12 Oscilloscope (Toolbox)

12.1 Introduction

As an optional add-on module, the Scopebox includes automotive oscilloscope and automotive ignition waveform.

Automotive oscilloscope can make the auto repair technician quickly judge the faults on automotive electronic equipment and wiring, and the oscilloscope sweep speed is far greater than the signal frequency of such vehicles, usually 5-10 times of the measured signal. The automotive oscilloscope not only can quickly acquire the circuit signal, but also can slowly display the waveform to observe and analyze. It can also record and store the tested signal waveform which can be recalled to observe for the fast signal, having great convenience to failure analysis. Either high-speed signal (e.g.: Injection nozzle, intermittent fault signal) or the slow-speed signal (e.g. the throttle position change and the oxygen sensor signal) can be observed through automotive oscilloscope in an appropriate waveform.

The electronic signal can be compared and judged via measuring five parameters indexes. The five parameters are the amplitude (the maximum voltage of signal), the frequency (the cycle time of signal), the shape (the appearance of signal), the pulse width (the duty cycle or the time range of signal), and the array (the repetition characteristic of signal), which can be tested, displayed, saved by the automotive oscilloscope. Via the waveform analysis can further detect the circuit fault on sensors, actuators, circuits, and electronic control units, etc.

12.2 Structure & Accessories

12.2.1 Scopebox structure

Fig 12-1 Scopebox Structure Diagram

Table 12-1 shows the ports and indicators for the Scopebox.

No.	Name	Description
1	Fixed signal generator	Generate a square signal with fixed 1K frequency.
2	CH1	Channel 1
3	CH2	Channel 2
4	CH3	Channel 3
5	CH4	Channel 4
6	External trigger	External trigger signal (*It only applies if the Scopebox failed to trigger the signal itself.)
7	B-shaped data I/O Port	Connect to the diagnostic tool via data cable so that the signal can be displayed on the tool.
8	Power interface	To provide power to it via the power adaptor or battery clamps cable.

9	Communication indicator	It blinks in process of data communication.
10	Running indicator	It remains steady green after the Scopebox is running.
11	Power indicator	It keeps steady red after the Scopebox is powered on.

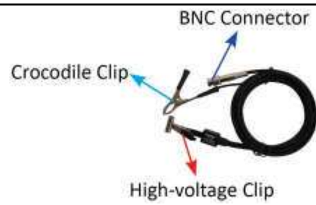
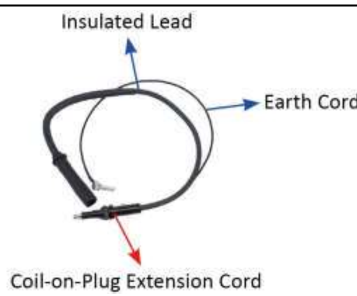
12.2.2 Scopebox accessories

The Scopebox includes the auto test leads, secondary pickup cable for 4-channel oscilloscope, crocodile clips for 4-channel oscilloscope, etc. See the packing list attached to the product for the detailed accessories.

Table 12-2 Accessory checklist

No.	Name	Picture
1	BNC to 4mm Test Leads	 Test lead of a male BNC connector to (2) 4mm connectors. It is a kind of special line for assisting automobile Scopebox to test various types of signals. 4mm connectors are coded in two colors: black (earth wire) and red (positive pole which should be connected with the 6-way Breakout Leads). Moreover, it can also work with the 20:1 Attenuator.
2	6-way Breakout Leads	 Each lead has 6 blades wired to 6 sockets, allowing you to insert it between a plug and socket pair, other ends are 6 (4 mm) sockets which can be connected to the BNC to 4mm Test Lead.

		With these 6-way leads, you will be able to test most of the sensors and actuators on all makes and models of vehicle, including MAP, temperature, throttle position and airflow sensors, fuel pumps, primary ignition circuits and fuel injectors.
3	Data cable	 Connects the Scopebox and diagnostic tool so that the sampled signal can be displayed on the diagnostic tool.
4	Power adaptor	 To supply power to the Scopebox through connection to AC outlet.
5	Battery clamps cable	 To supply power to the Scopebox through connection to vehicle's battery.
6	20:1 Attenuator	 It allows the Scopebox to measure fuel injector and primary ignition waveforms. *Note: Please note this attenuator should be not used for any high voltage measurements other than fuel injectors and primary ignition.

7	Secondary ignition pick-up	 This ignition pick-up is applied in the following situations: Secondary-distributor ignition analysis, Secondary-simultaneous ignition analysis and Secondary-direct ignition analysis. It has three ends: BNC connector (for connecting to CH1/CH2/CH3/CH4), crocodile clip (for Grounding) and high-voltage clip (for connecting high-voltage line), near which has an attenuator equipped for high-pressure attenuation to prevent the Scopebox from being impacted. *Notes: 1). The high voltage clip should be clamped on the insulated lead (COP Extension Cord, see Item 8) instead of on the spark plug to prevent breakdown and electric shock. 2). Please try to keep an instance of 2 inch from other high-voltage line to avoid the interference.
8	COP (Coil-on-Plug) Extension Cord	 Coil-on-Plug extension cord (including earth cord) allows you to take accurate secondary ignition measurements on secondary-direct (Coil-on-Plug)

		ignition systems. It can be applied in the condition that there are no, or limited access to any spark plug leads.
9	Multimeter probes	
10	Crocodile clips	 Designed to connect the bare terminals or leads.
11	Back Probe Pins Suite	 They are mainly used for piercing the insulation of wires to allow for automotive electrical measurements without causing damage to the wires. Additionally they can be used as pin-tip probes while working with small circuit boards.

12.3 Connection & Initial Use

12.3.1 Probe Compensation

Perform this function to match the characteristics of the probe (optional) and the channel input. The probe that has not been compensated may cause measurement tolerance or error.

