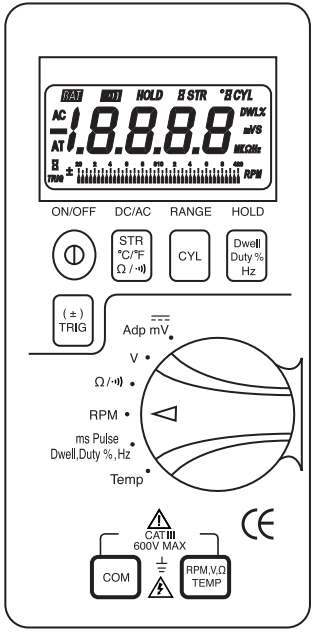
FINEST®

226
228

AUTOMOTIVE MULTIMETER



FINEST® a world leader in test & measurement

FINE INSTRUMENTS CORPORATION

Room # 601, DAEWOO TECHNOPIA, 768-1, WONSI-DONG, DANWON-GU,
ANSAN-SI, GYEONGGI-DO, SOUTH KOREA

- TEL: (82-31) 470-8888 - FAX: (82-31) 470-8887
- www.finest. co.kr - E-mail: fine@finest.co.kr

Litho in Korea.

USER'S MANUAL

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.

DO NOT FORGET INSTALL THE EXTRA BATTERY COVER AFTER REPLACING THE BATTERY FOR PROTECTION.

Measurement Limits:

DC Voltage	: 0.1 mV to 600 V
AC Voltage	: 1 mV to 600 V
RPM	: 30 to 9000 RPM
Resistance	: 0 to 40 MΩ
Frequency	: 0.5 Hz to 200 kHz [226 only]
Pulse Width	: 0.5 to 1999.9 mS
Dwell	: 0 ° to 356.4 °
% Duty Cycle	: 0 to 99.9 %
Temperature	: -40 ˚F to +2,498 ˚F [228 only] (-40 ˚C to +1,370 ˚C)
Continuity check	: Beep sounds at approx. < 100 Ω in the 4 KΩ range

WARNING!

READ " SAFETY CONSIDERATIONS" BEFORE USING THIS METER.

CONTENTS

1. INTRODUCTION

This instrument is handheld and battery operated. It is designed and tested according to IEC Publication 1010-1 (EN61010-1), (Overvoltage Category III), the EMC Directive (EN 50081-1 and EN 50082-1), UL 1244 & UL 201 and other safety standards (see " Specifications").

This User's Manual tells you how to use this instrument. 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 service repair manuals.

This User's Manual should be used as a guide to get you started in troubleshooting. Your real learning can best be accomplished through experiences.

Features:

- ¥ Accurate mS-Pulse Width function to test on-time of fuel injectors
- ¥ High-speed 41 segment analog bar graph updated 20 times/second — as fast as the eye can follow
- ¥ Accurate automotive electronics test and advanced measurements with dc/ac Volts, Resistance.....
- ¥ Direct reading of Dwell without using Duty Cycle to Dwell conversion chart when testing electronic fuel injection, feedback carburetors, and ignition systems
- ¥ RPM measurement for automotive engines with 1 to 8 Cylinders using the Inductive Pickup

¥ This instrument exercises 4 step adjustable +/- triggers on 1 to 8 Cylinders, motorcycles and conventional engines for accurate measurements of RPM, Dwell, Duty-cycle, and mS-Pulse Width of injectors.

¥ Accurate non-automotive Frequency measurements with 20000 count on the high resolution 4000 count display [226 Only]

¥ Temperature measurement up to 2,498 ˚F (or 1,370 ˚C) for catalytic converters, fan switch on/off,.... [228 Only]

¥ Non-TRMS

2. SAFETY CONSIDERATIONS

Electricity is dangerous and can cause injury and death. Always treat it with the greatest of respect and care. If you are not quite sure how to proceed, stop and take advice from a qualified person.

■ Exhaust gas contains carbon monoxide which is odorless, causes slower reaction time, and can lead to serious injury. When testing vehicle with engine running, testing should be always done in a well-ventilated area or route exhaust gas outside.

■ Set the parking brake and block the wheels before testing or repairing the vehicle, unless instructed otherwise. It is especially important to block the wheels on front-wheel drive vehicles: The parking brake does not hold the drive wheels. The ignition or fuel system must always be disabled when performing starting system tests.

■ Always wear an eye shield when working near batteries.

■ Do not smoke or allow open flames or sparks in the work area. Gasoline fumes and gases produced by batteries are highly explosive.

■ Keep cigarettes, sparks, and open flame away from battery at all times.

■ Keep yourself clear of all moving or hot engine parts.

■ Always avoid working alone.

■ Do not try to measure any voltage that exceeds 600 V dc or ac rms.

■ Voltages above 25 V dc or ac rms may constitute a serious shock hazard.

■ Do not attempt to use this instrument if either the instrument or the test leads have been damaged.

■ Use a clamp current probe.

■ Avoid electrical shock: do not touch the test leads, tips or the circuit being tested.

■ Select the proper function and range for the measurement. Do not try voltage measurements that may exceed the ratings marked on the input limit for switch or terminal.

■ Disconnect the live test lead before disconnecting the common test lead.

International symbols


Dangerous Voltage (Risk of electric shock)


Alternating Current (ac)


Direct Current (dc)


Either dc or ac

Ground (maximum permitted voltage between terminal and ground)

Caution! Refer to the user's manual before using this Meter.

Double Insulation (Protection Class II)

WARNING!

OBSERVE ALL SAFETY PRECAUTIONS WHEN MEASURING HIGH VOLTAGES. TURN OFF POWER TO THE CIRCUIT UNDER TEST, SET THIS METER TO THE DESIRED FUNCTION AND RANGE, CONNECT THE TEST LEADS TO THIS METER AND THEN TO THE CIRCUIT UNDER TEST. REAPPLY POWER. IF AN ERRONEOUS READING IS OBSERVED, DISCONNECT POWER IMMEDIATELY AND RECHECK ALL SETTINGS AND CONNECTIONS.

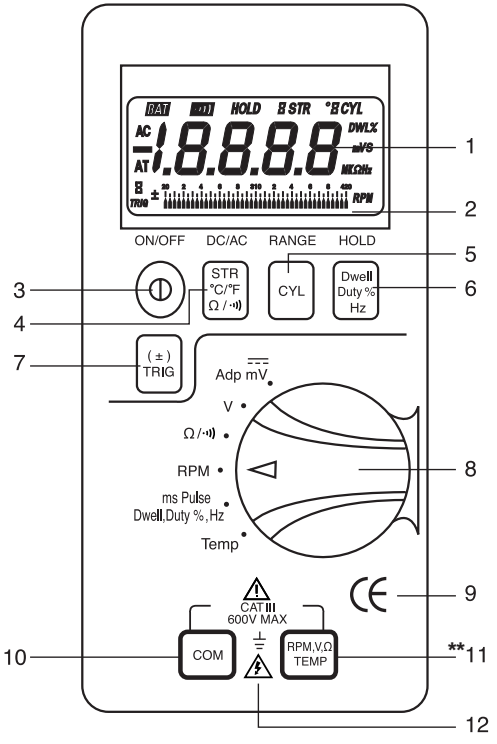
Don't Forget!

- To maintain accuracy of the Meter, replace the discharged battery immediately when the Low-Battery symbols, BAT , appears on the display of the Meter.
- Keep the Meter away from spark plug or coil wires to avoid measuring error from external interference.
- Remove the test leads from the test points before changing functions to avoid damaging the Meter when testing voltage.
- Do not exceed the input limits shown in the table below:

FUNCTION	(+) TERMINAL	MAXIMUM INPUT
~ V	VΩRPM	600 V
⎓ V	VΩRPM	600 V
⎓ mV		
* Ω ·ıı))	VΩRPM	600 V
**Hz		
RPM	VΩRPM	500 V DC/AC
Duty Cycle (%)		
Dwell		
***Temperature	VΩRPM	60 V DC or 24 V AC RMS

* Ohms can be measured only in a nonpowered circuit.
** Hz(non-automotive Frequency measurement) function is available in Model: 226 Only.
*** Temperature mode is available in Model: 228 Only.

