VS200 Automotive&Multimeter

User's Manual

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PRECISION A SU MEDIDA®

Brief introduction

VS200 Automotive&Multimeter is a 20MHz digital storage oscilloscope,6000 words True RMS Digital Multimeter, automotive electronics measurement functions integrated multifunctional handheld instrument, ideal for field use.

The main function

- 3-channel ,20MHz digital storage oscilloscope
- True 6000 words RMS digital multimeter
- Automotive electronic measurement: sensors, actuators, ignition systems, electrical component testing

Features

- 100MSa / s real-time sampling rate, 20MHz real-time bandwidth
- Automotive electrical measurements, 51 kinds of automotive standards Reference Waveform
- Automatic tracking measurement: automatic tracking based on external input signal to adjust the vertical amplitude \ horizontal time base and trigger stalls, without human intervention
- Large dynamic measurement range: no extended probe leads directly measure range from 10mV/div to 500V/div
- Screen can display 4 measurement parameters：the user can choose RMS, peak, average, frequency, period, in 22 kinds of parameters as needed, etc.
- Two kinds of cursor measurement mode selection
- 320 * 240 dot TFT LCD,
- Built-in battery, AC and DC
- Recorder --- continuous track record up to 12 hours of event
- Standard USB interface, through the PC software can easily communicate with a computer for data analysis and test results archive

General Safety Requirement

Carefully read the following safety information to avoid personal injury and the damages of this product or any other connected products. To avoid all possible dangers, this product only should be used in stated range.

Only an eligible technologist has the maintenance right

Avoiding fire or personal injury

Use the proper power adapter. Use only the power supply or sanctified power adapter.

Connect or disconnect correctly. Do not connect or disconnect probes and test leads at will when they are connected to the power.

Notice all terminals' ratings. To avoid electrical shock or fire, notice carefully all ratings and signs of this product. And read carefully the users manual to get more information about the ratings before connect to this product.

Do not operate the meter without its cover. Do not use the meter if its cover or panel has been unloaded.

Avoid touching bare circuit. Do not touch the bare nodes or parts of the product with power on.

Do not operate with dubious troubles. If you have dubious troubles on the product, let an eligible technologist have a check.

Do not operate under a humid environment.

Do not operate under an explosive environment.

Keep the meter clean and dry.

Safety terms and signs

This manual is possible to show following terms

⚠ **Warning.** The word Warning indicates that the condition or the operation maybe cause personal injury.

⚠ **Carefully.** The word Carefully indicates that the condition or the operation maybe cause the damages of this product or other properties

Package Checklist

The following items are included in this Instrument package.

No.	Description	Quantity	Remark
1	VS200 Automotive&Multimeter	1	
2	Li Battery Pack	1	installed
3	AC/DC Power Adapter	1	
4	Oscilloscope Probes	1	
5	Multimeter Test Leads	2	(red, yellow）
6	BNC-banana adapter	1	
7	The back of the input pins (red, yellow, black)	3	Optional
8	Alligator Clips : (red, yellow and black)	3	Optional
9	Secondary Pick-up	1	Optional
10	Inductive Pick-up	1	Optional
11	Current Probe	1	Optional
12	Diesel probe set	1	Optional
13	Temperature probe	1	Optional
14	Users Manual	1	

Chapter I.Recognizing this product

1、 Product Description

1.1 Front Pane

The Product is a handheld portable products, AC and DC power supply, 3.7V lithium battery inside the instrument; external AC-DC adapter with 220/5V can provide external power and charge the lithium battery inside the instrument instrument

1.2 Measurement port

CHA、 CHB： CHA、 CHB is used for all single channel measurements,can be connected through the banana \BNC conversion by oscilloscope probe or with dual banana plug .

In SCOPE mode you can use the instrument as a dual trace oscilloscope with CHA and CHB connected.

COM： Oscilloscope and multimeter measurements common ground port

TRIG:

1）Oscilloscope mode：Used in SCOPE mode to trigger (or start) acquisitions from an external source

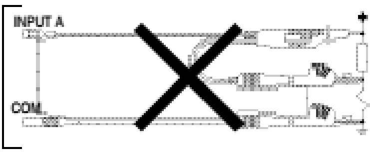
2）Multimeter mode：DC voltage \ AC voltage \ Resistance \ Continuity \ Diode \ capacitance \ current measurement input ports

Note:

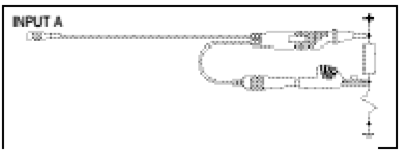
1、Note that each port safety limit, do not exceed the maximum test range。

2、The multimeter testing current mode, you must use the current probe

3、Note that proper grounding



(Incorrect Grounding)



(Correct Grounding)

A ground loop can be created when you use two ground leads connected to different ground potentials. This can cause excessive current through the grounding leads

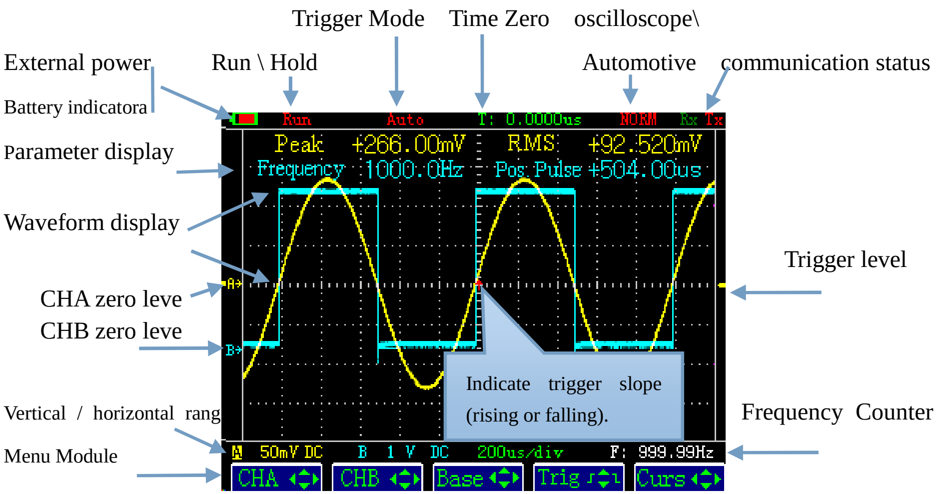
2 Panel keyboard and display interface

2.1 Panel function keys

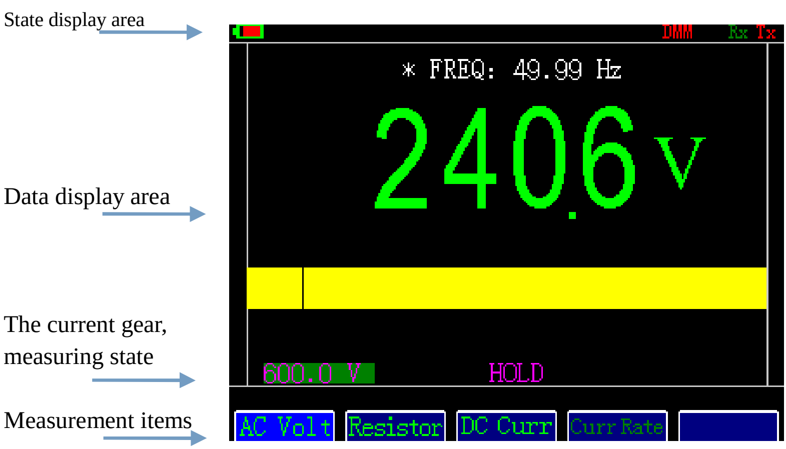
key	Description
F1 F2 F3 F4 F5	Function keys: The function assigned to each key is indicated by the Function Key Label displayed above the key on the bottom display ☞ F1 In most of the menu to return to the previous menu
R/H	Run \ hold, lock screen
AUTO	Sets automatic ranging on and off (toggle). When on, the top right display shows AUTO. When this function is set on, it searches for the best range and time base settings and once found it tracks the signal. When this function is off, you should manually control ranging.
DIV	Oscilloscope mode, press the button, so that the corresponding channel's Voltage Range effectively
nS	Oscilloscope mode, Press the button, making the timebase adjustment effectively
TRG	Oscilloscope mode, select the trigger level \ trigger edge \ trigger source \ trigger mode
MENU	Function key to switch between the main menu
↑ ↓	Move up and down a waveform \ trigger level \ voltage cursor; Manually change the sensitivity level of the base, multimeter voltage \ resistance \ capacitors \ Current gear change; ↑ Can also be used as a return to the previous menu key
← →	Moves a waveform or Time cursor right and left; Ranges amplitude up and dow or Change the trigger edge; Move around and select the current coefficient bits, Menu selection
ON	Turns the power on and off (toggle). When you turn the power on, previous settings are activated.

2.2 Display Interface

2.2.1 Oscilloscope



2.2.2 DMM



3、The main measurement function and menu structure

3.1 The main measurement function

The instrument has the oscilloscope, multimeter, automotive（component） three main measurement function, wherein, the oscilloscope and multimeter are two independent measuring function.

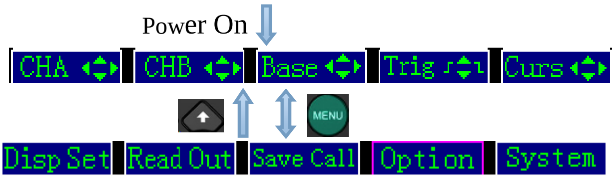
Automotive（component） measurement is an extension of the application on the basis of on the oscilloscope measurements,It is the automotive sensors, actuators, fuel injectors, and dozens of other electrical components measured waveform and the corresponding measurement settings are stored in the instrument, when the user measurements corresponding items directly recall the settings and Reference Waveform, greatly facilitate on-site testing

3.2 Menu structure

The menu has two major main menu module, divided into two screen display，Press  key switch, each screen 5 menu module

The main menu 1

The main menu 2



3.2.1 Oscilloscope menu operation

- **The vertical range**

1） Move up and down channel A \ B waveform and adjust the vertical range

The main menu ：

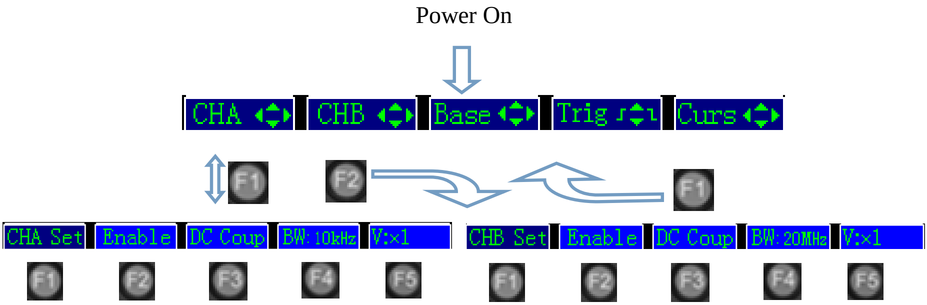
 or  Effective corresponding channel A, or channel B.

 or  Move up and down waveforms.

 or  Adjust the vertical range

Adjust the vertical range：10mV/div～500V/div(No probe attenuation，1:1）

2）Channel A\B other settings



Enable / disable the channel CHA / CHB；

The instrument can display the input A or B input signal waveform in dual-channel oscilloscope mode, the input A and input B signals simultaneously displayed.if the user wants to measure individual signals, selectable single-channel oscilloscope mode, simply connect the input A that to the input B closed; Conversely, if the user wants to simultaneously measure two signals ,directly using dual-channel oscilloscope mode while connected to input A, input B.

Select CHA / CHB signal coupling, **DC coup/AC coup**

DC Coupling allows you to measure and display both the DC and AC components of a signal. AC Coupling blocks the DC component and passes the AC component only.

Select the CHA/CHB bandwidthlimit**BW20MHz/BW10KHz**

There are cases where you may want to filter out noises in order to see a better signal. This can be especially true when ignition noise is present. The instrument provides a noise filter for each input channel which reduces the bandwidth from its normal 20MHz to10KHz. You can enable or disable CH A Filter or CH B Filter using the INSTRUMENT SETUP menu. When enabled, the FILTER indicator appears on the screen.。

Select the CHA/CHB voltage probe attenuation coefficient

V:×1/ **V:×10**/ **V:×100**/ **V:×1000**/ **V:×10000**

Or select the CHA/CHB current probe conversion coefficient

1mA/mV;**10mA/mV**;**0.1A/mV**;**1A/mV**;**10A/mV**

You can according to the probe type CHA or CHB (voltage probe, current probe) to select its corresponding attenuation factor or conversion factor

● Time base range

Main Menu

Or Effective timing adjustment function, or Horizontal compression expansion wave

Time base range: 10ns/div～2h/div

● Trigger

TRIGGER is a set of conditions that determine whether and when acquisitions start. The following will determine the trigger conditions

a) Trigger Edge; b) Trigger Level; c) Trigger Source; d) Trigger mode

1) Changing the trigger edge and trigger level

Main Menu

or TRG Effective trigger function

or Move up and down the trigger level

or Changing the trigger edge ,If you select ↑ , trigger occurs at a rising(positive) edge of the signal. If you select ↓ , trigger occurs at a falling(negative) edge of the signal.

2) Change the trigger mode and select the trigger source

Main Menu to continue F4 or TRG Go to Trigger Set menu

F2 Select CHA trigger; F3 Select CHB trigger;

F4 Select the external signal as the trigger source;

F5 Select trigger mode: **AUTO** \ **NORMAL** \ **SINGLE**

AUTO: The instrument always performs acquisitions, i.e., it always displays the signals on the input.

NORMAL: If NORMAL is selected, a trigger is always needed to start an acquisition

SINGLE: SINGLE allows you to perform single acquisition to snap events that occur only once. R/H is used to start a next single acquisition.

F1 Return to the previous menu

● Cursor

A cursor is a vertical line or a horizontal line placed over the displayed waveform to measure values at certain points.The instrument can measure signal details by using Cursors ,Single cursor mode is suitable for absolute measurements, dual cursor suitable relative measurement。

1）Single cursor measurement mode

Main Menu

F5 Effective single cursor mode, a red horizontal line and a red vertical line appears on the screen, representing the VOLTS and TIME cursors for measuring relative to the reference (amplitude and time) offset value。

or Move the cursor up and down the VOLTS cursor ; higher than the zero level line is positive, below the zero level line is negative.

or To move the TIME cursor left and right; negative at a time reference on the left, at the right time basis is positive。

Note: a single cursor mode is effective for channel A, channel B can be read out at the same time, the double channel value

2）Double cursor measurement model

Continue F5 Into double cursor measurement mode

F2 Effective CHA or CHB cursor

F3 The cursor 1 effective, or Move up and down VOLTS cursor; or to move the TIME cursor left and right。

F4 The cursor2 effective, or Move up and down VOLTS cursor; or to move the TIME cursor left and right。

In this mode, the two cursor is only valid for the current channel, two cursor each channel for the same type of cursor, or VOLTS cursor , or TIME cursor. Each cursor to measure the relative value of the deviation between the reference and the two cursors relative

Two cursor mode can be converted to each other。

In the VOLTS cursor mode, or converted to TIME cursor;

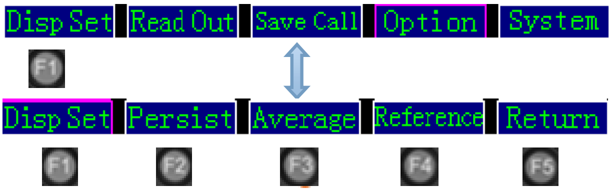
In the TIME cursor mode, or converted to VOLTS cursor.

F5 or F1 Return to the previous menu

- Display Set

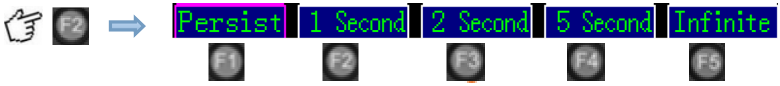
Main Menu

Display Set menu



1） **Persist**

When a new waveform display, before the waveform on the screen does not disappear immediately, but continue for some time, namely persistence time, by setting the persistence time waveform display allows more continuous, and then get a similar analog oscilloscope display



Select the persist time 1Second\2SSecond\5SSecond\Infinite

or  Return to the previous menu

2） **Average**

The average acquisition mode can reduce the display signal of random and unrelated noise, sampling value in real-time sampling mode, and then repeatedly sampled waveform average calculation

In the Display Set menu 

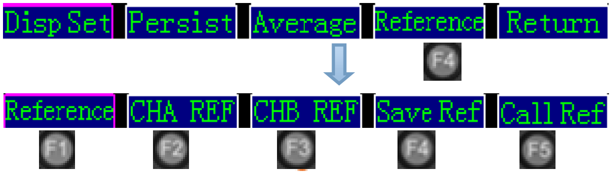
Select the average time 4 times \ 164 times \ 324 times \ 64times

or  Return to the previous menu

3）Reference Waveform

The user can be real-time measured waveform as the standard waveform storage, so the next measurement comparison

In the Display Set menu



F2 Turns the CHA Reference Waveform on and off (toggle).

F3 Turns the CHB Reference Waveform on and off (toggle)

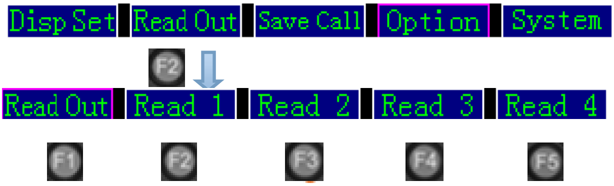
F4 Storage Reference Waveform

F5 Recall Reference Waveform

F1 or Return to the previous menu

- **Read Out**

Main Menu



F2 F3 F4 F5 Set out parameter types 1 to 4

F2 Select the active channel parameter readout(CHA\CHB)； F3 or F4 Select the type of read-out

F5 Open \ close Read out on screen display

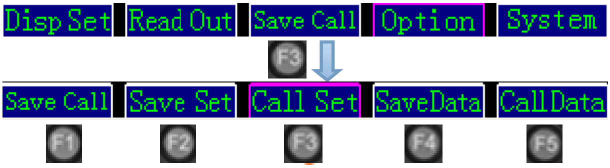
Measurement results can be displayed as numeric values (referred to as readings) and waveform.The types of readings depend on the test taking place:Maximum, minimum, peak, average, RMS and other 21 kinds of parameters for selection

F1 Or Return to the previous menu

- **Save Call**

Main Menu:

Save Call Menu:

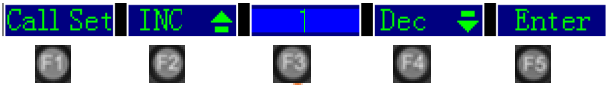


1） Save Call Set

In the Save Call Menu F2

F2 Increase Save set location; F4 Decreased Save set location F3 or F5 ok

In the Save Call Menu F3



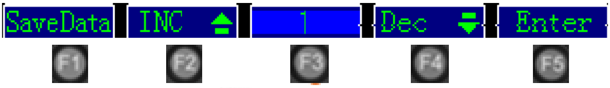
F2 Increase Call set location; F4 Decreased Call set location; F3 or F5 ok 。

Note: a total of 10 storage locations can be used, the factory settings in the tenth memory locations

F1 Or Return to the previous menu

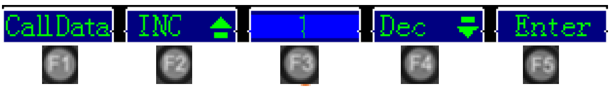
2） Save Call Waveform

In the Save Call Menu F4



F2 Increase Save Data locatio F4 Decreased Save Data location; F3 or F5 ok

In the Save Call Menu F5



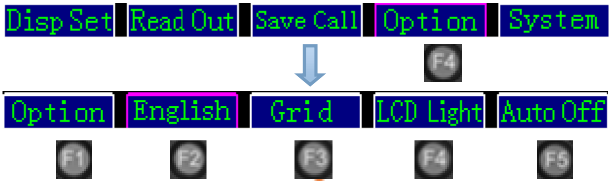
F2 Increase Call Data location; F4 Decreased Call Data location; F3 or F5 ok

F1 Or Return to the previous menu

- ## User Options

Main Menu

User Options Menu



☞ F2 Select Language 中文\English

☞ F3 Open \ close the screen grid

☞ F4 ⇒

☞ F2 Increase the brightness of the LCD， ☞ F4 Reduce the brightness of the LCD

☞ F1 or ⬆ Or F5 Return to the previous menu

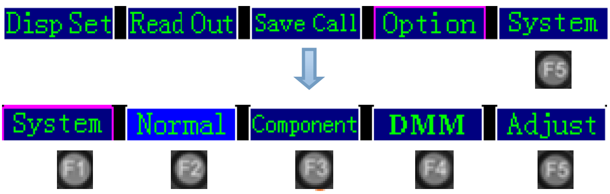
☞ F5 ⇒

☞ F2 Increase the auto-off time， ☞ F4 Reducing the auto-off time

☞ F1 or ⬆ Or F5 Return to the previous menu

- ## System

Main Menu



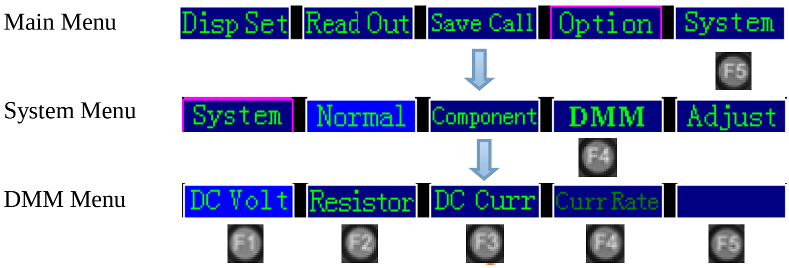
☞ F2 **Normal** ,Oscilloscope mode

☞ F3 **Component,** automotive electronic measurement, detailed operation, see the application of automotive electronics diagnostics and fault section

☞ F4 **DMM**

☞ F5 **Adjust**，This function is not open to users

3.2.2 DMM MENU



F1 Select the DC voltage \ AC voltage

Manually adjust the voltage range 600mV\6V\60V\600V\1000V

F2 Select the Resistance \ Continuity \ Diode \ Capacitance measurements

Note:Multimeter automatic measurement mode by default

Manually adjustable resistance range:600Ω\6KΩ\60KΩ\600KΩ\6MΩ;

Manually adjustable capacitance range:6nF\60nF\600nF\6uF\60uF\600uF\6mF

F3 Select DC \ AC current

F4 Set current coefficient Select the position to be adjusted.

Increased or Decrease the number

F5 Return to the previous menu

MENU F3 Exit multimeter mode, return the oscilloscope to measure

Chapter II、Use instrument

1、Oscilloscope

SCOPE mode provides a display of signal patterns from either CH A or CH B over times ranging from 10ns to 2Hours per division, and for voltage ranges from 10mV to 500 V full scale.

Using Single and Dual Input Scope Mode The instrument can be configured to show scope displays for either CH A or CH B signals: In DUAL INPUT SCOPE mode, both CH A and CH B may be displayed at the same time.

Use SINGLE INPUT SCOPE mode if you want to measure a single signal, INPUT B is turned off.
Use DUAL INPUT SCOPE mode if you want to simultaneously measure two signals.

