Sensor Signal Simulation Multi-meter

INSTRUCTION MANUAL

Version 01.3 /06
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**Disclaimer:**

The information contained in this manual is considered correct at the time of printing and it is subjected to change without prior notification.
1.0  INTRODUCTION

BEKOH Signal Simulation Multi-meter is designed with simulation signals that emulate the sensors signal in diagnosing the vehicle fault which is perfect to work together with an Automotive Scanner. In addition to this, it is also a digital multi-meter suitable for measurement of AC, DC Voltages, AC, DC Currents, Resistance, Capacitance, Frequency, Duty Cycle, Diode Test and Continuity Test. The design is compact, light, handy and durable in workshop conditions.

2.0  GENERAL SPECIFICATIONS:

Display: 3-3/4 digits LCD with 25mm high numerical displays.


Auto Power Off: The meter will enter into “Power Off” mode 30 minutes after no activity detected. When button is pushed or selector switch is turned, Power turns ON again.

Low Battery Indication: "□□□□".

Over range Indication: "OL".

Power Supply: Single 9V battery (NEDA 1604 or IEC 6F22)

Reading Rate Time: 3 reading per sec (approx.).

Max. Common Mode Voltage: 500 VDC or AC peak.
Sensor Signal Simulation Multi-meter

Safety Standards: The meter is up to the standards of IEC1010 Double Insulation, Pollution degree 2 over voltage Category II.

Operating Environment: 0 ~ 50℃ (32~122℉) at ≤70% relative humidity.

Storage Environment: -20~60℃ (-4~140℉) at ≤80% relative humidity.

Temperature Coefficient: \(0.1 \times \text{(specified accuracy)} / (\leq 18°C \text{ or } \geq 28°C)\)

Accessories: One pair test leads, single 9V battery (NEDA 1604or IEC 6F22), operating instructions.

Fuse: 0.5A/250V, 5×20mm fast acting 10A/250V, 5×20mm or 5×25mm, fast acting.

Dimension: 155mm×97mm×50mm

Weight: Approx. 320g (including battery and holster).

### 3.0 ELECTRICAL SPECIFICATIONS:

*Accuracy is given as \(\pm ([\% \text{ of reading}] + [\text{number of decimal digits}])\) at 18~28°C (65~83°F), with relative humidity up to 70%.

**DUTY CYCLE %**

Ranges: 0.0~90.0%
Resolution: 0.1%
Pulse width: > 100us, <100ms
Accuracy: \(\pm (2.5\%\text{rdg}+10\text{dgt})\)
Overload protection: 250VDC or RMS AC

**DC VOLTAGE (Auto Ranging)**

Ranges: 400mV
Accuracy: \(\pm (0.8\%\text{rdg}+10\text{dgt})\)
Ranges: 4V, 40V, 400V, 1000V
Accuracy: \(\pm (0.5\%\text{rdg}+5\text{dgt})\)
Resolution: 100uV
Input impedance: >10M Ω
Overload protection: 1000VDC or 750VAC RMS.

**AC VOLTAGE (Auto Ranging)**
Ranges: 400mV, 4V, 40V, 400V, 750V, (400mV only in manual)
Resolution: 100uV
Accuracy: 400mV, 750V ± (1.8%rdg+10dgt) at 50~100Hz
4V, 40V, 400V, ± (1.5%rdg+10dgt) at 50~400Hz
Input impedance: >10M Ω
Overload protection: 1000VDC or 750VAC RMS.

