Micsig®

Automotive Oscilloscope

ATO series

USER MANUAL

Shenzhen Micsig Technology Co., Ltd.

Version Info

Version	Date	Remarks
V1.0	2023.02	

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.

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Chapter 1. Safety Precautions

1.1 Safety Precautions

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

- **Only professionally trained personnel can operate the maintenance procedure.**
- **Avoid fire and personal injury.**
- **Use proper power cord.** Use only the power cord specified for this product and certified for the country/region of use.
- **Connect and disconnect probes properly.** Connect the instrument probe correctly, and its ground terminal is ground phase. Do not connect or disconnect probes or test leads while they are connected to a voltage source.

Disconnect the probe input and the probe reference lead from the circuit under test before disconnecting the probe from the measurement product.

- **Ground the product. To avoid electric shock, the instrument grounding conductor must be connected to earth ground**.
- **Observe all terminal ratings**. To avoid fire or shock hazard, observe all rating and markings on the product. Consult the product manual for further information of ratings before making connections to the product.
- **User correct probes**. To avoid excessive electric shock, use only correct rated probes for any measurement.
- **Disconnect AC power**. The adapter can be disconnected from AC power and the user must be able to access the adapter at any time.
- **Do not operate without covers**. Do not operate the product with covers or panels removed.
- **Do not operate with suspected failures**. If you suspect that there is damage to this product, have it inspected by service personnel designated by Micsig.

- **Use adapter correctly.** Supply power or charge the equipment by power adapter designated by Micsig, and charge the battery according to the recommended charging cycle.
- **Avoid exposed circuitry.** Do not touch exposed connections and components when power is present.
- **Provide proper ventilation.**
- **Do not operate in wet/damp conditions.**
- **Do not operate in a flammable and explosive atmosphere.**
- **Keep product surfaces clean and dry.**
- **The disturbance test of all models complies with Class A standards, based on EN61326:1997+A1+A2+A3, but do not meet Class B standards.**

Measurement Category

The ATO 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 ATO 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.

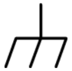
Symbols on the product

The following symbols may appear on the product:

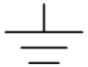
Hazardous Voltage

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 ATO series oscilloscope.

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

2.1 Inspect Package Contents

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

1) **Inspect if there is any damage caused by transportation**

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

2) **Inspect the accessories**

   A detailed description is given in "Annex 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 Use the Bracket

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

Figure 2-1 Open Bracket

2.3 Side Panel

Figure 2-2 Side Panel

There are various interfaces on the side of the oscilloscope, from left to right: Power-on button, Grounding, Probe compensation signal output, USB Host, HDMI, USB Device, Power-off lock, and Power port.

2.4 Rear Panel

Figure 2-3 Rear Panel

a) Ch1 – Ch4 are signal measurement channels

b) Aux out is an auxiliary channel, which is mainly used to measure the waveform refresh rate of the oscilloscope and cascade the current oscilloscope signal to other oscilloscopes.

2.5 Top Panel

Figure 2-4 Top Panel of Automotive Oscilloscope

On top of the oscilloscope is the Micsig UPI universal probe interface, which is designed to power active probes and automatically communicate scale factors on the scope display.

2.6 Front Panel

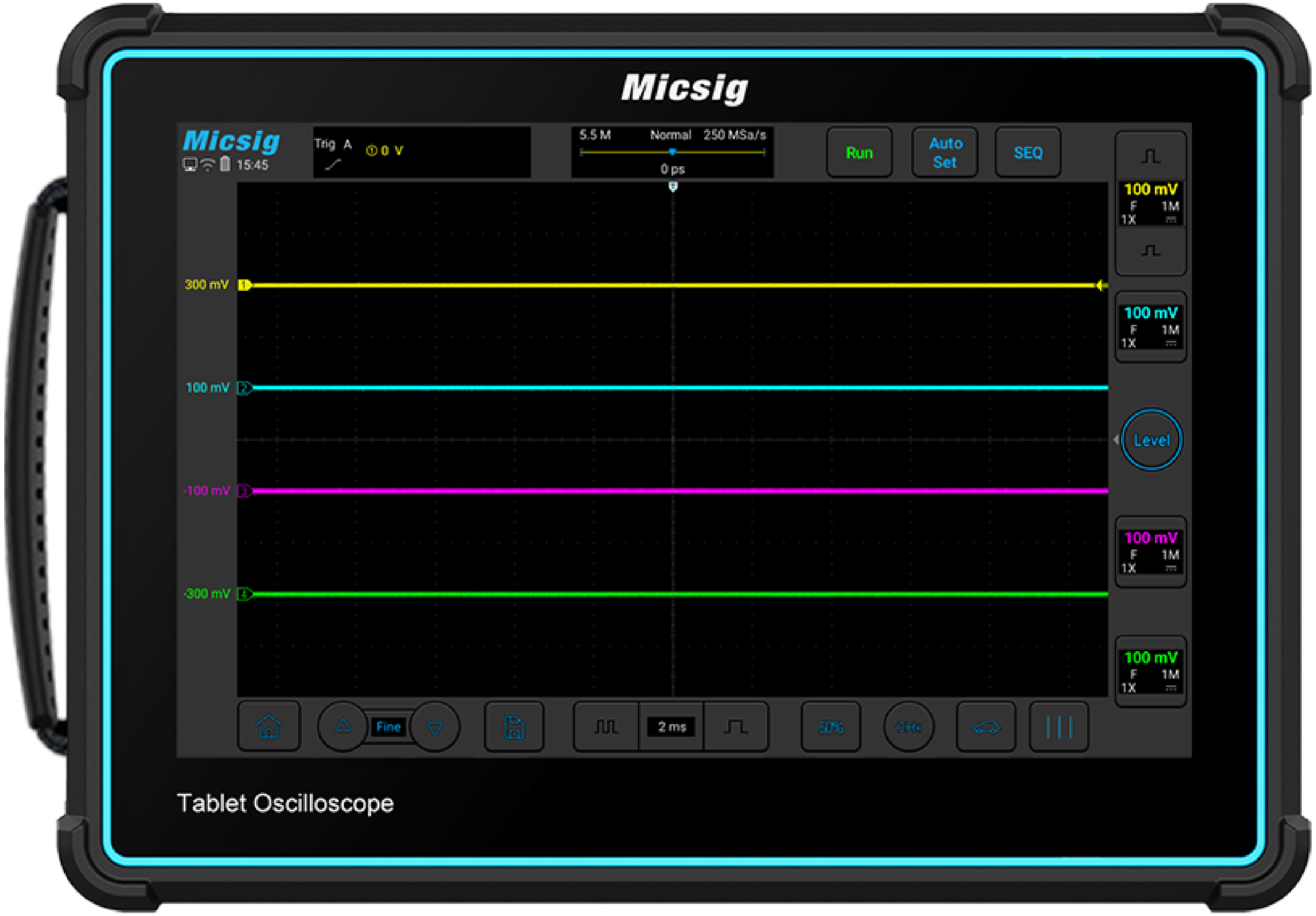


Figure 2-5 Front Panel of Automotive Oscilloscope

2.7 Power on/off the Oscilloscope

Power on/off the oscilloscope

First time start

- Connect power adapter to the oscilloscope, and the oscilloscope should not be pressed on the adapter cable.
- Check the Power-off lock on the side of oscilloscope and press the power button ⏻ to start the instrument.

Power on

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

Power off

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

Power-off lock

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

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

2.8 Understand the Oscilloscope Display Interface

This section provides a brief introduction and description of the ATO 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.

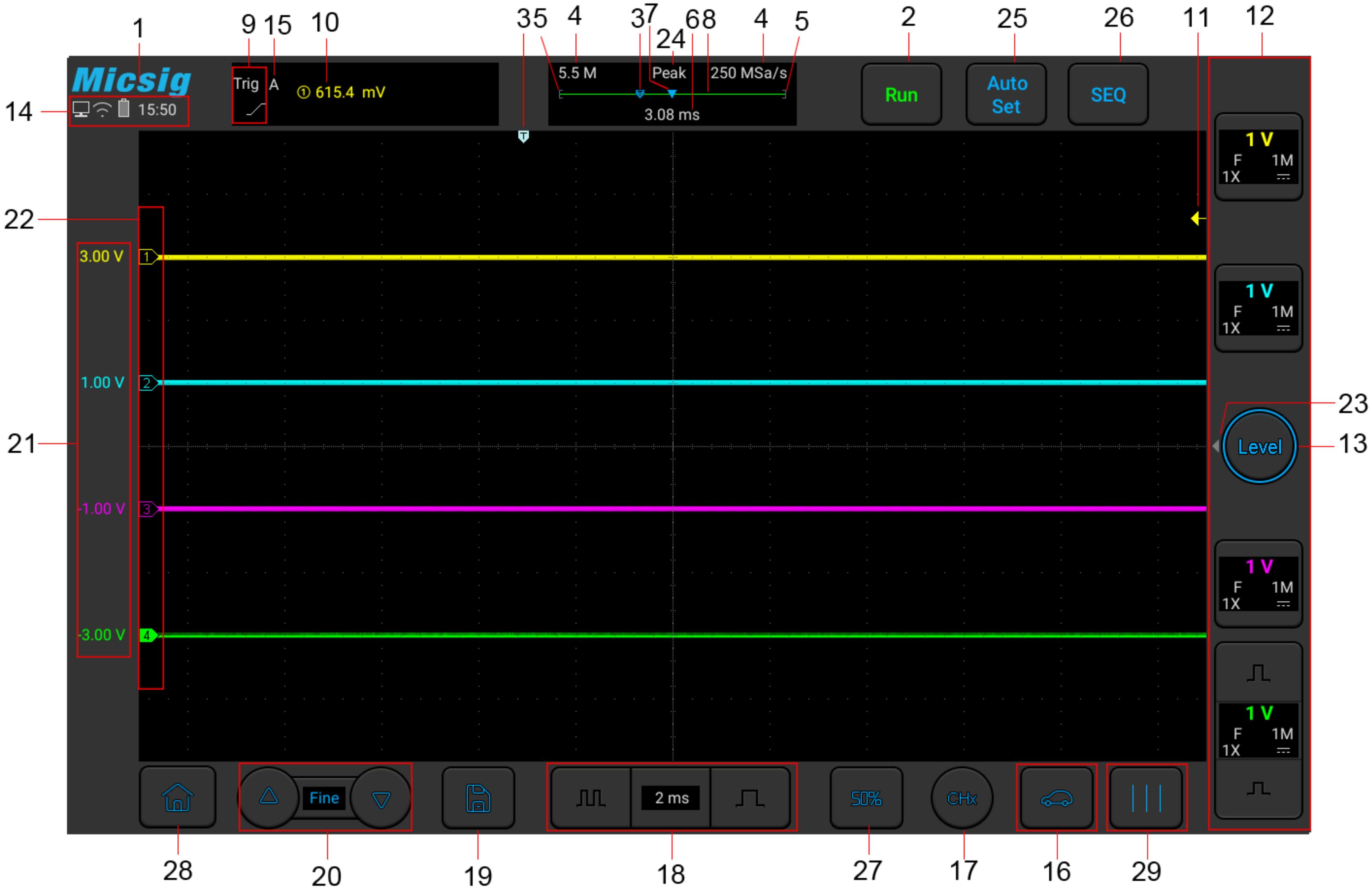
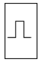
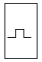


Figure 2-6 Oscilloscope Interface Display

No.	Description
1	Micsig logo
2	Oscilloscope status, including RUN, STOP, WAIT, Auto
3	Trigger point
4	Sampling rate, memory depth
5	The area in “[]” indicates the position of waveform displayed on the screen throughout the memory depth
6	Delay time, the time at which the center line of the waveform display area is relative to the trigger point
7	Center line of waveform display area
8	Memory depth indicatrix
9	Current trigger type indication
10	Current trigger source, trigger level

No.	Description
11	Trigger level indicator
12	CH1、CH2、CH3、CH4 channel icons and vertical sensitivity icon. Tap the channel icons to open channels; Click  or  to adjust the vertical sensitivity of channels; Open the channel menu by swipe left from the desired channel and swipe right to close; Display the vertical sensitivity of channels; Display couple method.
13	Trigger level adjustment, press on the button to modify the trigger level through upward and downward movements.
14	Display areas of USB-PC connection, USB connection, battery level, time etc.
15	Trigger Mode: A(auto), N(Normal).
16	Automotive diagnostic software presets
17	Current channel selection. Click to pop up the current channel switching menu to switch the current channel.

No.	Description
18	Horizontal time base control icon. Tap the left/right time base buttons to adjust the horizontal time base of the waveform. Tap the time base to open the time base table. Tap to select the desired time base.
19	Quick save. Tap to quickly save the waveform as a reference waveform.
20	Fine adjustment button. Tap the button to finely adjust the last operation, including waveform position, trigger level position, trigger point and cursor position.
21	The vertical position value of the channel indicator.
22	Channel indicator can indicate the zero-level position of the open channel.
23	Trigger quick start menu indicator: swipe left to open trigger quick start menu
24	Sample Mode: Normal, Average, Envelope, Peak
25	Auto Set, AutoRange
26	SEQ, Single Sequence Acquisition

<table>
<tr><th>No.</th><th>Description</th></tr>
<tr><td>27</td><td>50%: Touch to set:
● The vertical position of the current channel waveform to the zero point
● The horizontal position of the current channel waveform to center of the screen
● The trigger level to the center of the trigger channel's waveform
The activecursor back to the center of the scree</td></tr>
<tr><td>28</td><td>Home</td></tr>
<tr><td>29</td><td>Phase rulers: help to measure the timing of a cyclic waveform on a scope view.</td></tr>
</table>

Table 2-1 Description of Oscilloscope Display Interface

2.9 Introduction Basic Operations of Touch Screen

The ATO 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 Slide out of Main Menu

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

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.

Pinch

For fine adjustments of vertical sensitivity.

2.10 Mouse Operation

Connect the mouse to the "USB Host" interface, then operate the oscilloscope with the mouse. The left button, right button and scroll wheel of the mouse have the same functions as the finger touch function. Figure 2-8 is a schematic diagram of the mouse single click to select "Run/Stop" function under the "Menu" option in the "Short-cut Menus".

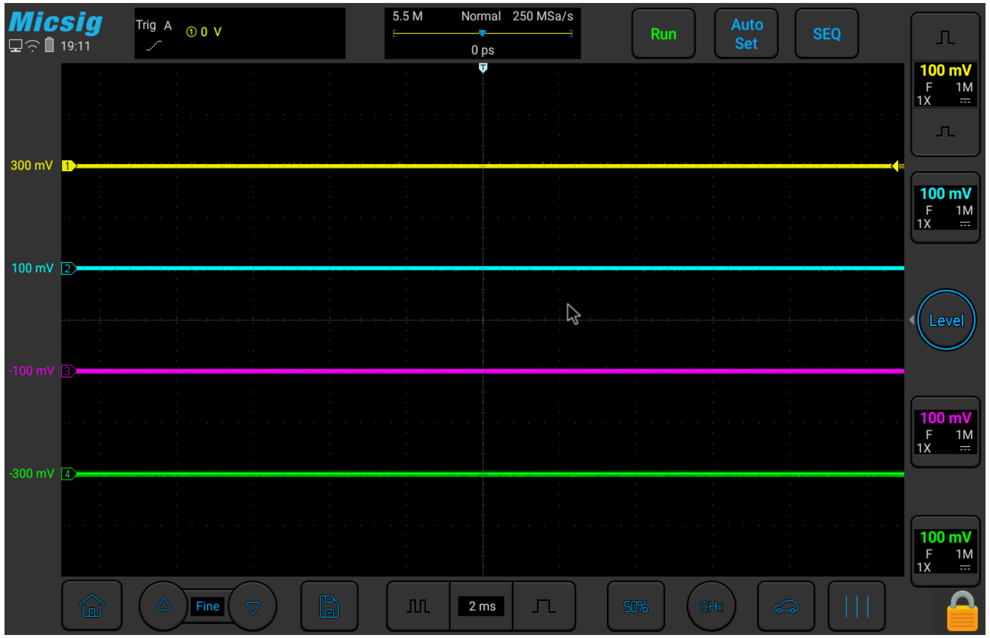


Figure 2-8 Mouse Cursor

2.11 Connect Probe to the Oscilloscope

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

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

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

Category I 300Vrms, 400Vpk.

2.12 Use Auto

Once the oscilloscope is properly connected and a valid signal is input, tap the Auto Set button 

to quickly configure the oscilloscope to be the best display effects for the input signal. While the oscilloscope in auto state, the Auto Set button will light up 

.

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

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

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

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

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

Figure 2-9 Open Auto Set

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

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

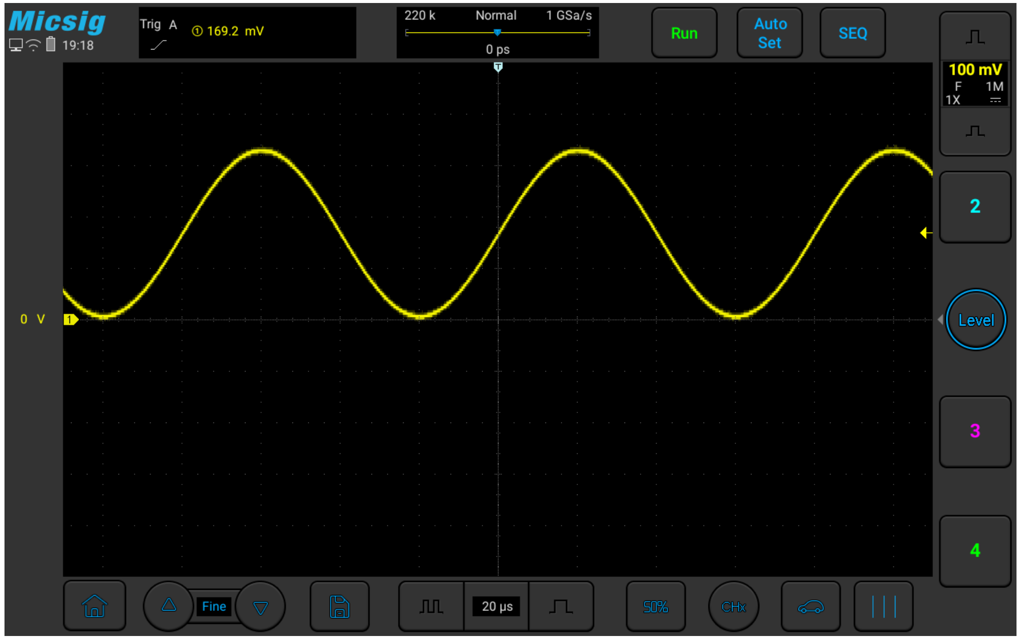


Figure 2-10 Auto Set Waveform

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

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

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

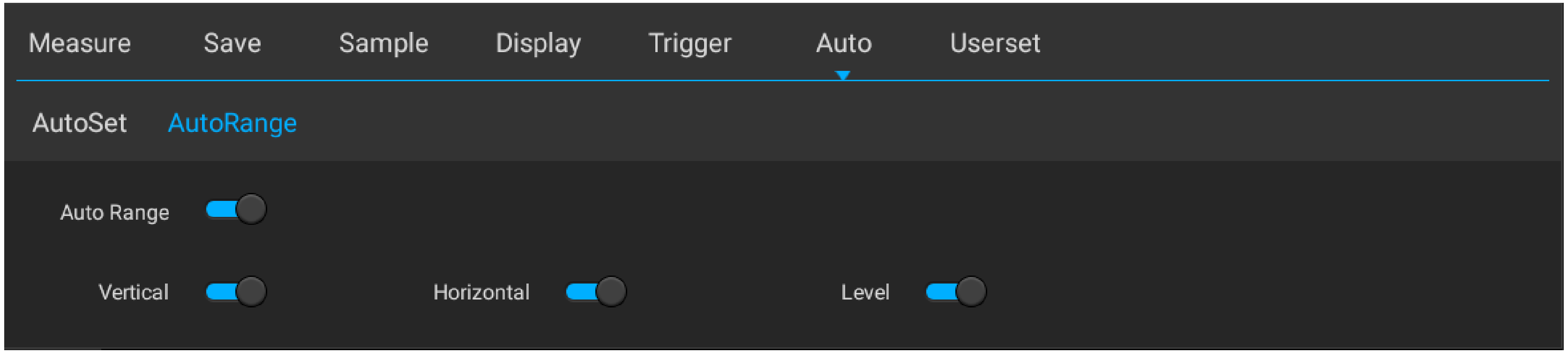


Figure 2-11 Open Auto Range

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

1) It can analyze signals subject to dynamic changes.

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

3) Control the automatic adjustment setting of the oscilloscope.

2.13 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 2-12.

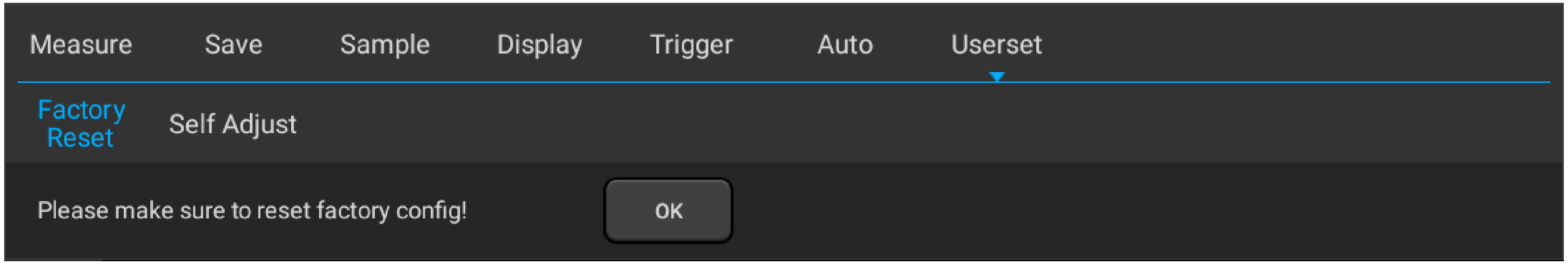


Figure 2-12 Load Factory Settings

2.14 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.

Manual zero calibration- The oscilloscope supports manual zero calibration for each channels. Click the "Fine" button in the lower left corner would open the forced channel selection menu and display the offset value, select the channel to be adjusted, and slide the waveform up and down to manually adjust the zero position. Tap “△”, “▽” button can fine-tune the zero position, as shown in Figure 2-13

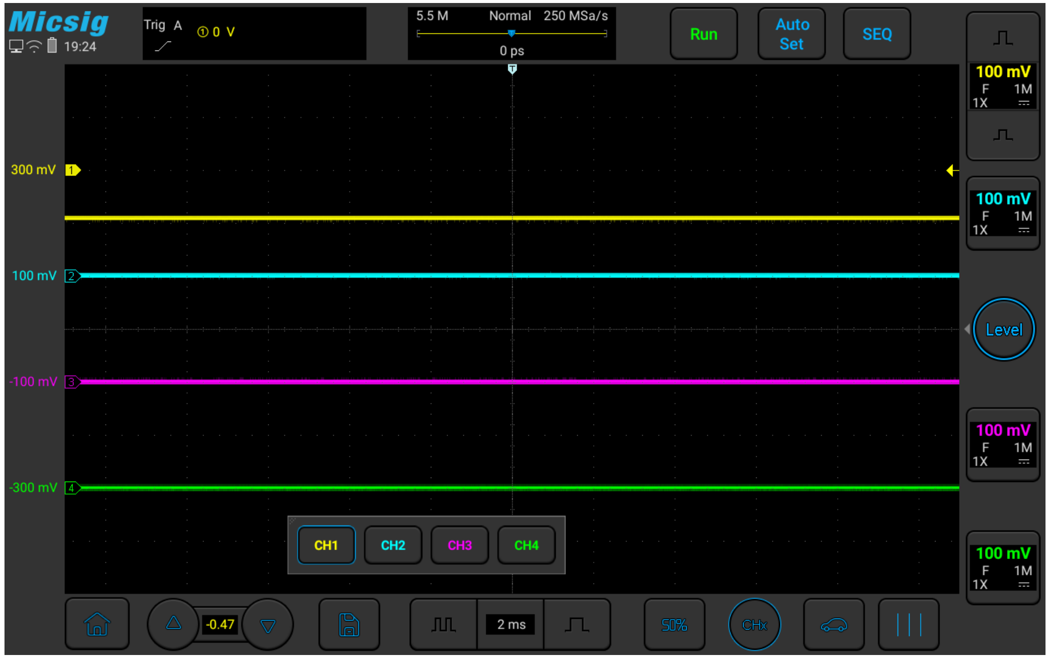


Figure 2-13 Manual zero calibration

2.15 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:

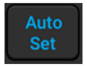
1) First, connect the oscilloscope probe to CH1. If a hook head is used, make sure that it is in good connection with the probe.

2) Connect the probe to the calibration output signal terminal and connect the probe ground to the ground terminal. As shown in Figure 2-13.

Figure 2-13 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 

button or manually adjust the waveform vertical sensitivity and horizontal time base. Observe the shape of the waveform, see Figure 2-14.

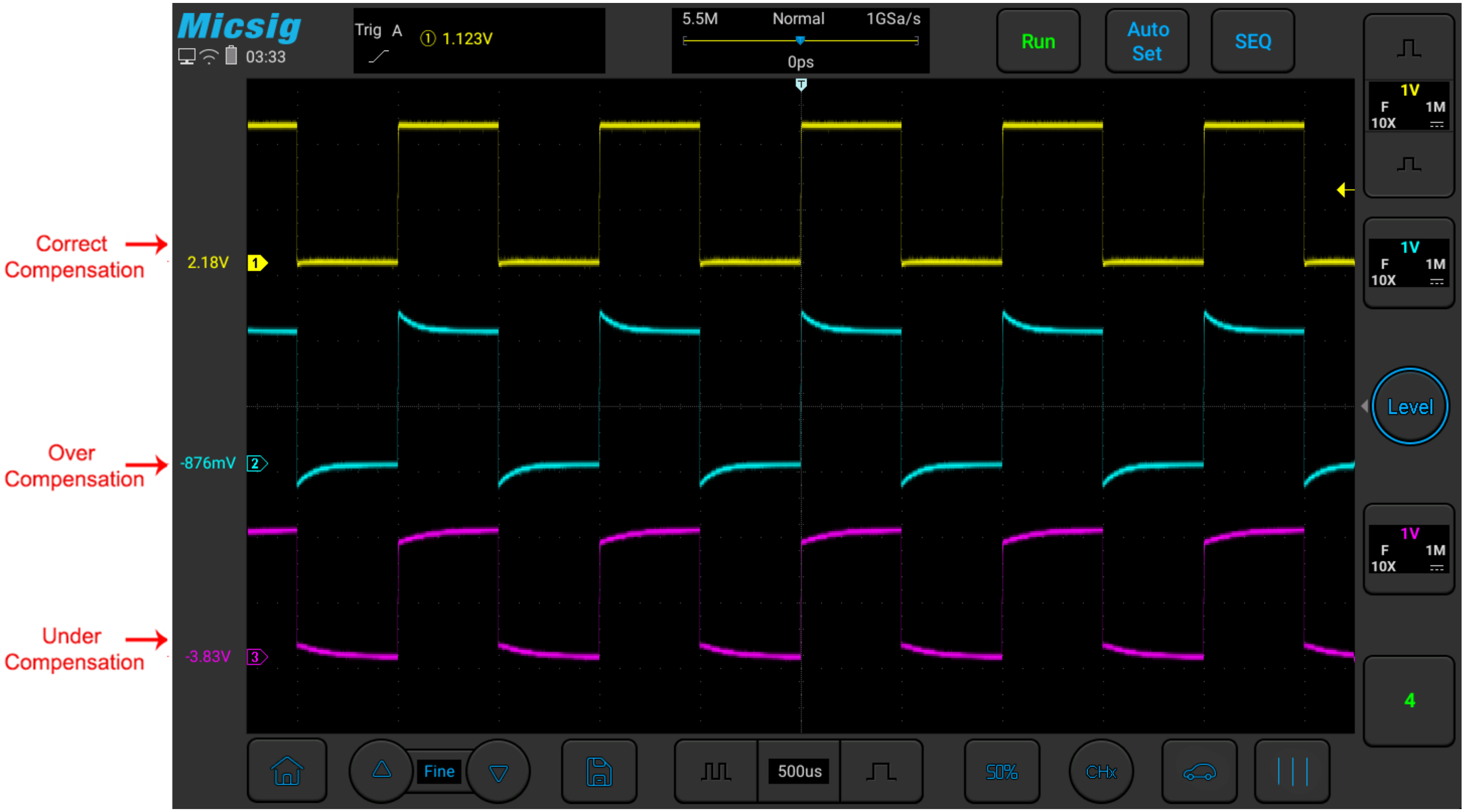


Figure 2-14 Probe Compensation

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 2-15.

Figure 2-15 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.*

2.16 Modify the Language

To modify the display language, please refer to “14.3 Settings - Language and Input Method”.