1.1 Test connection

The instrument has two kinds of test connection options

1）Use BNC-banana plug adapter head (note polarity), using an oscilloscope probes or BNC cable

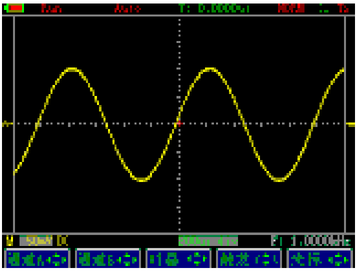
2） Use a multimeter pen directly

Note：The oscilloscope bandwidth can be up to 20MHz, while the banana plug line width ≤ 6MHz, so when measuring the high frequency signals in order to guarantee the measurement precision, using the first connection recommendation。

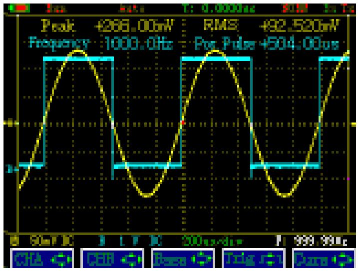
1.2 Oscilloscope measurement applications

- **Automatically capture waveform**

When you enter the scope mode, the instrument automatically optimizes vertical range, time base, and trigger settings to create a stable display. (Auto ranging is default)。



Single-channel measurements

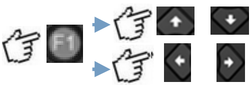


Dual-channel measurement

Automatic mode, the vertical / horizontal sensitivity status indication：

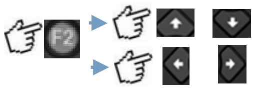
When you press one of the Voltage and Time control keys, the instrument switches to manual control of range and trigger settings

Manually set：



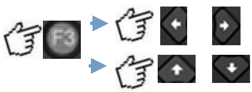
move up and down CHA Waveform

Change the CHA voltage range



move up and down CHB Waveform

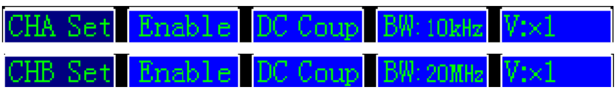
Change the CHB voltage range



Moving the waveform to the left and right

Change the Time base

Channel set in automatic mode

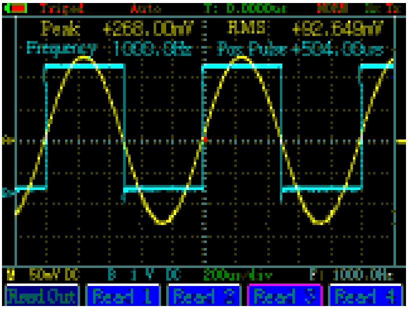
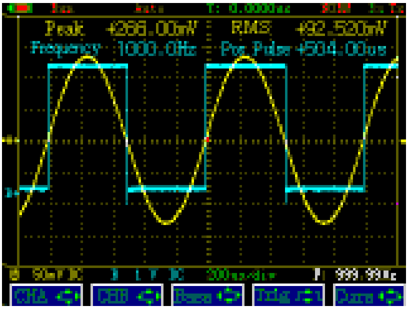


Trigger set in the automatic mode

Users can also manually change the settings

- **Read Out**

In **Read Out Menu Settings and select the parameter type(CHA or CHB)**

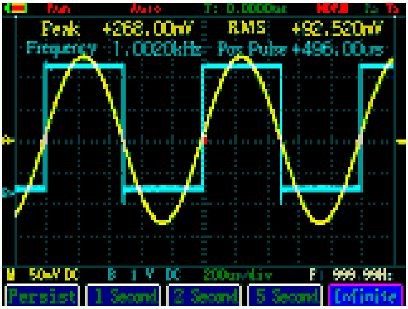



Parameter readout

- **Waveform display processing**

In the **Disp Set** menu Select the **persistence** and the **average** function

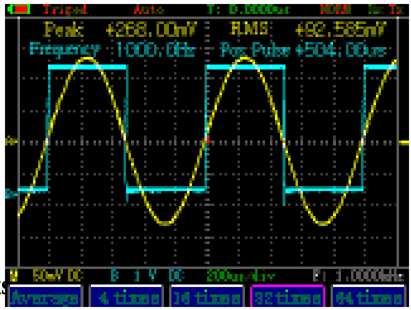
1） **persistence**



Infinite persistence

2） **average**

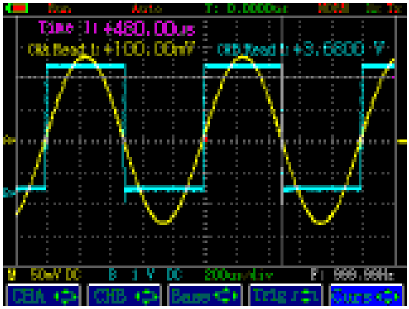
average32 times



- **Cursor measurements**

In the main menu F5 to start a single cursor mode; continue F5 to start dual cursor mode

1）Single cursor mode



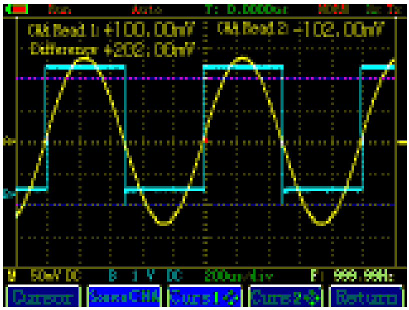
Move the voltage cursor up and down

Move the Time cursor left and right

2）Dual cursor mode

In the voltage cursor， or Converted into time cursor

In the Time cursor， or Converted into voltage cursor



F3 Select Cursor 1

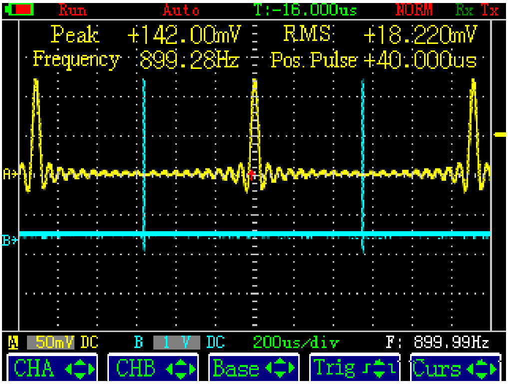
F4 Select Cursor 2

Move the cursor up and down

Move the cursor left and right

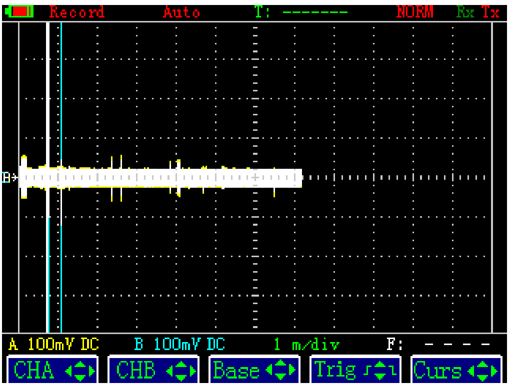
- **Scanning and recorder function**

Horizontal base in 200ms/div, or slower, the oscilloscope into a rolling screen status indication "scan", this way, the waveform scroll from left to right to update, easy to measure low-frequency signals in this manner and long period of mutation and very narrow pulse signal



Scan

Horizontal base in 10s/div, or slower, the oscilloscope into recording mode, the screen status indication "Record", the oscilloscope can record the maximum and minimum values, you can record up to 24 hours of the event。



Record

2、DMM

2.1 Test the connection

In the TRIG terminal and COM terminal directly connected multimeter pen or current probe

2.2 Multimeter

- DC voltage measurement

Right is automatic measurement


Manually change gears

600mV\6V\60V\600V\1000V

- AC voltage measurement

Right is automatic measurement


Manually change gears

600mV\6V\60V\600V\1000V

- Resistance measurement

Right is automatic measurement


Manually change gears

600Ω\6KΩ\60KΩ\600KΩ\6MΩ

- Continuity measurement

- Diode measurements

The maximum measured diode voltage drop of 3V

- Capacitance measurement

Right is automatic measurement

 Manually change gears

6nF\60nF\600nF\6uF\60uF \600uF\6mF

- Current Measurement

Use this menu option to test current with a current probe. (optional accessory)

Select the current coefficient according of the current probe "***A/V"

Don't forget to set the Current Probe to zero before using it for measurements.

Chapter III、The Instrument in the automotive fault diagnosis

1、Safety Precautions

⚠**CAUTION:**

When handing any extremely high voltage signals,e.g.the signals generated from the sparkplugs,NEVER PUT ANY TEST LEADS(Either the Red or Yellow test leads Or the Secondary ignition probe lead Or Power Cable from Cigarette Lighter)CONNECTED TO THE SCOPEINTHE AREAS NEAR THOSE STRONG SIGNALS.If so,the scope can be damaged or worked improperly.。

⚠ **CAUTION**

Avoid Electrical Shock:

- Make sure that the vehicle to be tested is at a safe potential before making any measurement connections.
- Connect the COM input of the instrument to vehicle ground before clamping the standard SECONDARY PICKUP (supplied) on the ignition wires. This ground connection is required IN ADDITION TO the normal measurement ground connections.
- Do not touch ignition coils, coil terminals, and spark plugs while operating. They emit high voltages.
- Do not puncture an ignition wire to connect the instrument, unless specifically instructed by vehicle manufacturer.
- Be sure the ignition is in the OFF position, headlights and other accessories are off, and doors are closed before disconnecting the battery cables. This also prevents damage to on-board computer systems.
- Avoid working alone.

- Inspect the test leads for damaged insulation or exposed metal. Check test lead continuity. Replace damaged leads before use.
- Do not use the instrument if it looks damaged.
- Select the proper function and range for your measurement.
- When using the probes, keep your fingers away from probe contacts.Keep your fingers behind the finger guards on the probes.
- Disconnect the live test lead before disconnecting the common test lead.
- Do not perform internal service or adjustment of this instrument unless you are qualified to do so
- Use only the standard test leads set supplied with the instrument.
- Do not use conventional exposed metal BNC or BANANA PLUG connectors.
- Use only one ground connection to the instrument (GROUND LEAD of the CH A's shielded test lead).
- Remove all probes and test leads that are not in use.
- Connect the power adapter to the AC outlet before connecting it to the instrument

Avoid Burns:

- Do not touch hot exhaust systems, manifolds, engines, radiators, sample probe, etc.
- Do not remove radiator cap unless engine is cold. Pressurized engine coolant may be hot.
- Wear gloves when handling hot engine components.
- Use a suitable battery carrier when transporting batteries

VEHICLE SERVICE MANUALS

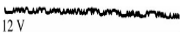
This instrument tells how to hook up it to the selected vehicle components to be tested. However, it is strongly recommended that you consult the manufacturer's service manual for your vehicle before any test or repair procedures are performed in order to get the color of the wire or the PCM's pin number from a wiring diagram. For availability of these service manuals, contact your local car dealership, auto parts store, or bookstore, The following companies publish valuable repair manuals

2、Introduction

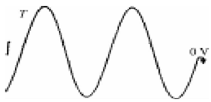
2.1 Primary Signal Types Found In Modern Vehicles

Once you become familiar with basic vehicle waveforms it will not matter how new or old the vehicle is, or even who manufactured the vehicle. You will be able to recognize signals that do not look right.。

Automotive electronic signals can be divided into analog signals and digital signals. Further broken down into five basic types, namely DC signal, the AC signal, frequency modulated signal, the pulse width modulated signal and serial data signals

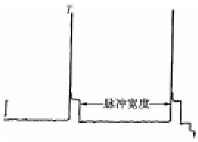


DC signal

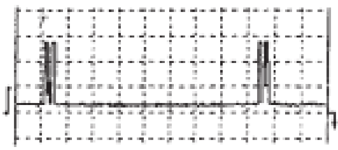


AC signal

frequency modulated signal



pulse width modulated signal



serial data signals

1）DC Signals

The types of sensors or devices in a vehicle that produce DC signals are:

- Power Supplies - Battery voltage or sensor reference voltages created by the PCM.
- Analog sensor signals-engine coolant temperature,fuel temperature,intake air temperature, throttle position, EGR pressure and valve position, oxygen, vane and hot wire mass airflow sensors, vacuum and throttle switches and GM, Chrysler and Asian manifold absolute pressure (MAP) sensors

2）Alternating Current (AC) Signals

The types of sensors or devices in a vehicle that produce AC signals are:

- Vehicle speed sensors (VSS)
- Antilock brake system wheel speed sensors (ABS wheel speed sensors)
- Magnetic camshaft (CM P) and crankshaft (CKP) position sensors
- Engine vacuum balance viewed from an analog MAP sensor signal
- Knock sensors (KS)

3）Frequency Modulated Signals

The types of sensors or devices in a vehicle that produce Frequency Modulated signals are

- Digital mass airflow (MAF) sensors
- Ford's digital MAP sensors
- Optical vehicle speed sensors (VSS)
- Hall Effect vehicle speed sensors (VSS)
- Optical camshaft (CM P) and crankshaft (CKP) position sensors
- Hall Effect camshaft (CM P) and crankshaft (CKP) position sensors

4)Pulse Width Modulated Signals

The types of circuits of devices in a vehicle that produce Pulse Width Modulated signals are

- Ignition coil primary
- Electronic spark timing circuits
- EGR, purge, turbo boost, and other control solenoids
- Fuel injectors
- Idle air control motors and solenoids

5)Serial Data (Multiplexed) Signals

The types of circuits or devices in a vehicle that produce Serial Data signals are:

- Powertrain control modules (PCM)
- Body control modules (BCM)
- ABS control modules
- Other control modules with self diagnostics or other serial data l communications capability

2.2Critical Characteristics Of Automotive Electronic Signals

Only 5 critical characteristics (or information types) given from the Automotive electronic signals are important because the vehicle's PCM considers them important.

• Amplitude- The voltage of the electronic signal at a certain point in time.

• Frequency- The time between events, or cycles, of the electronic signal, usually given in cycles per second (Hertz).

• Shape- The signature of the electronic signal, with its unique curves, contours, and corners.

• Duty Cycle- The on-time, or relative pulse width of the electronic signal.

• Pattern-The repeated patterns within the signal that make up specific messages, like synchronous pulses that tell the PCM that cylinder #1 is at TDC (Top Dead Center), or a repeated pattern in the serial data stream that tells the scan tool the coolant temperature is 212 F (or 100 C), etc

2.3 The Golden Rule Of Electronic System Diagnosis

For the vehicle's computer system to function properly, it must send and receive signals with the critical characteristics it was designed to communicate with.

Each of the primary types of electronic signals use the critical characteristics to establish electronic communication.

They each use different combinations of the critical characteristics to communicate. Here's a list of which critical characteristics each of the primary signal types uses to communicate:

• Direct Current signals use Amplitude only.

• Alternating Current signals use Amplitude, Frequency, and Shape.

• Frequency Modulated signals use Amplitude, Frequency, and Shape.

• Pulse Width Modulated signals use Amplitude, Frequency, Shape, and Duty Cycle.

• Serial Data signals use Amplitude, Frequency, Shape, Duty Cycle, and Pattern.

The list will help to give you a better understanding of which signal types use which critical characteristics to do their electronic communication. The above rules work very well and hold up in most cases, but there are exceptions to its rules. Not many, but a few.

It may come as no surprise to some that serial data signals are the most complex signals in the vehicle. They use all 5 critical characteristics to communicate with. Thus, they take a special analyzer to decode them - one very familiar to most technicians - the scan tool.

2.4 Signal Probing With An Oscilloscope

The engine compartment of a running vehicle is a very unfriendly environment for automotive signals to live.

Temperature extremes, dirt and corrosion, and electrical leaks, or noises from the high voltage pulses generated from a typical ignition system can produce interference that can contribute significantly to the cause of many driveability problems.

When you are probing components, sensors and circuits, be aware that the electrical noises from today's high output ignition systems can produce an RF energy that is similar to a radio station. Since oscilloscopes are so sensitive,this interference can actually override the signals you are trying to capture and give you a false reading on the display.

To minimize this possible interference with the oscilloscope, keep these tips and suggestions in mind:

Most interference will be picked up by the oscilloscope test leads.

• Route the test leads away from all ignition wires and components whenever possible.

• Use the shortest test leads possible, since other test leads may act as an antenna and increase the potential for interference, especially at higher frequency levels that are found when probing near the vehicle's on-board computer.

• With the potential for RF interference in the engine compartment, if possible, use the vehicle chassis as ground when connecting the oscilloscope test leads. In some cases the engine block can actually act as an antenna for the RF signals.

• The test leads are a very important part of any oscilloscope. Substituting other leads in both length and capability may alter the signals on your display.

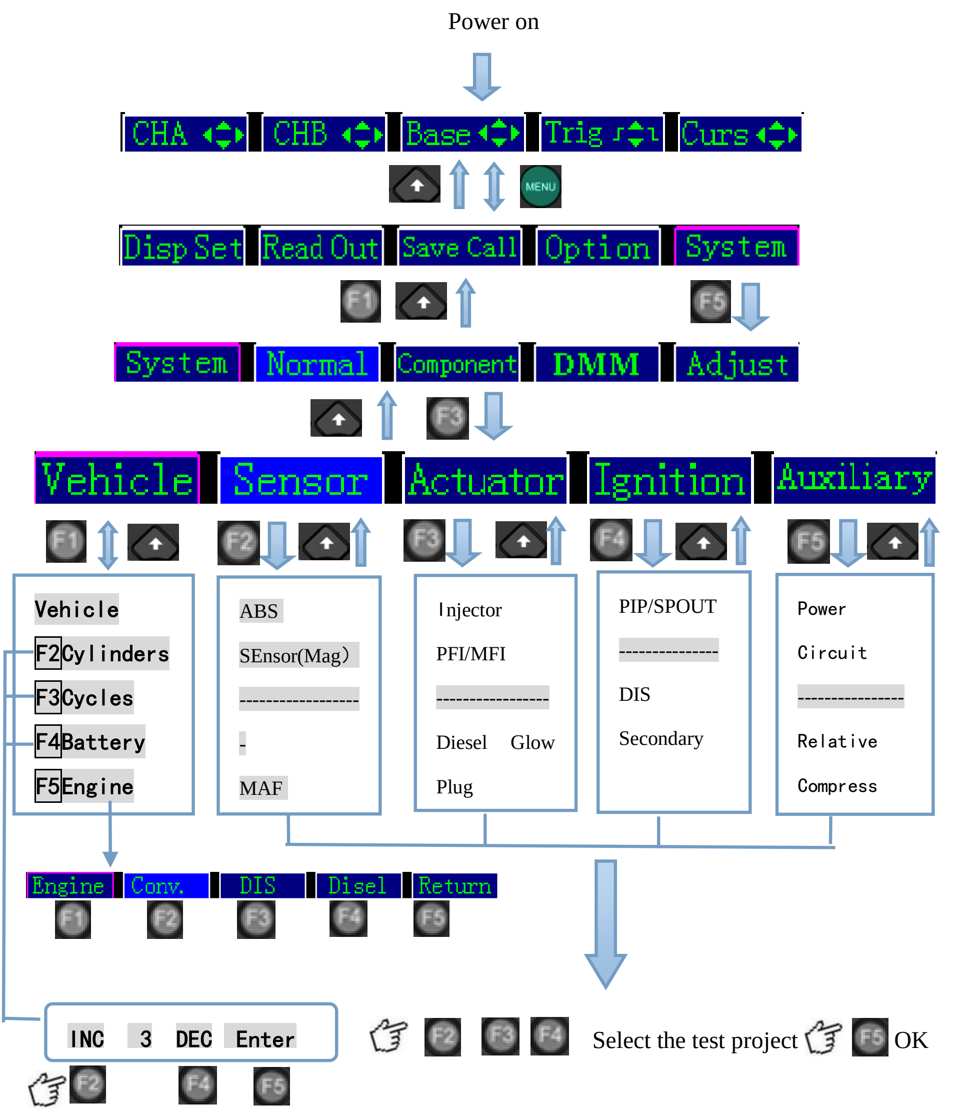
The oscilloscope can also pick up interference like the test leads.

• Because the oscilloscope circuits are so sensitive, and therefore powerful, do not place the oscilloscope directly on ignition wires or near high energy ignition components, like coil packs.

• If you are using the AC or DC charger/adaptor to power the oscilloscope, keep the external power leads far away from the engine and ignition if possible.

3、Automotive Testing

3.1 Into the automotive component testing menu



3.2 Sensor Test

3.2.1 Summary

Today's cars have complex sensor network, through the sensors circuits and systems, to obtain information from every part of the car running system, and the information is transmitted to the computer。Sensor tells the computer how fast the car go，how much is the engine rpm, the engine load is much, the car is in a turn or straight line etc. When all the sensor is working properly, the car is running well, emissions are relatively clean, the efficiency will be higher.However, like other devices, the sensor will be damaged,when it is damaged, the computer can't be maintained effective action required information, at this time, to find out which one sensor is bad, repair or replace it, let the system returns to normal working state.

This section describes how to use automobile oscilloscope to check the sensor in the car, how to check the waveform, how to check and find the faulty sensor.

3.2.2 Sensor Test Project

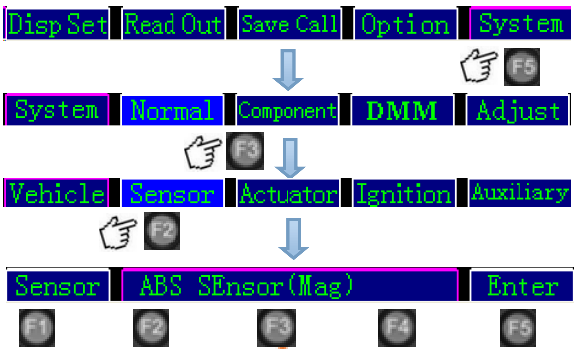
1）Into the sensor test menu

Main Menu

System Menu

Automotive menu

Sensor menu



F2 Or F4 select measurement project F5 Enter

F1 Return to the previous menu

2）Automotive Sensor Type

SENSOR TESTS MENU

ABS Sensor (Mag)

O2S Sensor (Zirc)

Dual O2 Sensor

ECT Sensor

Fuel Temp Sensor

IAT Sensor

Knock Sensor

TPS Sensor

CKP Magnetic

CKP Hall

CKP Optical

CMP Magnetic

SENSOR TESTS MENU

CMP Hall

CMP Optical

VSS Magnetic

VSS Optical

MAP Analog

MAP Digital

MAF Analog

MAF Digi Slow

MAF Digi Fast

MAF Karman-Vrtx

EGR (DPFE)

ABS Sensor-Magnetic

● Theory of Operation

ABS(Anti-lock Brake System) wheel speed sensors generate AC signals with frequency proportional to wheel speed. The amplitude (peak to peak voltage) increases as the wheel speed increases and is greatly affected by air gap between the magnetic tip and the wheel. The ABS computer compares the frequencies and uses this information to maintain wheel speeds while braking.

This test shows the sensor's output signal or the frequency proportional to wheel speed. The sensor's output signal should be continuous as long as the wheel rotates. Spikes or distortion of individual output pulses may indicate occasional contact between the sensor and the r wheel.

● Symptoms

ABS light on, no ABS signal generation

● Test Procedure

1. Connect the shielded test lead to the CH A input and connect the ground lead of the test lead t o the sensor output LO or GND and the test lead probe to the sensor output or HI. (Use a wiring diagram for the vehicle being serviced to get the ABS control unit pin number, or color of the wire for this circuit.)

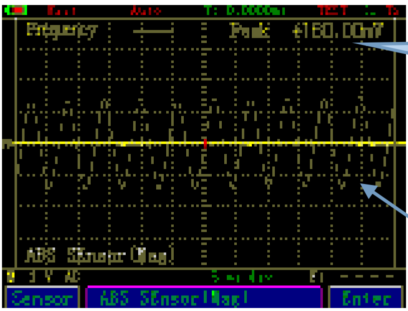
2. Drive vehicle or spin the wheel by hand to generate signal.
When driving vehicle, back probe the connector leading to the sensor. Place the transmission in drive, and slowly accelerate the drive wheels.If the sensor to be tested is on a drive wheel, raise the wheels off the ground to simulate driving conditions. Key OFF, Engine OFF

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

4. Compare ABS sensors on all wheels for similarities.

● Reference Waveform



Display the current CHA actual measurement value

Amplitude and Frequency increase with wheel speed. Output signal should be stable and repeatable without distorted pulses.

- **Troubleshooting Tips**

If the amplitude is low, look for an excessive air gap between the trigger wheel and the pickup.
If the amplitude wavers, look for a bent axle.
If one of the oscillations looks distorted, look for a bent or damaged tooth on the trigger wheel.

O2S Normal - Zirconia

- **Theory of Operation**

An O2 sensor provides an output voltage that represents the amount of oxygen in the exhaust stream. The output voltage is used by the PCM to adjust the air/fuel ratio of the fuel mixture between a slightly Rich condition and a slightly Lean condition.

A zirconia-type O2 sensor provides high output voltage (a Rich condition) and low output voltage (a Lean condition).

A titania-type O2 sensor changes resistance as the oxygen content of the fuel mixture changes. This results in a low output voltage (from a Rich condition) and a high output voltage (from a Lean condition). Most Titania O 2 sensors are found on MFI (Multiport Fuel Injection) systems.

A voltage swing between 100mV and 900mV indicates that the O2 sensor is properly signaling PCM to control the fuel mixture.

- **Symptoms**

Feedback Fuel Control System's (FFCS's) no entering Closed Loop operation, high emissions, poor fuel economy

- **Test Procedure**

1. Connect the shielded test lead to the CH A input and connect the ground lead of the test lead to the sensor output LO or GND and the test lead probe to the sensor output or HI. (Get the color of the O2 signal wire or PCM pin number from a wiring diagram.

2. Warm the engine and O2 sensor for 2-3 minutes at 2500 RPM, and let the engine idle for 20 seconds.

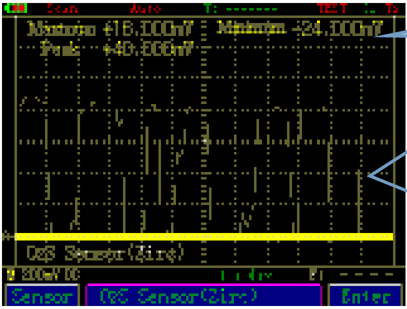
3. Rev the engine rapidly five or six times in 2 second intervals from idle to Wide Open Throttle (WOT). In order to obtain a clear acceleration and deceleration waveform, probably more appropriate to keep the engine speed at 4,000 rpm or less;

4. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

or select measurement project; Enter

5.  to freeze the waveform on the display to check the maximum O2 voltage, minimum O2 voltage and response time from Rich to Lean

- **Reference Waveform**



Display the current CHA actual measurement value

The maximum voltage when forced Rich should be greater than 800mV. The minimum voltage when forced Lean should be less than 200mV. The maximum allowable response time from Rich to Lean should be less than 100 ms.

NOTE

For a Titania-type O2sensor, change the vertical range to 1 V/div.

- **Troubleshooting Tips**

The response time increases by aging and poisoning of the O2sensor.

Peak to peak voltages should be at least 600mV or greater with an average of 450mV.

If the waveform is severely hashy, look for a misfire caused by Rich mixture, Lean mixture, ignition problem, vacuum leak to an individual cylinder, injector imbalance, or car boned intake valves.

IMPORTANT: Don't use a scan tool at the same time you are analyzing the O2waveform on the instrument. The PCM may go into a different operating strategy when diagnostics are activated by the scan tool.

Dual O2Sensor

- **Theory of Operation**

Many vehicles utilize dual O2sensors within the Feedback Fuel Control System. Both O2sensors provide an output voltage that represent the amount of oxygen in the exhaust stream respectively before and after the catalytic converter. The leading sensor signal is used as feedback for controlling the fuel mixture. The trailing sensor signal is used by PCM to test efficiency of the catalytic converter. The signal amplitude from the trailing sensor will increase when the efficiency of the catalytic converter declines over years. A good O2sensor located downstream from the catalyst should see much less fluctuations than its upstream counterpart during steady state operation. This is due to the properly operating catalyst's ability to consume oxygen when it is converting HC and CO, thus dampening the fluctuations in the downstream sensor's signal. That is, the difference in voltage amplitude from the sensors is a measure for the ability of the catalyst to store oxygen for the conversion of harmful exhaust constituents.