3. EXPLANATION OF CONTROLS AND INDICATORS



* * 11 RPM, V, Ω [226 Only]
Hz

1 – DIGITAL DISPLAY. Digital readings are displayed on a 4000 count display with polarity indication and automatic decimal point placement. When this Meter is turned on, all display segments and symbols appear briefly during a selftest. The display updates four times per second.

2 – ANALOG BAR GRAPH. The bar graph provides an analog representation of readings and updates 20 times per second. The 2 x 41 segment bar graph illuminates from left to right as the input increases. The bargraph is easier to read when the data causes the digital display to rapidly change. It is also useful for trend setting or directional data.

The bar graph is not displayed when measuring RPM, Pulse Width, Dwell, Duty cycle and Frequency.

3 – ON/OFF . Selects meter's power ON or power OFF.

4 – DC/AC. Toggle between volts dc and ac;

STR °C/°F Ω / ·ıı)

Toggles between 2-Cycle engines (or DIS* 4-Cycle engines) and 4-Cycle engines when the Meter is in the RPM mode (The change in the number of Cycles is indicated by the number preceding STR on the LCD display);

Toggles between ˚C and ˚F in the temperature mode [228 Only];

Toggles between Ω and ·ıı) in the Ω/ ·ıı) function.

** DIS = Distributorless Ignition System*

5 – RANGE. Press the RANGE button to select the Manual Range mode and turn off the "AT" symbol. (The Meter remains in the range it was in when manual ranging was selected.)

CYL

To exit the Manual Range mode and return to autoranging, press and hold down the RANGE button for 2 seconds. The “AT” symbol turns back on.

When the Meter is in the Dwell mode, press the CYL (RANGE) button to toggle between 1,2,3,4,5,6,8 cylinder engines. The change in the number of cylinders is indicated by the number preceding CYL on the LCD display.

6 – HOLD **(Fix Hold™).** Automatically captures a stable reading, beeps to acknowledge, and holds it on the LCD.

Dwell
Duty %
Hz

When the Meter is in the mS-Pulse mode, press this button to measure Dwell.

To measure Duty cycle (or Duty factor) in percent, press this button again; % is displayed on the LCD.

To measure automotive Frequency (Hz), press this button again.

You can step through mS-Pulse, Dwell, Duty cycle (%) and automotive Frequency (Hz) measurement mode by pressing this button.
Press any other button to exit these modes.

7 – (±)
TRIG

Toggles between a Negative (–) and Positive (+) Trigger Slope when the Meter is in the Pulse Width or Duty cycle (%) mode; Press this button down for 2 seconds to toggle between a negative (–) and positive (+) trigger slope. The change in the trigger slope is indicated by a + or - shown at the lower left corner of the display. The Meter defaults to a – trigger slope. Once the trigger slope is selected, press this button repeatedly to adjust trigger level if the Meter reading is too high or unstable.

- **The Trigger Level has Four steps and is different for each function combination.**

  Press this button to move one step at a time for selecting a suitable trigger level. The change in the number of step is indicated by the number above the “TRIG” symbol at the lower left corner of the LCD.

- **The step number on the LCD is a good indication of the Trigger Level.**

FUNCTION / STEP	TRIGGER LEVEL
	RPM, mS-Pulse, Dwell, Duty %
3	+ 8 V
2	+ 6.25 V
1	+ 3.2 V
0	+ 1.6 V

8 – ROTARY SWITCH. Describes functions that are selected by setting the rotary selector switch.

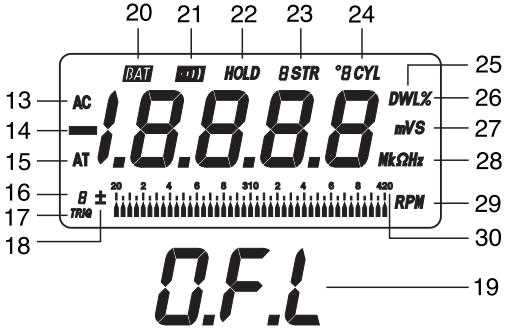
Adp mV	Millivolts dc or adaptor (current probe)
V	Volts dc/ac
Ω/ ·ıı)	Resistance/Continuity test
RPM	RPM measurement on 2 or 4 stroke engines using the Inductive Pickup on a spark plug wire
mS-Pulse Dwell, Duty%, Hz	Pulse Width, Dwell, Duty cycle (%) or automotive Hz(Automotive Hz) measurement
Hz	Frequency (Non-automotive Hz) measurement [226 Only]
TEMP	Temperature [228 Only]

9 – CE. This Meter is CE-marking certificated.

10 – COM (Common Terminal). The black test lead is plugged into this terminal for all measurements. When measuring temperature, a thermocouple adapter is plugged into this terminal.

11 – RPM, V, Ω . TEMP [228 Only] RPM, V, Ω Hz [226 Only] The red test lead is plugged into this terminal for all measurements. When measuring temperature, a thermocouple adapter is plugged into this terminal.

12 – CAT III 600V MAX ⏚ The maximum voltage that the Meter can measure is 600 V dc or ac rms.



13 – AC . Displayed when AC measurement function is selected.

14 – ▬ (Negative Polarity) . Automatically indicate negative inputs.

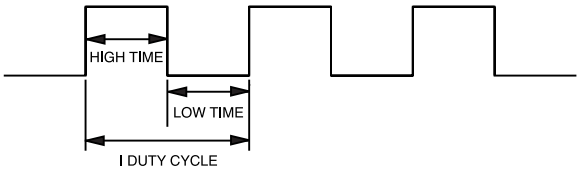
15 – AT . DIsplayed when the Auto Range mode is selected.

16 – 8. Displayed when a certain step of 4 trigger level steps is selected in the RPM, Pulse Width, Dwell or Duty % mode.

17 – TRIG . Displayed when a – or + trigger slope is selected while the Meter is in the RPM, Pulse Width, Dwell or Duty % mode. The Meter defaults or a – (negative) trigger slope.

18 – ± . Indicates a – (negative) or + (positive) trigger slope when a trigger slope is selected.

A negative (–) trigger slope should be selected to measure low (–) time and a positive (+) trigger slope should be selected to measure high (+) time. For example, when measuring a Duty cycle of Mixture Control Solenoid, the low (–) time is the On time in most cases.



19 – O.F.L (Overload Indication) . Displayed on the LCD when input value is too large to display.

20 – BAT (Low Battery) . Battery life warning. When BAT is first turned on, at least 8 hours of battery life remain. Replace the battery immediately. Never leave a weak or dead battery in the Meter. Even leak-proof types can leak and damage the Meter.

21 – . Displayed when the Meter is in the continuity test function.

22 – HOLD . Displayed when the Hold mode is selected.

23 – 8 STR. Displayed when either 2 or 4 strokes are selected in the RPM mode. Press the STR button to toggle between 2-stroke engines and 4-stroke engines.

24 – 8 CYL . Displayed when a certain number of cylinders is selected in the RPM or Dwell mode. Press the CYL button to toggle between 1,2,3,4,5,6,8 cylinder engines.

When the Meter is in the Temperature mode, °C or °F is displayed from °8. Press the °C/°F button to toggle between °C and °F.

25 – DWL¡ . Displayed when the Dwell mode is selected.

26 – % . Displayed when the Duty cycle mode is selected.

27 – mS (Milliseconds, 1 x 10^{-3} seconds) . Displayed when the mS-Pulse Width mode is selected.

28 – The following symbols indicate the unit of the value displayed.

DWL°	The number of degrees of distributor rotation when the points remain closed, measured for 1 to 8 cylinders.
%	Percent, used for duty cycle measurement
°C/°F	Centigrade or Fahrenheit temperature measurement
V	Volts
mV	Millivolts (1 x 10^{-3} Volts)
Ω	Ohms
KΩ	Kilohm (1 x 10^{3} Ohms)
MΩ	Megohm (1 x 10^{6} Ohms)
Hz	Hertz (1 cycle/sec)
KHz	Kilohertz (1 x 10^{3} cycles/sec)

29 – RPM . Displayed when the RPM mode is selected. In this mode, revolutions per minute on 2 or 4 stroke engines are measured using the Inductive Pickup on a spark plug wire.

30 – ANALOG DISPLAY SCALE. Displayed with 41 position analog pointers.

Using Inductive Pickup

The Meter comes with an Inductive Pickup. The Inductive Pickup takes the magnetic field generated by the current in the spark plug wire and converts it to a pulse that triggers the Meter's RPM measurement.