1. Set the switch to "X10" (the default is X1) on the probe and connect it to the any Channel of the Scopebox.
2. Follow Steps 1-2 in Item 2 "Connection" mentioned below to connect the Scopebox and diagnostic tool. Launch the App and open "Scope" to run it.
3. From the "Vertical Setting" menu, select the corresponding channel and set the Probe attenuation to 1:10.
4. Attach the probe tip to the Probe Compensator and the ground nip of the reference lead to the ground connector. When using the probe hook-tip,

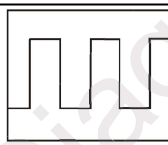
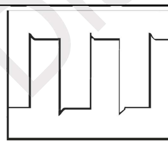
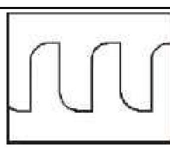
insert the tip onto the probe compensator firmly to ensure a proper connection.

Fig 12-2

5. Tap the  button located on the bottom of the screen, a square wave (approximately 1kHzm 2V peak-to-peak) will be displayed within several seconds.

   *Note: The above steps also can be applied to check whether the signal input/output of other Channels are normal or not.

   Check the shape of the displayed waveform to determine whether the probe is correctly compensated.

Correctly Compensated		
Over Compensated		*Note: If necessary, use a non-metallic tool to adjust the trimmer capacitor of the probe for the fattest square wave being displayed on the Scopebox.
Under Compensated		

*Warning: To avoid electric shock while using the probe, make sure the insulated cable is perfect, and do not touch the metallic portions of the probe head while it is connected with a high-voltage source.

12.3.2 Connection

For different applications, the connection methods may vary.

1. Power the Scopebox on: Power is provided to the Scopebox in either of the following ways:
   - _Power adaptor_: Insert one end of the power adaptor into the Power interface of the Scopebox, and the other end to the AC outlet.
   - _Battery clamps cable_: Plug one end of the power adaptor into the Power interface of the Scopebox, and then clamp the other two terminals to the vehicle's battery (Red to +, and Black to -) respectively.
2. Connect the B-shaped terminal of the data cable to the data I/O port of the Scopebox, and the other end to the data I/O port of the diagnostic tool.

A. While testing sensors or actuators,

3. Connect the BNC connector of the BNC to 4mm test lead to the CH1/CH2/CH3/CH4, and plug the black (GND) and red (SIGNAL) 4mm connectors into the Black (GND) and other color (SIGNAL) banana sockets of the 6-way breakout leads respectively.

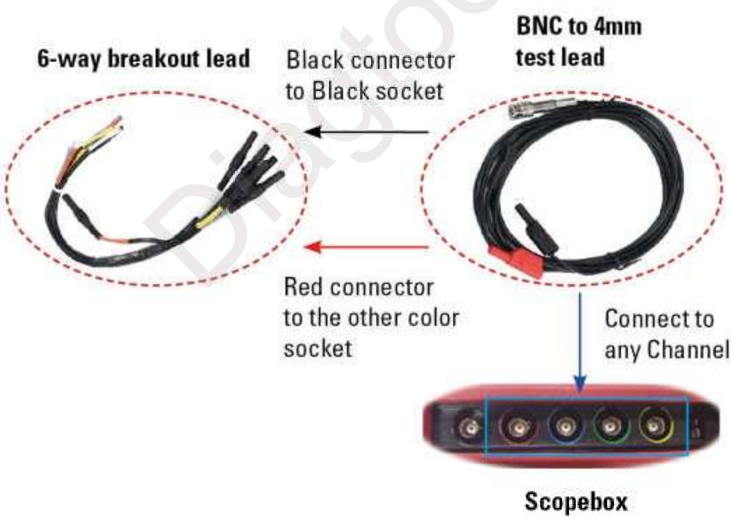


Fig. 12-3

4. Connect the black terminal and signal wire (its other end connected to the red 4mm connector) of the 6-way breakout lead to the GND and signal terminal of the vehicle sensor.

B. While testing Secondary-distributor ignition analysis/Secondary-simultaneous ignition analysis,

3. Connect the BNC connector of the secondary ignition pick-up to any channel of the Scopebox, and clamp the crocodile clips and high-voltage clips onto the vehicle ground and high-voltage line respectively.

   The connection is as follows:

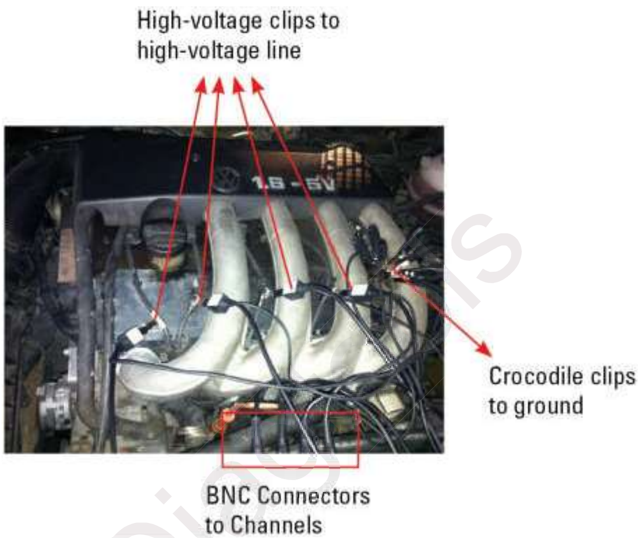


Fig. 12-4

   For detailed operations, please refer to Chapter 13.

C. While testing Secondary-direct ignition analysis,

3. *When the high-voltage wire is exposed*, plug the BNC end of secondary ignition pickup into CH1/CH2/CH3/CH4 channel of Scopebox, then connect the high-voltage clip to high-voltage line, and crocodile clips to ground.
4. *If no high-voltage wire is exposed*, dismantle ignition coil of tested cylinder. Connect one end of the COP extension cord to the ignition coil which should be grounded via COP earth cord, and insert the other end into the cylinder to joint with spark plug. Then plug the BNC end of secondary ignition pickup into CH1/CH2/CH3/CH4 channel of Scopebox, and then connect the high-voltage clip to high-voltage line, and crocodile clips to ground.