- **Symptoms**

Emissions test failure, poor fuel economy

- **Test Procedure**

1. Connect one shielded test lead to the CH A and the other test lead to the CH B. Connect the ground leads of both test leads to the engine GND's and one lead probe to the sensor 1 (upstream sensor) output or HI and the other lead probe to the sensor 2 (downstream sensor) output or HI

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

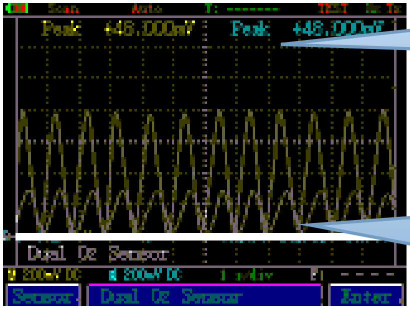
F2 or F4 select measurement project; F5 Enter

3. Run the engine until the O2sensors are warmed to at least 600 °F (315 °C) in closed loop operation

4. Run the engine at idle while increasing engine speed.

5. Use this test to check the efficiency of the catalytic converter.

- **Reference Waveform**

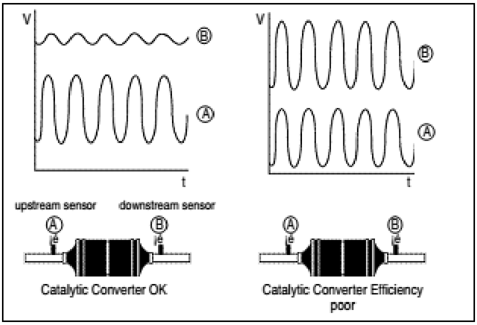


Display the current CHA CHB actual measurement

Downstream O2sensor voltage rises as converter heats up and begins to use excess oxygen to

Good O2sensor's output swing between 100mV and 900mV indicates that the O2 sensor is properly signaling PCM to control the fuel mixture.The fluctuations in the downstream sensor's signal are much smaller than that of the the upstream sensor. As the catalytic converter "lights off" (or reaches operating temperature) the signal goes higher due to less and less oxygen being present in the exhaust stream as the catalyst begins to store and use oxygen for catalytic conversion

- **Troubleshooting Tips**



When a catalytic converter is totally deteriorated, the catalytic conversion efficiency as well as the oxygen storage capability of the catalytic converter are essentially lost. Therefore, the upstream and downstream O2sensor signals closely resemble one another on an inactive converter.

ECT (Engine Coolant Temperature) Sensor

- **Theory of Operation**

Most ECT sensors are Negative Temperature Coefficient (NTC) type thermistors. This means they are primarily two wire analog sensors whose resistance decreases when their temperature increases. They are supplied with a 5 V V Ref power signal and return a voltage signal proportional to the engine coolant temperature to the PCM. When this instrument is connected to the signal from an ECT sensor, what is being read is the voltage drop across the sensor's NTC resistor

Typically, ECT sensor's resistance ranges from about 100,000 ohms at -40 °F (-40 °C) to about 50 ohms at +266 °F (+130 °C).

The ECT sensor signal is used by the PCM to control closed-loop operation, shift points, torque converter clutch operation, and cooling fan operation.

- **Symptoms**

No or hard start, high fuel consumption, emissions failure, driveability problems.

- **Test Procedure**

1.Back probe the terminals on the ECT sensor with the CH A lead and its ground lead.

2. Run the engine at idle and monitor the sensor voltage decrease as the engine warms. (Start the engine and hold the throttle at 2500 RPM until the trace goes across the screen.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

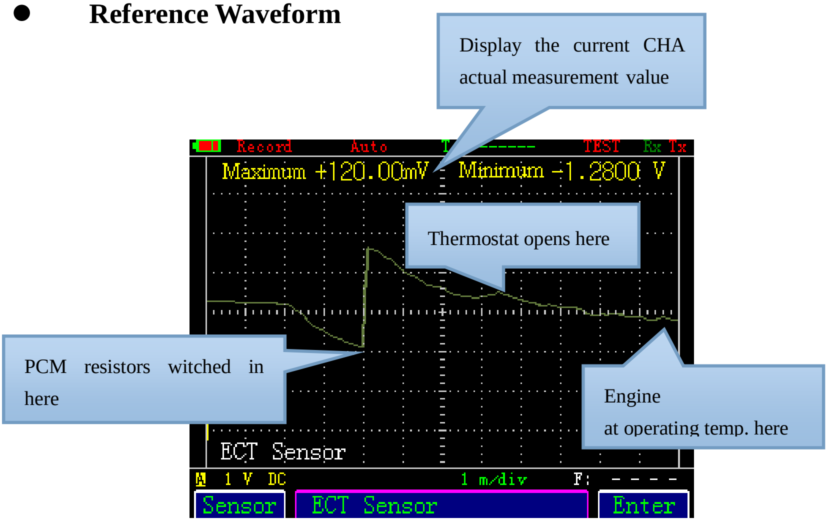
  or  select measurement project;   Enter

4. Set the time base to 1m/div to see the sensor's entire operating range, from stone cold to operating temperature.

5.  to freeze the waveform on the display for closer inspection

6. To measure resistance, disconnect the sensor before changing to the GMM mode and then connect the Ground and CH A leads to the terminals on the sensor.

- ## Reference Waveform



- ## Troubleshooting Tips

Check the manufacturer's specifications for exact voltage range specifications, but generally the sensor's voltage should range from 3 V to just under 5 V when stone cold, dropping to around 1 V at operating temperature. The good sensor must generate a signal with a certain amplitude at any given temperature

.

Opens in the ECT sensor circuit will appear as upward spikes to V Ref.

Shorts to ground in the ECT sensor circuit will appear as downward spikes to ground level

Fuel Temp Sensor

- **Theory of Operation**

Most Fuel Temperature (FT) sensors are Negative Temperature Coefficient (NTC) type thermistors. They are primarily two wire analog sensors whose resistance decreases when their temperature increases. Some sensors use their own case as a ground, so they have only one wire, the signal wire. They are supplied with a 5 V V Ref power signal and return a voltage signal proportional to the temperature to the PCM. FT sensors usually sense the engine's fuel temperature in the fuel rail. When this instrument is connected to the signal from a FT sensor, what is being read is the voltage drop across the sensor's NTC resistor.

Typically, FT sensor's resistance ranges from about 100,000 ohms at -40 °F (-40 °C) to about 50 ohms at +266 °F (+130 °C)

- **Symptoms**

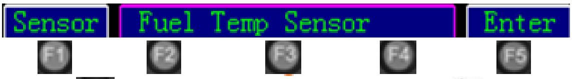
Hard start, poor fuel economy, driveability problems

- **Test Procedure**

1.Backprobe the terminals on the FT sensor with the CH A lead and its ground lead.

2.Start the engine and hold the throttle at 2500 RPM until the trace goes across the screen.

3.Enter the measurement setup menu, select test items, automatically the measurement setup of the project



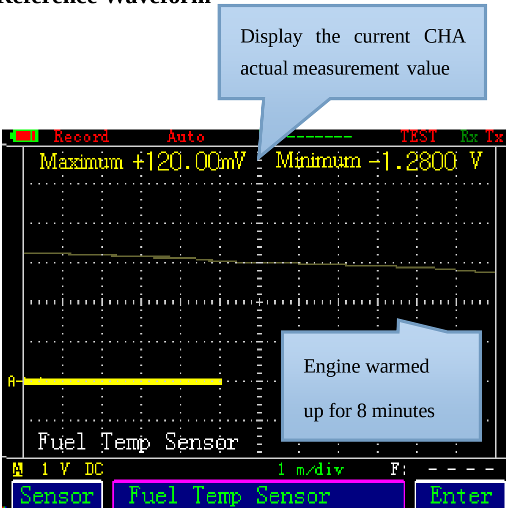
F2 or F4 select measurement project; F5 Enter

4.Se t the time base to 50 sec/ div to see the sensor ' s entire operating range, from stone cold to operating Temperature.

5. R/H key to freeze the waveform on the display for closer inspection.

6.To measure resistance, disconnect the sensor before changing to the GMM mode and then connect the Ground and CH A leads to the terminals on the sensor

- **Reference Waveform**



- **Troubleshooting Tips**

Check the manufacturer's specifications for exact voltage range specifications, but generally the sensor's voltage should range from 3 V to just under 5 V when stone cold, dropping to around 1 to 2 V at operating temperature. The good sensor must generate a signal with a certain amplitude at any given temperature.

Opens in the FT sensor circuit will appear as upward spikes to V Ref.

Shorts to ground in the FT sensor circuit will appear as downward spikes to ground level.

INTAKE AIR TEMP (IAT) Sensor

- **Theory of Operation**

Most Intake Air Temperature (IAT) sensors are Negative Temperature Coefficient (NTC) type thermistors. They are primarily two wire analog sensors whose resistance decreases when their temperature increases. They are supplied with a 5 V V Ref power signal and return a voltage signal proportional to the intake air temperature to the PCM. Some sensors use their own case as a ground, so they have only one wire, the signal wire. When this instrument is connected to the signal from an IAT sensor, what is being read is the voltage drop across the sensor's NTC resistor.

Typically, IAT sensor's resistance ranges from about 100,000 ohms at -40 ˚F (-40 ˚C) to about 50 ohms at +266 ˚F (+130 ˚C).

- **Symptoms**

Poor fuel economy, hard start, high emissions, tip-in hesitation

- **Test Procedure**

1. Backprobe the terminals on the IAT sensor with the CH A lead and its ground lead.

2. When the IAT sensors are at engine operating temperature , spray the sensors with a coo ling spray, a wat er spray, or evaporative solvent spray and monitor the sensor voltage. Perform this test with the Key ON, Engine Off. The waveform should increase in amplitude as the sensor tip cools.

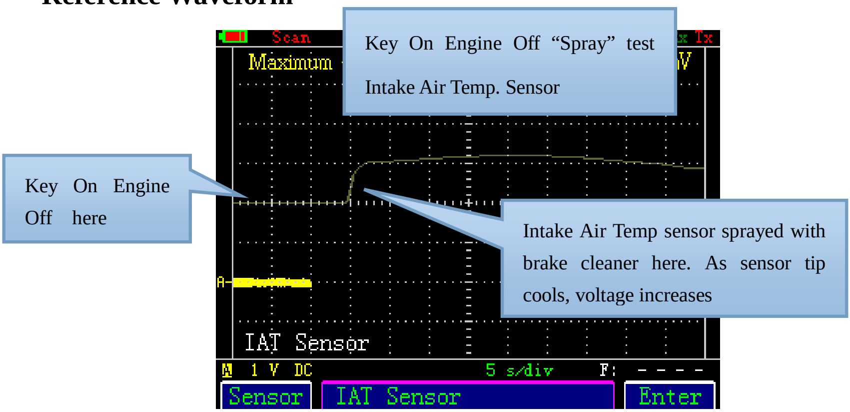
3.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

4 R/H to freeze the waveform on the display for closer inspection.

5.To measure resistance, disconnect the sensor before changing to the GMM mode and then connect the Ground and CH A leads to the terminals on the sensor.

- **Reference Waveform**



- **Troubleshooting Tips**

Check the manufacturer's specifications for exact voltage range specifications, but generally the sensor's voltage should range from 3 V to just under 5 V when stone cold, dropping to around 1 to 2 V at operating temperature. The good sensor must generate a signal with a certain amplitude at any given temperature.

Opens in the IAT sensor circuit will appear as upward spikes to V Ref.

Shorts in the IAT sensor circuit will appear as downward spikes to ground level.

Knock Sensor

- **Theory of Operation**

AC sign al generating Knock Sensors are pie zo electric devices that sense vibration or mechanical stress (knock) f rom engine detonation. They are quite different from most other AC signal generating automotive sensors that sense the speed or position of a rotating shaft.

Engine detonation resulting from over advanced ignition timing ca n cause severe engine damage. Knock sensors supply the PCM (sometimes via a spark control module) with Knock detection so the PCM can retard ignition timing to prevent further Knocking.

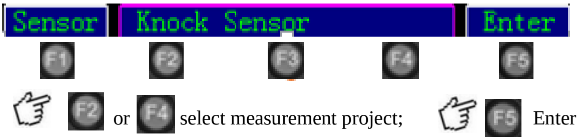
- **Symptoms**

No AC signal generation at all from Knock Sensors.

- **Test Procedure**

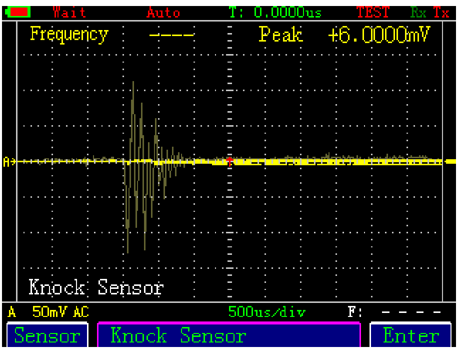
1. Connect the CH A lead to the sensor output or HI and its ground lead to the engine block or the sensor wire labeled LO (if internally grounded).

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



3. Test 1: With the Key On, Engine Running, put a load on the engine and watch the Scope display. The peak voltage and frequency of the waveform will increase with engine load and RPM increment. If the engine is detonating or pinging from too much advanced ignition timing, the amplitude and frequency will also increase. Test 2: With the Key On, Engine Off, tap the engine block lightly near the sensor with a small hammer or a ratchet extension. Oscillations will be displayed immediately following a tap on the engine block. The harder the tap, the larger the amplitude of the oscillations.

- **Reference Waveform**



Typical Knock Sensor test.Note signal goes above and below zero volts(AC).Logged during slight acceleration

- **Troubleshooting Tips**

Knock sensors are extremely durable and usually fail from physical damage to the sensor itself. The most common type of Knock Sensor failure is not to generate a signal at all due to its physical damage, when the waveform stays flat even if you rev the engine or tap on the sensor. In this case, check the sensor and the instrument connections; make sure the circuit is not grounded, then condemn the sensor.

Throttle Position Sensor (TPS)

- **Theory of Operation**

A TPS is a variable resistor that tells the PCM the position of the throttle, that is, how far the throttle is open, whether it is opening or closing and how fast. Most throttle position sensors consist of a contact connected to the throttle shaft which slides over a section of resistance material around the pivot axis for the movable contact.

The TPS is a three wire sensor. One of the wires is connected to an end of the sensor's resistance material and provides 5 V via the PCM's V Ref circuit, another wire is connected to the other end of the resistance material and provides the sensor ground (GND). The third wire is connected to the movable contact and provides the signal output to the PCM. The voltage at any point in the resistance material is proportional to the throttle angle as sensed through the movable contact.

The voltage signal returning to the PCM is used to calculate engine load, ignition timing, EGR control, idle control and other PCM controlled parameters such as transmission shift points. A bad TPS can cause hesitation, idle problems, high emissions, and Inspection/ Maintenance (I/M) test failures.

Generally, throttle position sensors produce just under 1 V with the throttle closed and produce just under 5 V with the throttle wide open (WOT). The PCM determines the sensor's performance by comparing the sensor output to a calculated value based on MAP and RPM signals.

- **Symptoms**

Hesitation, stall at stops, high emissions, I/M test failures, transmission shifting problems.。

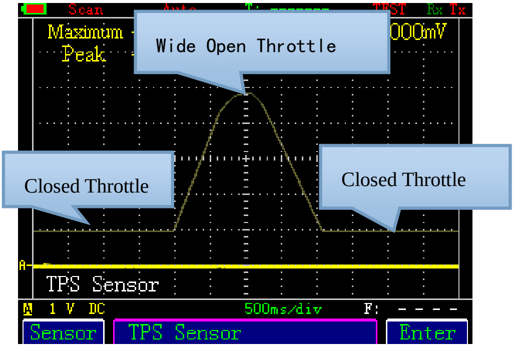
- **Test Procedure**

1. Connect the CH A lead to the output or signal circuit of TPS and its ground lead to the TPS's GND.
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

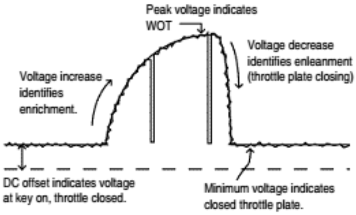
3. With the Key On, Engine Running, slowly sweep the throttle from closed to the wide open position (WOT) and then the closed position again. Repeat this process several times.

- **Reference Waveform**



- ## Troubleshooting Tips

Check the manufacturer's specifications for exact voltage range. Generally, the sensor output should range from just under 1 V at idle to just under 5 V at wide open throttle (WOT). There should be no breaks, spikes to ground or dropouts in the waveform.



(Defective TPS Pattern)

Dropouts on the slopes of the waveform indicate a short to ground or an intermittent open in the sensor's carbon track (resistance materials).
The first 1/8 to 1/3 of the sensor's carbon track usually wears out most because this portion is most used while driving. Thus, pay particular attention to the waveform as it begins to rise.

Magnetic Crankshaft Position (CKP) Sensor

- ## Theory of Operation

The magnetic CKP sensors are AC signal generating analog sensors. They generally consist of a wire wrapped, soft bar magnet with two connections. These two winding, or coil, connections are the sensor's output terminals. When a ring gear (a reluctor wheel) rotates past this sensor, it induces a voltage in the winding. A uniform tooth pattern on the reluctor wheel produces a sinusoidal series of pulses having a consistent shape. The amplitude is proportional to the rotating speed of the reluctor wheel (that is, the crankshaft or camshaft). The frequency is based on the rotational speed of the reluctor. The air gap between the sensor's magnetic tip and the reluctor wheel greatly affects the sensor's signal amplitude.

They are used to determine where TDC (Top Dead Center) position is located by creating a "synchronous"pulse which is generated by either omitting teeth on the reluctor wheel or moving them closer together.

The PCM uses the CKP sensors to detect misfire. When a misfire occurs, the amount of time it takes for a waveform to complete its cycle increases. If the PCM detects an excessive number of misfires within 200 to 1000 crankshaft revolutions, a misfire code (OBD II DTC) is set.

● Symptoms

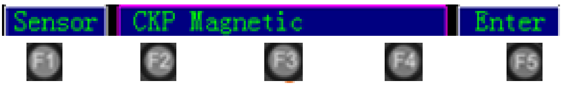
No or hard start, intermittent misfire, driveability problems

● Test Procedure

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. With KOER (Key On, Engine Running), let the engine idle, or use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

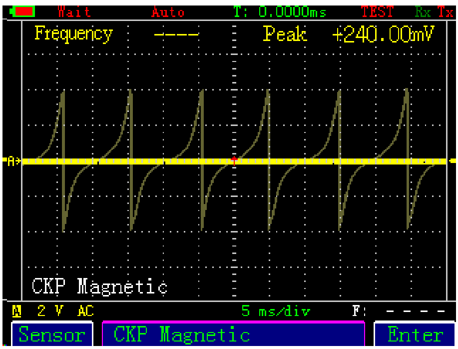


or 

select measurement project; 

Enter

● Reference Waveform



The amplitude and frequency increase with engine speed (RPM).
The amplitude, frequency and shape should be all consistent for the conditions (RPM,etc.), repeatable (except for "sync"pulses), and predictable.
Generally, the oscillations may not be perfect mirror images of each other above and below the zero level mark, but they should be relatively close on most sensors.

● Troubleshooting Tips

Make sure the frequency of the waveform is keeping pace with engine RPM, and that the time between pulses only changes when a "sync"pulse is displayed. This time changes only when a missing or extra tooth on the reluctor wheel passes the sensor. That is, any other changes in time between the pulses can mean trouble.

Look for abnormalities observed in the waveform to coincide with an engine sputter or driveability problem.

Before assuring the sensor's failure, when waveform abnormalities are observed, make sure that a chafed wire or bad wiring harness connector is not the cause, the circuit isn't grounded, and the proper parts are spinning.

Hall Effect CranKshaft Position (CKP) Sensor

- **Theory of Operation**

These CKP sensors are classified as "CKP Sensors-Low Resolution"in industry.
The Hall CKP sensors are low resolution digital sensors which generate the CKP signal, that is a low frequency (hundreds of Hz) square wave switching between zero and V Ref, from a Hall sensor.

The Hall CKP sensor, or switch, consists of an almost completely closed magnetic circuit containing a permanent magnet and pole pieces. A soft magnetic vane rotor travels through the remaining air gap between the magnet and the pole piece. The opening and closing of the vane rotor's windows interrupt the magnetic field, causing the Hall sensor to turn on and off like a switch - so some vehicle manufacturers call this sensor a Hall switch.

These sensors operate at different voltage levels depending on the vehicle manufacturers and deliver a series of pulses as the shaft rotates.
They are used to switch the ignition and/or fuel injection triggering circuits on and off.
The PCM uses the Hall CKP sensors to detect misfire.

- **Symptoms**

Long cranking, poor fuel economy, emissions problem

- **Test Procedure**

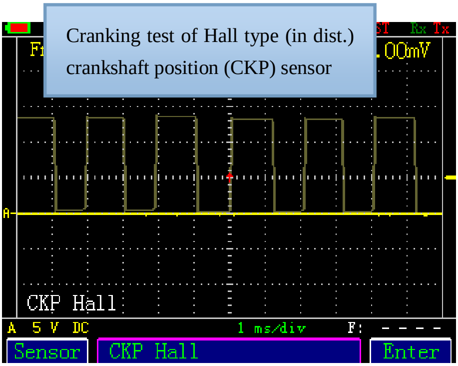
1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. Key On, Engine Cranking, or,Key On, Engine Running ,use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

- **Reference Waveform**



The amplitude, frequency, and shape should be all consistent in the waveform from pulse to pulse. The amplitude should be sufficient (usually equal to sensor supply voltage), the time between pulses repeatable (except for "sync" pulses), and the shapes repeatable and predictable.

- **Troubleshooting Tips**

The duty cycle of the waveform changes only when a "sync"pulse is displayed. Any other changes in duty cycle can mean troubles.

The top and bottom corners of the waveform should be sharp and voltage transitions of the edge should be straight and vertical.

Make sure the waveform isn't riding too high off the ground level. This could indicate a high resistance or bad ground supply to the sensor.

Although the Hall CKP sensors are generally designed to operate in temperatures up to 318 °F (150 °C), they can fail at certain temperatures (cold or hot).

Optical CranKshaft Position (CKP) Sensor

Theory of Operation

These CKP sensors are classified as "CKP Sensors - High Resolution"in industry.

The optical CKP sensors can sense position of a rotating component even without the engine running and their pulse amplitude remains constant with variations in speed. They are not affected by electromagnetic interference (EMI). They are used to switch the ignition and/or fuel injection triggering circuits on and off.

The optical sensor consists of a rotating disk with slots in it, two fiber optic light pipes, an LED, and a phototransistor as the light sensor. An amplifier is coupled to the phototransistor to create a strong enough signal for use by other electronic devices, such as PCM or ignition module.
The phototransistor and amplifier create a digital output signal (on/off pulse).

- ## Symptoms

No or hard starts, stall at stops, misfires, poor fuel economy, emissions failure

- ## Test Procedure

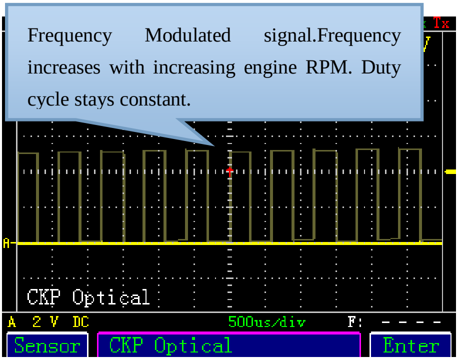
1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. With KOER (Key On, Engine Running), let the engine idle, or use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

- ## Reference Waveform



The amplitude, frequency, and shape should be all consistent in the waveform from pulse to pulse. The amplitude should be sufficient, the time between pulses repeatable (except for "sync"pulses), and the shapes repeatable and predictable. Consistency is the key.

- ## Troubleshooting Tips

The duty cycle of the waveform changes only when a "sync"pulse is displayed. Any other changes in duty cycle can mean troubles.

The top and bottom corners of the waveform should be sharp. However, the left upper corner may appear rounded on some of the higher frequency (high data rate) optical distributors. This is normal.

Optical CKP sensors are very susceptible to malfunction from dirt or oil interfering with the light transmission through the rotating disk. When dirt or oil enters into the sensitive areas of the sensors, no starts, stalls, or misfires can occur.

Magnetic Camshaft Position (CMP) Sensor

- **Theory of Operation**

The magnetic CMP sensors are AC signal generating analog sensors. The generally consist of a wire wrapped, soft bar magnet with two connections. These two winding, or coil, connections are the sensor's output terminals. When a ring gear (a reluctor wheel) rotates past this sensor, it induces a voltage in the winding. A uniform tooth pattern on the reluctor wheel produces a sinusoidal series of pulses having a consistent shape. The amplitude is proportional to the rotating speed of the reluctor wheel (that is, the crankshaft or camshaft). The frequency is based on the rotational speed of the reluctor. The air gap between the sensor's magnetic tip and the reluctor wheel greatly affects the sensor's signal amplitude.

They are used to determine where TDC (Top Dead Center) position is located by creating a "synchronous"pulse which is generated by either omitting teeth on the reluctor wheel or moving them closer together.
The PCM or ignition module uses the CMP sensors to trigger ignition or fuel injector events. The magnetic CMP and CKP sensors are susceptible to Electromagnetic Interference (EMI or RF) from high voltage spark plug wires, car phones or other electronic devices on the vehicle. This can cause a driveability problem or set a Diagnostic Trouble Code (DTC).