**DC CURRENT (Auto Ranging)**
Ranges: 400uA, 4000uA, 40mA, 400mA, 10A.
Resolution: 0.1uA
Accuracy: 400uA, 4000uA ± (1.2%rdg+5dgt)
40mA, 400mA ± (1.5%rdg+5dgt)
10A ± (2.0%rdg+10dgt)
Input protection: 0.5A/250V fuse on 400mA range
10A/250V high energy fuses on 10A range

**AC CURRENT (Auto Ranging)**
Ranges: 400uA, 4000uA, 40mA, 400mA, 10A.
Resolution: 0.1uA
Frequency response: 50Hz to 400Hz
Accuracy: 400uA, 4000uA ± (1.8%rdg+5dgt)
40mA, 400mA ± (1.8%rdg+10dgt)
10A ± (2.5%rdg+10dgt)
Input protection: 0.5A/250V fuse on 400mA range
10A/250V high energy fuses on 10A range

**RESISTANCE Ω (Auto Ranging)**
Ranges: 400 Ω, 4KΩ, 40KΩ, 400KΩ, 4MΩ, 40MΩ
Accuracy: ± (1.2%rdg+10dgt) on 400 Ω range
±(1.0%rdg+5dgt) on 4k Ω to 4M Ω ranges
±(2.5%rdg+15dgt) on 40M Ω ranges
Open circuit voltage: 0.4VDC
Overload protections: 250VDC or RMS AC.
FERQUENCY (Auto Ranging)
Ranges: 100Hz, 1 KHz, 100 KHz, 200 KHz
Resolution: 0.01Hz
Accuracy: ± (0.1%rdg+5dgts)
Sensitivity: 1V
Overload protection: 250VDC or RMS AC

CAPACITANCE (Auto Ranging)
Ranges: 40nF, 400nF, 4uF, 40uF, 100uF.
Resolution: 10pF
Accuracy: ± (2.5%rdg+10dgts) on 40nF range
±(1.5%rdg+10dgts) on 400nF to 4uF ranges
±(2.5%rdg+15dgts) on 40uF to 100uF ranges
Overload protection: 250V DC or RMS AC

DIODE TEST
Test current: 0.6mA typical
Resolution: 1mV
Accuracy: ± (2.5%rdg+2gdts)
Open circuit voltage: 3.0Vdc typical
Overload protection: 250VDC or RMS AC.

AUDIBLE CONTINUITY
Open circuit voltage:
0.4Vdc≤60Ω: Buzzer sounds
Overload protections: 250VDC or RMS AC.

SIGNAL OUTPUT:
DC voltage: 0~1V, 0~5V, 0~12V
FREQUENCY signal: 0~5V, 0~12V.
Duty Cycle: 10~90%
FREQUENCY: 20Hz~3 KHz
RESISTANCE: 0~5KΩ, 0~200KΩ
3.0 SAFETY PRECAUTIONS:

- Warnings:

- Engines produce carbon monoxide gas which is odorless, has a slower reaction time and this can lead to serious injury or even death. When the engine is operating, keep the service areas WELL VENTILATED or attach the vehicle exhaust outlet to the shop exhaust removal system.

- Set the parking brake and chock the wheels before testing or repairing the vehicle. It is especially important to chock the wheels on front-wheel drive vehicles as their parking brakes do not sufficiently hold wheels.

- Wear face shield or safety goggles when testing or repairing vehicles. Exceeding the range limits of the multi-meter is dangerous as it will expose you to serious or possibly fatal injury. Carefully read and understand the precautions and the specification limits of the multi-meter.

- Voltage between any terminal and ground must not exceed 1000V DC or 750V AC.

- Be cautious when measuring voltages above 25Volts AC or DC.

- Circuit being tested must be protected by a 10A fuse or circuit breaker.

- Do not use the multi-meter if it has been damaged.

- Do not use the test leads if the insulations are damaged or metal is exposed.

- Use current clamps to measure circuits exceeding 10A.
Cautions:

- To avoid electrical shocks, do not touch the test leads, tips or the circuit being tested.

- Do not measure voltages with the test leads plugged in the 10A terminal.

- When testing for the presence of voltage or current make sure the meter is functioning correctly. Take a reading of a known voltage or current before accepting a zero reading.

- Choose the proper range and function for the measurement. Do not measure voltages or currents that may exceed the ratings marked on the function/range switch or terminal.

