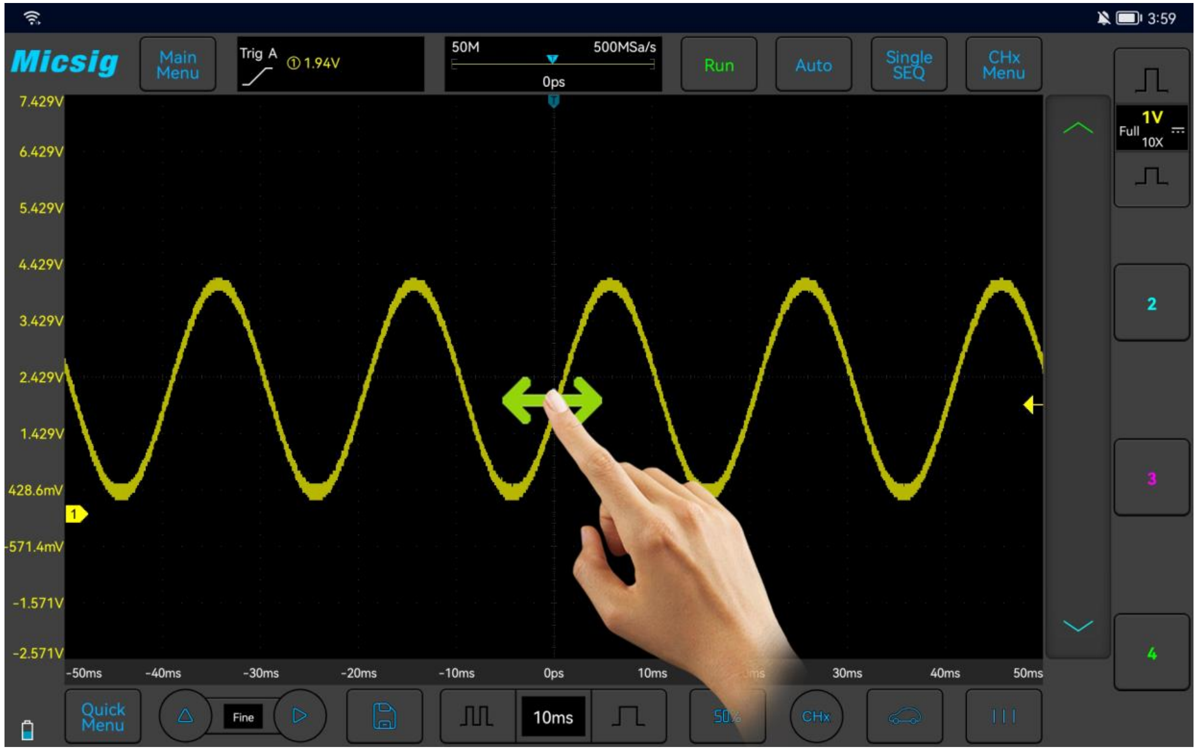


Figure 4-2 Move the Waveform Horizontally on the Screen

4.2 Adjust the Horizontal Time Base (time/div)

Method 1: Soft Keys

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

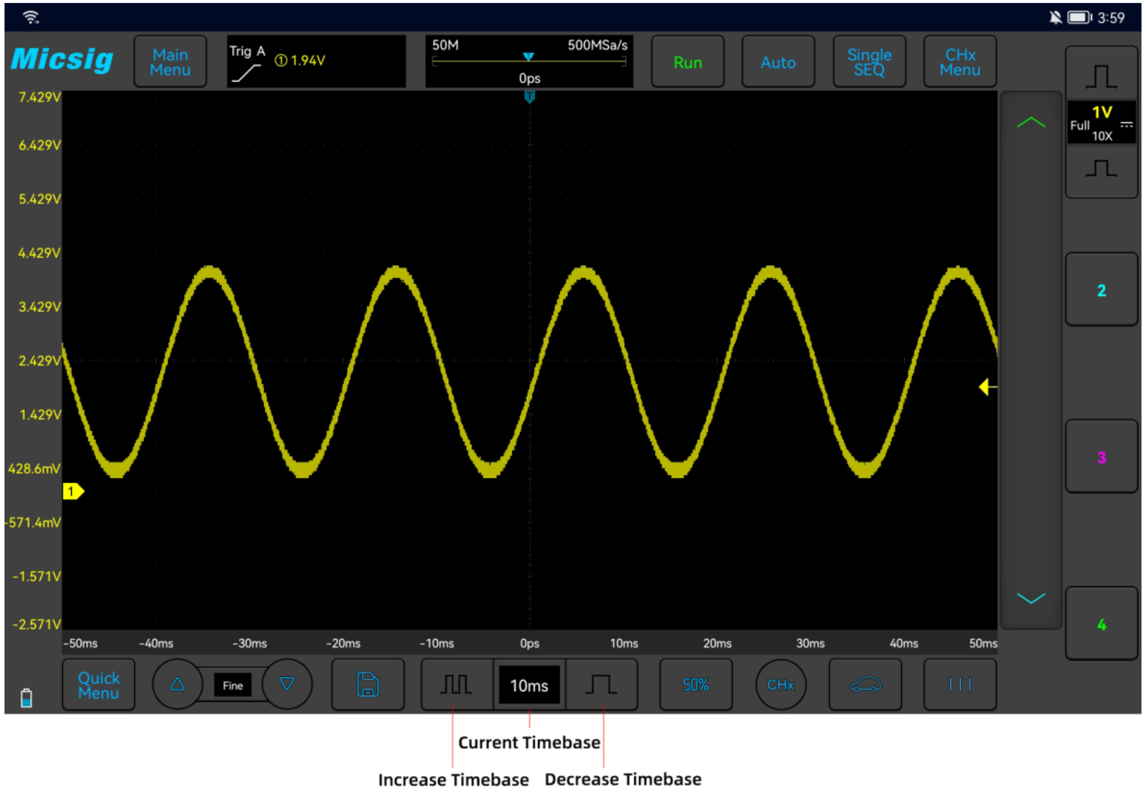
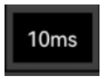


Figure 4-3 Adjust the Horizontal Time Base

Method 2: Time Base Knob

Tap 

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

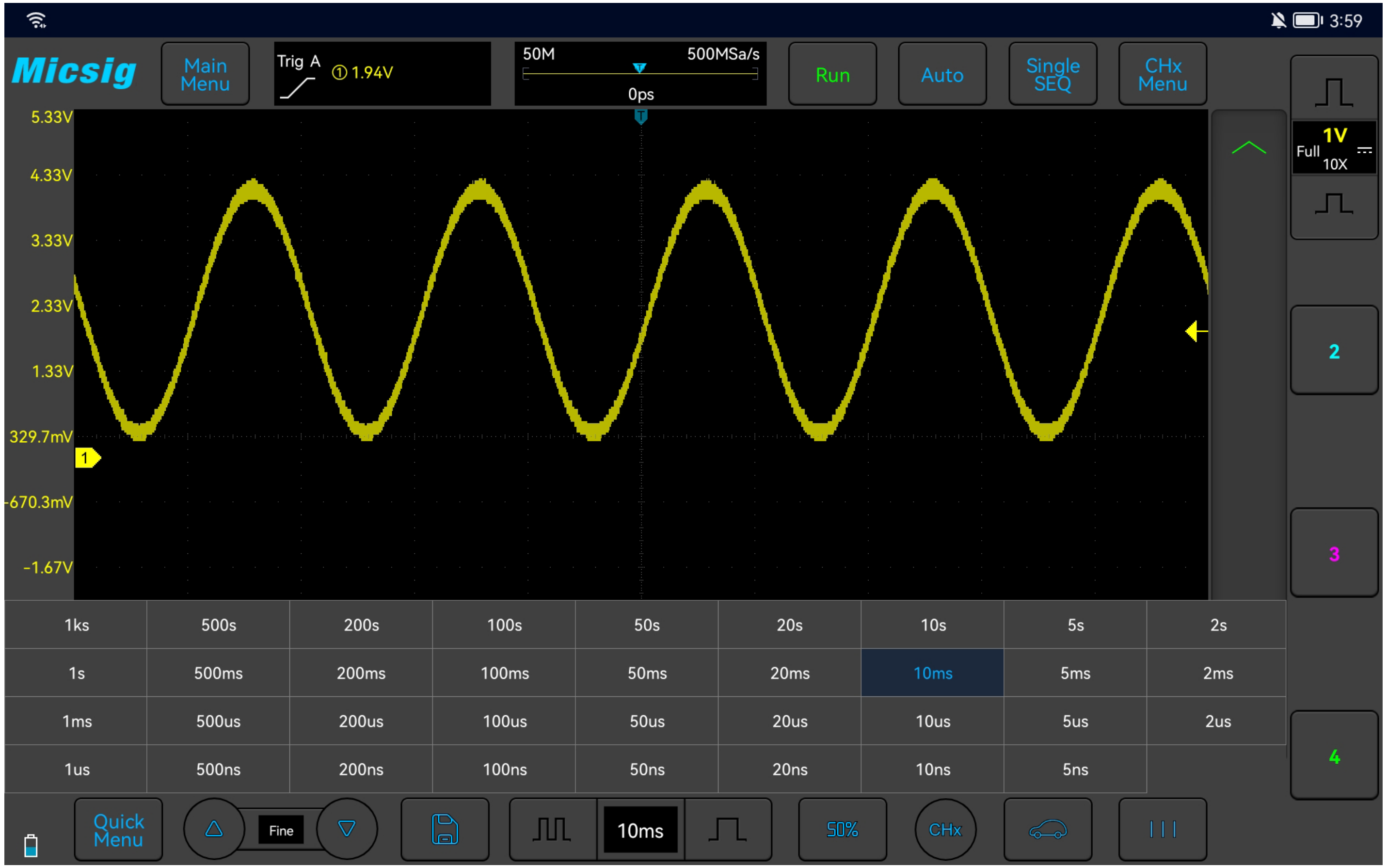


Figure 4-4 Horizontal Time Base Knob

4.3 Pan and Zoom Single or Stopped Acquisitions

After the oscilloscope is stopped, the stopped display screen may contain several acquired data with useful information, but only the data in the last acquisition can be horizontally moved and zoomed. The data of the single acquisition or stopped acquisition is moved horizontally and zoomed. For details, refer to "4.1 Move the Waveform Horizontally" and "4.2 Adjust the Horizontal Time Base (time/div)".

4.4 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 4-5 Zoom Interface). The upper part of the display screen shows the normal display window view and the lower part shows the zoomed display window.

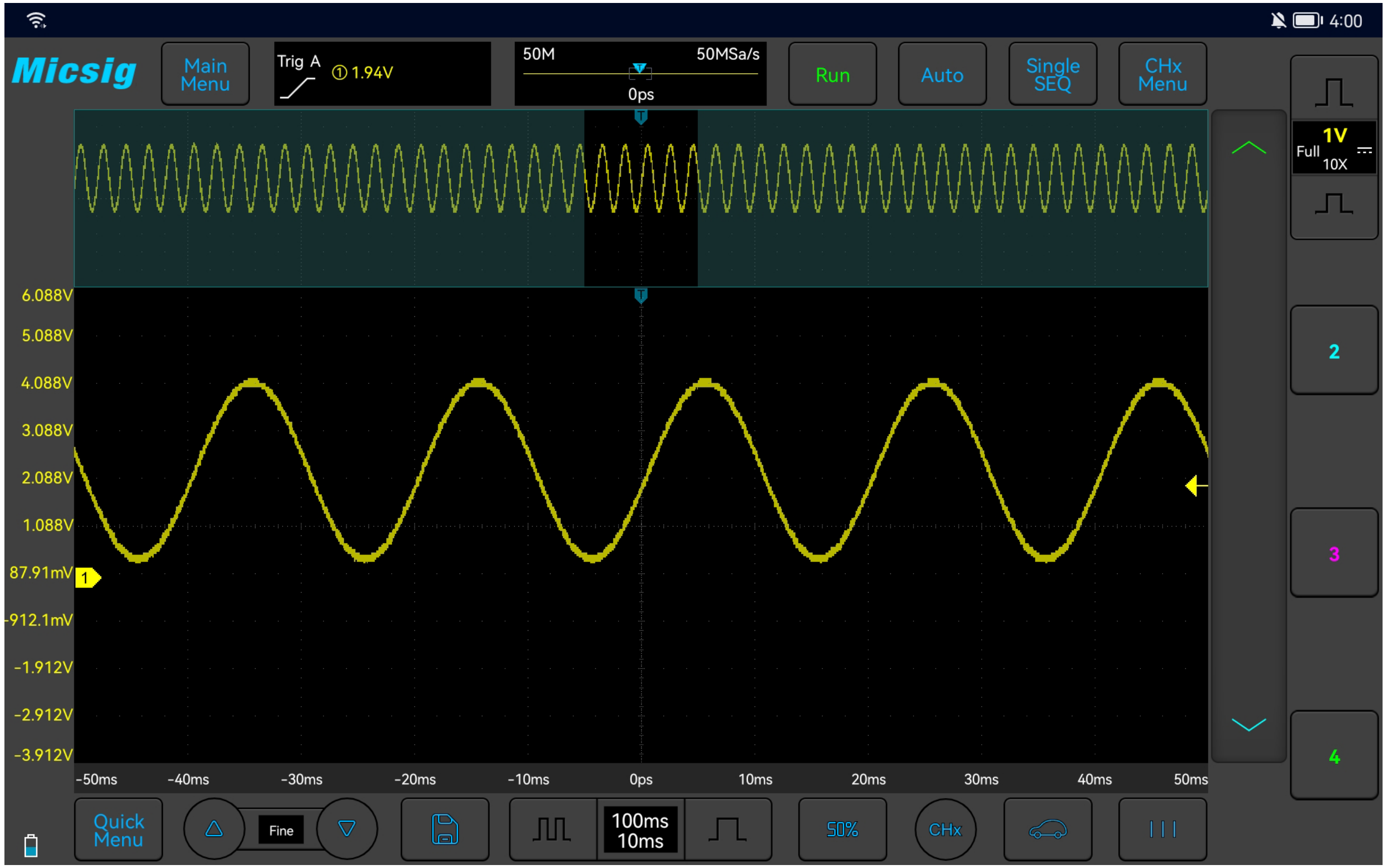
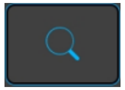


Figure 4-5 Zoom Interface

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

Zoom on/off:

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

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

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

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

Note:

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

current memory depth, when the zoom window is opened, the time base in the normal window is automatically set to the minimum time base in the normal window at the current memory depth.

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

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

Chapter 5 Vertical System

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

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

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

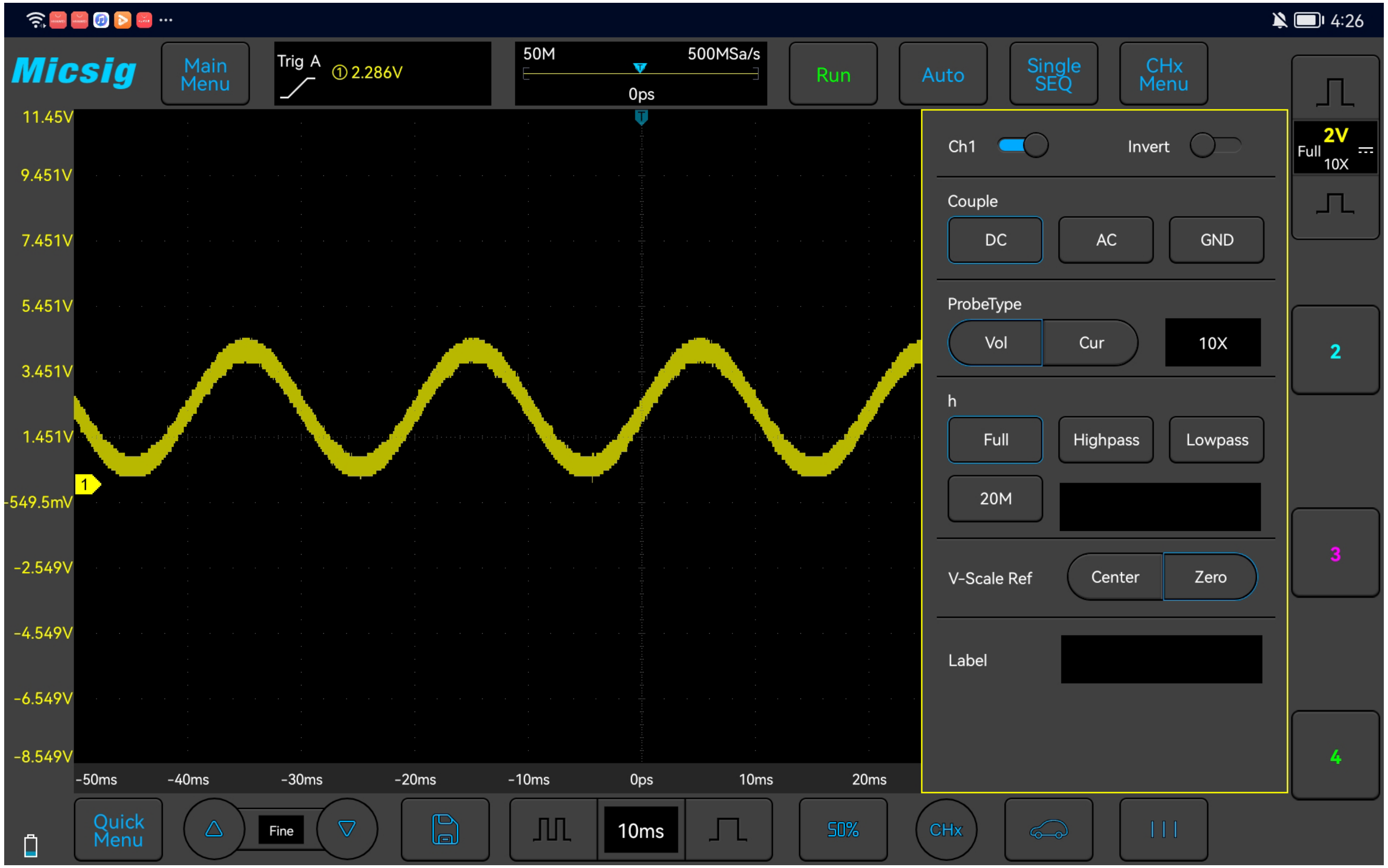


Figure 5-1 Channel Menu Display Interface

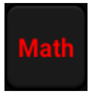
5.1 Open/Close Waveform (Channel, Math, Reference Waveforms)

The channel icons

、

、

、

、

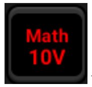
、

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

、

、

、

、

、

Swipe right to close the desired channel.