- **Symptoms**

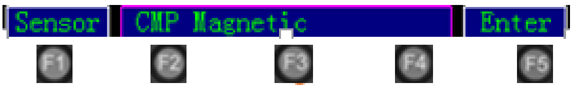
Long cranking time, poor fuel economy, emissions failure

- **Test Procedure**

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

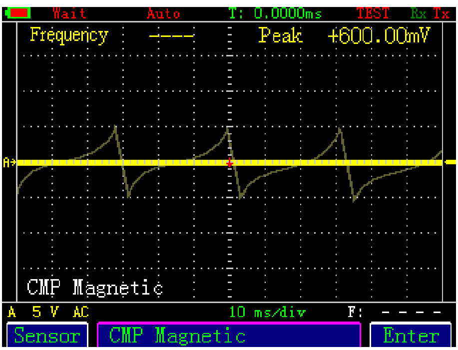
2. Key On, Engine Running,let the engine idle, or use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



F2 or F4 select measurement project; F5 Enter

- **Reference Waveform**



The amplitude and frequency increase with engine speed (RPM).

The amplitude, frequency and shape should be all consistent for the conditions (RPM,etc.), the time between pulses repeatable (except for "sync"pulses), and the shapes repeatable and predictable

- **Troubleshooting Tips**

Make sure the frequency of the waveform is keeping pace with engine RPM, and that the time between pulses only

changes when a "sync"pulse is displayed. This time changes only when a missing or extra tooth on the reluctor wheel passes the sensor. That is, any other changes in time between the pulses can mean trouble.

Look for abnormalities observed in the waveform to coincide with an engine sputter or driveability problem.

Hall Effect Camshaft Position (CMP) Sensor

- **Theory of Operation**

These CMP sensors are classified as "CMP Sensors - Low Resolution"in industry.

The Hall CMP sensors are low resolution (accuracy) digital sensors which generate the CMP signal, that is a low frequency (tens of Hz) square wave switching between zero and V Ref, from a Hall sensor.

The Hall CMP sensor, or switch, consists of an almost completely closed magnetic circuit containing a permanent magnet and pole pieces. A soft magnetic vane rotor travels through the remaining air gap between the magnet and the pole piece. The opening and closing of the vane rotor's window interrupts the magnetic field, causing the Hall sensor to turn on the off like a switch - so some vehicle manufacturers call this sensor a Hall switch.

These sensors operate at different voltage levels depending on the vehicle manufacturers and deliver a series of pulses as the shaft rotates.

They are used to switch the ignition and/or fuel injection triggering circuits on and off.

The PCM uses the Hall CMP sensors to detect misfire.

- **Symptoms**

Long cranking time, poor fuel economy, emissions failure

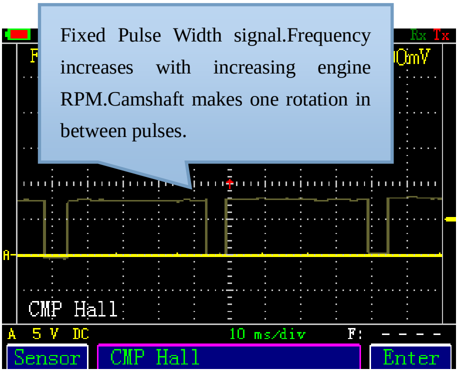
- **Test Procedure**

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.
2. With Key On, Engine Running, let the engine idle, or use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

- **Reference Waveform**



The amplitude, frequency, and shape should be all consistent in the waveform from pulse to pulse. The amplitude should be sufficient (usually equal to sensor supply voltage), the time between pulses repeatable (except for "sync"pulses), and the shape repeatable and predictable. Consistency is the key.

- **Troubleshooting Tips**

The duty cycle of the waveform changes only when a "sync"pulse is displayed. Any other changes in duty cycle can mean troubles.

The top and bottom corners of the waveform should be sharp and voltage transitions of the edge should be straight and vertical.

Make sure the waveform isn't riding too high off the ground level. This could indicate a high resistance or bad ground supply to the sensor.

Although the Hall CMP sensors are generally designed to operate in temperatures up to 318 °F (150 °C), they can fail at certain temperatures (cold or hot)

Optical Camshaft Position (CMP) Sensor

● Theory of Operation

These CMP sensors are classified as "CMP Sensors - High Resolution"in industry.

The optical CMP sensors are high resolution (accuracy) digital sensors which generate the CMP signal, that is a high frequency (hundreds of Hz to several kHz) square wave switching between zero and V Ref.
The optical CMP sensors can sense position of a rotating component even without the engine running and their pulse amplitude remains constant with variations in speed. They are not affected by electromagnetic interference (EMI). They are used to switch the ignition and/or fuel injection triggering circuits on and off.

The optical sensor consists of a rotating disk with slots in it, two fiber optic light pipes, and LED, and a phototransistor as the light sensor. An amplifier is coupled to the phototransistor to create a strong enough signal for use by other electronic devices, such as PCM or ignition module.
The phototransistor and amplifier create a digital output signal (on/off pulse)

● Symptoms

No or hard starts, stall at stops, misfires, poor fuel economy, emissions failure

● Test Procedure

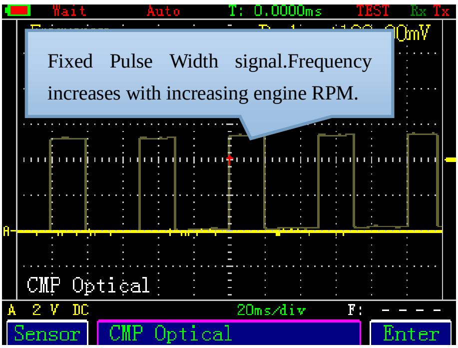
1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. With KOER (Key On, Engine Running), let the engine idle, or use the throttle to accelerate or decelerate the engine or drive the vehicle as needed to make the driveability, or emissions, problem occur.

3.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

● Reference Waveform



The amplitude, frequency, and shape should be all consistent in the waveform from pulse to pulse. The amplitude should be sufficient, the time between pulses repeatable (except for "sync"pulses), and the shapes repeatable and predictable. Consistency is the key

Troubleshooting Tips

The duty cycle of the waveform changes only when a "sync"pulse is displayed. Any other changes in duty cycle can mean troubles.

The top and bottom corners of the waveform should be sharp and voltage transitions of the edge should be straight and vertical.

Make sure the waveform isn't riding too high off the ground level. This could indicate a high resistance or bad ground supply to the sensor.

Although the Hall CMP sensors are generally designed to operate in temperatures up to 318 °F (150 °C), they can fail at certain temperatures (cold or hot)

Magnetic Vehicle Speed Sensor (VSS)

Theory of Operation

The vehicle speed sensors provides vehicle speed information to the PCM, the cruise control, and the speedometer. The PCM uses the data to decide when to engage the transmission torque converter clutch lockup and to control electronic transmission shift levels, cruise control, idle air bypass, engine cooling fan, and other functions.

The magnetic vehicle speed sensors are usually mounted directly on the transmissions or transaxles. They are two wire sensors and AC signal generating analog sensors. They are very susceptible to Electromagnetic Interference (EMI or RF) from other electronic devices on the vehicle.

They generally consist of a wire wrapped, soft bar magnet with two connections. These two winding, or coil, connections are the sensor's output terminals. When a ring gear (a reluctor wheel) rotates past this sensor, it induces a voltage in the winding.

A uniform tooth pattern on the reluctor wheel produces a sinusoidal series of pulses having a consistent shape. The amplitude is proportional to the rotating speed of the reluctor wheel. The signal frequency is based on the rotational speed of the reluctor. The air gap between the sensor's magnetic tip and the reluctor wheel greatly affects the sensor's signal amplitude.

Symptoms

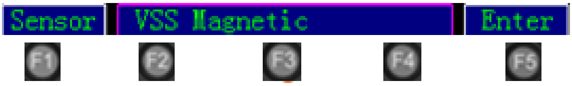
Inaccurate speedometer, improper transmission shifting, problems affecting ABS and cruise control

Test Procedure

1. Raise the drive wheels off the ground and place the transmission in drive.
2. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

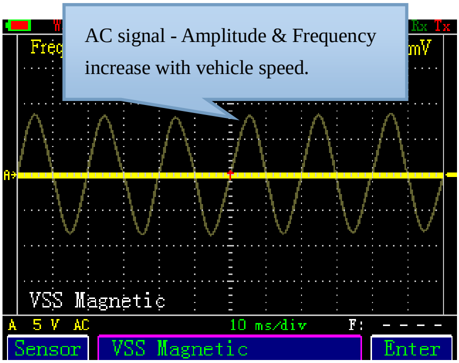
3.Key On, Being Driven, monitor the VSS output signal at low speed while gradually increasing the speed of the drive wheels.

4. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



F2 or F4 select measurement project; F5 Enter

- ## Reference Waveform



The amplitude and frequency increase with vehicle speed. Vehicle Speed Sensors make waveforms whose shapes all look and behave very similar. Generally, the oscillations (the ups and downs in the waveform) are very symmetrical at constant speed.

- ## Troubleshooting Tips

If the amplitude is low, look for an excessive air gap between the trigger wheel and the pickup.

If the amplitude wavers, look for a bent trigger wheel or shaft.

If one of the oscillations look distorted, look for a bent or damaged tooth on the trigger wheel.

IMPORTANT:

When troubleshooting a missing VSS signal, check the fuse first. If there is no power to the buffer, there will be no square wave output. If the fuse is good, check the sensor first than a buffer mounted under the dash. If you have a sine wave coming from the sensor, but no square wave from the buffer, don't assume the problem is in the buffer; it may not be there because of a loose connector between the sensor and the buffer.v

Optical Vehicle Speed Sensor (VSS)

- **Theory of Operation**

The optical vehicle speed sensors are usually driven by a conventional cable and are found under the dash. They are digital sensors and are not affected by electromagnetic interference (EMI).

They generally consist of a rotating disk with slots in it, two fiber optic light pipes, a light emitting diode, and a phototransistor as the light sensor. An amplifier is coupled to the phototransistor to create a strong enough signal for use by other electronic devices, such as the PCM or ignition module. The phototransistor and amplifier create a digital output signal (on/off pulse).

Optical sensors are very susceptible to malfunction from dirt or oil interfering with the light transmission through the rotating disk. When dirt or oil enters into the sensitive areas of the sensors, driveability problems can occur and DTC's can be set.

- ## Symptoms

Improper transmission shifting, inaccurate speedometer, problems affecting ABS and cruise control

- ## Test Procedure

1. Raise the drive wheels off the ground and place the transmission in drive.

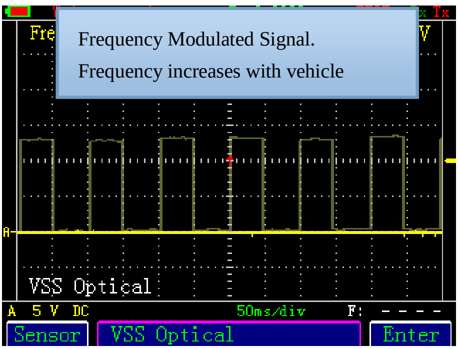
2. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

3. With KOBD(Key On, Being Driven), monitor the VSS output signal at low speed (about 30 MPH) while gradually increasing the speed of the drive wheels

4. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

- **Reference Waveform**



The signal frequency should increase with increasing vehicle speed, but the duty cycle should stay consistent at any speed. The amplitude, frequency, and shape should be all consistent in the waveform from pulse to pulse. The amplitude should be sufficient (usually equal to sensor supply voltage), the time between pulses repeatable and the shapes repeatable and predictable

- **Troubleshooting Tips**

The top and bottom corners of the waveform should be sharp and voltage transitions of the edge should be straight and vertical.

All of the waveforms should be equal in height due to the constant supply voltage to the sensor.
Make sure the waveform isn't riding too high off the ground level. This could indicate a high resistance or bad ground supply to the sensor. (Voltage drop to ground should not exceed 400mV.)

Look for abnormalities observed in the waveform to coincide with a driveability problem or a DTC..

Analog Manifold Absolute Pressure (MAP) Sensor

- **Theory of Operation**

Almost all domestic and import MAP sensors are analog types in design except Ford's MAP sensor. Analog MAP sensors generate a variable voltage output signal that is directly proportional to the intake manifold vacuum, which is used by the PCM to determine the engine load. They are primarily three wire sensors and are supplied with 5V V Ref power, a ground circuit, and the signal output to the PCM.

High pressure occurs when the engine is under a heavy load, and low pressure (high intake vacuum) occurs when there is very little load. A bad MAP sensor can affect the air-fuel ratio when the engine accelerates and decelerates. It may also have some effect on ignition timing and other PCM outputs. A bad MAP sensor or its hose can trigger DTC's for MAF, TP, or EGR sensors.

- **Symptoms**

Low power, stall, hesitation, excessive fuel consumption, emissions failure

- **Test Procedure**

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

or select measurement project; Enter

3.Shut off all accessories, start the engine and let it idle in park or neutral. After the idle has stabilized, check the idle voltage.

4. Rev the engine from idle to Wide Open Throttle (WOT) with a moderate input speed (this should only take about 2 seconds - don't overrev the engine.)

5. Let engine speed drop back down to idle for about two seconds.

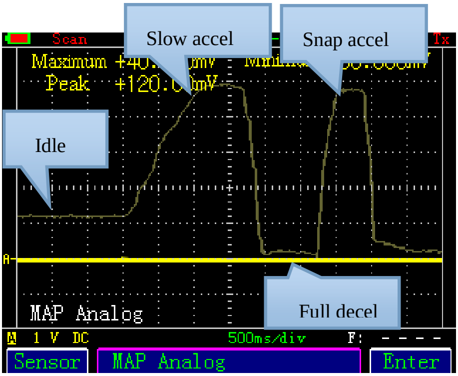
6. Rev the engine again to WOT (very quickly) and let it drop back to idle again.

7 .  key to freeze the waveform on the display for closer inspection.

NOTE

It may be advantageous to put the sensor through its paces by using a handheld vacuum pump to see that it generates the correct voltage at a specific vacuum.

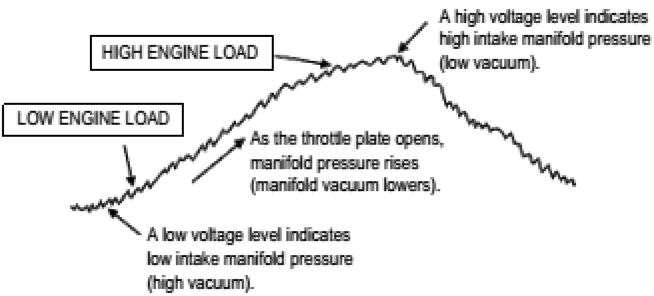
● Reference Waveform



Check the manufacturer's specifications for exact voltage range versus vacuum levels,and compare them to the readings on the display. Generally the sensor voltage should range about 1 .2 5 V a t idle to just unde r 5 V a t WOT and close to 0 V on full deceleration.High vacuum (around 24 In.Hg on full decel) produces low volt age (close to 0 V), and low vacuum (around 3 In. Hg at full load) produces high voltage(close to 5 V).

IMPORTANT: There are a few MAP sensors designed to do the opposite (high vacuum = high voltage). Some Chrysler MAP sensor s just stay at a fixed voltage when they fail, regardless of changes i n vacuum level. Generally 4 cylinder engines make nosier waveforms because their vacuum fluctuates more between intake strokes.

● Troubleshooting Tips



Digital Manifold Absolute Pressure (MAP) Sensor

- **Theory of Operation**

Ford's digital MAP sensor is found on many Ford and Lincoln Mercury vehicles from the early 1980's to well into the 199 0' s. This sensor produce s a frequency modulated square wave whose frequency varies with the amount of intake vacuum sensed. It generates about 160 Hz with no vacuum applied, and it generates about 105 Hz when it is sensing around 19 In.Hg at idle. Check the manufacturer's specs for the year, make and model for exact vacuum versus frequency reference numbers. This is a three wire sensor, supplied with 5 V V Ref power, a ground circuit, and the digital signal output pulses based on the amount of vacuum it senses.

- **Symptoms**

Low power, stall, hesitation, excessive fuel consumption, emissions failure

- **Test Procedure**

1.Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND

2.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

 or  select measurement project;  Enter

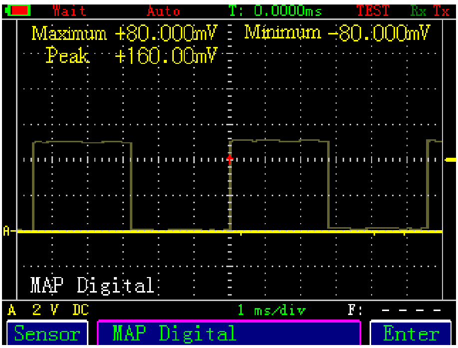
3. With the Key On, Engine Off , apply different amounts of vacuum to the sensor using a handheld vacuum pump.

4. Make sure that the amplitude, frequency and shape are all present, repeatable, and consistent. Amplitude should be close to 5 V.

Frequency should vary with vacuum. Shape should stay constant (square wave).

5. Make sure the sensor produces the correct frequency for a given amount of vacuum, according to t he specification chart for the vehicle you are working on.

- **Reference Waveform**



Frequency decreases as vacuum increases. Look for pulses that are a full 5V in amplitude. Voltage transitions should be straight and vertical. Voltage drop to ground should not exceed 400mV. If the voltage drop is greater than 400mV, look for a bad ground at the sensor or the PCM.

- ## Troubleshooting Tips

A bad digital MAP sensor can produce incorrect frequencies, runted (shortened) pulses, unwanted spikes and rounded off corners that could all have the effect of garbling "electronic communication", thus causing a driveability or emissions problem

Analog Mass Air Flow (MAF) Sensor

- **Theory of Operation**

There are two main varieties of analog MAF sensors; Hot Wire type and Vane type. Hot wire type MAF sensors use heated-metal-foil sensing element to measure air flow entering the intake manifold. The sensing element is heated to about 170 ˚F (77 ˚C), above the temperature of incoming air. As air flows over the sensing element, it cools the element, causing resistance to drop. This causes a cor responding increase in current fl ow, which causes supply voltage to decrease. This signal is seen by the PCM as a change in voltage drop (high air flow = high voltage) and is used as an indication of air flow. The PCM uses this signal to calculate engine load, to determine the right amount of fuel to be mixed with the air, and ignition timing, EGR control, idle control, transmission shift points, etc

Vane type MAF sensors, mainly, consist of a variable resistor (potentiometer) that tells the PCM the position of the vane air flow door. As the engine is accelerated and more air passes through the vane air flow sensor, the vane air door is pushed open by the incoming air. The angle of the vane air flow door is proportional to the volume of air passing by it. A vane type MAF sensor consists of a contact connected to the vane door which slides over a section of resistance material that is places around the pivot axis for the movable contact. The voltage at any point in the resistance material, as sensed through the movable contact, is proportional to the angle of the vane air door. Frequency decreases as vacuum increases. Look for pulses that are a full 5V in amplitude. Voltage transitions should be straight and vertical. Voltage drop to ground should not exceed 400 mV. If the voltage drop is greater than 400mV, look for a bad ground at the sensor or the PCM.

Overswing of the door caused by snap accelerations provides information to the PCM for acceleration enrichment.[Many Toyotas are equipped with vane type MAF sensors operating opposite the above –their voltage is high when airflow is low.

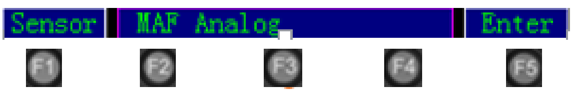
- ## Symptoms

Hesitation, stall, low power, idle problems, excessive fuel consumption, emissions failure

- ## Test Procedure

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



F2 or F4 select measurement project; F5 Enter

3.Shut off all accessories, start the engine and let it idle in park or neutral. After the idle has stabilized, check the idle voltage.

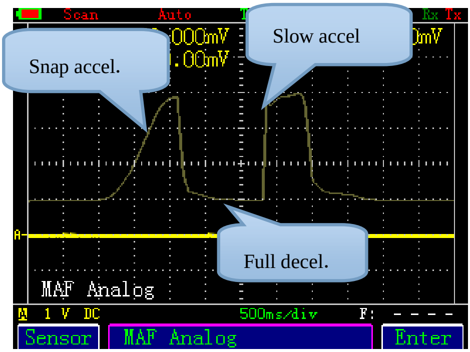
4. Rev the engine from idle to Wide Open Throttle (WOT) with a moderate input speed (this should only take about 2 seconds –don't overrev the engine).

5. Let engine speed drop back down to idle for about two seconds.

6. Rev the engine again to WOT (very quickly) and let it drop back to idle again.

7.  to freeze the waveform on the display for closer inspection.

● Reference Waveform



Hot wire type MAF sensor voltage should range from just over 2 V at idle to just over 4V at WOT, and should dip slightly lower than idle voltage on full deceleration.
Vane type MAF sensor voltage should range from about 1 V at idle to just over 4 V at WOT and not quite back to idle voltage on full deceleration.
Generally, on non-Toyota varieties, high airflow makes high voltage and low airflow makes low voltage. When the sensor voltage output doesn't follow airflow closely, the waveform will show it and the engine operation will be noticeably affected.

● Troubleshooting Tips:

If overall voltage is low, be sure to check for cracked, broken, loose, or otherwise leaking intake air ducts.

IMPORTANT: 0.25 V can make the difference between a good sensor and a bad one, or an engine that is blowing black smoke and one that is in perfect control of fuel mixture.
However, because the sensor output voltages will vary substantially depending on vehicle engine families, in some cases, this sensor can be difficult to diagnose definitively.

Digital Slow MAF (Mass Air Flow) Sensor

● Theory of Operation

There are three main varieties of digital MAF sensors; Digital Slow type (output signals in the 30 to 500 Hz range),Digital Fast type (output signals in the kHz range), and Karman Vortex type (which changes pulse width as well as frequency). A digital MAF sensor receives a 5 V reference signal from the PCM and sends back a variable frequency signal that is proportional to the mass of air entering the engine. The output signal is a square wave, in most cases,with a full 5 V in amplitude. As the airflow increases, the frequency of the signal generated increases. The PCM uses these signals to calculate fuel injector ON time and ignition timing and also determines MAF sensor deterioration by comparing the MAF signal to a calculated value based on MAP, TP, IAT, and RPM signals.

Digital Slow MAF sensors can be found on early to mid 1980's GM vehicles, and many other engine systems. Generally, the older the MAF sensor, the slower the frequency it produces.

● Symptoms

Hesitation, stall, low power, idle problems, excessive fuel consumption, emissions failure

● Test Procedure

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

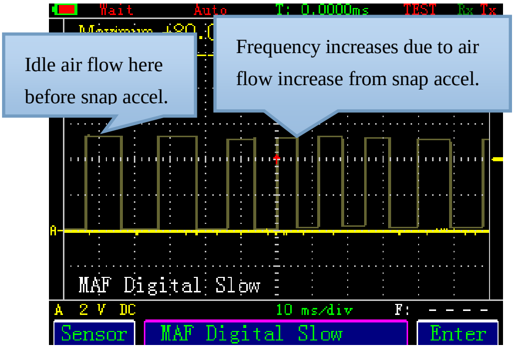
 or  select measurement project;  Enter

3. With the Key On, Engine Running (KOER), use the throttle to accelerate and decelerate the engine. Try different RPM ranges while spending more time in the RPM ranges that correspond to the driveability problem.

4. Make sure that the amplitude, frequency and shape are all correct, consistent, and repeatable.

5.Make sure that the sensor generates the correct frequency for a given RPM or airflow rate.

● Reference Waveform



Frequency stays constant when airflow is constant.Frequency increases as air flow increases from snap acceleration.
Look for pulses that are a full 5 V in amplitude. Voltage transitions should be straight and vertical. Voltage drop to ground should not exceed 400 mV. If greater than 400mV, look for a bad ground at the sensor or the PCM.

- **Troubleshooting Tips**

Possible defects to watch for are runted (shortened) pulses, unwanted spikes, and rounded off corners that could all have the effect of garbling an electronic communication, causing a driveability or emissions problem. The sensor should be replaced if it has intermittent faults.

Digital Fast MAF (Mass Air Flow) Sensor

- **Theory of Operation**

Digital Fast type MAF sensors can be found on GM's 3800 V-6 engine with the Hitachi sensor, Lexus models, and many others. The Hitachi sensor has a square wave output in the 10 kHz range.Voltage level of square waves should be consistent and frequency should change smoothly with engine load and speed.

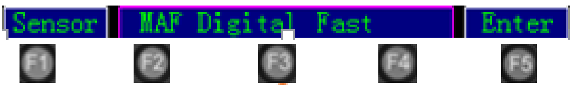
- **Symptoms**

Hesitation, stall, low power, idle problems, excessive fuel consumption, emissions failure

- **Test Procedure**

1. Connect the CH A lead to the sensor output or HI and its ground lead to the sensor output LO or GND;

2.. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

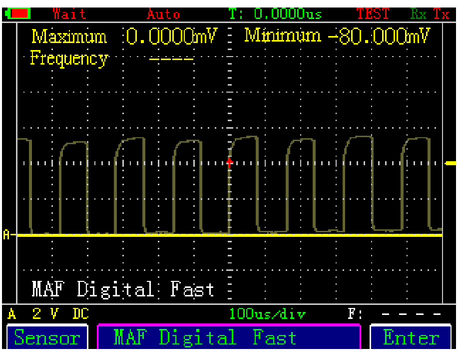


 or  select measurement project;  Enter

3. Make sure that the amplitude, frequency and shape are all consistent, repeatable, and accurate.

4. Make sure that the sensor generates the correct frequency for a given RPM or airflow rate.

- **Reference Waveform**



Frequency stays constant when air flow is constant. Frequency increases as air flow increases from snap acceleration . Look for pulses that are a full 5V in amplitude. Voltage transitions should be straight and vertical. Voltage drop to ground should not exceed 400mV. If greater than 400mV, look for a bad ground at the sensor or the PCM

NOTE

On some Digital Fast MAF sensors, such as the GM Hitachi sensor found on 3800Buick V-6s, the upper left corner of the pulse is rounded off slightly. This is normal

and doesn't indicate a bad sensor.Troubleshooting Tips

- **Troubleshooting Tips**

Possible defects to watch for are runted (shortened) pulses, unwanted spikes, and rounded off corners that could all have the effect of garbling an electronic communication, causing a driveability or emissions problem. The sensor should be replaced if it has intermittent faults.