- When measuring current, connect the meter in series with the load.

- Never connect more than one set of test leads to the meter.

- Disconnect the live (RED) test lead first before disconnecting the common (BLACK) test lead.

- The mA and the 10A terminals are protected by fuse to avoid possible injury or damage. Use only in circuits limited to 400mA or 10A continuous for 15 seconds.

IMPORTANT

- To maintain accuracy of the meter, replace the weak battery immediately when the battery symbol appears on the meter display.

- To avoid measurement error from outside interference, always keep the meter away from spark plug or coil wires.
When doing voltage measurement, always disconnect the test leads from the test points first before selecting the functions to avoid damaging the meter.

Do not exceed the limits as shown in the table below:

<table>
<thead>
<tr>
<th>Function</th>
<th>Terminal</th>
<th>Input Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC Volts</td>
<td>V/Ω/RPM</td>
<td>750V AC rms</td>
</tr>
<tr>
<td>DC Volts</td>
<td>V/Ω/RPM</td>
<td>1000V DC</td>
</tr>
<tr>
<td>Frequency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohm (resistance)</td>
<td>V/Ω/RPM</td>
<td>250V AC/DC</td>
</tr>
<tr>
<td>Diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC/DC 400mA</td>
<td>mA</td>
<td>400mA AC/DC</td>
</tr>
<tr>
<td>AC/DC 10A</td>
<td>10A</td>
<td>*10A AC/DC</td>
</tr>
<tr>
<td>RPM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duty Cycle (%)</td>
<td>V/Ω/RPM</td>
<td>250V AC/DC</td>
</tr>
<tr>
<td>Dwell angle</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1: Continuous *10Amp measurement: Only 15 seconds maximum.

2: Ohm (Ω or resistance) can not be measured if voltage is present. It can only be measured in a non-powered circuit. However, the meter is protected to 250 volts.

5.0 GETTING STARTED

This chapter will help you get started. It describes the basic functions of the diagnostic digital meter.
1) **Hz/Duty switch**:  
When test or simulate frequency signal, press button Hz/Duty and select Hz/Duty function.
2) **Select Hz switch:**
   Press the button to select a function. A symbol will display to your choice. When test or simulate frequency signal, press Hz/Duty switch key, and then enter into the mode of voltage adjustment.

3) **Hold/Back light switch:**
   Press it for 2 seconds till the white light on the display lights up.

   **Data Hold:**
   The **Data Hold** feature stores the last reading in memory.
   *Press the **HOLD** button once to hold the present reading.
   *Press the **HOLD** button again to exit and resume readings.

4) **Resistance (Ω) select:**
   Switch the selector to the respective ohm range to measure the resistance.

5) **Function/Range switch:**
   Turn this switch to select a function or turn the meter OFF.

   **OFF:** Power switch OFF
   **V~:=** AC/DC Voltage Test
   **CAP:** Resistance/Diode/Continuity/Capacitance Test
   **mA (10A):** AC/DC Test
   **Hz/Duty:** Frequency/Duty Test
   **5K/200K:** Resistance Simulation Function
   **DC OUTPUT:** DC Voltage Simulation OUTPUT function
   **1V:** Simulate 0~1 Voltage range
   suitable for O2 sensors.
   **5V:** Simulate 0~5 Voltage range.
   **12V:** Simulate 0~12 Voltage range.

   **Frequency signal OUTPUT function:**
   **5V:** Simulate 0~5V Square Wave signal.
   Set Hz/Duty/Value adjustment control will change Hz/Duty/Voltage readings.
12V: Simulate 0~12V Square Wave signal.
Set Hz/Duty/Value adjustment control will change Hz/Duty/Voltage readings.

**CHARGE**: Charging inlet for internal battery.

6) **Hz/Duty/Value Adjustment controls:**
These controls are for setting the simulation output signals of Hz, Duty and Voltage when Frequency signal output is selected.