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

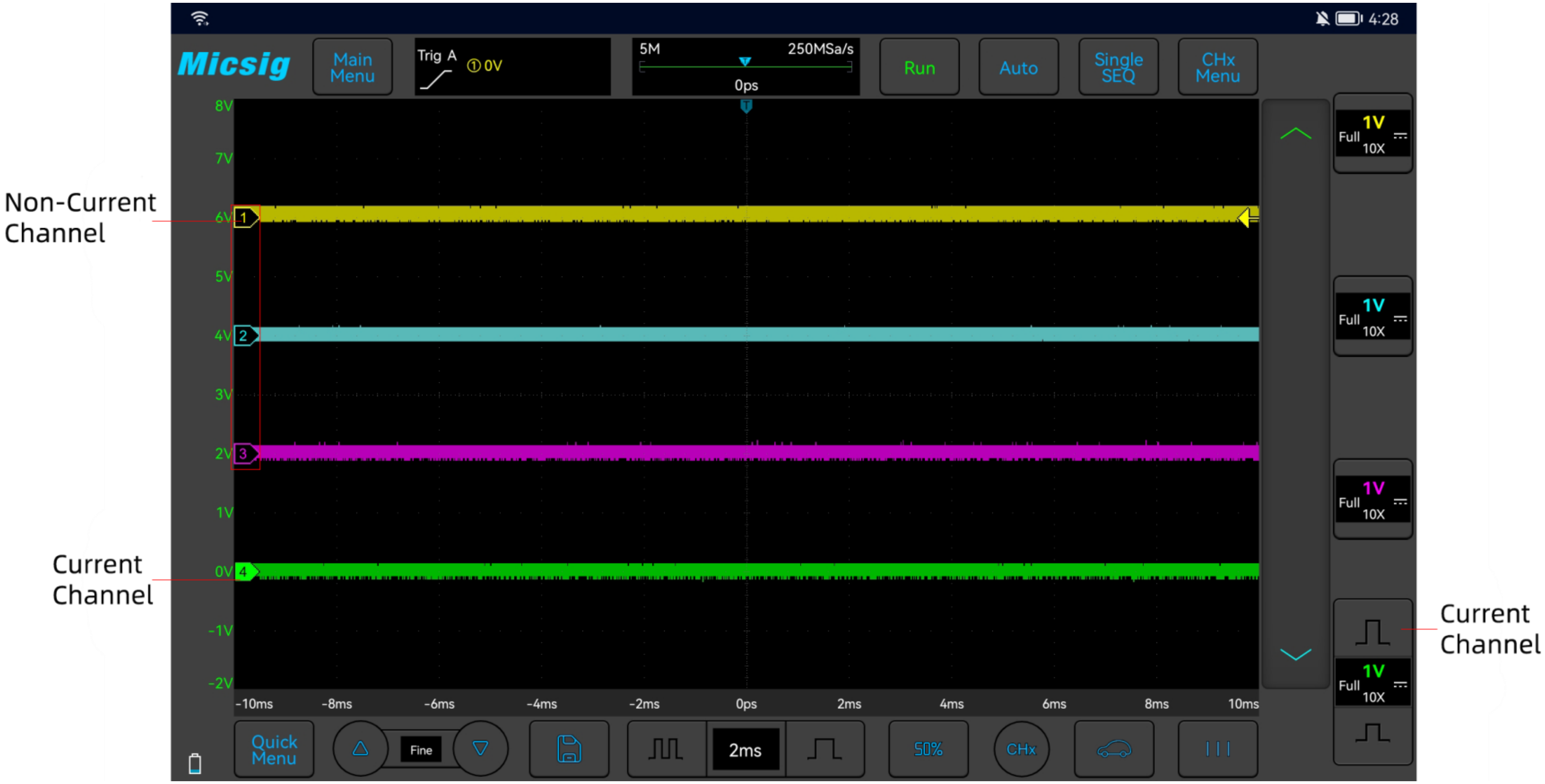


Figure 5-2 Current Channel and Non-Current Channel

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

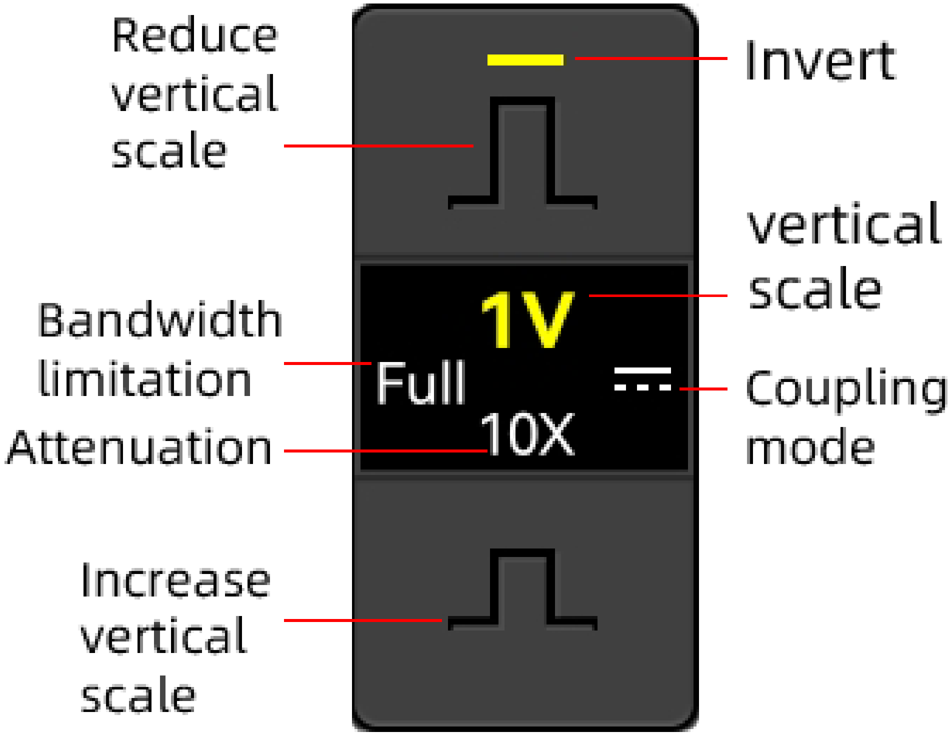


Figure 5-3 Channel Display Interface

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

Figure 5-4 Channel Open, Close and Switching

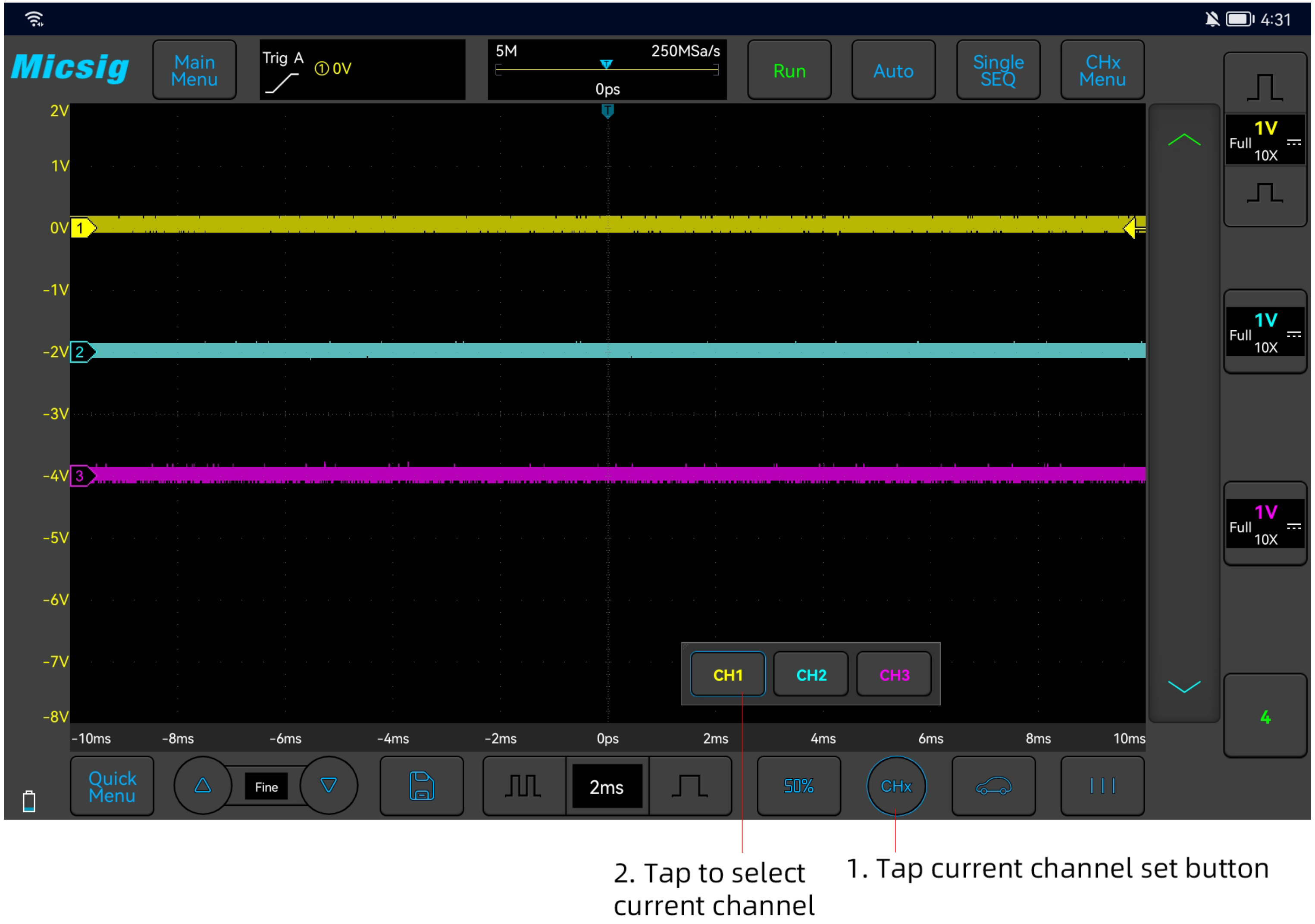


Figure 5-5 Using the Current Channel Selection Button

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

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

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

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

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

5.2 Adjust Vertical Sensitivity

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

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

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

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

5.3 Adjust Vertical Position

The method of adjusting vertical position is as follows:

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

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

5.4 Open Channel Menu

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

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

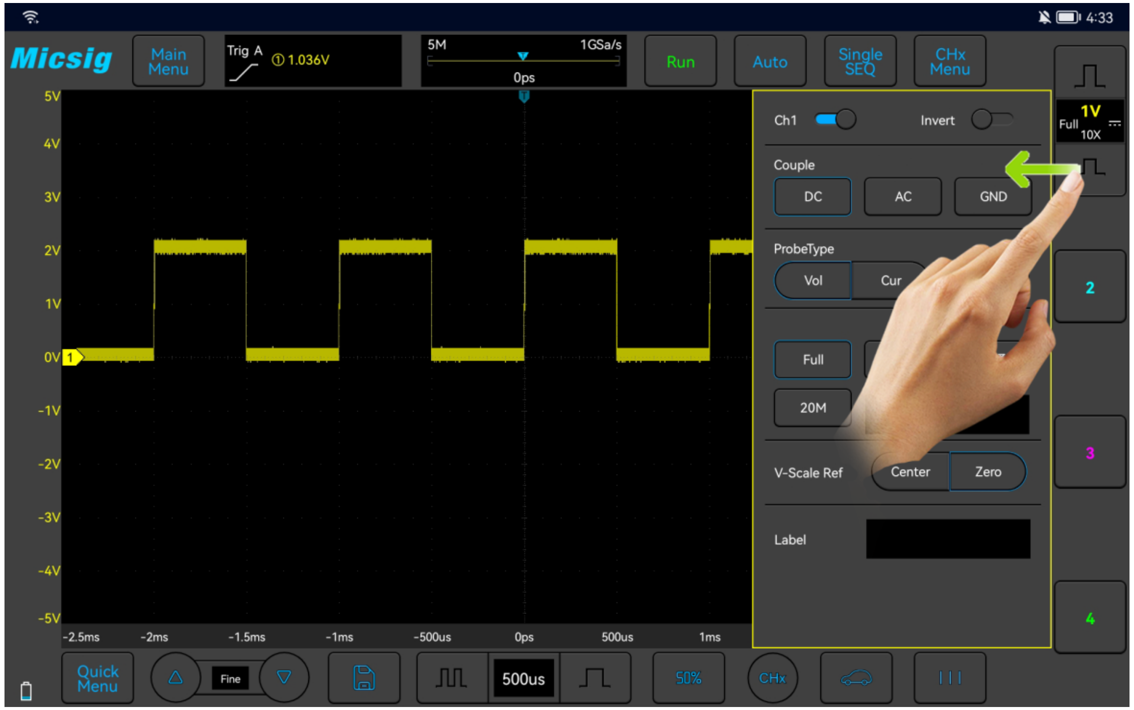


Figure 5-6 Channel menu

5.4.1 Set Channel Coupling

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

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

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

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

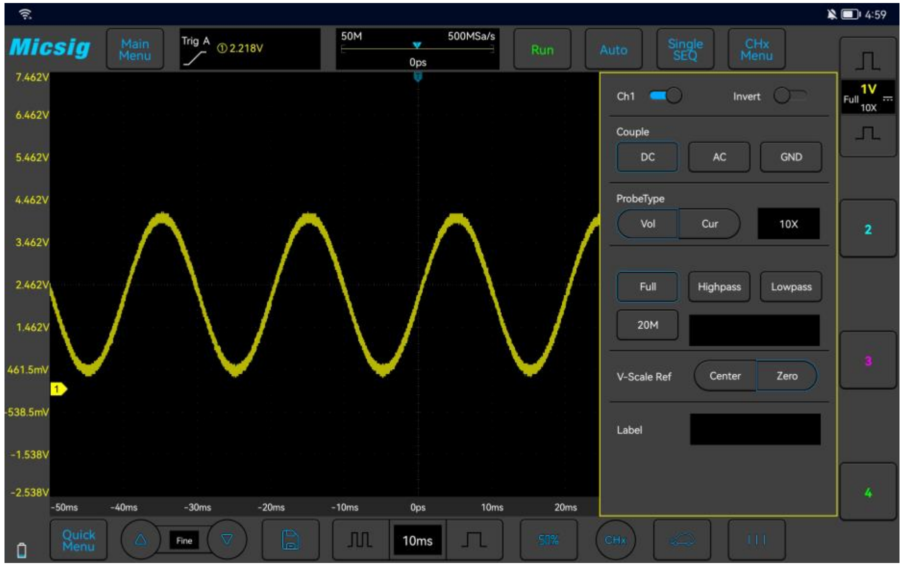


Figure 5-7 DC Coupling

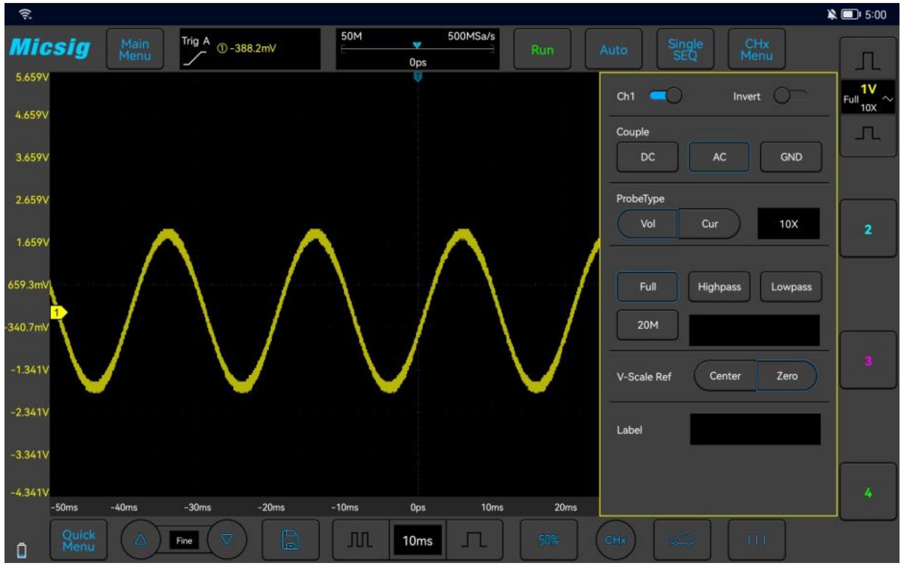


Figure 5-8 AC Coupling

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

5.4.2 Set Bandwidth Limit

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

Full Bandwidth: Allows signals of all frequencies to pass.

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

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

Select low pass, tap the frequency box 

to open the frequency setting interface, tap "MHz" and "KHz" to select the frequency range, drag or tap the slider bar to roughly adjust the highest frequency allowed to pass, tap "+", " -" button to accurately adjust the frequency.

The settable frequency range of low-pass filter is 30kHz-100MHz.

The difference in bandwidth limit can be intuitively shown through the waveform. The full bandwidth is shown in Figure 5-9, and the low-pass is shown in Figure 5-10.

