



Model 716 Automotive Multimeter



USER'S
MANUAL



FINE INSTRUMENTS CORPORATION

341-5, SONGNAE-DONG, SOSA-GU, BUCHON-SHI, KYUNGGI-DO
KOREA

-TEL: (82-32) 668-6042 -FAX: (82-32) 656-5844

-E-mail: fine@finest.co.kr

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WARNING!

SOURCES LIKE SMALL HAND-HELD RADIO TRANSCEIVERS, FIXED STATION RADIO AND TELEVISION TRANSMITTERS, VEHICLE RADIO TRANSMITTERS AND CELLULAR PHONES GENERATE ELECTROMAGNETIC RADIATION THAT MAY INDUCE VOLTAGES IN THE TEST LEADS OF THE MULTIMETER. IN SUCH CASES THE ACCURACY OF THE MULTIMETER CANNOT BE GUARANTEED DUE TO PHYSICAL REASONS.

Basic Specifications





DC Voltage	: 0 to 1000 V
AC Voltage	: 0 to 1000 V (40 Hz to 2 kHz)
Basic Accuracy	: DC voltage – 0.1 % AC voltage – 0.5 %
RPM (4-stroke)	: 120 to 20000 RPM
RPM (DIS & 2-stroke)	: 60 to 10000 RPM
DC Current	: 0 to 10 A (20 A for 30 seconds)
AC Current	: 0 to 10 A (20 A for 30 seconds)
Resistance	: 0 to 50 M Ω
Frequency	: 0.5 Hz to 1 MHz
Duty Cycle	: 0 to 99.9 %
Dwell	: 0 to 356.4
Pulse Width	: 0.50 ms to 250.00 ms
Diode Test	: 3.0 V
Temperature	: – 50 °C to 1,300 °C (– 58 °F to 2,372 °F)
Audible Continuity Test	: For quick open-short test
O ₂ Sensor Test	: For quick and accurate diagnosing and simulating O ₂ sensors
Ground Test	: For locating bad grounds, voltage drops, intermittent connections or any source of high resistance in automotive electrical circuits and grounds
Charging System Test	: For diagnosing battery and alternator
Battery Drain Test	: For measuring the car's battery current when it is turned off.



Warning

Read "Safety Information" before using this Meter.

CONTENTS

1. Safety Information	3
2. Introduction	6
3. Controls and Indicators	8
4. Basic Meter Functions	12
4-1. Voltage (V)	13
4-2. Dual Display RPM	14
4-3. Temperature	15
4-4. Resistance (Ω)	16
4-5. Continuity ()	17
4-6. Diode test ()	18
4-7. Frequency	19
4-8. RPM	20
4-9. Fuel Injection On Time	21
4-10. Dwell	22
4-11. Duty Cycle	23
4-12. Charging System Test	24
4-13. Ground Test	26
4-14. O2 Sensor Test	28
4-15. AC or DC Current ()	30
4-16. Battery Drain Test	31
5. Advanced Features	32
5-1. MIN/MAX Mode	32
5-2. 1 ms Peak Mode	32
5-3. Manual and Auto Ranging	33
5-4. Trigger Level and +/- Trigger Slope Selection	33
5-5. RPM  Selection	34
5-6. Relative Mode	34
5-7. Hold or Auto Hold	34
5-8. Memory (Data Store, Recall, & Clear) Mode	35
5-9. Backlight	36
5-10. Auto-Power-Off	36
5-11. RS-232C Interface	37
6. Maintenance and Replaceable Parts	38
7. Specifications	40

1. SAFETY INFORMATION

This manual contains information and warnings that must be followed for operating the meter safely and maintaining the meter in a safe operating condition.

If the meter is not used in a manner specified in this manual, the protection provided by the meter may be impaired.


This meter complies with the requirements for double insulation to IEC 1010-1 (2001), UL 3111-1 (6, 1994), EN 3121-1 (1998), CSA C 22.2 No. 1010-1-92 ; Overvoltage 1000 V Category II and also the E. M.C. standards to EN61326 : 1997 +A1.

TERMS IN THIS MANUAL


A **Warning** identifies conditions and actions that could pose serious hazards to the user. A **Caution** identifies conditions and actions that could cause damage the meter or the vehicle under test. **Notes** are added to provide clarity and helpful tips.

INTERNATIONAL ELECTRICAL SYMBOLS

 AC (Alternating Current)


 DC (Direct Current)

 Either DC or AC


 Caution! Refer to the explanation in the manual.

 Dangerous voltage (Risk of electric shock)

 Earth (Ground)





 Double insulation or Reinforced insulation

 Fuse

 Battery

WARNING

- To avoid electrical shock hazard or damage to the meter, do not exceed the input limits shown in the table below :

FUNCTION	TERMINALS	MAXIMUM INPUT
 mV	V Hzms & COM Elec Temp	1000 V DC or 1000 V _{peak}
 V		
Temperature		600 V DC or 600 V AC rms
 Ω		
Hz		
ms-Pulse		
Dwell		
Duty Cycle		
Elec, O ₂		
RPM	RPM + & -	
 A	A & COM	10 A / 600 V
Battery Drain		

- Observe the proper safety precautions when working with voltages above 60 V DC or 25 V AC rms to avoid an electrical shock. These voltage levels pose a potential shock hazard to the user.
- Wear an ANSI eye shield when testing or repairing vehicles. Objects can be propelled by whirling engine components.
- Inspect test leads, connectors, and probes for damaged insulation or exposed metal before using the instrument. If any defects are found, replace them immediately.
- Never attempt a voltage measurement with the test leads inserted into the "A" terminal and the "COM" terminal. The "A" terminal is protected by a fuse. You might be injured or damage the meter.
- Turn the engine off before connecting or disconnecting inductive pickup to avoid a shock.

CAUTION

- Disconnect the test leads from the test points before changing functions to avoid damaging the meter when testing above 350 V AC.
- Choose the proper range and function for the measurement. Always set the meter to the highest range and work downward for an unknown value if you are using manual ranging mode.
- Do not try voltage or current measurements that may exceed the ratings marked on the input limit for switch or terminal.
- Use current probes to measure circuits exceeding 10 A.
- Disconnect the "live" test lead before disconnecting the "common" test lead.
- Do not test a recently recharged lead-acid battery.
- Disconnect the power and discharge all high-voltage capacitors before testing in the resistance, continuity, and diode functions.
- If the engine has been running, do not place the meter and its accessories near the engine or the exhaust manifold which might be hot and can damage the meter.

2. INTRODUCTION

This meter is a handheld and battery operated professional automotive multimeter designed to provide troubleshooting solutions to the most difficult problems encountered with today's sophisticated automotive electronic systems.

The User's Manual tells you how to use this meter. You may also need a manual that provides technical information for the vehicle you plan to test. The most important information resources are the vehicle's repair service manuals generally available for purchase through automotive dealers. They are also available through a number of publishers that specialize in providing technical information manuals to the independent repair garages.

This User's Manual should be used as a guide to get you started in troubleshooting. Your real learning can best be accomplished through experience. As you become more proficient in using the automotive multimeters to troubleshoot, you will very quickly learn how certain electrical symptoms can relate to various driveability problems.

This meter is much more than a standard multimeter. This meter can replace the following several automotive testers.

- Full Function Multimeter
- O₂-Sensor Tester
- (PFI type or TBI type) Fuel Injector Tester
- Battery Drain Tester
- Ground Tester
- Charging System Tester

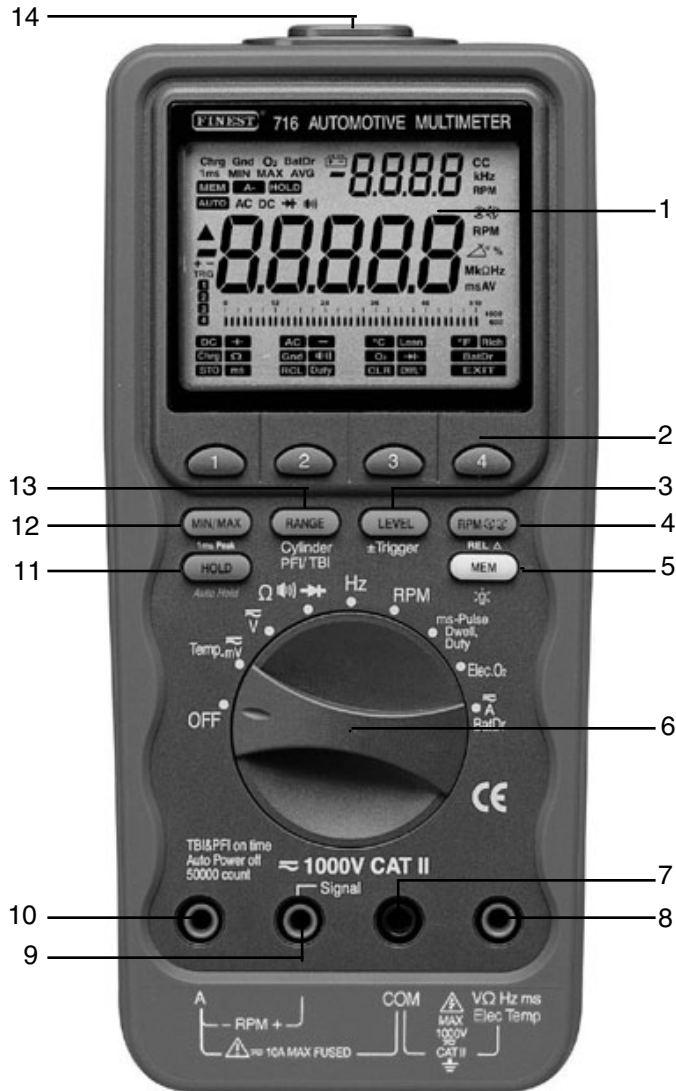
Especially, this meter gets a quick and accurate diagnosis of the complete O₂ circuit. This meter is capable of sending a Rich/Lean signal to the ECM, and displaying crossing-per-second (CC) and O₂ voltage simultaneously, when the secondary display shows test results.