Using (Optional) Clamp-on Current Probe

The Meter sometimes has to be used to make a high current measurement. In higher current applications where high accuracy is not needed, a clamp-on current probe is very useful.

There are two basic types of current probes; current transformers (CT), which measure **ac** current only and Hall effect probes, which can measure **ac** or **dc** current.

The output of a Hall effect probe is typically 1000 to 1, however the current is converted to a voltage. For example, 1 millivolt equals 1 amp **dc** or **ac** so that 100 amps **ac** is converted to 100 mV **ac**. The probe leads are connected to the "V" and "COM" input terminals and the Meter function switch is set to "mV" setting.

A Hall effect **ac/dc** current probe is optionally supplied with the Meter.

4. POWER-ON OPTIONS

The Meter has two power-on options.

Auto-Power-Off Mode

The meter automatically turns off after approximately 20 minutes of no activities to extend the battery life.

To disable the Auto-power-off mode, turn the Meter on by pressing the ON/OFF button while holding down the HOLD button for more than 2 seconds.

Continuous Turn-on of LCD Segments

Each time the Meter is powered on by pressing the ON/OFF button, all LCD segments will turn on for two seconds as part of a selftest routine.

To turn all LCD segments on continuously, turn the Meter on by pressing the ON/OFF button while continuously pressing the RANGE button.

5. BASIC ELECTRICAL TESTS AND MEASUREMENTS

Voltage Measurements

WARNING!

TO AVOID THE RISK OF ELECTRICAL SHOCK AND INSTRUMENT DAMAGE, INPUT VOLTAGES MUST NOT EXCEED 600 V DC OR AC RMS. DO NOT ATTEMPT TO TAKE ANY UNKNOWN VOLTAGE MEASUREMENT THAT MAY BE IN EXCESS OF 600 V DC OR AC RMS.

NOTE: When taking voltage measurements, this Meter must be connected in PARALLEL with the circuit, or circuit element under test.

To measure voltage:

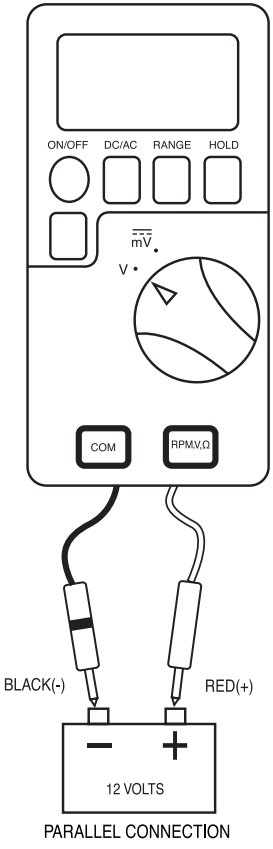
- Select the Voltage (V or mV) range with the rotary switch.
- Press the DC/AC button to select AC or DC.

Insert

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Touch the Black probe to the negative (–) circuit or to ground.

Touch the Red probe to the circuit coming from the power source.



PARALLEL CONNECTION

■Accuracy

A measurement range determines the highest value the Meter can measure. Most Meter functions have more than one range. Being in the right measurement range is very important when measuring.

Selection of a lower range will move the decimal point one place and increase the accuracy of the reading.

An O.F.L (overload) display means the range is too low; select the next higher range.

■Analog Bar Graph

The 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.

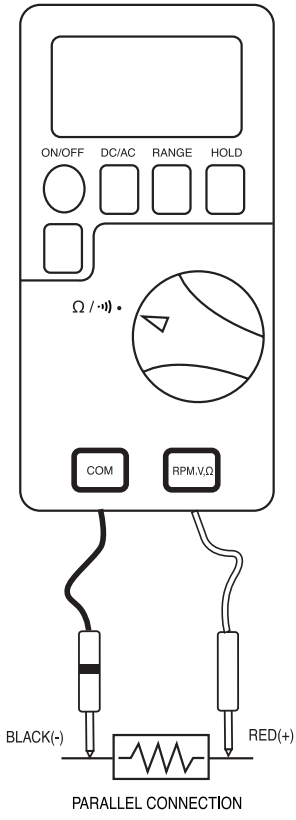
Resistance Measurements

Resistance is measured in Ohms (Ω) and the values can greatly vary from a few Milliohms (mΩ) for contact resistance to billions of ohms for insulators. The Meter can measure down to about 0.1 Ohms and measure as high as 40 MΩ.

WARNING!

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.

NOTE: The resistance in the test leads can affect accuracy in the 400 Ω range. Short the leads together and subtract the test lead resistance from the resistance measurements.



PARALLEL CONNECTION

To measure resistance:

- Select the Resistance (Ω) setting with the rotary switch.
- If a more accurate measurement is desired, select the proper Resistance range using the RANGE button.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Touch the test lead probes across the resistance or circuit to be tested.

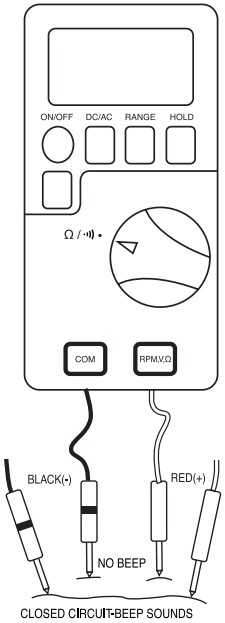
■Accuracy

Rapidly changing display readings (noise) can sometimes be eliminated if you change to a higher range.

Continuity Test

A DMM with a continuity beeper allows you to quickly and easily distinguish between an open and a closed circuit. The Meter beeps when it detects a closed circuit or short, so you do not have to look at the Meter during the test. This can be a valuable troubleshooting aid when determining: good or blown fuses and fusible links, open or shorted conductors and wires, the operation of switches, etc.

NOTE: Turn the power off to the circuit to be tested. A beeper tone does not necessarily mean zero resistance.



To test circuit continuity:

- Select the Ω / •))) setting with the rotary switch and press the DC/AC button to select the continuity (•)))) range.
  The •))) symbol appears on the display and the Meter defaults to the 4 KΩ range.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect one test probe to each end of the circuit to be tested.

- If circuit is closed, the Meter will beep @ < 100 Ω.
- If circuit is open, there is no beep.

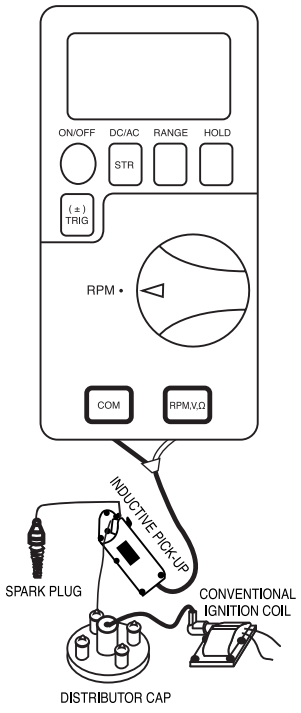
RPM Measurements Using the Inductive Pickup

RPM refers to revolutions per minute. Using the inductive pickup, which comes with the Meter, RPM can be measured by clamping it around any spark plug wire of a two stroke or a four stroke automotive engine. The inductive pickup takes the magnetic field generated by the current flown in the spark plug wire and converts it to a pulse that triggers the Meter's RPM measurement.

Using the inductive pickup allows you to make RPM measurements on any 2 or 4 stroke automotive engine with any number of cylinders without physically touching any wires.

WARNING!

THE IGNITION SYSTEM CAN GENERATE A POTENTIAL SHOCK HAZARD. ENSURE THAT THE ENGINE IS OFF BEFORE CONNECTING OR REMOVING THE INDUCTIVE



To measure RPM:

- Select the RPM range with the rotary switch.
- Press the DC/AC button to select either 2 or 4 stroke engine.

Insert:

- The DUAL BANANA CONNECTOR into the input jacks as shown. Ensure that the plug with the GROUND TAB goes into the COM jack.

Connect the inductive pickup to a spark plug wire and start the engine. If no reading is received, unhook the pickup, turn it over and connect again.

If the reading is too high or unstable, adjust trigger level.