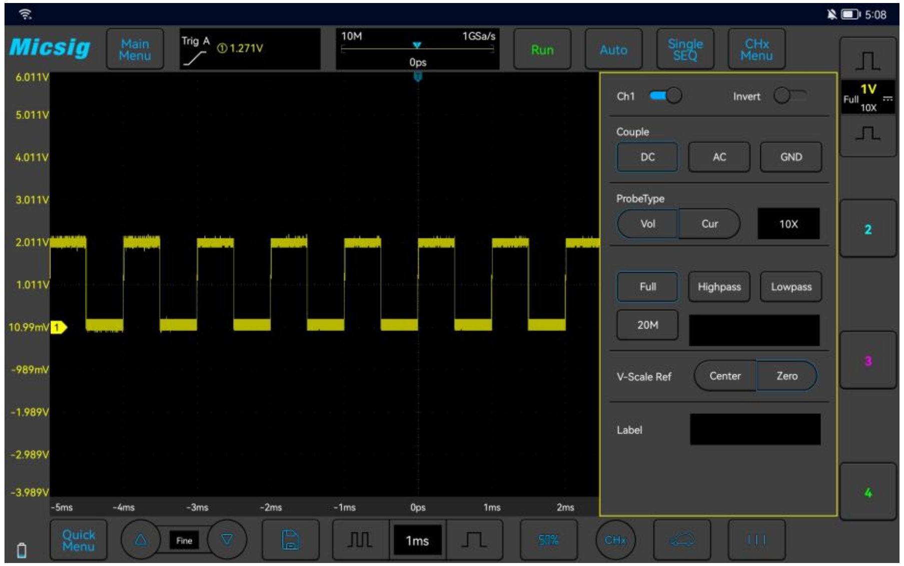


Figure 5-9 Full Bandwidth

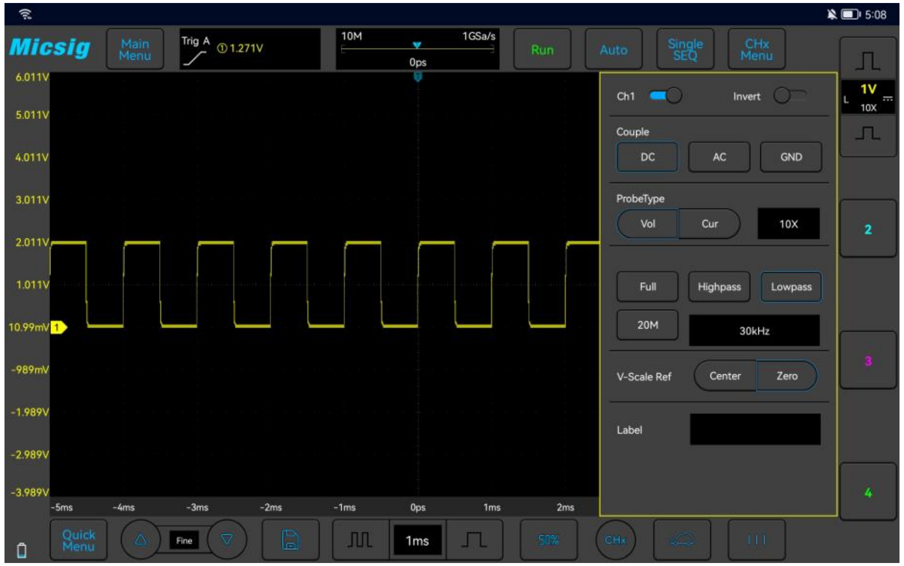
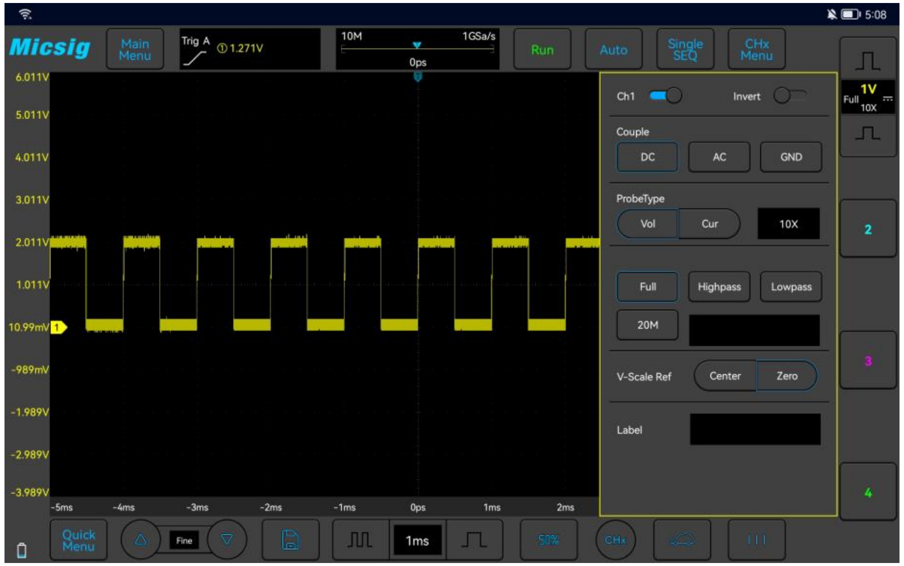


Figure 5-10 Low Pass

5.4.3 Waveform Inversion

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



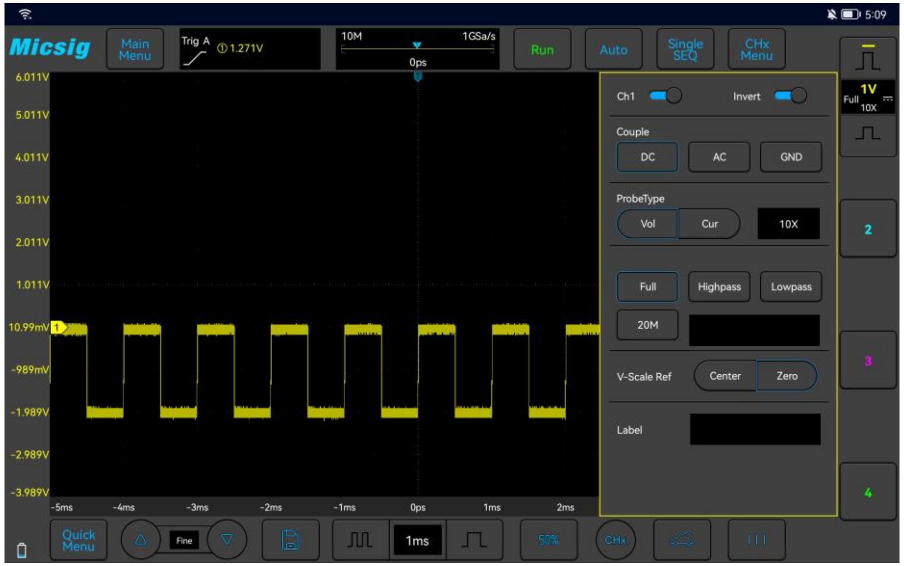


Figure 5-11 Before Inversion

Figure 5-12 After Inversion

5.4.4 Set Probe Type

Probe types are divided into voltage probe and current probe.

Probe type adjustment steps:

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

- Vol - corresponding the voltage probe.

- Cur - corresponding the current probe.

5.4.5 Set Probe Attenuation Coefficient

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

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

Probe attenuation ratio / Menu attenuation ratio		Probe attenuation ratio / Menu attenuation ratio		Probe attenuation ratio / Menu attenuation ratio		Probe attenuation ratio / Menu attenuation ratio	
0.001:1	1mx	0.1:1	100mx	10:1	10x	1000:1	1kx
0.002:1	2mx	0.2:1	200mx	20:1	20x	2000:1	2kx
0.005:1	5mx	0.5:1	500mx	50:1	50x	5000:1	5kx
0.01:1	10mx	1:1	1x	100:1	100x	10000:1	10kx
0.02:1	20mx	2:1	2x	200:1	200x		
0.05:1	50mx	5:1	5x	500:1	500x		

Table 5-1 Probe Attenuation Ratio Correspondence Table

5.4.6 Vertical expansion datum

When using vertical expansion, you can click the center or zero point respectively.

Center: When you click the center, adjust the vertical scale, and the oscilloscope waveform will be expanded based on the center of the screen.

Zero point: When you click zero point, adjust the vertical scale, and the oscilloscope waveform will be expanded based on the waveform zero point.

5.4.7 Channel label

You can add labels to each analog channel as needed, and the added labels appear after the channel indicator.

Channel labels available: none, custom, preset (including ACK, ADDR, CAN_H, CAN_L, CLK, CS, DATA, H_L, IN, L_H, MISO, MOSI, RX, SCL, SDA, SS, TX, OUT) . As shown in Figure 5-13.

Note: Customization supports up to 16 characters, and supports input of Chinese and English characters.

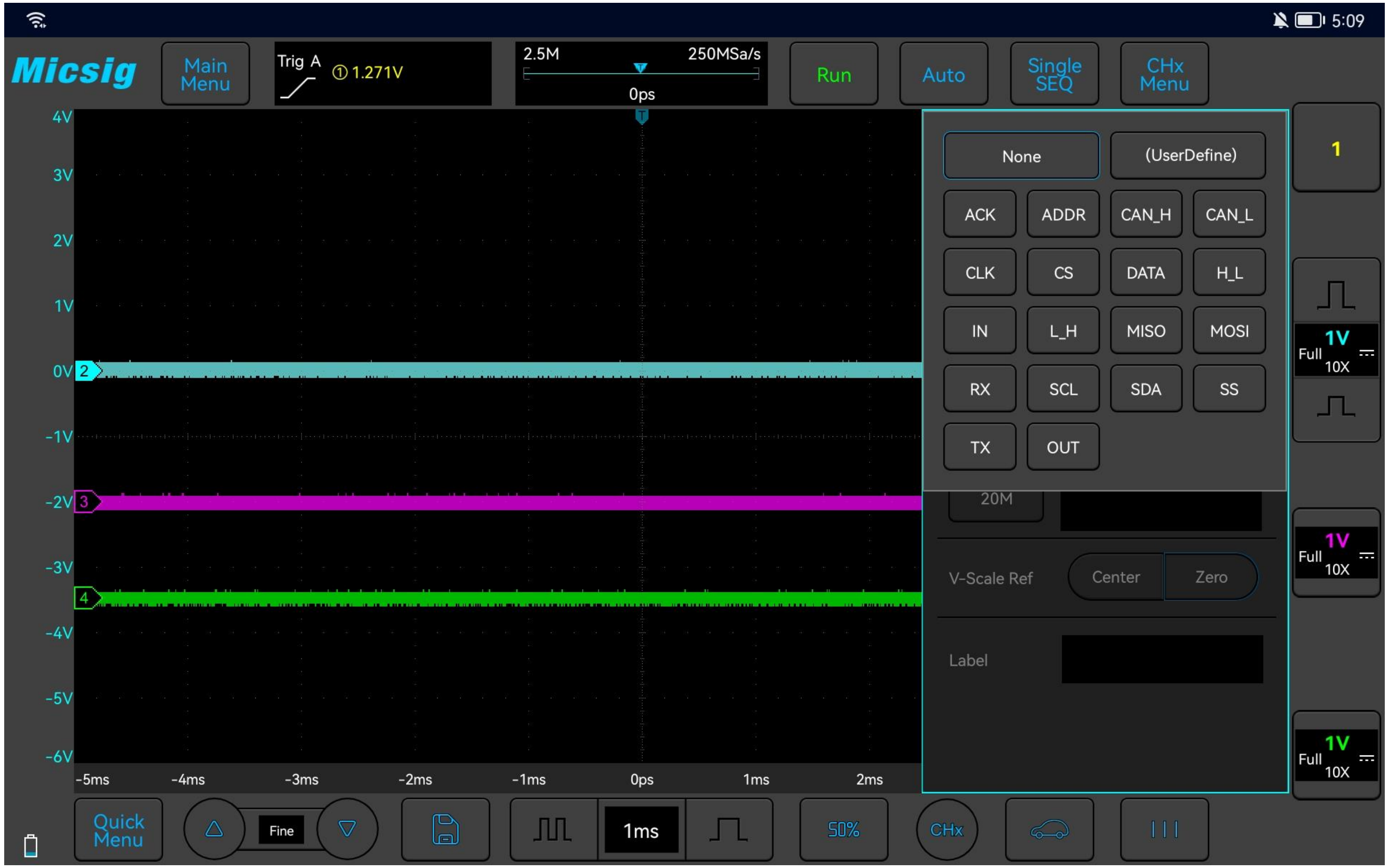


Figure 5-13 Channel label

Chapter 6 Trigger System

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

- Trigger and trigger adjustment
- Edge trigger
- Pulse width trigger
- Serial bus trigger

6.1 Trigger and Trigger Adjustment

What is Trigger?

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

What can Trigger be used for?

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

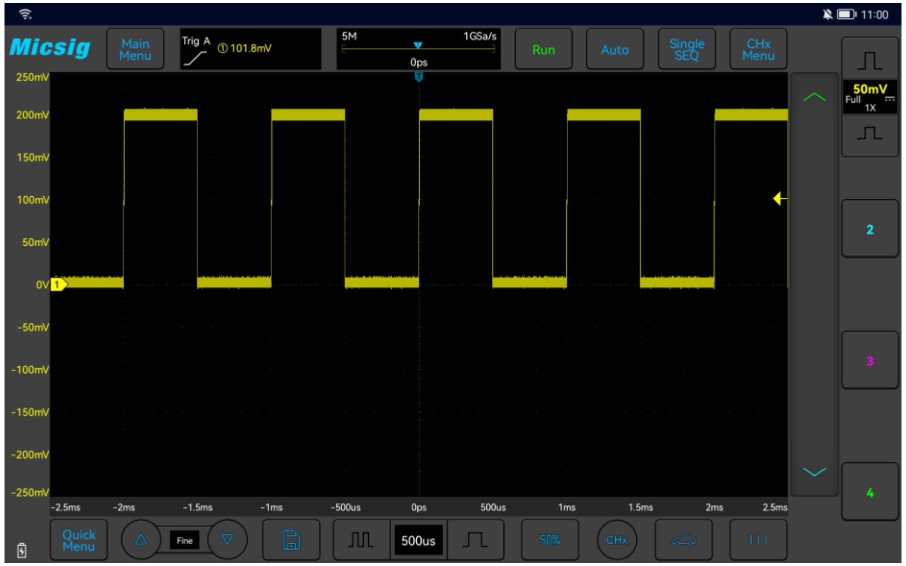


Figure 6-1 Stably Displayed Periodic Signal

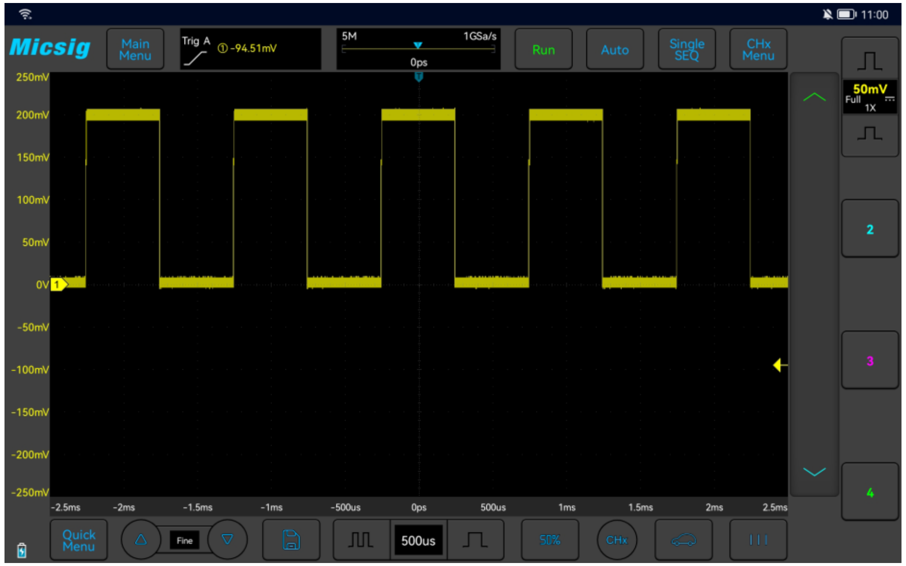


Figure 6-2 Non-Stably Displayed Periodic Signal

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

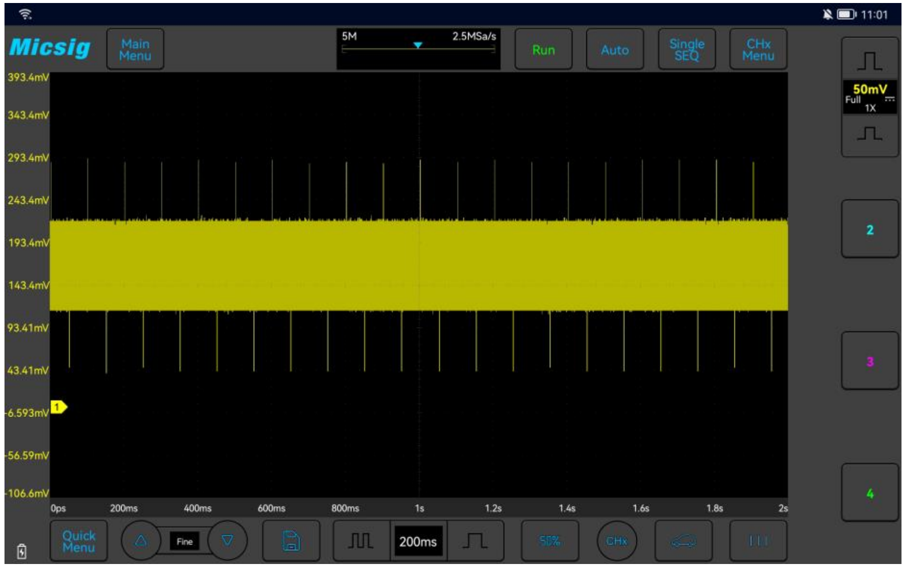


Figure 6-3 Abnormal Signal in Periodic Signals

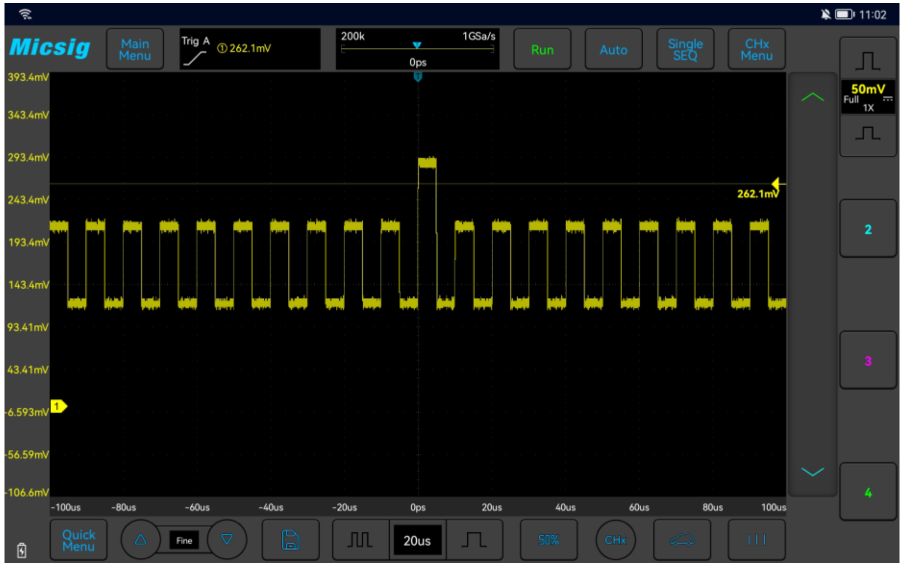


Figure 6-4 Abnormal Signal Captured by Setting Trigger Level

What is Forced Trigger?