This meter has a bright LED backlight as well as enhanced LCD with larger digits, wide viewing angle and on screen menu selection. A battery access door allows users to replace the battery and fuse without voiding calibration seals. Overmoulding technology in the case disperses various shock over more of the case than a conventional rubber boot design. Convenient closed case calibration allows adjustments to be made directly through the RS-232C port.


FEATURES

- 4 $\frac{1}{5}$ digit, 50000 count (primary) and 9999 count (secondary) dual display with bar-graph. (Frequency range : 99999 counts)
- Closed case calibration through the phototronic RS-232C serial port.
- Accurate RPM measurements for 2- and 4-stroke automotive engines with 1 to 12 Cylinders using the Inductive Pickup.
- ms-Pulse Width function to test on-time of both PFI type and TBI type fuel injectors, idle air control motors, and electronic transmission controls.
- Duty Cycle and direct DWELL reading for electronic fuel injection, feedback carburetors, and ignition systems.
- 4 steps adjustable triggers on 1 to 12 Cylinders, either 2- or 4-Cycle for outboards, motorcycles and conventional engines.
- Measure temperature of fan switch and catalytic converters up to 2,372 °F (1,300 °C).
- O₂ Sensor test for a quick diagnosis and simulation of the complete O₂ Sensor.
- Ground test to locate bad ground, voltage drops, intermittent connections, or any source of high resistance in automotive electrical circuits and grounds.
- Charging system test to diagnose the battery and the alternator.
- Battery drain test to measure the car's battery current when it is turned off.
- Auto Hold, 50 ms highspeed MIN/MAX/AVG, and Relative mode.
- 1 ms Peak mode.
- Memory store and recall (20 locations).
- Backlit display.
- Auto-power-off.
- RS-232C phototronic serial port.
- Overmoulded case.
- IEC 1010-1, CAT II 1000 V rating.

3. CONTROLS AND INDICATORS

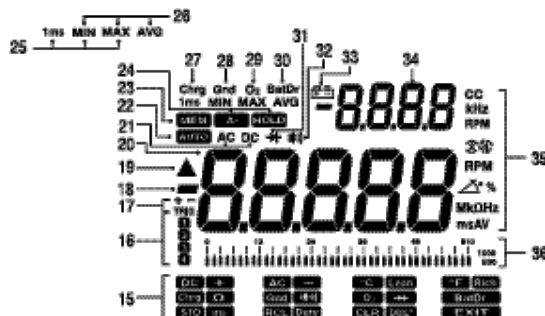


1. **LCD display** 4 $\frac{1}{2}$ digit, 50000 count (primary) and 9999 count (secondary) dual display with bar-graph
2. 1 2 3 4 On screen menu selection pushbuttons
3. **LEVEL** Press this pushbutton momentarily to select trigger levels. Press this pushbutton for more than 1 second to toggle between positive and negative trigger slopes.
4. **RPM/G2** Press this pushbutton momentarily to toggle between **RPM** and **RPM** in **RPM** function. Press this pushbutton for more than 1 second to select Relative Zero.
5. **MEM** Press this pushbutton momentarily to select Memory mode. Press this pushbutton for more than 1 second to turn the LCD backlight on.
6. **Selector** Turn the power **On** or **Off** and select a functions.
7. **COM** Common (Ground reference) input terminal for all functions except **RPM** function
8. **VΩ Hz ms Elec Temp** Input terminal for all functions except **Current** and **RPM** functions
9. **RPM + / Signal** Input terminal (+) for **RPM** function. **Output** terminal for sending out a **Rich** command or a **Lean** command for 5 seconds in **O₂ Sensor** test mode.
10. **A/RPM-** Input terminal (+) for current function. Ground reference (-) input terminal for **RPM** function.
11. **HOLD** Press this pushbutton momentarily to activate **HOLD** for simply freezing a reading. Press this pushbutton for more than 1 second to activate **Auto Hold** for automatically capturing a stable reading, beeping to acknowledge, and holding it on the LCD.
12. **MIN/MAX** Press this pushbutton momentarily to activate Record function. Press this pushbutton for more than 1 second to activate 1 ms Peak function.






13.  Press this pushbutton momentarily to select ranges in the manual ranging mode of most functions or number of cylinders on Dwell function. Press this pushbutton momentarily to toggle between the PFI mode and the TBI mode when measuring on-time of fuel injectors.








Press this pushbutton for more than 1 second to toggle Auto/Manual ranging in most functions.

14. RS-232 Optical interface



15. Menu on screen

16.  These annunciators indicate trigger level status.
17.  These annunciators indicate that positive (+) or negative (-) Trigger Slope is selected.
18.  This symbol indicates Negative Polarity.
19.  This symbol indicates the Relative function is activated.
20. **DATA** Primary digital readings of data being measured.
21.  This annunciator indicates Autoranging.
22. **AC DC** AC annunciator indicates alternating current is selected. DC annunciator indicates direct current is selected.

23.  This annunciator indicates the Memory function is activated.
24.  **HOLD** annunciator indicates the HOLD functions is selected and  annunciators indicate the Auto Hold function is selected.
25. **1 ms MAX MIN** These annunciators indicate 1 ms MAX (+) Peak, or 1 ms MIN (-) Peak reading is being displayed.
26. **MAX MIN AVG** These annunciators indicate MAX (Maximum), MIN(Minimum), or AVG(Average) reading is being displayed.
27. **Chrg** This annunciator indicates the Charging system test function is selected.
28. **Gnd** This annunciator indicates the Ground test function is selected.
29. **O₂** This annunciator indicates the O₂ Sensor test function is selected.
30. **BatDr** This annunciator indicates the Battery Drain test function is selected.
31.  This symbol indicates the Diode test function is selected.
32.  This symbol indicates the Continuity test function is selected.
33.  Low Battery alert. Replace the battery as soon as possible to ensure accuracy.
34. **DATA** Secondary display for Dual Display data.
35. **CC...** These annunciators indicate the function being selected and/or the appropriate measurement units.
36.  Analog bar-graph with scale.

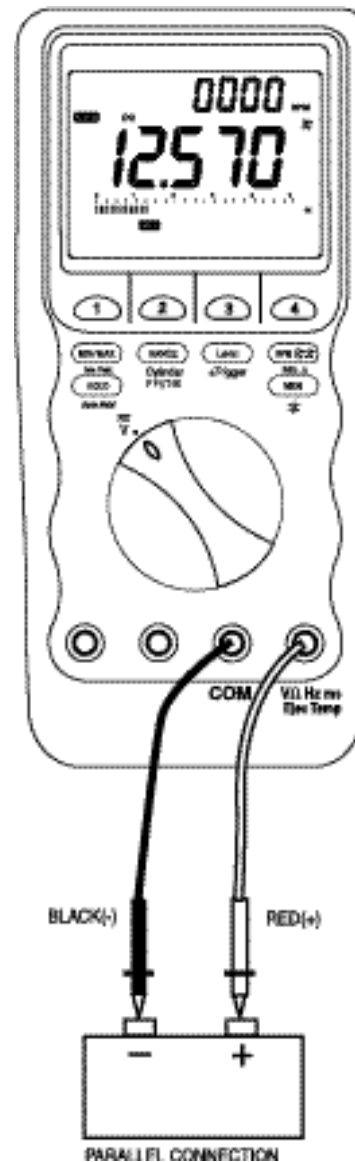
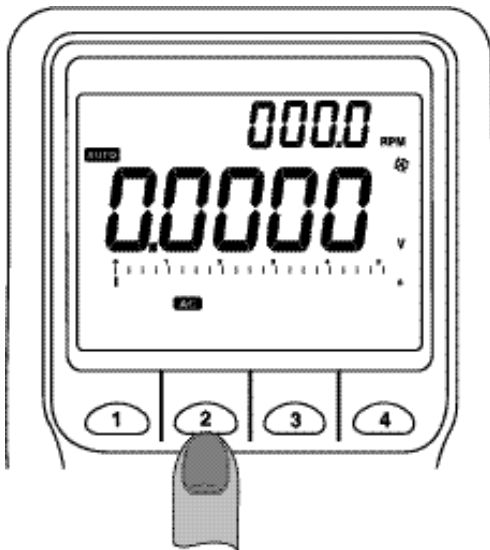
4. BASIC METER FUNCTIONS

Making Measurements and Tests

All measurements and tests are made by first setting the rotary selector switch to a function setting (so that the meter is put in the default measurement function) and then selecting a measurement from the menukeys. Note that not all function knob settings have corresponding menukey settings.

For example, the steps below show how to make an ac voltage measurement.

1. Set the rotary selector switch to \overline{V} position for voltage measurements. Then, the meter is set to the default dc voltage measurement mode.
2. Select the menukey 2 for ac voltage measurement.
3. Connect the test leads to the measurement points.