Chapter 3 Automotive Test

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

3.1 Charging/Start Circuit

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

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

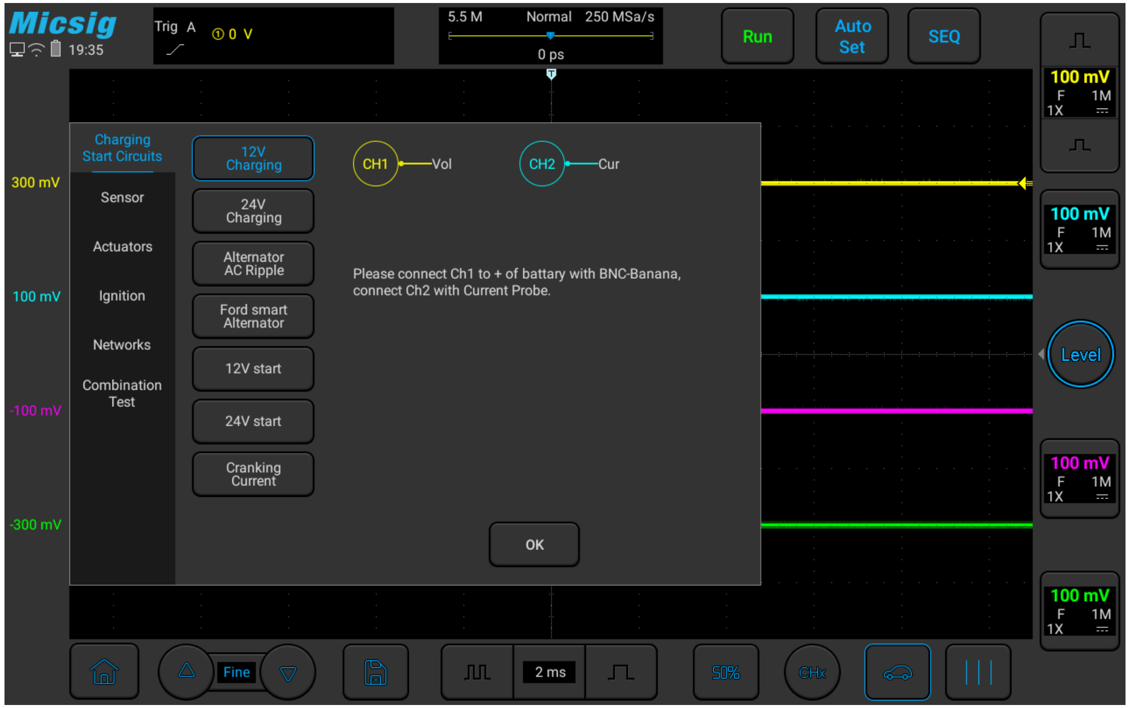


Figure 3-1 Charging/Start Circuits

3.1.1 12V Charging

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

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

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

The specific operation is shown in Figure 3-2:

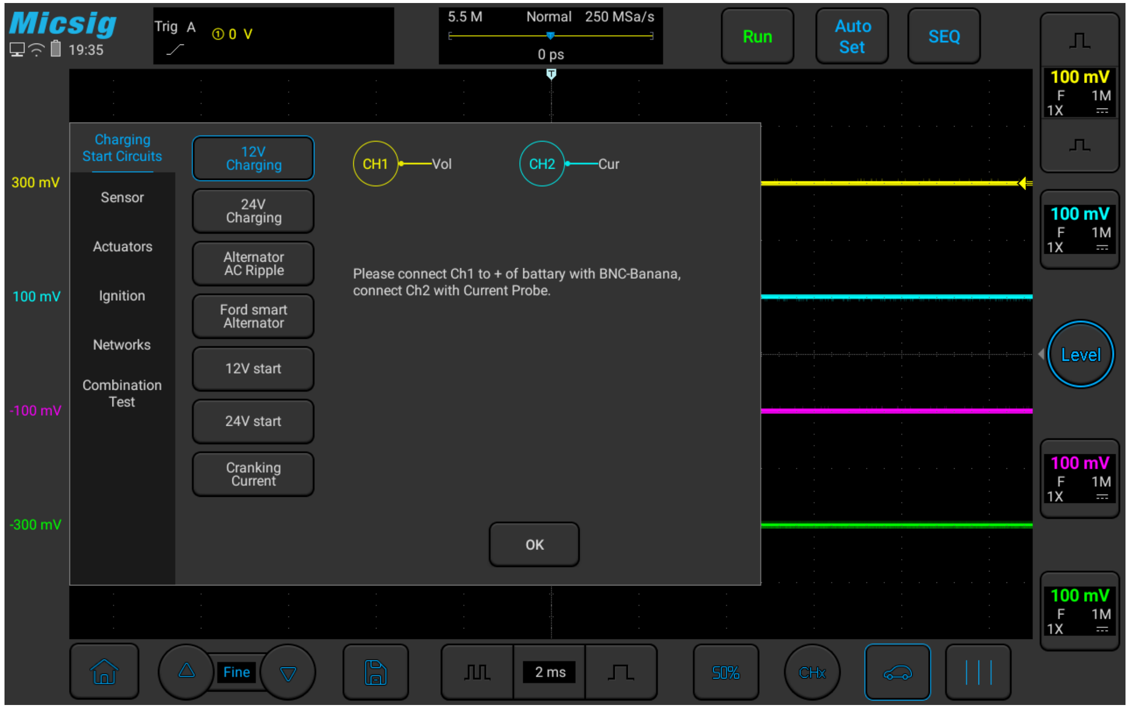


Figure 3-2 12V Charging

3.1.2 24V Charging

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

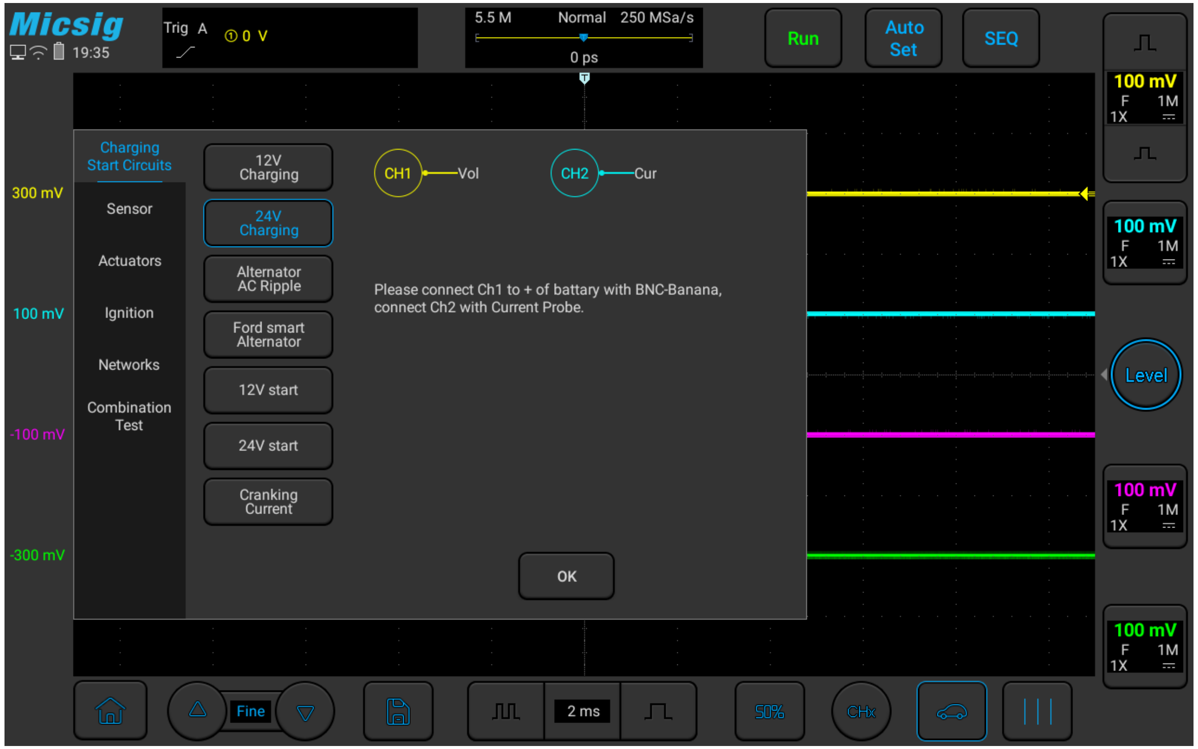


Figure 3-3 24V Charging

3.1.3 Alternator AC Ripple

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

As shown in Figure 3-4 below:

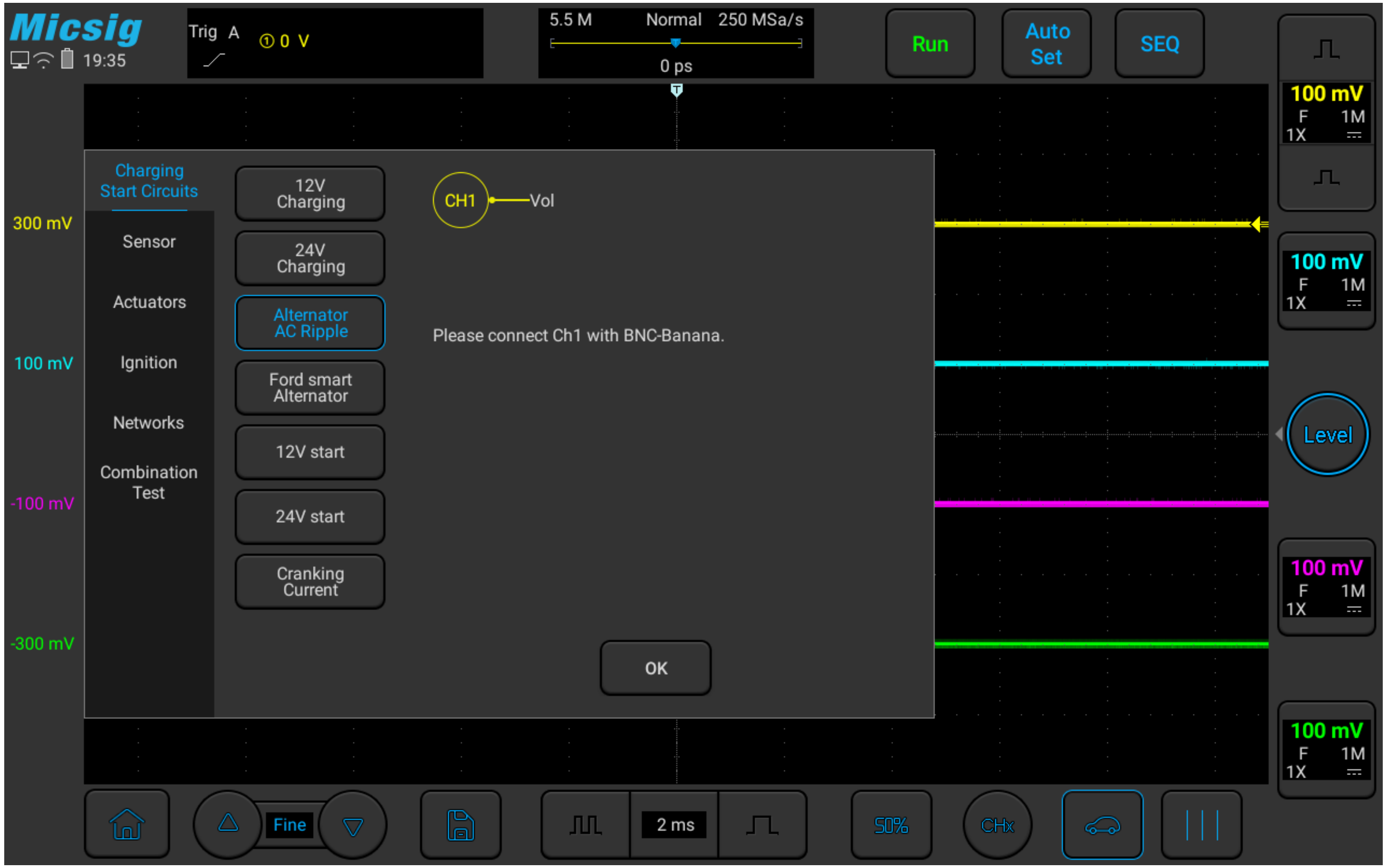


Figure 3-4 Charging Ripple

3.1.4 Ford Focus Smart Generator

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

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

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

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

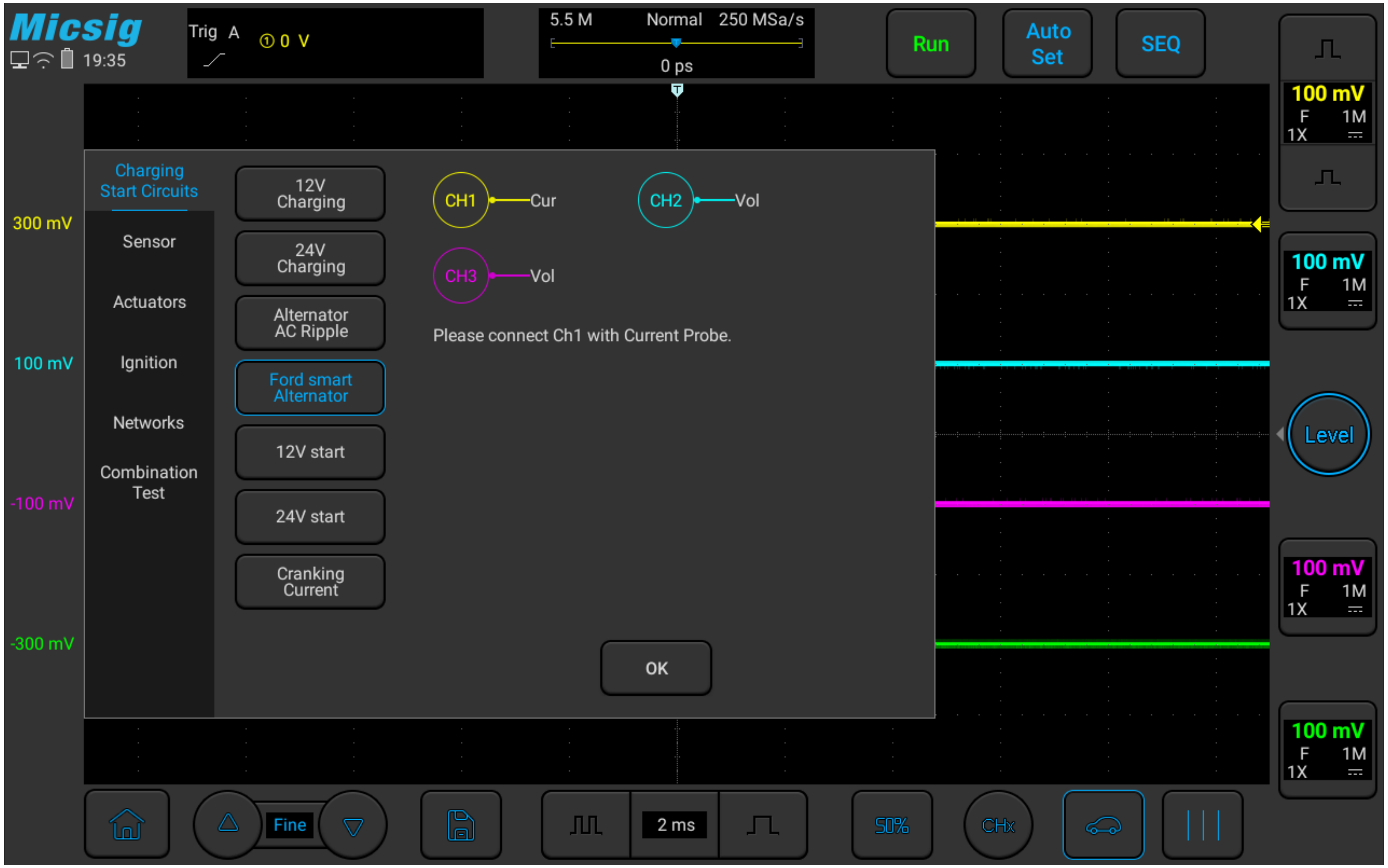


Figure 3-5 Ford Focus Smart Generator

3.1.5 12V Start

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

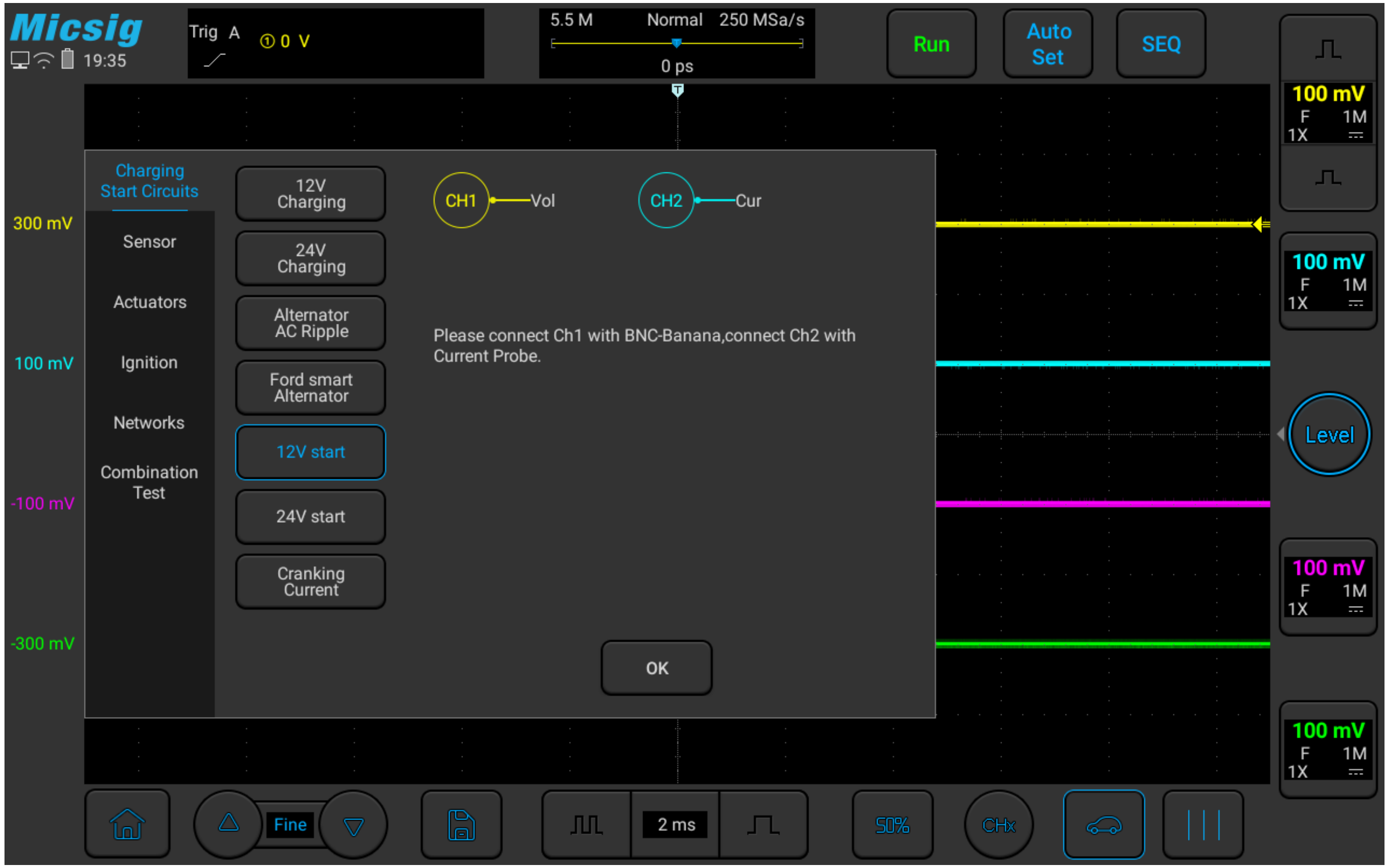


Figure 3-6 12V Start

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

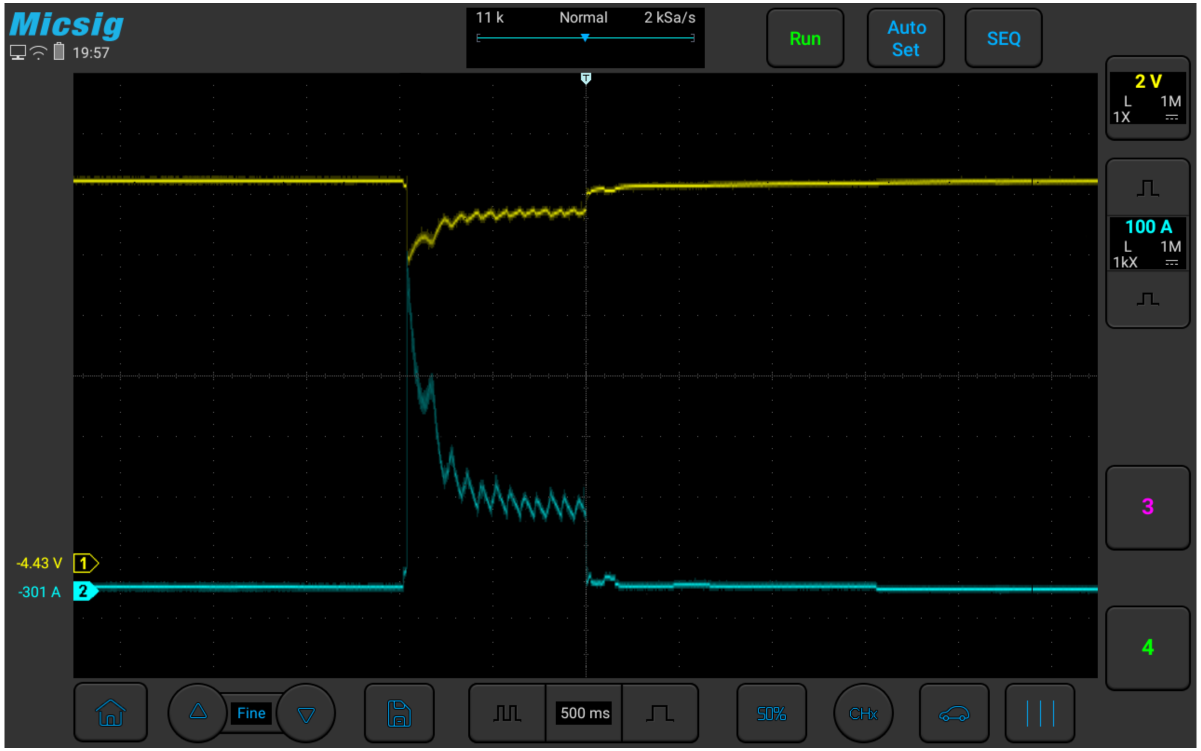


Figure 3-7 Starting voltage and current

3.1.6 24V Start

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

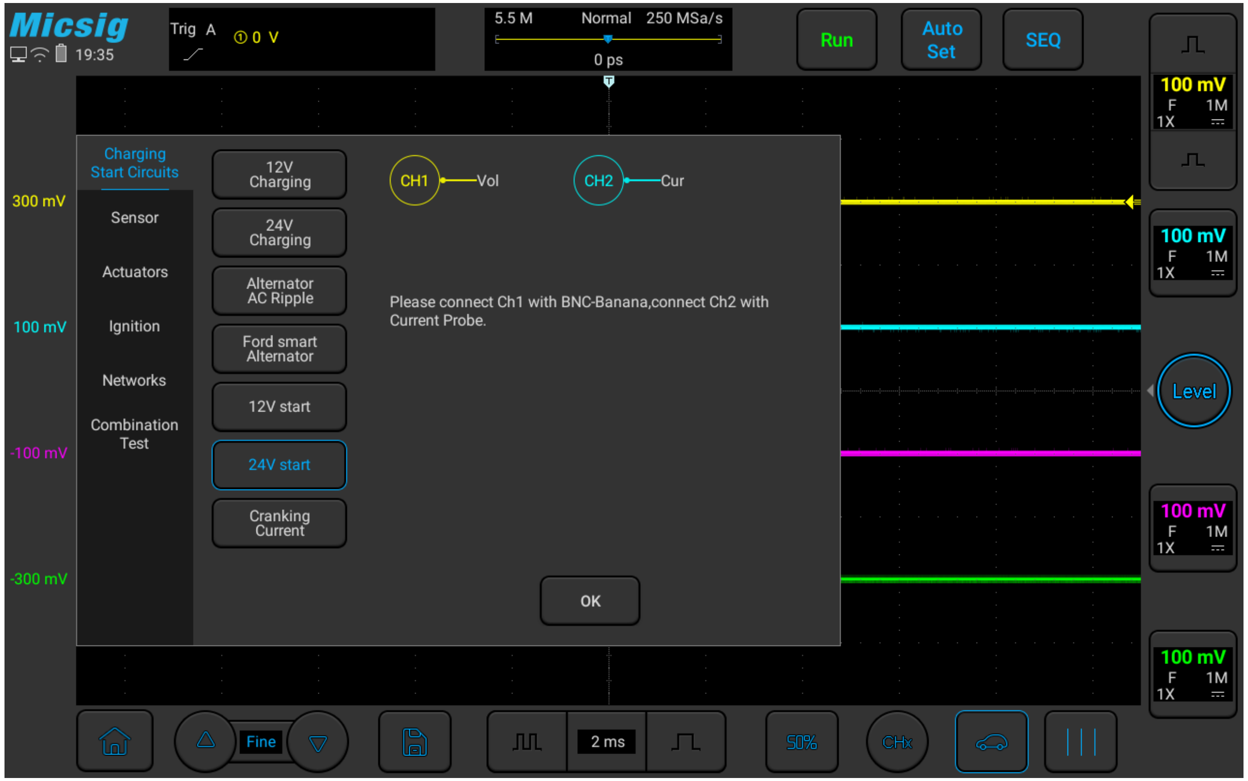


Figure 3-8 24V Start

3.1.7 Cranking Current

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

The specific operation is shown in Figure 3-9:

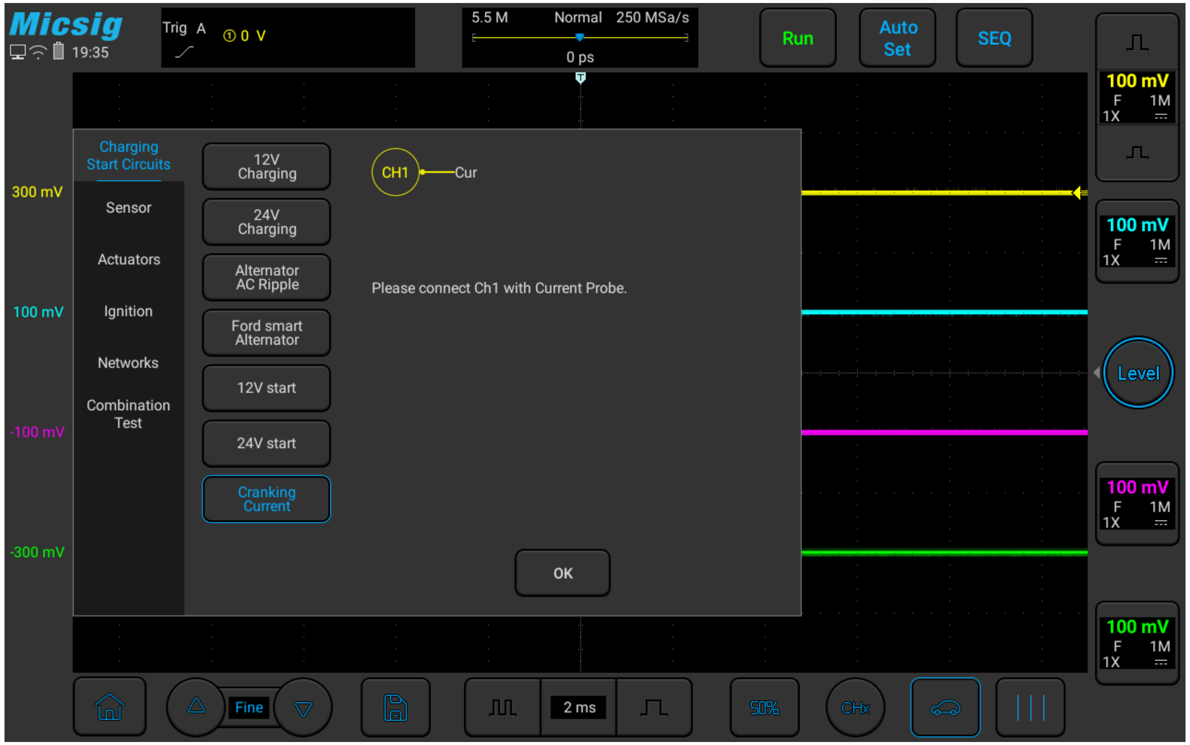


Figure 3-9 Cranking Current

3. 2 Sensor Tests

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

With the continuous development of cars in the direction of intelligence and new energy, the number of sensors on the car body has shown a trend of sharp increase, and there are nearly 100 sensors on the mid-to-high-end cars of the company. The ATO series special oscilloscope can directly measure the signal waveform of the sensor. By comparing with the standard waveform during normal operation, it is easy to find whether the sensor is normal. The