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

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

Figure 6-5 Oscilloscope Trigger Mode Setting

If a signal feature is not understood, the oscilloscope should be set as “**Auto**” mode, which can ensure that the oscilloscope can also display the waveform when other trigger settings are not correct. Although the waveform is not necessarily stable, it can provide the intuitive judgment for our further adjustment of the oscilloscope.

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

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

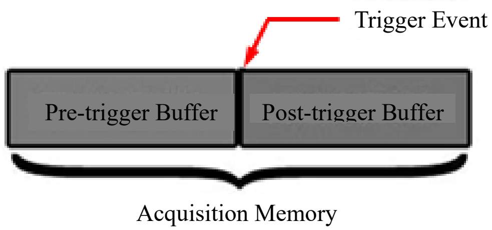


Figure 6-6 Conceptual Demonstration of Acquisition Memory

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

Adjust trigger position (horizontal delay)

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

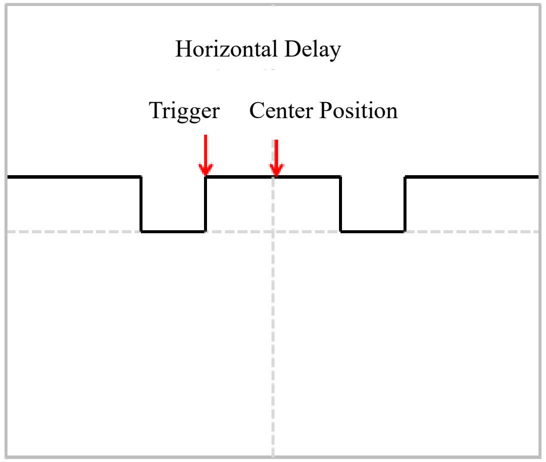


Figure 6-7 Horizontal Delay

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

Trigger level

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

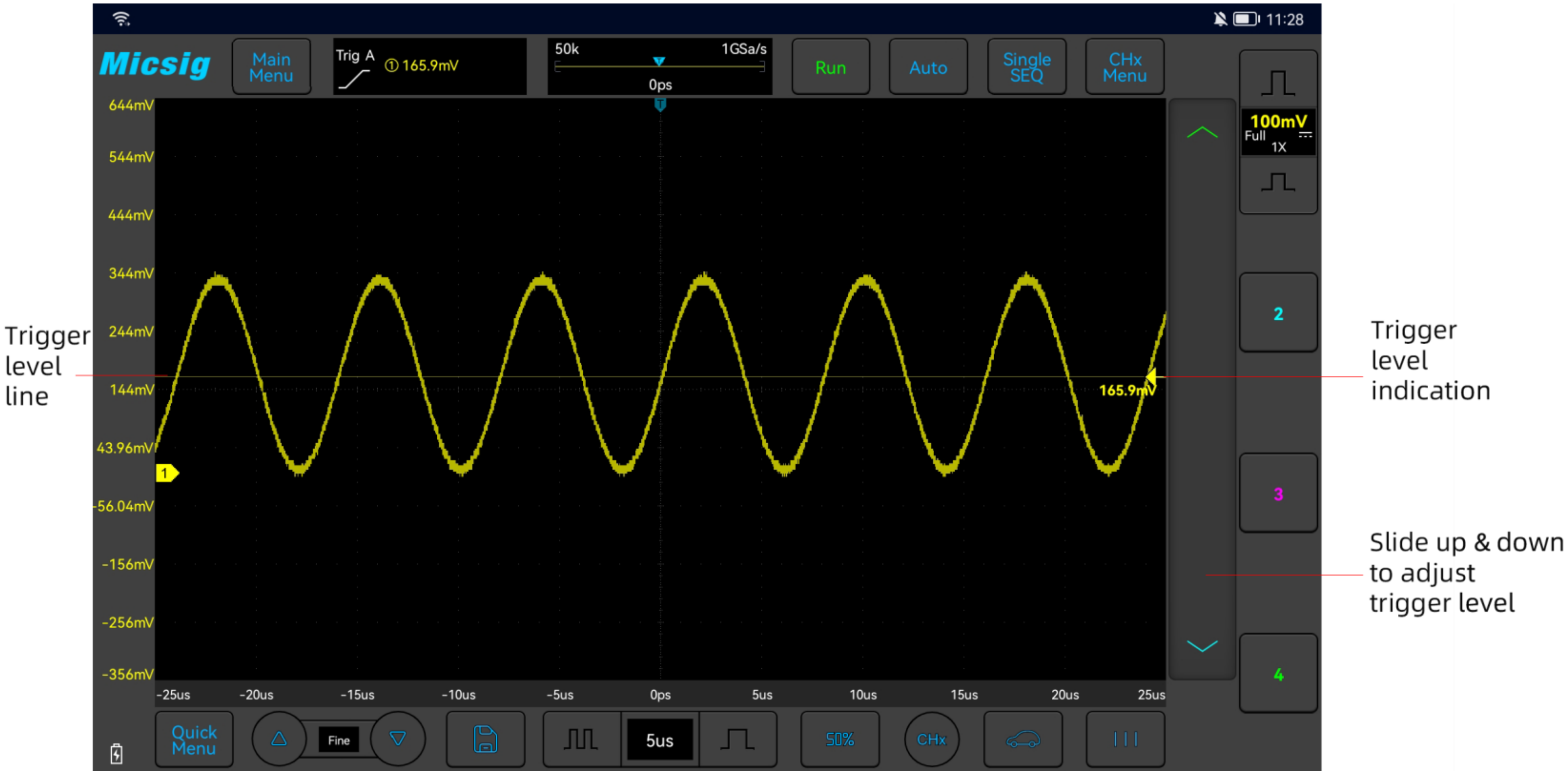


Figure 6-8 Trigger Level

Adjust trigger level

The trigger level can be coarsely adjusted and finely adjusted.

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

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

Set trigger hold-off time

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

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

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

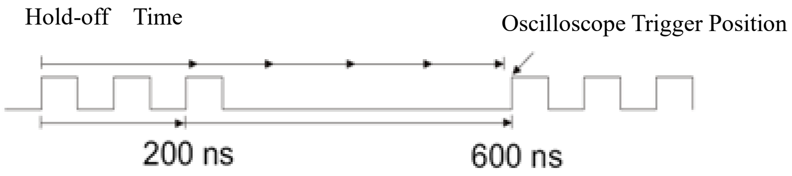


Figure 6-9 Trigger Hold-Off Time

Set trigger hold-off time:

1) Tap "Trigger" on the main menu to open the trigger menu. Under "Common", tap the box after "Rejection Time" to open the hold-off time adjustment interface. The trigger time is displayed on the upper left, the fine adjustment time scale is displayed on the upper right, and the coarse time scale is displayed below, as shown in Figure 6-10.

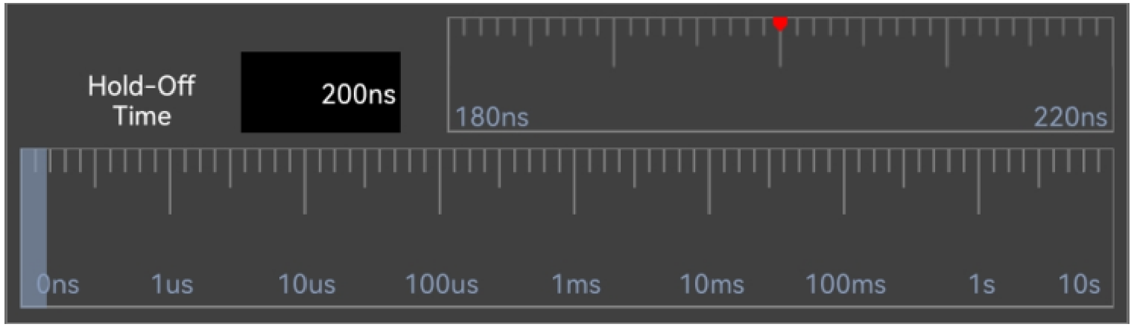


Figure 6-10 Trigger Hold-Off Time Set Interface

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

Trigger hold-off operation prompt

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

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

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

- Use “SEQ” button for single acquisition

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

6.2 Edge Trigger

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

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

	CH4	Set CH4 as trigger signal source
Slope	Rising edge	Set signal trigger on the rising edge
	Falling edge	Set signal trigger on the falling edge
	Dual edge	Set signal trigger on either rising edge or falling edge
Coupling	DC	AC and DC components getting through trigger signals
	AC	Filter out the DC component of trigger signals
	HF rejection	Suppress signals above 50KHz in trigger signals
	LF rejection	Suppresses signals below 50KHz in trigger signals
	Noise rejection	Low-sensitivity DC coupling to suppress high-frequency noise in trigger signals

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

1) Tap "Trigger" on the main menu to open the trigger menu, select edge trigger in the trigger type, and set edge trigger as follows, as shown in Figure 6-11:

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

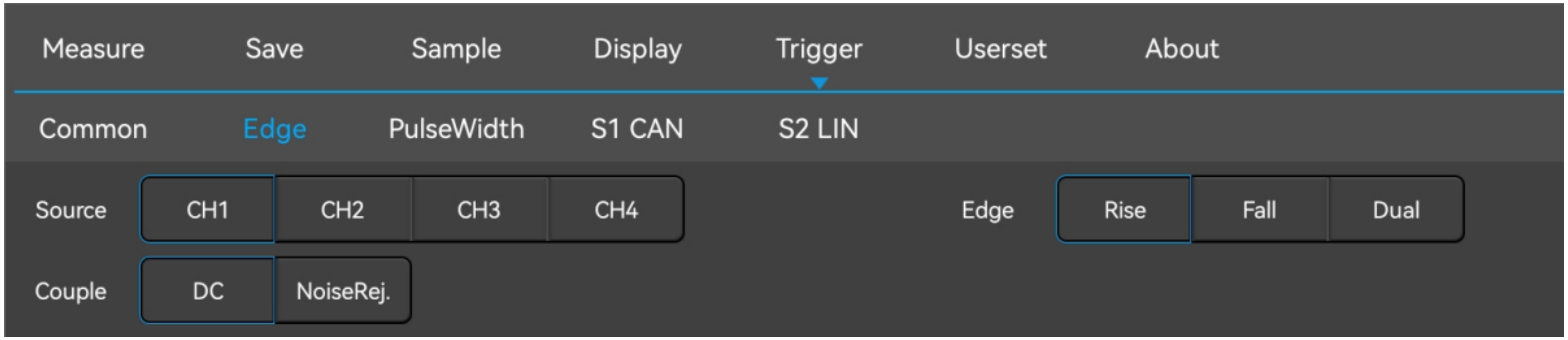


Figure 6-11 Edge Trigger Setting Menu

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

Note: Trigger coupling is independent of channel coupling.

6.3 Pulse Width Trigger

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

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

Trigger Option	Setting	Description
	＝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

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

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

1) Tap "Trigger" on the main menu to open the trigger menu, select the pulse width trigger in the trigger type, and set the pulse width trigger as follows, as shown in Figure 6-13:

- 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 appears in the upper left corner of the display. When triggering on a positive polarity pulse, if the constraint is true, the trigger will occur on the pulse transition from high to low; when triggering on a negative polarity pulse, if the constraint is true, the trigger will occur on the pulse transition from low to low. High flips occur. (Figure 6-14 Negative polarity 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).

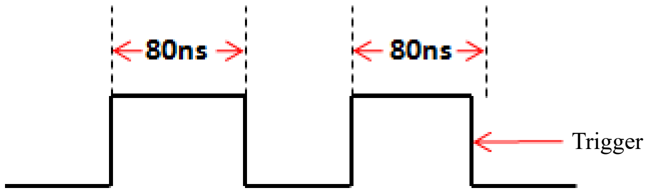


Figure 6-15 Trigger Time T<80ns

- 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).

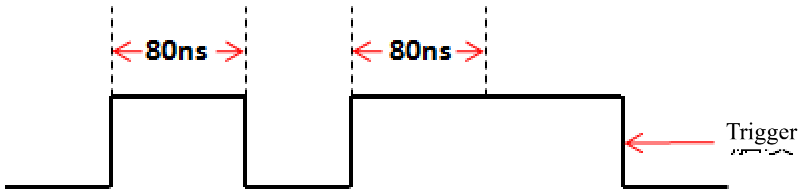


Figure 6-16 Trigger Time T>80ns

- 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).

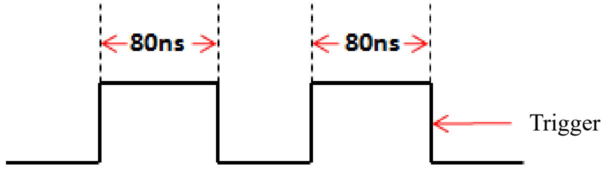


Figure 6-17 Trigger Time T=80ns

- 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).

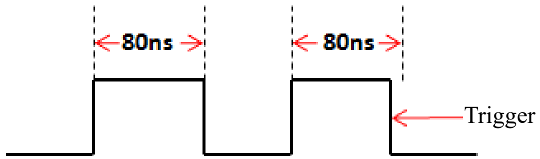
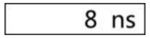


Figure 6-18 Trigger Time T≠80ns

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

Tap the pulse width time setting box  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.

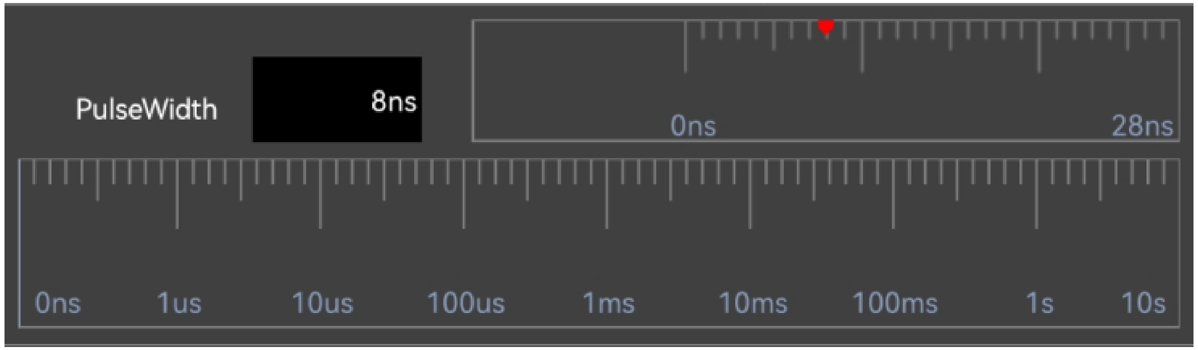


Figure 6-19 Pulse Width Time Adjustment Interface

6.4 Serial Bus Trigger

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

Chapter 7 Analysis System

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

- Automatic measurement
- Cursor
- Phase Rulers

7.1 Automatic Measurement

Measurement setting

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

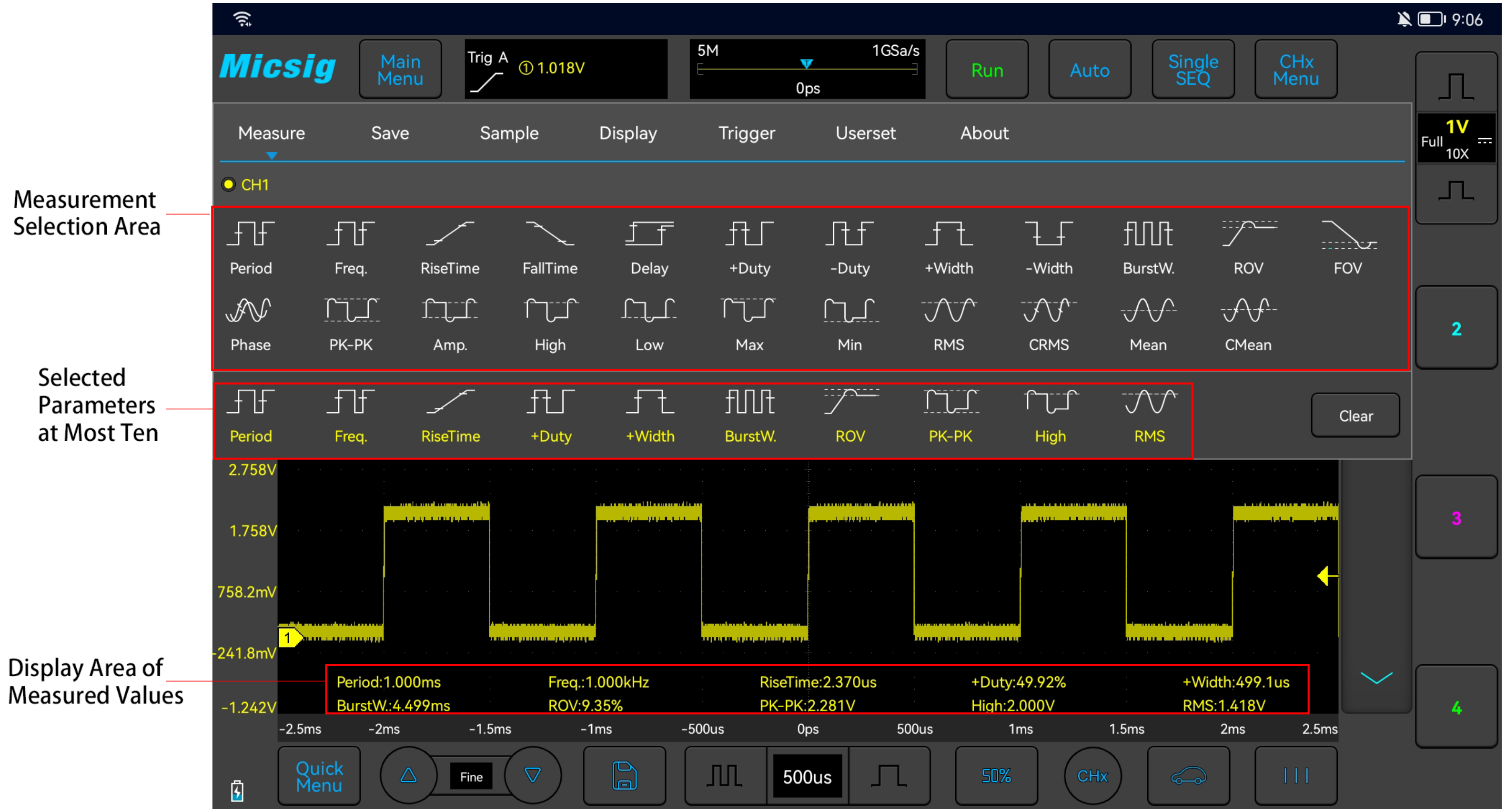


Figure 7-1 Automatic Measurement Menu

Automatic measurement

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

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

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

button to clear all measurement items.