4-1. Voltage (V)

1. Set rotary selector to \overline{V} position. The meter defaults at DC.
2. Press menukey 2 momentarily to select AC, and press $\text{RPM} \oplus \text{S}$ twice to select Hz in the secondary display, if required.
3. Insert red lead into V terminal and black lead into COM terminal.
4. Touch black probe to ground or negative side of the circuit and touch red probe to positive side of the circuit coming from the power source.
5. Set rotary selector to \overline{mV} position for voltage application below 0.4 V with similar operation procedures.
6. Refer to 4-2 for convenient dual display RPM function.

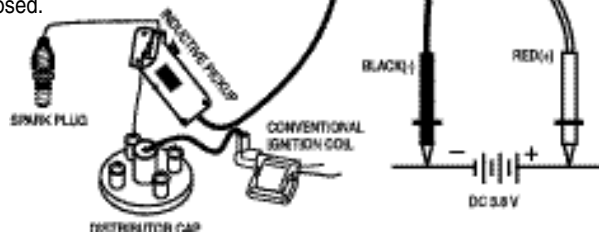
NOTE: Voltage must be measured in parallel (red probe measuring circuit from power source).

The analog bar graph is easier to read when the data causes the digital display to rapidly change. It is also useful for trend setting or directional data.

4-2. Dual Display RPM

This function is available for the primary functions ; DC mV, AC mV, DC V, AC V, Dwell, ms-Pulse, and Duty Cycle. The trigger level selection is not available for this function, but available for the primary display RPM function. See 4-8 for more details.

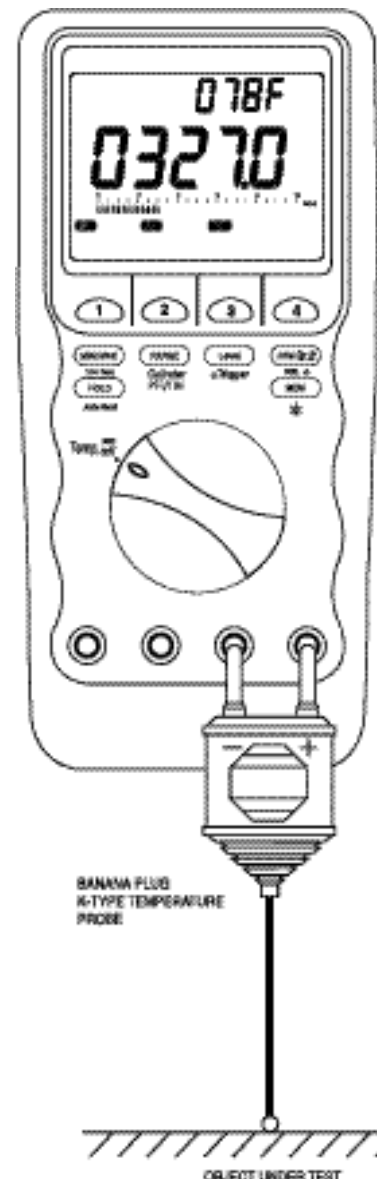
1. Set the meter to the corresponding primary function.
2. Press **RPM** button to toggle between RPM $\frac{1}{4}$ (for 4-stroke engine) and RPM $\frac{1}{2}$ (for 2-stroke or DIS engine).
3. Insert the Dual Banana Connector into the **RPM -** and the **RPM +** input terminals as shown. Ensure the plug with the Ground Tab goes into the **RPM -** terminal.
4. Clamp the inductive pickup to a spark plug wire with the arrow sign facing the spark plug as shown. Ensure the pickup jaws are completely closed.
5. Read RPM in the secondary display.



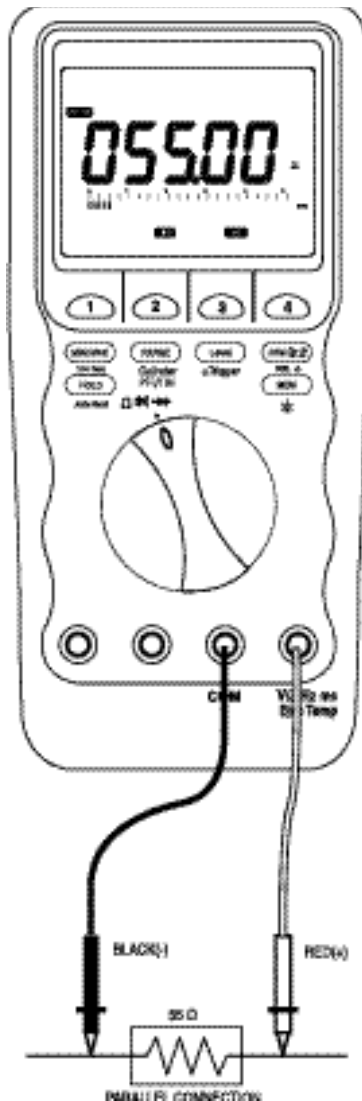
NOTE: Position the pickup as far away from the distributor and the exhaust manifold as possible.
Position the pickup within 6 inches of the spark plug or move it to another plug wire if no reading or an erratic reading is received.

4-3. Temperature

1. Set rotary selector to **Temp.** position.
2. Press menukey 3(or 4) to select temperature function. The primary display will show **0FL**, and the secondary display will always show the meter's internal temperature in °C or °F alternatively matching with the selected primary display mode of °C or °F.
3. Insert banana plug K-type temperature bead probe with correct + / - polarities. You can also use a thermocouple probe adapter (optional accessory) to adapt other standard K-type temperature probes.
4. Touch the end of the thermocouple probe to the measurement surface and read the primary digital display with °C (or °F). We can easily recognize the temperature unit of the primary display from the secondary display.



NOTE: The measured temperature is displayed with 0.1 °C (or 0.1 °F) resolution. For example, 98°C is displayed as 0098.0 and 98 °F is displayed 0098.0.



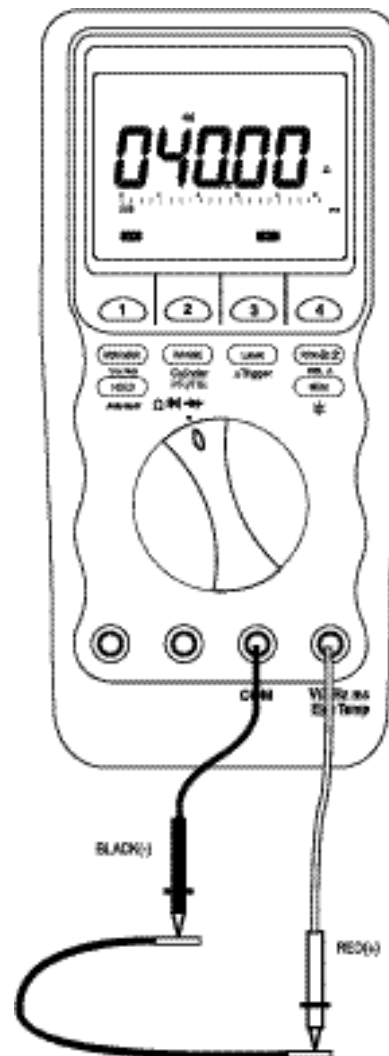
4-4. Resistance (Ω)

CAUTION

Turn off power and discharge all capacitors on circuit to be tested before attempting incircuit resistance measurements. Accurate measurement is not possible if external or residual voltage is present.

1. Set rotary selector to Ω position. The meter defaults at Ω function. *O.F.L* is displayed in the primary display.
2. Insert black lead into COM terminal and red lead into Ω terminal.
3. Touch the test lead probes across the resistance or circuit to be tested.

NOTE: *The resistance in the test leads can affect accuracy in the 500 Ω range. Short the leads together and press the REL button to automatically subtract the test lead resistance from the measured resistance.*



4-5. Continuity ()

CAUTION

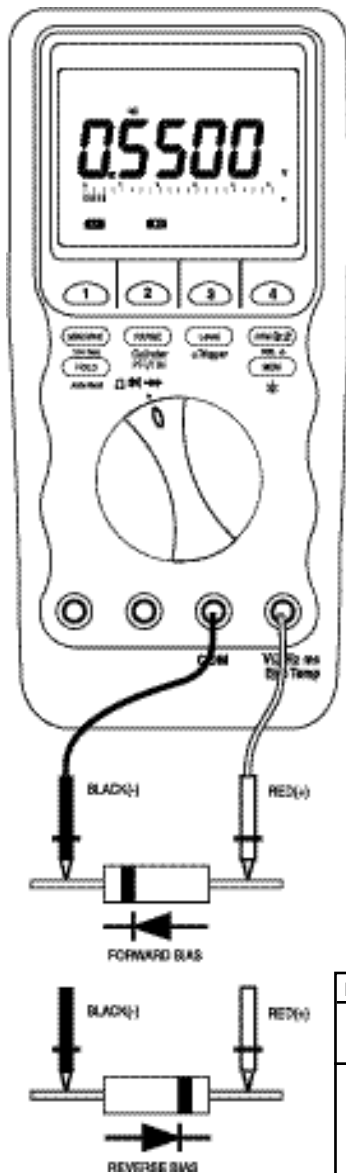
Turn the power OFF on the test circuit. A beeper tone does not necessarily mean zero resistance.