ATO series oscilloscope can test the following types of sensors. The purpose is to compare the real-time waveforms with the standard waveforms to help users find problems. The following are expanded and explained separately:

3.2.1 ABS

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

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

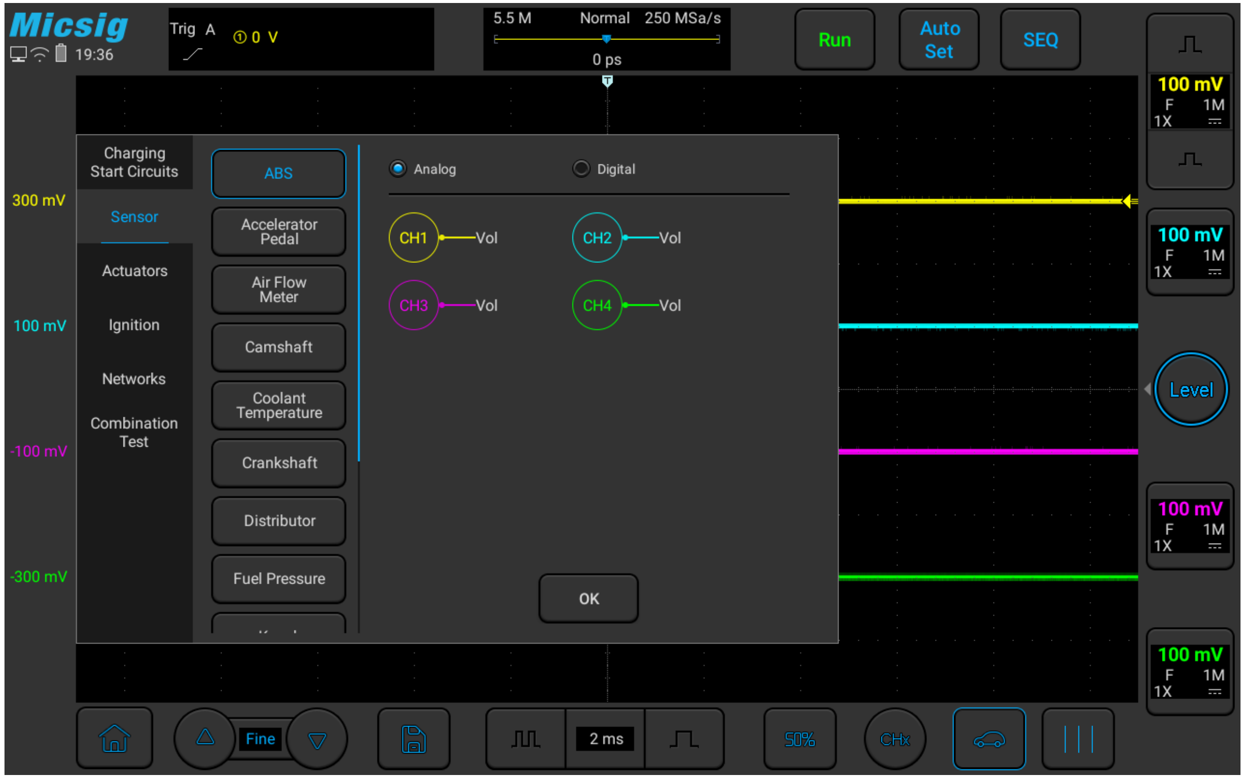


Figure 3-10 ABS Wheel Speed Sensor

3.2.2 Accelerator pedal

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

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

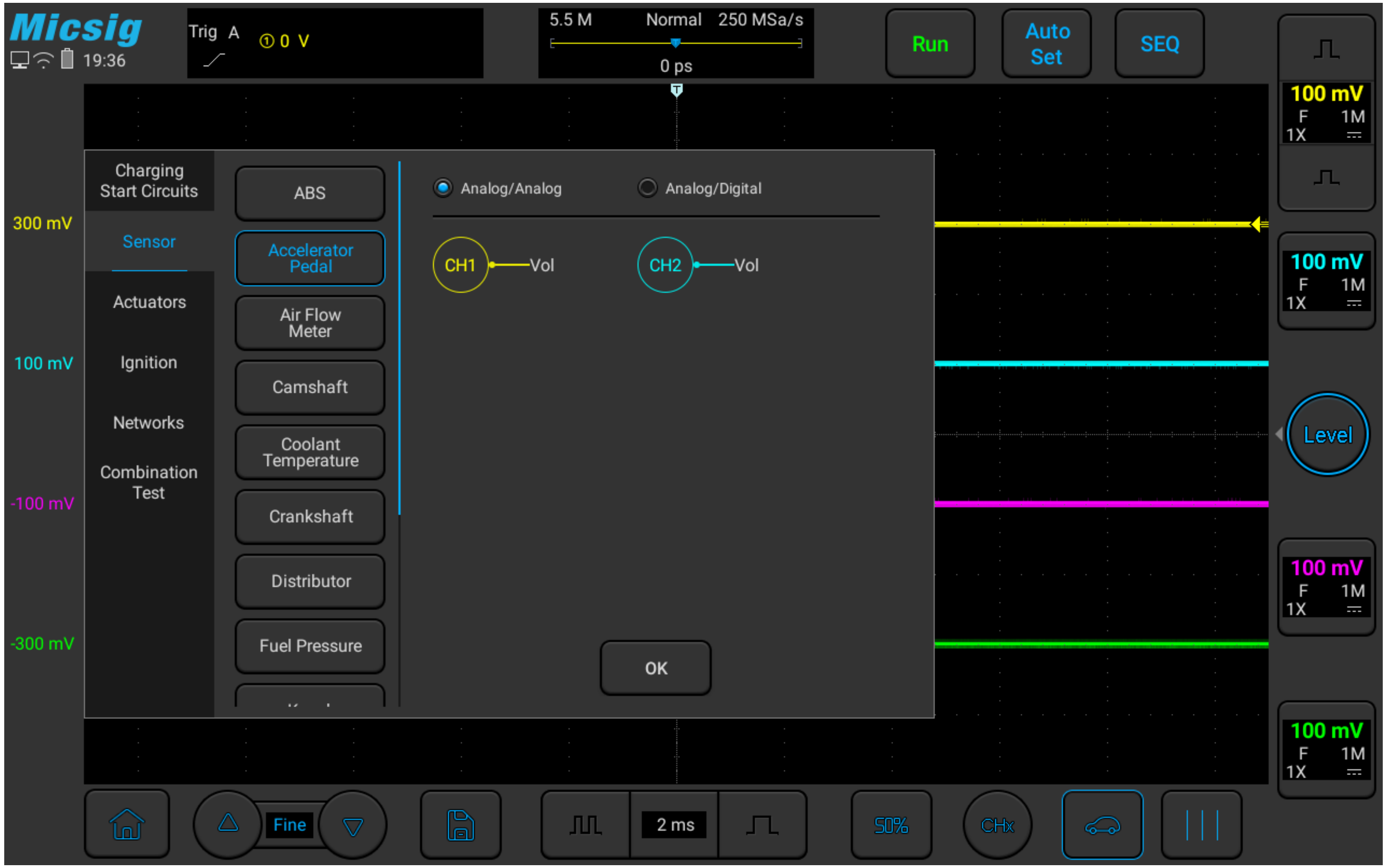


Figure 3-11 Accelerator Pedal

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

3.2.3 Air Flow Meter

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

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

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

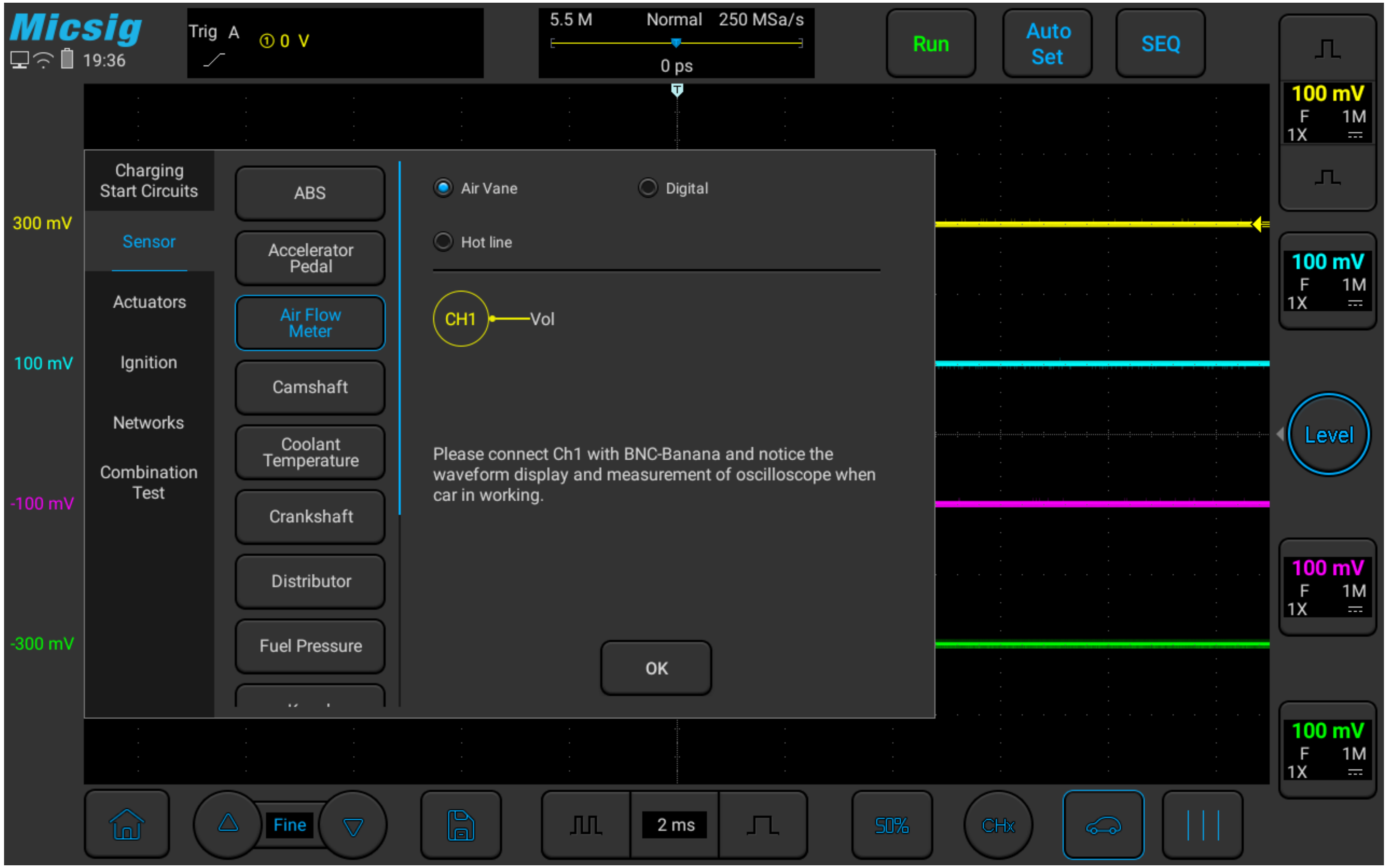


Figure 3-12 Air flow meter

3.2.4 Camshaft

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

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

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

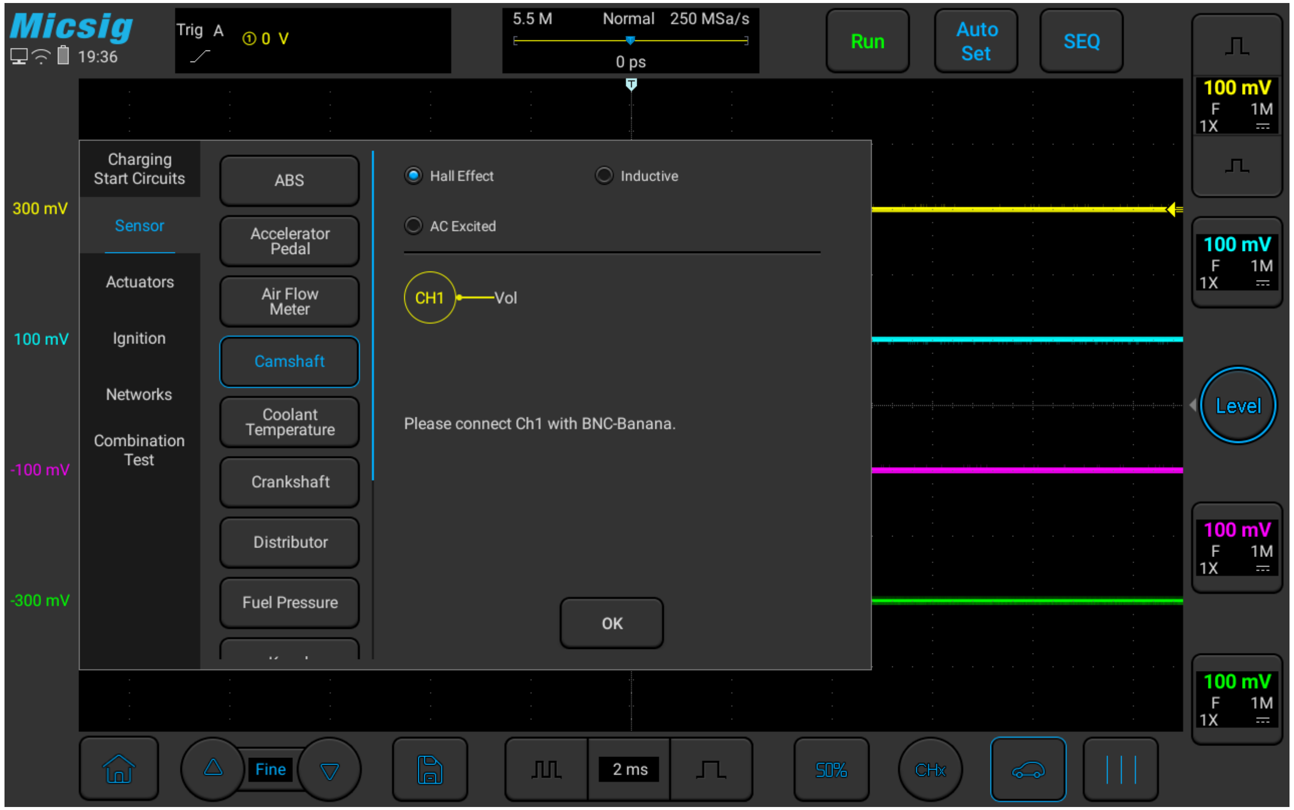


Figure 3-13 Camshaft

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

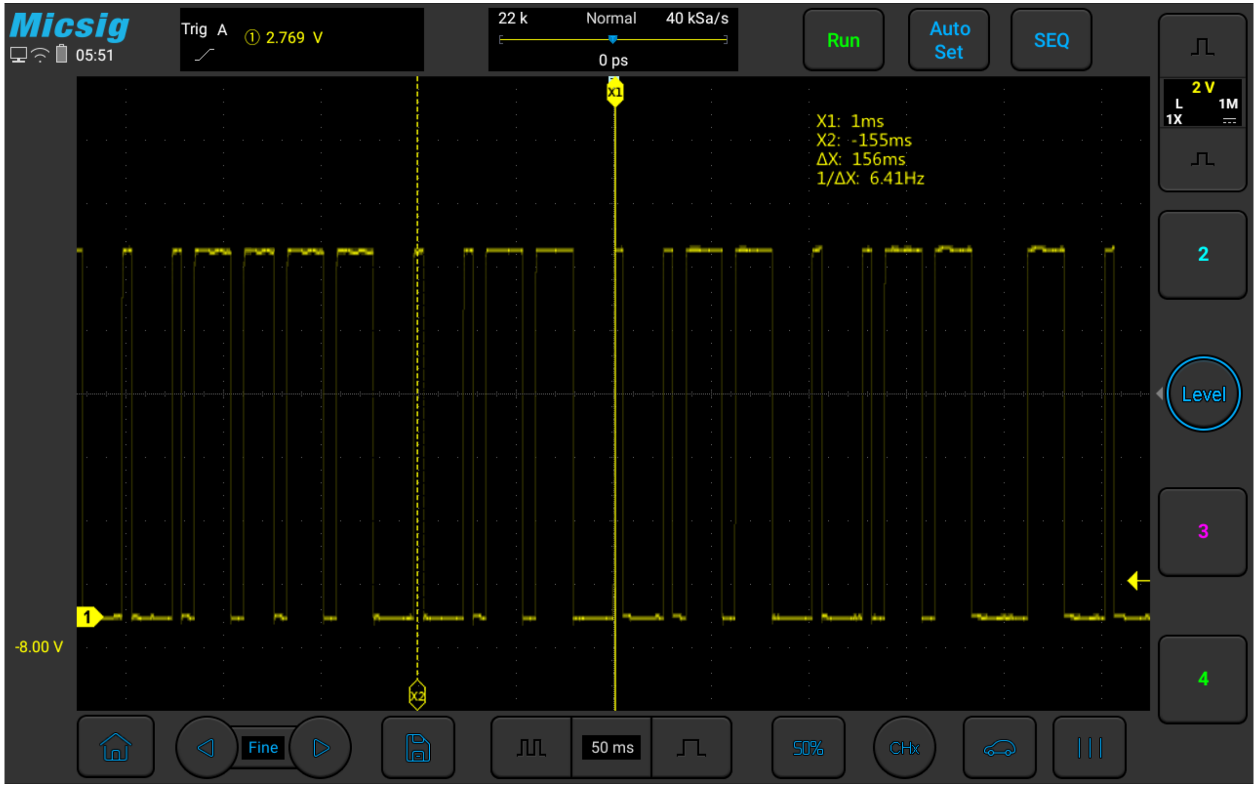


Figure 3-14 Camshaft position sensor (Hall type)

3.2.5 Coolant Temperature

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

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

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

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

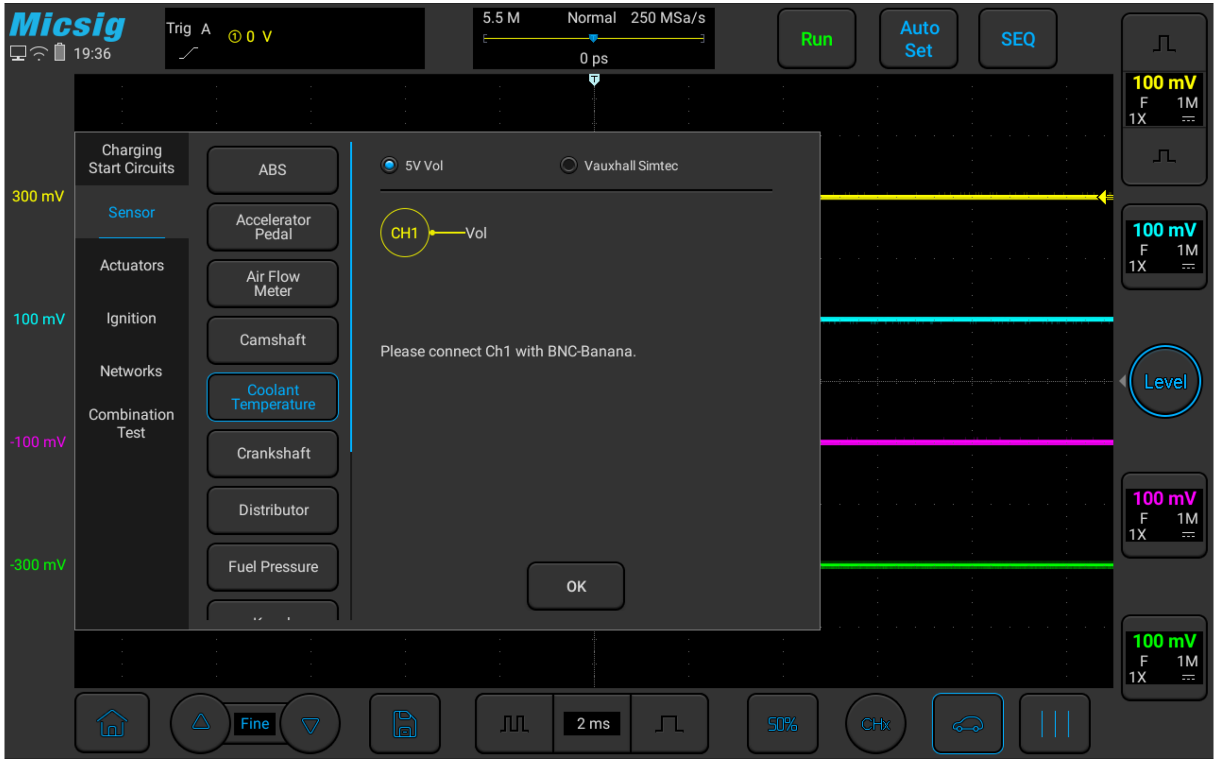


Figure 3-15 Coolant Temperature

3.2.6 Crankshaft

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

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

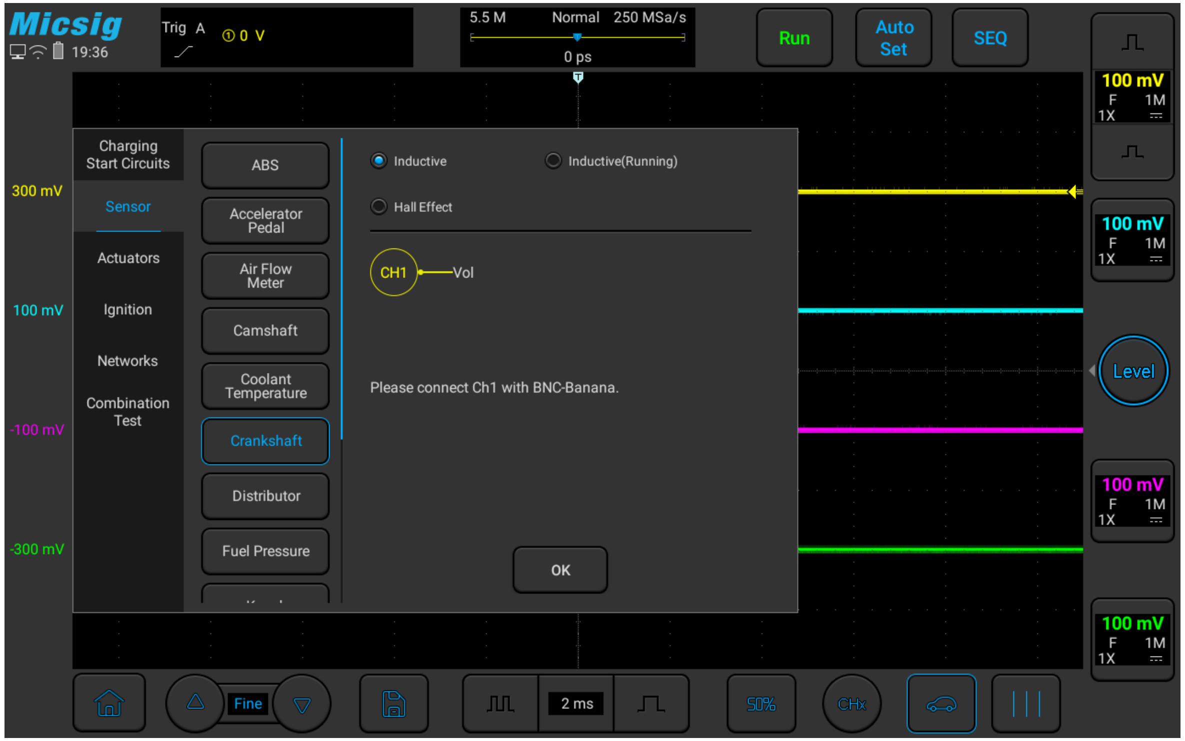
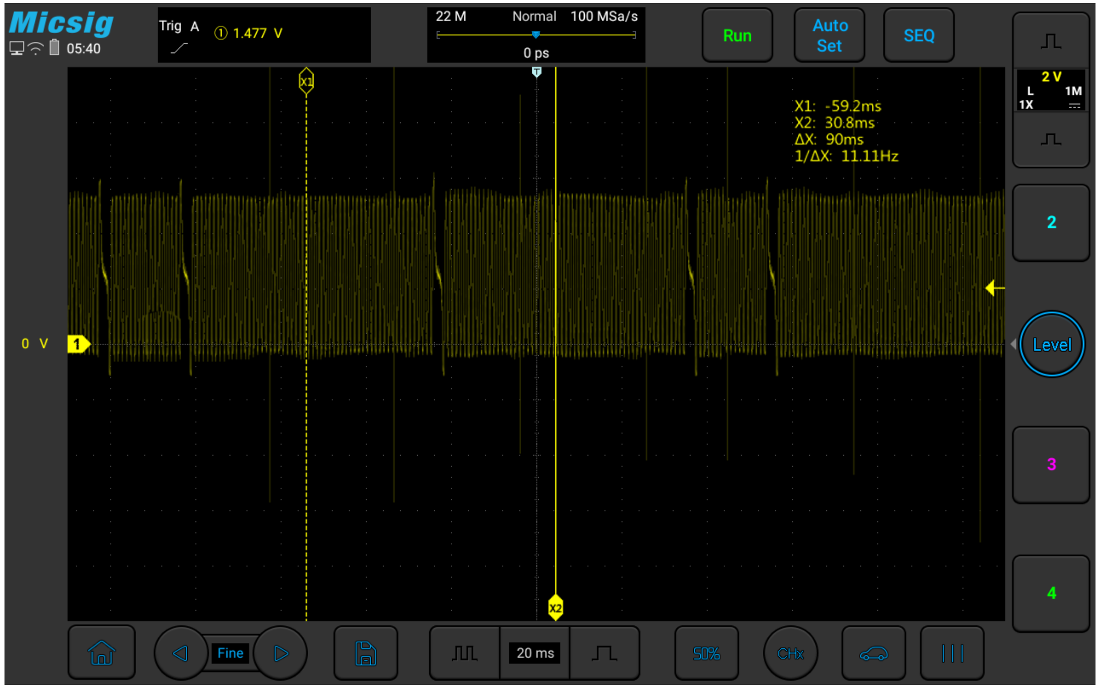


Figure 3-16 Crankshaft position sensor

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



3.2.7 Distributor

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

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

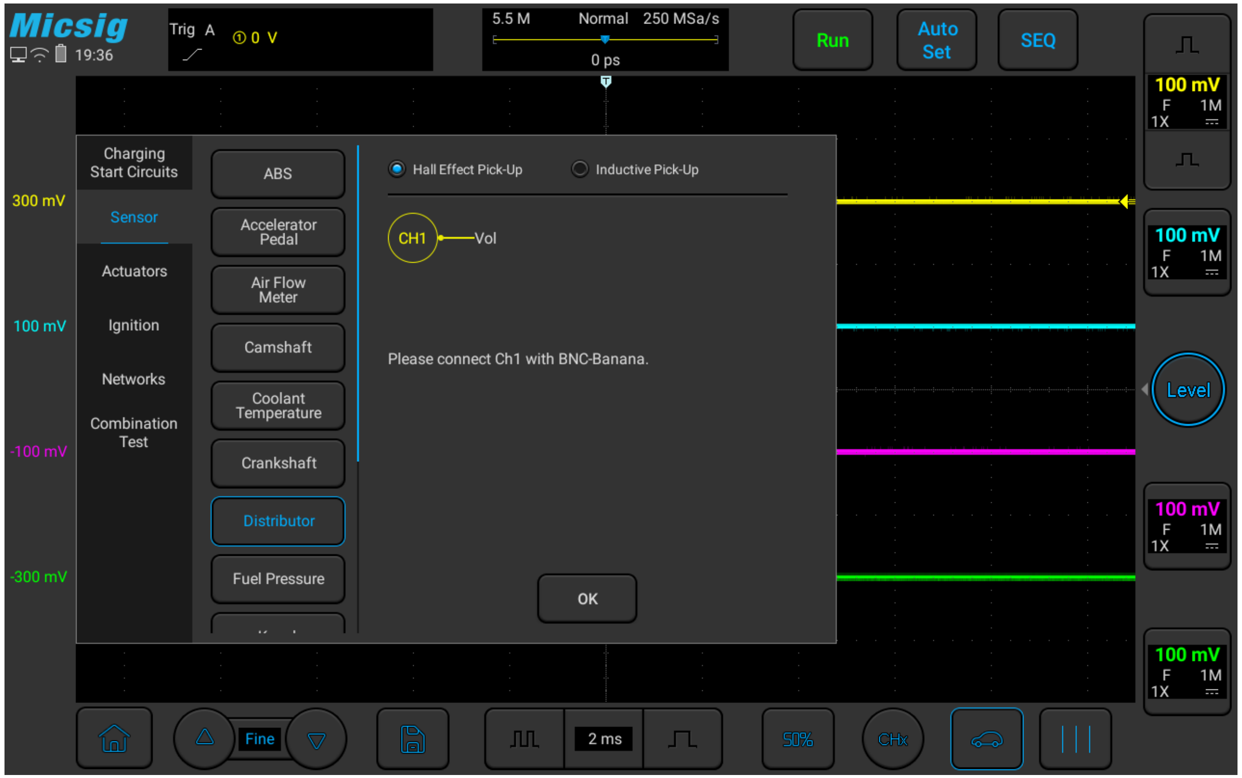


Figure 3-17 Distributor

3.2.8 Fuel pressure

Fuel pressure signals generally appear on high-pressure fuel rails or sensors or common rail diesel vehicles, and the pressure is relatively high. Generally, the fuel pressure is proportional to the output voltage, and the voltage increases with the angle of the accelerator pedal (no-load and full-load will affect the voltage rise time).
Use a BNC to banana cable, connect one end to channel 1 of the oscilloscope, the other end of the black plug is grounded, and the red connector uses a needle to connect the signal line of fuel pressure.