   The connection is as follows:

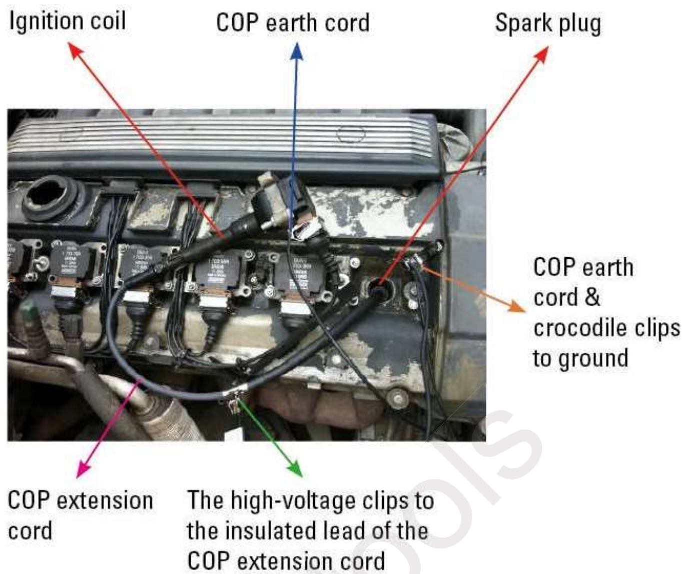


Fig. 12-5

For detailed operations, please refer to Chapter 13.

12.3.3 Initial interface introduction

Fig. 12-6 displays the initial interface of the Scopebox.

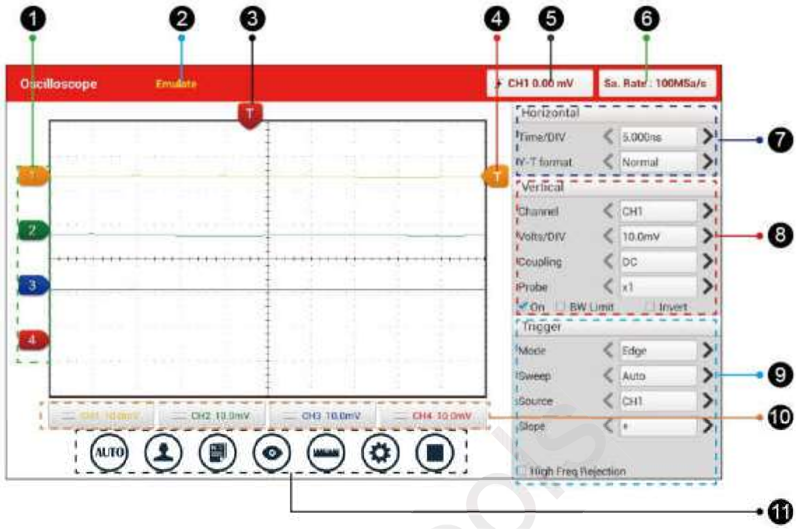


Fig. 12-6

No.	Descriptions
1	Displays the CH1/CH2/CH3/CH4 information: Readouts show the coupling and vertical scale factors of the channels. A “B” icon indicates that the channel is bandwidth limited.
2	Working mode
3	Horizontal trigger position marker
4	Edge trigger level marker
5	Displays the trigger information, including the edge trigger slope, source and level.
6	Sample rate
7	Horizontal Settings Panel: Controls the time base.

8	Vertical Settings Panel: Controls the amplitude of the displayed signal. User can change the volt/div, coupling and probe attenuation of the CH1/CH2/CH3/CH4.
9	Trigger Settings Panel: Controls the start event of the sweep.
10	Channel Selection Button
11	Function Menu [Auto]: It indicates auto trigger setting. [Ref]: There are expert reference and base reference available. Expert reference enables you to recall your customized expert database, whereas base reference provides automatic pre-setting function of specialized sensors. [File]: Provides save snapshot, snapshot manager, waveform record and waveform replay. [View]: Calibration and display settings are available. [Measure]: Includes signal source measurement, horizontal measurement, vertical measurement and clear measurement. [Settings]: Shows/hides the parameter settings area including horizontal settings, vertical settings and trigger settings. / [Start/Stop]: Starts/stops collecting waveforms.

12.4 Operations

12.4.1 Channel selection and attributes setting

<1> Channel selection

There are two ways available for channel selection:

A. Select from the channel tab shown at the bottom of the waveform display area

B. Select from Vertical settings

*Note: For better comparison and identification, each channel and waveform are marked in different colors.

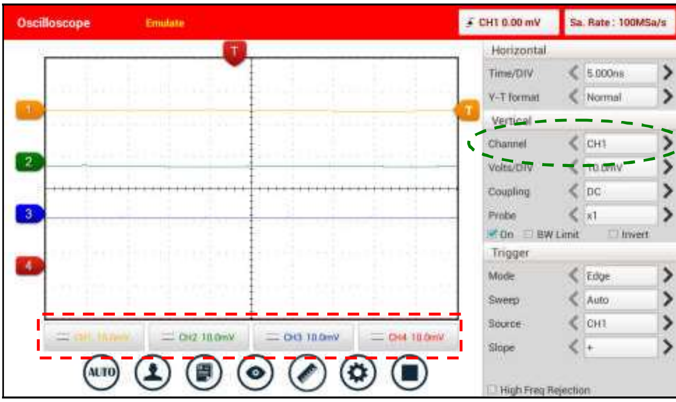


Fig. 12-7

<2> Channel attributes & trigger setting

Channel attributes can be set via horizontal settings and vertical settings.

Horizontal Settings

User can make some settings directly by tapping < or > next to options.

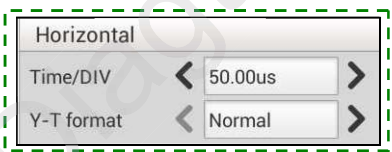


Fig. 12-8

Options descriptions:

Menu	Comments/Settings
Time/DIV	Horizontal scale. If the waveform acquisition is stopped (using the / button), the Time/DIV selector expands or compresses the waveform.
Y-T format	The conventional oscilloscope display format. It shows the voltage of a waveform record (on the vertical axis) as it varies over time (on the horizontal axis).

Vertical Settings

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

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

User can make some settings directly by tapping < or > next to options.