7) **Simulator Signal Output Control Switch:**
Press the button can control the simulating signal OUTPUT or NO OUTPUT.

8) **Test Lead Terminals:**

10A: Ampere measurement up to 10Amps maximum for 10 seconds period.

**COM**: The **BLACK** probe is plugged in this common terminal for all tests.

**V/Ω/Hz/Cap**: The **RED** probe is plugged into this terminal for testing of Voltage/ Resistance/ Diode/ Continuity/ Capacitance.

**Ω OUTPUT**: For resistance output signal simulation.

**DC Π OUTPUT**: For DC square wave signal output simulation

**+CHARGE-**: Input jacks for charging internal batteries.
NOTE:

The range is automatically selected by the meter. But, you can also select a range within a function by pressing the range button. Always select a range higher than you expect the current or voltage to be. Then select a lower range if better accuracy is needed.

*If the range is too high, the readings are less accurate.
*If the range is too low, the meter shows OL (over limit).

Push Button Functions:

SELECT Hz Button

When the meter rotary switch is switched to “CAP/Sound/Resistance/Diode”, pressing this button once every time will alternate the testing function.

AUTO Power off Disable

To disable the automatic power off function, hold down the “SELECT Hz” button while turning the meter switch from OFF to ON.

6. OPERATIONS:

6.1 AC / DC Voltage (V) Measurements:

The meter will automatically select the best Voltage (V) range. Press “SELECT Hz” button to select AC or DC.

Insert:

*Black test lead in COM input terminal.
*Red test lead in V/Ω/Hz/Cap input terminal.

Using the Black probe, touch the circuit coming from one phase of the power source. Then use the Red probe touch the circuit coming from another phase of the power source.
IMPORTANT: Voltage must be measured in parallel (Red probe measuring circuit from one live power source and the Black probe is from the other).

Accuracy
Selection of a lower range will move the decimal point one place and increase the accuracy of the reading. An OL (Over limit) display means the range is too low. Select the next higher range.

6.2 Resistance (\(\Omega\)) Ohm Measurements:

IMPORTANT:
If testing an application that has capacitors in the circuit, be sure to turn the power OFF on the test circuit and discharge all capacitors. Accurate measurement is not possible if external or residual voltage is present.

Select the resistance (\(\Omega\)) setting with the rotary switch. Set the resistance (\(\Omega\)) range with the button labeled “RANGE” if a more accurate measurement is desired.

Insert:
* Black lead in COM terminal.
* Red lead in V/\(\Omega\)/Hz/Cap terminal.

NOTE:
The resistance in the test leads can affect accuracy at the 400\(\Omega\) range.

Touch the test lead probes across the resistor to be tested and read the display value.
6.3 Audible Continuity \( \Rightarrow \) Test:

**IMPORTANT:** Turn the circuit power OFF before testing.

Select the **Audible continuity \( \Rightarrow \)** range with the rotary switch.

Press “SELECT Hz” button to select **Audible continuity**.

**Insert:**
* Black lead in **COM** terminal.
* Red lead in **V/Ω/Hz/Cap** terminal.

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

* When circuit is complete, the meter will beep.
* If the circuit is open, there is no “beep” and the display shows “OL”

6.4 Diode checks \( \Rightarrow \) Test:

**IMPORTANT:** Turn the circuit power OFF before testing.

Select the **diode Check \( \Rightarrow \)** setting with the rotary switch.

**Insert:**
* Black lead in **COM** terminal.
* Red lead in **V/Ω/Hz/Cap** terminal.

Touch the Black test probe to the negative (-) side of the diode.

Touch the Red test probes to the positive (+) side of the diode.
Reverse the probes: Black to the positive (+) side and Red to the negative (-) side.

**NOTE:**
A “good” diode will read low in one direction and high in the other direction when the probes are reversed (or vice versa).
A defective diode will have the same reading in both directions or read between 1.0 ~ 3.6V in both directions.