Note:

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

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

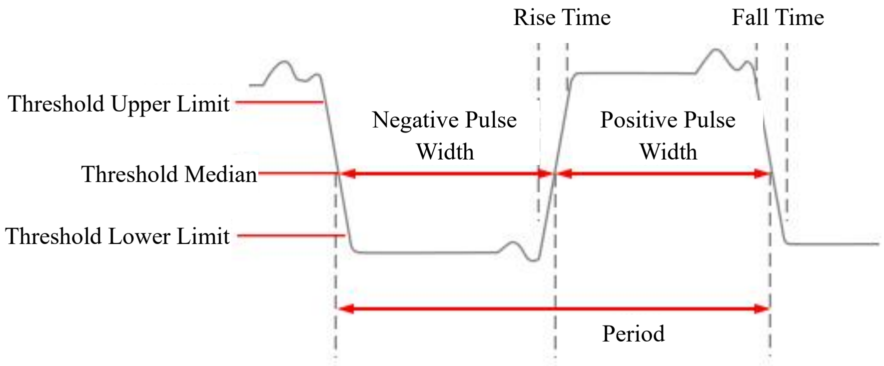


Figure 7-2 Time Parameter

Period

Time of the first complete signal cycle in the waveform

Frequency

Reciprocal to the cycle time

Rise time

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

Fall time

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

Delay

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

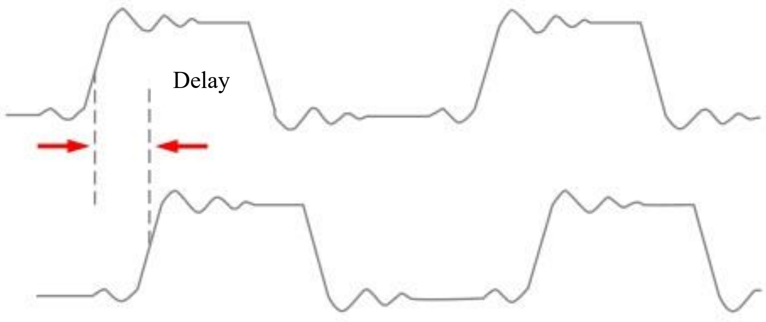


Figure 7-3 Delay Measurement Schematics

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: first rising edge, first falling edge, last rising edge, last falling edge .

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

4) Tap ok button to confirm.

Positive duty cycle

Measured value of the first cycle in the waveform

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

Negative duty cycle

Measured value of the first cycle in the waveform

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

Positive pulse width

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

Negative pulse width

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

Burst width

Duration of a burst measured over the entire waveform

Overshoot

Positive overshoot

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

Negative overshoot

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

Phase

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

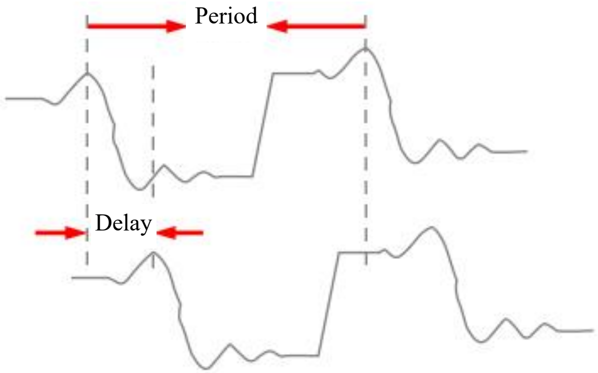


Figure 7-4 Phase Measurement Schematics

Peak-peak

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

Amplitude

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

The figure below shows voltage measurement points.

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

Refer to "5.4.4 Set Probe Type".

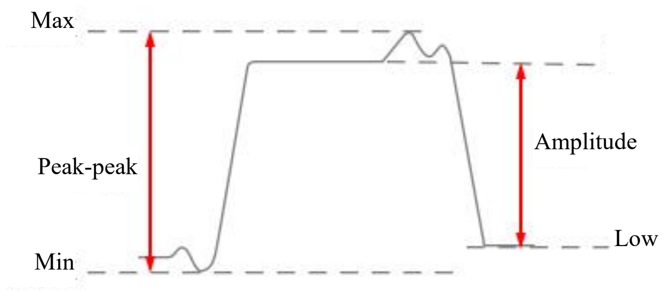


Figure 7-5 Voltage Measurement

High

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

Low

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

Max

Highest positive peak measured over the entire waveform

Min

Highest negative peak measured over the entire waveform

RMS

True root mean square value over the entire waveform

C RMS

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

Mean

Arithmetic mean over the entire waveform

C mean

Arithmetic mean over the first cycle in the waveform

Note:

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

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

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

7.2 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 7-6.

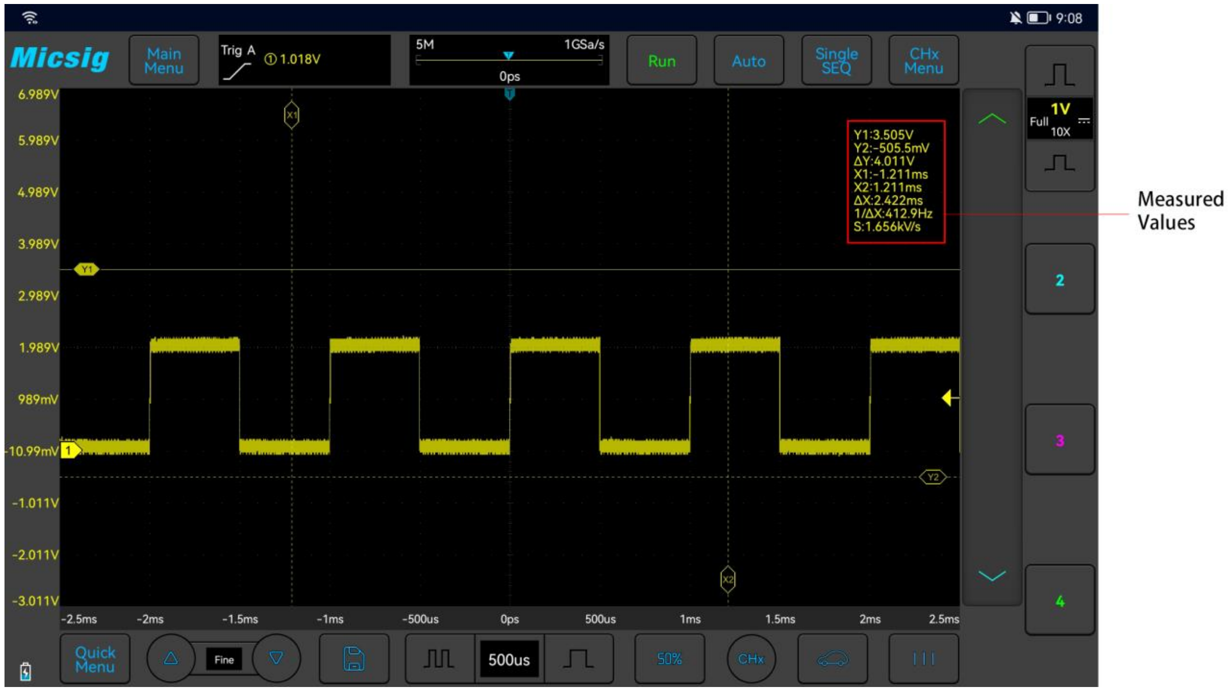


Figure 7-6 Cursor Measurement Description

Note:

△ reading: indicates the difference between two cursor positions.

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

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

1/**△X: frequency**

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

Vertical cursor on/off and activation

Vertical cursor on/off

Vertical cursor on: Open pull-up menu and tap cursor icon  to open vertical cursors and the icon is on and activated.

Vertical cursor off: Open pull-up menu and tap cursor icon  to turn off vertical cursors.

Tap the vertical cursor indicator line to switch the cursors.

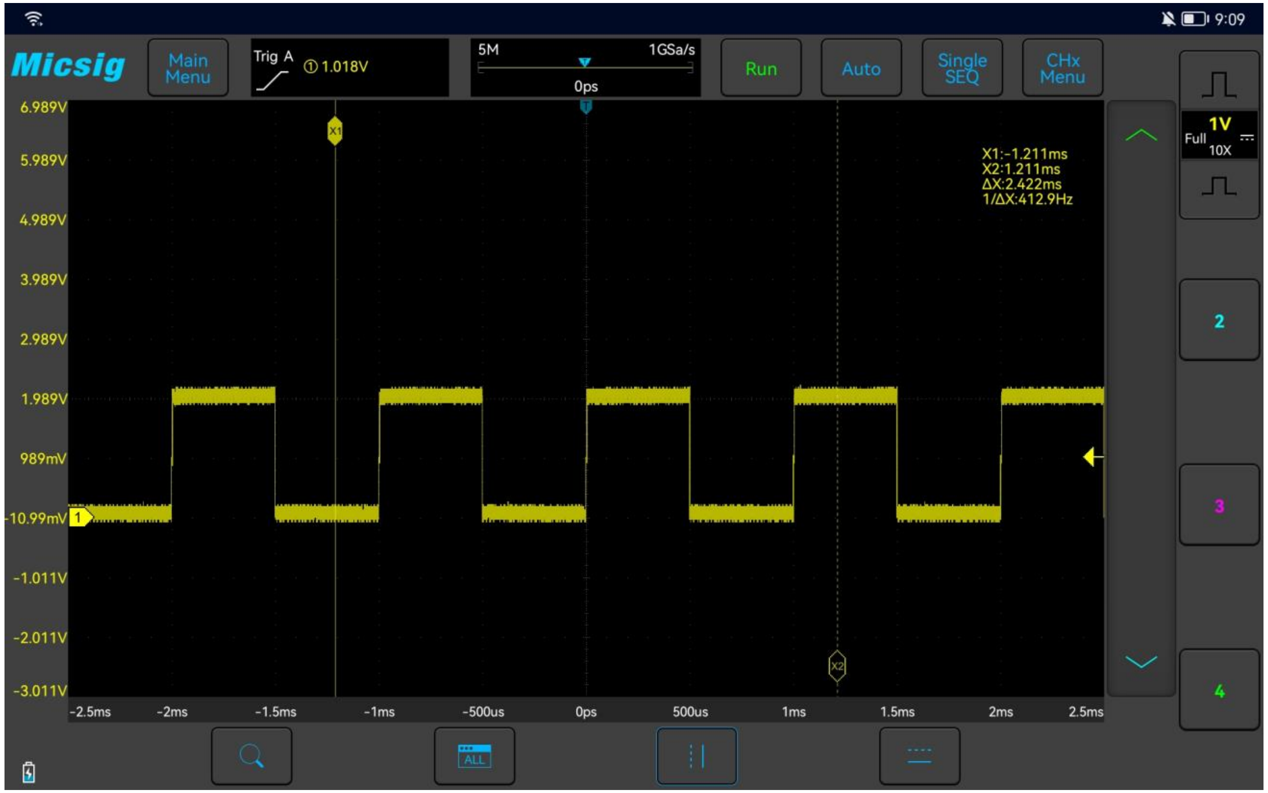


Figure 7-7 Open Cursor Selection Box and Close Cursor

Vertical cursor movement descriptions:

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

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

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

Horizontal cursor on/off and activation

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

Cursor test example

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

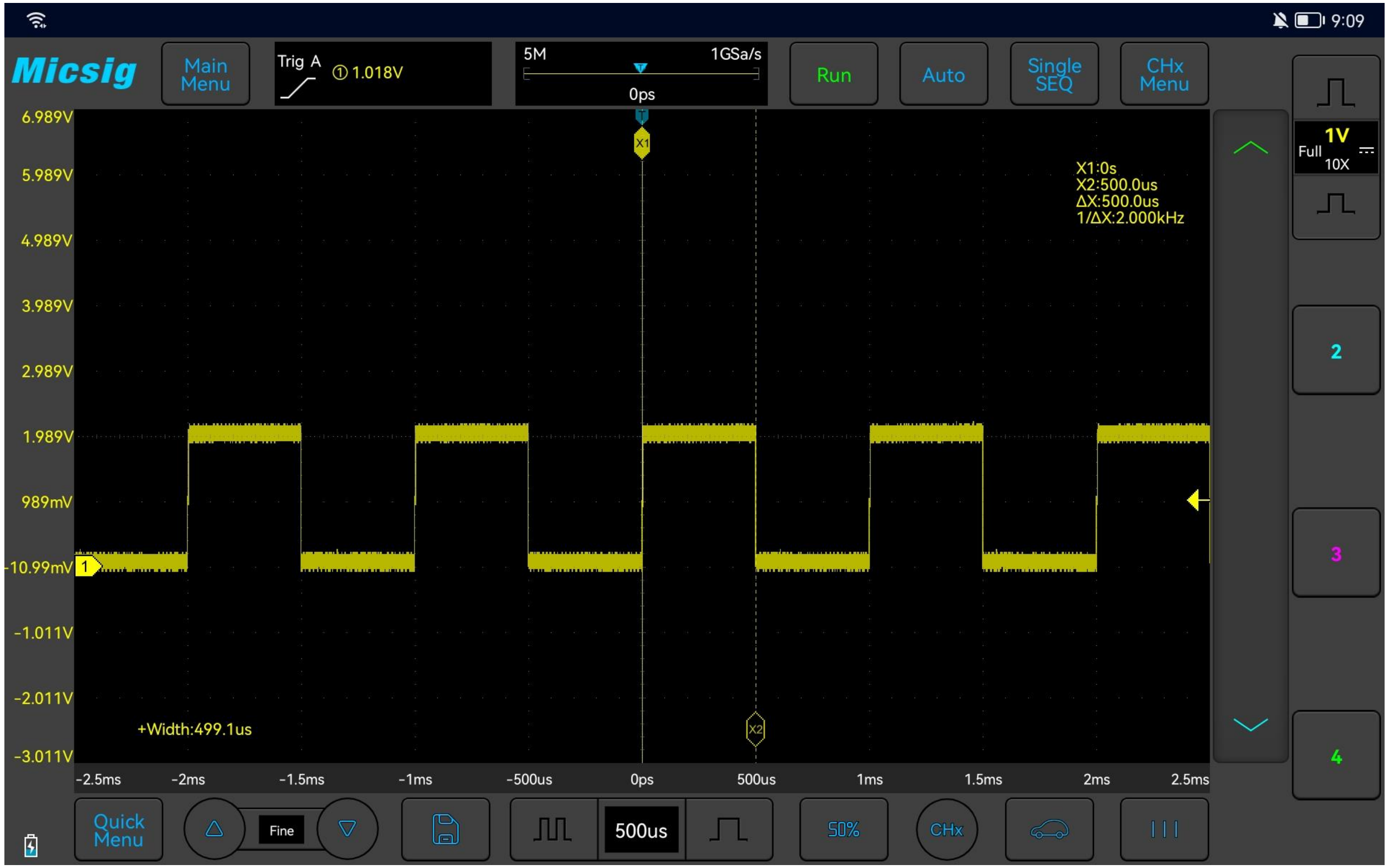


Figure 7-8 Cursor Measurement Pulse Width

7.3 Phase Rulers

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

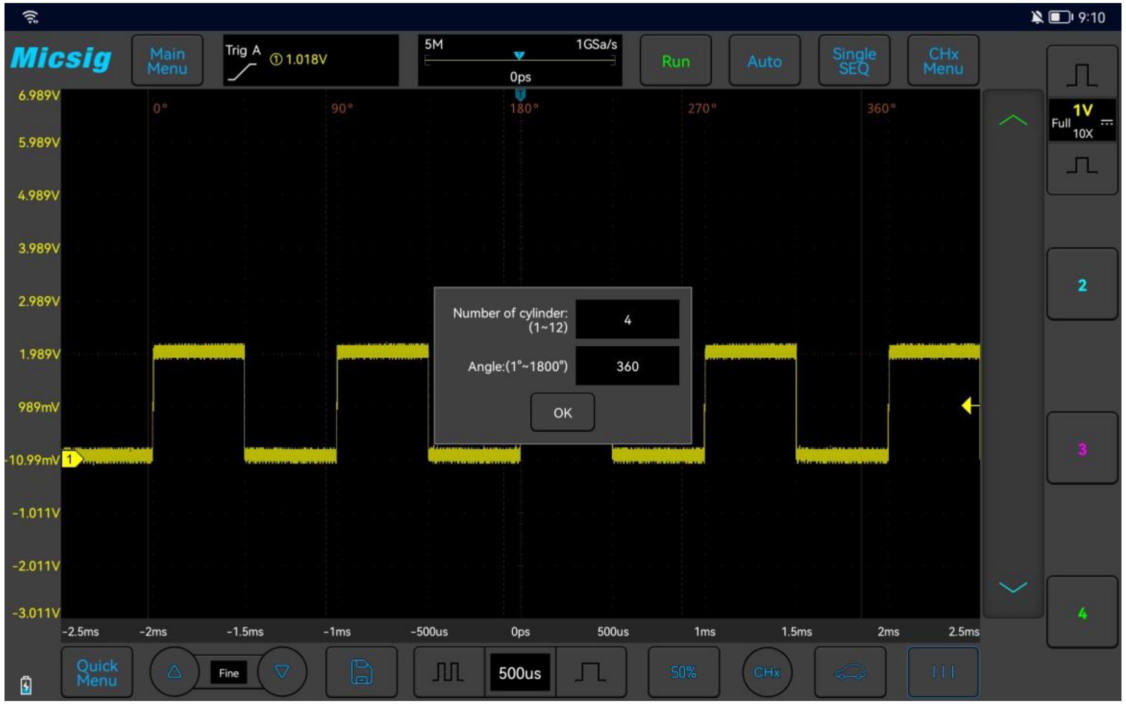


Figure 7-9 Phase Cursors

Chapter 8 Storage

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

- Screen capture function
- Video recording
- Waveform storage
- Save settings

8.1 Screen Capture Function

Screenshots and video recording can use the related functions that come with Android devices to store the display information of the current display screen locally in picture format and video format.