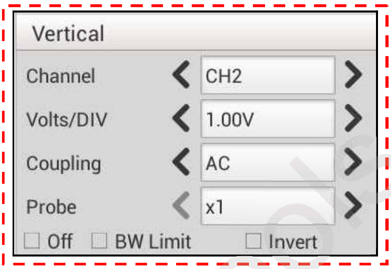


Fig. 12-9

Options descriptions:

Menu	Comments/Settings
Channel	To select the channel source.
Volts/DIV	It is defined as "Volts/Division" and mainly used to change the resolution.
Coupling	Trigger coupling determines what part of the signal passes to the trigger circuit. AC, DC and Ground are included: AC: Blocks the DC component of the input signal. DC: Passes both AC and DC components of the input signal. Ground: Disconnects the input signal.
Probe	When using a probe, the Scopebox allows you to select the attenuation factor for the probe. The attenuation factor changes the vertical scaling of the Scopebox so that the measurement results reflect the actual voltage levels at the probe tip.

BW Limit	ON: Limits the channel bandwidth to 20MHz to reduce display noise. OFF: Get full bandwidth.
Invert	ON: Turn on the invert function. OFF: Restore to the original display of the waveform.

Trigger setting

Trigger indicates that when certain waveform meets the conditions that are predefined according to the requirements, the Scopebox acquires the waveform and its adjacent section, and then presents it on the screen.

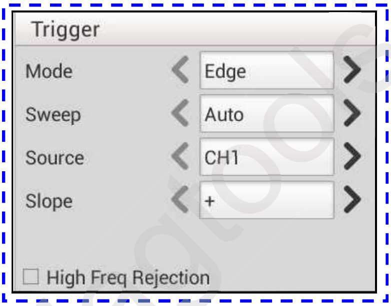


Fig. 12-10

1) If **Edge** trigger is selected (An edge trigger determines whether the Scopebox finds the trigger point on the rising or the falling edge of a signal.):

Menu	Comments/Settings
Sweep	The sweep mode determines how the Scopebox behaves in the absence of a trigger event. The Scopebox provides three trigger modes: Auto, Normal, and Single. Auto: It allows the Scopebox to acquire waveforms even when it does not detect a trigger condition. If no trigger condition occurs while the Scopebox is waiting for a specific period, it will force itself to trigger. When forcing invalid triggers, the Scopebox can not synchronize the waveform, and then waveform seems to roll across the display. If valid triggers occur, the display becomes stable on the screen.

	Normal: This mode allows the Scopebox to acquire a waveform only when it is triggered. If no trigger occurs, the Scopebox keeps waiting, and the previous waveform, if any, will remain on the display. Single: In this mode, it only acquires the waveform that generates for the first time the trigger conditions are met, and then stops after finishing capture.
Source	Select which channel as trigger signal.
Slope	+ : Trigger on rising edge - : Trigger on falling edge
High Freq Rejection	Reject high frequency signals when selected.

2) If **Pulse Width** trigger is selected (Pulse trigger occurs according to the width of pulse. The abnormal signals can be detected through setting up the pulse width condition):

Menu	Comments/Settings
Sweep	The sweep mode determines how the Scopebox behaves in the absence of a trigger event. The Scopebox provides three trigger modes: Auto, Normal, and Single. Auto: It allows the Scopebox to acquire waveforms even when it does not detect a trigger condition. If no trigger condition occurs while the Scopebox is waiting for a specific period, it will force itself to trigger. When forcing invalid triggers, the Scopebox can not synchronize the waveform, and then waveform seems to roll across the display. If valid triggers occur, the display becomes stable on the screen. Normal: This mode allows the Scopebox to acquire a waveform only when it is triggered. If no trigger occurs, the Scopebox keeps waiting, and the previous waveform, if any, will remain on the display. Single: In this mode, it only acquires the waveform that generates for the first time the trigger conditions are met, and then stops after finishing capture.

Source	Select which channel as trigger signal.
Condition	To select pulse condition.
Pulse Width	Set required pulse width.
High Freq Rejection	Reject high frequency signals when selected.

12.4.2 Auto

The Scopebox has an Auto feature that sets up the Scopebox automatically to display the input signal in a best fit.

Tap , the Scopebox may change the current settings to display the signal. It automatically adjusts the vertical and horizontal scaling, as well as the trigger coupling, position, slope, level and mode settings.

12.4.3 View Settings

<1> Calibration

This option adjusts the Scopebox's internal circuitry to get the best accuracy. Use this function to calibrate the Scopebox's vertical and horizontal systems.

Tap  and then tap [Calibration], a dialog box similar to Fig. 12-11 will appear.

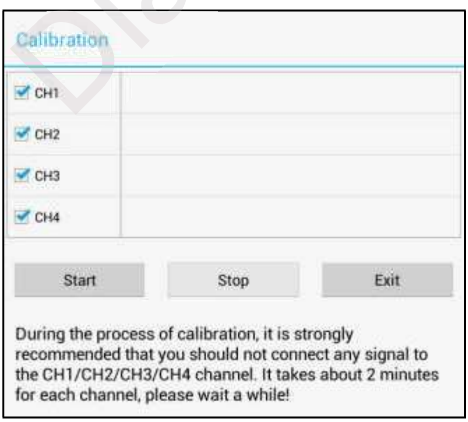


Fig. 12-11

Check the box before the channel to select it. To deselect it, just uncheck it. After choosing the desired channel(s), tap [Start] to start calibration and [Start] button will be temporarily invalid during calibrating. Tap [Stop] to stop calibrating. Once it becomes active, it indicates calibration has completed.

*Note: In process of calibration, make sure CH1/CH2/CH3/CH4 has no signal input. Moreover, calibration may take several minutes and please be patient to wait.

<2> REF settings

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

Tap and then [REF] to enter the REF setting screen.

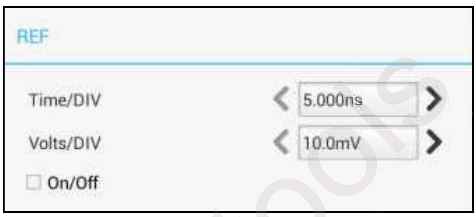


Fig. 12-12

Tap < or > to select the desired reference value for time/DIV and volts/DIV. To show or hide the REF, just check/uncheck the box before On/Off.