NOTE:

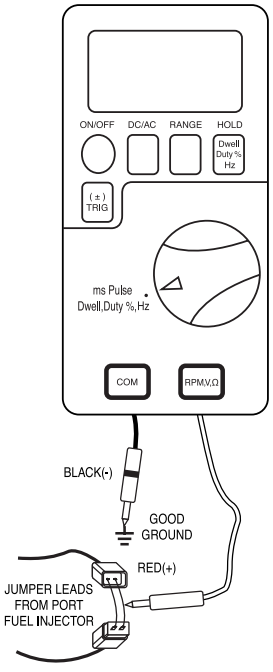
1. ***Position the pickup as far away from the distributor and the exhaust manifold as possible.***
2. ***Position the pickup within six inches of the spark plug or move it to another plug wire if no reading or an erratic reading is received.***

Pulse Width Measurements

Pulse Width is the length of time an actuator is energized. For example, fuel injectors are activated by an electronic pulse from the Engine Control Module (ECM). This pulse generates a magnetic field that pulls the injector nozzle valve open. The pulse ends and the injector nozzle is closed. This Open to Close time is the Pulse Width and is measured in milliseconds (mS).

The most common automotive application for measuring pulse width is on fuel injectors. You can also measure the pulse width of the fuel mixture control solenoid and the idle air control motor.

This exercise shows how to measure Pulse Width on Port Fuel Injectors.



To measure pulse width (mS):

- Select the mS-Pulse range with the rotary switch.
- Press the ± TRIG button for 2 seconds until the negative (–) trigger slope is displayed on the lower left side of the display.

NOTE: The applied time for most fuel injectors is dis-played on the negative (–) slope.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect:

- Jumper wires between the fuel injector and the harness connector.
- Black test probe to a good ground at the fuel injector or the negative (–) vehicle battery post.
- Red test probe to the fuel injector solenoid driver input on the jumper cable.

Start the engine. A pulse width in milliseconds should be read.

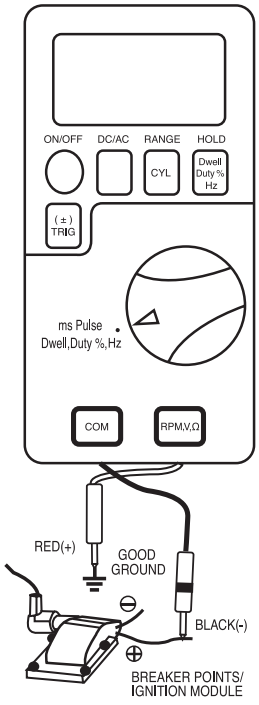
If reading is too high or unstable, adjust the trigger level pressing the ± TRIG button repeatedly.

Dwell Measurements

Dwell is the number of degrees of distributor rotation where the points remain closed. Dwell can be measured for 1,2,3,4,5,6,8 cylinder engines using the Meter so you need to determine how many cylinders are in the engine to measure Dwell.

In the Dwell mode, the Meter defaults to 4 cylinders so DWL°, 4 CYL and TRIG on the display. If you want to select the other number of cylinder, press the CYL (RANGE) button repeatedly to select the required number of cylinders.

This exercise shows how to measure Dwell.



To measure Dwell:

- Select the mS-Pulse range with the rotary switch.
- Press the HOLD (DWELL) button until DWL°, 4CYL, TRIG, and – appear on the display.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect:

- Red test probe to a good ground or the negative (–) vehicle battery post.
- Black test probe to the wire that connects to the breaker points.

Press the CYL (RANGE) button repeatedly to select the required number of cylinders.

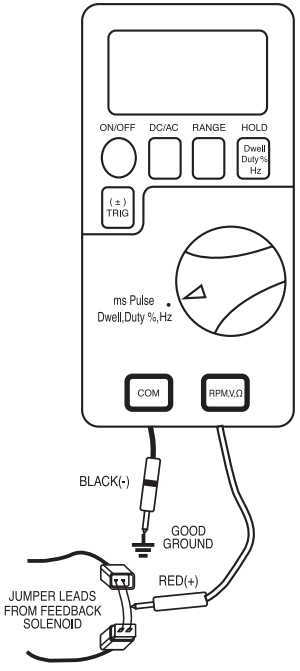
Start the engine and observe the reading.

Adjust trigger level pressing the ± TRIG button repeatedly, if the reading is too high or unstable.

Duty Cycle Measurements

Duty Cycle is the percentage (%) of time that voltage is positive compared to negative: On compared to Off. There are many signals on a vehicle where you might be required to measure duty cycle. Signals from Mixture Control Solenoid of a feedback carburetor, signals from Cam or Crank sensors and the control signals for fuel injectors are good examples.

This exercise shows how to measure duty cycle on the signal for the mixture control solenoid of a feedback carburetor using the Meter.



To measure duty cycle (%):

- Select the mS-Pulse range with the rotary switch.
- Press the HOLD (DUTY %) button until % appears on the right side of the display.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect:

- Black test probe to a good ground at the carburetor or the negative (–) vehicle battery post.
- Red test probe to the solenoid signal.

Press the ± TRIG button for 2 seconds to toggle between the negative (–) and positive (+) slope.

Start the engine. A duty cycle of approximately 50 % should be read.

Adjust the trigger level pressing the ± TRIG button repeatedly if reading is too high or unstable.

Most car have the points of the solenoid closed for a duty cycle between 50 ~ 70%.

Once the engine warms up and goes into open loop, the duty cycle should fluctuate.

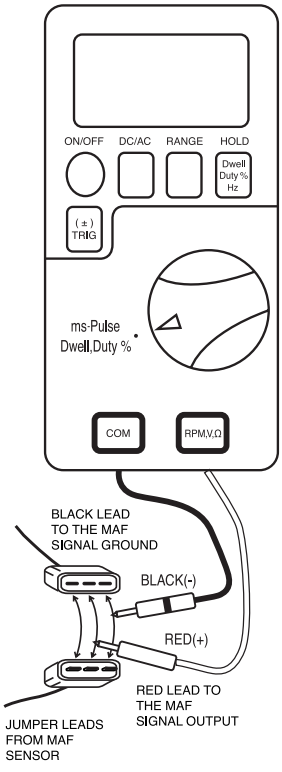
NOTE: Consult the car's service manual to verify slope assigned to position for each component.

Frequency (Automotive Hz) Measurements
[Model: 228 Only]

Frequency (Hz) is the number of times a voltage pattern repeats positive compared to negative, On Compared to Off, during 1 second of time. There are many sensors and signals on a vehicle that have a frequency that can be measured. Wheel Speed sensors, Vehicle Speed sensors, Fuel Injector control signals, Cam and Crank outputs and engine reference signals are good examples.

This example measures the frequency output of a digital Mass Air Flow sensor. Depending on the type of MAF sensor, the output can be from several hundred to ten thousand Hz.

NOTE: Although similar in appearance, MAF sensors made by different manufacturer function differently, have different frequency range's square waves and are not Interchangeable. Voltage level of square waves should be consistent. Frequency should change smoothly with engine load and speed.



To measure frequency (Hz):

- Select the mS-Pulse range with the rotary switch.
- Press the HOLD (Hz) button until Hz appears on the right side of the display.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect:

- Jumper wires between the MAF sensor and the harness connector.
- Black test probe to the ground jumper wire.
- Red test probe to the signal output jumper wire.

Start the engine. At idle, note the frequency displayed on the Meter. Move the throttle and note the change in frequency displayed.

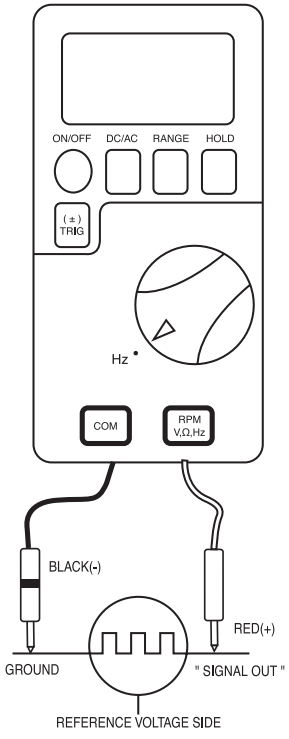
If reading is unstable, adjust the trigger lever pressing the ± TRIG button repeatly.

Frequency (Non-Automotive Hz) Measurements
[Model: 226 Only]

The Meter has two frequency measurement modes: The non-automotive Hz measurement (Approximate Trigger Level: 300 mV) mode for the general frequency counter mode and the automotive Hz measurement mode for the automotive mesurement.