8.2 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.

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

Save reference file

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

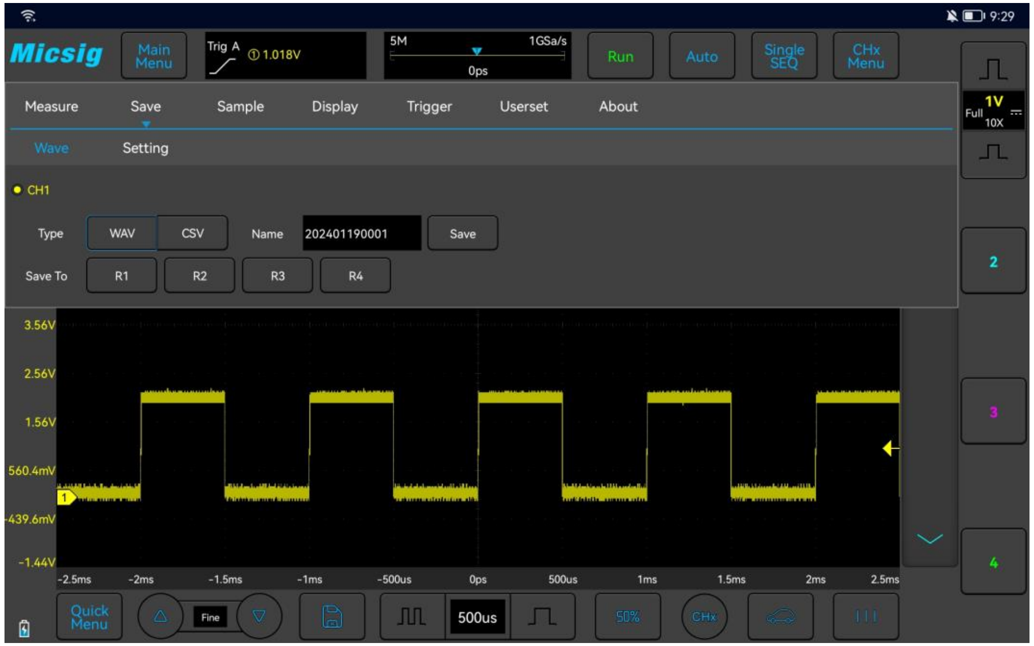


Figure 8-1 Save CH1 Reference Waveform Interface

File types: WAV, CSV.

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

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

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

Back: Tap to return to the previous level.

Method 1: Click the "save" button

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

Save the reference waveform by steps as follows:

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

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

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

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

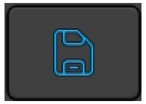
4) Tap "Save" to save the reference file. The save success prompt box is popped up.

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

Method 2: Click R* button

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

Method 3: Click "Quick Save" button

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

CSV files

CSV file structure

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

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

Max and Min in CSV files

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

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

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

8.3 Oscilloscope setting save

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

Open the main menu, tap Save and enter Setting menu, as shown in Figure 8-2.

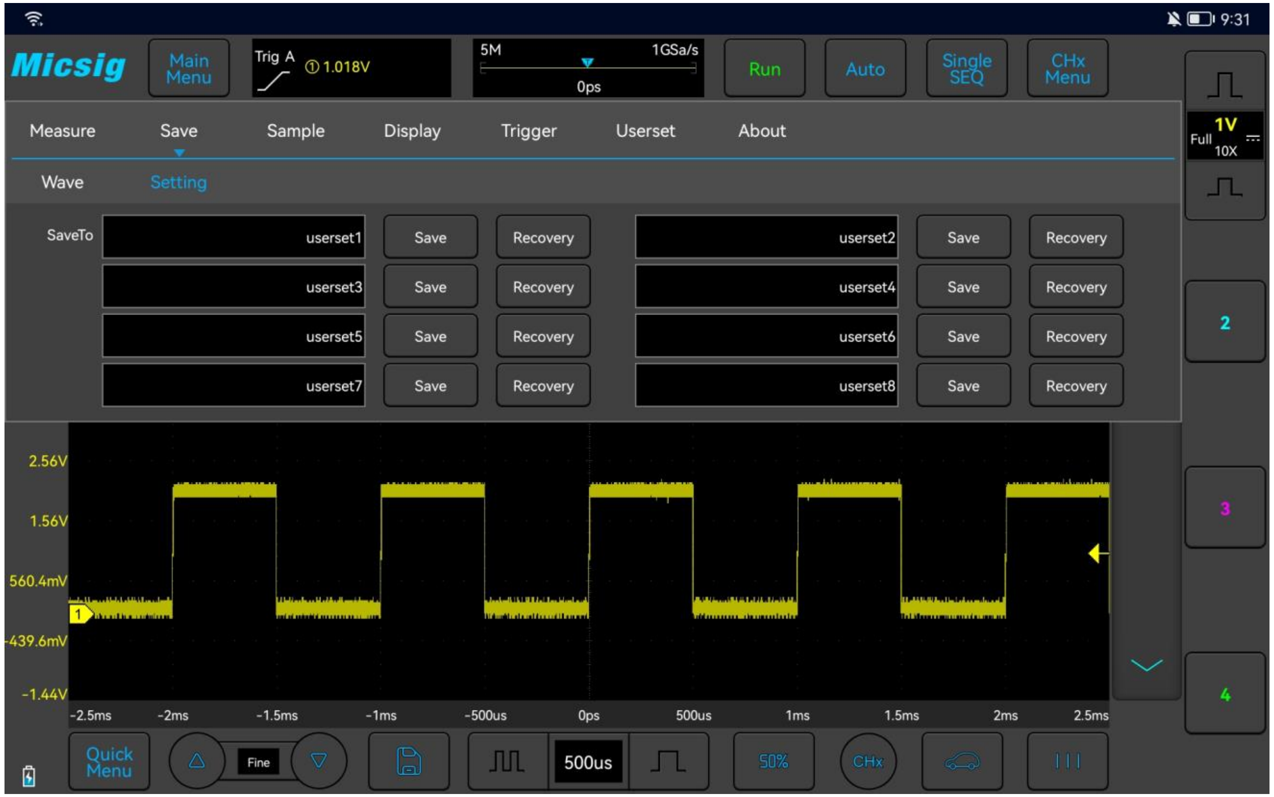


Figure 8-2 oscilloscope setting save

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

Chapter 9 MATH and Reference

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

- Dual waveform calculation
- FFT measurement
- Reference waveform call

9.1 Dual Waveform Calculation

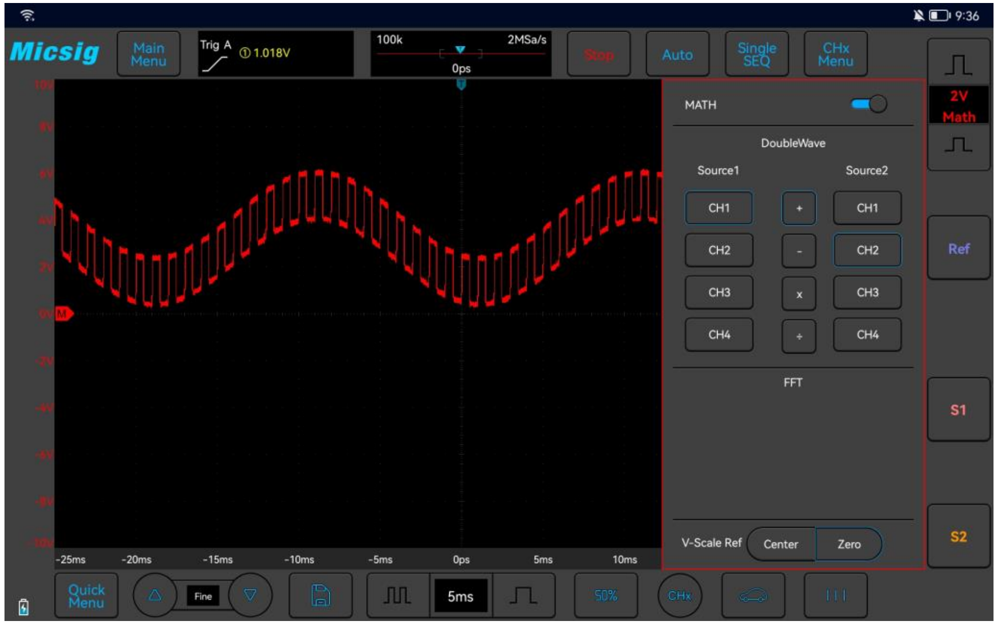


Figure 9-1 MATH Channel Waveform

Display math waveform

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

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

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

Math operation prompt

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

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

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

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

Adjust the math waveform

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

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

3) The vertical sensitivity, unit and time base corresponding to the math waveform are displayed in the channel area of the math channel. For details, see "2.6 Understand the Oscilloscope Display Interface".

Math waveform units

Use "Probe Type" on the channel menu to adjust the channel unit (refer to "5.4.4 Set Probe Type") and set the unit of each input channel to Volt or Ampere. The units of math function waveform include:

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

Table 9-1 List of Mathematical Units

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

Math operators

Math operators perform arithmetic operations on the analog input channels.

Addition or subtraction

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

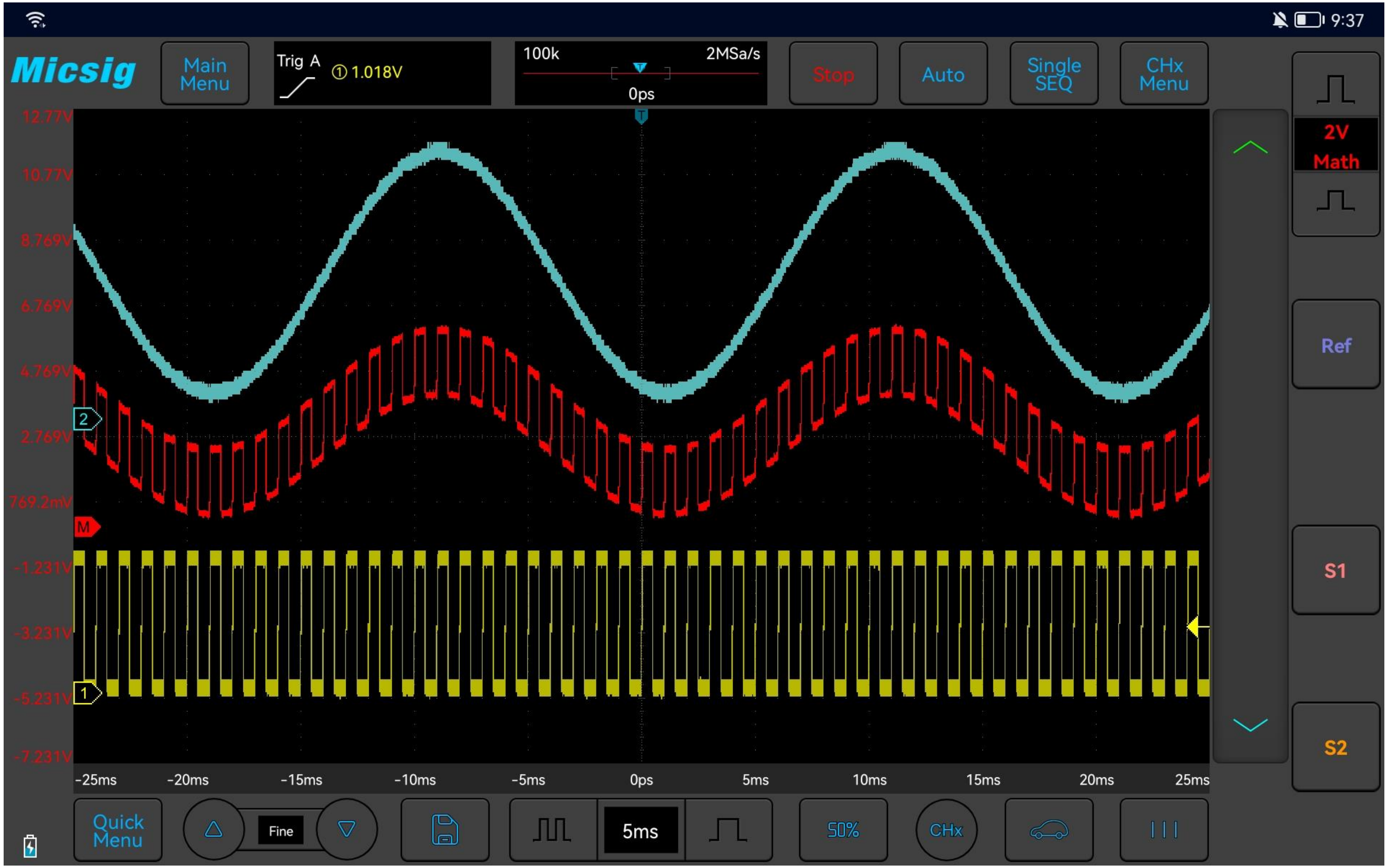


Figure 9-2 Mathematical Operation of CH1 adding CH2

Multiplication or division

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

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

9.2 FFT Measurement

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

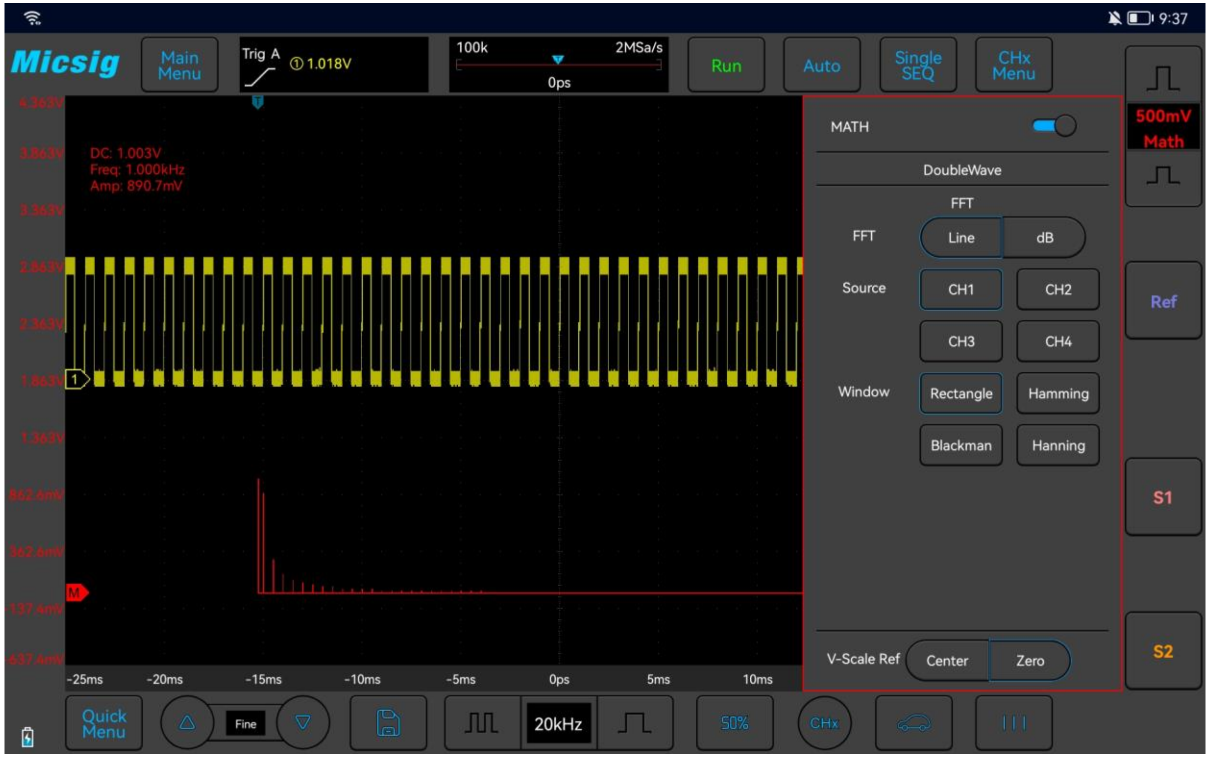


Figure 9-3 FFT Window

Open FFT

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

to open the math channel, left swipe to open math channel menu.