<3> Display settings

Tap and then [Display settings] to enter the setting screen.

Fig. 12-13

Select “Vectors” or “Dots” to display waveforms as vectors or dots. Check / uncheck the box before Grid to turn on/off grid display.

12.4.4 Measure

<1> Channel source

Tap and then [Source], a screen similar to Fig. 12-14 will appear.

Fig. 12-14

<2> Horizontal / Vertical measure

Horizontal Measure / Vertical Measure are used to measure voltage parameter and time parameter respectively. Drag A line upwards or downwards to control voltage. Move A line left or right to fine-tune timebase. A line is a solid line and B line is a dotted line.

Tap and then [Horizontal Measure], a screen similar to Fig. 12-15 will appear.

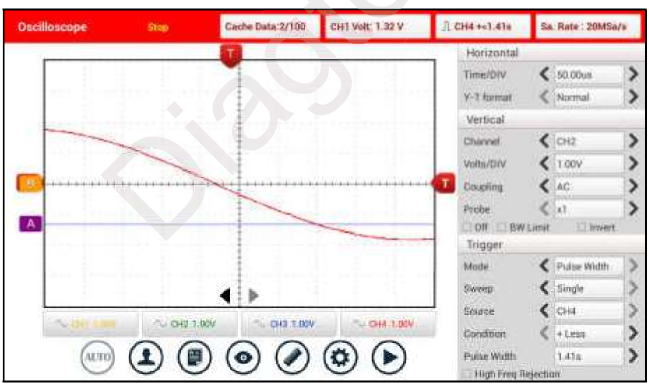


Fig. 12-15

*Note: If no desired channel is selected, the system will take the current source as the default channel.

<3> Clear measure

Tap and then [Clear Measure], the system will clear the measurement result on screen.

12.4.5 File management

<1> Save snapshot

While viewing sampling data, tap and then [Save Snapshot] to store the current screen.

<2> Snapshot manager

While viewing sampling data, tap and then [Snapshot Manager] to enter. View, delete and edit operations are supported.

<3> Record waveform

This function is used to record input waveforms that are acquired by the Scopebox at a specific period, and save it as waveform file which can be recalled in future.

It can be performed only when the Scopebox is collecting data in Normal mode.

Tap , then select [Record] from the pop-up menu to start recording.

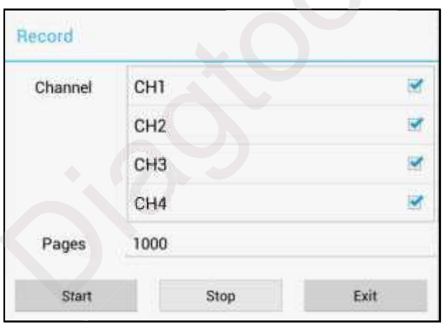


Fig. 12-16

Tap [Start] to start recording with a minimum record length of 10 frames, and [Stop] to stop recording. While recording, the recorded pages will be shown on the screen.

<4> Load waveform for playback

The Import function enables you to import the stored waveform file for playback and review. During replaying, the Scopebox stops collecting data automatically.

Tap , then select [Waveform replay] from the pop-up menu to enter:

Fig. 12-17

Select the file first, and then tap to open the waveform file. Tap to starting the playback and tap to stop it.

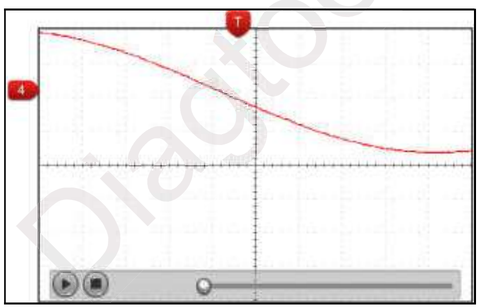


Fig. 12-18

To delete the waveform file, tap .

Tap to return to the previous screen.

12.4.6 Expert reference

<1> Expert Reference

By default, it appears blank. As a matter of fact, Expert reference database is generated by doing the following:

1. Open and edit a snapshot;
2. Select "Joint the expert database" (refer to the following illustration), and then tap to save the waveform being displayed on the screen as REF.

Fig. 12-19

Tap and then [Expert Reference] to enter, the following operation can be done:

: To load and recall the selected file.

: To delete the selected file.

: To edit the selected file.

<2> Base Reference

Preset waveforms of some sensors are available for your reference.

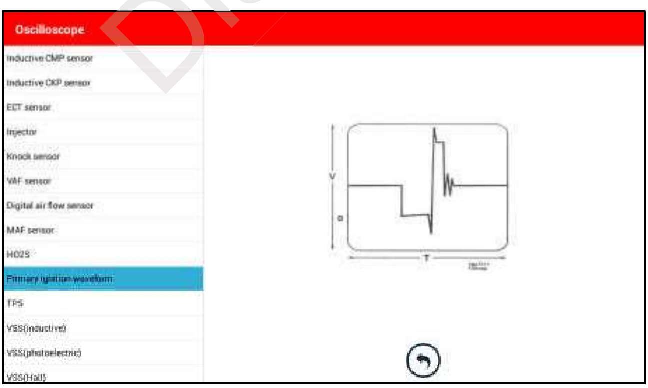


Fig. 12-20

13 Automotive Ignition waveform (Toolbox)

The ignition system is the system which has greatest impact on the performances of gasoline engine, as the statistical data shows that nearly half of the failures are caused by poor work of electrical system. And the performance tests of engine often start from the ignition system. Nowadays ignition system includes distributor and distributorless. Distributorless includes independent ignition and simultaneous ignition.

1. Distributor ignition system i.e. contact breaker with contact-controlled ignition system (commonly known as the platinum) and contact breaker with noncontact-controlled ignition system combined with magnet, hall components or infrared.
2. Independent ignition system: crankshaft sensor send out the ignition timing signal and cylinder identification signal so that the ignition system can send out ignition signal to specified cylinder in specified time, each cylinder has its independent ignition coil.
3. Simultaneous ignition system: two cylinders share one ignition coil, when two cylinder pistons reach top dead center at the same time (one is compression, another is the exhaust), two spark plugs will be ignited at the same time, at this time, the ignition for the former cylinder is in high-pressure low temperature gas mixture, the ignition is valid, while for the latter one is in low-pressure high temperature exhaust gas, the ignition is invalid.