### 6.5 Capacitance Measurement:

**IMPORTANT:**
Disconnect the battery terminals or turn OFF the ignition switch before testing the vehicle circuit.
Discharge the capacitor by shorting its leads together. Use the DC volts function to confirm that the capacitor is fully discharged.

[Diagram of multimeter with rotary switch labeled]

Select the **CAP** range with the rotary switch.

Press “SELECT Hz” button to select **CAP**

**Insert:**
- Black lead in **COM** terminal.
- Red lead in **V/ Ω /Hz /Cap** terminal.

**NOTE:**
*Holding the capacitor with your hands may charge the capacitance in circuit and generate a false reading.*
*Residual voltage charges on the capacitor. Poor insulation resistance or poor dielectric absorption may cause measurement errors.*
6.6 Frequency (Hz) Measurement:

Select the frequency (Hz) setting with the rotary switch.

Insert:
*Black lead in COM terminal.
*Red lead in V/Ω/Hz/Cap terminal.

Connect the Black test probe to ground.

Connect the Red test probe to “signal out” Wire of the sensor to be tested.

**NOTE:**
For frequencies below 1 Hz, the display will show 0.000Hz.

6.7 Duty Cycle (%) Test:

Select the Hz/Duty range with the rotary switch.

Insert:
*Black lead in COM terminal.
*Red lead in V/Ω/Hz/Cap terminal.

Connect the Black test probe to ground.

Connect the Red test probe to the signal wire circuit.
6.8 AC or DC Current (Amp) Measurement:

Select the **10A** or **mA** range with the rotary switch.

Press the “SELECT Hz” function button to select AC or DC.

**Insert:**
*Black lead in **COM** terminal.
*Red lead in the 10A or mA terminal.

**IMPORTANT:**
Turn OFF all power to the circuit or disconnect the circuit from the power source.

**Connect:**
*The Red probe to the side of the circuit closest to the power source.
*The Black probe to the other side of the circuit.
*Turn the power ON and test not more than 10 seconds for 10 Amps.

**NOTE:**
Current must always be measured with the meter test probes connected in **series** circuit as described.

7.0 **SIMULATING THE FUNCTION OF SENSORS:**
With the unique sensor simulating function, the instrument can simulate the input signal of sensor to substitute the work of sensor to judge stand or fall of sensor during the process of automotive diagnosis using a Scanner.
7.1 The Resistance Signal simulation:

This application can simulate resistance signal within 0~5kΩ or 0~200kΩ: such as the signals of temperature sensor.

**Procedures:**

1. Refer the standard value of the sensor which needs to be simulated by referring to the maintenance manual of original car manufacturer.

2. Switch off the ignition power and disconnect sensor connector.

3. Insert the Black lead into the “Ω OUTPUT” (COM) socket of the instrument, connect its other end to the ground (using the crocodile clip or test leads).

4. Insert the Red lead into the “Ω OUTPUT” (V/Ω/Hz/Cap) socket, connect its other end with the input signal terminal of sensor (can use multi-test leads).

5. Turn the rotary switch in either direction to select a simulating function of signal 5k or 200k “Ω OUTPUT”.

6. Press to select “Output/No Output” button to “No Output”.

7. Adjust 5k or 200k volume control and set the numerical value of Ohm to standard value as described by maintenance manual.

8. Press to select “Output/No Output” button to “Output”.

9. Turn ON the ignition switch (without starting the engine).
**Hint:** Compare the changing signals of the sensor according to that of the Auto Scanner data stream.

**NOTE:**
When adjusting the 5K or 200K resistance values, press button to “No Output”. There will be no change in the resistance value if it is on “Output mode”.

10. Change the numerical value of simulating signal, then compare if the sensor data is consistent with simulating signal through Auto Scanner data stream. If it is consistent, that means there is no fault in the engine control unit (ECU).

11. Start the engine and set the simulating Resistance value according to the sensor resistance as described in the manual. If the fault of the engine disappear, obviously it means that fault exist in sensor.