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

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

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

Selection of window function

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

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

- **Rectangular window**

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

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

- **Hamming window**

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

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

- **Hanning window**

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

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

- **Blackman-Harris window**

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

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

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

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

Spectrum type

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

Figure 9-4 Spectrum Amplitude as V-Hz

Adjust FFT waveforms

Waveform position

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

Horizontal time base scale

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

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

Vertical sensitivity

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

Note: FFT waveform does not support automatic parameter measurement.

9.3 Reference Waveform Call

Reference waveform call and close

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

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

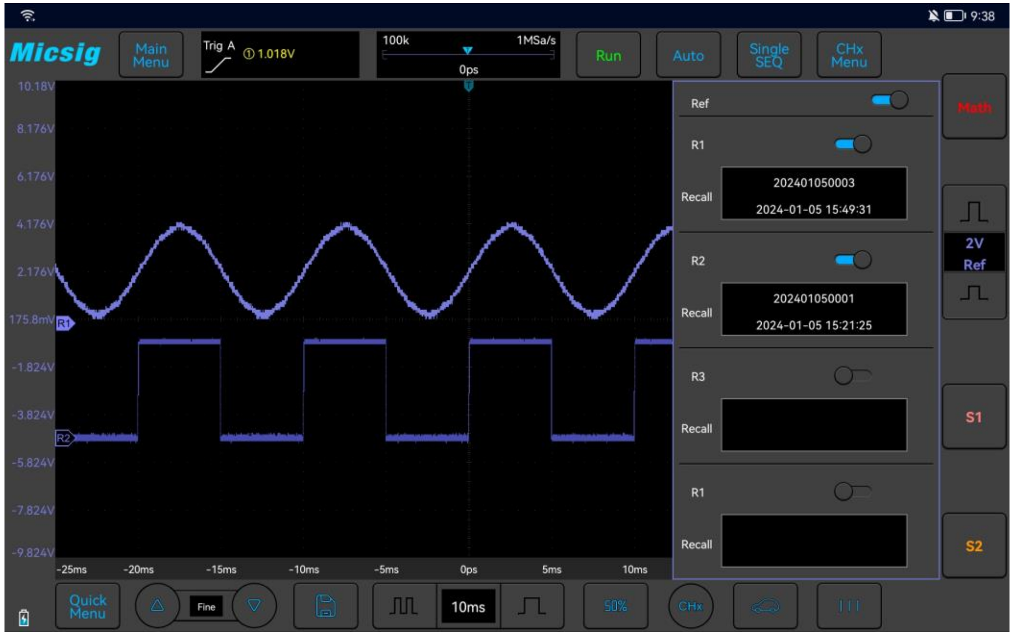


Figure 9-5 Reference Channel Menu

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) Open reference menu.

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

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

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

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

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

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

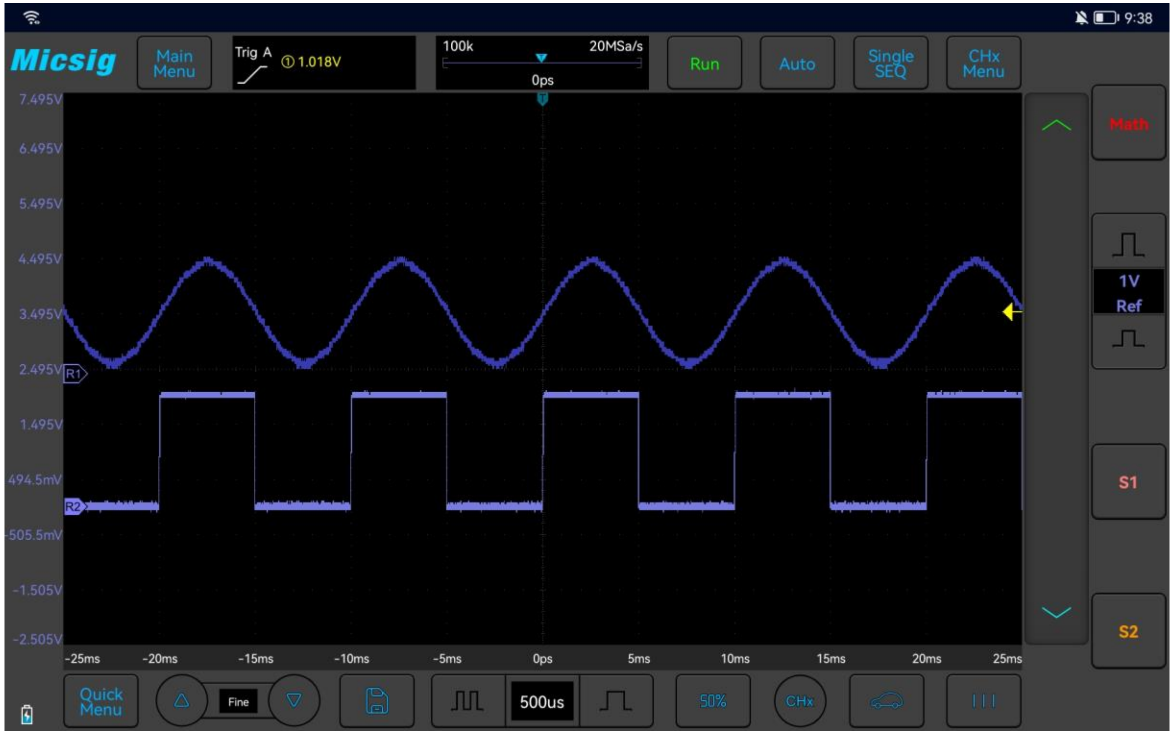
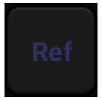


Figure 9-6 Current Reference Waveform

Close the reference waveform:

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

2) Repeat step 1 to close other reference channels.

3) Right swipe 

to turn off all reference waveforms.

Reference waveform movement and time base adjustment

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

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

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

Chapter 10 Display Settings

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

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

Figure 10-1 Display Settings and Function Buttons

10.1 Common settings

Open the common settings of the display menu. This item is used to set the time base reference mode and brightness of the waveform. The waveform brightness percentage is adjustable. The time base reference is divided into two types: screen center and trigger position:

1) Screen center

Select to adjust the time base waveform to expand or contract to both sides with the center of the screen as the base point, and the delay time remains unchanged.

2) Trigger position

Select to adjust the time base waveform to expand or contract to both sides with the trigger position as the base point, and the delay time changes with the change of the horizontal time base.

The general settings are 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”, “Crosshair” and “Frame”, and the brightness percentage is adjustable.

Figure 10-3 Graticule Menu Displa

Chapter 11 Sampling System

This chapter contains the detailed information of the sampling system of the oscilloscope. You are recommended to read this chapter carefully to understand the setting and operation of the sampling system of the VATO series oscilloscope.

- Sampling overview
- Run, stop and single sequence acquisition (running control)
- 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.

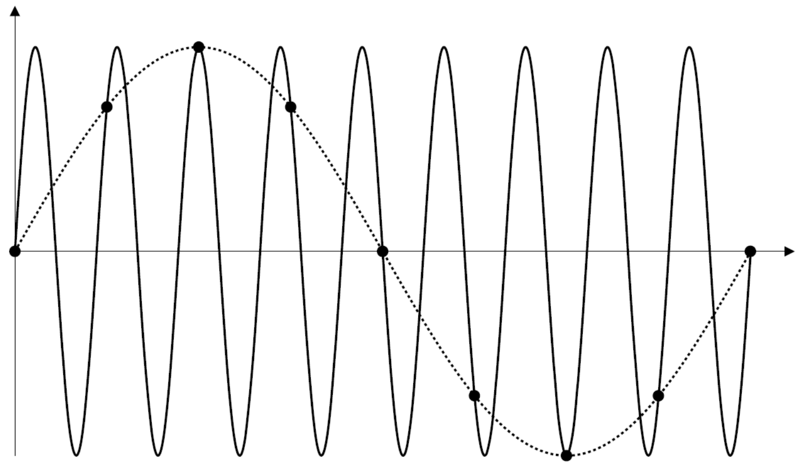


Figure 11-1 Aliasing

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.

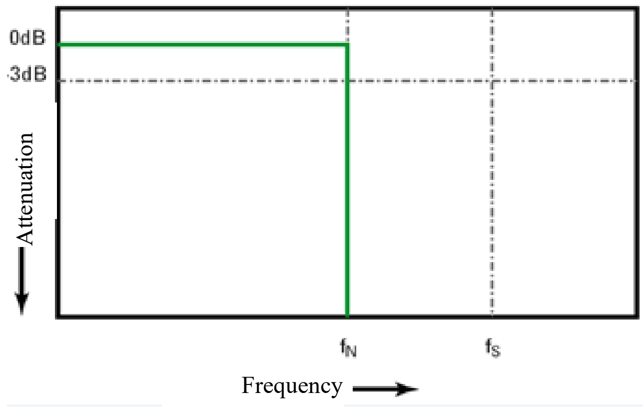


Figure 11-2 Theoretical Brick-Wall Frequency Response

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.

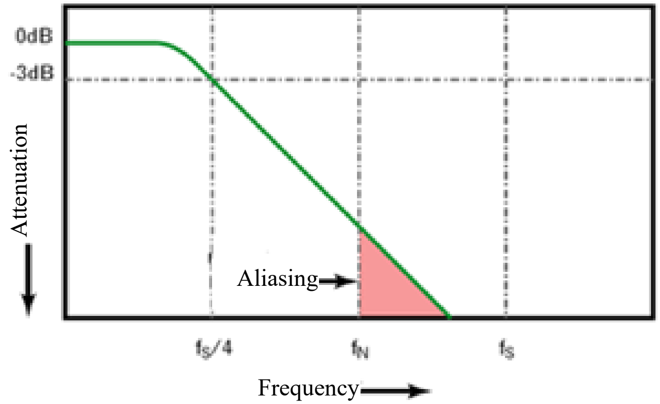


Figure 11-3 Sampling Rate and Oscilloscope Bandwidth

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%	$f_{BW}=1.9xf_{knee}$

Figure 11-4 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 and Single Sequence Acquisition Single SEQ button.

- When the Run/Stop button Run 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  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  for a single acquisition.

11.3 Record Length and Sampling Rate

The record length is the data volume for each captured waveform. For example, if the record length is 500K, it means that 500K sample points are captured by one trigger.

In the main menu, tap "Sample" to enter the record length setting menu, which can be set by tapping the corresponding record length.

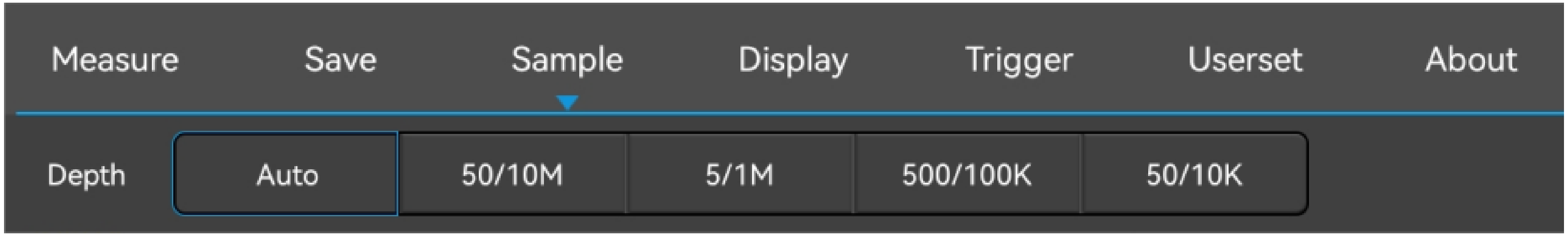


Figure 11-5 Record Length

In normal refresh mode, if it is a single channel, the record length can be set to 50k, 500k, 5M, 50M, Auto; if it is more than one channel, the record length can be set to 10k, 100k, 1M, 10M, 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 VATO series oscilloscope is 1GSa/s.

If any two channels are opened, the sampling rate per channel will become 1/2 of the maximum sampling rate.

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 Serial Bus Trigger and Decode

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 Smart bus trigger and decode.

This chapter mainly include the below contents:

- LIN bus trigger and decode
- CAN bus trigger and decode

Swipe up or down at the channel selection area to enter the second channel selection area, tap 

or 

to enable decoding, open bus configuration menu, select bus type, there are seven bus types: LIN, CAN, 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 500us 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 12-1:

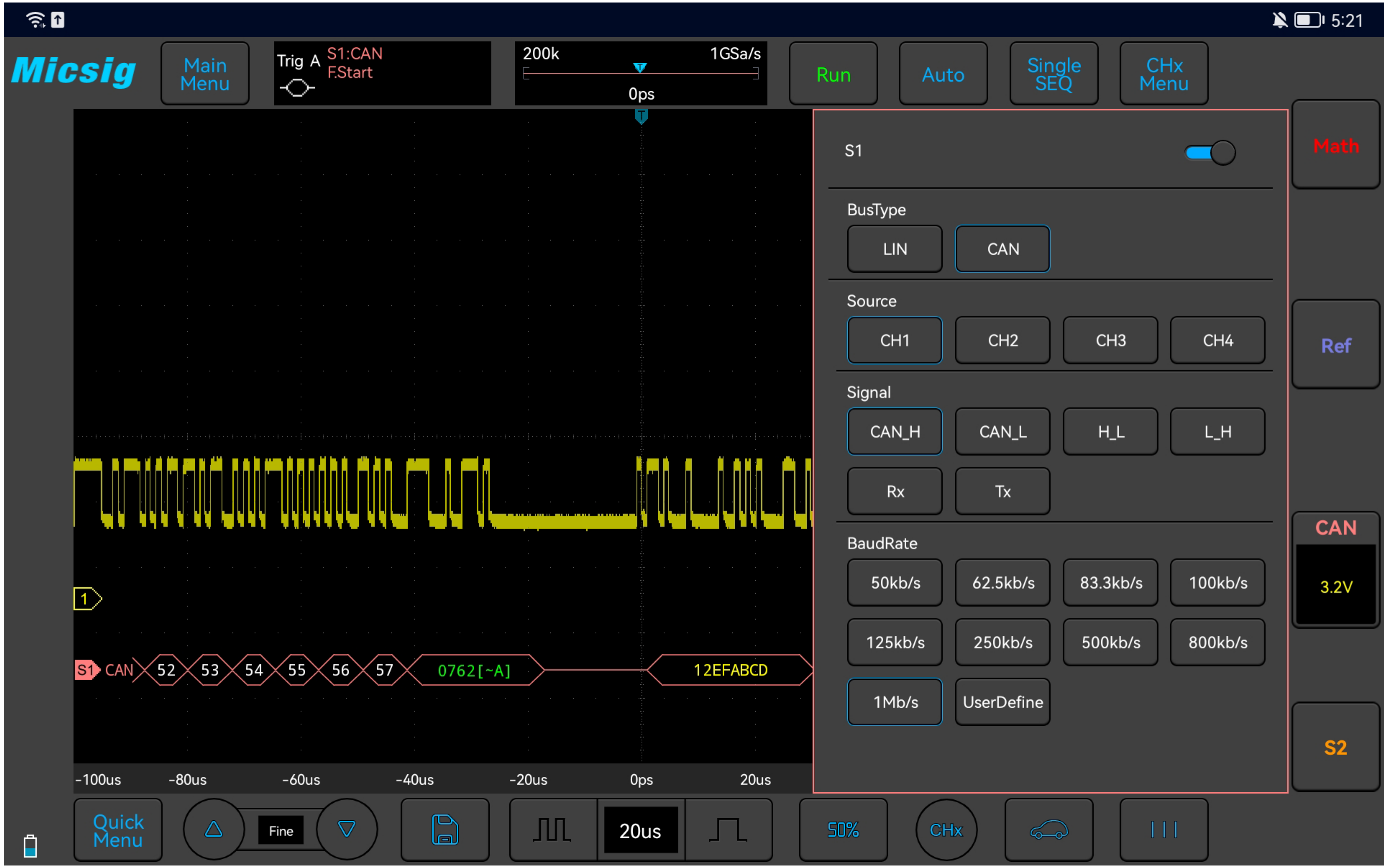


Figure 12-1 Bus Type Selection Menu

12.1 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**

Left swipe 

or 

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.

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

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

(2) Select the bus type as “LIN”, click “Ch1”, “Idle High”, “Parity 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 LIN trigger graphic interface is shown in Figure 12-2:

Method: 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.As shown in Figure 12-2:

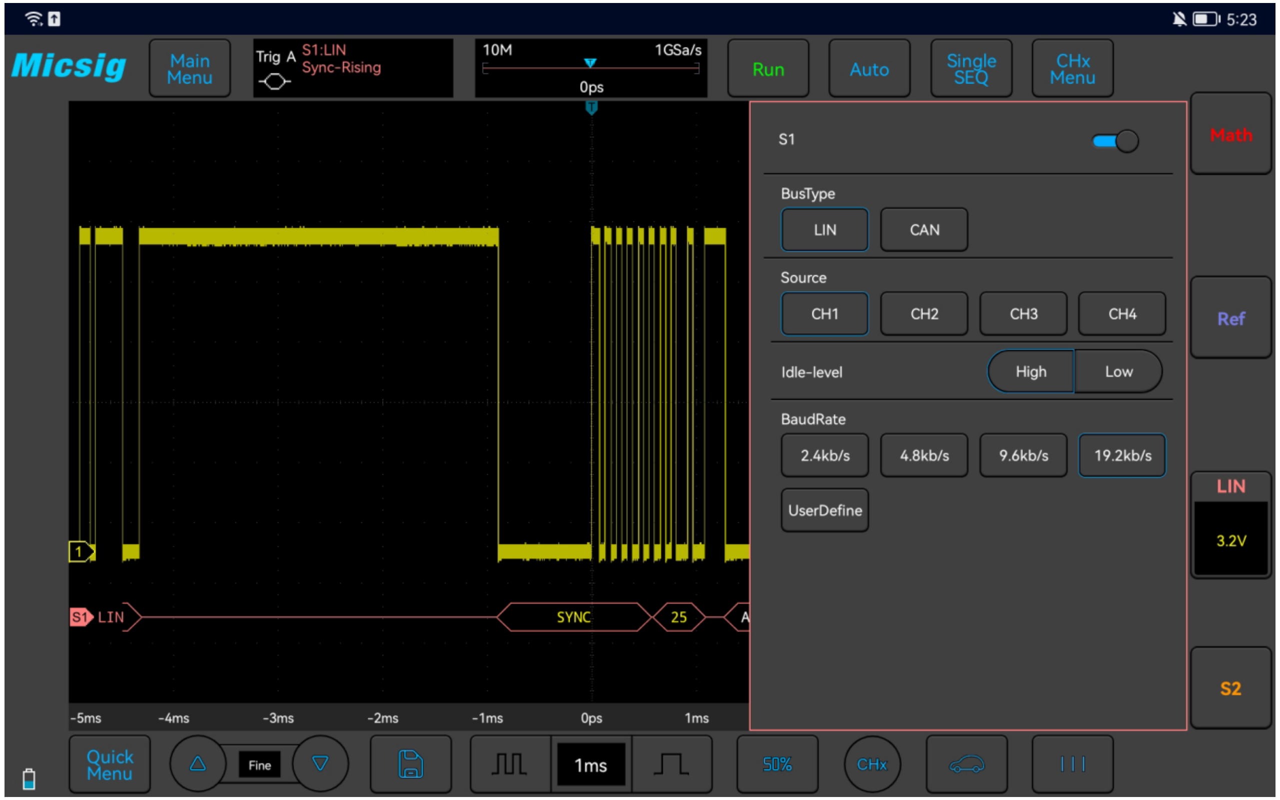


Figure 12-2 LIN Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type. When the LIN bus trigger is selected, the trigger mode includes: synchronous rising edge, frame ID, frame ID and data. See Figure 12-3:

Figure 12-3 LIN Trigger Mode Configuration Menu

a) Synchronous rising edge – 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) Frame ID and data—triggered when a frame with ID and data equal to the set value is detected. After selecting "Frame ID and Data", click ID or data, and set them.