The tablet can test and analyze the secondary signal for various engine ignition systems.

13.1 Secondary-distributor ignition analysis

The following connection should be made before performing it:

1. Power the Scopebox on: Power is provided to the Scopebox in either of the following ways:
   - *Power adaptor*: Insert one end of the power adaptor into the Power interface of the Scopebox, and the other end to the AC outlet.
   - *Battery clamps cable*: Plug one end of the power adaptor into the Power interface of the Scopebox, and then clamp the other two terminals to the vehicle's battery (Red to +, and Black to -) respectively.

2. Connect the B-shaped terminal of the data cable to the data I/O port of the Scopebox, and the other end to the data I/O port of the diagnostic tool.
3. Plug the BNC end of secondary ignition pickup into CH1/CH2/CH3/CH4 channel of the Scopebox, and connect the high-voltage clip to high-voltage line, and crocodile clips to ground.

*Tips: Common ignition sequence (the specific sequence is subject to the actual engine ignition sequence)

Four-stroke in-line four-cylinder: 1-2-4-3, or 1-3-4-2

Four-stroke in-line six-cylinder: 1-5-3-6-2-4, or 1-4-2-6-3-5

Four-stroke in-line eight-cylinder: 1-8-4-3-6-5-7-2

Five-cylinder: 1-2-4-5-3

V 6 engine: generally speaking, based on the person sitting on the driver cab, if the right side cylinder numbers on the right side, from the front to the back are as follows: 1, 3, 5; and the cylinder numbers on the left side, from the front to the back are as follows: 2, 4, 6; then the ignition sequence is: 1 − 4 − 5 − 2 − 3 − 6. If the cylinder numbers on the right side, from the front to the back are as follows: 2, 4, 6; and cylinder numbers on the left side, from the front to the back are as follows:1, 3, 5; then the ignition sequence is: 1 − 6 − 5 − 4 − 3 − 2.

Figure 13-1 below shows the normal ignition waveform of distributor ignition system, the upper one is the secondary waveform, and the lower one is the primary waveform.

The secondary waveform

A section is contact open period; B section is make contact period, which is the magnetizing field of ignition coil.

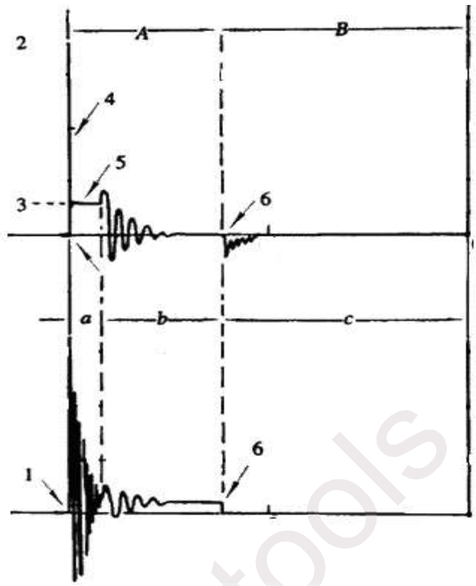


Fig. 13-1

1) Contact break point: the primary circuit of ignition coil cut off, the secondary voltage was sensed and increased sharply.
2) Ignition voltage: secondary coil voltage overcome the damper of high voltage line, the contact breaker gap and the spark plug gap to release magnetizing energy, 1-2 section is the breakdown voltage
3) Spark voltage: For the capacitor discharge voltage
4) Ignition voltage pulse: For the charge and discharge sections
5) Spark line: The inductance discharge process, i.e. the mutual inductance voltage of ignition coil maintains the conduction of secondary circuit
6) Contact point close the current flow into primary coil, the primary coil oscillates due to the mutual inductance.

Primary ignition waveform

Section **a** shows the voltage oscillation on the primary circuit due to the magnetic induction of spark in the duration;

Section **b** shows the damped oscillation generated by remaining magnetic field energy after the spark;

Section **c** shows the make contact magneting period of primary coil.

Seen from the waveform, the amplitudes of breaker contact closed angle, break angle and breakdown voltage and spark voltage are very clear, besides, the spark delay period and two oscillations can also be tested. For the ignition system without faults, compared with the whole cycle, the contact closed angle just 45%-50% (four-cylinder), 63%-70% (six-cylinder), or 64%-71% (eight-cyliner); the breakdown voltage is over 15kv; the spark voltage is about 9kV, the spark period is greater than 0.8ms. If these values or waveform are abnormal, it means there is fault or the system needs to be adjusted.

13.2 Secondary-simultaneous ignition analysis

The following connection should be made before performing it:

1. Power the Scopebox on: Power is provided to the Scopebox in either of the following ways:
   - *Power adaptor*: Insert one end of the power adaptor into the Power interface of the Scopebox, and the other end to the AC outlet.
   - *Battery clamps cable*: Plug one end of the power adaptor into the Power interface of the Scopebox, and then clamp the other two terminals to the vehicle's battery (Red to +, and Black to -) respectively.
2. Connect the B-shaped terminal of the data cable to the data I/O port of the Scopebox, and the other end to the data I/O port of the diagnostic tool.
3. Connect the BNC connector of the secondary ignition pick-up to any channel of the Scopebox, and clamp the crocodile clips and high-voltage clips onto the vehicle ground and high-voltage line respectively.