Digital Karman-Vortex MAF (Mass Air Flow) Sensor

- **Theory of Operation**

Karman-Vortex type MAF sensors are usually manufactured as part of the air cleaner assembly. They are commonly found on Mitsubishi engine systems. While most digital MAF sensors var y only their frequency with changes in airflow rate, the Karman-Vortex type's signal varies Pulse Width as well as Frequency with changes in airflow rate. As the airflow increases, the frequency of the signal generated increases.

Karman-Vortex sensors differ from other digital MAF sensors during acceleration modes. During acceleration, not only does the sensor's frequency output increases, but also its pulse width changes.

- **Symptoms**

Hesitation, stall, low power, idle problems, excessive fuel consumption, emissions failure

- **Test Procedure**

1.Connect the CH A lead to the sensor output HI and its ground lead to the sensor output LO or GND

2.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

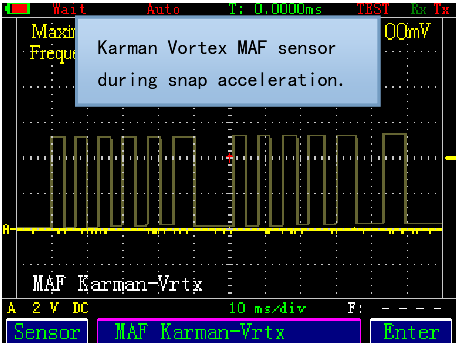
F2 or F4 select measurement project; F5 Enter

3. With the Key On, Engine Running (KOER), use the throttle to accelerate and decelerate the engine. Try different RPM ranges while spending more time in the RPM ranges that correspond to the driveability problem.

4. Make sure that the amplitude, frequency, shape, and pulse width are all consistent, repeatable and accurate for any given operating mode.

5. Make sure that the sensor generates the correct and steady frequency for a given RPM or airflow rate.

● Reference Waveform



Frequency increases as airflow rate increases. Pulse width (duty cycle) is modulated in acceleration modes. Look for pulses hat are a full 5 V in amplitude. Look for the proper shape of the waveform in terms of consistent, square corners, and consistent vertical legs.

● Troubleshooting Tips

Possible defects to watch for are runted (shortened) pulses, unwanted spikes, and rounded off corners that could all have the effect of garbling an electronic communication, causing a driveability or emissions problem. The sensor should be replaced if it has intermittent faults.

Differential Pressure Feedback EGR (DPFE) Sensor

● Theory of Operation

A n EGR (Exhaust Gas Recirculation) pressure sensor is a pressure transducer that tells the PCM the relative pressures in the exhaust stream passages and, sometimes, intake manifold. It is found on some Ford EEC IV and EEC V engine systems.

Ford calls it a PFE (Pressure Feedback EGR) sensor when the sensor outputs a signal that is proportional to the exhaust backpressure.

Ford calls it a DPFE (Differential Pressure Feedback EGR) sensor when the sensor outputs the relative difference in pressure between intake vacuum and exhaust.

These are important sensors because their signal input to the PCM is used to calculate EGR flow. A bad EGR pressure sensor can cause hesitation, engine pinging, and idle problems, among other driveability problems, and I/M emission test failures.

The EGR pressure sensor is usually a three wire sensor. One wire supplies the sensor with 5 V via the PCM's V Ref circuit, another wire provides the sensor ground, and the third wire is the sensor's signal output to the PCM. Generally, Ford's DPFE sensors are found on late model 4.0 L Explorers and other vehicles and produce just under 1 V with no exhaust gas pressure and close to 5 V with maximum exhaust gas pressure.

NOTE

Ford's PFE sensors produce 3.25 V with no exhaust back pressure increasing to about 4.75 V with 1.8P SI of exhaust back pressure. On properly operating vehicles the voltage wo n' t ever ge t to 5 V. P FE sensors can be found on many Taurus and Sable models

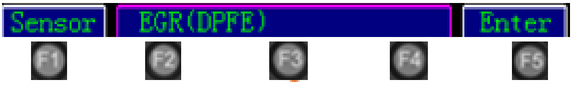
- **Symptoms**

Hesitation, engine pinging, idle problems, I/M emission test failure

- **Test Procedure**

1. Hesitation, engine pinging, idle problems, I/M emission test failure

2.. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



 or  select measurement project;  Enter

3. Start the engine and hold throttle at 2500 RPM for 2–3 minutes until the engine is full y warmed up and the Feedback Fuel System is able to enter closed loop. (Verify this by viewing the O2 sensor signal, if necessary.)

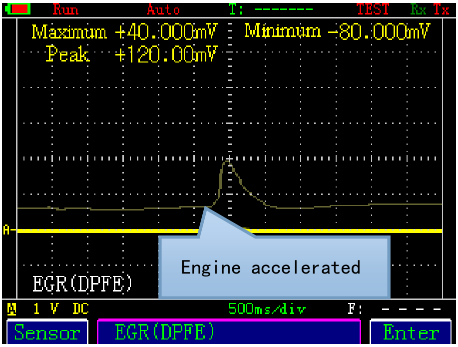
4. Shut off A/C and all other accessories. Drive the vehicle under normal driving modes; start from dead stop, light acceleration, heavy acceleration, cruise, and deceleration.

5. Make sure that the amplitude is correct, repeatable, and present during EGR conditions. T he sensor signal should be proportional to exhaust gas versus manifold vacuum pressures.

6. Make sure that all the hoses and lines to and from the intake manifold, EGR valve, and vacuum solenoid valve are intact, and routed properly, with no leaks. Make sure the EGR valve diaphragm can hold the proper amount of vacuum (check manufacturer's specs.). Make sure that the EGR passageways in and around the engine are clear and unrestricted from internal carbon buildup.

7.  to freeze the waveform on the display for closer inspection.

- **Reference Waveform**

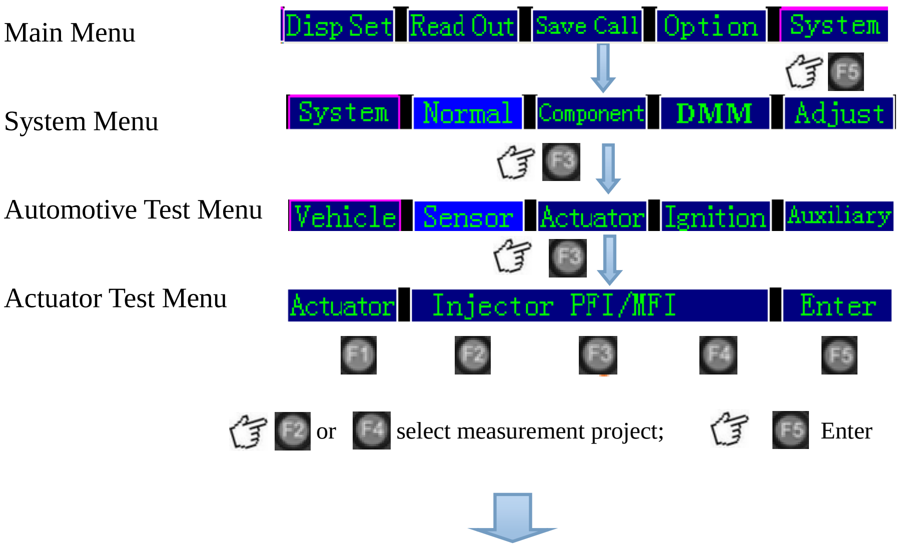


As soon as the engine reaches the predetermined EGR requirement conditions, the PCM will begin opening the EGR valve. The waveform should rise when the engine is accelerated. The waveform should fall when the EGR valve closes and the en gi ne decelerates. EGR demands are especially high during accelerations. During idle and deceleration, the valve is closed

- **Troubleshooting Tips**

There should be no breaks, spikes to ground, or dropouts in the waveform.

3.3 ACTUATOR TESTS



ACTUATOR TESTS MENU

Injector PFI/MFI

Injector TBI

Injector PNP

Injector Bosch

Mixture Cntl Sol

EGR Cntl Sol

IAC Motor

IAC Solenoid

Trans Shift Sol

Turbo Boost Sol

Diesel Glow Plug

Saturated Switch Type (MFI/PFI/SFI) Injector

● Theory of Operation

The fuel injector itself determines the height of the release spike. The injector driver (switching transistor) determines most of the waveform features. Generally an injector driver is located in the PCM that turns the injector on and off.

Different Kinds (Saturated Switch type, Peak-and-Hold type, Bosch type Peak-and-Hold, and PNP type) of injector drivers create different waveforms. Knowing how to interpret injector waveforms (determining on-time, referencing Peak height , recognizing bad drivers, etc .) can be a very valuable diagnostic talent for driveability and emission repair.

Saturated switch injector drivers are used primarily on multiport fuel injection (MFI , P F I, SF I) systems where the injectors are fired i n groups or sequential l y. Deter mining the injector on- time is fairly easy .
The injector on- ti me begins where the PCM grounds the circuit to turn it on and ends where the PCM opens the control circuit. Since the injector is a coil, when its electric field collapses from the PCM turning it off, it creates a spike. Saturated Switch type injectors have a single rising edge. The injector on-time can be used to see if the Feedback Fuel Control System isdoing its job

● Symptoms

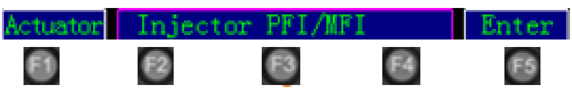
Hesitation, rough idle, intermittent stall at idle, poor fuel mileage, emissions test failure, low power on acceleration

● Test Procedure

1. Connect the CH A lead to the injector control signal from the PCM and its ground lead to the injector GND.

2. Start the engine and hold throttle at 2500 RP M for 2- 3 minutes until the engine is fully warmed up and the Feedback Fuel System enters closed loop. (Verify this by viewing the O2 sensor signal, if necessary.)

3.Enter the measurement setup menu, select test items, automatically the measurement setup of the project



F2 or F4 select measurement project; F5 Enter

4. Shut off A/C and all other accessories. Put vehicle in park or neutral. Rev the engine slightly and watch for the corresponding injector on-time increase on acceleration.

1) Induce propane into the intake and drive the mixture rich. If the system is working properly, the injector ontime will decrease.

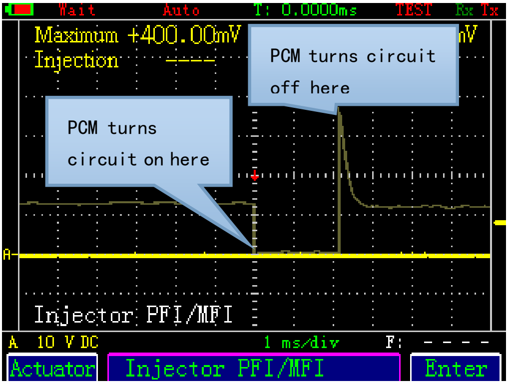
2) Create a vacuum leak and drive the mixture lean. The injector on-time will increase.

3) Raise the engine to 2500 RPM and hold it steady. The injector on-time will modulate from slightly larger to

slightly smaller as the system controls the mixture. Generally, the injector on-time only has to change from 0.25 ms to 0.5 ms to drive the system through its normal full rich to full lean range.

IMPORTANT: If the injector on-time is not changing, either the system may be operating in an "open loop" idle mode or the O2 sensor may be bad.

- ## Reference Waveform



When the Feedback Fuel Control System controls fuel mixture properly, the injector on-time will modulate from about 1-6 ms at idle to about 6-35 ms under cold cranking
or Wide Open Throttle (WOT) operation.
The injector coil release spike(s) ranges are from 30 V to 100 V normally.

- ## Troubleshooting Tips

Spikes during on-time or unusual high turn off spikes indicate the injector driver's malfunction.

Peak and Hold Type (TBI) Injector

● Theory of Operation

Peak and Hold fuel injector drivers are used almost exclusively on Throttle Body Injection (TBI) systems. These drivers are only used on a few selected MFI systems like GM's 2.3 L Quad-4 engine family, Saturn 1.9 L, and Isuzu 1.6 L. The driver is designed to allow approximately 4 A to flow through the injector coil and then reduce the current flow to a maximum of about 1 A. Generally, far more current is required to open the pintle valve than to hold it open.

The PCM continues to ground the circuit (hold it at 0 V) until it detects about 4 A flowing through the injector coil. When the 4 A "Peak"is reached. the PCM cuts back the current to a maximum of 1 A, by switching in a current limiting resistor. This reduction in current causes the magnetic field to collapse partially, creating a voltage spike similar to an ignition coil spike, The PCM continues the "Hold"operation for the desired injector on-time, then it shuts the driver off by opening the ground circuit completely. This creates the second spike. Under acceleration the second spike move to the right, while the first remains stationary. If the engine is running extremely rich, both spikes are nearly on top of one another because the PCM is attempting to lean out the mixture by shortening injector on time as much as possible.

● Symptoms

Hesitation on throttle tip in, rough idle, intermittent stall at idle, poor fuel mileage, emissions test failure, low power on acceleration.

● Test Procedure

1. Connect the CH A lead to the injector control signal from the PCM and its ground lead to the injector GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

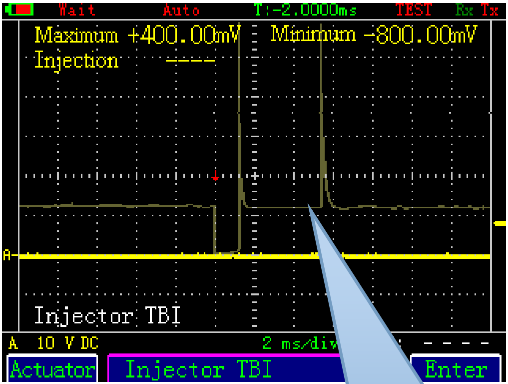
3. Shut off A/C and all other accessories. Put vehicle in park or neutral. Rev the engine slightly and watch for the corresponding injector on-time increase on acceleration.

1)Induce propane into the intake and drive the mixture rich. If the system is working properly, the injector ontime will decrease.

2)Create a vacuum leak and drive the mixture lean. The injector on-time will increase.

3)Raise the engine to 2500 RPM and hold it steady. The injector on-time will modulate from slightly larger to slightly smaller as the system controls the mixture. Generally, the injector on-time only has to change from 0.25 ms to 0.5 ms to drive the system through its normal full rich to full lean range.

- **Reference Waveform**



When the Feedback Fuel Control System controls fuel mixture properly, the injector on-time will modulate from about 1-6 ms at idle to about 6-35 ms under cold cranking or Wide Open Throttle (WOT) operation.
The injector coil release spike(s) ranges are from 30 V to 100 V normally. The turn off spikes less than 30 V may indicate shorted injector coil.
Initial drive voltage should go close to 0 V. If not, injector driver may be weak

Straight line here (just below battery voltage) indicates good injector

- **Troubleshooting Tips**

Spikes during on-time or unusual high turn off spikes indicate the injector driver's malfunction. On GM and some ISUZU dual TBI systems lots of extra oscillations or "hash"in between the peaks indicates a faulty injector driver in the PCM

PNP type injector

- **Theory of Operation**

A PNP type injector driver within the PCM has two positive legs and one negative leg. PNP drivers pulse power to an already grounded injector to turn it on. Almost all other injector drivers (NPN type) are opposite. They pulse ground to an injector that already has voltage applied. This is why the release spike is upside-down. Current flow is in the opposite direction. PNP type drivers can be found on several MFI systems; Jeep 4.0 L engine families, some pre-1988 Chrysler engine families, a few Asian vehicles, and some Bosch vehicles in the early 1970s like the Volvo 264 and Mercedes V-8s.

The injector on-time begins where the PCM switches power to the circuit to turn it on. The injector on-time ends where the PCM opens the control circuit completely.

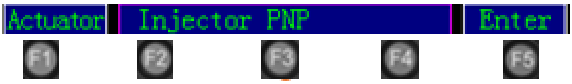
- **Symptoms**

Hesitation on throttle tip in, rough idle, intermittent stall at idle, poor fuel mileage, emissions test failure, low power on acceleration

- **Test Procedure**

1. Connect the CH A lead to the injector control signal from the PCM and its ground lead to the injector GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



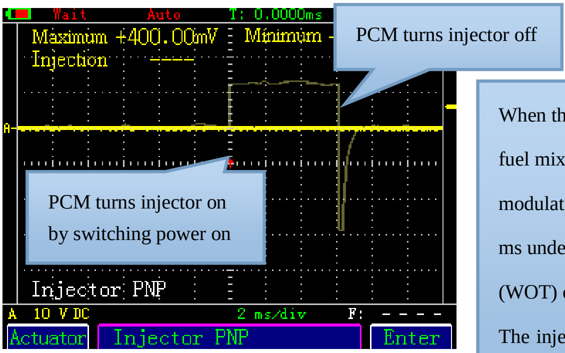
F2 or F4 select measurement project; F5 Enter

3. Start the engine and hold throttle at 2500 RPM for 2-3 minutes until the engine is fully warmed up and the Feedback Fuel System enters closed loop. (Verify this by reviewing the O2sensor signal, if necessary.)

4. Shut off A/C and all other accessories. Put vehicle in park or neutral. Rev the engine slightly and watch for the corresponding injector on-time increase on acceleration.
1)Induce propane into the intake and drive the mixture rich. If the system is working properly, the injector ontime will decrease.
2)Create a Vacuum leak and drive the mixture lean. The injector on-time will increase.
3)Raise the engine to 2500 RPM and hold it steady. The injector on-time will modulate from slightly larger to slightly smaller as the system control the mixture. Generally, the injector on-time only has to change from 0.25 ms to 0.5 ms to drive the system through its normal full rich to full lean range.

IMPORTANT: If the injector on-time is not changing, either the system may be operating in an "open loop"idle mode or the O2sensor may be bad.

- ## Reference Waveform



When the Feedback Fuel Control System controls fuel mixture properly, the injector on-time will modulate from about 1-6 ms at idle to about 6-35 ms under cold cranking or Wide Open Throttle (WOT) operation.

The injector coil release spike(s) ranges are from -30 V to -100 V normally.

NOTE

Some injector spike heights are "chopped"to between -30 V to -60 V by clamping diodes. There are usually identified by the flat top on their spike(s) instead of a sharper point. In those cases, a shorted injector may not reduce the spike height unless it is severely shorted

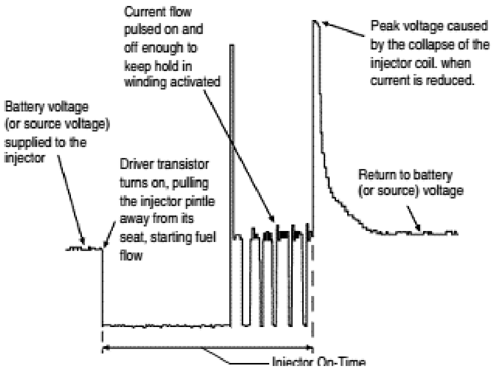
- ## Troubleshooting Tips

Spikes during on-time or unusual large turn off spikes indicate the injector driver's malfunction.

Bosch injector (BOSCH)

● Theory of Operation

Bosch type Peak and Hold injector drivers (within the PCM) are designed to allow about 4 A to flow through the injector coil, then reduce the flow to a maximum of 1 A by pulsing the circuit on and off at a high frequency. The other type injector drivers reduce the current by using a "switch-in"resistor, but this type drivers reduce the current by pulsing the circuit on and off.



Bosch type Peak and Hold injector drivers are found on a few European models with MFI systems and some early to mid-1980s Asian vehicles with MFI systems.

● Symptoms

Hesitation on throttle tip in, rough idle, intermittent stall at idle, poor fuel mileage, emissions test failure, low power on acceleration

● Test Procedure

1. Connect the CH A lead to the injector control signal from the PCM and its ground lead to the injector GND.

2. Start the engine and hold throttle at 2500 RPM for 2-3 minutes until the engine is fully warmed up and the Feedback Fuel System enters closed loop. (Verify this by reviewing the O2sensor signal, if necessary.)

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

4. Shut off A/C and all other accessories. Put vehicle in park or neutral. Rev the engine slightly and watch for the corresponding injector on-time increase on acceleration.

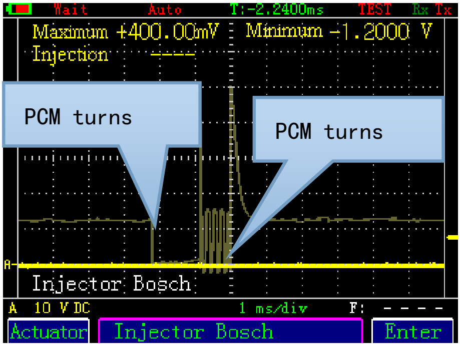
1)Induce propane into the intake and drive the mixture rich. If the system is working properly, the injector on time will decrease.

2)Create a vacuum leak and drive the mixture lean. The injector on-time will increase.

3)Raise the engine to 2500 RPM and hold it steady. The injector on-time will modulate from slightly larger to slightly smaller as the system control the mixture. Generally, the injector on-time only has to change from 0.25 ms to 0.5 ms to drive the system through its normal full rich to full lean range.

IMPORTANT: If the injector on-time is not changing, either the system may be operating in an "open loop"idle mode or the O2sensor may be bad.

- **Reference Waveform**



When the Feedback Fuel Control System controls fuel mixture properly, the injector on-time will modulate from about 1-6 ms at idle to about 6-35 ms under cold cranking or Wide Open Throttle (WOT) operation. The injector coil release spike(s) ranges are from 30 V to 100 V

IMPORTANT : On some European vehicles like Jaguar, there may be only one release spike because the first release spike does not appear due to a spike suppression diode.

- **Troubleshooting Tips**

Spikes during on-time or unusual high turn off spikes indicate the injector driver's malfunction.

Mixture Control Solenoid

- **Theory of Operation**

The mixture control signal is the most important output signal in a carbureted Feedback Fuel Control system. On a GM vehicle, this circuit pulses about 10 times per second, with each individual pulse (pulse width or on-time) varing, depending upon the fuel mixture needed at that moment.

In a GM vehicle, this circuit controls how long (per pulse) the main jet metering rods in the carburetor stay down (lean position). Most feedback carburetor systems operate in the same way –more mixture control on-time means lean mixture command. Generally, mixture control commands (from the PCM) that oscillate around duty cycles greater than 50 % mean the system is commanding a lean mixture in an effort to compensate for a long term rich condition.

- **Symptoms**

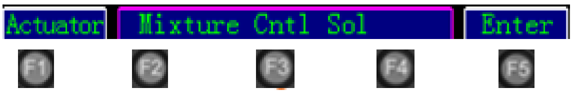
Hesitation on throttle tip in, poor fuel economy, erratic idle, rich or lean emissions

- **Test Procedure**

IMPORTANT : Before performing the test procedure, the O2sensor must be tested and confirmed good.

1. Connect the CH A lead to the mixture solenoid control signal from the PCM and its ground lead to GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

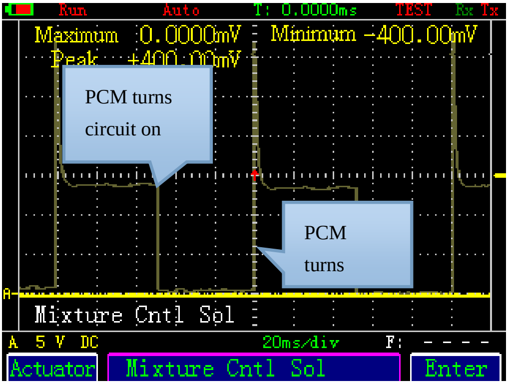


F2 or F4 select measurement project; F5 Enter

3. Start the engine and hold throttle at 2500 RPM for 2-3 minutes until the engine is fully warmed up and the Feedback Fuel System enters closed loop. (Verify this by viewing the O2sensor signal.)

4.. Shut off A/C and all other accessories. Put vehicle in park or neutral. Adjust lean stop, air bleed, and idle mixture as per recommended service procedures for the carburetor being serviced.

● Reference Waveform



NOTE: O2sensor must be good to test this circuit

When the main venturi metering circuits are adjusted properly (lean stop, air bleed,etc.), the mixture control signal should oscillate around 50 % duty cycle normally.When the main metering and idle mixture adjustments are set correctly, the tall spike will oscillate slightly from right to left and back again, but remain very close to the

middle of the two vertical drops in the waveform. The PCM is oscillating the signal

● Troubleshooting Tips

If the duty cycle does not remain around 50 %, check for vacuum leaks or a poor mixture adjustment.If the waveform oscillates around 50 % duty cycle during one operating mode (for instance, idle) but not another,then check for vacuum leaks, misadjusted idle mixture, main metering mixture, or other non-feedback system problems that affect mixture at different engine speeds.