1. Set rotary selector to Ω position.
2. Press menukey 2 to select Continuity function. *O.F.L* is displayed in the primary display.
3. Insert black lead into COM terminal and red lead into Ω terminal.
4. Touch the test lead probes across the device being tested.

If the resistance of the device is below 70 Ω , there is a continuous beep tone.

If the resistance of the device is more than 70 Ω , there is no beep tone.

This is useful for checking wiring connections and operation of switches.



4-6. Diode (→|←) Test

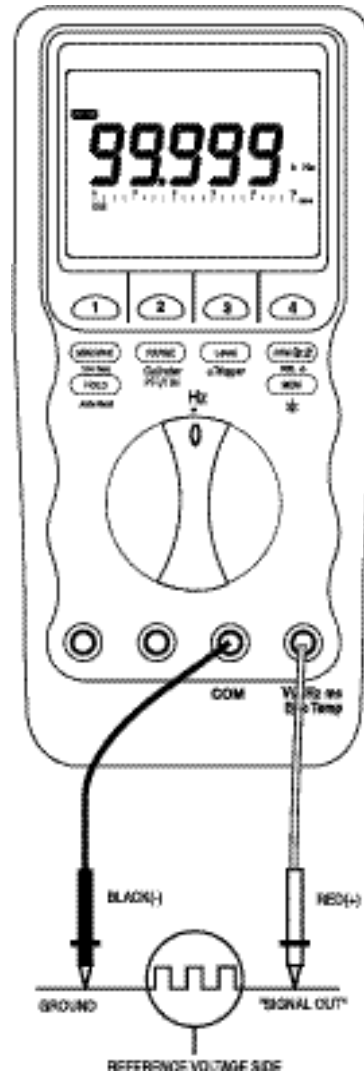
CAUTION

Turn the power OFF on the test circuit.

1. Set rotary selector to Ω (diode symbol) position.
2. Press menukey 3 to select Diode Test function. .OFL is displayed in the primary display.
3. Connect the test leads as shown and observe the digital display. Normal forward voltage drop (forward biased) for a good silicon diode is between 0.4 V to 0.9 V. A reading higher than that indicates a leaky diode (defective). A zero reading indicates a shorted diode (defective). An .OFL indicates an open diode (defective).
4. Reverse the test leads connections (reverse biased) across the diode.
5. The primary display shows .OFL if the diode is good. Any other readings indicate the diode is resistive or shorted (defective).

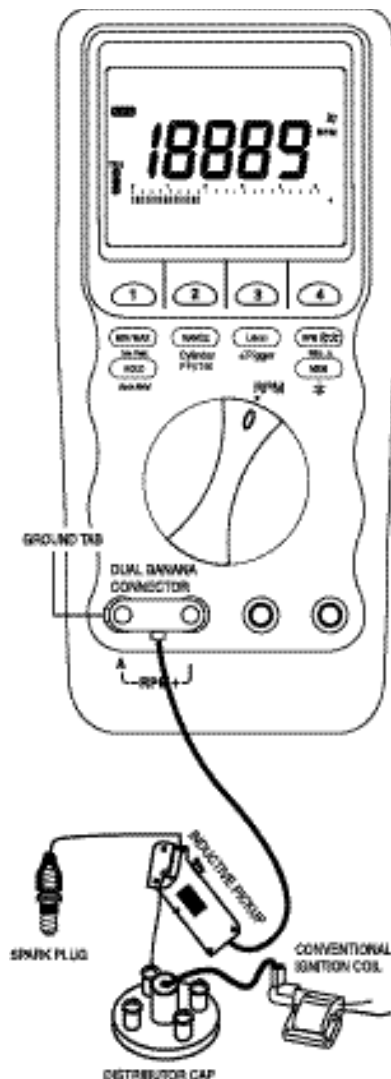
Use the table below to determine if the diode is Good or Bad.

DIODE	FORWARD BIAS(→ ←)	REVERSE BIAS(← →)
Good	0.4 to 0.9 V	OFL
	OFL	0.4 to 0.9 V
Bad	OFL	1.0 to 3.0 V
	1.0 to 3.0 V	OFL
	0.4 to 0.9 V	0.4 to 0.9 V
	OFL	OFL
	0.0000 V	0.0000 V



4-7. Frequency

1. Set rotary selector to Hz position.
2. Insert black lead into COM terminal and read lead into Hz terminal.
3. Touch black probe to ground and touch red probe to the "Signal out" wire on the sensor.



4-8. RPM (primary display)

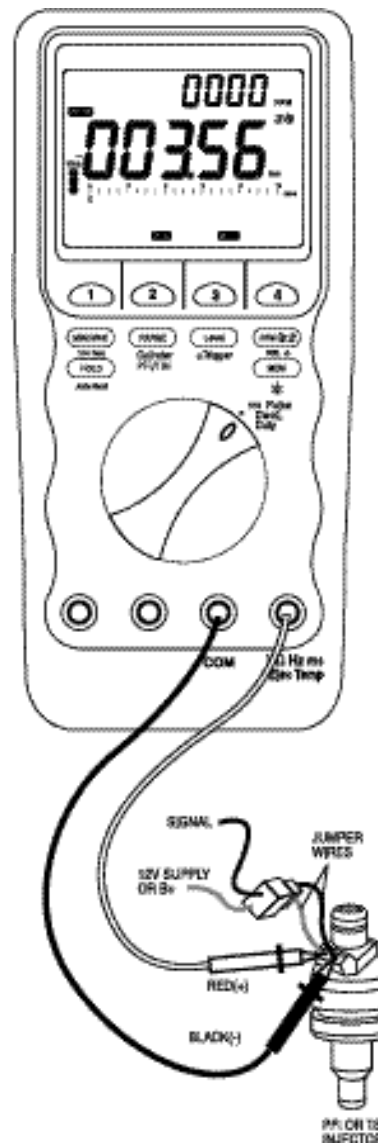
WARNING

Be sure the inductive pickup is in the terminals marked “- RPM +” when measuring RPM’s. If the pickup is in the wrong terminal, personal injury or meter damage may occur.

The ignition system can generate a potential shock hazard. Ensure that the engine is off before connecting or removing the inductive pickup.

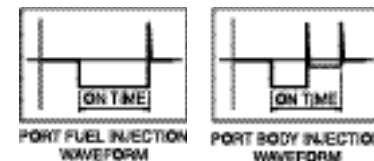
1. Set rotary selector to RPM position. The meter defaults at TRIG **1 2 3** (trigger) level.
2. Press **RPM** button to toggle between RPM **4** for 4-stroke engine and RPM **2** for 2-stroke and DIS engine.
3. Insert the Dual Banana Connector into the RPM - and the RPM+ input terminals as shown. Ensure the plug with the Ground Tab goes into the RPM- terminal.
4. Clamp the inductive pickup to a spark plug wire with the arrow sign facing the spark plug as shown. Ensure the pickup jaws are completely closed.
5. Read RPM in the primary display.

NOTE: 4 trigger levels (TRIG **1 2 3 4** → TRIG **1 2** → TRIG **1** → TRIG **1 2 3 4**) are selectable by pressing **LEVEL** button momentarily in this function. Refer to 5-5 for more details.



4-9. Fuel Injection On Time

This function applies to both Port Fuel Injectors (PFI) which operate with a single On Time pulse and Throttle Body Injectors (TBI) which operate with twin pulses.



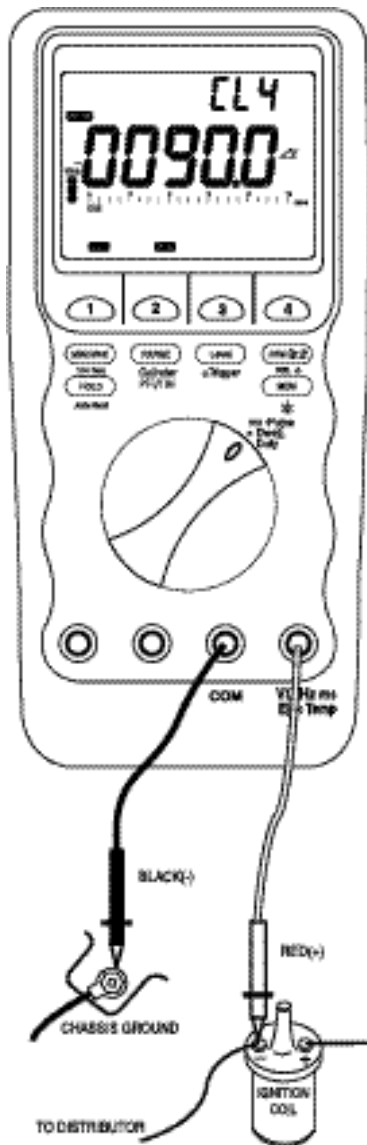
1. Set rotary selector to ms-Pulse, Dwell, Duty position.

The meter defaults at ms-Pulse with -TRIG **1 2 3** level in the PFI mode. (“**PFI**”) appears in the secondary display for 1 second.)

Press **RANGE** button to toggle between the PFI mode and the TBI mode. (“**TBI**”) appears in the secondary display for 1 second.)

4 trigger levels (-TRIG **1 2 3 4** → -TRIG **1 2** → -TRIG **1** → -TRIG **1 2 3 4**) are selectable by pressing **LEVEL** button momentarily in this function.