   The connection is as follows:

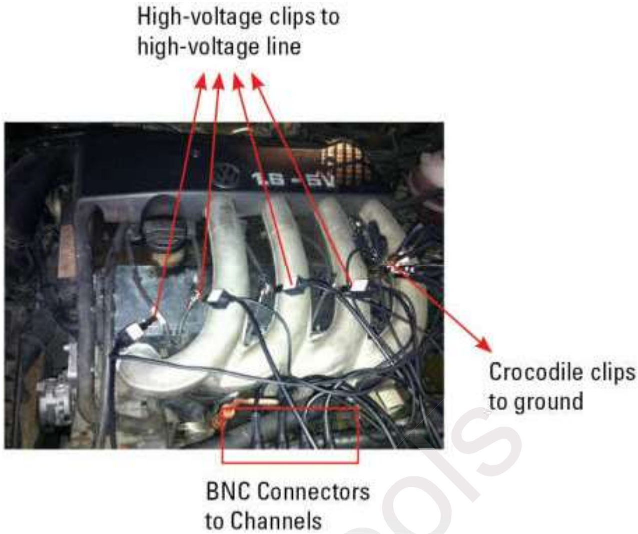


Fig. 13-2

Fig. 13-3 below shows the valid and invalid ignition waveforms. Under the working status of valid ignition, the breakdown voltage and spark voltage are higher because the cylinder is filled with fresh combustible mixture gas, which has a lower ionization level and vice versa.

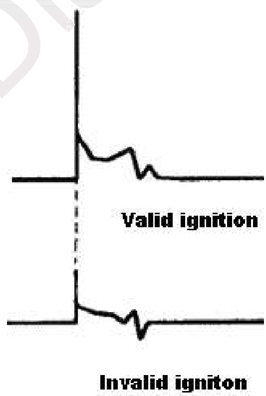


Fig. 13-3

13.3 Secondary-direct ignition analysis

Connection：

1. Power the Scopebox on: Power is provided to the Scopebox in either of the following ways:
   - *Power adaptor*: Insert one end of the power adaptor into the Power interface of the Scopebox, and the other end to the AC outlet.
   - *Battery clamps cable*: Plug one end of the power adaptor into the Power interface of the Scopebox, and then clamp the other two terminals to the vehicle's battery (Red to +, and Black to -) respectively.
2. Connect the B-shaped terminal of the data cable to the data I/O port of the Scopebox, and the other end to the data I/O port of the diagnostic tool.
3. *When the high-voltage wire is exposed*, plug the BNC end of secondary ignition pickup into CH1/CH2/CH3/CH4 channel of Scopebox, then connect the high-voltage clip to high-voltage line, and crocodile clips to ground.
4. *If no high-voltage wire is exposed*, dismantle ignition coil of tested cylinder. Connect one end of the COP extension cord to the ignition coil which should be grounded via COP earth cord, and insert the other end into the cylinder to joint with spark plug. Then plug the BNC end of secondary ignition pickup into CH1/CH2/CH3/CH4 channel of Scopebox, and then connect the high-voltage clip to high-voltage line, and crocodile clips to ground.

   The connection is as follows:

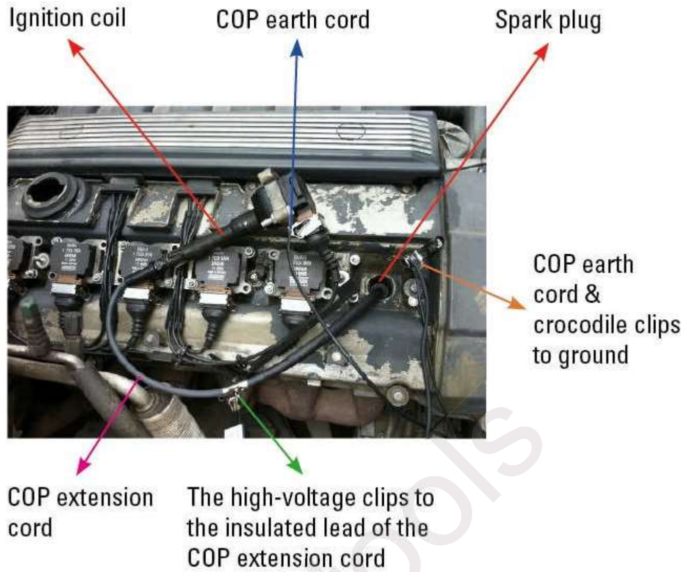


Fig. 13-4

Fig. 13-5 shows the normal secondary (the upper one) and (the lower one) primary ignition waveform of direct ignition system. Beause the on/off of primary circuit is not opening/closing of mechanical contact, but the conduction of transistor. The primary voltage has no obvious oscillations within the duration, but the voltage increases during the magnetization process due to current limiting, and this change can cause corresponding fluctuations of secondary voltage line as a result of induction of ignition coil.

Fig. 13-5

13.4 Waveform analysis mode

The ignition secondary single-cylinder waveform test is mainly used to:

a. Analyze the ignition dwell angle of single cylinder.(ignition coil charging time)
b. Analyze the capability of ignition coil and secondary high tension circuit (from ignition line to ignition voltage line).
c. Find the improper mixture A/F ratio of single cylinder (from combustion line).
d. Analyze the capability of capacitance (platinum or ignition system).
e. Find the spark plug that causes misfire of the cylinder (from combustion line).

This test can provide very meaningful information about the combustion quality for each cylinder. If necessary, this test can also be performed during driving. Since the secondary ignition waveform is significantly affected by different engines, fuel systems and ignition conditions, it is useful for detecting the faults of engine mechanical parts, fuel system components, and ignition system components. Different parts of the waveform can specify that some components and systems on the specific cylinder have faults. Refer to the instructions for various parts of waveform for the related component working status of specific waveform section.

Test methods and conditions:

Start the engine or drive the vehicle according to the driving performance fault or poor ignition, etc. Confirm the consistence of judgment standard (the amplitude, frequency, shape and pulse width, etc., for each cylinder), check the fault of the waveform for corresponding components.

Waveform results: observe the ignition coil at the beginning of charging, the relative consistent falling edge represents the dwell angle and ignition timing of each cylinder are precise.

Ignition line:

Observe the height consistence of flashover voltage. Too high flashover voltage (even out of the oscilloscope screen) represents a high resistance existed in the ignition secondary circuit (for example, open circuit, or damaged spark plug or high voltage line, or too large time gap on spark plug), while the too short sparking voltage represents the resistance of ignition secondary circuit is lower than normal value (due to pollutant and broken spark plug or the high voltage line of spark plug has electrical leakage, etc.).

Spark or combustion voltage:

Observe the consistence of spark or combustion voltage, as it represents the consistence of spark plug and the air-fuel ratio of each cylinder. In case that the mixing ratio is too lean, the combustion voltage will be lower than normal value.