EGR (Exhaust Gas Recirculation) Control Solenoid

● Theory of Operation

EGR systems are designed to dilute the air-fuel mixture and limit NOx formation when combustion temperatures generally exceed 2500 °F (1371 °C) and air-fuel ratios are lean. The effect of mixing exhaust gas (a relatively inert gas) with the incoming air-fuel mixture is a sort of chemical buffering or cooling of the air and fuel molecules in the combustion chamber. This prevents excessively rapid burning of the air-fuel charge, or even detonation, both of which can raise combustion temperatures above 2500 °F. The initial formation of NOx is limited by EGR flow and then the catalytic converter acts to chemically reduce the amounts of produced NOx entering the atmosphere.

How much and when EGR flow occurs is very important to emissions and driveability. To precisely control EGR flow,the PCM sends Pulse Width Modulated signals to a vacuum solenoid valve to control vacuum flow to the EGR valve.When applying vacuum, the EGR valve opens, allowing EGR flow. When blocking vacuum, EGR flow stops. Most engine control systems do not enable EGR operation during cranking, engine warm up, deceleration, and idling. EGR is precisely controlled during acceleration modes to optimize engine torque.

● Symptoms

Hesitation, loose power, stall, emissions with excessive NOx, engine detonation (pinging)

● Test Procedure

1. Connect the CH A lead to the EGR control signal from the PCM and its ground lead to GND.

2. Start the engine and hold throttle at 2500 RPM for 2-3 minutes until the engine is fully warmed up and the Feedback Fuel System enters closed loop. (Verify this this by viewing the O2sensor signal.)

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

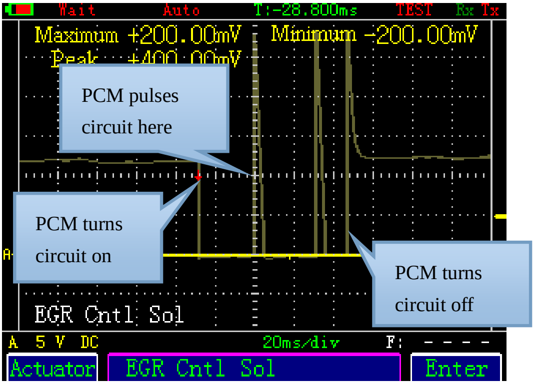
F2 or F4 select measurement project; F5 Enter

4.Shut off A/C and all other accessories. Drive the vehicle under normal driving modes; start from dead stop, light acceleration, heavy acceleration, cruise, and deceleration.

5. Make sure that the amplitude, frequency, shape, and pulse width are all correct, repeatable, and present during EGR flow conditions.

6. Make sure that all the hoses and lines to and from the intake manifold, EGR valve, and vacuum solenoid valve are all intact, and routed properly, with no leaks. Make sure the EGR valve diaphragm can hold the proper amount of vacuum. Make sure that the EGR passageways in and around the engine are clear and unrestricted from internal carbon buildup.

- **Reference Waveform**



As soon as the engine reaches the predetermined EGR requirement conditions, the PCM should begin pulsing the EGR solenoid with a pulse width modulated signal to open the EGR solenoid valve. EGR demands are especially high during accelerations

- **Troubleshooting Tips**

If the waveform has runted (shortened) spike heights, it indicates a shorted EGR vacuum solenoid.If the waveform has a flat line (no signal at all), it indicates a PCM failure, PCM's EGR conditions not met, or wiring or connector problem

Too much EGR flow can make the vehicle hesitate, loose power, or even stall. Not enough EGR flow can result in emissions with excessive NOx and engine detonation (pinging).

IAC(Idle Air Control) Motor

● Theory of Operation

Idle air control valves keep the engine idling as low as possible, without stalling, and as smoothly as possible when accessories such as air conditioning compressors, alternators, and power steering load the engine.

Some IAC valves are solenoids (most Fords), some are rotating motors (European Bosch), and some are gear reduction DC stepper motors (most GM, Chrysler). In all cases, however, the PCM varies the amplitude or pulse width of the signal to control its operation and ultimately, idle speed.

Rotating IAC motors receive a continuous pulse train. The duty cycle of the signal controls the speed of the motor,and in turn the amount of air bypassing the throttle plate.

● Symptoms

Erratic high or low idle, stalling, high activity but no change in idle

● Test Procedure

1. Connect the CH A lead to the IAC control signal from the PCM and its ground lead to GND.

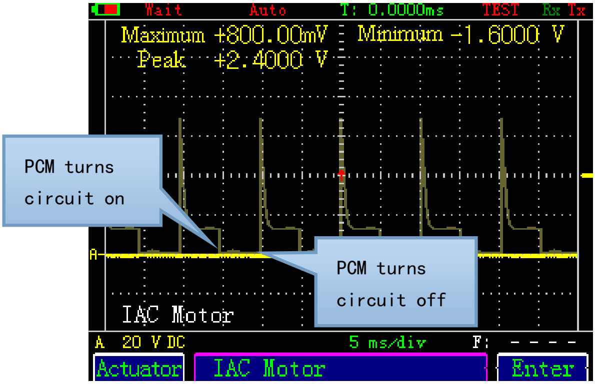
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

3. Run the engine at idle while turning accessories (A/C, blowers, wipers, etc.) on and off. If the vehicle has an automatic transmission, put it in and out of drive and park. This will change the load on the engine and cause the PCM to change the output command signal to the IAC motor.

4. Make sure that idle speed responds to the changes in duty cycle.

● Reference Waveform



The idle control output command from the PCM should change when accessories are switched on and off or the transmission is switched in and out of gear.
The pulse width modulated signals from the PCM should control the speed of the motor, and in turn the amount of air bypassing the throttle plate.
The turn off spikes may not be present in all IAC drive circuits.

IMPORTANT :Before diagnosing IAC motor, several things must be checked and verified; the throttle plate should be free of carbon buildup and should open and close freely, the minimum air rate (minimum throttle opening) should be set according to manufacturer's specifications, and check for vacuum leaks or false air leaks.

- ## Troubleshooting Tips

If the engine idle speed doesn't change corresponding with the change of the PCM's command signal, suspect a bad IAC motor or clogged bypass passage.

IAC (Idle Air Control) Solenoid

- **Theory of Operation**

Idle air control solenoids keep the engine idling as low as possible, without stalling, and as smoothly as possible when accessories such as air conditioning compressors, alternators, and power steering load the engine.

Ford's IAC solenoids are driven by a DC signal with some AC superimposed on top. The solenoid opens the throttle plate in proportion to the DC drive it receives from the PCM. The DC drive is applied by holding one end of the solenoid coil at battery positive while pulling the other end toward GND. The DC voltage at the driven pin decreases as the solenoid drive current is increased.

- **Symptoms**

Erratic high or low idle, stalling, high activity but no change in idle

- **Test Procedure**

1. Connect the CH A lead to the IAC control signal from the PCM and its ground lead to the chassis GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

or 

select measurement project; 

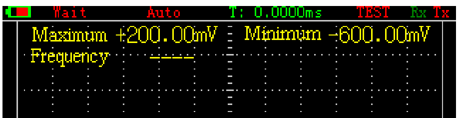
Enter

3. Run the engine at idle while turning accessories (A/C, blowers, wipers, etc.) on and off. If the vehicle has an automatic transmission, put it in and out of drive and park. This will change the load on the engine and cause the PCM to change the output command signal to the IAC solenoid.

4. Make sure that the amplitude, frequency, and shape are all correct, repeatable, and consistent for the various idle compensation modes.

5.Make sure that idle speed responds to the changes in the IAC drive

- Reference Waveform



The idle control output command from the PCM should change when accessories are switched on and off or the transmission is switched in and out of gear.

DC level should decrease as the IAC solenoid drive current is increased.

IMPORTANT : Before diagnosing IAC solenoid, several things must be checked and verified; the throttle plate should be free of carbon buildup and should open and close freely, the minimum air rate (minimum throttle opening) should be set according to manufacturer's specifications, and check for vacuum leaks or false air leaks.

- **Troubleshooting Tips**

If the engine idle speed doesn't change corresponding with the change of the PCM's command signal, suspect a bad IAC solenoid or clogged bypass passage.

Transmission Shift Solenoid

● Theory of Operation

The PCM controls an automatic transmission's electronic shift solenoid or torque converter clutch (TCC) lockup Solenoid.

The PCM opens and closes the solenoid valves using a DC switched signal. These solenoid valves, in effect, control transmission fluid flow to clutch pack, servos, torque converter lockup clutches, and other functional components of the transmission under the PCM's control.

Some electronic shift solenoid systems use ground feed controlled solenoids that are always powered up and some systems use power feed controlled solenoids that are always grounded. A ground feed controlled solenoid on a DC switched circuit appears as a straight line at the system voltage, and drops to ground when the PCM activates the solenoid. A power feed controlled solenoid on a DC switched circuit appears as a straight line at 0 V until the PCM activates the solenoid.

Many vehicle PCM's are programmed not to enable TCC operation until the engine reaches a certain temperature as well as a certain speed.

● Symptoms

Slow and improper shifting, engine stops running when vehicle comes to a stop

● Test Procedure

1. Connect the CH A lead to the transmission shift solenoid control signal from the PCM and its ground lead to the chassis GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

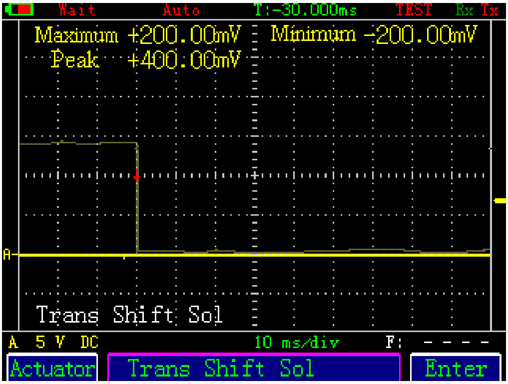
F2 or F4 select measurement project; F5 Enter

3. Drive the vehicle as needed to make the driveability problem occur or to exercise the suspected shift solenoid circuit.

4. Make sure that the amplitude is correct for the suspected transmission operation.

5. Use the proper transmission fluid pressure gauges to make sure the transmission fluid pressure and flow being controlled by the solenoid is being effected properly by solenoid operation. This will help discriminate between an electronic problem and a mechanical problem (such as a sticking solenoid valve, clogged fluid passages, or leaking internal seals, etc.) in the transmission.

● Reference Waveform



The drive signal should be consistent and repeatable.

- ## Troubleshooting Tips

If the waveform appears as a flat line (no signal at all), it can indicate a PCM failure, PCM conditions not met (shift points, TCC lockup, etc.), or wiring or connector problems.

Turbo Boost Control Solenoid

- ## Theory of Operation

Turbochargers increase horsepower considerably without increasing engine piston displacement. Turbochargers also improve torques over the useful RPM range and fuel economy, and reduces exhaust gas emissions.

Turbocharger's boost pressure must be regulated to obtain optimum acceleration, throttle response, and engine durability. Regulating the boost pressure is accomplished by varying the amount of exhaust gas that bypasses the exhaust side turbine. As more exhaust gas is routed around the turbine, the less boost pressure is increased.

A door (called the waste gate) is opened and closed to regulate the amount of bypass. The waste gate is controlled by a vacuum servo motor, which can be controlled by a vacuum solenoid valve that receives a control signal from the PCM. When the PCM receives a signal from the MAP sensor indicating that certain boost pressure is reached, the PCM commands the vacuum solenoid valve to open in order to decrease boost pressure. The PCM opens the solenoid valve via a pulse width modulated signal.

● Symptoms

Poor driveability, engine damage (blown head gasket), hard stall under acceleration

● Test Procedure

1. Connect the CH A lead to the solenoid control signal from the PCM and its ground lead to the chassis GND.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

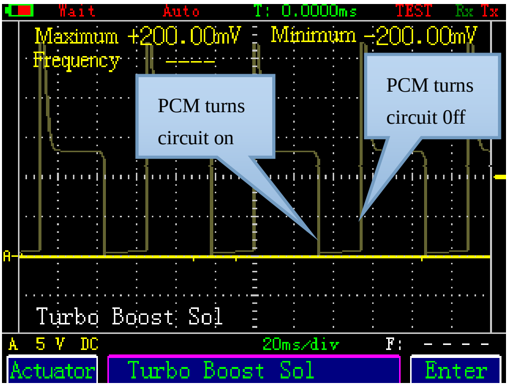
F2 or F4 select measurement project; F5 Enter

3. Start the engine and hold throttle at 2500 RPM for 2-3 minutes until the engine is fully warmed up and the Feedback Fuel system enters closed loop. (Verify this by viewing the O2sensor signal, if necessary.)

4. Drive the vehicle as needed to make the suspected problem occur.

5. Make sure that the drive signal comes on as the boost pressure is regulated and the wastegate actually responds to the solenoid control signal

● Reference Waveform



As soon as the turbo engine reaches a predetermined boost pressure under acceleration, the PCM should begin pulsing the turbo boost solenoid with a varying pulse width modulated signal to open the waste gate. On deceleration, the signal is stopped and the valve is closed.

● Troubleshooting Tips

If the turn off spikes are not present, the solenoid coil may be shorted.

If the drive signal never appears under the high boost conditions, the driver within the PCM may have failed.

If the turn off spikes are runted (shortened), the vacuum solenoid valve may be shorted.

Diesel Glow Plug

Theory of Operation Starting cold diesel engines are not easy because Blowby past the piston rings and thermal losses reduce the amount of compression possible. Cold starting can be improved by a sheathed element glow plug in the precombustion chamber (in case of Direct-injection (DI) engines, in the main combustian chamber).

When current flows through the heating coil of the glow plug, a portion of the fuel around the glow plug's hot tip is vaporized to assist in igniting the air-fuel mixture. Newer glow plug systems, which continue to operate after engine startup for up to 3 minutes, improve initial engine performance, reduce smokes, emissions, and combustian noises.

Usually, a glow plug control unit supplies power to the glow plug during appropriate conditions. Some newer glow plugs are designed with a heater element that changes resistance with temperature. The glow plug's resistance increases as the heating element gets hotter by the combustian temperature's increment after startup.

Usually, glow plug systems are power feed controlled so the waveform of the current going through its heating element appears as a straight line at 0 V until the ignition key is switched on.

● Symptoms

No or hard start, emissions with excessive smokes, excessive combustian noises (knocks)

● Test Procedure

1. Set the instrument up with the current probe. (Connect the probe to the CH A.)

2. Adjust the probe to read DC Zero.

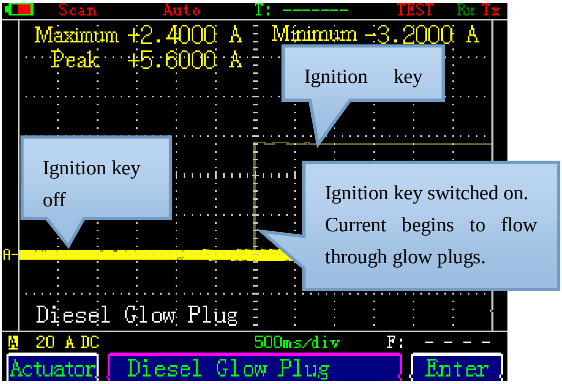
3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

4. With the diesel engine stone cold, turn on the ignition key and watch for the readings.

5. Make sure that the amplitude of the current is correct and consistent for the glow plug systems under test.

● Reference Waveform



Look for the current going through the glow plug to be at its maximum when the ignition key is switched on. Maximum current and operating current specifications maybe available from the manufacturer's service manual.
All glow plugs should draw about the same current under cold or hot conditions

- **Troubleshooting Tips**

If the waveform stays flat (at 0 V), suspect a faulty glow plug. If the waveform has drop outs, suspect an open circuit in the glow plug's heating element. An open circuit may be caused by overheat from a faulty controller, vibration, or fatigue related malfunctions.

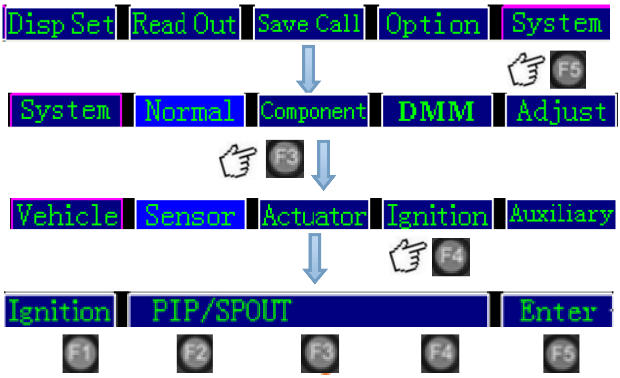
3.3 Ignition System Test

Main Menu

System Menu

Automotive Test Menu

IGNITION TESTS MENU



F2 or F4 select measurement project; F5 Enter

IGNITION TESTS MENU

PIP/SPOUT

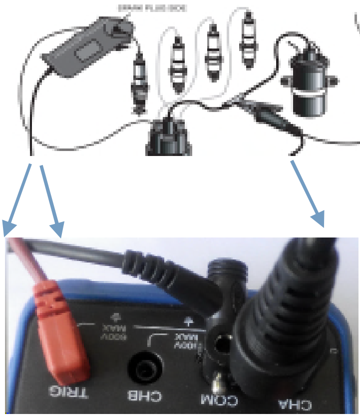
DI Primary

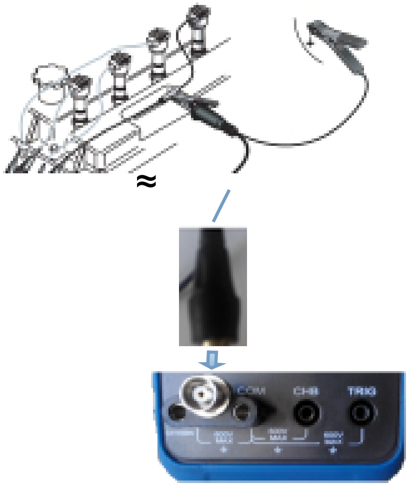
DI Secondary

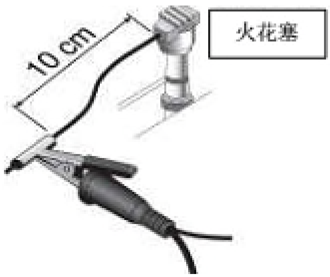
DIS (El) Primary

DIS (El) Secondary

How to connect and measure secondary ignition







CAUTION:

When handing any extremely high voltage signals,e.g.the signals generated from the sparkplugs,NEVER PUT ANY TEST LEADS(Either the Red or Yellow test leads Or the Secondary ignition probe lead Or Power Cable from Cigarette Lighter)CONNECTED TO THE SCOPEINTHE AREAS NEAR THOSE STRONG SIGNALS.If so,the scope can be damaged or worked improperly.。

PIP (Profile Ignition Pickup)/SPOUT (Spark Output)

- **Theory of Operation**

The most common electronic ignition system found on Ford vehicles (primarily on Ford/Lincoln/Mercury) has been dubbed TFI tor Thick Film Ignition. This system uses a Hall Switch in the TFI module, mounted on the distributor, to produce a basic spark timing signal, PIP (Profile lgnition Pickup). This signal is sent to the PCM and the PCM uses this signal to monitor results and accurately 1ime the fuel injector and electronic spark 1iming output(SPOUT)signals. The PCM sends 1he SPOUT back to the TFI module, which then fires the ignition coil primary circuit. The PIP signal is primarily a frequency modulated signal that increases and decreases its frequency with engine RPM,but il has also a pulse width modulated component because it is acted upon by the TFI module, based on information previously received via the SPOUT signal.

The SPOUT signal is a pulse width modulated signal because the PCM continually alters the SPOUT signals pulse width, which has the primary ignition dwell and ignition timing advance information encoded in it. The frequency of the SPOUT signal also increases and decreases with engine RPM because it simply mimics the frequency of the PIP signal.

Many GM/European/Asian vehicles use a similar overall ignition circuit design

The rising and falling edges of the SPOUT move in relation to PIP. The rising edge controls spark timing and the falling edge controls coil saturation (dwell).

Watching both simultaneously using this instrument will sensor inputs. For example, if the MAP sensor tails, the edges of PIP when Manifold Absolute Pressure changes.

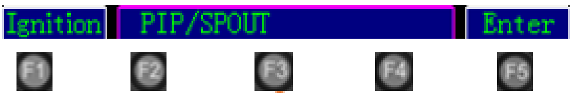
- **Symptoms**

Engine stall out, misfire, slow advance timing, hesitations, no start, poor fuel economy, low power, high emissions

- **Test Procedure**

1.Connect the ground leads of both channel test leads to the chassis GND's. Connect the CH A to the PIP signal and the CH B to the SPOUT signal. Use a wiring diagram for the vehicle being serviced to get the PCM pin number, or color of the wire for each circuit.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project



F2 or F4 select measurement project; F5 Enter

3. Crank or start the engine.

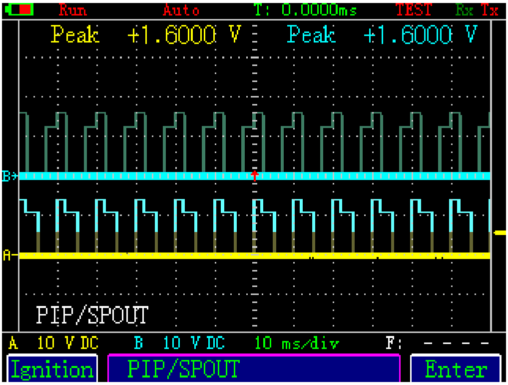
4. With the Key On, Engine Running, let the engine idle or use the throttle to accelerate and decelerate the

engine, or drive the vehicle as needed to make the driveability problem occur.

5. Look closely to see that the frequency of both signals is keeping pace with engine RPM and that 1he pulse width on the pulse width modulated notches of 1he signal changes when 1iming changes are required.

6. Look for abnormalities observed in the waveforms to coincide with an engine sputter or driveability problem

Reference Waveform



The edges must be sharp. Anything that affects ignition timing should change the position of SPOUT (upper trace) with respect to PIP (lower trace) . The notches out of the top and bottom corner of PIP go away when the SPOUT connector is removed because this cuts off the TFI's ability to encode the PIP signal with the SPOUT information.

Troubleshooting Tips

If changing manifold vacuum has no effect on the rising edges of SPOUT, check for a faulty BP/MAP sensor

If PIP is absent, the engine will not start; check for a bad TFI module or other distributor problem

If SPOUT is absent, the system may be in LOS (Limited Operation Strategy) or limp-home mode. Check tor problems in the PCM or bad wiring harness connectors.

If the rising edges of PIP or SPOUT are rounded, timing will be inaccurate, although the system may not set an error code. Check for problems in the module producing each signal.

DI(Distributor lgnition) Primary

● Theory of Operation

The ignition coil primary signal is one of the top three most important diagnostic signals in powertrain management systems. This signal can be used tor diagnosing the driveability problems such as no starts, stalls at idle or while driving, misfires, hesitation, cuts out while driving, etc.

The waveform displayed from the ignition primary circuit is very useful because occurrencies in the ignition

This test can provide valuable information about the quality of combustion in each individual cylinder. The waveform is primarily used to：

1 .analyze individual cylinder's dwell (coil charging time)

2.analyze the relationship between ignition coil and secondary circuit performance (from the tiring line or ignition

3. locate incorrect air-fuel ratio in individual cylinder (from the burn line), and

4. locate fouled or damaged spark plugs that cause a cylinder misfire (from the burn line)

it's sometimes advantageous to test the ignition primary when the ignition secondary is not easily accessible

● Symptoms

No or hard starts, stalls, misfires, hesitation, poor fuel economy

● Test Procedure

1． Connect the CH A lead to the ignition coil primary signal (driven side) and its ground lead to the chassis GND

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

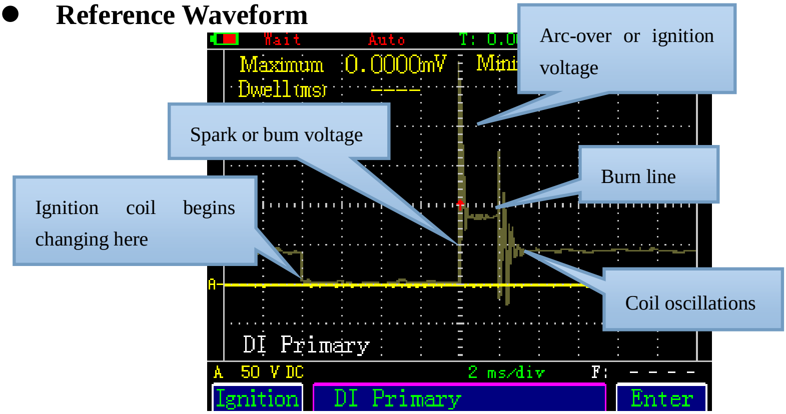
3. With the Key On, Engine Running (KOER), use the throttle to accelerate and decelerate the engine or drive the vehicle as needed to make the driveability problem or misfire occur.

4. For cranking test, set the Trigger mode to Normal

5. Make sure that the amplitude, frequency, shape and pulse width are all consistent from cylinder to cylinder.

Look for abnormalities in the section of the waveform that corresponds to specific components.

- **Reference Waveform**



The Ignition Peak voltage and Burn voltage measurements are available in this test,but they should be corrected to account for the turns ratio of the coil windings.Look closely to see that the pulse width (dwell) changes when engine load and RPM Changes.

- . **Troubleshooting Tips**

Look for the drop in the waveform where the ignition coil begins charging to stay relatively consistent, which indicates consistent dwell and timing accuracy of individual cylinder.

Look for a relatively consistent height on the "arc-over" voltage or firing line. A line that is too high indicates high resistance in the ignition secondary due to an open or bad spark plug wire or a large spark gap. A line that is too short indicates lower (than normal) resistance in the ignition secondary due to to fouled, cracked, or arcing spark plug wire, etc.