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

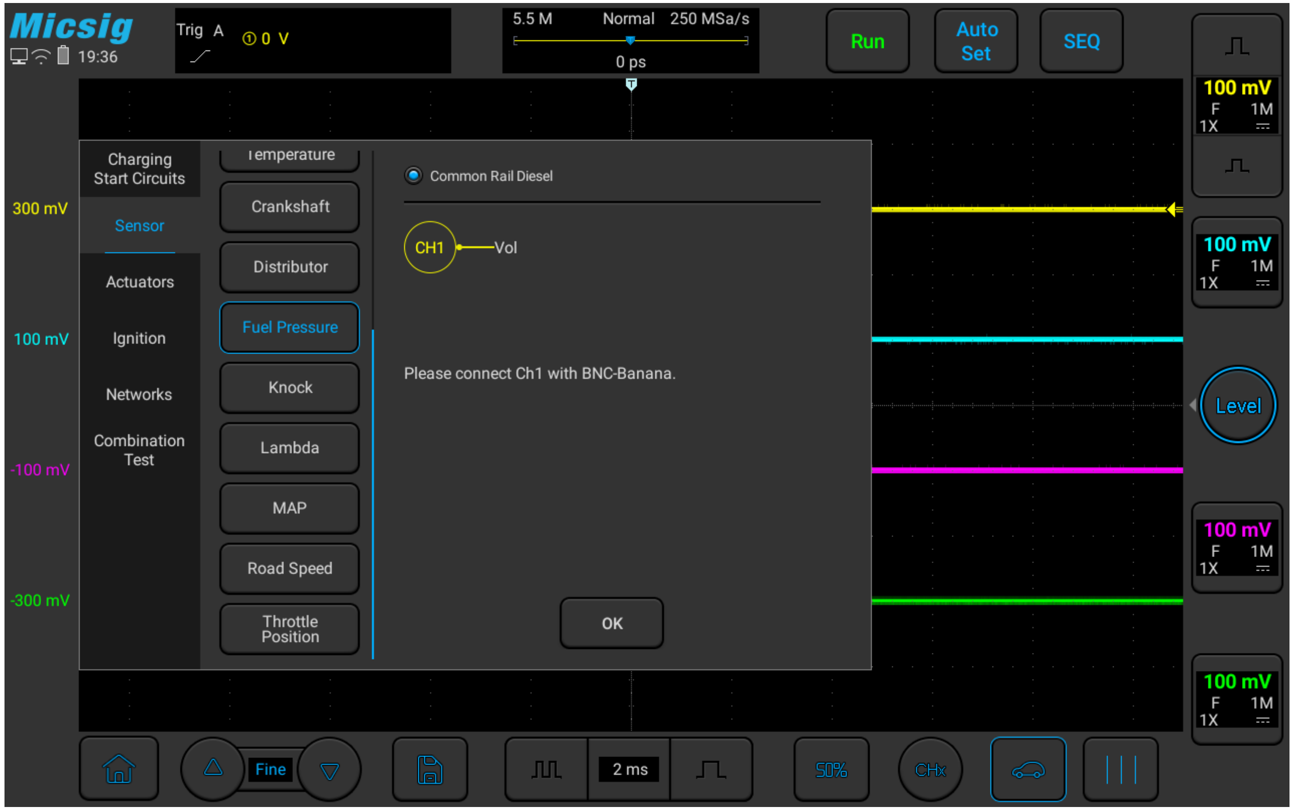


Figure 3-18 Fuel Pressure Sensor Test

3.2.9 Knock

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

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

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

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

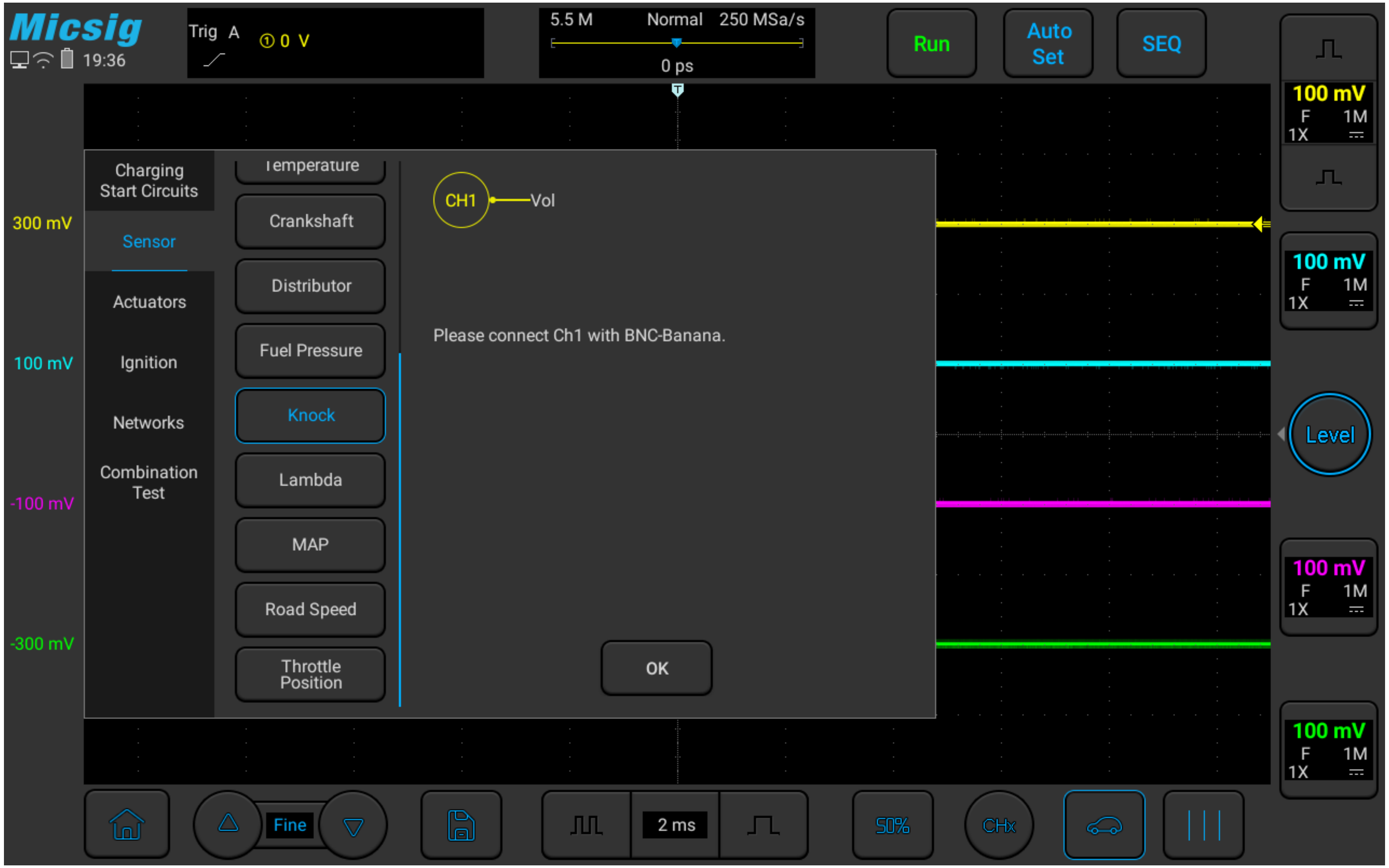
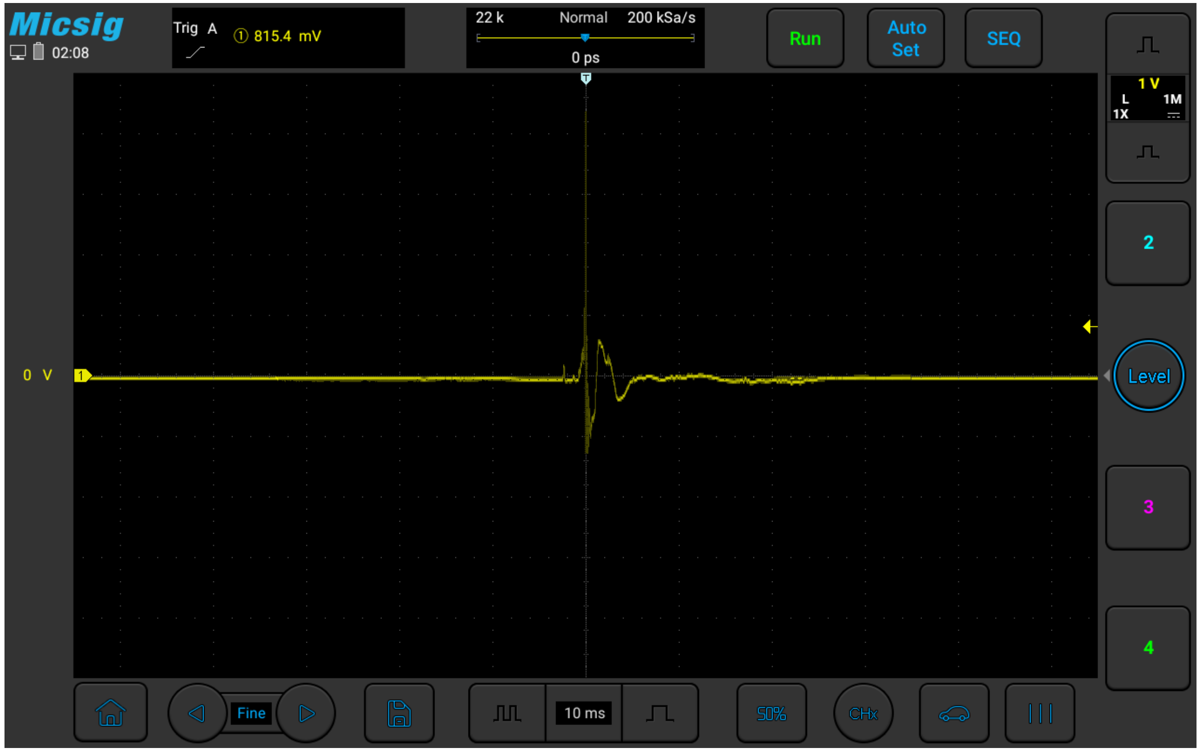


Figure 3-19 Knock Sensor test

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



3.2.10 Lambda

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

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

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

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

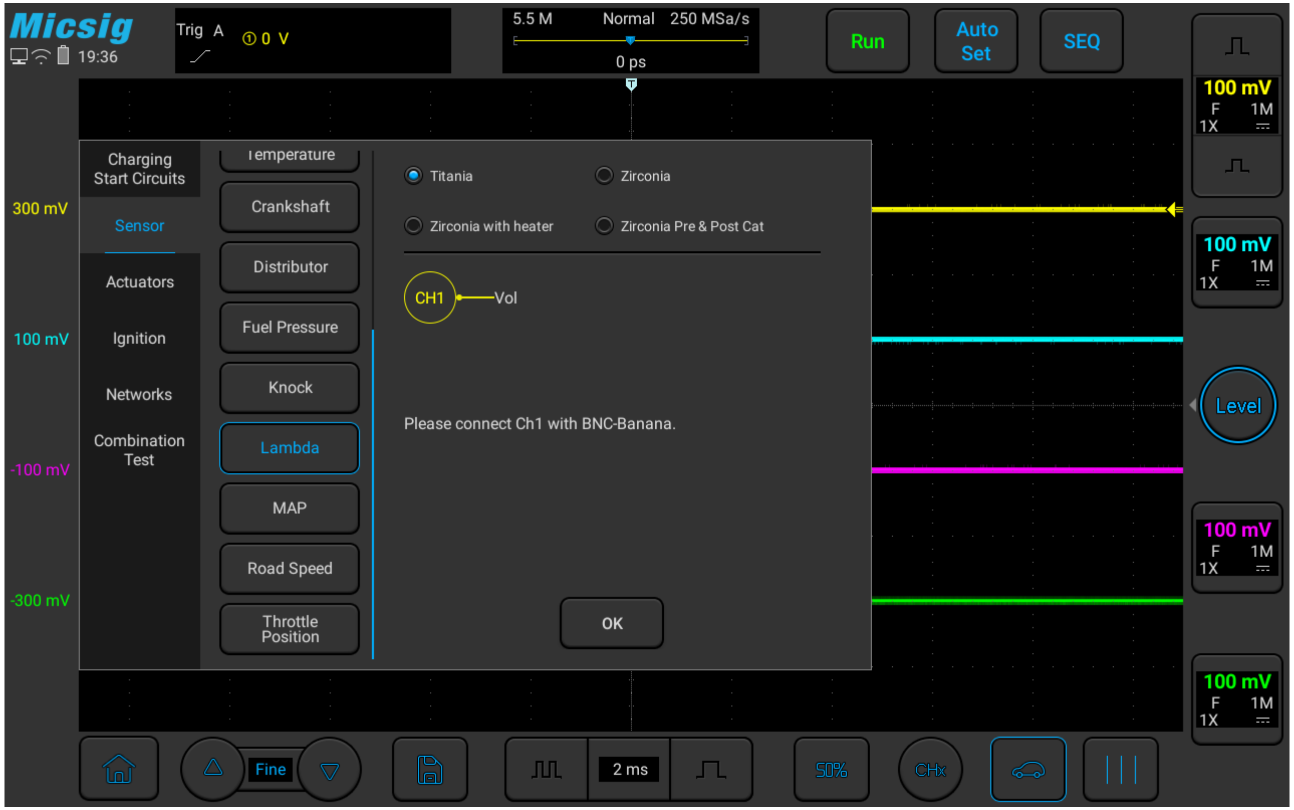


Figure 3-20 Lambda (oxygen sensor) test

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

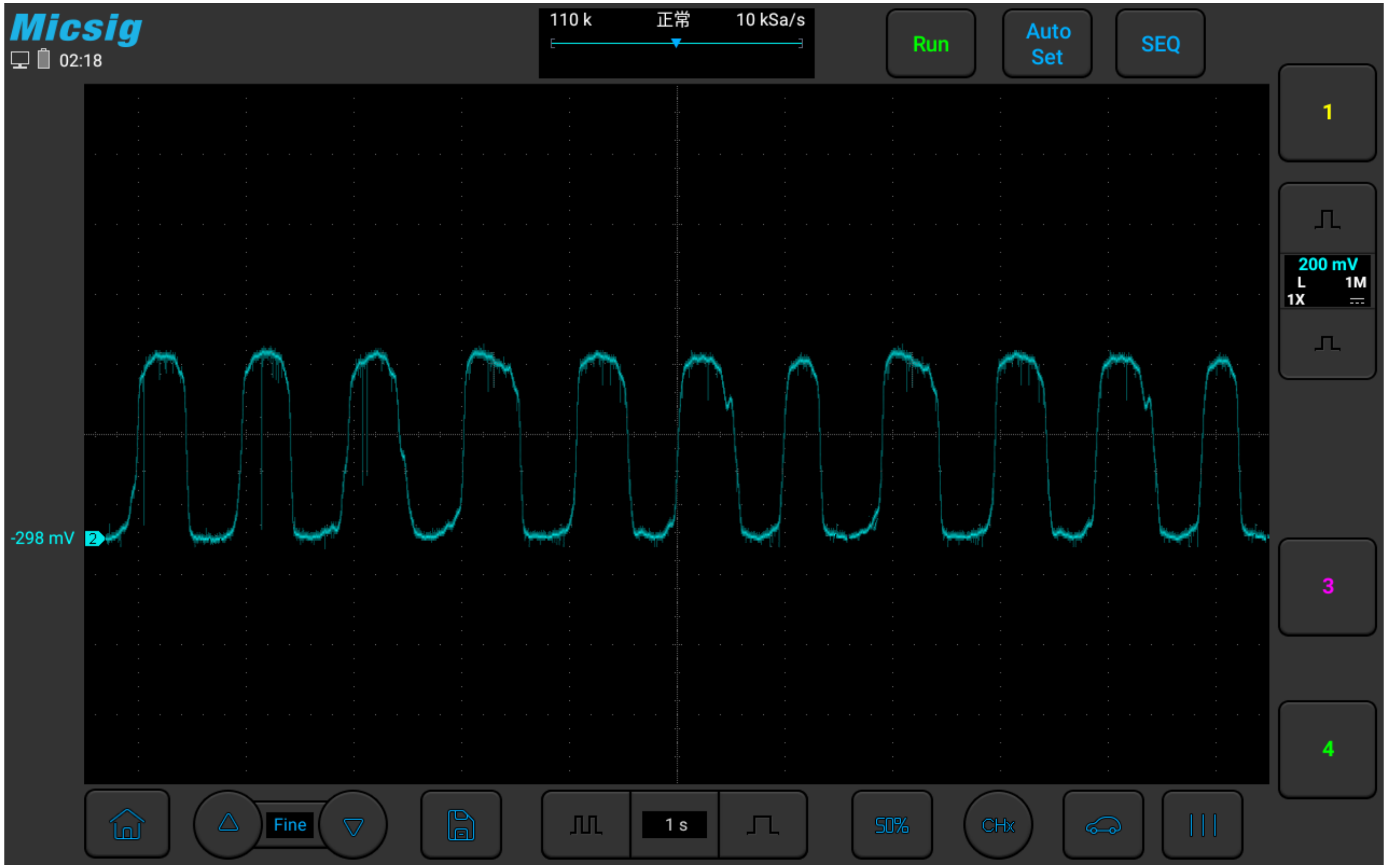


Figure 3-21 Lambda (Oxygen Sensor) diagram

3.2.11 MAP

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

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

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

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

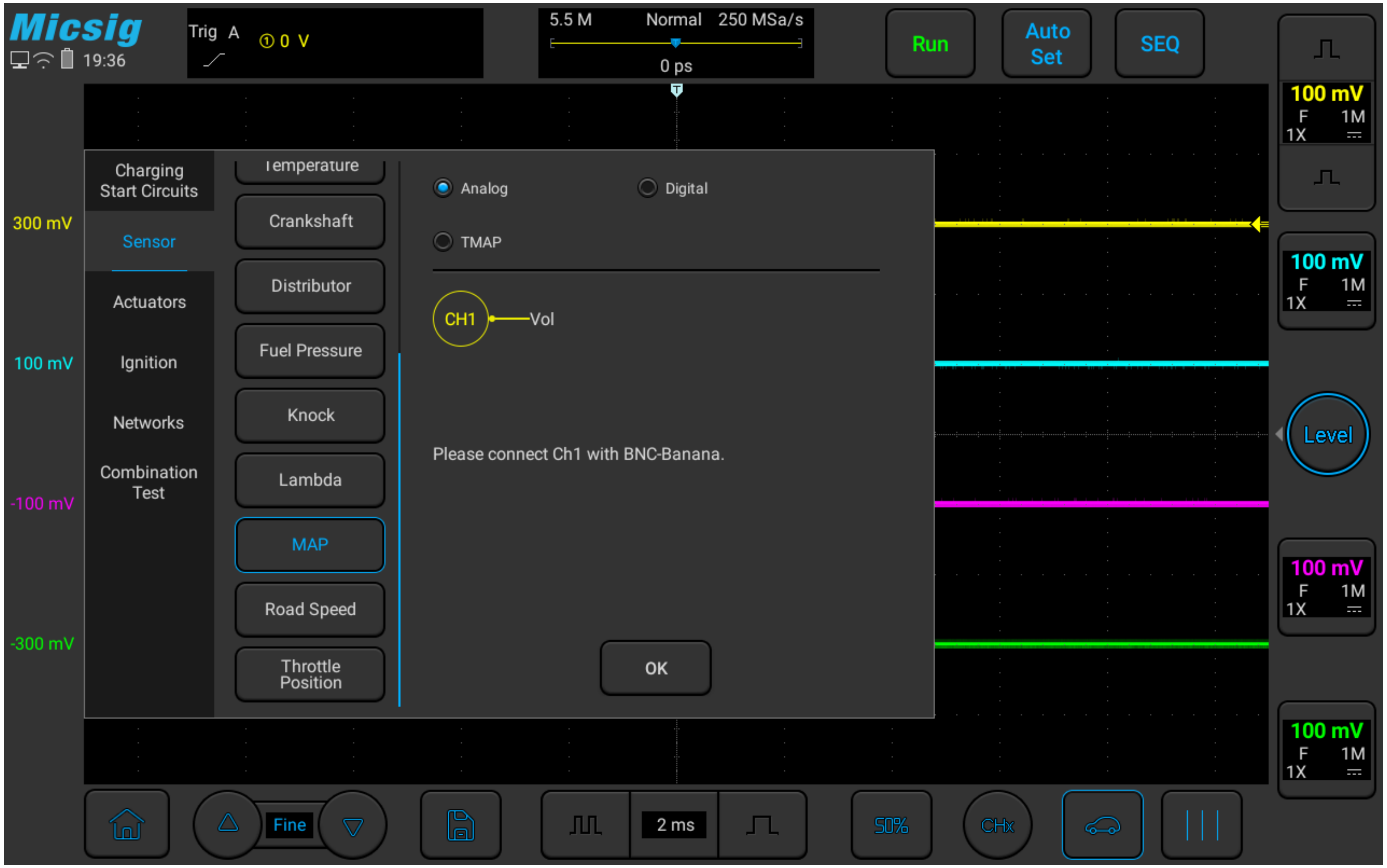


Figure 3-22 MAP (intake pressure sensor)