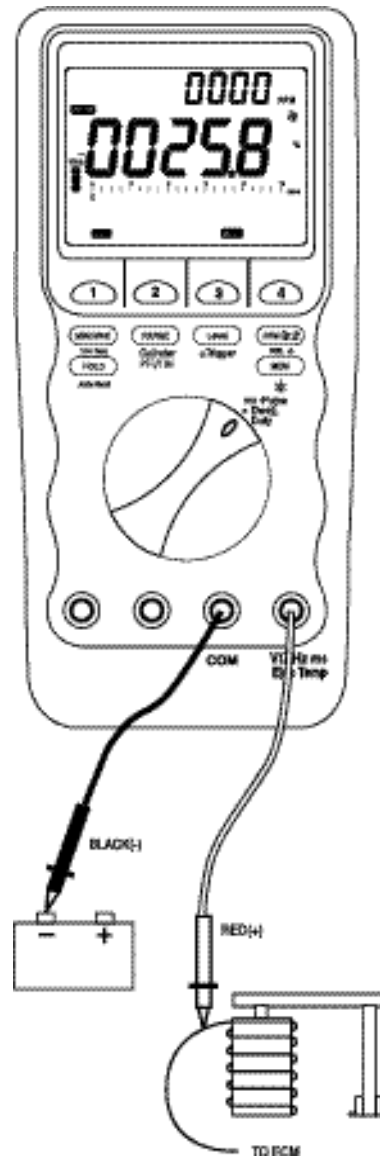
2. Insert black lead into COM terminal and red lead into ms(-Pulse) terminal.
3. Connect the test leads as shown and read On Time in the primary display.
4. The fuel injection frequency can be displayed in the second display by pressing the **RPM** button momentarily twice.



4-10. Dwell

1. Set rotary selector to ms-Pulse, Dwell, Duty position.
2. Press menukey 3 to select Dwell function. The meter defaults at 4 cylinders (CL4). Press **RANGE** (Cylinder) button momentarily and repeatedly to select the required number of cylinder and display the cylinder setting in the second display.
3. Insert black lead into COM terminal and red lead into ms(-Pulse) terminal.
4. Connect the test leads as shown and read Dwell angle in the primary display. Adjust trigger levels by pressing **LEVEL** button momentarily, if necessary.
5. Press menukey 2 momentarily to display Dwell reading in terms of percentage if required.
6. The frequency of the same signal source can be displayed in the second display by pressing the **RPM** button momentarily twice.
7. Adjust the dwell angle according to the procedures outlined in your vehicle service manual.

NOTE: *Recheck the timing whenever the dwell angle has been adjusted.*

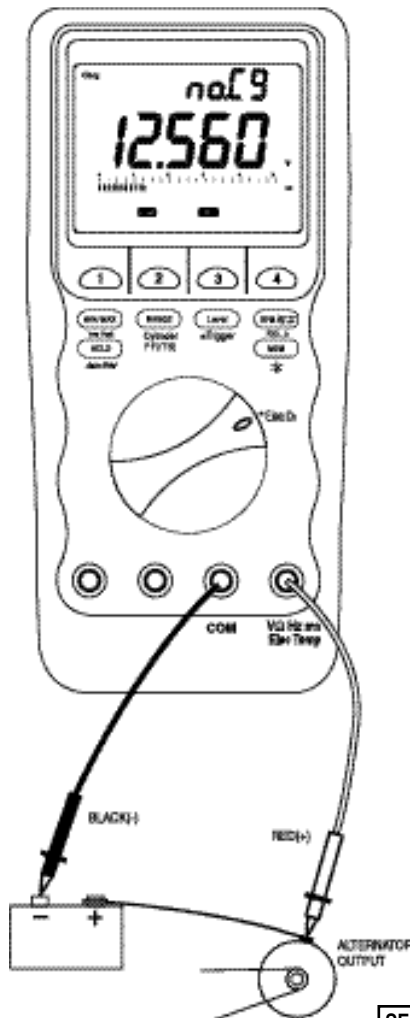


4-11. Duty Cycle

1. Set rotary selector to ms-Pulse, Dwell, Duty position.
2. Press menukey 2 to select Duty function.
3. Insert black lead into COM terminal and red lead into ms(-Pulse) terminal.
4. Connect the test leads as shown and read the duty cycle percentage in the primary display. Adjust trigger levels by pressing **LEVEL** button momentarily, if necessary.
5. Press menukey 1 or 3 momentarily to display Duty Cycle reading in terms of ms (Pulse Width) or (Dwell) angle if required.
6. The frequency of the same signal source can be displayed in the second display by pressing the **RPM** button momentarily twice.

In most applications, the negative trigger slope is assigned to display the percentage of time that the plunger is in the closed position (low duty cycle) during one duty cycle. The positive slope is assigned to display the percentage of time that the plunger is in the open position. Refer to the car's service manual to verify slope assigned to position for each component.

Press the **LEVEL** (\pm Trigger) button for more than 1 second to toggle between the negative (-) slope and the positive (+) slope, if required.



4-12. Charging System Test

Charging system problems often are identified with a No-Start complaint. The battery will have discharged and the starter won't crank the engine. To properly check the charging system, the battery must be fully charged.

WARNING

Be sure the battery to alternator connection and lead connections are all secure, or damage may result.

1. Set rotary selector to Elec position. The meter defaults at Charge System Test function.
2. Insert black lead into COM terminal and red lead into Elec terminal.

Battery Condition Test

1. Connect red lead probe to the alternator output.
2. Connect black lead probe to ground.
3. With engine Off, turn the headlights On low.
4. Read the secondary display to check the condition of the battery. Use the table below.

SECONDARY DISPLAY (Battery Condition)	PRIMARY DISPLAY
(Low Battery)	< 11.399 V
(No Charge)	11.400 ~ 13.299 V
(Good)	13.300 ~ 15.599 V

- “noL9” not displayed : Check wiring and battery leads.
- “noL9” displayed : Good battery, proceed.
- “noL9” and “ ” displayed : Low Battery, correct before proceeding.

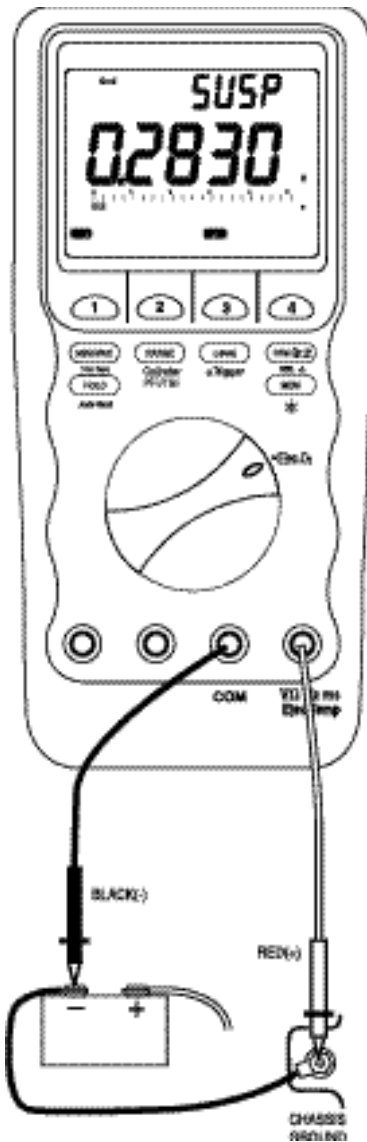
Alternator Charging Test

1. Connect red lead probe to the alternator output.
2. Connect black lead probe to ground.
3. Start engine and run at 1000 - 2000 rpm.
4. Turn the headlights On low.
5. Allow the secondary display to stabilize.
6. Read the secondary display to check the alternator charging conditions.
A display “ ” or “noL9” in the secondary display together with beep sound indicates that the alternator charging system is in bad condition.



- No display in the secondary display : System normal.
- “noL9” displayed : Suspect open field (current) or regulator.
- “noL9” or “ ” displayed alternatively : Suspect bridge rectifier or grounded stator winding.
- “ ” displayed : Suspect bridge rectifier or open stator winding.

NOTE: When the alternator and the associated rectifier diodes are in good condition, the ripple voltage of the alternator output signal should be less than 0.49 V AC (typical).



4-13. Ground Test

This function is designed to locate bad grounds, voltage drops, intermittent connections, or any source of high resistance in automotive electrical circuits and grounds.

It provides a very efficient check of a vehicle's electrical system condition.

This test works by measuring the voltage drop across any cable to which it is connected. The amount of voltage drop is displayed as "Good", "SUSP", "Bad", and "OPEN" annunciators in the secondary display.