Look for the spark or burn voltage to remain fairly consistent. This can be an indicator of air-fuel ratio in the cylinder It the mixture is too lean, the burn voltage may be higher, and if too rich, the voltage may be lower than normal.

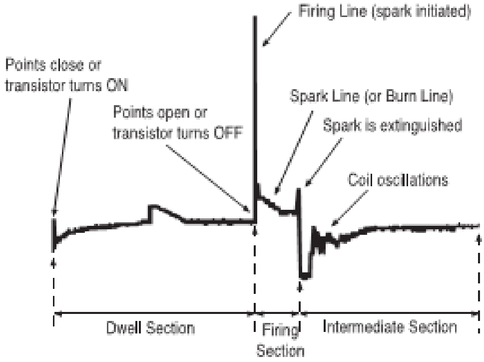
Look for the burn line to be fairly clean without a lot of hash ("noise"). A lot of hash can indicate an ignition misfire in the cylinder due to over-advanced ignition timing, bad injector, fouled spark plug, or other causes. Longer burn lines (over 2 ms) can indicate an abnormally rich mixture and shorter burn line (under 0.75 ms) can indicate an abnormally lean mixture.

Look for at least 2, preferably more than 3 oscillations after the burn line.
This indicates a good ignition coil (and a good condenser on point-type ignitions)

DI (Distributor Ignition) Secondary (Conventional Single and Parade)

- **Theory of Operation**

Secondary ignition patterns are very useful when diagnosing ignition related malfunctions. The secondary scope pattern is divided into three sections:



SECONDARY FIRING SECTION

The firing section consists of a firing line and a spark (or burn) line. The firing line is a vertical line that represents the voltage required to overcome the gap of the spark plug. The spark line is a semi-horizontal line that represents the voltage required to maintain current flow across the spark gap

SECONDARY INTERMEDIATE SECTION

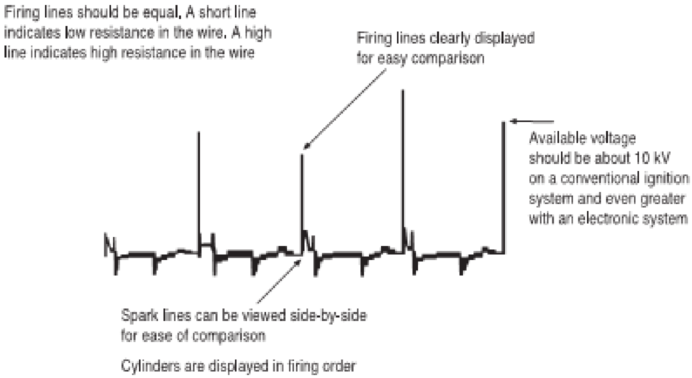
The intermediate section displays the remaining coil energy as it dissipates itself by oscillating between the primary and secondary side of the coil (with the points open or transistor off) .

SECONDARY DWELL SECTION

The dwell section represents coil saturation, which is the period of time the points are closed or the transistor is on.The ignition (or distributor) dwell angle is the number of degrees of distributor rotation during which the points or transistor are closed (or magnetic saturation time in degrees) .Normally, it takes about 10 to 15 ms for an ignition coil to develop complete magnetic saturation from primary current.

The secondary ignition test has been an effective driveability check for over three decades along with the primary ignition test. The ignition secondary waveform can be useful in detection of problems in mechanical components of engine and fuel system, as well as the ignition system components.

When the PARADE mode is selected, this instrument will present a parade of all the cylinders, starting at the left with the spark line of the number 1 cylinder. The instrument will display the pattern for each cylinder's ignition cycle in the engine's firing order. For example, if the tiring order for a given engine is 1,4,3,2, the instrument will display the ignition cycles for each cylinder as shown starting with cylinder number 1 , then 4, then 3, and then 2.



- ## Symptoms

No or hard starts, stalls, misfires, hesitation, poor fuel economy

- ## Test Procedure

NOTE:A Capacitive type ignition secondary probe must be used to test the ignition secondary circuit.

Connecting the CH A or CH B leads directly to an ignition secondary circuit can cause severe damage to the instrument or even personal injury.

Connect the test leads as shown in Figure below

1. Connect the capacitive type ignition secondary probe to the CH A input terminal and its ground lead to chassis GND.

2. Connect the Inductive Pickup to the COM/TRIGGER input terminals

NOTE

The Inductive Pickup must be used to synchronize triggering between the spark plug wire signal and the coil secondary signal clamped by the capacitive secondary probe.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

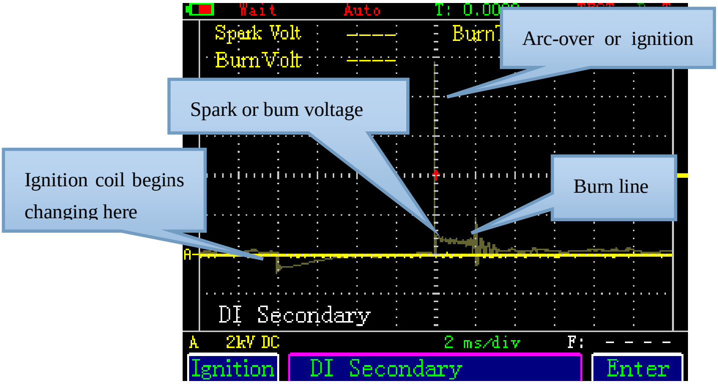
4. Clip the secondary probe to the coil secondary lead wire and clamp the pickup probe on the spark plug wire close to the spark plug.

IMPORTANT : Signals from individual spark plug wires are useful only for triggering. lgnition Peak Voltage, Burn Voltage, and Burn Time measurements may not be accurate, if the signal is taken on the spark plug side of the distributor, due to the rotor spark gap. For accurate measurements, use the coil secondary signal before the distributor.

5.With the Key On, Engine Running (KOER), use the throttle to accelerate and decelerate the engine or drive the vehicle as needed to make the driveability problem or misfire occur.

6.Make sure that the amplitude, frequency, shape and pulse width are all consistent from cylinder to cylinder. Look for abnormalities in the section of the waveform that corresponds to specific components.

- ## Reference Waveform



Look closely to see that the pulse width(dwell)changes when engine load and RPM changes

- ## Troubleshooting Tips

Look for the drop in the waveform where the ignition coil begins charging to stay relatively consistent, which indicates consistent dwell and timing accuracy of individual cylinder.

Look for a relatively consistent height on the "arc-over" voltage or firing line. A line that is too high indicates high resistance in the ignition secondary due to an open or bad spark plug wire or a large spark gap. A line that is too short indicates lower (than normal) resistance in the ignition secondary due to fouled, cracked, or arcing spark plug wire, etc.

Look for the spark or burn voltage to remain fairly consistent.This can be an indicator of air-fuel ratio in the cylinder .If the mixture is too lean, the burn voltage may be higher, if too rich, the voltage may be lower than normal.

Look for the burn line to be fairly clean without a lot of hash, which can indicate an ignition misfire in the cylinder due to over-advanced ignition timing, bad injector, fouled spark plug or other causes. Longer burn lines (over 2 ms) can indicate an abnormally rich mixture and shorter burn lines <under 0.75 ms) can indicate an abnormally lean mixture.

Look for at least 2, preferably more than 3 oscillations after the burn line. This indicate a good ignition coil (a good condenser on point-type ignitions) .

DIS (Distributorless Ignition System) Primary

Theory of Operation

The DIS (or El) primary ignition test is an effective test for locating ignition problems that relate to El ignition coils.The waveform is very useful because occurrences in the ignition secondary burn are induced back into the primary through mutual induction of the primary and secondary windings. The waveform is primarily used to :

1 . analyze individual cylinder dwell (coil charging time) ,
2. analyze ignition coil and secondary circuit performance (from the firing line),
3. locate incorrect air-fuel ratio in individual cylinders (from the burn line), and
4. locate fouled or damaged spark plugs that cause a cylinder misfire (from the burn line).

This test can be useful in detection of problems in mechanical engine and fuel system components, as well as ignition system components.

Symptoms

No or hard starts, stalls, misfires, hesitation, poor fuel economy

Test Procedure

1. Connect the CH A lead to the ignition coil primary signal (driven side) and its ground lead to the chassis GND

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

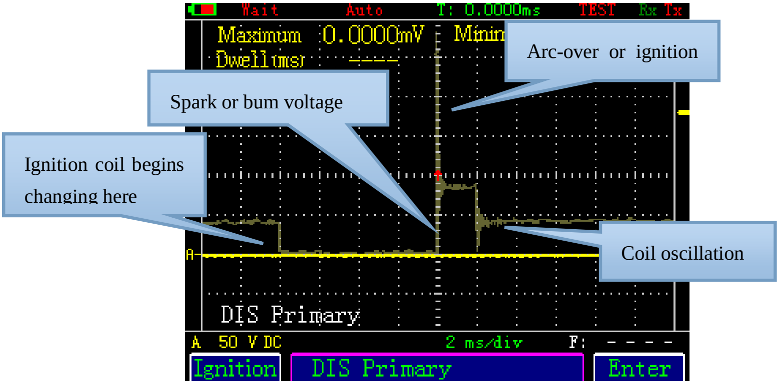
F2 or F4 select measurement project; F5 Enter

3. With the key on, engine running, let the engine idle, or use the throttle to accelerate and decelerate the engine or drive the vehicle as needed to make the driveability problem or misfire occur.

4. Make sure that the amplitude, frequency, shape and pulse width are all consistent from cylinder to cylinder. Look for the abnormalities in the section of the waveform that corresponds to specific components.

5. If necessary, adjust the trigger level for a stable display

- **Reference Waveform**



The Ignition Peak voltage and Burn voltage measurements are available in this test but they should be corrected to account for the turns ratio of the coil windings.

- **Troubleshooting Tips**

Look for the drop in the waveform where the ignition coil begins charging to stay relatively consistent, which indicates consistent dwell and timing accuracy of individual cylinder.

Look for a relatively consistent height on the "arc-over" voltage or firing line. A line that is too high indicates high resistance in the ignition secondary due to an open or bad spark plug wire or a large spark gap. A line that is too short indicates lower (than normal) resistance in the ignition secondary due to fouled, cracked, or arcing spark plug wire, etc.

Look for the spark or burn voltage to remain fairly consistent. This can be an indicator of air-fuel ratio in the cylinder It the mixture is too lean, the burn voltage may be higher, and if too rich, the voltage may be lower than normal.

Look for the burn line to be fairly clean without a lot of hash, which can indicate an ignition misfire in the cylinder due to over-advanced ignition timing, bad injector, fouled spark plug or other causes. Longer burn lines (over 2 ms) can indicate an abnormally rich mixture and shorter burn lines (under 0.75 ms) can indicate an abnormally lear mixture.

Look for at least 2, preferably more than 3 oscillations after the burn line. This indicate a good ignition coil (a good condenser on point-type ignitions) .

DIS (Distributorless Ignition System) Secondary

Theory of Operation

Most Distributorless Ignition systems use a waste spark method of spark distribution. Each cylinder is paired with the cylinder opposite to it (1-4, or 3-6, or 2-5). The spark occurs simultaneously in the cylinder coming up on the compression stroke and in the cylinder coming up on the exhaust stroke. The cylinder on the exhaust stroke requires very little of the available energy to fire the spark plug.

The remaining energy is used as required by the cylinder on the compression stroke. The same process is repeated when the cylinders reverse roles.

The secondary POWER/WASTE spark display waveform can be used to test several aspects of El (or DIS) system operation. This test can be used to :

1. analyze individual cylinder dwell (coil charging time)
2. analyze ignition coil and secondary circuit performance (from the firing line),
3. locate incorrect air-fuel ratio in individual cylinders (from the burn line), and
4. locate fouled or damaged spark plugs that cause a cylinder misfire (from the burn line).

Generally on modern high energy ignition (HEI) systems, tiring voltages should be around 15 kV to beyond 30 kV. Firing voltages vary based on spark plug gap, engine compression ratio, and air-fuel mixture. On dual spark El systems, the WASTE spark is usually much lower in peak voltage than the POWER spark. Close to 5 kV can be normal.

Symptoms

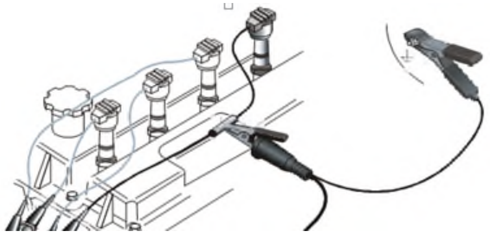
No or hard starts, stalls, misfires, hesitation, poor fuel economy

Test Procedure

NOTE

A Capacitive type ignition secondary probe must be used to test the ignition secondary circuit. Connecting the CH A or CH B leads directly to an ignition secondary circuit can cause severe damage to the instrument or even personal injury.

Connect the test leads as displayed shown in Figure below



1. Connect the capacitive type ignition secondary probe to the CH A input terminal and its ground lead to chassis GND.

2. Clip the secondary probe to the coil secondary lead wire before the distributor3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

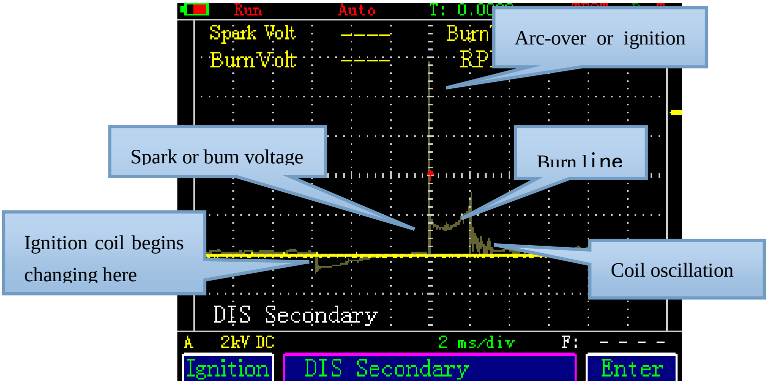
F2 or F4 select measurement project; F5 Enter

3. With the Key On, Engine Running , use the throttle to accelerate and decelerate the engine or drive the vehicle as needed to make the driveability problem or misfire occur.

4. It the tiring line is negative, press ~ to invert the pattern

5. Make sure that the amplitude, frequency, shape and pulse width are all consistent from cylinder to cylinder. Look for abnormalities in the section of the waveform that corresponds to specific components.

- **Reference Waveform**



Look closely to see that pulse width(dell) changes when engine load and RPM changes

- **Troubleshooting Tips**

Look for the drop in the waveform where the ignition coil begins charging to stay relatively consistent, which indicates consistent dwell and timing accuracy of individual cylinder.

Look for a relatively consistent height on the "arc-over" voltage or firing line. A line that is too high indicates high resistance in the ignition secondary due to an open or bad spark plug wire or a large spark gap. A line that is too short indicates lower (than normal) resistance in the ignition secondary due to fouled, cracked, or arcing spark plug wire, etc.

Look for the spark or burn voltage to remain fairly consistent. This can be an indicator of air-fuel ratio in the cylinder It the mixture is too lean, the burn voltage may be higher, and if too rich, the voltage may be lower than normal.

Look for the burn line to be fairly clean without a lot of hash, which can indicate an ignition misfire in the cylinder due to over-advanced ignition timing, bad injector, fouled spark plug or other causes. Longer burn lines (over 2 ms) can indicate an abnormally rich mixture and shorter burn lines (under 0.75 ms) can indicate an abnormally lear mixture.

Look for at least 2, preferably more than 3 oscillations after the burn line. This indicate a good ignition coil (a good condenser on point-type ignitions)

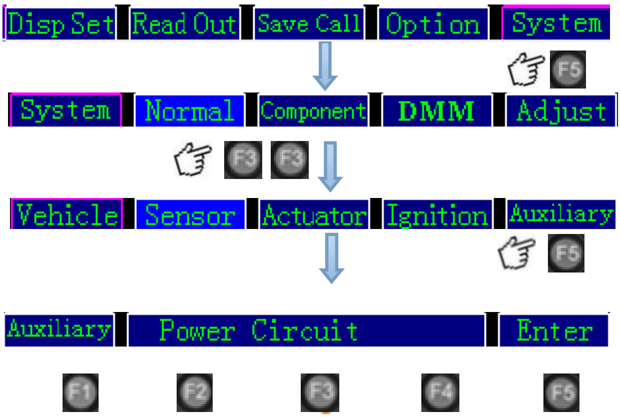
3.4 Auxiliary Test

Main Menu

System Menu

Automotive Test Menu

Auxiliary Test Menu



F2 Or F4 select measurement project; F5 Enter

Auxiliary Test
Power Circuit
V Ref Circuit
Alternator Output
Alternator Field VR
Alternator Diode
Audio Diode
DC Switch Circuit

Power Supply Circuit

- **Theory of Operation**

This test procedure tests the integrity of the battery power supply to vehicle as well as to subsystems or switches that rely on battery power to operate. This test procedure can be used to assure components and devices are getting the quality and quantity of power supply necessary for proper operation. This procedure can be applied to a lot of different automotive circuits that use battery voltage as their power source, such as power supply circuits (to PCM and other control modules), temperature switches, throttle switches, vacuum switches, light switches, brake switches, cruise control switches, etc.

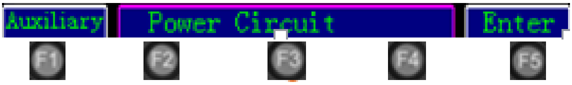
- **Symptoms**

No start, loss of power

- **Test Procedure**

1. Connect the CH A lead to the power supply circuit of the device to be tested and its ground lead to the device's

2.Enter the measurement setup menu, select test items, automatically the measurement setup of the project



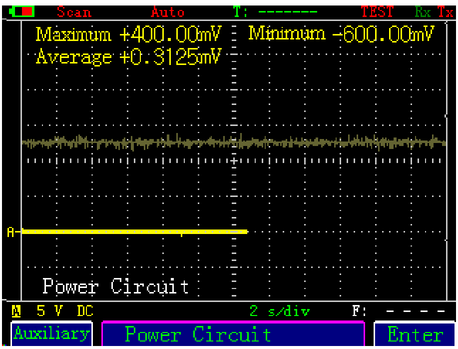
F2 or F4 select measurement project; F5 Enter

3.Make sure power is switched on in the circuit so that the sensor, device or circuit is operational and current is flowing through the circuit.

4.Exercise the sensor, device, or circuit while watching for the amplitude of the signal. The amplitude should stay in a predetermined voltage range for a given condition.

5.In most cases, the amplitude of the waveform should stay at the battery voltage when the circuit is on, and go to 0 V when the circuit is off.

- **Reference Waveform**



The voltage should stay in a predetermined voltage range for a given condition (during normal operation). Transient spikes above average voltage level are normal with engine running

- Troubleshooting Tips

If the amplitude is changing when it is not supposed to (for example, when the switch in the circuit is not being operated), there may be a failure in the circuit.

If the waveform has some spikes to ground, there may be an open circuit in the power side or there may be a voltage short to ground.

If the waveform has some upward spikes, there may be an open circuit in the ground side.

Voltage Reference (V Ref) Circuit

Theory of Operation

The PCM provides a stable regulated voltage, normally 5 V DC (8 V or 9 V DC on some older vehicles), to sensors and components controlled by it for operation. The V Ref circuit should stay at their specified voltage during normal operation. (The voltage level should not vary more than 200 mV under normal operation.)

• Symptoms

Low power, sensor output values out of range

• Test Procedure

1. Connect the CH A lead to the V Ref signal from the PCM and its ground lead to the sensor or chassis GND.

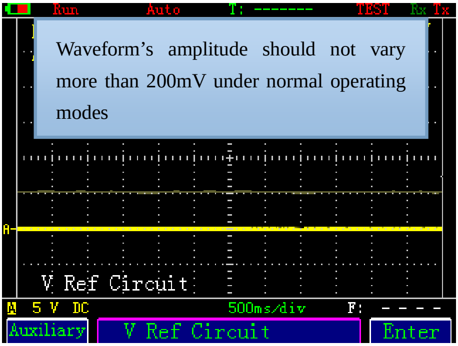
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

3. Make sure power is switched on to the PCM and monitor the voltage level of the V Ref signal from the PCM. Compare it with the manufacturer's recommended limits.

4. If the voltage level is unstable or the waveform shows spikes to ground, check the wiring harness for shorts or intermittent connections.

- **Reference Waveform**



The voltage should stay in a predetermined voltage range for a given condition.
Normal V Ref voltage ranges are from 4.50 V to 5.50 V Average voltage drop should not exceed 100 - 300mV. If there is too much resistance in the ground circuit, the waveform's amplitude will be too high

- **Troubleshooting Tips**

If the voltage level is unstable or the waveform shows spikes to ground, check the wiring harness for shorts or bad connections.

Waveform's amplitude should not vary more than 200 mV under normal operation.

Ground Circuit

- **Theory of Operation**

A ground circuit controls the feedback on any controlled circuit by grounding that circuit to a common conductor (ground).

This test procedure tests the integrity of ground circuits by performing a voltage drop test across the suspected resistance in a ground circuit or the suspect junction.

This test procedure can be used to assure components and devices are getting the quality of ground supply necessary for proper operation. This procedure can be applied to a lot of different automotive circuits that are grounded to the vehicle's electrical systems either through the engine block, chassis, or through a wire connected to the negative side of the battery.

- **Symptoms**

  Poor performance, inaccurate sensor outputs

- **Test Procedure**

1.Connect the CH A lead to the GND pin of the grounded device or the one side of the suspect junction and its ground lead to the chassis GND or the other side of the suspect junction.

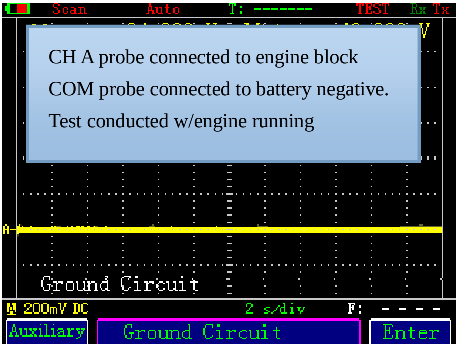
2.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

3. Make sure power is switched on in the circuit so that the sensor, device, or circuit is operational and current is flowing through the circuit.

4. The average voltage drop across the junction should be less than 100mV to 300mV；

- ## Reference Waveform



Average voltage drop should not exceed 100 - 300mV. If there is too much resistance in the ground circuit, the waveform's amplitude will be too high

- ## Troubleshooting Tips

If average voltage drop is excessive, clean or replace the connections and cables

Alternator Output

- ## Theory of Operation

Alternators replaced generators due to their higher output at low engine speed, and their more compact and lightweight design. An alternator is an AC generator with diode rectification, which converts the AC signal to a pulsating DC signal. The DC signal charges the vehicle's battery and supplies power to run the vehicle's electrical and electronic systems. Field current is supplied to the rotor in the alternator to vary its output. Alternator output voltage increases as engine RPM increases.

The alternator's output voltage is controlled by a solid state regulator within the PCM, in some cases. The regulator limits the charging voltage to a preset upper limit and varies the amount of the excitation current supplied to the field winding. The field winding excitation is varied according to the battery's need for charge and ambient temperature.

Check the manufacturer's specs regarding the upper and lower limits of charging voltage permitted for the vehicle being checked.

The alternator's output voltage should be roughly 0.8 V to 2.0 V above the static battery voltage with the Key Off , Engine Off

- **Symptoms**

No start, low battery, slow cranking

- **Test Procedure**

Before performing the alternator output voltage test, the battery's state of charge should be checked and a battery load test should be performed.

1. Connect the CH A lead to the battery positive post and its ground lead to the battery negative post

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

Or

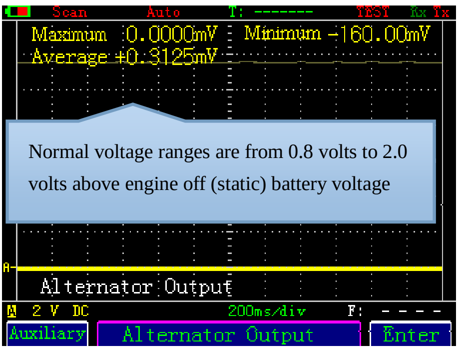

select measurement project;


Enter

2. Turn off all electrical loads and start the engine.

3. Hold the engine at 2500 RPM for about 3 minutes and check the alternator's output voltage.

- **Reference Waveform**



Normal voltage ranges are about 0.8 V to 2.0 V above the static battery voltage with the Key Off Engine Off. Over 2.0 V may indicate an overcharge condition and less than 0.8 V may indicate an undercharge solution. Different vehicles have different charging system specifications. Consult the manufacturer's specs.

General rules of thumb; GM 14.5 to 15.4 V, Ford 14.4 to 14.8 V. and Chrysler 13.3 to13.9 V

IMPORTANT : The test results can be different in a big way according to the ambient temperature, what electrical loads are on the battery during testing, the age of battery, the battery's charging state, the level and quality of the battery's electrolyte, or the battery design.

- **Troubleshooting Tips**

If the output voltage is excessively high, or the battery is leaking, wet, smells like acid, or is boiling, the alternator may be defective. Check the regulator for its proper operation. Also perform a voltage drop test on both sides of the alternator housing and at the battery. If the voltage is different, the alternator may be grounded improperly.

Alternator Field/ VR (Voltage Reference)

• Theory of Operation

A voltage regulator (in the PCM) controls alternator output by adjusting the amount of current flowing through the rotor field windings. To increase alternator output, the voltage regulator allows more current to flow through the rotor field windings. The field control current is varied according to the battery's need for charge and ambient temperature.

If the battery is discharged, the regulator may cycle the field current on 90 % of the time to increase the alternator output. If the electrical load is low, the regulator may cycle the field current off 90 % of the time to decrease the alternator output. That is the signal is usually pulse width modulated.