**7.2 The Voltage Signal simulation:**
This application can simulate voltage signal within 0~1/ 0~5V/0~12: such as the signals of TPS /Oxygen Sensor.

**Procedures:**
1. Refer the standard value of sensor which needs to be simulated by referring to the maintenance manual of original car manufacturer.

2. Switch off the ignition power and disconnect sensor connector.

3. Insert the Black lead into the “DC Ω OUTPUT” (CHARGE -) socket of the instrument, connect its other end to the ground (using the crocodile clip).
4. Insert the Red lead into the “DC Π OUTPUT” (+ CHARGE) socket, connect its other end with the input signal terminal of sensor (can use multi-test leads).

5. Turn the rotary switch in either direction to select a simulating function of signal “DC OUTPUT”.

6. Set the rotary switch to 1V/ 5V/ 12V Voltage.

7. Select the Voltage value according to the standard sensor data as described by maintenance manual.

8. Turn ON the ignition switch (without starting the engine).

   **Hint:** Compare the signal changing of sensor according data stream of Auto Scanner.

9. Change the numerical value of simulating signal and then compare if the data of sensor is consistent with simulating signal through Scanner data stream.
   If consistent, that means there is no fault in engine control unit (ECU).

10. Start the engine and set the simulating voltage signal according to the sensor voltage value as described in the manual. If the fault of engine disappears, obviously it means that fault exist in sensor.

**7.3 The Frequency Signal simulation:**

   This application can simulate frequency signal with 0~5V, 0~12V, 10Hz~ 40 kHz and DUTY CYCLE 10~90%
Procedures:

1. Refer the standard numerical value of frequency sensor which needed to simulate by referring to the maintenance manual of the original car manufacturer.

2. Switch off the ignition power and disconnect the sensor connector.

3. Insert the Black lead into the “DC Π OUTPUT” socket of the meter, connect its other end to the ground (using the crocodile clip).

4. Insert the Red lead into the “DC Π OUTPUT” socket, connect its other end with the input signal of sensor (can use multi-test leads).

5. Turn the rotary switch in either direction to select the simulating function of signal 5V or 12V “Π OUTPUT”.

6. Adjust the “Hz Output” volume control to the Frequency according to the standard value. Then press “SELECT Hz” button to Voltage display and adjust “Value Output” volume control to the standard voltage. Next press “Hz/Duty” button to “%”. Adjust the “Duty Output” volume control to the Duty Cycle as described in the manual.

7. Turn ignition key on (without starting up the engine).
   **Hint:** Compare the changing signal of the sensor according function of Data Stream of Auto Scanner.

8. Change the numerical value of simulating signal of sensor, then compare if the data of sensor is consistent with simulating signal through Auto Scanner data stream. If consistent, that means there is no fault in engine control unit (ECU).
9 Start the engine and set the numerical value of the simulating signal to the sensor value according to the service manual. If the fault of the engine disappears obviously, that means fault exist in sensor.

7.4 The Duty Cycle Signal simulation:

This application can simulate frequency signal with 0~5V 10Hz~40 kHz and Duty Cycle: 10~90%.

**Procedures:**

1. Refer the standard numerical value of the sensor which needed to simulate from the manual of original car manufacture.

2. Switch OFF the ignition and disconnect the sensor connector.

3. Insert the Black lead into the “π OUTPUT” socket of the meter, connect the other end to the ground (using the crocodile clip).

4. Insert the Red lead into the “π OUTPUT” socket, connect the other end with the input signal of sensor (can use multi-test leads)

5. Set the rotary switch to 5V or 12V (π OUTPUT). Adjust the numerical value of voltage to standard data as described in the service manual by pressing “SELECT Hz” button and adjust “Value Output” volume control.

6. Then press “SELECT Hz” button again to “Hz” display. Press “Hz/Duty” button and select “%” adjust the “Duty Output” volume control to the standard value and then select “Hz” by pressing “Hz/Duty” button again. Adjust the “Hz Output” volume control to the standard value mentioned in the manual.