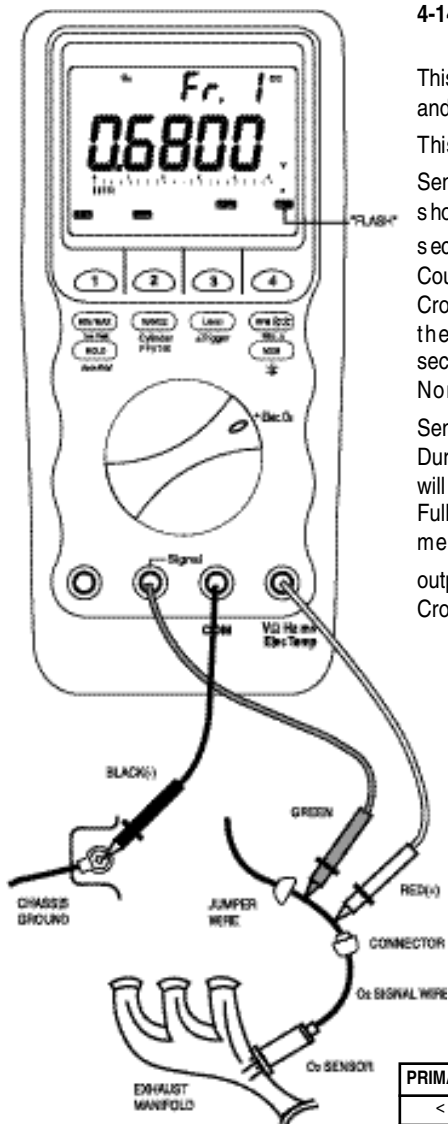
1. Set rotary selector to Elec position.
2. Press menukey 2 to select Ground Test function. "VFL" is displayed in the primary display and "OPEN" is displayed in the secondary display.
3. Insert black lead into COM terminal and red lead into Elec terminal.
4. Connect the two probes to the cable being tested. A good connection is indicated by the display of "Good" in the secondary display.
5. Apply power to the vehicle. The condition of the cable between the two probes is indicated by either "Good", "SUSP", or "Bad" in the secondary display.

SECONDARY DISPLAY	PRIMARY DISPLAY (Amount of Voltage Drop)
Good (Good)	< 0.1999 V
SUSP (Suspect)	0.2000 ~ 0.3999 V
Bad (Bad)	0.4000 ~ 1.9999 V
OPEN (Open)	≥ 2.0000 V

If either "SUSP" or "Bad" is displayed, check the cable closely for poor connections between the two test leads.

Make certain all connectors are clean and secure.

NOTE: When checking ground connections, always clean or scrape off the area of the chassis where the ground lead is being connected. Dirt, grease, and paint are insulators and will prevent the unit from making a good connection. If a ground connection is suspect, connect the unit to the chassis as close as possible. When testing charging or starting circuits from the battery, always make the first connection to the battery post, and not the battery connector. Corrosion on the battery post and connector surfaces can be the source of the problem very frequently.



4-14. O₂ Sensor

This is a very efficient method to check and simulate O₂ Sensors.

This test hooks in parallel with the O₂ Sensor circuit. The primary display will show O₂ Sensor voltage, while the secondary display will show Cross Counts (CC).

Cross Counts are the number of times the reading crosses 0.45 V DC per second.

Nominal CC is 1 to 3 for a good O₂ Sensor.

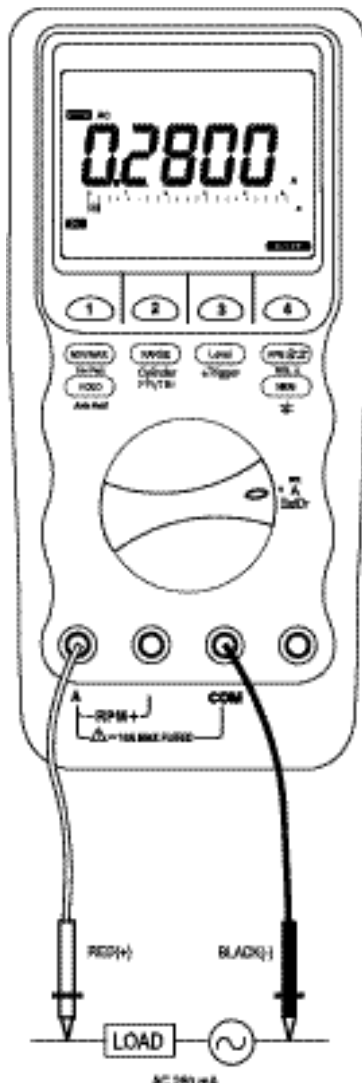
During this test, the secondary display will indicate Full Lean, Lean, Rich, and Full Rich respectively, according to the measuring value of the O₂ Sensor output, together with the corresponding Cross Counts(x).

Also during this test the menukey 3 (Lean) or menukey 4 (Rich) might be pressed to send out a rich command or a lean command for 5 seconds, which will make the "Lean" or "Rich" annunciator on menu screen flash depending upon which was commended. During this time the primary display will show the signal level that is at the O₂ Sensor to see that the condition is being compensated for. The green lead is required to be connected between the "Signal" terminal and the O₂ connector on the ECM side.

NOTE: Signal out and CC may not function properly on some Toyota O₂ Sensors.

1. Set rotary selector to Elec position.
2. Press menukey 3 to select O₂ Sensor function.
"Lean" and "Rich" annunciators will be displayed on menu screen.
3. Insert black lead into COM terminal, red lead into Elec terminal, and green lead into Signal terminal.
4. Unplug the O₂ Sensor connector.
5. Connect a jumper wire between the connector halves.
6. Connect red lead probe to the O₂ Sensor side of the jumper wire.
7. Connect black lead probe to ground.
8. Connect green lead probe to the ECM side of the jumper wire.
9. Press menukey 3 (Lean) or 4 (Rich) to send out a Lean or Rich signal for 5 seconds.

PRIMARY DISPLAY	SECONDARY DISPLAY
< 0.29999 V	FL. X (Full Lean)
0.3000 ~ 0.4499 V	FL. X (Lean)
0.4500 ~ 0.5999 V	FL. X (Rich)
≥ 0.6000 V	FL. X (Full Rich)



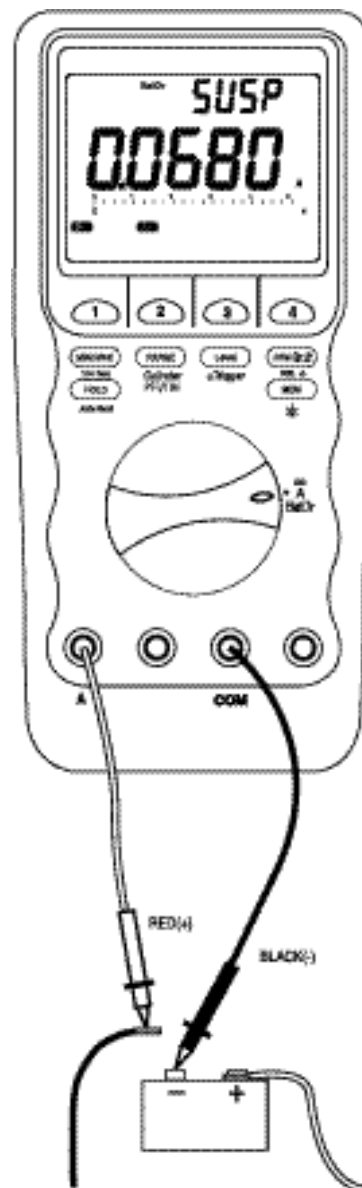
4-15. AC or DC Current (A)

WARNING

Do not measure any circuit that draws more than the current rating of the installed fuse. Replace the defective fuse with a proper fuse only. Failure to do this may result in injury or damage to the meter. Do not attempt current measurements where the open circuit voltage is above 600 V.

For measuring circuits of more than 10 A, use voltage output current clamp adapters compatible with the meter voltage functions.

1. Set rotary selector to \overline{A} BatDr position. The meter defaults at DC current.
2. Press menukey 2 to select AC.
3. Insert black lead into COM terminal and red lead into A terminal
4. Connect red lead probe to the side of the circuit closest to the power source.
5. Connect black lead probe to the side of the circuit closest to ground.
6. turn the power ON and test. **DO NOT** crank the engine.



4- 16. Battery Drain Test

This function measures the car's battery current when it is turned off. This test will run continuously so the Auto-Power-Off feature will be automatically disabled in this mode.

1. Set rotary selector to \overline{A} BatDr position.
2. Press menukey 4 to select BatDr test function.
3. Insert black lead into COM terminal and read lead into A terminal.
4. Turn the ignition and accessories Off.
5. Disconnect the negative battery cable.
6. Touch red lead probe to the cable.
7. Touch black lead probe to the negative battery post.
8. Observe the secondary display (allowing up to 30 minutes).

SECONDARY DISPLAY	PRIMARY DISPLAY
Good (Low Drain)	< 0.0199 A
SUSP (Marginal Drain)	0.0200 ~ 0.0799 A
Bad (High Drain)	≥ 0.0800 A

If a "**SUSP**" or "**Bad**" is displayed, check fused and non-fused circuit for malfunction.

5. ADVANCED FEATURES

5-1. MIN/MAX Mode

Press the **MIN/MAX** button momentarily to activate MIN/MAX(Record) mode with LCD annunciators MAX MIN AVG turned on. Press this button momentarily to read throughout the maximum(MAX), Minimum(MIN), and Average(AVG) readings in the primary display. Press this button for more than 1 second to exit MIN/MAX (Record) mode.

With the Autoranging MIN/MAX (Record) mode, you can easily track intermittent signals, capture turn on/ turn off surges, and monitor line voltage changes over a much wider dynamic range with the best resolution. It surpasses manual ranging recording which is apt to be overflowed or to have insufficient resolution. The meter features a fast sampling speed of 50 ms for MAX, MIN and AVG readings. The faster the sampling speed, the more accurate the measurements will be. The true average (AVG) feature calculates all readings continually taken over time. The Auto-Power-Off feature will be automatically disabled in this mode.

5-2. 1 ms Peak Mode

Press the **MIN/MAX** (1 ms Peak) button for more than 1 second to activate 1 ms Peak mode with LCD annunciators 1 ms MAX MIN turned on. The meter defaults at 1 ms MAX (positive peak value reading) mode.