3.2.12 Road Speed

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

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

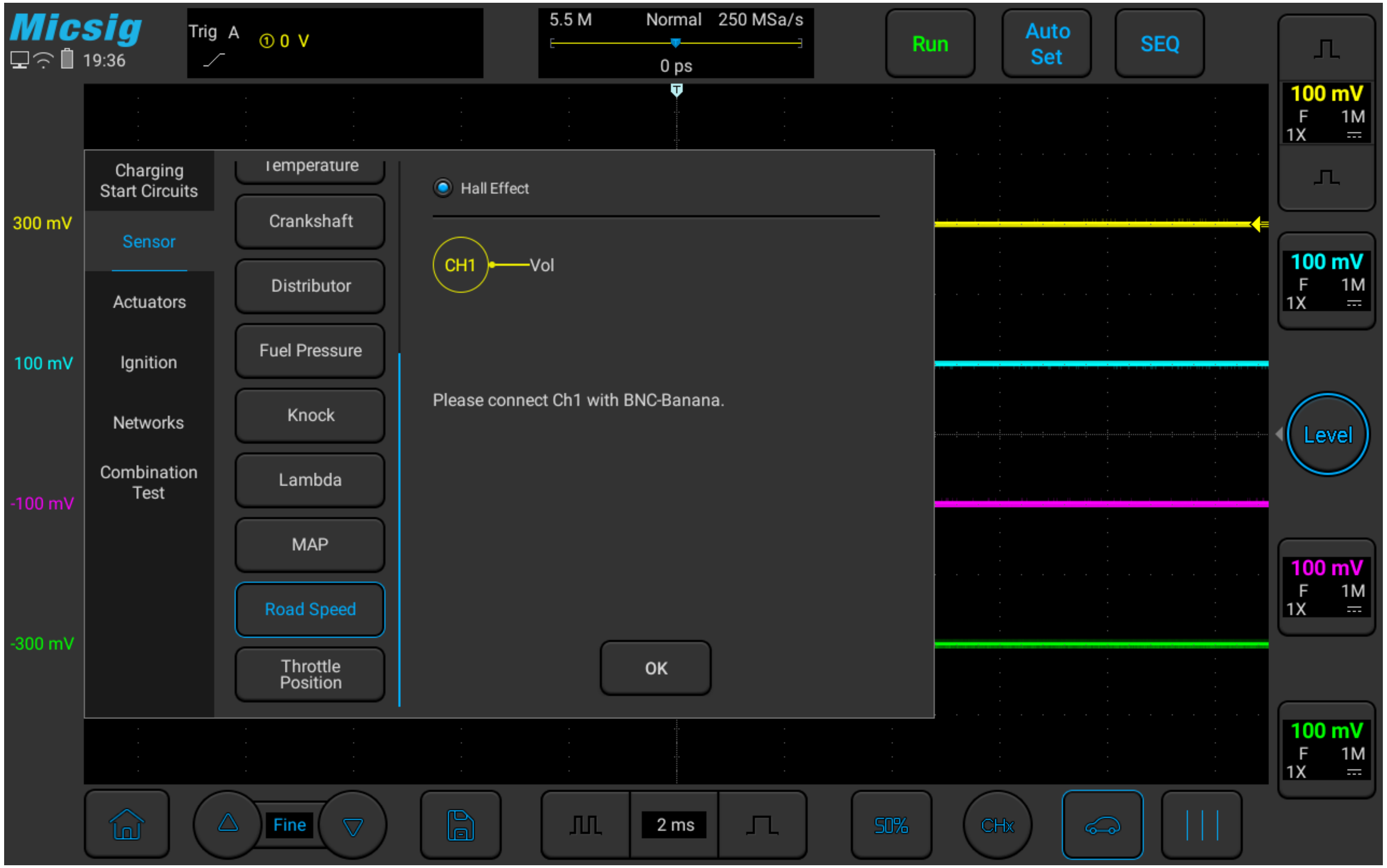


Figure 3-23 Vehicle speed sensor test

3.2.13 Throttle Position

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

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

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

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

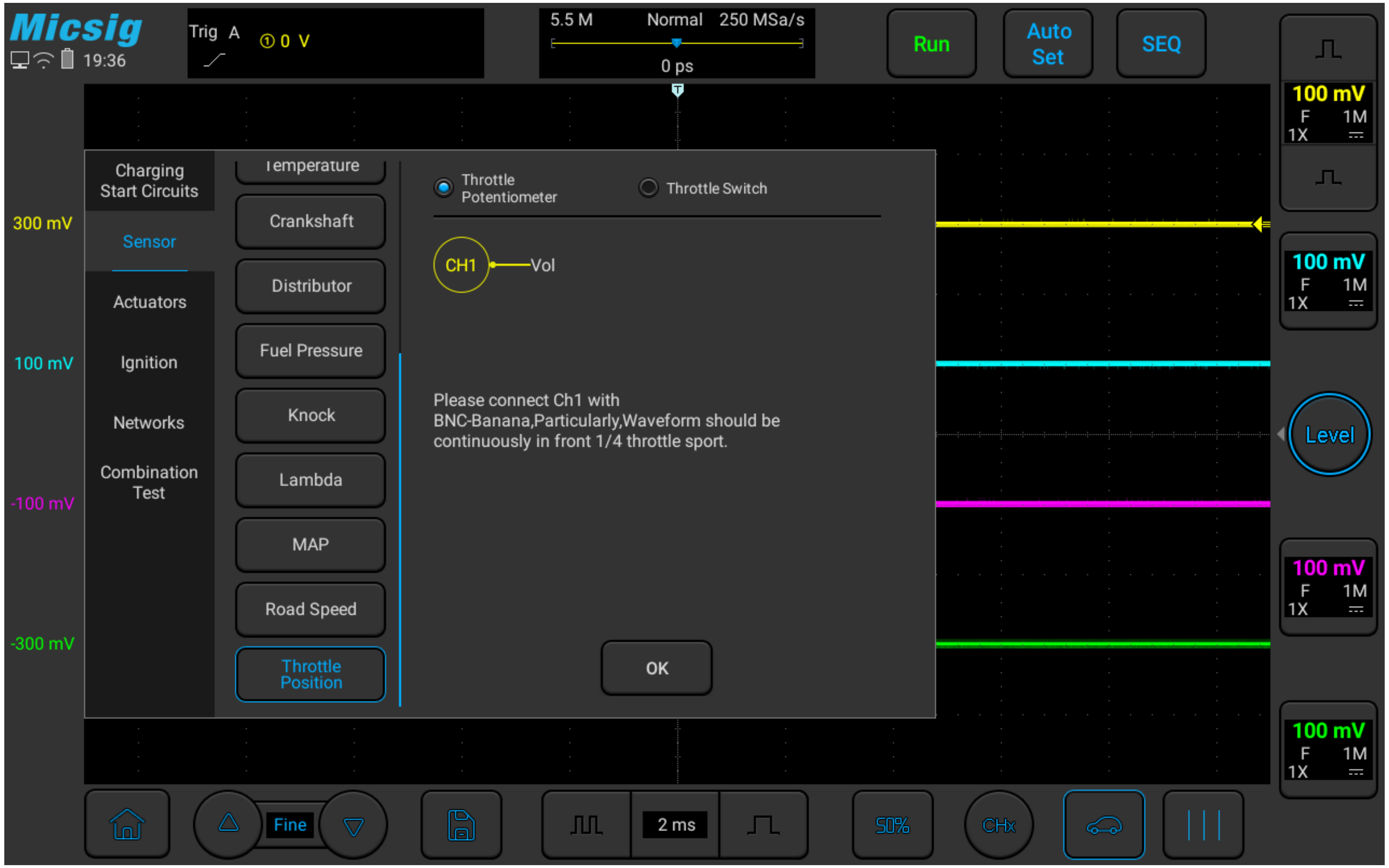


Figure 3-24 Throttle Position Sensor test

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

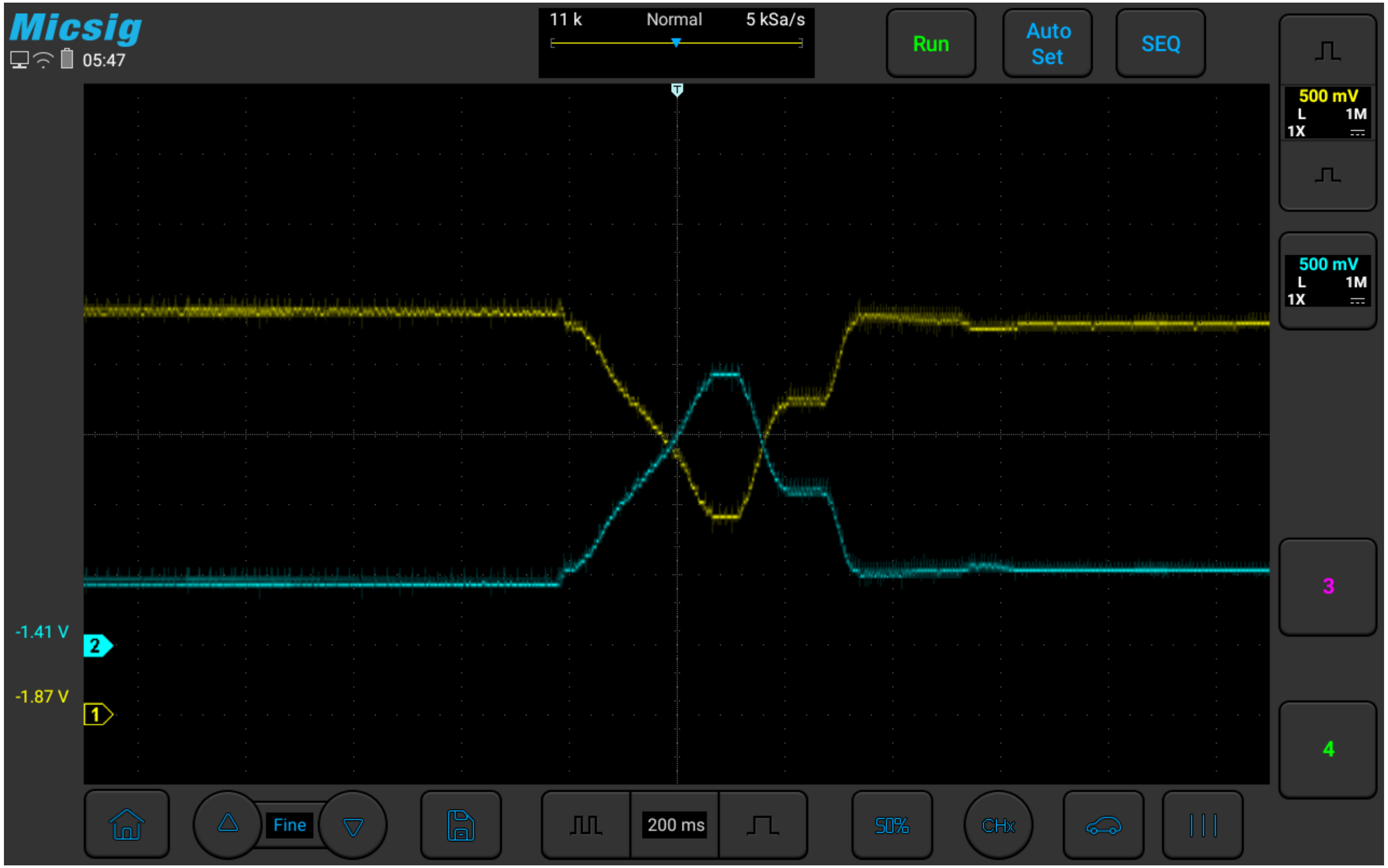


Figure 3-25 Throttle Position Sensor Diagram

3.3 Actuators

3.3.1 Carbon canister solenoid valve

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

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

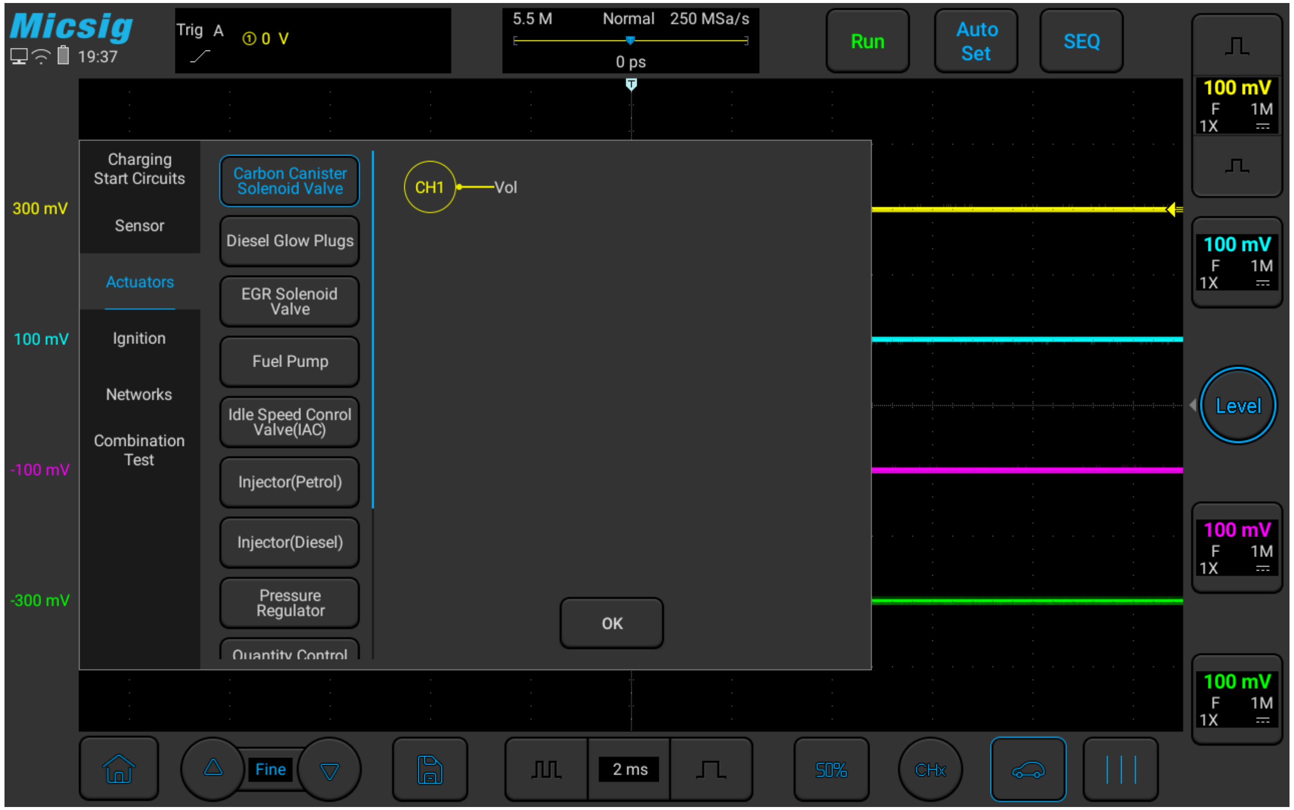


Figure 3-26 Carbon canister solenoid valve test

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

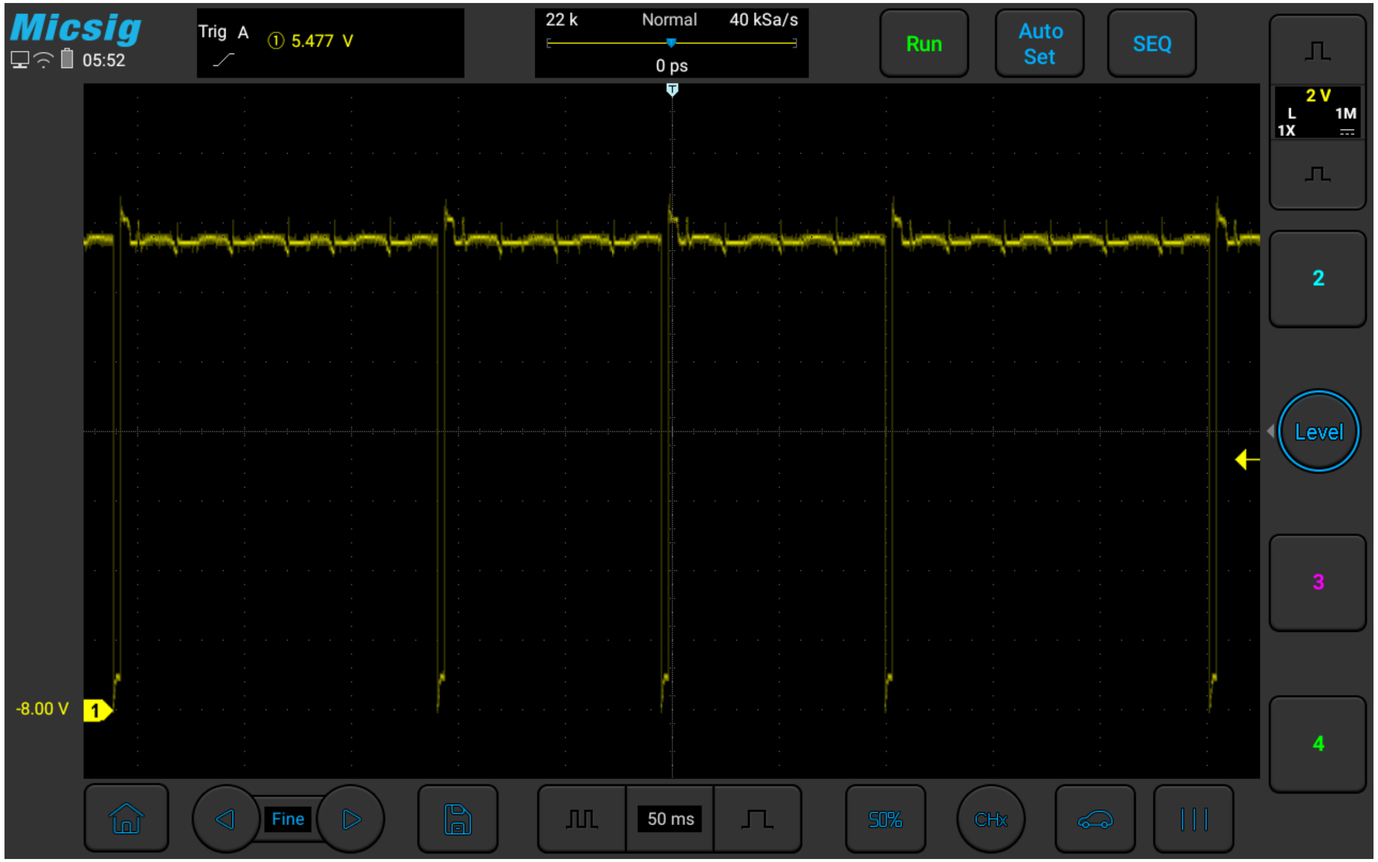


Figure 3-27 Audi A6 Carbon canister solenoid valve signal

3.3.2 Disel Glow Plugs

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

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

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

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

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

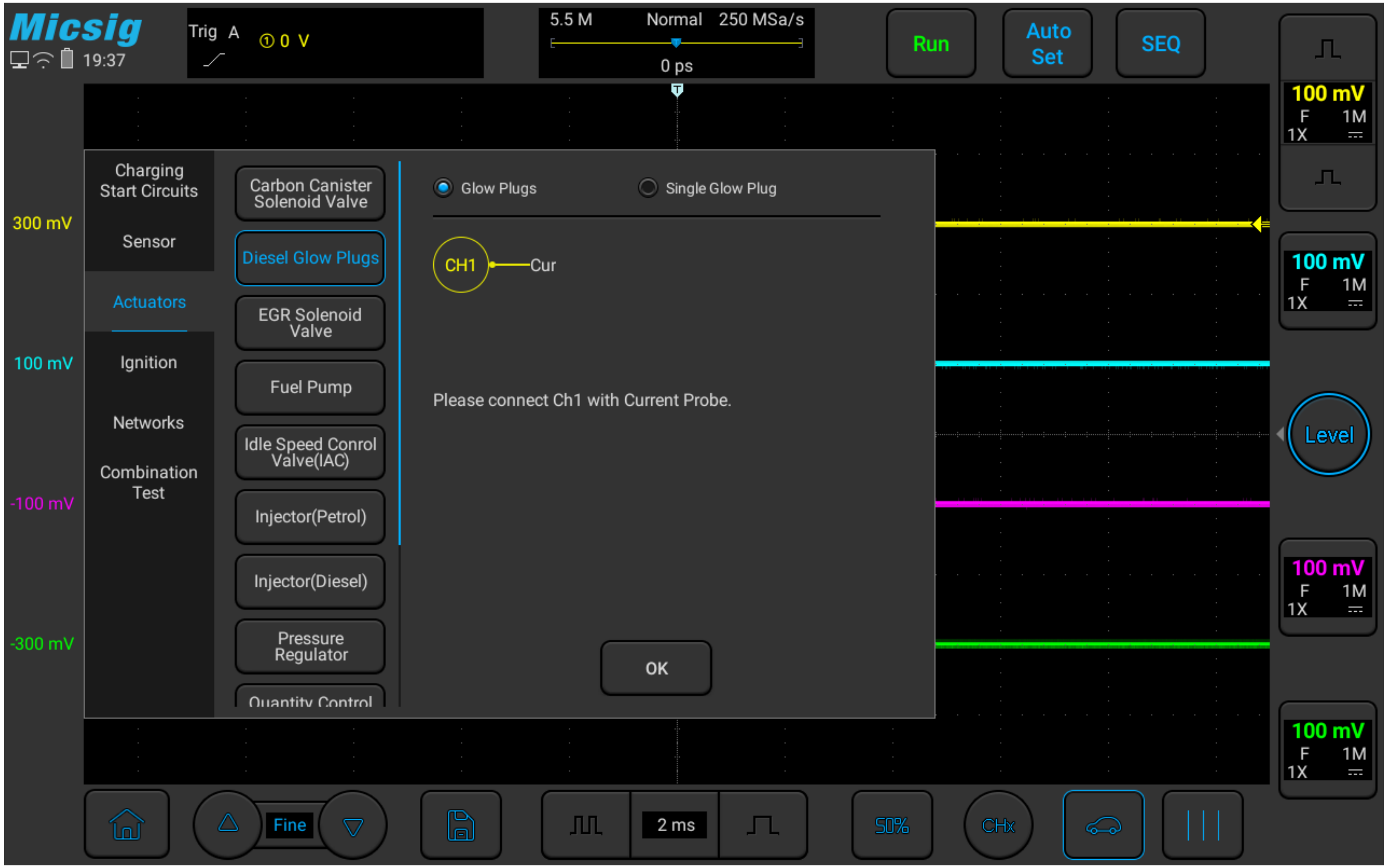


Figure 3-28 Disel Glow Plugs

3.3.3 EGR Solenoid Valve

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

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

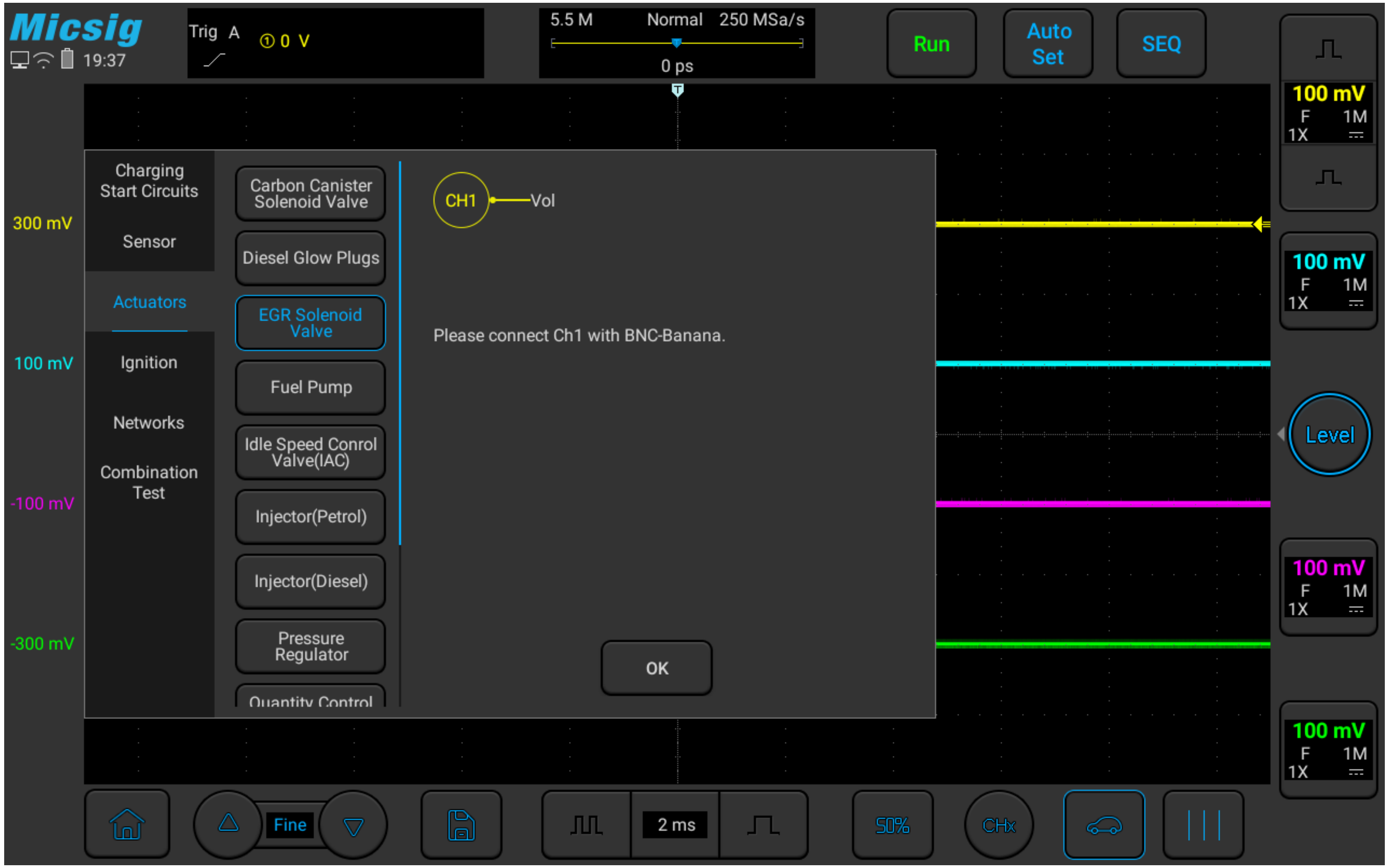


Figure 3-29 EGR solenoid valve test

3.3.4 Fuel Pump

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

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

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

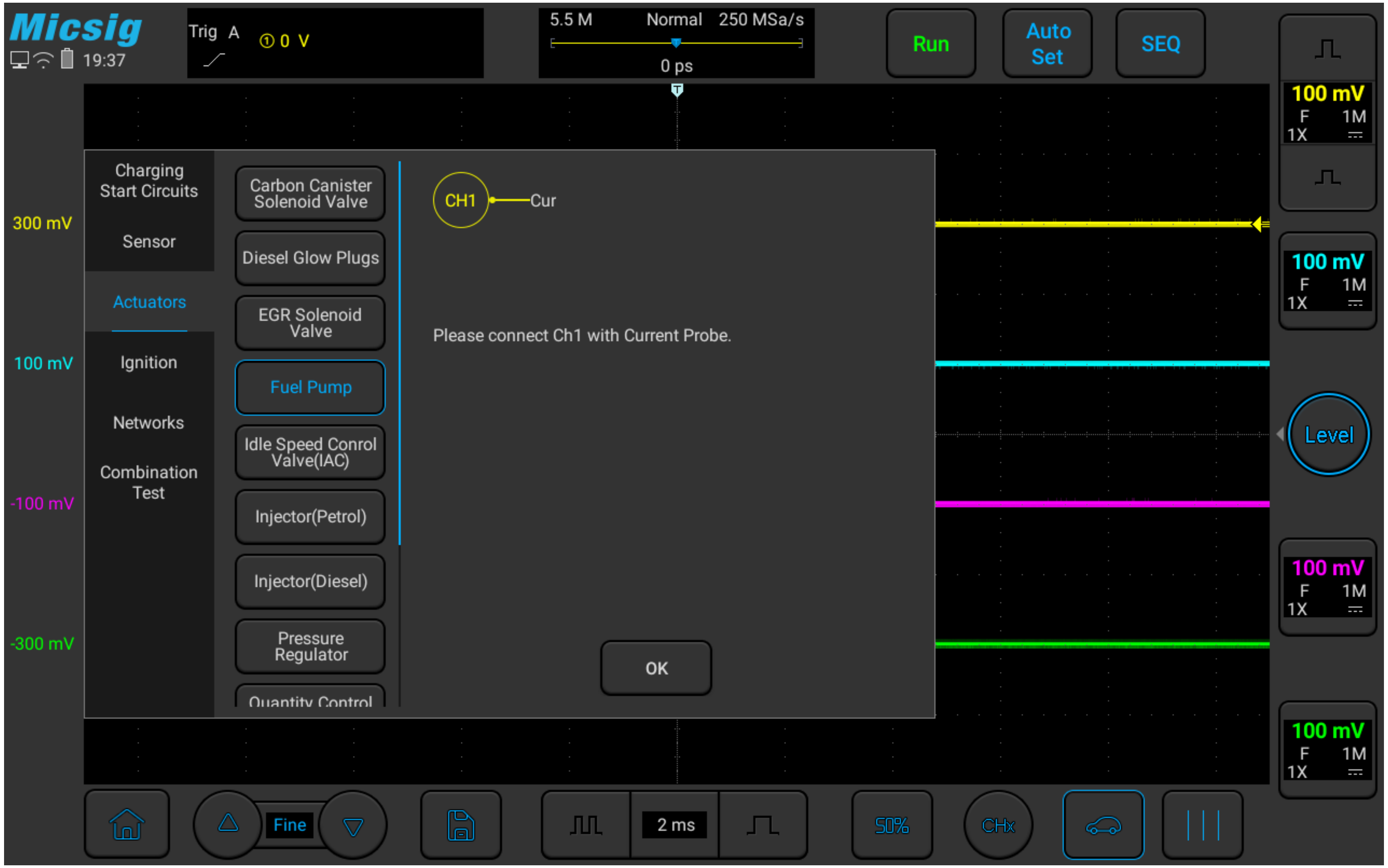


Figure 3-30 Electronic fuel pump test

3.3.5 Idle speed control valve