**Caution:**

Always adjust Duty Cycle signal first and then follow by the Frequency. If the standard numerical value of the Duty Cycle is unknown, then set the Duty Cycle to 50%.
7. Turn ignition key on (without starting engine).
   **Hint:** Compare the signal changing of sensor according to the Scanner data stream.

8. Change the numerical value of simulating signal and then compare if the data of sensor is consistent with simulating signal through Scanner data stream. If consistent, that means there is no fault in engine control unit (ECU).

9. Start the engine and set the numerical value of simulating signal according to the standard sensor value. If the fault of engine disappear obviously, that means fault exist in sensor.

### 8.0 MAINTENANCE

1. This multi-meter is a precision instrument. Do not drop or tamper with the circuitry to avoid damage.
   
   ➢ Never connect to a voltage source when the meter is set to resistance measurement.
   
   ➢ Never operate the meter unless the cover is in place and fully closed.
   
   ➢ Battery replacement should be done after the test leads have been disconnected and POWER IS OFF.

2. Turn OFF the power if the meter is not in use, removed the battery if the meter is to be kept away for a long period.

3. If a sign “?” appear on the display, open the compartment cover, remove the weak battery and replace it with a new battery of the same type.

4. Contact your supplier for assistance if you have problem with the multi-meter.
9.0 BASIC DIAGNOSTIC TESTING
This chapter leads you through a systematic series of tests that check the vehicle electrical system. These tests should be performed before testing individual components.

9.1 Electrical System Diagnostics
It is important to diagnose a vehicle electrical problem thoroughly and efficiently.

The series of tests that follow check primary areas that are responsible for the majority of the electrical problems found in an automobile.

Perform these basic tests, even if a vehicle has a trouble code set in the computer. A component malfunction detected by the computer can be caused by a basic ground problem in the electrical system.

Simply replacing a failed component will not fix the problem if a poor ground caused the component failure.

The 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. An excessive voltage ground in a circuit effects the entire electrical circuit.

This is why it is important to make sure the basic circuits are in good shape before checking trouble codes and components.
9.2 Battery Testing

[1]Battery Test (Surface Discharge)

NOTE:
* Remove the positive and negative battery cables and thoroughly clean the cable terminals and the battery posts. Reassemble and begin testing.

*The ignition switch must be OFF to prevent damaging the vehicle computer when connecting or disconnecting battery cables.

This test checks for a low current discharge across the battery case.

* Set the rotary switch to voltage.
* Connect the negative (-) lead to the negative battery post.
* Set the Min/Max feature on the meter.
* Touch the positive (+) lead to the battery case around the Positive (+) battery post, Do not touch the post.

A reading of more than 0.5V indicates excessive surface discharge. Dirt, moisture and corrosion are a cause of surface discharge.

Clean the battery with a baking soda and water solution.

Do not allow the solution to get into the battery.
[2] **Static Battery Test (No Load)**

This test checks for battery change state.

Turn the headlights on for 15 seconds to dissipate battery surface charge.

**IMPORTANT:** The ignition switch must be OFF when connecting or disconnecting battery cables to prevent damaging the vehicle computer.

- Disconnect the negative (-) battery terminal.
- Set the rotary switch to voltage.
- Connect the positive (+) lead to the positive (+) battery post.
- Connect the negative (-) lead to the negative (-) battery post.

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

**NO LOAD TEST**

<table>
<thead>
<tr>
<th>Meter Reading</th>
<th>Battery Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.6V</td>
<td>100%</td>
</tr>
</tbody>
</table>

Ampere draw should not exceed 100mA.

If there excessive draw, remove the circuit fuse, one at a time, until the excessive draw is located. Also check the non-fused applications such as head lights, relays, ecu and capacitors in the instrument panel.