In the non-automotive Hz measurement mode, the Meter autoranges to one of four ranges: 199.99 Hz, 1999.9 Hz, 19.999 KHz and 199.99 KHz.

If the input signal is below the trigger level, frequency measurement will not be taken. If your readings are unstable, the input signal may be near the trigger level for that range. You can usually correct this by selecting a lower range using the RANGE button. If your readings seem to be a multiple of what you expected, your input signal may have distortion or ringing like the signals from electronic motor controls. In this case, use the automotive Hz measurement mode to get the correct readings.



To measure frequency (Hz).

- Select the Hz setting with the rotary switch.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω Hz jack.

Connect:

- The Black test probe to GROUND side.
- The Red test probe to the "SIGNAL OUT" wire of the object to be tested.

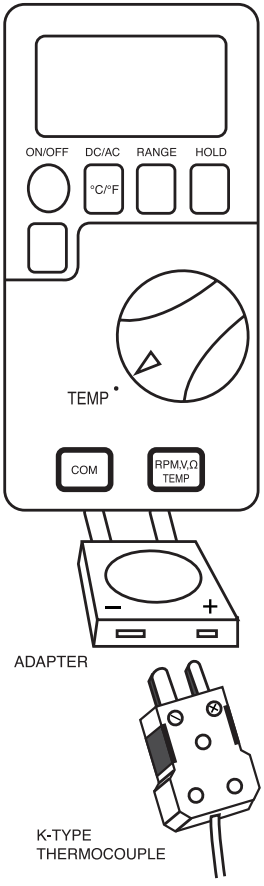
NOTE: The display will show 00.00 Hz for frequencies below 0.5 Hz.

Temperature Measurements [Model: 228 Only]

CAUTION!

DO NOT ALLOW TEMPERATURE PROBES TO CONTACT ANY LIVE VOLTAGE THAT MAY EXCEED 30 V AC RMS OR 42 V AC PEAK OR 60 V DC. UNPLUG TEMPERATURE PROBE BEFORE TAKING MEASUREMENTS OTHER THAN TEMPERATURE. TO AVOID HEAT DAMAGE TO THE METER, KEEP IT AWAY FROM SOURCES OF VERY HIGH TEMPERATURE. THE LIFE OF TEMPERATURE PROBE IS ALSO REDUCED WHEN EXPOSED TO VERY HIGH TEMPERATURES (OPERATING RANGE IS -40 °F TO 2,498 °F).

NOTE: This Meter automatically defaults to the Centigrade scale. To measure in Fahrenheit, toggle the DC/AC button when the rotary switch is set to TEMP position.



To measure temperature:

- Select the TEMP setting with the rotary switch.
- Press the DC/AC button to toggle between °C and °F.

Insert:

- The thermocouple adaptor and thermocouple into TEMP (RPM, V, Ω) and COM jack.

Touch the end of K– type thermocouple to the area or surface of the object to be measured.

NOTE: To avoid error, it is very important to use a thermocouple adaptor whose materials match the thermocouple you are using.

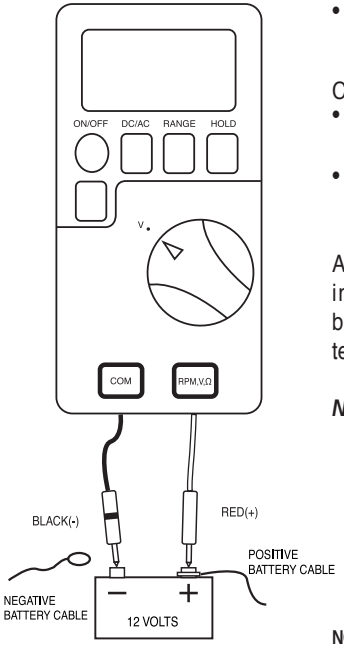
6. BASIC AUTOMOTIVE DIAGNOSTIC TESTING

These basic diagnostic tests begin by checking the main source of power and the chassis ground circuit connections. Ground circuits are one of the least understood but potentially most troublesome areas of automotive electronics. One of the most frustrating electrical problems you will encounter in an automobile is a high resistance ground. This can create some very strange symptoms that seem to be unrelated to the cause. The symptoms can include problems with turn signals, lights that stay dim, the wrong lights turning on, transmission shifting problems, gauges that change when certain accessories are operated, or even lights that will not turn on at all. You can find a bad ground by checking the voltage between the component's ground wire and a clean chassis ground or the negative vehicle battery terminal. An excessive voltage drop in a ground circuit affects the entire electrical circuit. This is why it is so important to make sure the basic circuits are in good shape before checking trouble codes in the on-board computer and individual components.

Battery Tests

(1) No Load Test

This test checks for battery charge state. A fully charged battery will display at least 12.6V. Since voltage tests only show the charge state, not the battery condition, you should also perform a load test to indicate the battery's performance.



To check battery charge state:

- Turn the headlights on for 15 seconds to dissipate battery surface charge.
- Disconnect the negative (–) battery cable terminal.
- Set the rotary switch to voltage ($\overline{V}$).

Connect:

- Black test probe to the negative (–) battery post.
- Red test probe to the positive (+) battery post.

A reading of less than 12.4V indicates an undercharged battery. Recharge before testing.

NOTE: The ignition switch must be off when connecting or disconnecting battery cables to prevent damaging the vehicle computer.

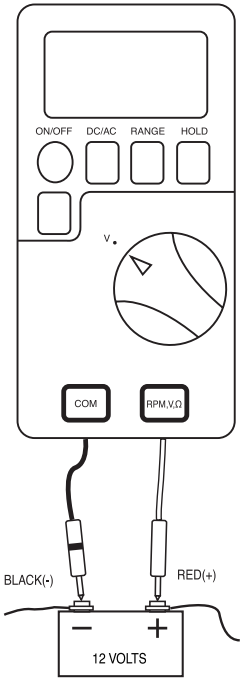
NO LOAD 12V VEHICLE BATTERY TEST

(Meter Reading)	(% Battery Charge)
12.60V (or greater)	100%
12.45V	75%
12.30V	50%
12.15V	25%

(2) Voltage Load Test

Batteries are often blamed for “No–Start” conditions, when in fact the real problem exists in the charging system. After the charging system problem exists for some period of time the battery will become discharged and will not be able to supply enough current for the starter to crank the engine.

This test checks for the battery’s capacity to deliver sufficient cranking voltage.



To measure voltage load:

- Set the rotary switch to voltage ($\overline{\overline{V}}$).

Connect:

- Black lead to the negative (–) battery post.
- Red lead to the positive (+)battery post.

Crank the engines for 15 seconds after disabling the ignition and check the minimum display.

A reading of less than 9.40V at 60°F/16°C indicates a weak battery. Recharge or replace the battery before testing.

VOLTAGE LOAD TEST

(Meter Reading)	(Battery/Air Temperature)
10.0V	90°F/33°C
9.8V	80°F/27°C
9.6V	70°F/21°C
9.4V	60°F/16°C
9.2V	50°F/10°C
9.0V	40°F/ 4°C
8.8V	30°F/–1°C
8.6V	20°F/–7°C

NOTE: Battery temperature can be checked with the Meter temperature function.

Voltage Drop Test

Voltage drop tests measure the amount of voltage expended to overcome resistance (an opposing force created by a circuit or component to the flow of electrical current); the lower the voltage drop reading, the less resistance there is in the circuit being tested.

The Meter has a very useful Fix Hold function for measuring voltage drops on many different components and connections. Measuring the voltage drop across the connections and components in the starter circuit, while cranking the engine with the ignition or fuel system disabled to prevent starting, will indicate if there is any resistance in a starter circuit.

To measure voltage drop, current must be flowing in the circuit, and both voltage test probes must be connected on the same side of the circuit.

Voltage drop can also be determined from available voltage readings by noting the difference between each successive reading.

Always refer to the vehicle manufacturer's specification for voltage drop information. If the voltage drop specification is not available, refer to the following list to determine the circuit's maximum allowable voltage drop. Typical maximum allowable voltage drop values for 12 volt systems are as follows:

Battery cable length up to 3 feet 0.1V
Battery cable length over 3 feet. 0.2V
Magnetic switches. 0.3V
Solenoid switches. 0.2V
Mechanical switches. 0.1V
Battery cable connectors 0.05V
Connections 0.0V

NOTE: Do not use the allowable voltage drop values listed above on circuits that use aluminum cables.