Combustion line:

Observe the spark or the combustion line which shall be clean with few clutter, as lots of clutter indicates the cylinder has poor ignition due to ignite too early, damaged nozzle, pollutant spark plug, or other reasons. The duration of combustion line indicates the mixing ratio of the cylinder is abnormal lean or rich. Too long combustion line (usually greater than 2ms) represents the mixing ratio is rich, whereas too short of combustion line (usually less than 0.75ms) represents the mixing ratio is lean.

Ignition coil oscillation:

Observe at least two oscillation waveforms after the combustion line, which will be better if more than three oscillation waveforms, as it represents the ignition coil and capacitor (on Platinum or ignition system) are normal.

Primary voltage analysis

According to the faulty primary voltage waveform collected by the ignition analysis, the related components and mechanical equipment status of ignition system electrical circuit can be analyzed, which provides a reliable basis for the adjustment and maintenance of power circuit to avoid the blind demolition.

The waveform shown on Fig. 13-6, appears a lot of clutter on the contact break point, which is obviously caused by the serious erosion on contact break point. It can be verified via burnishing the contact or changing the circuit breaker.

Fig. 13-6

For the primary voltage waveform shown on Fig. 13-7, the damped attenuation cycles obviously reduced on the spark period, the amplitude became lower, which is evidently caused by capacitor leakage.

Fig. 13-7

The waveform on Fig. 13-8 shows the accidental pumping during contact closing period. The irregular beating is caused by insufficient spring force.

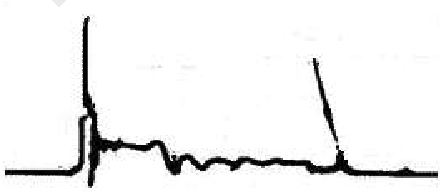


Fig. 13-8

The curve on Fig. 13-9 shows the contact angle is too small during the magnetizing period, which is caused by too large contact gap.

Fig. 13-9

A lot of clutter will be displayed on the horizontal section of primary waveform if contact has poor grounding, as shown below figure 13-10.

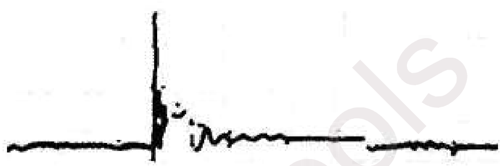


Fig.13-10

Fig. 13-11 shows the fault of low-voltage waveform in electronic ignition system. The voltage does not rise during magnetizing, which indicates that the effect of limitation of the circuit failed and no components on distributorless ignition system can be adjusted. When this waveform is abnormal, you can only replace the ignition coils, igniter, ignition signal generator and cam position sensor, etc., one by one, to find out the faulty component or module.

Fig. 13-11

The secondary waveform is also affected by the spark plug, the combustion process, mixture gas composition, the engine thermal state of the ignition coil, etc., which is more complicated. The following lists a large number of measured secondary faulty waveform for reference. Since various factors lead to the failures, Fig. 13-12 just shows the major possible factors for the failures.

Secondary circuit resistance is too large

Oil or coke was attached in spark plug

Spark plug gap is too large or mixture gas is too lean

Injector of electronic fuel injection poor work

Spark plug overheated or value guide leakage

Mixture ratio is too rich or spark plug leak electricity

Mixture ration is too lean or cylinder pressure is too low

Distributor cover or distributor lead is matched un-tightly

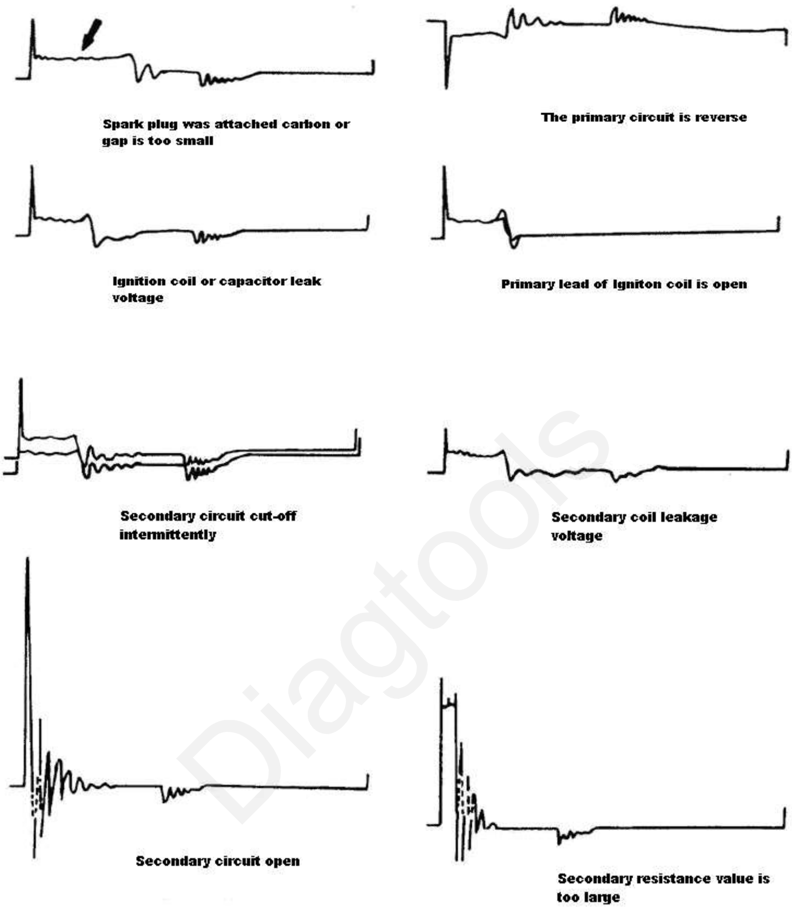

Spark plug was attached carbon or gap is too small
The primary circuit is reverse
Ignition coil or capacitor leak voltage
Primary lead of Igniton coil is open
Secondary circuit cut-off intermittently
Secondary coil leakage voltage
Secondary circuit open
Secondary resistance value is too large

Fig 13-12