If the field control circuit is malfunctioning, the charging system can overcharge or undercharge, either creating problems.

• Symptoms

Undercharging, overcharging, or no charging output

• Test Procedure

1. Connect the CH A lead to the field control circuit, and its ground lead to the chassis GND.

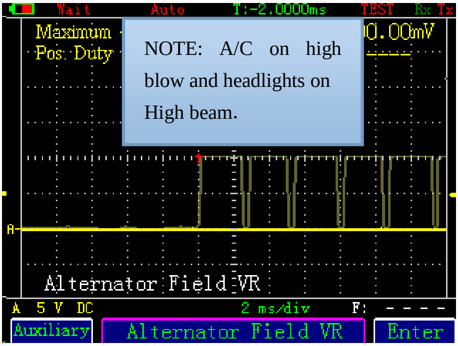
2.Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

3. Start the engine and run at 2500 RPM. Operate the heater fan on high with the headlight on high beam, or use battery load tester to vary the amount of load on the vehicle's electrical system.

4. Make sure that the voltage regulator is properly controlling the duty cycle of the alternator field drive signal as the load changes.

- ## Reference Waveform



The charging system's voltage regulator should vary the on-time of the alternator's field control drive signal depending on the electrical system requirements. The regulator should pulse the field drive signal with the overall duty cycle average meeting the electrical system demands. When electrical load is put on the battery, the field control circuit should go high to compensate for it. Frequency may increase during conditions of increased charging demand.

Troubleshooting Tips

If the voltage is high, there is no command to turn the alternator on or the regulator does not have the ability to decrease the voltage.

If the voltage is low, the alternator will be on all the time and cause an overcharging state.

If the voltage can not be pulled to ground sufficiently, there may be bad regulator within the PCM.

Alternator Diode

• Theory of Operation

An alternator generates current and voltage by the principles of electromagnetic induction. Accessories connected to the vehicle's charging system require a steady supply of direct current (DC) at a relatively steady voltage level. A set of diodes, part of the alternator's rectifier bridge, modifies the AC voltage (produced in the alternator) to the DC voltage. When analyzing a vehicle's charging system, both AC and DC level should be analyzed because the AC level (called "ripple voltage") is a clear indication of diode condition. Too high a level of AC voltage can indicate a defective diode and discharge the battery.

Usually, a bad alternator diode produces Peak to Peak voltages of more than 2 V.

• Symptoms

Overnight battery draining, excessive AC current from alternator output, flickering lights, poor driveability

• Test Procedure

NOTE

This test is made at the rear case half of the alternator and not battery.

The battery can act as a capacitor and absorb the AC voltage.

1. Connect the CH A lead to the B+ output terminal on the back of the alternator and its ground lead to the alternator case.

2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

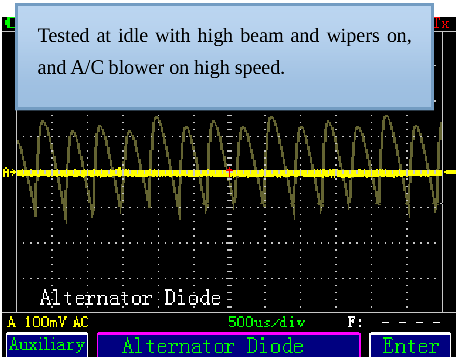
3. With the Key On, Engine Off, turn on the high beam headlights, put the A/C or heater blower motor on high speed, turn on the windshield wipers, and rear defrost (if equipped) for 3 minutes.

4. Start the engine and let it idle.

5. Make sure that pulses in ripple waveform are all about the same size and that pulses are not grouped into pairs

● Reference Waveform

Tested at idle with high beam and wipers on, and A/C blower on high speed.



A bad alternator diode produces Peak to Peak voltages exceeding 2 V usually and its waveform will have "humps"that drop out and go much lower than the normal ones shown above.A shorted diode splits the pulses into pairs.

● Troubleshooting Tips

If the waveform has very noticeable dropouts with two or three times the peak to peak amplitude of a normal ripple, the diodes are defective. Dropouts from bad diodes usually have a peak to peak voltages of around 1.5 V to 2.0 V.

f the humps in the waveform are grouped into pairs, the alternator has one or more bad diodes

Audio System Speaker

- **Theory of Operation**

Automotive speakers are electromechanical devices that convert electrical signal from a vehicle's radio (or monitoring system) into mechanical vibrations. The mechanical vibrations produced by automotive speakers are in the audible frequency range from 16 to 20,000 Hz.

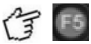
Audio signals to the speaker usually range between 0.5 and 10 V Peak to Peak. DC resistance of the speaker voice coils is normally less then 10 ohms.

- **Symptoms**

A blown speaker with an open circuit

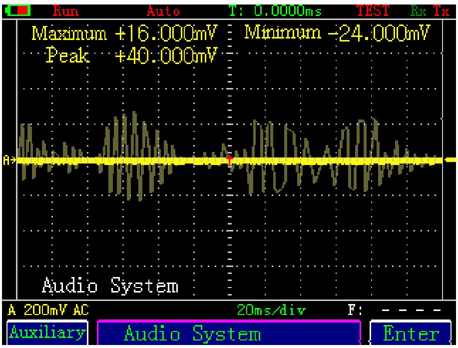
- **Test Procedure**

1. Connect the CH A lead to the positive speaker circuit and its ground lead to the negative speaker circuit.
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

 or  select measurement project;  Enter

3. Turn on the radio at normal listening level and make sure that the speaker drive signal is present.
4. To measure the resistance of the speaker voice coils, set the instrument to the GMM mode. Measure the resistance with the drive signal disconnected.

- **Reference Waveform**



Automotive speaker drive signals normally range between 0.5 V and 10 V Peak to Peak.
Resistance of the speaker voice coils is normally less than 10 ohms.

- **Troubleshooting Tips**

If the speaker is blown, suspect an open circuit。

DC Switch Circuits

- **Theory of Operation**

This test procedure can be applied to a lot of different automotive circuits that use B+ as their power source, such as power supply circuits (to the PCM and other control modules), temperature switches, throttle switches, vacuum switches, light switches, brake switches, cruise control switches, etc.

This test can be used to test the integrity of the battery power supply to the switches that rely on the battery power to operate.

- **Symptoms**

No start, lose of power, no working of switches

- **Test Procedure**

1. Connect the CH A lead to the power supply circuit of the switch to be tested and its ground lead to the switch GND circuit.

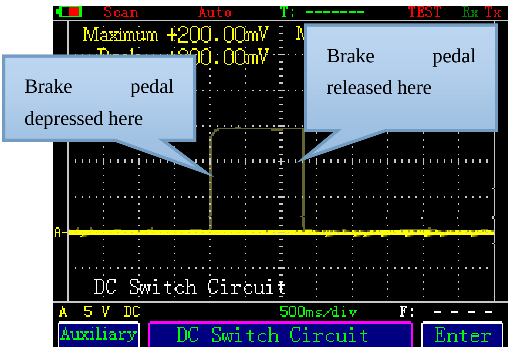
2. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

F2 or F4 select measurement project; F5 Enter

3.Make sure power is switched on in the circuit so that the switch is operational.

4.Exercise the switch while paying attention to the amplitude of the signal. It should stay in a predetermined voltage range for a given condition. In most cases, the amplitude of the waveform should stay at B+ or battery voltage when the circuit is on, and go to 0 V when the switch is activated.

- **Reference Waveform**



If there is a failure in the circuit,the waveforms amplitude will change when it is not supposed to

- **Troubleshooting Tips**

If the waveform has spikes to ground, there may be an open circuit in the power side or a voltage short to ground

If the waveform has upward spikes, there may be an open in the ground side

Relative Cylinder Compression Test

Relative Cylinder Compression Test

- **Theory of Operation**

It is helpful in some diagnoses to see if an engine has a weak cylinder due to low compression. A direct measurement of each cylinder's compression using a compression gauge can be somewhat labor intensive. A simple and effective relative cylinder compression test can be conducted using an accessory current probe on the SCOPE.

When the starter motor turns the crankshaft, its rotational speed is not constant. Every time a piston begins its compression stroke, the starter motor has to work harder to turn the crankshaft. The starter motor requires more current to do this and the starter motor slows down slightly. This repeated slowing down and speeding up, requiring more, then less current, is what comprises the distinctive sound of an engine cranking.

If an engine has a weak cylinder, the crankshaft speeds up instead of slowing down during the weak cylinder's compression stroke.The starter motor's current requirement is also much less than that of a cylinder with good compression. A high amperage current probe accessory for the SCOPE enables easy viewing of the starter motor's current requirements during cranking. If all cylinders are relatively equal in compression, then the starter motor's current fluctuations, as displayed on the SCOPE, will be relatively equal as well.

- **Symptoms**

A blown speaker with an open circuit

- **Test Procedure**

1. Connect a high current probe to the CH A and the CH B lead to the No.1 TDC sensor.

2. Clamp the high current probe around the positive starter cable.

3. Enter the measurement setup menu, select test items, automatically the measurement setup of the project

☞ F2 or F4 select measurement project; ☞ F5 Enter

4. Choose the proper current probe setting: usually "0.1mV=1A", "1mV=lA "10mV=lA", or "100mV=1A".

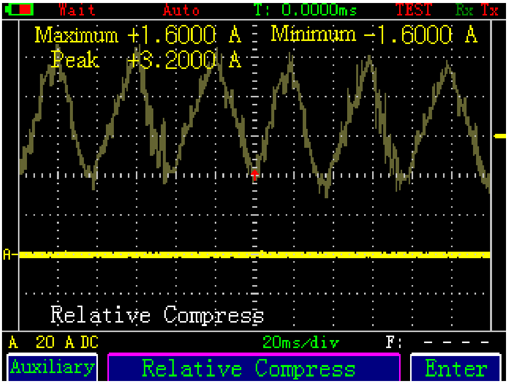
5. Make sure the setting on the current probe matches the setting of the output range {F4).

6. Zero the current probe and begin the test.

Note: Disable the ignition or fuel injection system to prevent the engine from starting. Crank the engine and watch the display

Use the measured No.1 TDC waveform above the INPUT B zero level to determine the No.1 Cylinder on the waveforms measured by the hight current probe.

- ## Reference Waveform



Relative compression test of good engine with equal compression on all cylinders

Pulses of approximately equal magnitude indicate approximately equal compression in all cylinders

- ## Troubleshooting Tips

There should be one hump for each cylinder of the engine. Adjust the horizontal scale if necessary until there is al least one hump for each cylinder (at least 6 humps for a six cylinder engine, etc.). If all of the cylinders have relatively equal compression, then the humps will all have roughly the same amplitude (peak 1o peak height). Cylinders that have considerably less compression will show up on the display as very small humps that try to dissolve into the previous hump to the left. The hump corresponding to the bad cylinder will essentially be non existent..

3.5 Diesel menu

1）In the engine type options, pre-selected Diesel

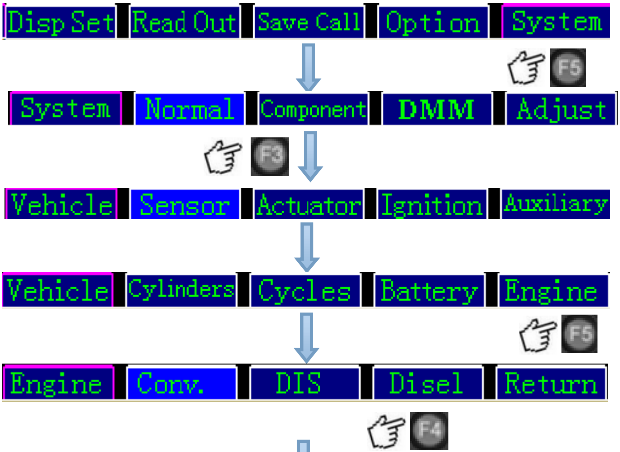
Main Menu

System Menu

Automotive Test Menu

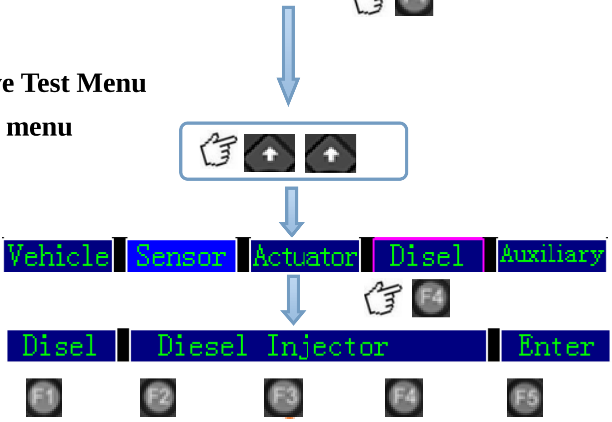
Vehicle Test Menu

Engine menu



2）Return to Automotive Test Menu

Enter the engine test menu



F2 or F4 select measurement project; F5 Enter

DIESEL TEST MENU

DIESEL INJECTOR

ADVANCE

Introduction

During the compression stroke of a diesel engine, the intake air is compressed to about 735 psi (50 Bar). The temperature hereby increases up to 1,292 o to 1,652 oF (700 o to 900 oC). This temperature is sufficient to cause automatic ignition of the Diesel fuel which is injected into the cylinder, shortly before the end of the compression stroke and very near to the TDC (Top Dead Center) .

Diesel fuel is delivered to the individual cylinders at a pressure of between 5145 psi and 17,640 psi (350 Bar and 1200 Bar). The start of the injection cycle should be timed within 1 o Crankshaft to achieve the optimum trade-off between engine fuel consumption and combustion noise (knock). A timing device controls the start of the injection and will also compensate tor the propagation times in the fuel delivery lines.

Diesel RPM measurements are necessary for adjusting idle speed, checking maximum RPM, and performing smoke tests at fixed RPM values.

Measurement Conditions

Cleaning : The fuel lines (to be measured on) should be cleaned in order to assure a good contact of the fuel line itself to the Piezo Pickup and ground clip. Use sandpaper (preferably a de-greaser) to clean the lines.

Positioning and Probe Connection : The Piezo Adapter should be placed as close as possible to the Diesel injector on a straight part of the fuel line. Clamp the ground clip close to the Piezo Pickup. Make sure that the ground clip does not make contact to the piezo itself or to adjacent fuel lines. Connect the adapter to the instrument. Notice that the ground wire is shorter than the signal wire in order to have the weight of probe and cable loaded on the ground wire, not on the signal wire. The piezo element may not bounce or rattle on the fuel line, or make contact to other fuel lines or any other material close by.

Some tips to keep in mind :

- Always position the piezo pickup on the fuel line at about the same distance from the injector.
- Place the pickup on a straight part of the fuel line. Don't place it on a bent part of the line.
- Always compare results with a reference waveform from a good diesel engine to get acquainted with the signal shape.
- Always compare signals at the same engine speed (RPM).
- Pump timing is critical and should occur within 1 degree of crankshaft rotation.

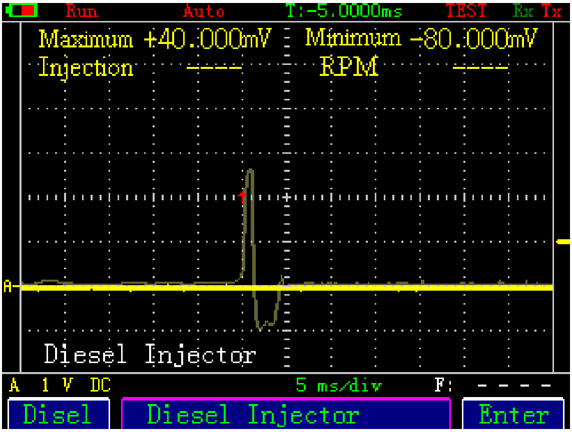
Diesel Injector

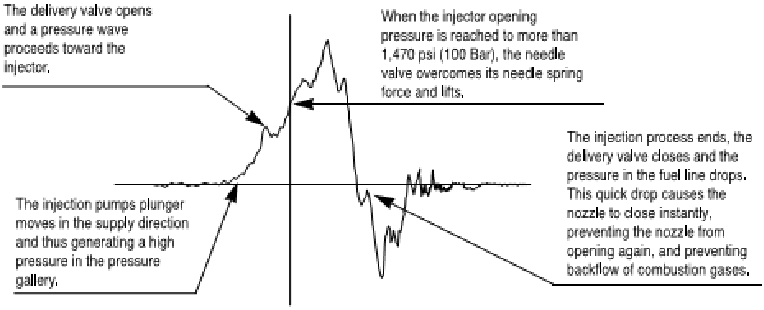
(Diesel RPM Measurement and Diesel Injection Pattern Display)

Use the optional Diesel Probe Set consisting of a Piezo Pickup, which is clamped on the diesel fuel pipe, and a Diesel Adaptor to be connected to the CH A input of the instrument.

- **Reference Waveform**

Dur=Duration of the **Injection pulse**





Diesel Advance

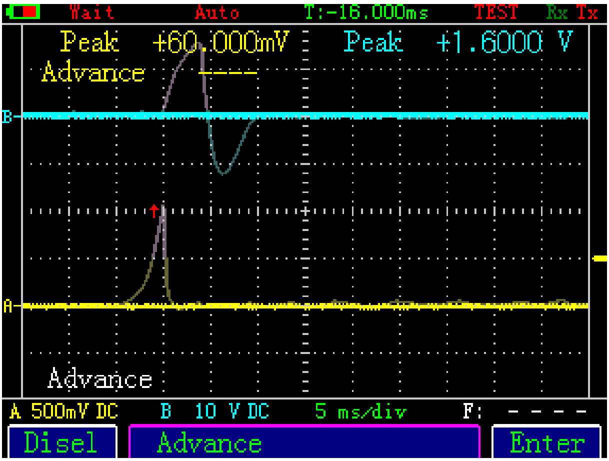
Diesel pump testers are used to calibrate pumps exactly to the engine's requirements. The testers monitor the signals from the reference on the engine's flywheel. The start of the delivery is monitored and timing adjustments can be made at different speeds.

We can reveal problems in the timing of the start of fuel delivery compared to the TDC signal of the flywheel sensor through this advance measurement, which cannot be an absolute and accurate diesel pump adjustment test.

- **Test Procedure**

1. Clamp the piezo pickup and its ground clip on the fuel line of the first cylinder close to the injector and connect the adapter to the CH A.
2. Connect the CH B to the TDC sensor signal output or HI. Don't use the ground lead of the CH B test lead, since the instrument is already grounded through the pickup adapter to the fuel line (double grounding).
3. Use the cursors to read the advance in degrees of the flywheel rotation

- **Reference Waveform**

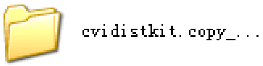


Chapter IV Interface and Software

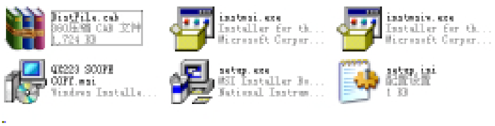
Oscilloscope can through the USB interface and the computer connection, transmission, analysis and printing data

1、Install software

1）Folder and software



Open the folder

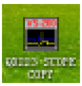


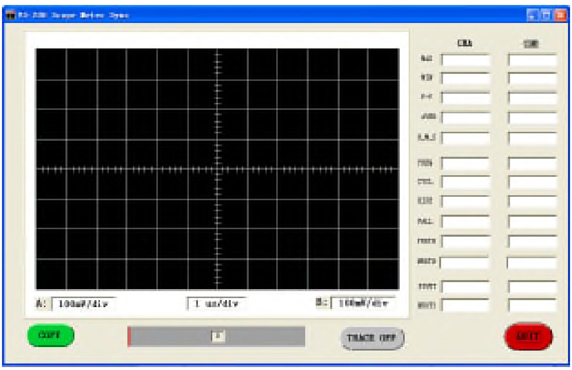
Double click  Installation of communication software

2）After the success of the installation to generate the desktop shortcut icon 

2、Use Software

Using the oscilloscope and computer via USB cable connection

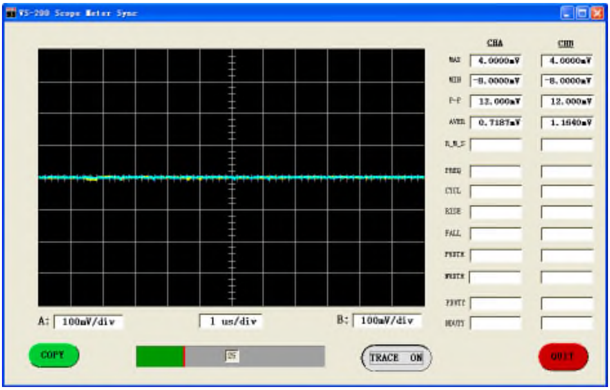
Double click  Start the software，Pop up the following interface



Available for real-time tracking (TRACE) and the copy screen operation (copy)

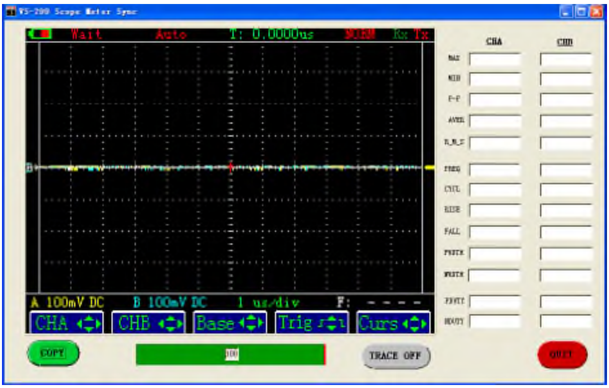
1）TRACE

Software real-time tracking changes to wave form measurement



2）copy

Executed copy screen operation



Chapter V　Maintenance and repair

- Cleaning the Instrument

Check often the Instrument and probe according to the operation conditions. To clean the surface of the Instrument, do the following:

1、Clean dusts on the surface of the Instrument and probe with fluffy cloth. Do avoid abrasion on the transparent plastic of the display filter netting.

2、Clean the meter with a damp soft cloth. And also can use water liquor containing 75% cymene and alcohol to get better cleaning effect.

Carefully.

Do not use any erosive or chemic cleanout lotion,to avoid damaging theInstrument or probe

- Storing the Instrument

Please do not store or placed the Instrument in the place where has intense electromagnetic effect or exposes long-time to the sun.

The Instrument's long-term store, which means six months since packaged, should not be over two years. If storing time is over six months, theInstrument should be took out from the package box, and repackaged to store after checking out with power on

- To charge the lithium battery

The new Instrument is not fully charged when delivered to users. The new batteries must be charged and discharged completely two or three times, can get to a optimal performance.

Be sure to use the accessories about power adapter / charger to charge the Instrument. A fully charge for the Instrument needs 2-3 hours with power off, and charge speed will be decrease with power on.

The battery can be charged or discharged hundreds times, and invalidate at last. It needs to buy a new battery when the battery's work time shortens obviously.

- Replacing and Disposing of the Li Battery Pack

Warning.

To avoid electrical shock, remove the test leads, probes and connected cables before replacing the battery pack. To replace the battery pack, do the following:

1. Disconnect the test leads, probes and connected cables.
2. Locate the battery access cover on the bottom rear. Loosen the screw with a crossed screwdriver.
3. Lift the battery access cover away, and take the battery pack out of the battery compartment. Remove the battery plug from the connector.
4. Install a new battery pack.
5. Reinstall the battery cover, and secure the screw.

⚠ **Warning.** Do not throw the battery into water

Carefully.

Do not dispose of this battery pack with other solid waste. Used batteries should be disposed of by a qualified recycler or hazardous materials handler.

- Calibration and Repair Instrument

Calibration and repair Instrument by qualified personnel to operate. Need to re calibration or repair, please contact the production factory company designated agents contact.

Chapter VII Technical Specifications

Main Technological Specifications

Oscilloscope	
Horizontal	
Bandwidth	DC-20MHz (-3dB)
Channel Number	3
Raise Time	17.5 ns
Sampling Rate	100MSa/s
Horizontal Sensitivity	10ns/div - 5s/div,With 1-2-5 Steps
Horizontal Precision	0.01% + 1 Pixel
Vertical	
Vertical Sensitivity	10mV/div - 500V/div,With 1-2-5 Steps
Vertical Precision	± (3% + 1 pixel)
Vertical Resolution	8 Bit
Maximum Input Voltage	DC or AC 600Vrms
Coupling	AC,DC
Input impedance	1MΩ ≤20pF
Trigger	
Trigger Source	CHA,CHB,External trigger
Trigger Mode	Normal, Auto, Single
Trigger Sensitivity	≤1.0div
Trigger slope	Rising and falling edge
Trigger Coupling	AC,DC

Others		
Cursor Measure	Time and Volt	
Screen Display	3.5″TFT LCD 52mm×70mm Screen; 240 ×320 Dots;	
Display Mode	Dots Display, Vectors Display	
Setup memory	10 waveforms and setup	
Reference waveforms	51 waveforms and setup	
Multimeter		
DC (V)	600mV/ 6V/ 60V/ 600V/1000V	±(1%+5 pixel)
AC (V)	600mV/ 6V/ 60V/ 600V/1000V	±(1.2%+5 pixel)
DC (A)		
AC (A)		
OHM	600Ω/6KΩ/60KΩ/600KΩ/60MΩ	±(1.2%+5 pixel)
CAP	6nF\60nF\600nF\6uF\60uF\600uF\6mF	±(3%+5 pixel)
Diode	≤2V	
On/Off Test	Lower 50Ω,Beep	
Battery	3.6V Lithium Battery	
Battery life	≥5 Hours	
AC Adapter	DC 5V/8W	
Dimension	222mm×114mm×50mm	
Weight	0.7kg	
Pc Interface software	USB PC Software	