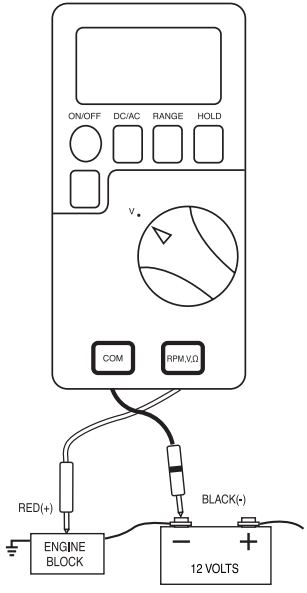
Maximum voltage drop, normally, should not be more than 0.1V per wire, ground, connection, switch or solenoid. Thus, with the negative test probe connected to the negative battery post and the positive test probe connected to the starter drive housing frame, total voltage drop should not exceed 0.4 volts.

If the voltage drop reading is within the allowable maximum voltage drop specification, the circuits resistance is acceptable.

If the voltage drop reading exceeds the maximum allowable voltage drop, the point of excessive resistance can be located by checking the voltage reading at each connection and cable end. When a sharp decrease in voltage drop is observed, the cause of the excessive resistance will be located between that test point and the previous test point.

(1) Battery Ground to Engine Block Voltage Drop Test

This test checks for engine ground efficiency.



To check voltage drop:

- Set the rotary switch to voltage ($\overline{\overline{V}}$).
- Touch the Black test probe to the negative (–) battery post and the Red test probe to the positive (+) battery post; this reading will be the base voltage to compare your test voltage reading against.

Move and connect:

- Red test probe to a clean spot on the engine block.

Disable the ignition so the engine doesn't start and crank the engine for 4 ~ 5 seconds.

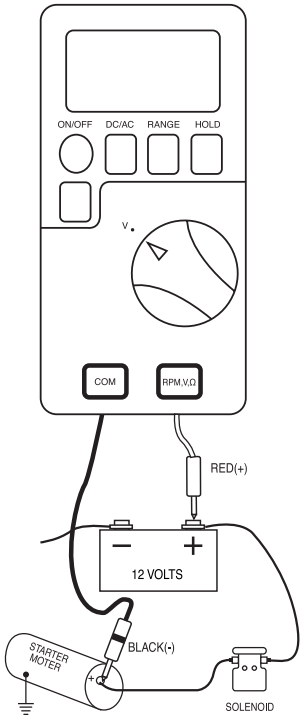
This connection has 2 connectors, 1 wire, 1 ground and 1 cable terminal to battery post so a voltage drop of more than 500mV would indicate a poor ground circuit.

Test again after cleaning and inspecting the battery cable connections and the ground.

NOTE: Repeat this test when the engine is thoroughly warmed up. Heat expansion of metal may cause voltage drop to increase.

(2) Battery Ground to Complete Starter Circuit (+) Voltage Drop Test

This test checks for battery power efficiency to the starter motor system including the starter solenoid. Check the resistance in the starter circuit. Even very low resistance in the starter circuit can cause the starter turn slowly, because of low voltage.



To check voltage drop:

- Set the rotary switch to voltage (⎓ V).
- Touch the Black test probe to the negative (–) battery post and the Red test probe to the positive (+) battery post to establish the base voltage that you will compare test voltage against.

Connect:

- Black test probe direct to the positive (+) terminal on the starter motor.
- Red test probe to the positive (+) battery post.

Disable the ignition so the engine doesn't start and crank the engine for 4 ~ 5 seconds.

This connection has 4 connectors, 2 wires and 2 solenoid connections so a voltage drop of more than 800mV would indicate a poor circuit.

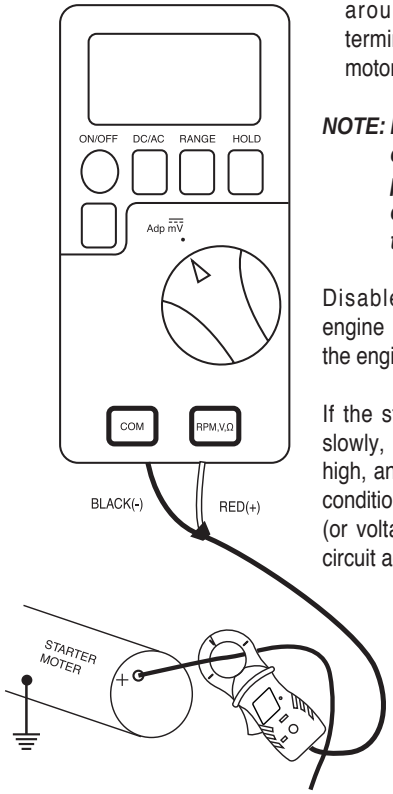
Test again after cleaning and inspecting the battery, starter cables, solenoid and cable connections.

A defective starter solenoid cause an excessive voltage drop. Check the cables and connections before replacing the solenoid.

NOTE: Repeat this test when the engine is thoroughly warmed up. Heat expansion of metal may cause voltage drop to increase.

Starter Motor Current Test

The battery tests and the voltage drop tests have verified that there is adequate battery voltage at the starter. Next, investigate how much current the starter is drawing by using a DC clamp-on current probe. Under normal operating conditions, with an outside air temperature of 70°F, a good rule of thumb for calculating cranking current is 1A per CID (Cubic Inch Displacement) or 60A per liter ± about 25%. Under No Load conditions, it is 1/2A per CID ± about 10%. Check the manufacturer's specifications for the correct starter cranking current.



To measure start current:

- Set the rotary switch to the millivolts DC (mV) setting.
- Connect a DC clamp-on current probe to the Meter.
- Let this current probe clamp around the positive (+) terminal cable of the starter motor.

NOTE: Make sure the arrow on the clamp is pointed in the direction of the current flow in the cable.

Disable the ignition so the engine doesn't start and crank the engine for 4 ~ 5 seconds.

If the starter turns the engine slowly, the current draw is not high, and the battery is in good condition, check the resistance (or voltage drop) in the starter circuit again.

Charging System Tests

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.

To diagnose and adjust regulators/alternators, on a typical GM vehicle, you must first determine if the system has an integral (internal) regulator, then whether it is a type A or B alternator.

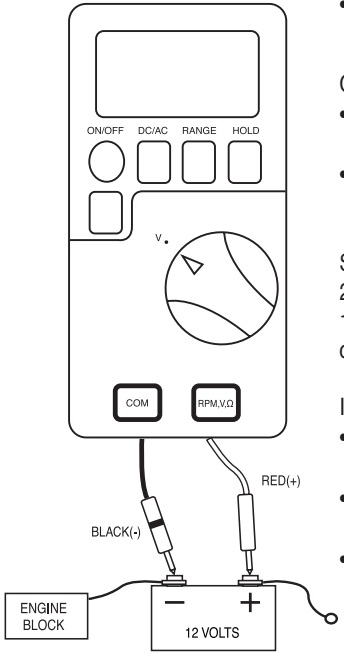
The Type A alternator has one brush connected to t he battery (+) and the other brush grounded through the regulator. The Type B regulator has one brush tied to ground and the other connected to the battery (+) through the regulator. Next isolate the problem to either the alternator or regulator. To do this you need to by-pass the regulator (this is called "Full Fielding"), ground the Type A field terminal, or connect the Type B field terminal to the battery (+) side. If the system now charges, the regulator is faulty.

CAUTION!

WHEN PERFORMING THIS TEST, IDLE THE ENGINE WITH THE LIGHTS ON SO THE OUTPUT VOLTAGE DOES NOT GO OVER 15V. CHECKING AN ALTERNATOR WITH AN INTEGRAL REGULATOR, YOU MUST KNOW WHICH TYPE YOU ARE TESTING TO AVOID ANY DAMAGE TO THE ALTERNATOR OR REGULATOR.

(1) Alternator Output Voltage Test at the Battery (+)

This test checks for alternator output voltage at the battery.



To measure alternator output voltage:

- Set the rotary switch to voltage ($\overline{\overline{V}}$).
- Turn all vehicle accessories off.

Connect:

- Black lead to the negative (–) battery post.
- Red lead to the positive (+) battery post.