Press the menukey 2 momentarily to select 1 ms MIN (negative peak value reading) mode.

Press the menukey 4 (**EXIT**) on menu screen) to exit 1 ms Peak mode.

With 1 ms Peak mode, transient signal peak voltage as short as 1 ms can be captured.



5-3. Manual and Auto Ranging

Press the **RANGE** button momentarily to select manual ranging, and the meter will remain in the range it was with LCD annunciator **AUTO** turned off. Press this button momentarily again to step through the ranges. Press this button for more than 1 second to resume autoranging.

In Dwell() function, press this **RANGE** (Cylinder) button momentarily to display the cylinder setting on the secondary display. Default is CL4 (4 Cylinder). Press this button momentarily again to select the number of cylinders from 1 through 12 (1, 2, 3, 4, 5, 6, 8, 10, and 12 cylinders) to match the engine under test.

NOTE: The secondary display defaults at 0000 rpm in the \overline{mV} , \overline{V} and Hz function.

The selected cylinder setting or RPM setting is maintained until the meter is turned off.

5-4. Trigger Level and +/- Trigger Slope Selection

This feature is available for RPM, Dwell, ms-Pulse, or Duty measurement function. The meter is set at selected trigger level as power up default in individual function as follows :

FUNCTION	DEFAULT TRIGGER LEVEL
RPM	+ TRIG 1 2 3
Dwell, ms-Pulse, Duty	- TRIG 1 2 3

However, car signal levels under test may vary due to aging of components, abnormal conditions, and each car manufacturer's different design. Therefore, positive and/or negative 4 selectable trigger levels, which are carefully designed and tested to cover all the extreme conditions, are available in these functions to provide more flexibility to cope with your applications.

If your reading is unstable, select lower sensitivities (higher trigger level number) by pressing the **LEVEL** button momentarily. If your reading shows zero, select higher sensitivities (lower trigger level number).

The 4 selectable trigger levels are cycled through as follows :

- RPM : $\rightarrow +\text{TRIG } \boxed{1} \boxed{2} \boxed{3} \rightarrow +\text{TRIG } \boxed{1} \boxed{2} \rightarrow +\text{TRIG } \boxed{1} \rightarrow +\text{TRIG } \boxed{1} \boxed{2} \boxed{3} \boxed{4} \rightarrow$
- Dwell, ms-Pulse, Duty
 $\rightarrow -\text{TRIG } \boxed{1} \boxed{2} \boxed{3} \rightarrow -\text{TRIG } \boxed{1} \boxed{2} \rightarrow -\text{TRIG } \boxed{1} \rightarrow -\text{TRIG } \boxed{1} \boxed{2} \boxed{3} \boxed{4} \rightarrow$

In some cases, positive trigger levels may be required for measuring Dwell, ms-Pulse, or Duty. Press the $\boxed{\text{LEVEL}} \pm \text{Trigger}$ button for more than 1 second to toggle between positive (+) and negative (-) trigger level for the selected trigger level.

NOTE: *Positive (+) trigger or negative (-) trigger is to identify whether the On or Off portion of the signal under test is of measuring interest. For example, if you get a reading of 10 % Duty Cycle in the Positive (+) Trigger (On portion), you then will get a reading of 90 % Duty Cycle in the Negative (-) Trigger (Off portion).*

5-5. RPM $\boxed{\text{RPM}} \boxed{\text{2}}$ Selection

In the RPM function, the meter defaults to RPM $\boxed{\text{RPM}} \boxed{\text{4}}$ for conventional 4-stroke engine. Press the $\boxed{\text{RPM}} \boxed{\text{2}}$ button momentarily to toggle to RPM $\boxed{\text{RPM}} \boxed{\text{2}}$ for 2-stroke or DIS engine. And also in the $\boxed{\text{mV}} \boxed{\text{V}}$ or Hz function, press the $\boxed{\text{RPM}} \boxed{\text{2}}$ button momentarily to toggle between RPM $\boxed{\text{RPM}} \boxed{\text{4}}$ and RPM $\boxed{\text{RPM}} \boxed{\text{2}}$ setting for the dual display RPM function.

5-6. Relative $\boxed{\text{REL}} \boxed{\Delta}$ Mode

Press the $\boxed{\text{RPM}} \boxed{\text{2}} \boxed{\text{REL}} \boxed{\Delta}$ button for more than 1 second to select the Relative Zero (Δ) mode with LCD annunciator Δ turned on. This feature allows the user to offset the measured value with a relative reference value.

Press the $\boxed{\text{RPM}} \boxed{\text{2}} \boxed{\text{REL}} \boxed{\Delta}$ button for more than 1 second to exit relative mode and resume normal measurements.

5-7. Hold or Auto Hold

Press the $\boxed{\text{HOLD}}$ button momentarily to activate the Hold function with LCD annunciator $\boxed{\text{HOLD}}$ turned on. Press this button momentarily again to exit Hold function. This feature freezes the display for later view.

Press the $\boxed{\text{HOLD}}$ (Auto Hold) button for more than 1 second to activate the Auto Hold function with LCD annunciators $\boxed{\text{A-}} \boxed{\text{HOLD}}$ turned on. This feature automatically freezes the display and the meter beeps when the measurement reading is stabilized. The displayed value will be updated when a new measurement value is stabilized. This mode is very useful when it is impossible for you to press the $\boxed{\text{HOLD}}$ button or see the meter display while probing and taking measurements. Press the $\boxed{\text{HOLD}}$ (Auto Hold) button for more than 1 second to exit Auto Hold function.

5-8. Memory (Data Store, Recall, & Clear) Mode

Press the $\boxed{\text{MEM}}$ button momentarily to activate the Memory mode with LCD annunciators $\boxed{\text{MEM}}$ and $\boxed{\text{HOLD}}$ turned on. The menu screen shows four menu selections : $\boxed{\text{STO}}$ (Store), $\boxed{\text{RCL}}$ (Recall), $\boxed{\text{CLR}}$ (Clear), and $\boxed{\text{EXIT}}$ (Exit).

Store : Press the menukey 1 to store the displaying data. The available memory location number momentarily shows in the secondary display and "SAUE" momentarily shows in the primary display. If no memory location is available, "FULL" and "ERR" momentarily show in the primary display and in the secondary display respectively and nothing is stored, when you must clear all the memory locations by pressing the Clear menukey to secure memory locations. You can store up to 20 data. You can exit the store mode by pressing either the EXIT menukey or the $\boxed{\text{MEM}}$ button momentarily.



Recall : Select Recall to review the stored data by pressing the menukey 2. When you press the menukey 2, the last memory location number used in the previous memory operation will momentarily show in the secondary display with four menu selections ; **+** , **-** , **CLR** and **EXIT** turned on in the menu screen. The required

memory location can be selected by using the menukey 1 and the menukey 2, when the data stored at the selected memory location will show in the primary display. In the Recall mode, when you press the Clear menukey, the

data stored at the recalled memory location only is erased. If no stored data is available in the Recall mode, when you press the Recall menukey, "ALP" and "no" momentarily show in the primary display and in the secondary display respectively and nothing is retrieved. You can exit the Recall mode by pressing either the EXIT menukey or the **MEM** button momentarily



Clear : Select Clear to clear all stored data in the Store mode or only the data stored at the selected memory location in the Recall mode. In the Store mode, when you press the Clear menukey, "SAFE" and "ALL" continuously show in the primary display and in the secondary display respectively with two menu selections ; **AD** (ALL CLEAR) and **EXIT** turned on in the menu screen. When you press the menukey 2, "done" momentarily shows in the primary display and all the stored data are erased. Press the EXIT menukey to exit the memory mode without erasing any stored data.

EXIT : Select EXIT to exit memory mode. You can also exit memory mode by pressing the **MEM** button momentarily or turning the rotary selector.

5-9. Backlight

Press the **MEM** (**⏻**) button for more than 1 second to toggle the backlight On and Off. The backlight will also automatically be Off 30 seconds after each activation to extend the battery life.

5-10. Auto-Power-Off

The meter automatically turns off after approximately 30 minutes of no activities to extend battery life.

You can enable or disable the Auto-Power-Off mode. Turn the meter on while pressing the menukey 4 to activate this feature, when the meter shows 'ALP' in the Secondary display, and 'EnH' (or 'd 158') in the primary display with three menu selections ; **+** , **-** and **EXIT** turned on in the menu screen. You can toggle EnH/d 158 by pressing the **+** and **-** menukeys. Press the **EXIT** menukey to get into the next Setup.

The meter will display "MIN" annunciator at the upper left corner of the LCD, "ALP" in the secondary display, and a two digit number in the primary display with three menu selections ; **+** , **-** , and **EXIT** turned on in the menu selection. You can set up a new auto-power-off time by using the **+** and **-** menukeys. Press the **EXIT** menukey to save the newly customized default values during the entire Setup cycle. The meter will resume normal operation just after "SAFE" is displayed in the primary display.

NOTE: The newly customized default values in any Setup can be saved only when the entire Setup cycle is ended. The meter displays "SAFE" at the end of the entire Setup cycle only.

5-11. RS-232C Interface

The meter provides an optically isolated interface port at the top for the data communication. The RS70 optical adapter cable and the WS716 software disc are required to connect the meter to the PC computer. These accessories are provided to the end users as optional items.