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

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

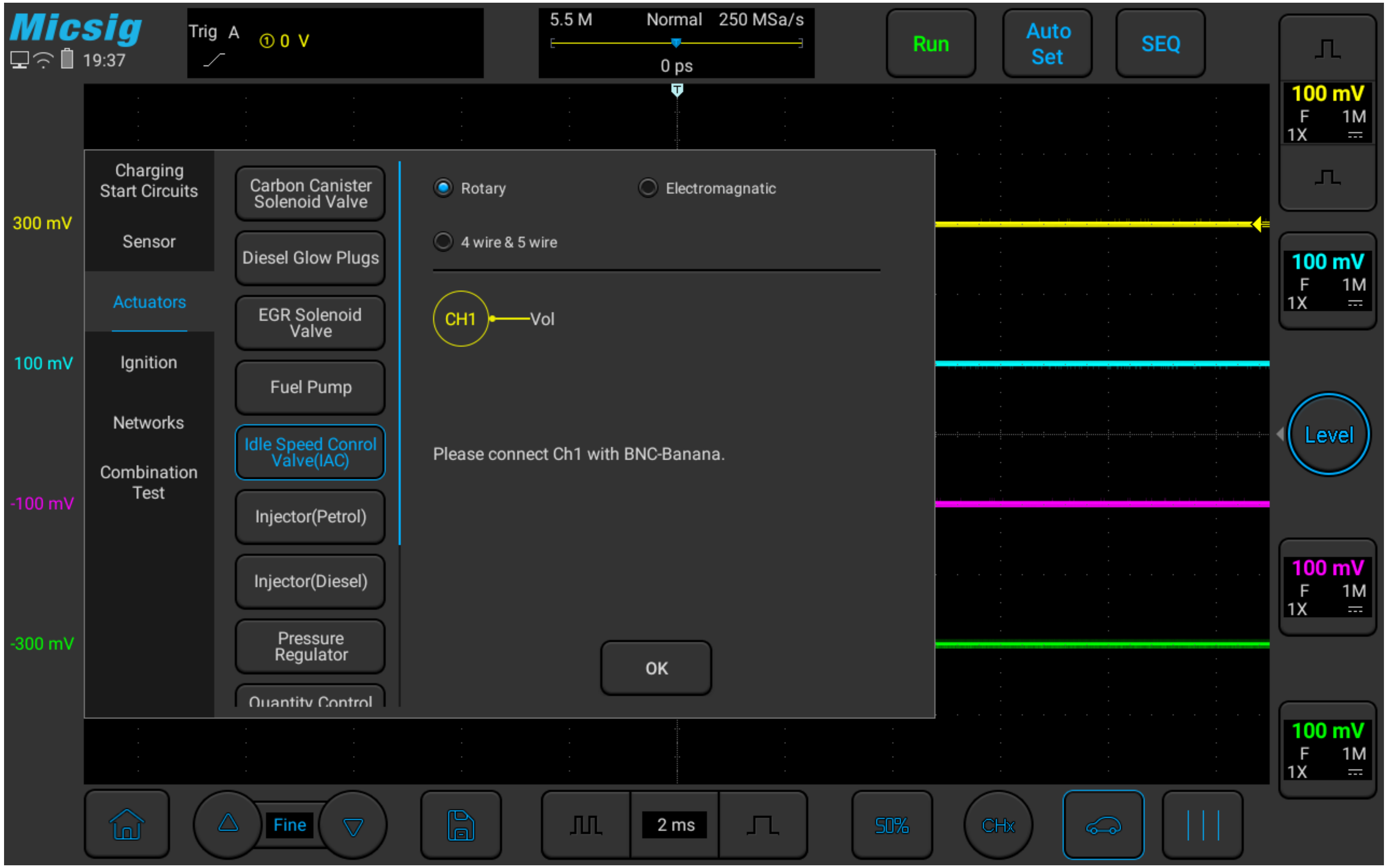


Figure 3-31 Idle speed control valve test

3.3.6 Injector (gasoline engine)

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

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

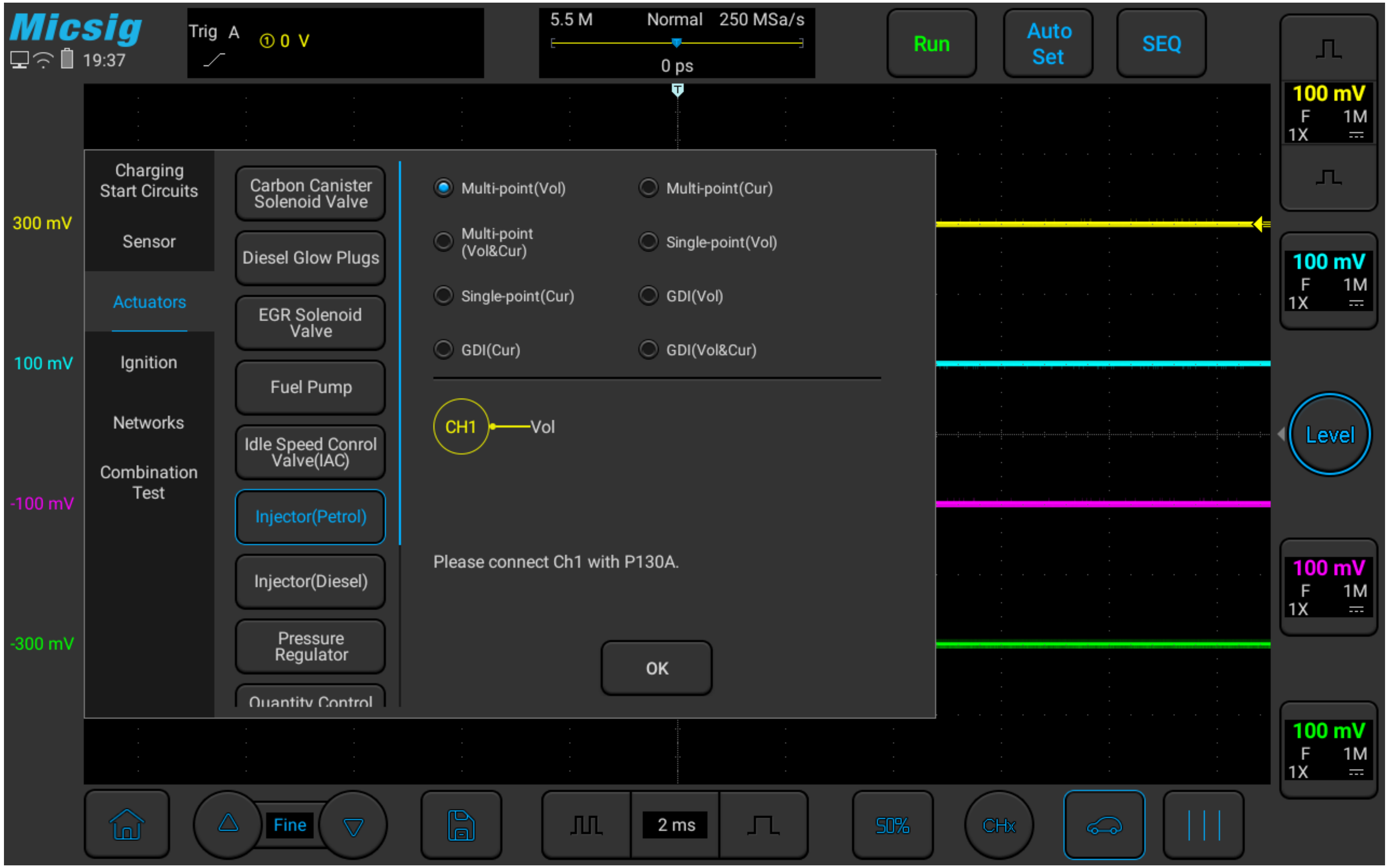


Figure 3-32 Injector (Petrol) Test

3.3.7 Injector (Diesel)

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

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

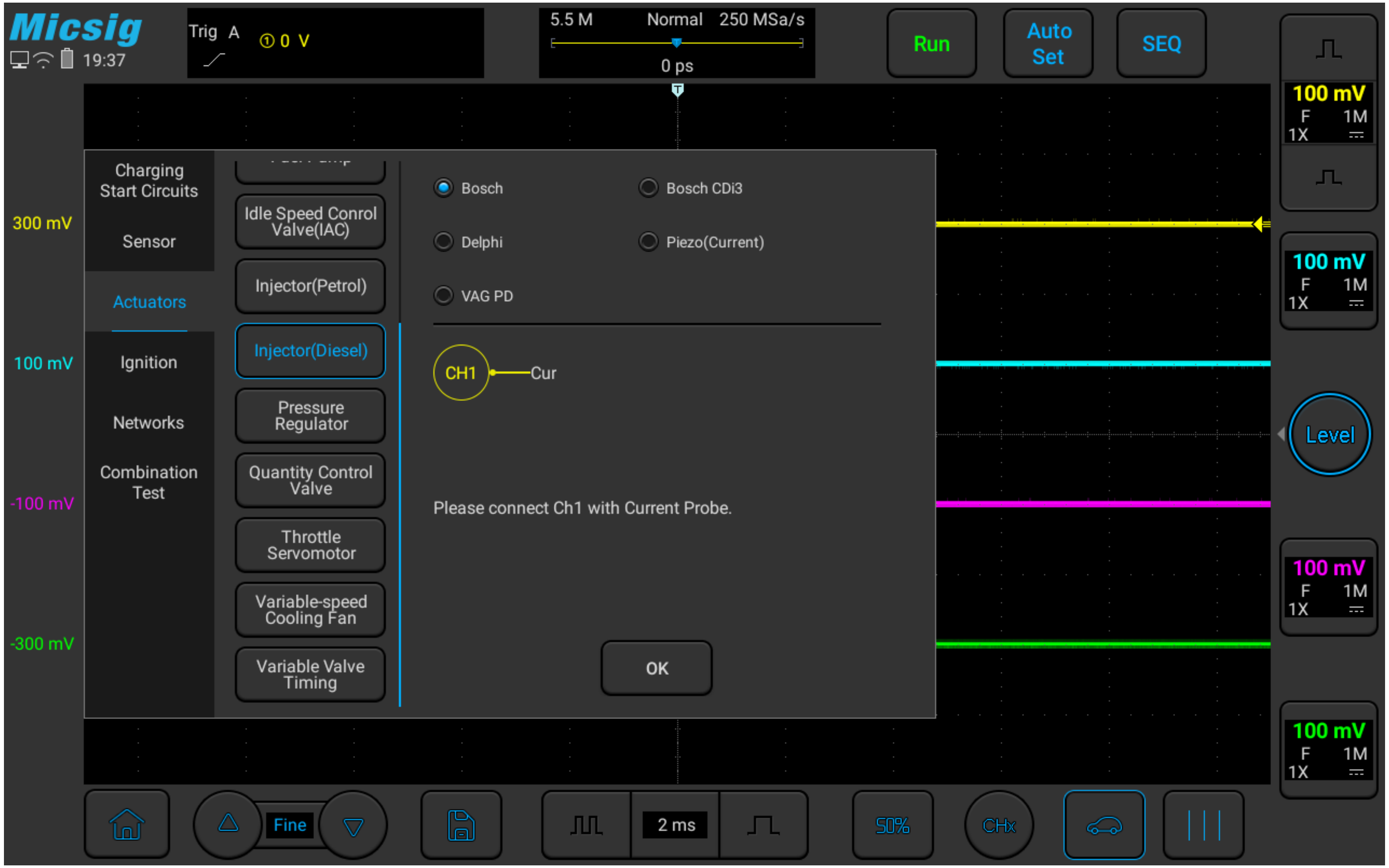


Figure 3-33 injector (diesel engine) test

3.3.8 Pressure regulator

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

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

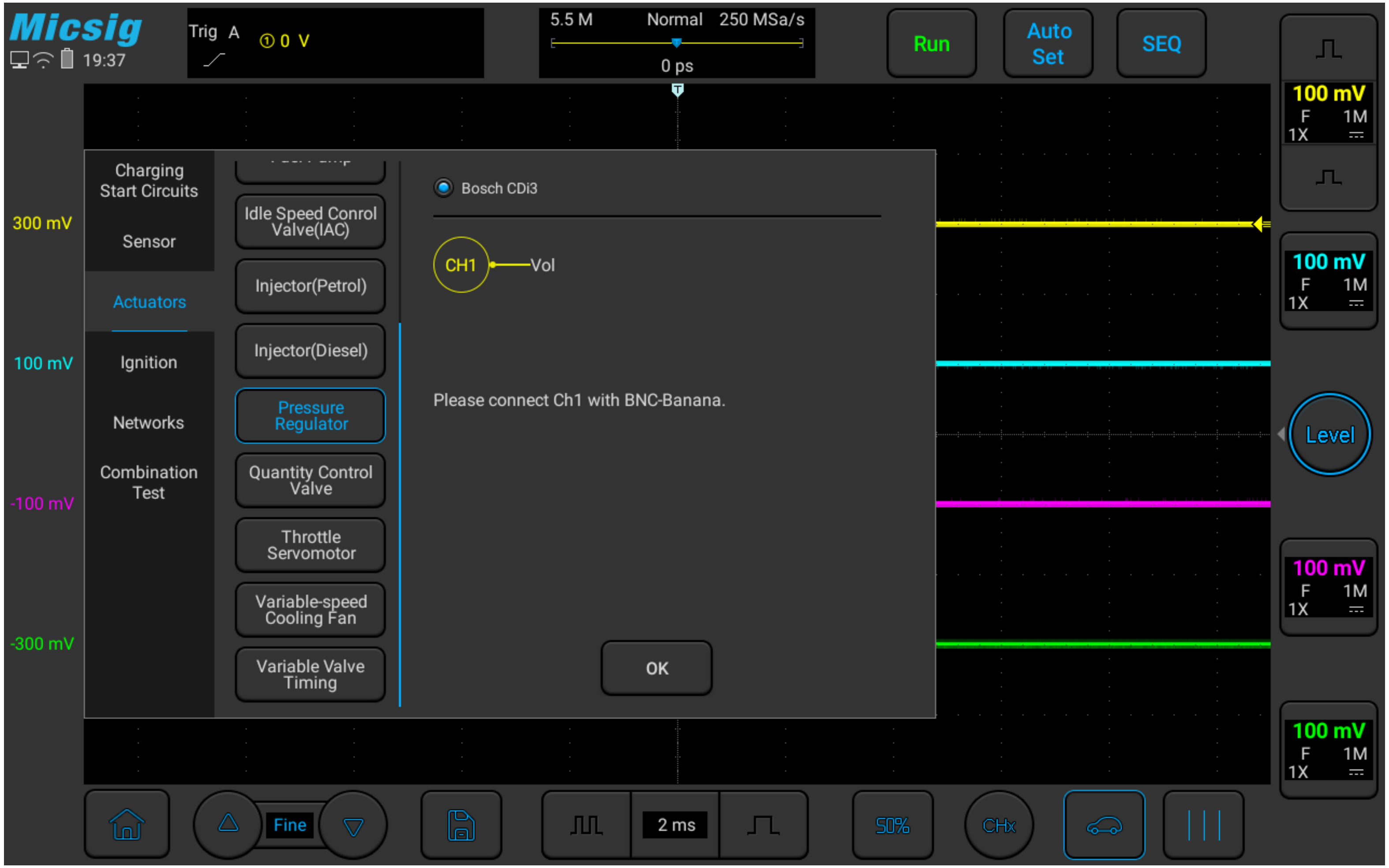


Figure 3-34 Pressure Regulator test

3.3.9 Quantity (Flow) control valve

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

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

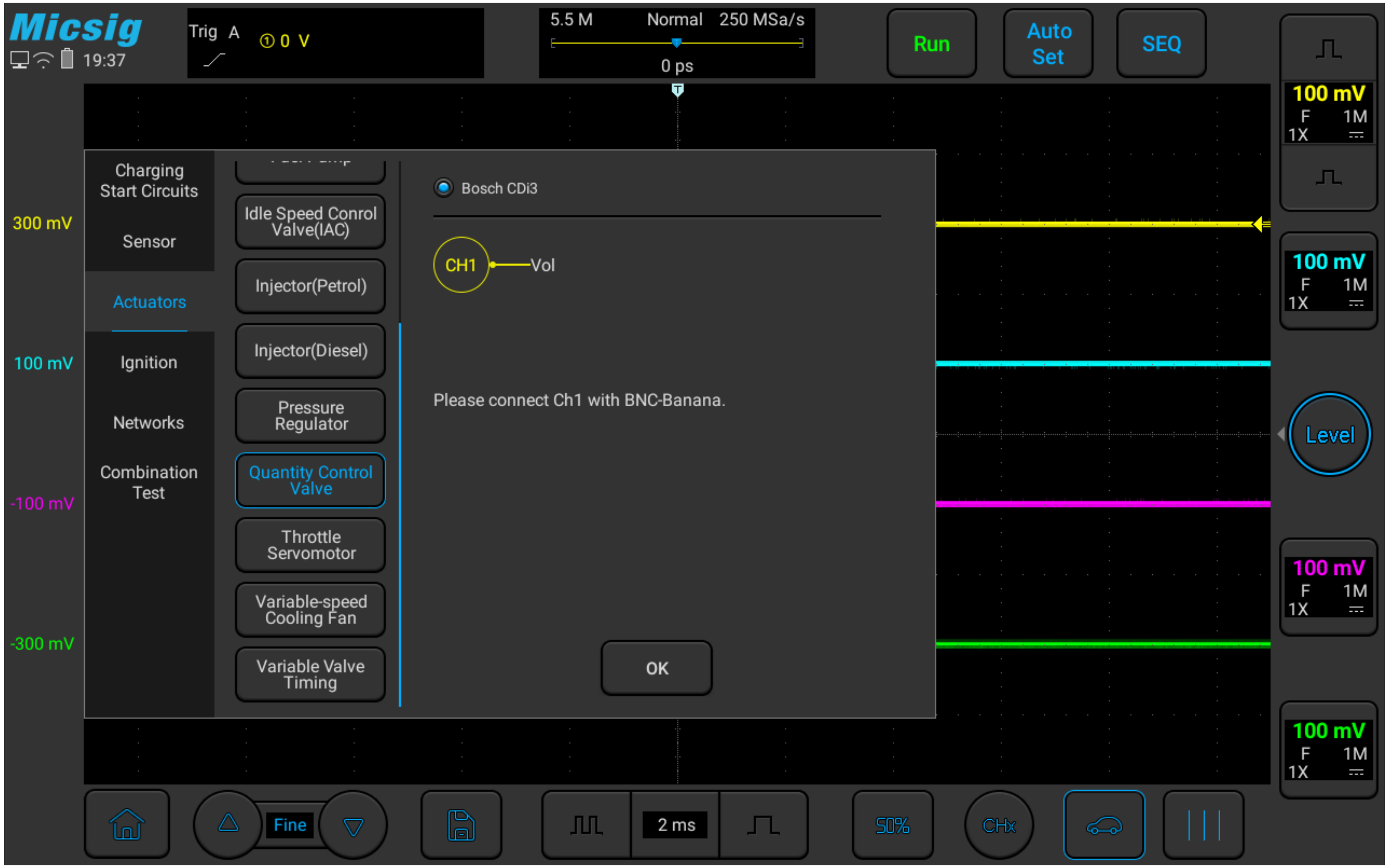


Figure 3-35 Quantity (Flow) control valve test

3.3.10 Throttle Servo Motor

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

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

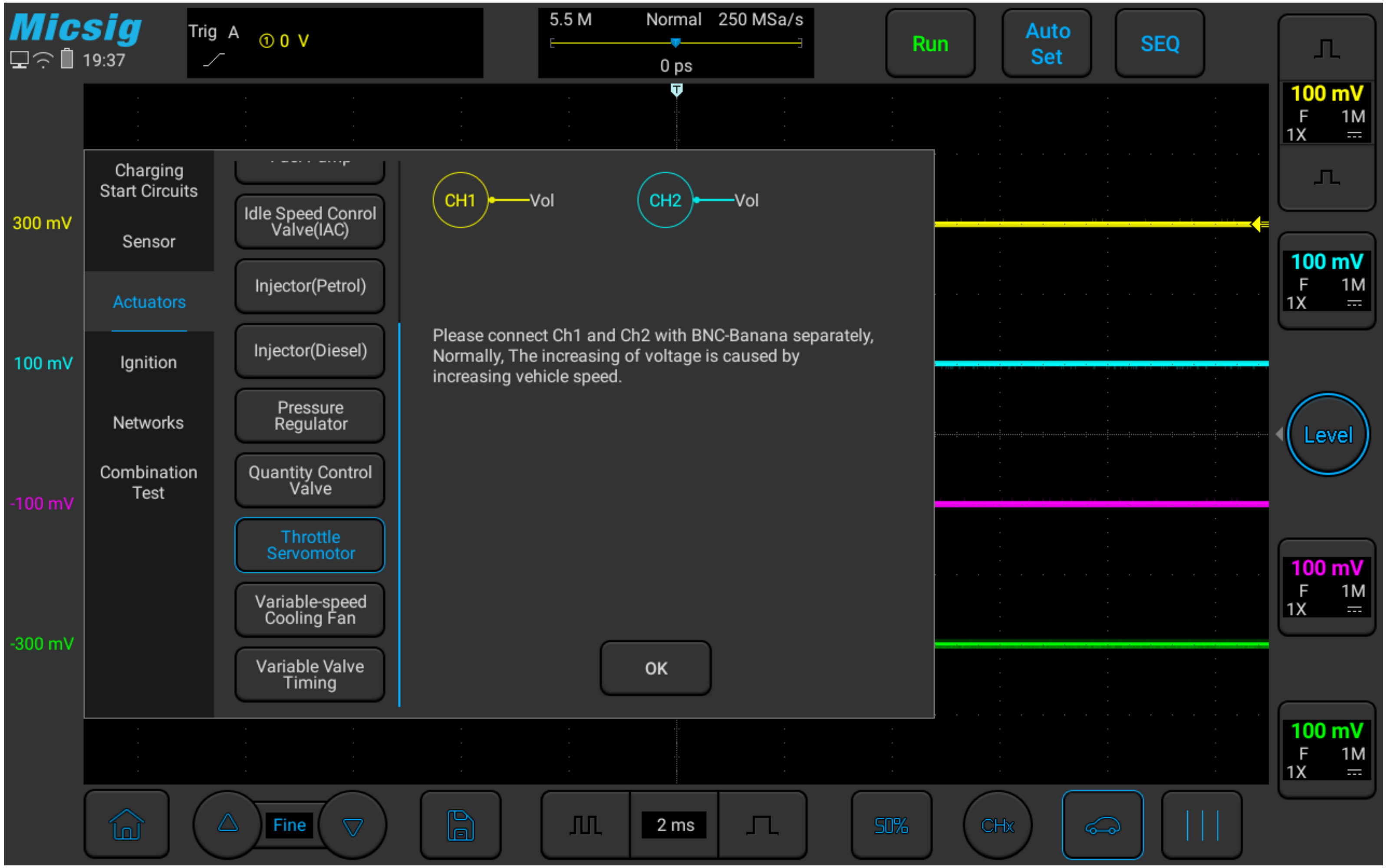


Figure 3-36 Throttle servo motor test

3.3.11 Variable speed cooling fan

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

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

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

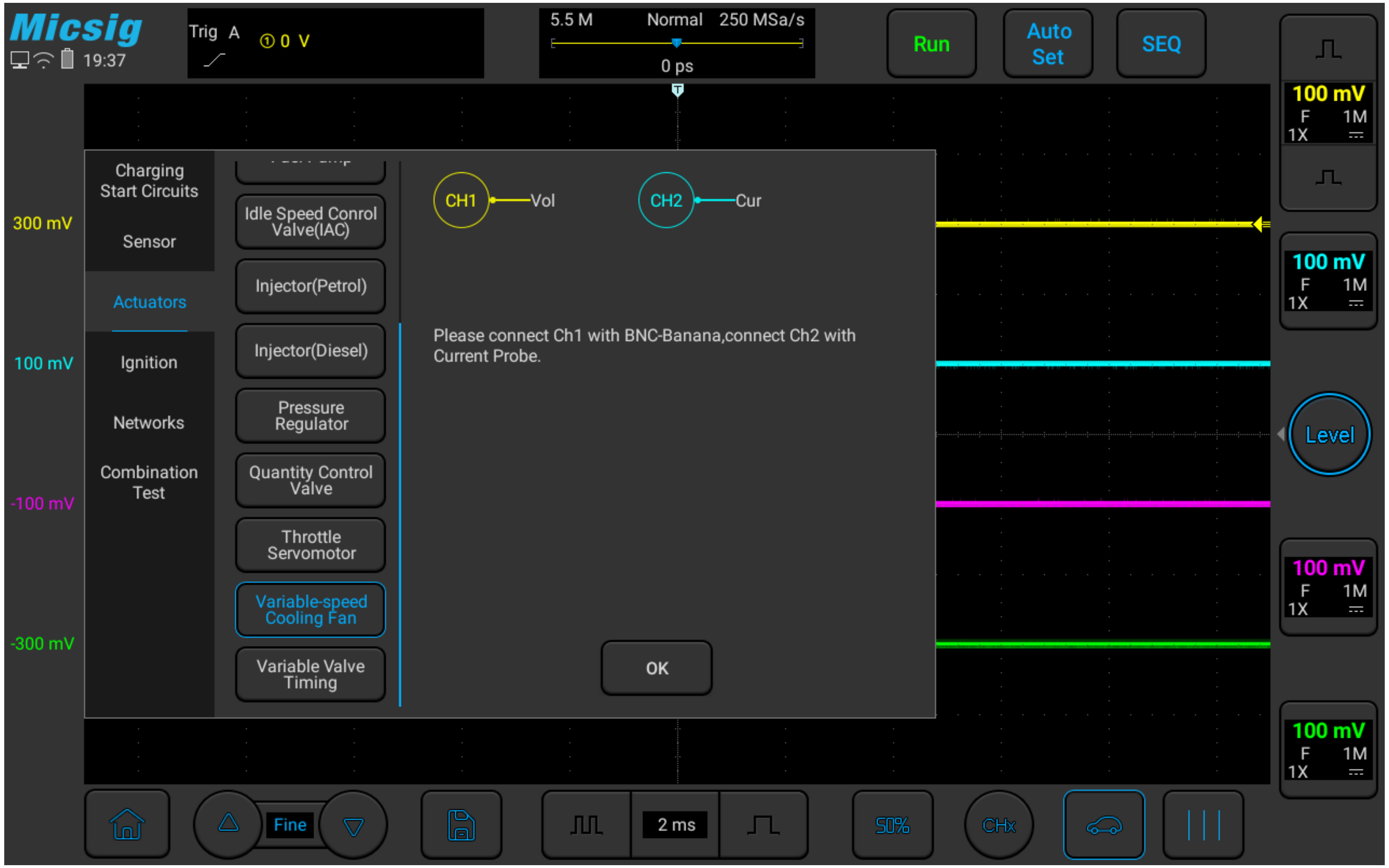


Figure 3-37 Variable-speed Cooling fan test

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

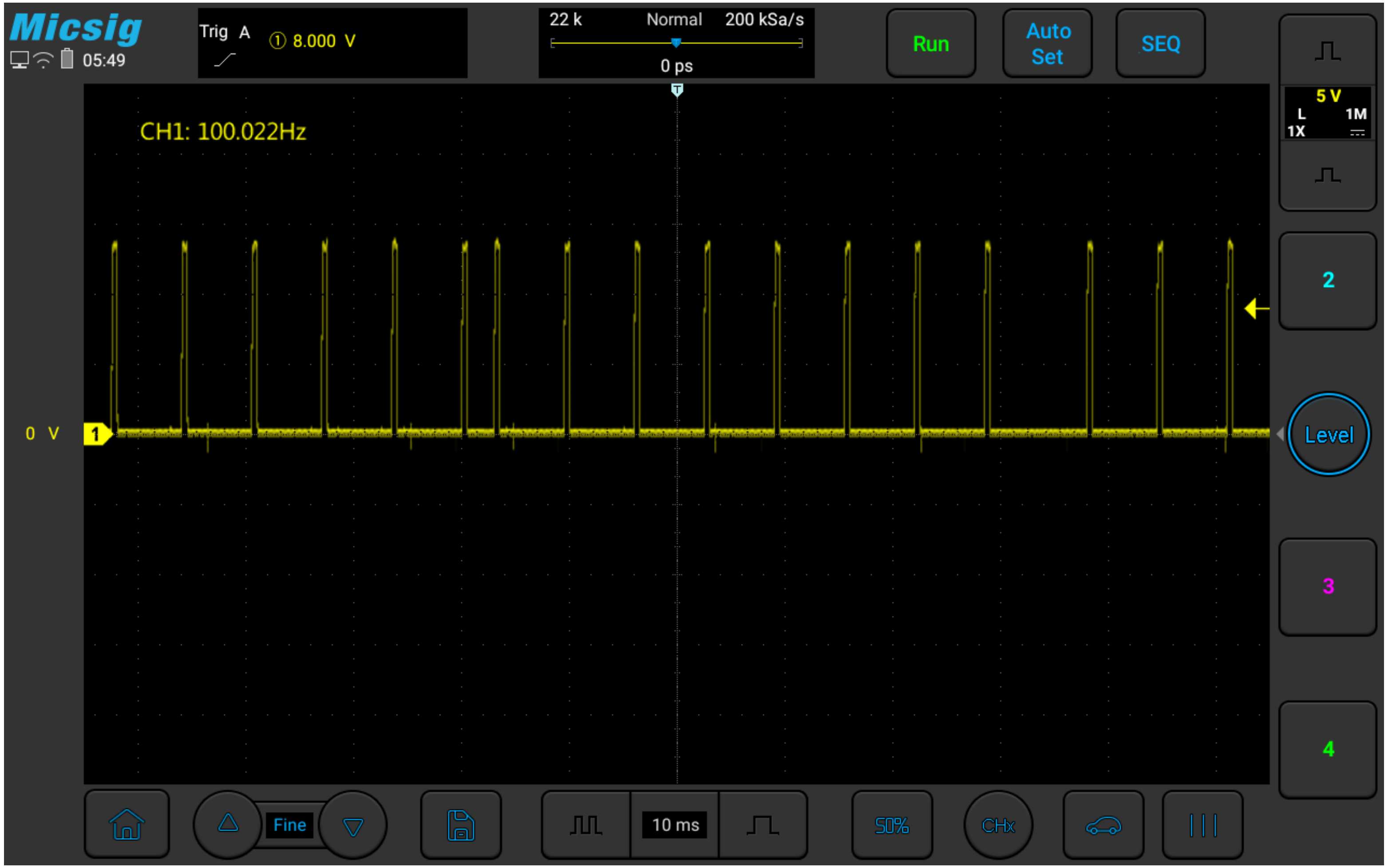


Figure 3-38 Cooling fan measurement diagram

3.3.12 Variable valve timing

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

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

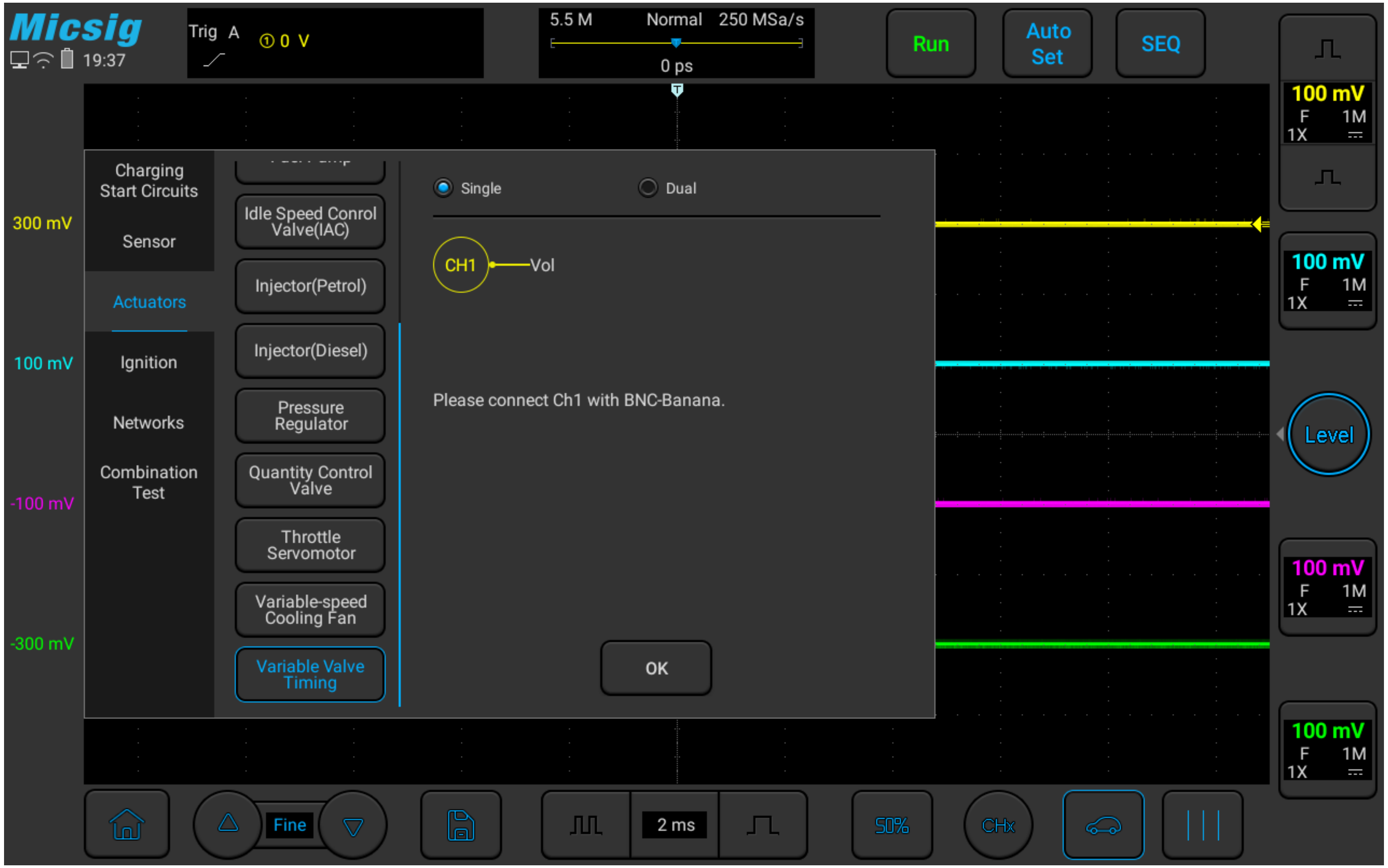
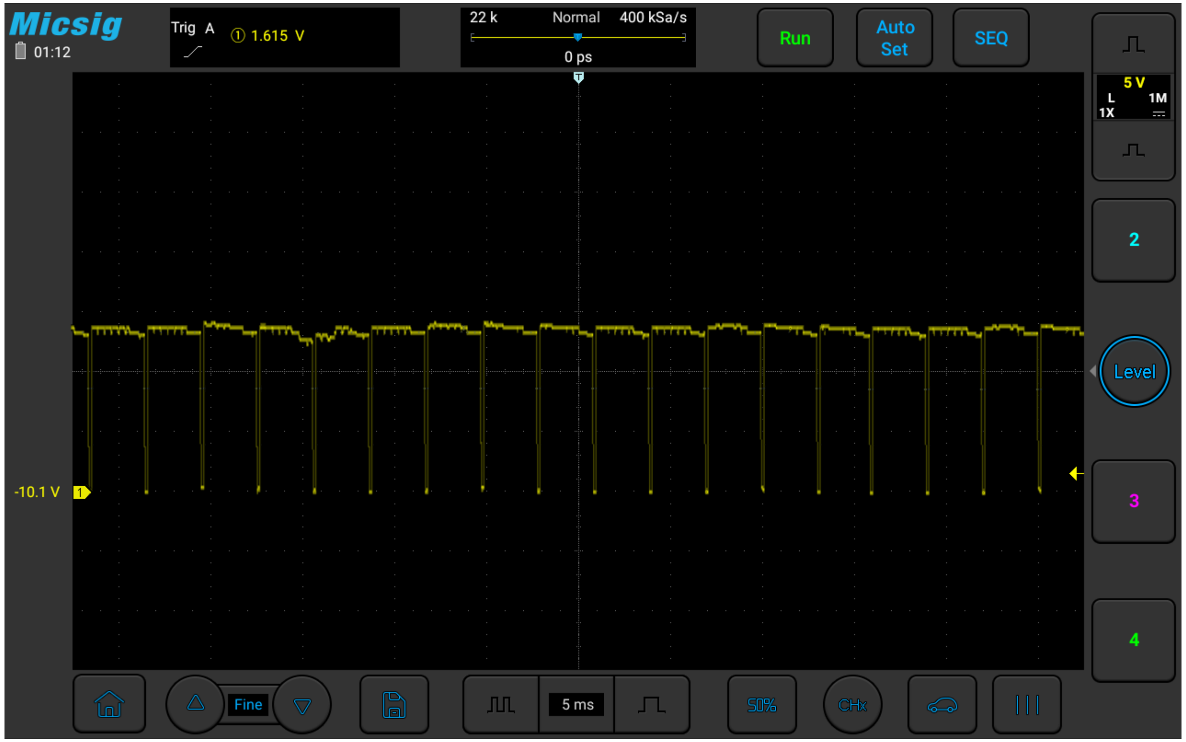