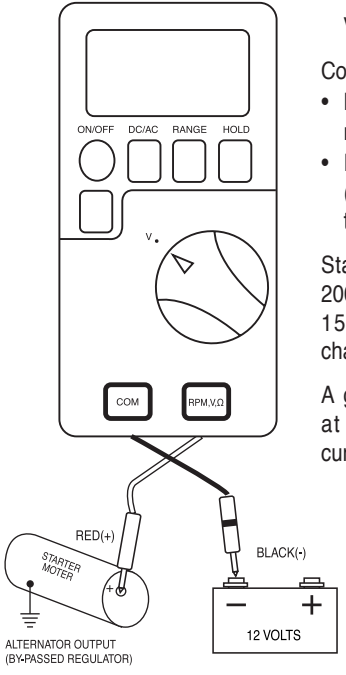
Start the engine and run it at 2000RPM. A reading of 13.5-15.5V is an acceptable charging rate.

If the voltage is low, check for:

- Defective alternator or regulator.
- Cracked, glazed or loose drive belt.
- Faulty or loose wires or connectors.

(2) Alternator Output (+) Voltage Test (Loaded)

This test is necessary only if the vehicle failed the above test.



To measure alternator output voltage:

- Set the rotary switch to voltage ($\overline{\overline{V}}$).

Connect:

- Black test probe to the negative (–) battery post.
- Red test probe to the battery (+) terminal on the back of the alternator.

Start the engine and run it at 2000 RPM. A reading of 13.5-15.5V is an acceptable charging rate.

A good alternator will maintain at least 13.6V at the rated current output.

Ignition System tests

Since the Meter can measure from tenths of an ohm up to 40 million ohms, this makes it very useful for testing the resistance in most ignition system components. If you suspect bad ignition wires, you can test resistance of the wire while moving, twisting and bending the wire. The resistance values will typically be around 10KΩ per foot.

You can also check the resistance of the ignition coil's primary and secondary windings, if you suspect a problem with the ignition coil. You will need to do this test, first, when the coil is hot, and again when it is cold. You should also measure from the coil's case to each connector and between the primary and secondary windings should have a very low resistance, typically from a few tenths of an ohm to a few ohms and the secondary windings have a much higher resistance typically in the 10K ohm range. To get the actual figures for a specific coil, check the manufacturer's specs.

WARNINGS!

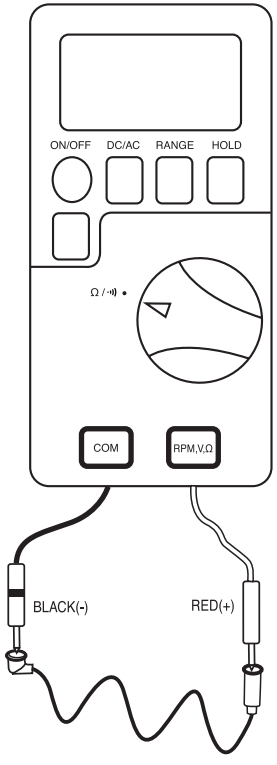
ALWAYS DISCONNECT THE IGNITION COIL FROM THE IGNITION SYSTEM BEFORE TESTING TO AVOID AN ELECTRICAL SHOCK.

(1) Spark Plug Wire (Secondary Ignition Wire) Resistance Test

Spark plug wires should be checked if your oscilloscope indicates that there may be a problem or if they are more than two years old. You should be careful when pulling the spark plug boot from the insulator as bonding may have occurred.

If you suspect a bad wire, test its resistance while gently twisting and bending the spark plug wire. If the resistance value changes wile moving, twisting or bending the wire and you are confident you have a good connection, then replace the wire.

This test checks for high resistance or open circuits in the secondary ignition wires (spark plug wires).



To measure the wire resistance:

- Set the rotary switch to resistance (Ω).

Insert:

- Black lead in COM jack.
- Red lead in RPM,V, Ω jack.

Connect:

- The test probes to opposite ends of the spark plug wire.

Typical measurements are approximately 10KΩ per foot of wire. For example, 2 feet spark plug wire has about 20KΩ.

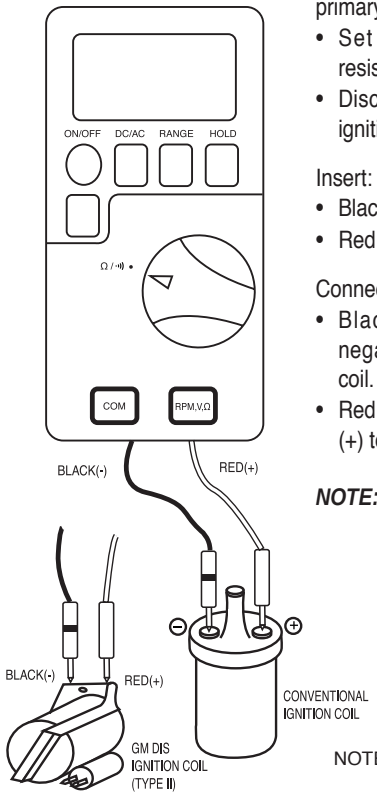
The measurement you make will be dependent on the length of wire you select.

Compare readings to other spark plug wires found on the engine to insure the accuracy of the test.

NOTE: Be sure the test probe tips make contact with the center conductor of the wire.

(2) Primary Windings Resistance Test

This test checks for resistance in the primary windings of conventional and DIS (distributorless) ignition coils.



To measure resistance in the primary windings:

- Set the rotary switch to resistance (Ω).
- Disconnect the coil from the ignition system.

Insert:

- Black lead in COM jack.
- Red lead in RPM,V, Ω jack.

Connect:

- Black test probe to the negative (–) terminal on the coil.
- Red test probe to the positive (+) terminal on the coil.

NOTE: For accurate low resistance measurements, the resistance in test leads must be subtracted from the total resistance measured.

NOTE: Both Primaries of Type II are located on the back of the coil.

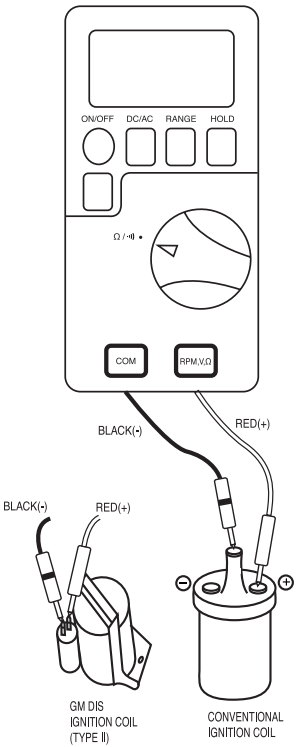
Typical measurements are between 0.5 ohms and 2.0 ohms.

To get the actual figures for a specific coil, check the manufacturer's specs.

Don't forget: Test the ignition coil when it is hot, and again when it is cold.

(3) Secondary Windings Resistance Test

This test checks for resistance in the secondary windings of conventional and DIS (distributorless) ignition coils.



To measure resistance in the secondary windings:

- Set the rotary switch to resistance (Ω).
- Disconnect the coil from the ignition system.

Insert:

- Black lead in COM jack.
- Red lead in RPM, V, Ω jack.

Connect:

- Black test probe to the high tension terminal on the coil.
- Red test probe to the positive (+) terminal on the coil.

Typical measurement are between 6KΩ and 20KΩ.

To get the actual figures for a specific coil, check the manufacturer's specs.

Don't forget: Test the ignition coil when it is hot, and again when it is cold.