6. MAINTENANCE AND REPLACEABLE PARTS



WARNING

To avoid electrical shock or personal injury, remove test leads and any input signals before replacing the battery or fuse. To prevent damage or injury, install only the same type fuse or equivalent.

Cleaning and Storage


Periodically wipe the case with a damp cloth and mild detergent; do not use abrasives or solvents.

Clean the input terminals as follows :

1. Turn the meter off and remove all test leads.
2. Shake out any dirt that may be in the terminals.
3. Soak a new swab with alcohol and work the swab around in each terminal.

If the meter is not to be used for periods of longer than 60 days, remove the battery and store it separately.

Auto Fuse Detection

The meter automatically verifies the integrity of the internal fuse when you set the rotary selector to  position and plug 1 test lead into the A terminal. If an open fuse or no fuse is detected, " FUSE " shows in the primary display.

Battery and Fuse Replacement

The meter uses a single standard 9 V battery (NEDA 1604, JIS006P, IEC 6F 22) and a 600 V/15 A IR 100 kA fast acting fuse for A input.



WARNING

To avoid false readings, which could lead to possible electric shock or personal injury, replace the battery as soon as the low battery indicator appears.

Replace the battery or the fuse as follows :

1. Turn the rotary switch to OFF and remove the test leads from the input terminals.
2. Remove the battery door by using a screwdriver.
3. Replace the battery or the fuse with ONLY specified replacement battery or fuse.
4. Reinstall the battery door by using a screwdriver.

7. SPECIFICATIONS


Safety & Compliances

Maximum voltage between any terminal and earth ground : 600 V dc/ac (but, 1000 V dc/ac peak for \overline{mV} and \overline{V} functions)

Compliances : Complies with UL&cUL standard UL 3111-1, CSA C22.2 No. 1010.1-92, ANSI/ISA-S82, 01-94 to 1000 V Overvoltage Category II.

Certifications : CE-marking certificated

Surge Protection : 6.5 kV peak per IEC 1010.1-92

 Fuse Protection for A input : 600 V / 15 A IR 100 kA Fast fuse

Physical Specifications

Display (LCD) : Digital – 50000 count primary display / 9999 count secondary display ; updates 4 / sec. nominal
Analog – 25 segments, updates 40 / sec.

Operating Temperature : 32 °F to 122 °F (0 °C to 50 °C)

Storage Temperature : -4 °F to 140 °F (-20 °C to 60 °C)

Temperature Coefficient : nominal 0.15 x (specified accuracy) / °C @ (0 °C to 18 °C or 28 °C to 50 °C), or otherwise specified

Relative Humidity : 0 % to 80 % @ (32 °F to 95 °F)
0 % to 70 % @ (94 °F to 122 °F)

Altitude : Operating – up to 2000 m
Storage – 10000 m

Battery Type : Single 9 V battery –NEDA 1604, JIS 006P or IEC 6F 22

Battery Life : 150 hrs. typical (with backlight off)

Shock Vibration : Per MIL-T-PRF 28800 for a Style D, Class III Instrument

Pollution Degree : 2

E.M.C. : Meets EN 61326 : 1997 + A1

Size (H x W x D) : 8.19 x 4.05 x 2.13" (208 x 103 x 54 mm) without mounted accessory

Weight : Approx. 655 g (1.45 lbs)

Warranty : 3 years

Calibration Interval : 1 year

Feature Summary

Backlight : For clear readings in poorly lighted areas

Fast Autoranging : Meter automatically selects the best range momentarily

Auto HOLD : Automatically holds readings on display for later view

Continuity / Open test : Beeper sounds

Fast Bar Graph : 25 segments for peaking and nulling

Memory Locations : 20

Dual Display : Plus individual RPM input & display

MIN/MAX Mode : Record maximum, minimum, and average values

1 ms Peak Mode : Captures peaks to 1 millisecond

Relative : Relative zero

Level : 4 selectable trigger levels

±Trigger : Selectable Positive & negative trigger slope

Cylinder : 9 selectable number of cylinders in Dwell

RPM 4 : For 4-stroke engine application

RPM 2 : For DIS & 2-stroke engine application

ms-Pulse/Duty Cycle : Measure the time signal is ON or OFF in milliseconds or in %

Close-Case calibration : No internal adjustments needed

Battery/Fuse Access Door : Battery or fuse replaceable without voiding calibration

High-Impact Overmolded Case : Protective holster features

Electrical Specifications

Accuracy is given as \pm ([% of reading] + [number of digits]), or otherwise specified, at 23 °C \pm 5 °C and less than 80 % R.H. for a period of one year after calibration.

DC Voltage

Range	Resolution	Accuracy
500.00 mV	0.01 mV	0.1 % + 2 d
5.0000 V	0.1 mV	
50.000 V	1 mV	
500.00 V	0.01 V	
1000 V	0.1 V	

NMRR : > 60 dB @ 50/60 Hz
 CMRR : > 120 dB @ DC 50/60 Hz, Rs=1 k Ω
 Input Impedance : 10 M Ω , 30 pF nominal
 (50 M Ω , 100 pF nominal for 500 mV range)

AC Voltage

Range	Resolution	Accuracy	
		40 - 400 Hz	400 Hz - 2 kHz
500.00 mV	0.01 mV	0.5 % + 10 d	1.0 % + 10 d
5.0000 V	0.1 mV		
50.000 V	1 mV		
500.00 V	0.01 V		
1000.0 V	0.1 V		

CMRR : > 60 dB @ DC to 60 Hz, RS = 1 k Ω
 Input Impedance : 10 M Ω , 30 pF nominal
 (50 M Ω , 100 pF nominal for 500 mV range)

DC Current

Range	Resolution	Accuracy
5.0000 A	100 μ A	0.5 % + 10 d
10.000 A	1 mA	0.5 % + 20 d

AC Current (40 - 1 kHz)

Range	Resolution	Accuracy
5.0000 A	100 μ A	0.75 % + 10 d
10.000 A	1 mA	1.0 % + 20 d

Burden Voltage : 0.03 V/A

Ohms

Range	Resolution	Accuracy
500.00 Ω *	0.01 Ω	0.1 % + 5 d
5.0000 k Ω	0.1 Ω	0.1 % + 2 d
50.000 k Ω	1 Ω	0.1 % + 2 d
500.00 k Ω	0.01 k Ω	0.1 % + 2 d
5.0000 M Ω	0.1 k Ω	0.3 % + 5 d
50.00 M Ω	10 k Ω	0.75 % + 10 d

Open Circuit Voltage : 1.3 Vdc

* Using Relative mode

Diode Tester

Range	Accuracy	Open Circuit Voltage
2.0000 V	2.0 % + 1 d	< 3.0 Vdc

Temperature

Range	Resolution	Accuracy *
-50 °C to 0 °C	0.1 °C	±3.0 °C
0 °C to 100 °C	0.1 °C	±1.0 °C
100 °C to 1300 °C	0.1 °C	±3.0 °C
-58.0 °F to 32 °F	0.1 °F	±5.0 °F
32 °F to 212 °F	0.1 °F	±2.0 °F
212 °F to 2372 °F	0.1 °F	±5.0 °F

* With k-type thermocouple

Frequency

Range	Resolution	Accuracy
99.999 Hz	0.001 Hz	0.005 % + 3 d
999.99 Hz	0.01 Hz	
9.9999 kHz	0.1 Hz	
99.999 kHz	1 Hz	
999.99 kHz	0.01 kHz	

Minimum frequency 0.5 Hz, sensitivity 250 mV

* Minimum frequency 1 Hz in the Secondary display

RPM(Primary Display)

Mode	Range	Accuracy
4-stroke	120 - 20000 RPM	2 RPM
2-stroke	60 - 10000 RPM	

4 Selectable trigger levels

RPM(Secondary Display)

Range	Resolution	Accuracy
4-stroke	240 - 9999 RPM	2 RPM
2-stroke	120 - 9999 RPM	

Dwell

Range *	Resolution	Accuracy
0.0 - 356.4	0.1	1.2 / krpm + 2 d

4 Selectable trigger levels and ± trigger slopes

9 Selectable cylinders 1, 2, 3, 4, 5, 6, 8, 10, 12

* Specified ranges depend on ± trigger slopes, engine rpm

ms-Pulse and Duty cycle

Mode	Range	Accuracy
Multi-Point-Injection	0.50 ms - 250.00 ms	0.05 ms + 1 d
	0.0 % - 100.0 %	0.04 % / krpm + 2 d
Single-Point-Injection	0.50 ms - 250.00 ms	0.05 ms + 1 d
	0.0 % - 100.0 %	0.04 % / krpm / cyl + 2 d

Fuel Injection Detector (Both TBI & PFI)

4 Selectable trigger levels and ± trigger slopes

* Specified ranges depend on ± trigger slopes, engine rpm and number of cylinders

Audible Continuity Test

Application: For quick open-short test.

Threshold : The beeper turns on when the measured resistance is lower than 10 Ω, and turns off when greater than 70 Ω. Response time < 200 μS.

O2 Sensor test

Application: For quick and accurate method to diagnose and simulate oxygen sensors.

Ground Test

Application: Designed to locate bad grounds, voltage drops, intermittent connections, or any source of high resistance in an automotive electrical circuits and grounds.

Charging system test

Application: Designed to diagnose the battery and the alternator.

Battery Drain Tester

Application: Measures the car's battery current when it is turned off.