Figure 3-39 Variable valve timing test

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



3. 4 Ignition Tests

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

3.4.1 Primary

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

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

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

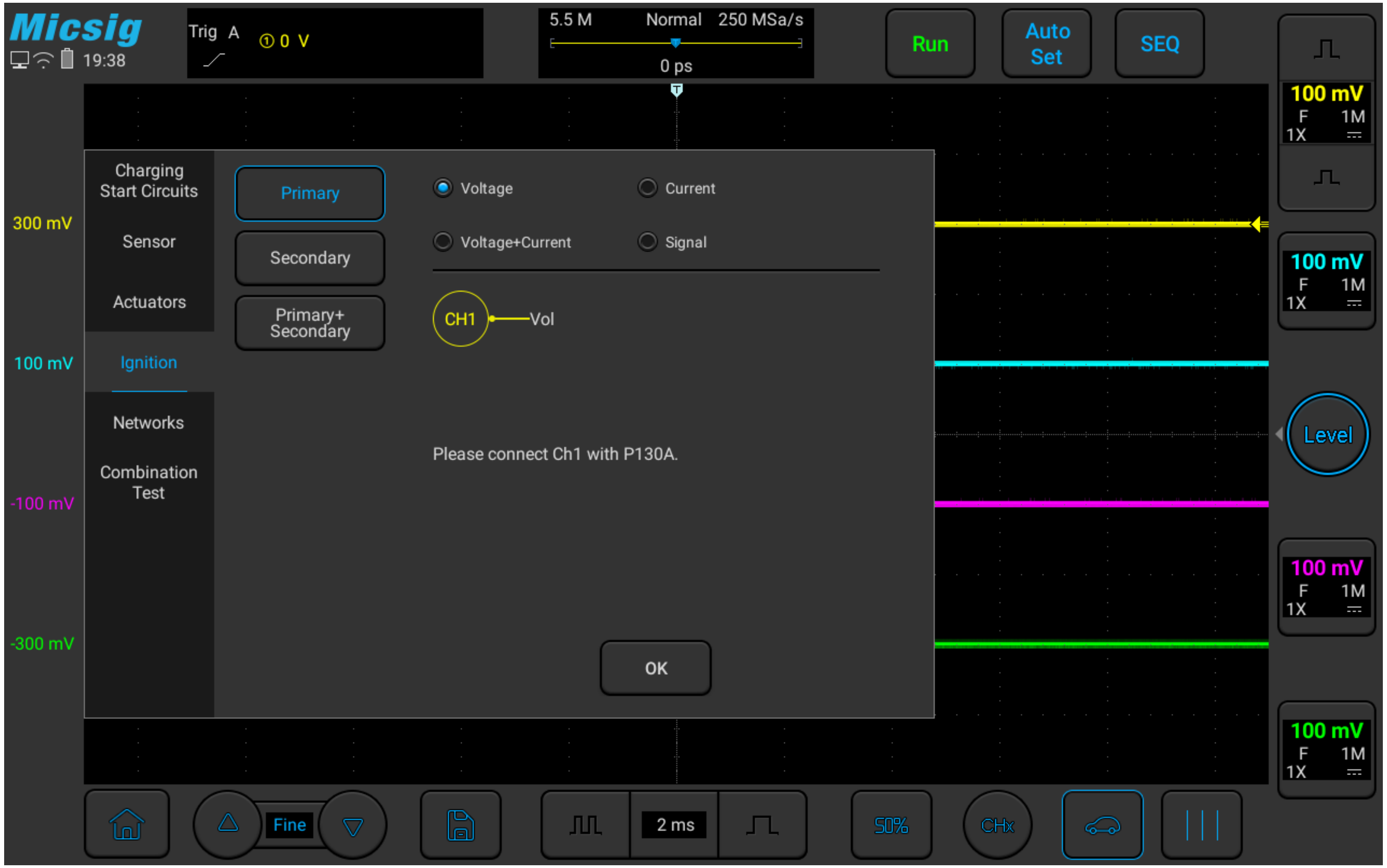


Figure 3-40 Primary ignition

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

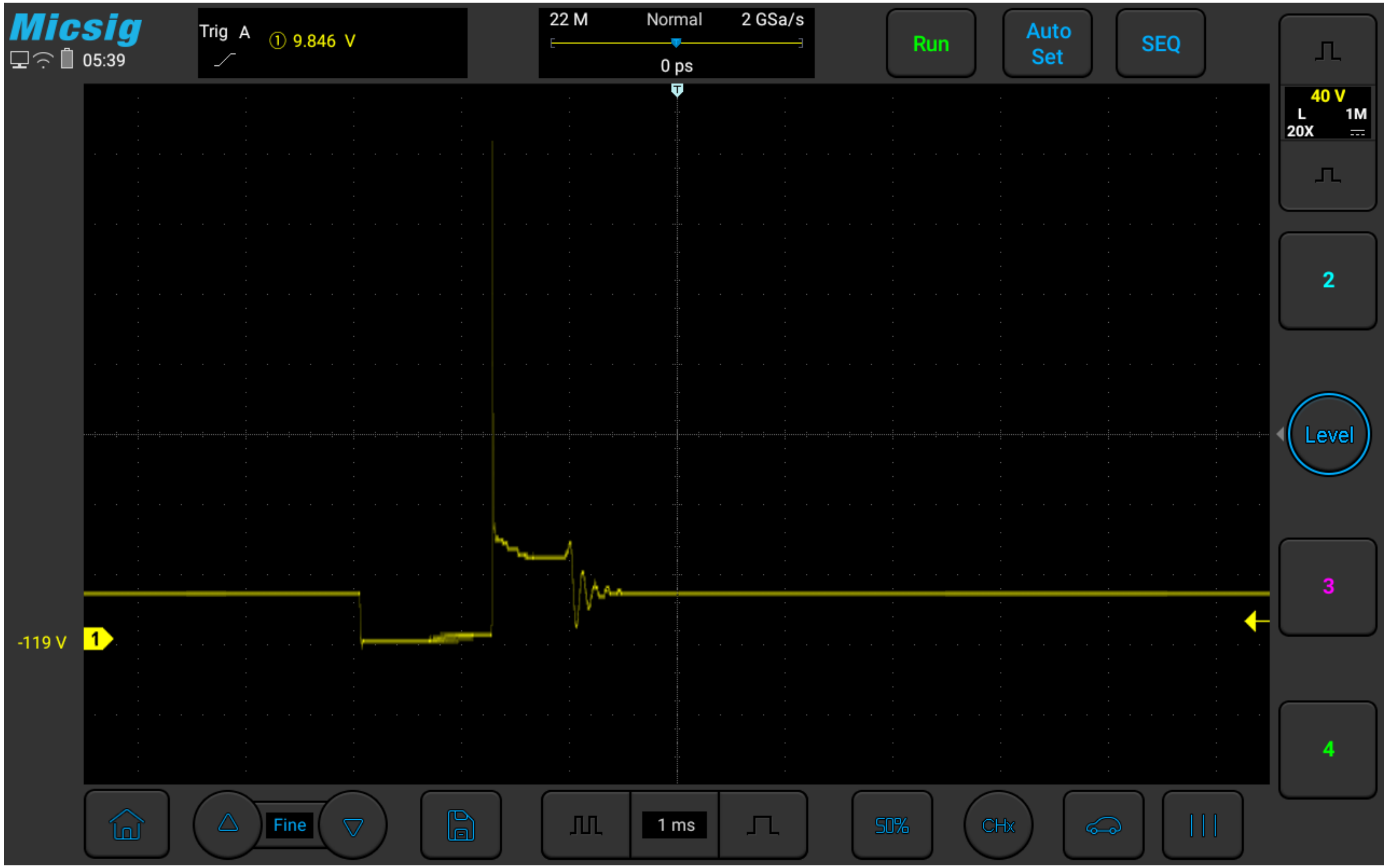


Figure 3-41 Primary ignition actual test

3.4.2 Secondary

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

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

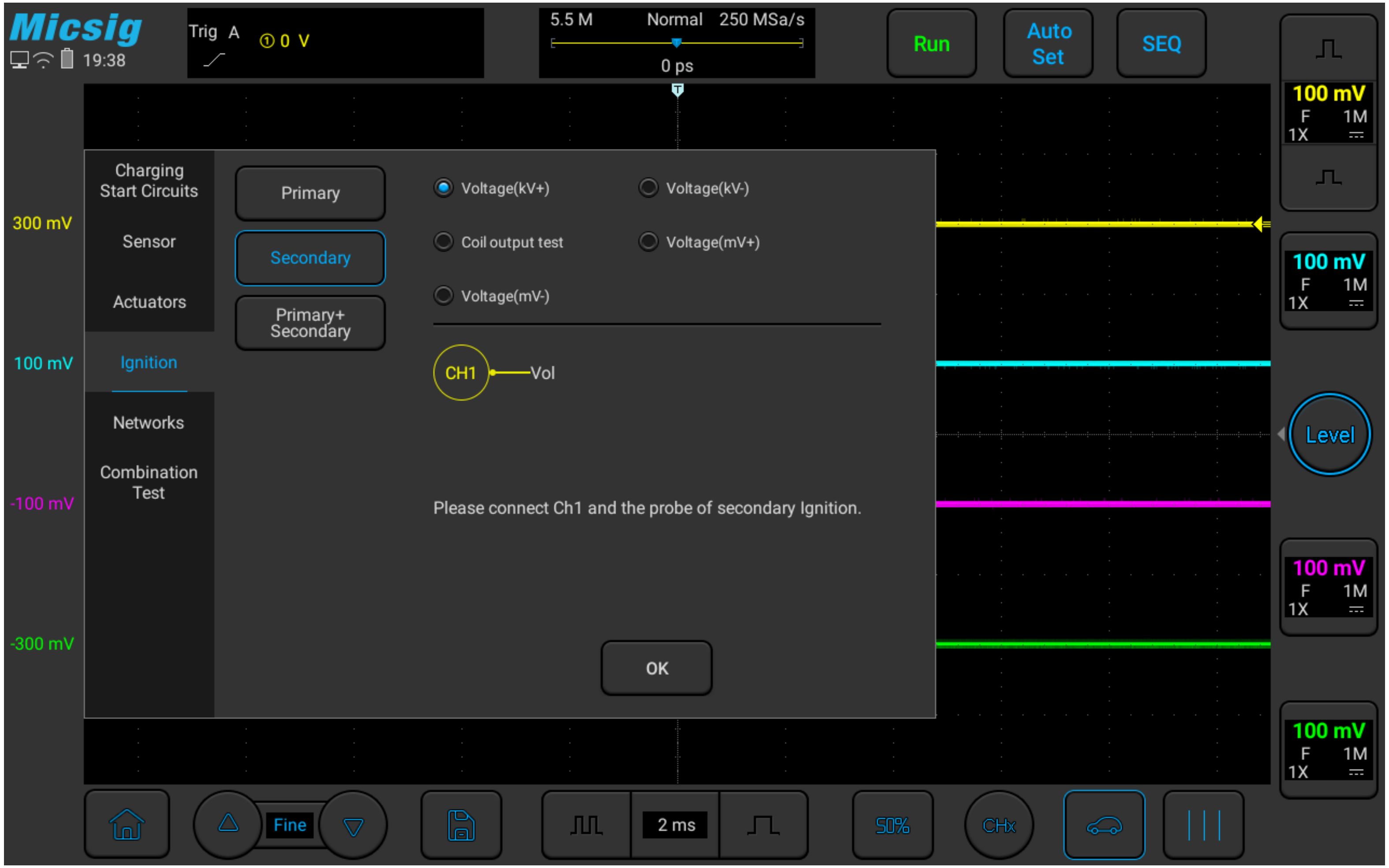


Figure 3-42 Secondary ignition test

3.4.3 Primary + Secondary

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

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

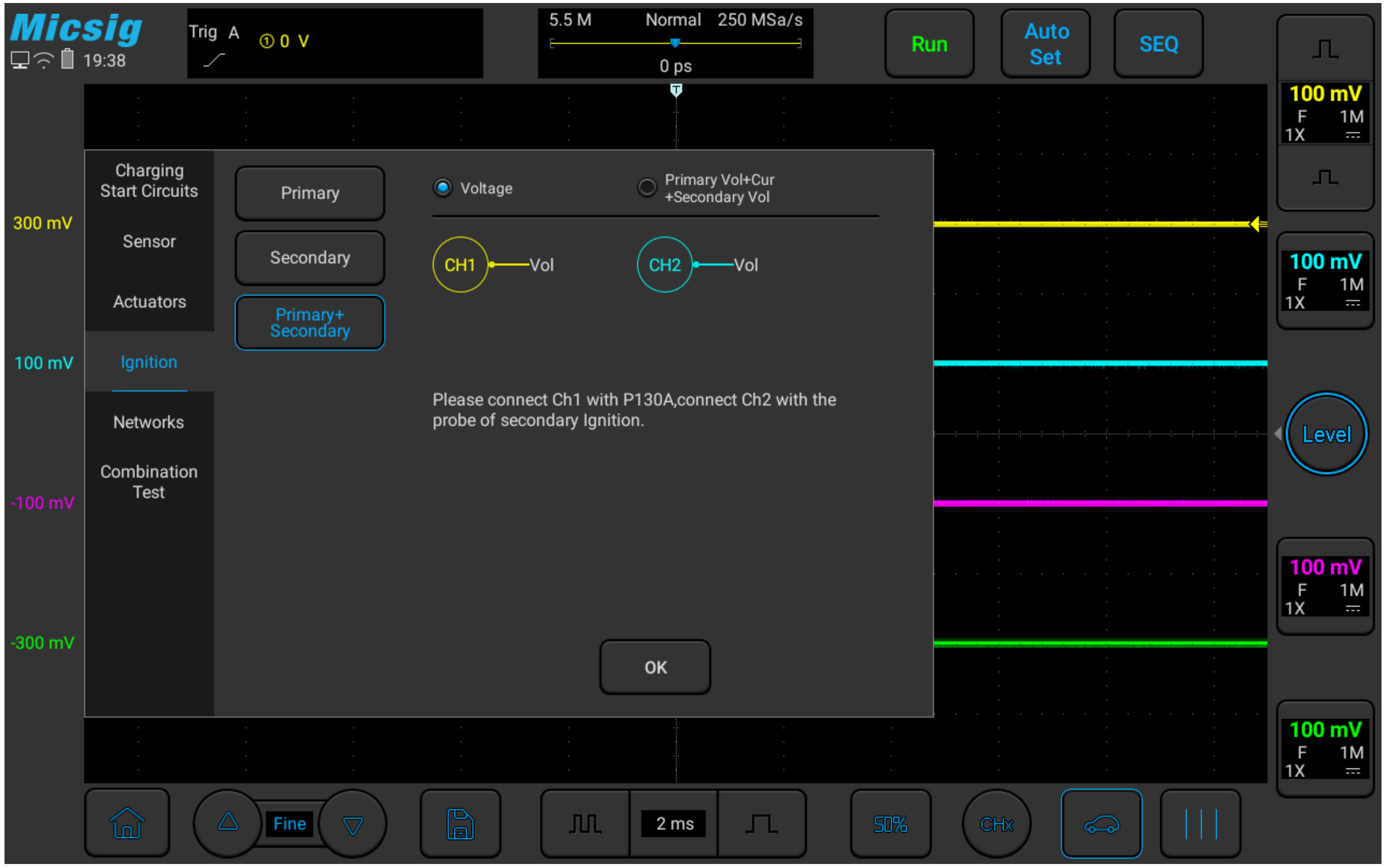


Figure 3-43: Primary + Scondary ignition test

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

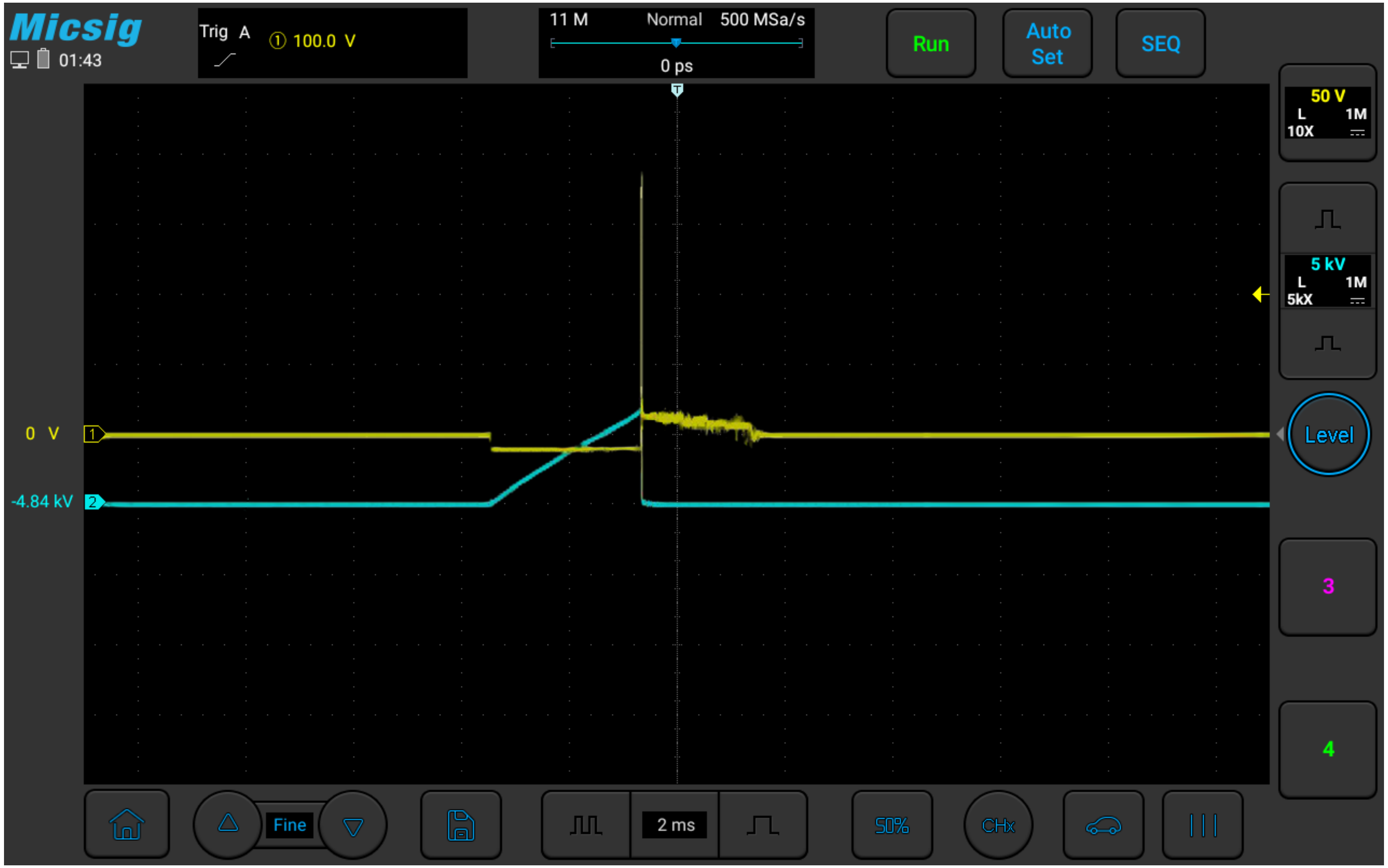


Figure 3-44 BMW 5 Series N20 Primary + Secondary ignition signal

3. 5 Networks

3.5.1 CAN High & CAN Low

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

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

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

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

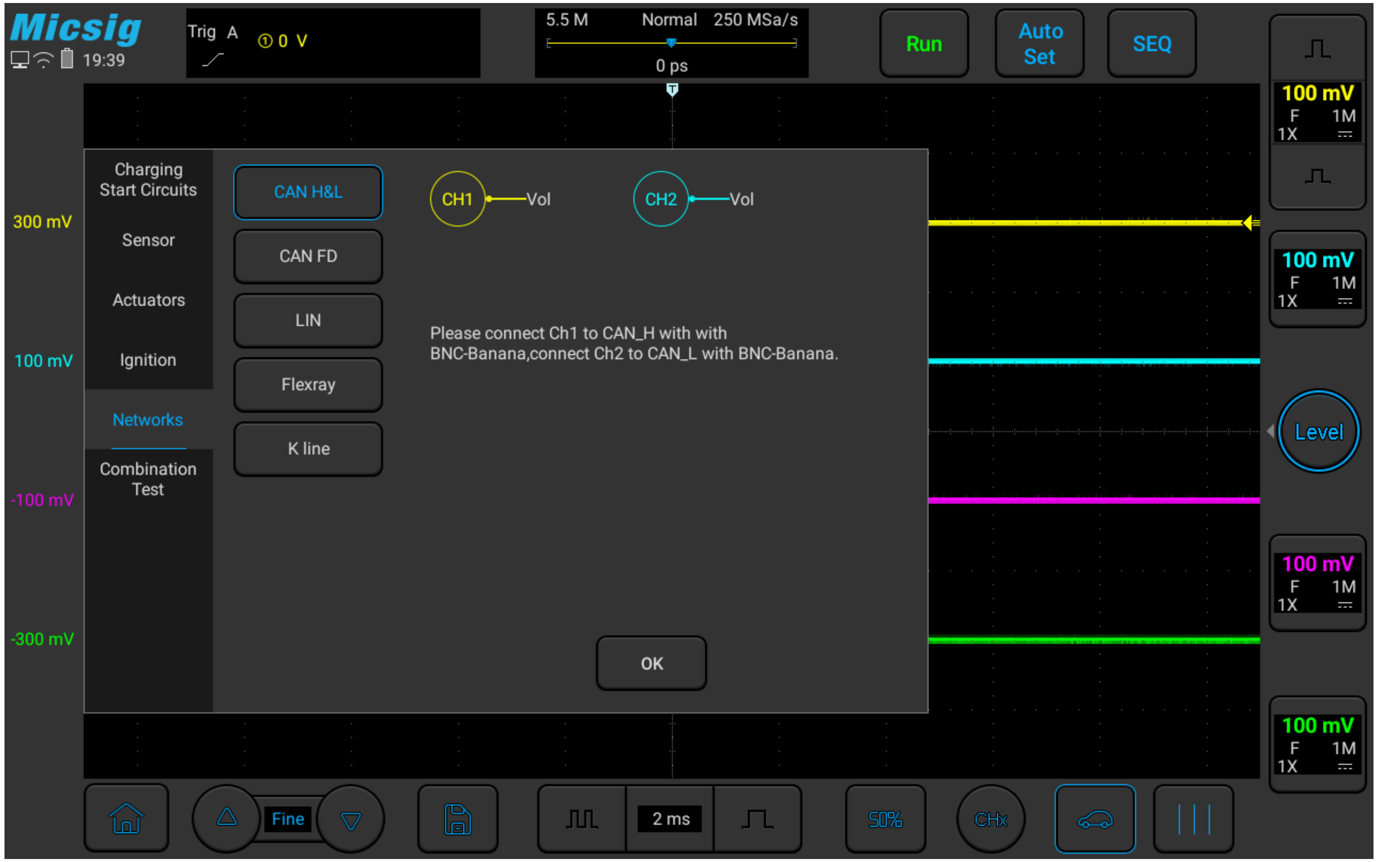
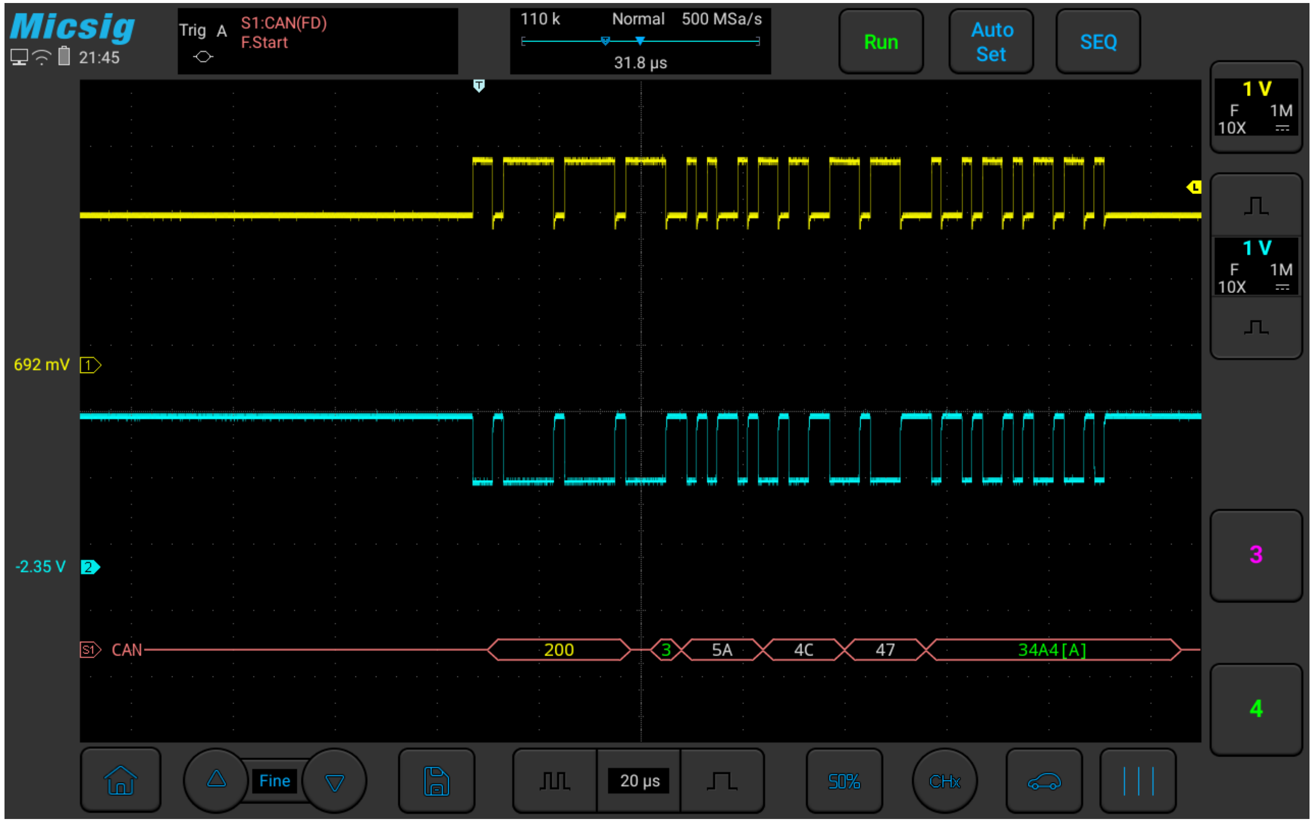


Figure 3-45 CAN BUS Test

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



3.5.2 LIN Bus

The LIN protocol is short for Local Interconnect Network.