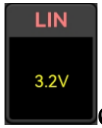
- **LIN serial decode**

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 “Synchronous Rising Edge”;

(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 12-4:

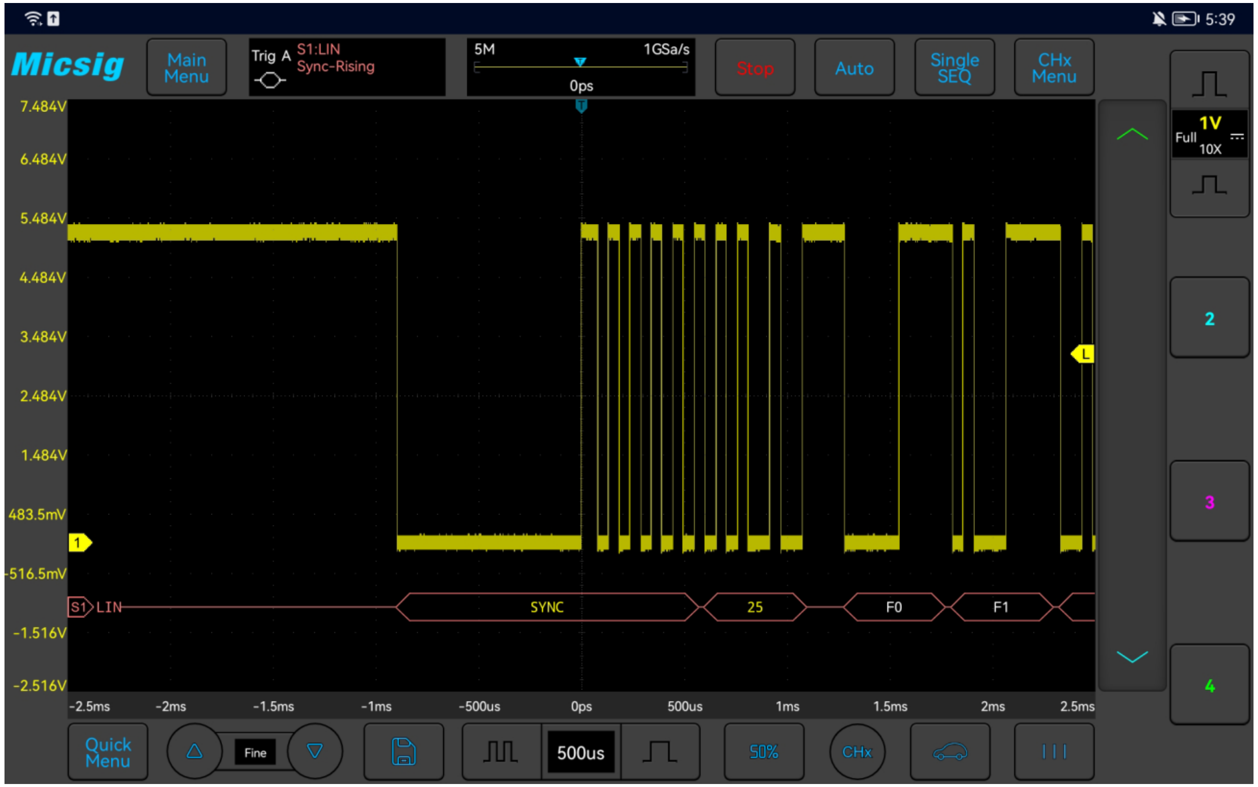


Figure 12-4 LIN Interface

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.

12.2 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**

  Left swipe 

 or 

 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 LIN and will not be repeated here. See Figure 12-5:

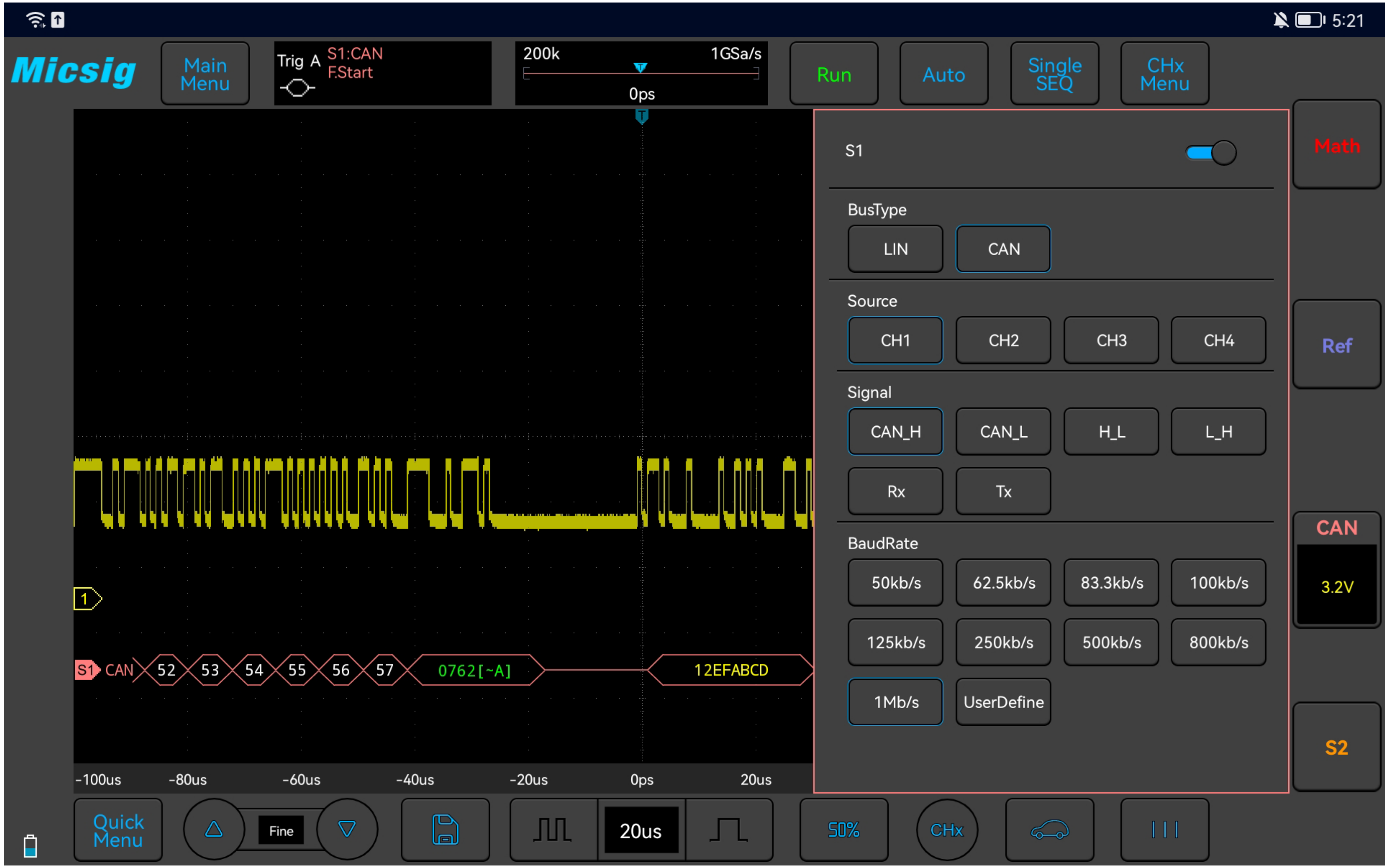


Figure 12-5 CAN Bus Configuration Menu

- **Trigger mode**

Open the trigger configuration menu and select the appropriate trigger type; when S1 CAN bus trigger is selected, as shown in Figure 12-6:

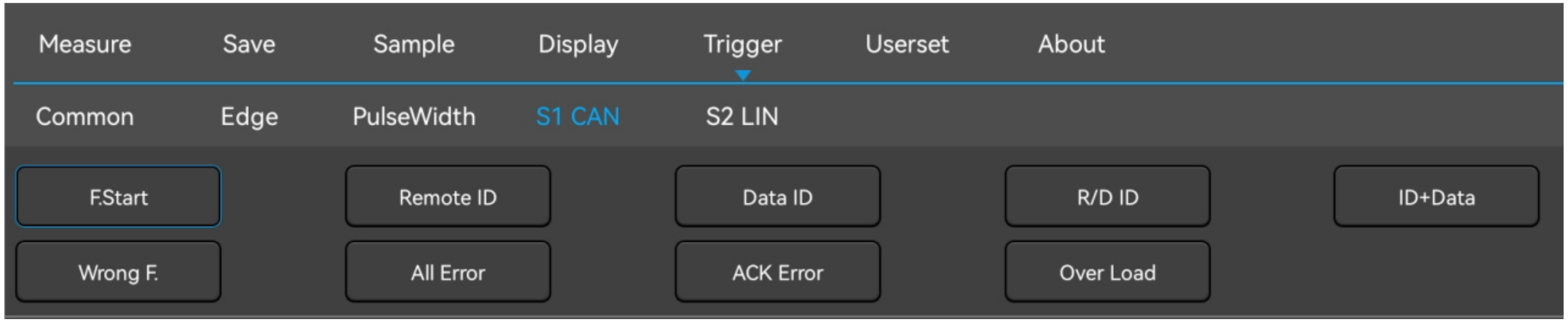


Figure 12-6 CAN Trigger Mode Configuration Menu

Trigger mode selection menu description:

a) Frame start — trigger at the start of the frame;

b) Remote frame 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 framed 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) Remote frame/data frame 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) Data frame ID and data ID — trigger on data frame that matches set ID and data. The configuration method is the same as the remote frame ID configuration;

f) Error frame — trigger on CAN error frame;

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

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

i) Overload frame — 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 “Frame Start”;

(4) Adjust the threshold level according to the signal amplitude; the CAN trigger graphic interface is shown in Figure 12-7:

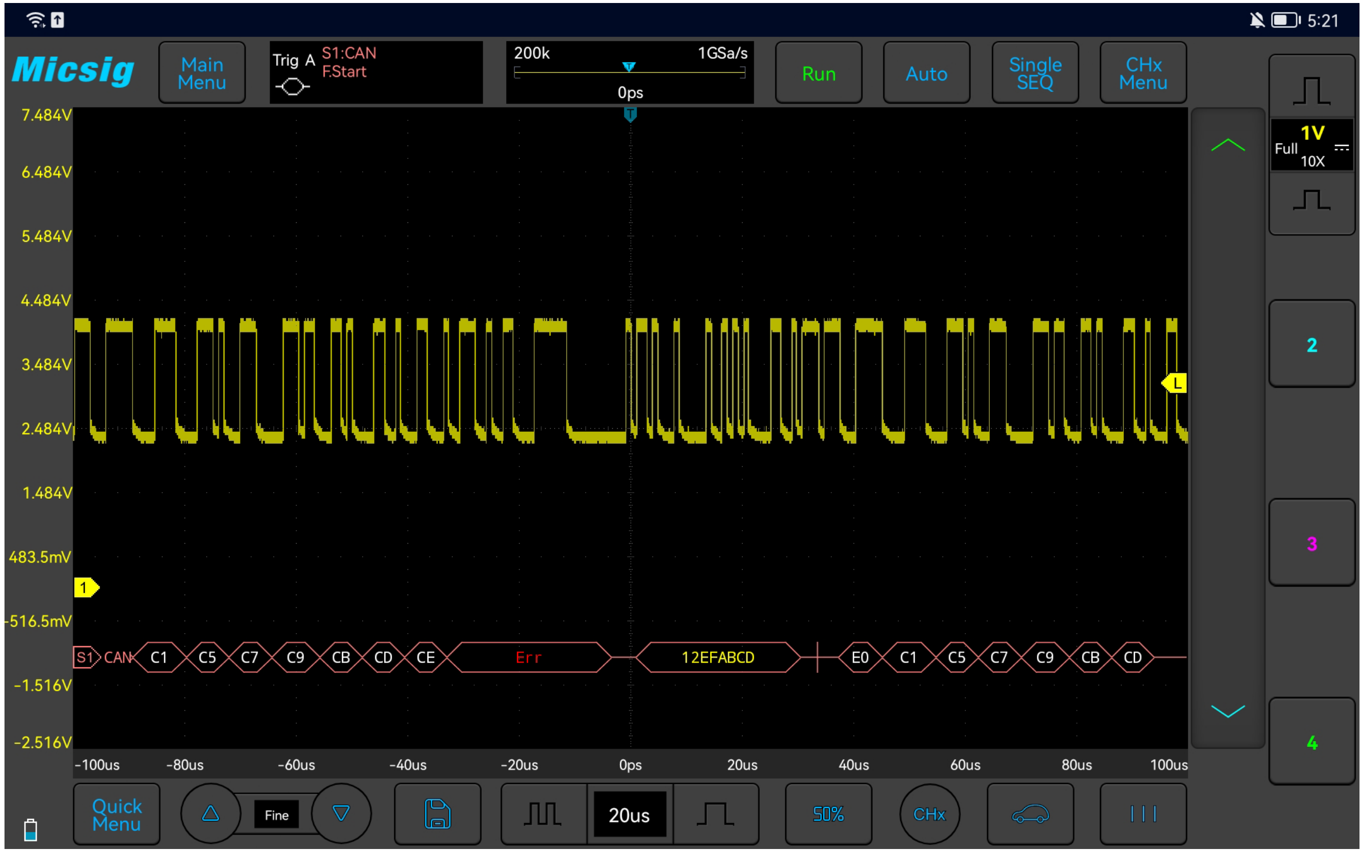


Figure 12-7 CAN Interface

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.

Chapter 13 Reference

This chapter contains the measurement category suitable for the oscilloscope and the environmental level of pollution degree supported. You are recommended to read this chapter carefully to understand the conditions of use of the VATO series oscilloscope.

- Measurement Category
- Pollution Degree

13.1 Measurement Category

Oscilloscope measurement category

VATO oscilloscopes are primarily used for measurements in Measurement Category I.

Measurement category definitions

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

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.

13.2 Pollution Degree

Pollution Degree	VATO series oscilloscopes can operate in environments with pollution degree 2 (or pollution degree 1).
Pollution Degree Categories	Pollution degree 1: No pollution or only dry, non-conductive pollution occurs. The pollution has no influence. For example: a clean room or air-conditioned office environment. Pollution degree 2: Normally only dry, non-conductive pollution occurs. Occasionally temporary conductivity caused by condensation may occur. For example: general indoor environment. Pollution degree 3: Conductive pollution, or dry, non-conductive pollution occurs which becomes conductive due to condensation. For example: sheltered outdoor environment. Pollution degree 4: Pollution that generates persistent conductivity through conductive dust, rain, or snow. For example: outdoor locations.

Chapter 14 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;
- Check the Power-off lock on the side of oscilloscope;
- 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 rejection or low-frequency rejection to 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 

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. 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.

8. 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 -----.

9. CSV files cannot be selected when loading reference:

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

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

- Check whether the sound volume setting is correct.

11. Oscilloscope backlight has low brightness:

- Check whether the backlight settings are correct.

12. A waveform being moved changes abruptly:

- Check whether the picture is displayed in full screen.

Chapter 15 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. During the warranty period, in case the product is verified by Micsig to have deficiencies, Micsig will conduct free maintenance for the user. The detailed warranty clauses can be referred to the product warranty card or obtained by contacting the official after-sales customer service of Micsig.

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 2 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

Shenzhen Micsig Technology Co., Ltd.

Address: 1F, Bldg A, Huafeng International Robot Industrial Park, Hangcheng Rd, Bao'an District, Shenzhen, Guangdong, China

Tel: (0755)-8860-0880

Website: www.micsig.com

Email: sales@micsig.com

Postal Code: 518126

Annex

Annex A: Maintenance and Care of 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 B: Accessories

Standard accessories

1) 2 pcs for 10X passive probes；

2) 4 x BNC banana lines (4CH);

3) 4 x alligator clips (4CH)

4) 4 x Flexible needle (4CH)

5) Power adapter (12V DC, 4A)

6) Battery

7) Power cord

8) VATO calibration certificate

9) VATO packing list

Optional accessories

1) Oscilloscope suitcase/handbag

2) High voltage probe

3) Differential probe

4) Current probe

This manual is subject to change without notice.

The contents of this manual are considered correct. If the user finds any error or omission, please contact Micsig.

The company will assume no responsibility for accident or hazard caused by the improper operation of the user.