Summary of Automotive Electrical System Tests

Electrical System Tests

SYSTEM & COMPONENTS	MEASUREMENT TYPES				
	Voltage presence & Level	Voltage Drop	Current (Amps)	Resistance (Ohms)	Frequency Hz
Charging System					
Alternators	•		•		•
Connectors	•	•		•	
Diodes		•		•	
Regulators	•				•
Cooling System					
Connectors	•	•		•	
Fan Motors	•		•	•	
Relays	•	•		•	
Temperature Switches	•	•		•	
Ignition System					
Coils	•			•	
Condensers	•			•	
Connectors	•	•		•	
Contact Set (points)	•			•	
MAF Sensors	•			•	
Magnetic Pickup	•		•	•	
MAP/BP Sensors	•			•	
O_2 Sensors	•			•	
Starting System					
Batteries	•	•			
Connectors		•	•		
Interlocks		•	•		
Solenoids	•			•	
Starters	•	•	•		

Applications Guide

	Amps DC*	Analog Pointer	Continuity	% Duty	Hz**	Temperature	Millivolts	Ohms	mS-Pulse	RPM	HOLD	Volts DC	DWELL
IGNITION/ENGINE													
Coils						●		●				●	
Computer Temp Sensors						●		●				●	
Condensers (Capacitors)		●				●		●				●	
Connectors			●			●	●	●			●	●	
Contacts Set		●	●	●		●	●	●				●	
Distributor Cap								●					
Engine Speed										●			
Feedback Carburetors				●	●			●				●	●
Fuel Injectors (Electronic)		●		●	●			●	●			●	●
Hall-Type Sensors		●			●	●	●	●		●		●	
Idle Air Motors		●		●	●	●		●	●				●
Ignition Modules		●					●	●				●	
MAF Sensor					●								
Magnetic Pickups		●	●		●		●	●		●		●	
MAP & BP Sensors		●			●							●	
O_2 Sensors		●			●		●						
Throttle Position Sensors		●						●				●	
STARTING SYSTEM													
Battery	●					●						●	
Connectors						●	●	●			●	●	
Interlocks (neutral safety switch)			●					●				●	
Solenoids			●			●	●	●				●	
Starters	●					●	●			●		●	
COOLING SYSTEM													
Connectors			●				●	●			●	●	
Fan Motor			●			●		●				●	
Radiator						●							
Relays			●				●	●				●	
Temperature Sensors						●		●					
Temperature Switches						●		●		●	●	●	
CHARGING SYSTEM													
Alternators	●					●		●				●	
Computerized Regulators	●				●				●			●	●
Connectors			●				●	●			●		
Diodes, (AC Ripple)								●					
Diode Rectifier			●									●	
Regulators	●	●						●	●			●	
BODY ELECTRIC													
Compressor Clutch			●				●	●			●	●	
Lighting Circuits			●					●				●	
Relay and Motor Diodes			●										
Transmissions			●					●					

* Use with a DC current clamp

* * Available in Model 226 Only

7. MAINTENANCE AND REPLACEABLE PARTS

General Maintenance

WARNING!

REPAIRS OR SERVICING NOT COVERED IN THIS MANUAL SHOULD ONLY BE PREFORMED BY QUALIFIED PERSONNEL. TO AVOID ELECTRICAL SHOCK, DO NOT SERVICE UNLESS YOU ARE QUALIFIED TO DO SO.

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

Calibrate this Meter once a year to maintain its performance specifications.

Battery Replacement

The Meter uses a 9V battery (NEDA 1604 or IEC 6F22). To replace the battery, remove the two screws of the battery compartment from the back of the Meter and lift off the cover of the compartment. Replace the battery. Reattach the compartment cover to the back of the Meter, and reinstall the screws.

Replaceable Parts and Accessories

NOTE: When servicing the Meter, use only the replaceable parts and accessories specified.

DESCRIPTION	PART NO.
Battery, 9V (NEDA 1604, IEC 6F22)	BT1
Test Lead Set	FTL-500 V1
Alligator Clips	AC2
K-type Thermocouple [228 Only]	TP1
Thermocouple Adaptor [228 Only]	TP1A
Inductive Pickup	RPM206
Rubber Boot (Yellow)	C2Y
AC/DC Clamp-on Current Probe (Optional)	CA113

8. SPECIFICATIONS

Electrical Specifications

Accuracy is given as ± ([% of reading]+[number of least significant digits]) at 18°C to 28°C with relative humidity up to 80%, for a period of one year after calibration.

Frequency, RPM, Duty Cycle, Dwell and Pulse Width

FUNCTION	RANGE	RESOLUTION	ACCURACY	PULSE WIDTH	
				RANGE (mS) #	RESOLUTION (mS)
Frequency	199.99**	0.01Hz	± (0.05% + 2)	1999.9	0.1
(0.5Hz to	1999.9**	0.1Hz	± (0.05% + 2)	5.00	0.01
200kHz	19.999kHz	0.001kHz	± (0.05% + 2)		
Pulse Width	199.99kHz	0.01kHz	± (0.05% + 2)		
> 2µS)	200 kHz	0.1kHz	Unspecified		
RPM	30-9,000	1 RPM	± 2 RPM		
% Duty Cycle *	0.0-99.9% (30 RPM to 19,999RPM, Pulse Width > 2 µS)				
Dwell *	0.0-356.4° (30 RPM to 19,999RPM, Pulse Width > 2 µS)				
Pulse Width *	0.5-1999.9mS (30 RPM to 19,999 RPM, Pulse Width > 2 µS)				

\# Pulse Width range is determined by RPM.

* For rise > 1µS. Duty Cycle accuracy : Width ± (0.2% per KHz + 0.1%),
Pulse Width accuracy : Duty Cycle accuracy + 1 digit

** The automotive Frequency (Hz) of ms-Pulse, Dwell, Duty %, Hz mode has only these 2 range specifications. (228 Only)

Voltage

FUNCTION	RANGE	RESOLUTION	ACCURACY	INPUT IMPEDANCE
DC V	4V	1mV	± (0.5%+2 dgts)	Approx. 11MΩ
	40V	10mV		Approx. 10MΩ
	400V	0.1V		
	600V	1V	± (0.5%+2 dgts)	
DC mV	400mV	0.1mV	± (0.5%+2 dgts)	> 10MΩ

FUNCTION	RANGE	RESOLUTION	ACCURACY		INPUT IMPEDANCE
			50Hz-60Hz	45Hz-1kHz	
AC V	4V	1mV	± (0.75%+3dgts)	Unspecified	Approx. 11MΩ
(45Hz to	40V	10mV			
1kHz)	400V	0.1V	± (0.75%+3dgts)	± (2.5%+5dgts)	Approx. 10MΩ
	600V	1V			

Ohms

FUNCTION	RANGE	RESOLUTION	ACCURACY	OPEN CIRCUIT VOLTAGE
Ohms	400Ω	0.1Ω	± (0.75%+10dgts)	< 1.2V
	4KΩ 40KΩ 400KΩ 4MΩ	1Ω 10Ω 0.1KΩ 1KΩ	± (0.75%+3dgts)	
	40MΩ	10KΩ	± (1.5%+10dgts)	
Continuity	Open Circuit Voltage : < 1.2V Threshold : Approx. < 100Ω			

Temperature Specification

RANGE	RESOLUTION	ACCURACY
-40°C to -10°C (-40°F to 14°F)	0.1°C (0.1°F)	± (3.0°C + 1 dgt) ± (3.0°F + 1 dgt)
-10°C to 20°C (14°F to 68°F)	0.1°C (0.1°F)	± 3.0°C (± 3.0°F)
20°C to 400°C (67°F to 400°F)	0.1°C (0.1°F)	± (1.0% + 2°C) ± (1.0% + 2°F)
400°C to 1,370°C (400°F to 2,498°F)	1°C (1°F)	± 3.0% of reading (± 3.0% of reading)

* This specification is effective at the ambient temperature of 23 °C only.

General Specifications

Display (LCD) Digital : Counts– 4000 (Frequency range: 20000)
Updates – 1 time/sec. in RPM, FREQ, Duty Cycle, Dwell and Pulse Width,
4 times/sec. in all other functions and ranges.

Analog : 2 x 41 segments
Updates – 20 times/sec.

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

Operating Temperature : 0°C to 45°C (32°F to 113°F)

Relative Humidity : 0% to 80%
(0°C 35°C; 32°F to 95°F)
0% to 70%
(35°C to 45°C; 95°F to 113°F)

Temperature Coefficient: 0.05 x (Specified Accuracy)/°C
(< 18°C or > 28°C; < 64°F or >82°F)

Battery Type : 9V, NEDA 1604 or 6F22 or 006P

Battery Life : 140 hrs typical (alkaline)

Shock, Vibration : Designed to MIL-T-28800D for a Class 3 instrument, 1 meter shock

Size (H X W X D)
- Meter Only : 140 X 70 X 36 mm
- With Holster : 154 X 80 X 54 mm

Weight
- Meter Only : 252g
- With Holster : 425g

Safety Standards
- Meter : Designed to both IEC 1010-1 and the EMC Directive, UL 964, CSA C22.2 No. 231 and ISA-DS82
  CE-mark Certificated.
- Pickup : Specified for use with spark-plug wire only.