The Lin bus communication is very common in automobiles, it is low speed, there are multiple control devices mounted on a network. It can contril non-safety-critical and low-speed devices on vehicles, such as wipers, windows, mirrors, air conditioners, electronic seats, etc. LIN is single-wired, has high level and low level when transmitting data, the high level is 12V, and the low level is 0V. The LIN bus generally has a sync header followed by data. If there is only a signal from the sync header, it means that the device has not responded.

Use the ATO oscilloscope to test the LIN bus, the specific operation is shown in Figure 3-46:

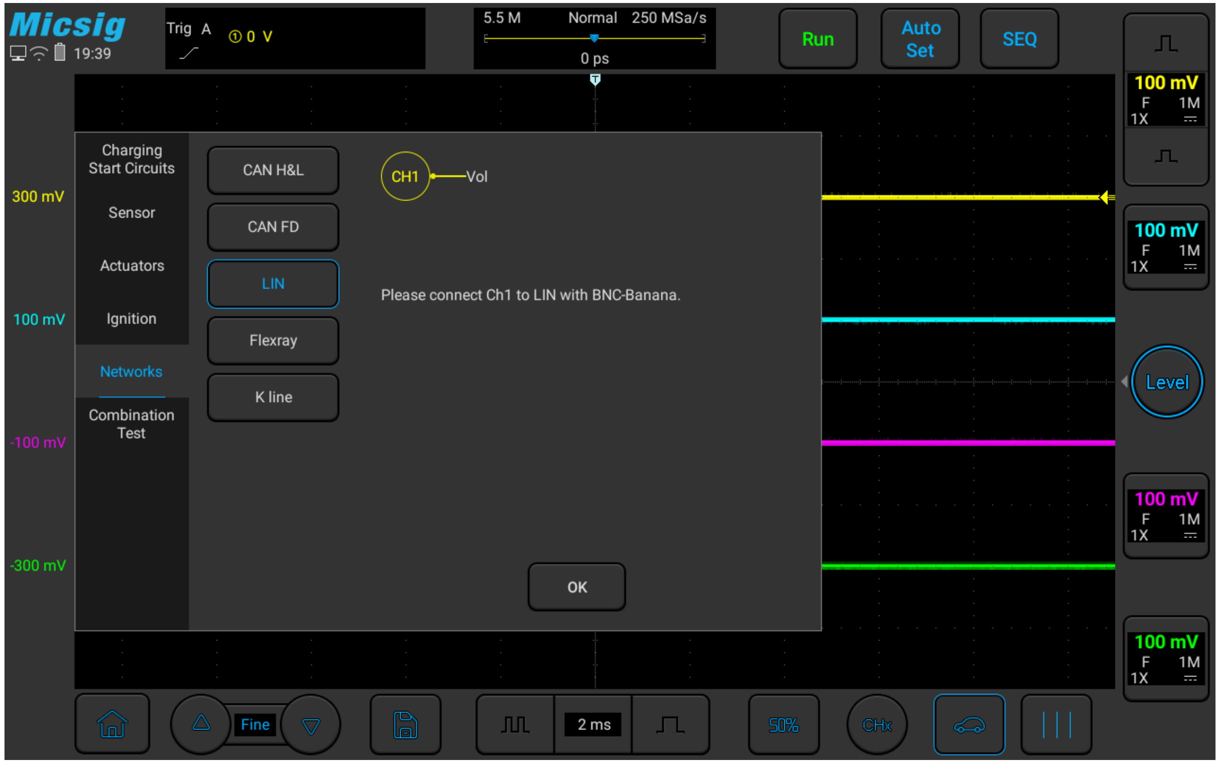


Figure 3-46 Lin bus test

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

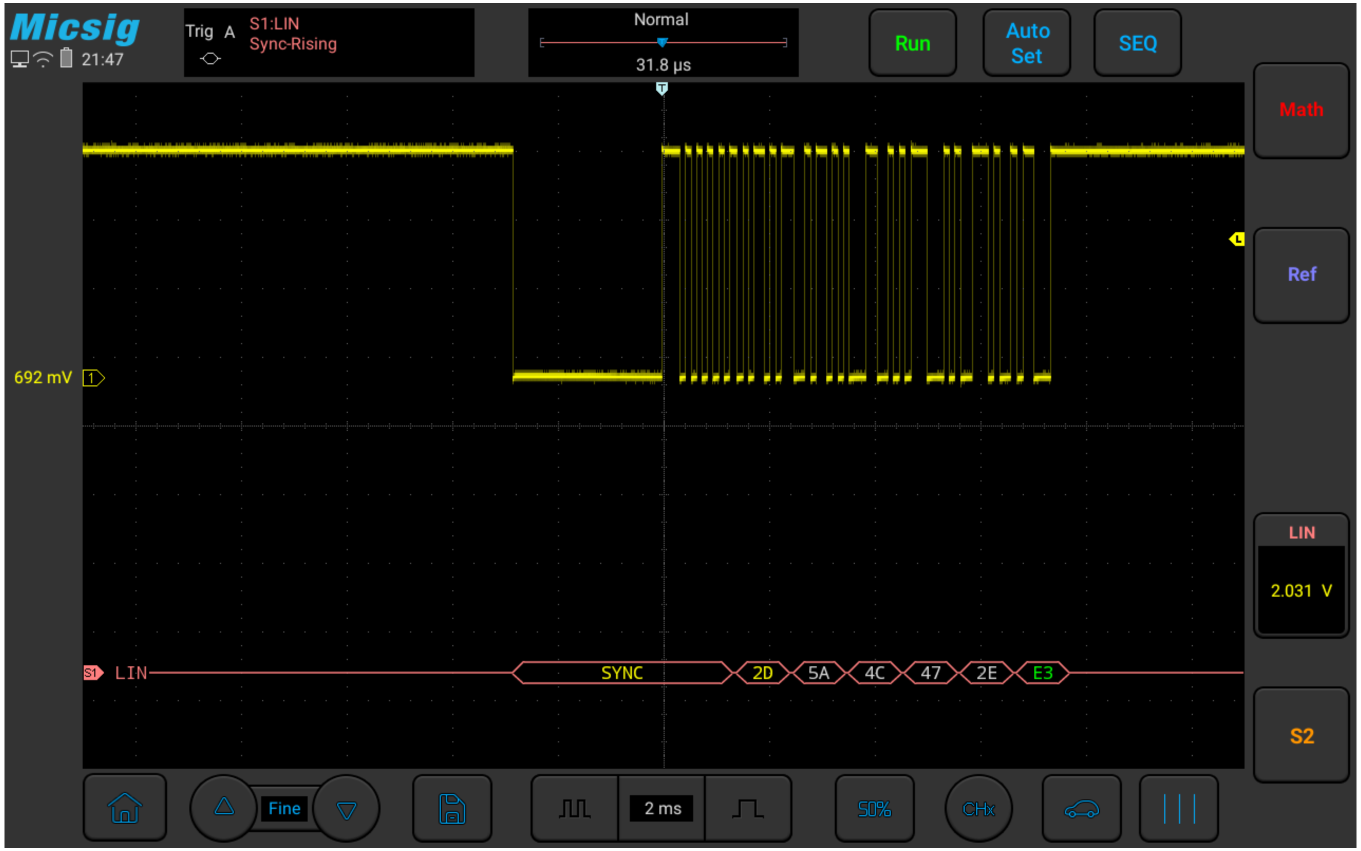


Figure 3-47 Audi A6 LIN bus measurement

3.5.3 FlexRay Bus

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

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

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

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

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

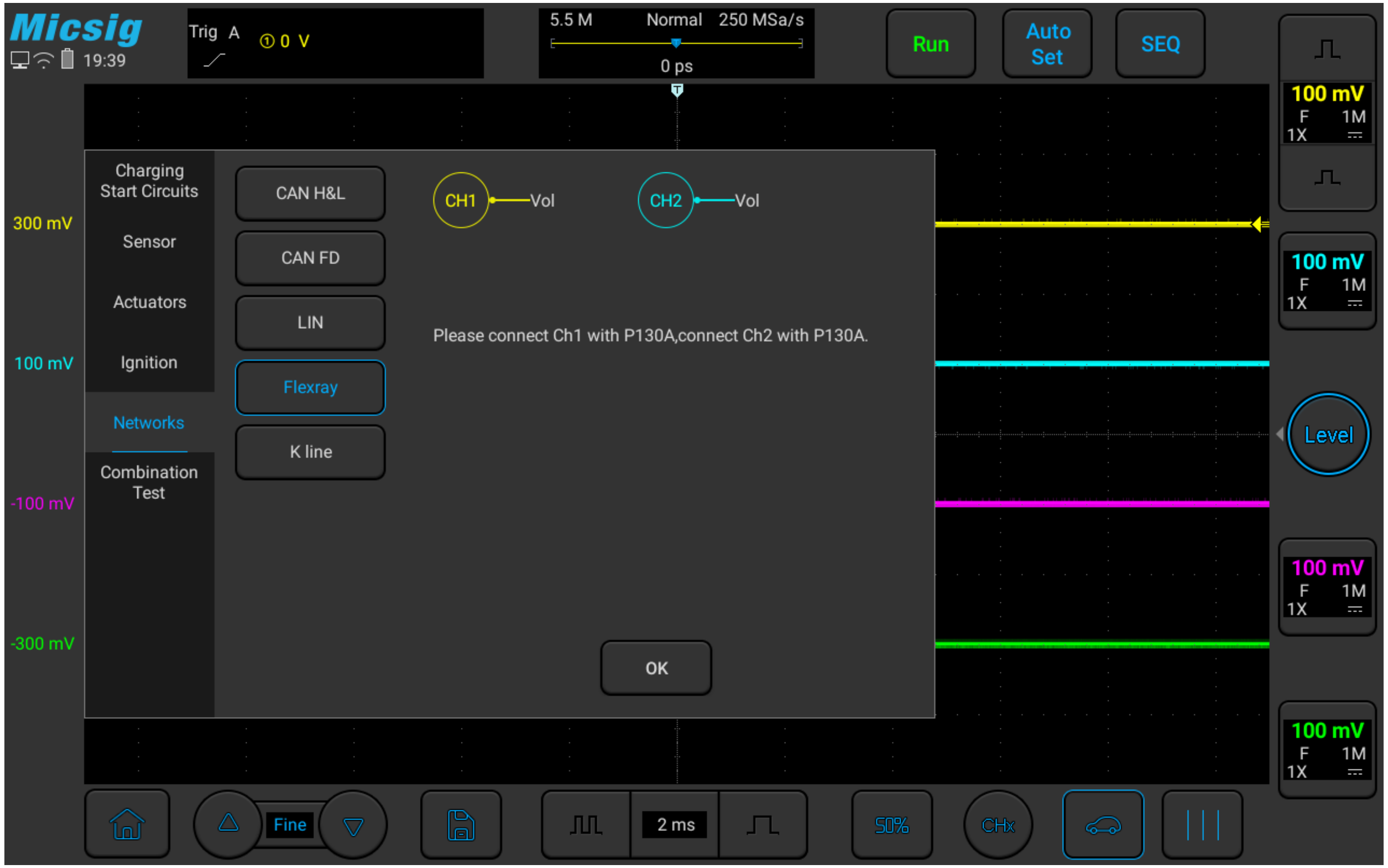


Figure 3-48: FlexRay bus test

3.5.4 K line

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

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

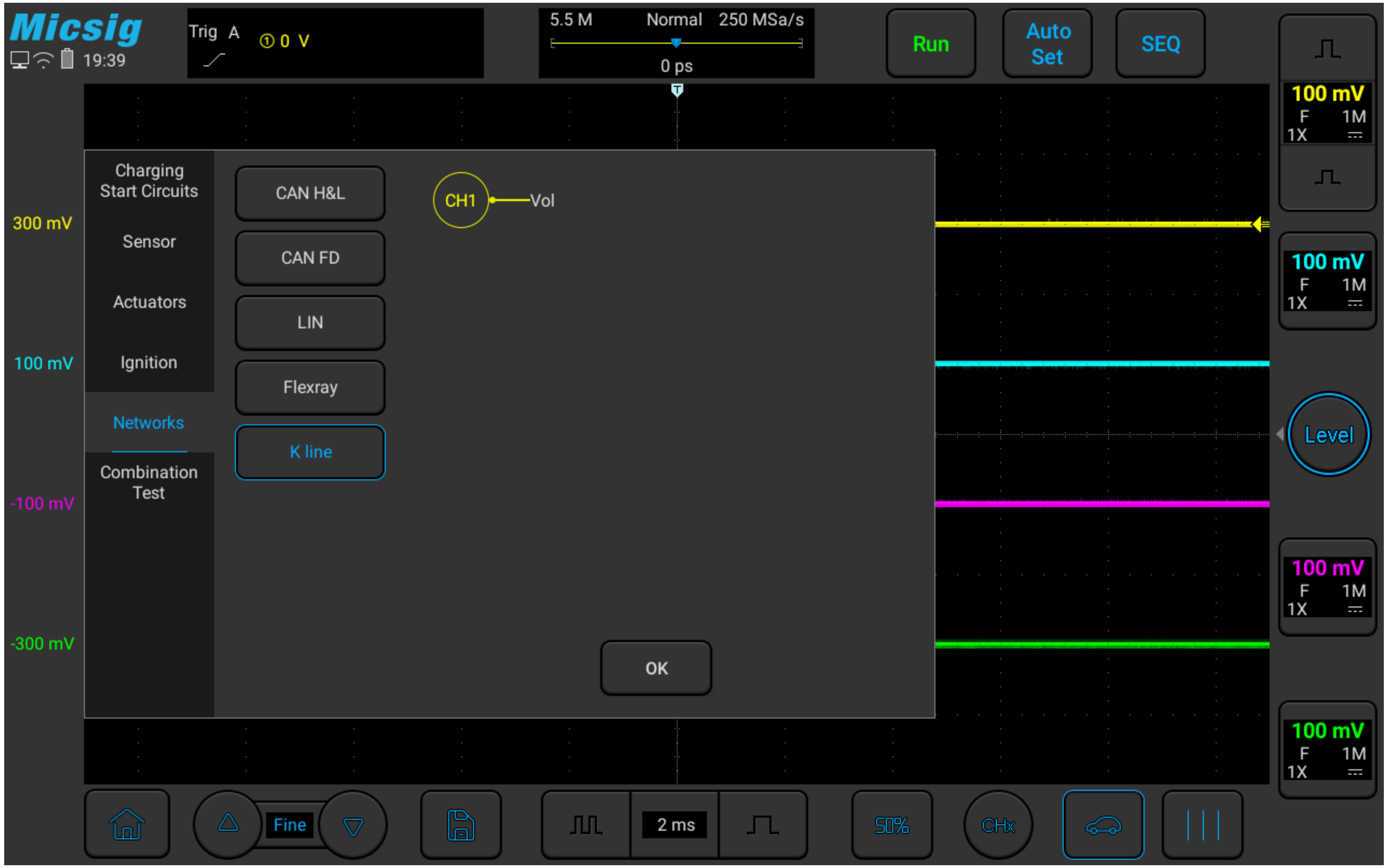


Figure 3-49 K line test

3. 6 Combination Tests

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

3.6.1 Crankshaft + Camshaft

Use a BNC to banana cable, one end is connected to channel 1 of the oscilloscope, the other end is grounded with a black plug, and the red connector is pierced into the signal line of the crankshaft sensor with a needle; use a BNC to banana cable, one end is connected to channel 2 of the oscilloscope, and the other black end is grounded, the red connector is pierced into the signal line of the camshaft sensor with a needle probe.

Use ATO oscilloscope to perform combined test on crankshaft + camshaft, the specific operation is shown in Figure 3-50:

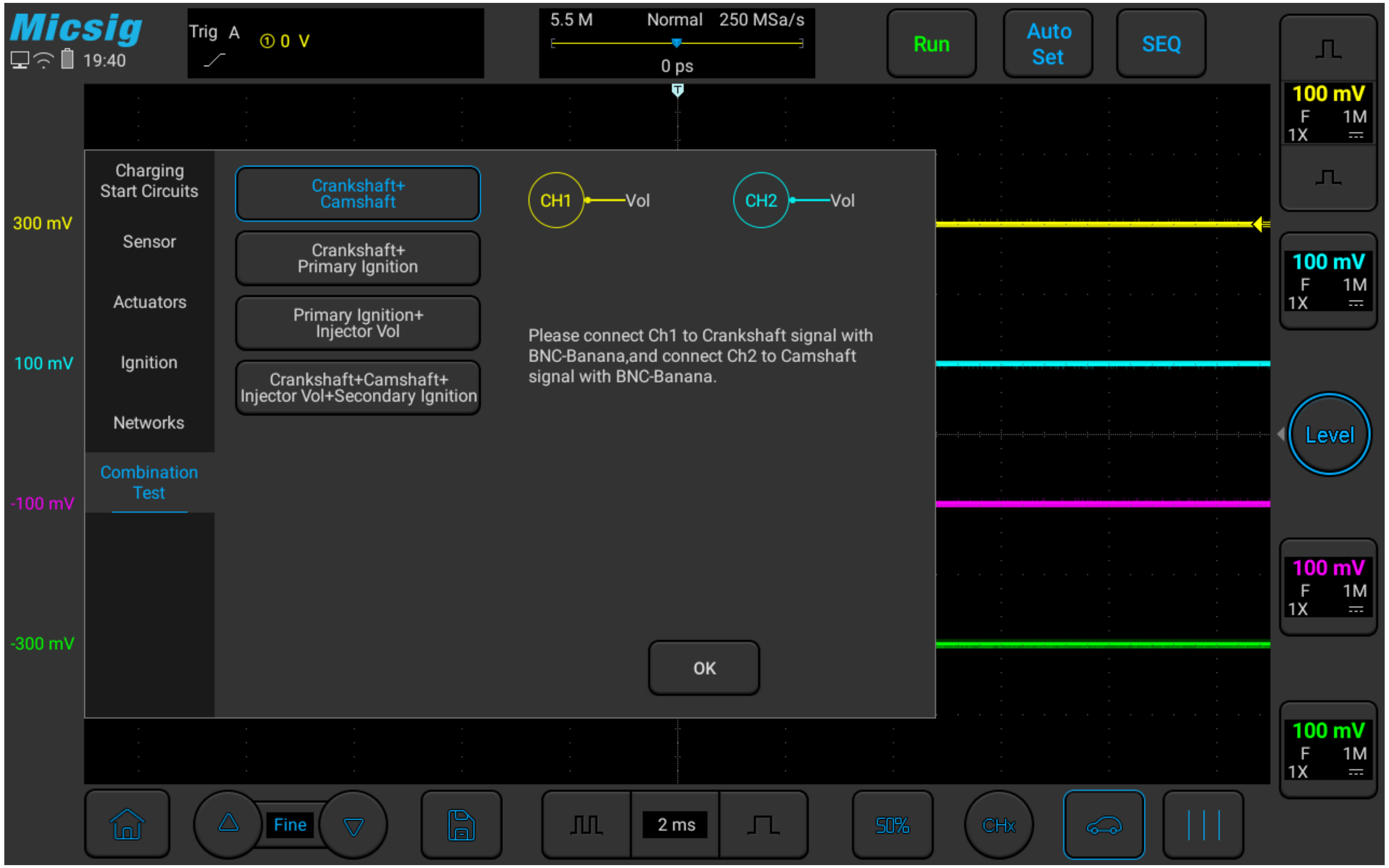


Figure 3-50 Crankshaft + Camshaft Combination Test

3.6.2 Crankshaft + Primary ignition

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

Use a P130A probe, one end is connected to channel 1 of the oscilloscope, and the other end is grounded with a black clip. Use a needle to pierce the signal line at the end of the injector plug, and hook the probe to the metal needle of the needle;

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

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

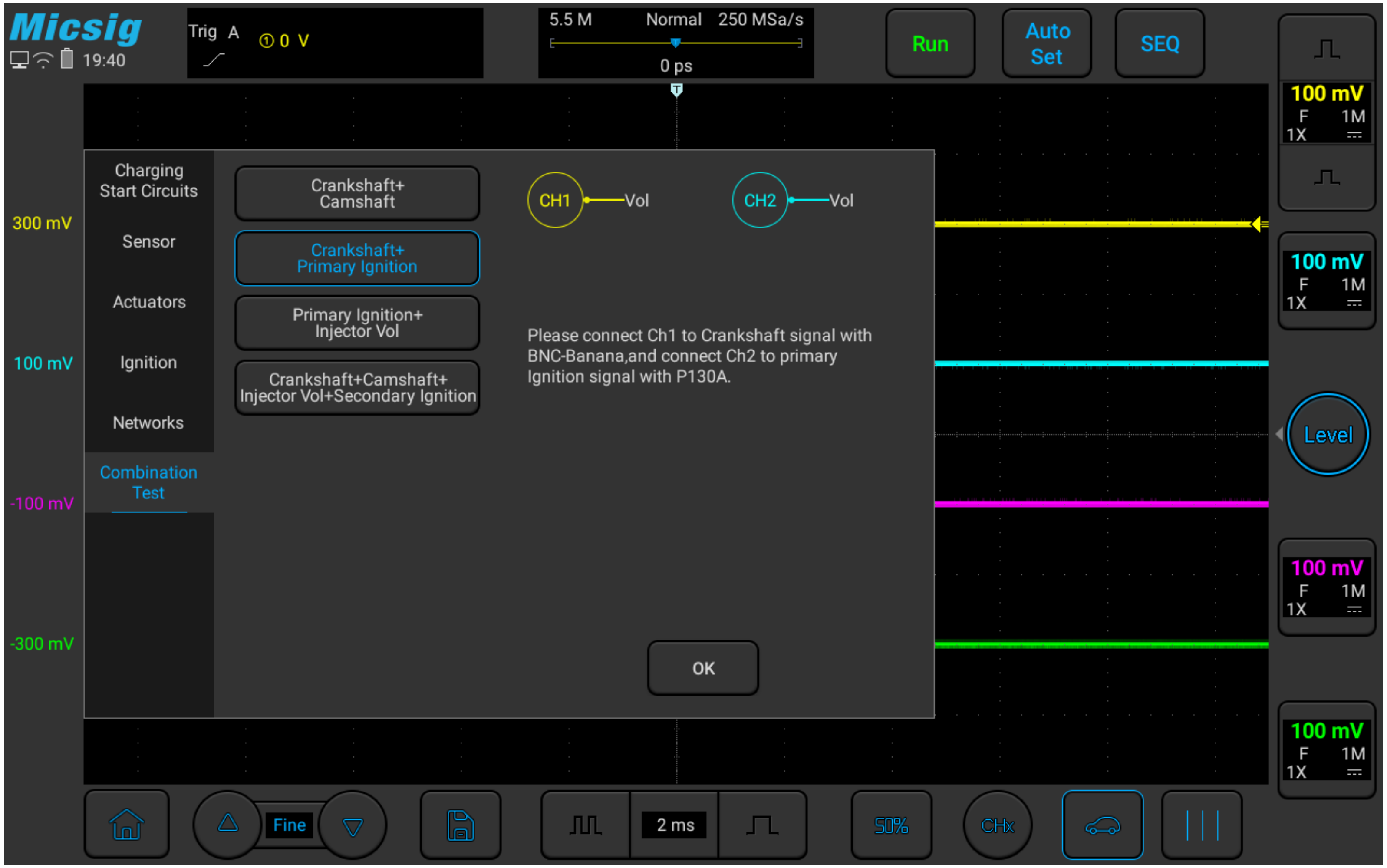


Figure 3-51 Crankshaft + Primary ignition test

3.6.3 Primary ignition + Injector voltage

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

Use a P130A probe, one end is connected to channel 1 of the oscilloscope, and the other end is grounded with a black clip. Use a needle to pierce the signal line at the end of the injector plug, and hook the probe to the metal needle of the needle;

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

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

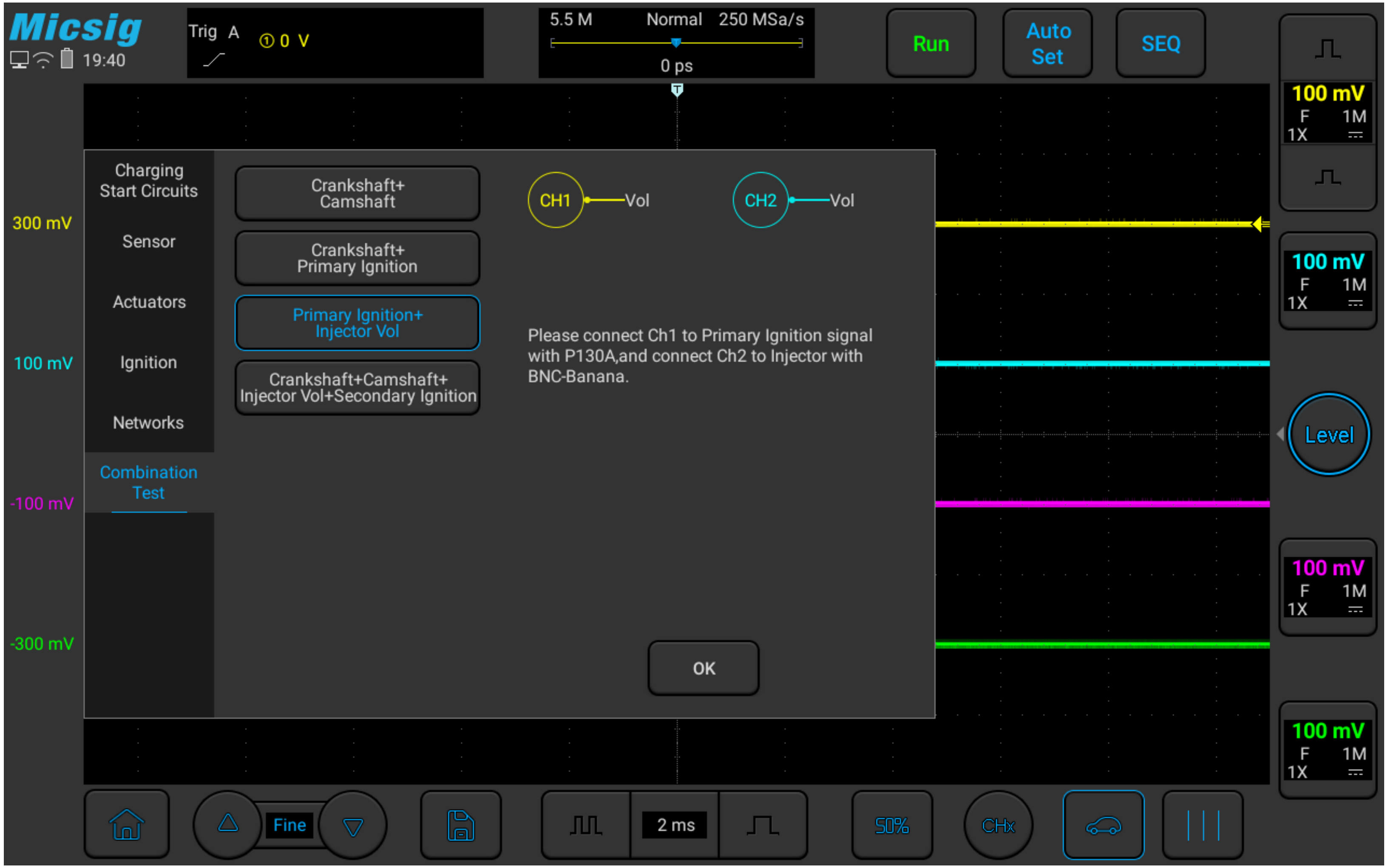


Figure 3-52 Primary ignition + Injector voltage