Reconnect the battery cable for the next test.
<table>
<thead>
<tr>
<th>Voltage</th>
<th>Battery Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.4V</td>
<td>75%</td>
</tr>
<tr>
<td>12.2V</td>
<td>50%</td>
</tr>
<tr>
<td>12.0V</td>
<td>25%</td>
</tr>
</tbody>
</table>

**NOTE:**
Leave the battery cable unhooked and proceed to the test on the following page.


This is for excessive load drain on the battery.
- Turn the ignition switch and all accessories OFF.

**IMPORTANT:**
**Do not start the vehicle during this test; may result in meter damage.**

- Set the rotary switch to 10A.
- Insert the positive (+) lead into the 10A meter terminal.
- Disconnect the battery positive (+) cable.
- Connect the positive (+) lead to the positive (+) battery terminal.
- Connect the negative (-) lead to the Disconnect positive (+) battery terminal.
- Set the Min/Max feature on the meter.
- Refer to the readings displayed.

### [4] Battery Test (Load)

This tests the battery’s capacity to deliver sufficient cranking voltage.
- Set the rotary switch to **Voltage**.
- Connect the positive (+) lead to positive (+) battery terminal.
- Connect the negative (-) lead to negative (-) battery terminal.
- Set the Min/Max feature on the meter.
Sensor Signal Simulation Multi-meter

- Disable the ignition and crank the engine for 15 seconds.
- Check the Min. display.

A reading of less than 9.60V@70°F for 21°C indicates a weak battery. Recharge or replace battery before testing.

**Voltage Load Test**

<table>
<thead>
<tr>
<th>Meter reading</th>
<th>Battery/air temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.0V</td>
<td>90°F/33°C</td>
</tr>
<tr>
<td>9.8V</td>
<td>80°F/27°C</td>
</tr>
<tr>
<td>9.6V</td>
<td>70°F/21°C</td>
</tr>
<tr>
<td>9.4V</td>
<td>60°F/16°C</td>
</tr>
<tr>
<td>9.2V</td>
<td>50°F/10°C</td>
</tr>
<tr>
<td>9.0V</td>
<td>40°F/4°C</td>
</tr>
<tr>
<td>8.8V</td>
<td>30°F/-1°C</td>
</tr>
<tr>
<td>8.6V</td>
<td>20°F/-7°C</td>
</tr>
</tbody>
</table>

**NOTE:**
- For each 10°F above or below 70°F, add or subtract 0.2 volt.
- Battery temperature can be checked with the meter temperature probe.
What is Resistance?

Resistance is an opposing force, created by a circuit or component, to the flow of electrical current.

There is a small amount of natural resistance when voltage flows though wires, switches, grounds or connections.

The resistance increases beyond acceptable limits if corrosion develops, fittings become loose or wires corrode.

Resistance increases each time something, such as wire, a switch, connections, or the ground are added in the circuit.

What is Voltage Drop?

Voltage drop is the difference in voltage potential when measured across a circuit or component creating resistance.

The resistance decreases the amount of voltage available.

The bulb will not light or the motor will not turn if the voltage is too low.

Maximum Voltage Drop

| Maximum voltage drop should not be more than 0.1 volt per wire, ground, connection, switch or solenoid. |

What should be tested?

Each wire, ground, connection, switch solenoid and the complete circuit should be tested. Each connection point is a potential source of increased resistance.
9.3 Voltage Drop Testing

[1] Negative (-) Engine Ground

This test checks for engine ground efficiency.

- Set the rotary switch to **Voltage**.

- Touch the positive (+) lead to the positive (+) battery post and the negative (-) lead to the negative (-) battery post. Note the reading. This will be the base voltage to compare your test voltage reading against.

- Connect the positive (+) lead to a clean spot on the engine block.

- Connect the negative (-) lead to the negative battery post.

- Set the Min/Max feature on the meter.

- Disable the ignition so the engine does not start.

- Crank the engine for 2-3 seconds.

A voltage drop of more than 0.5 volts would indicate a poor ground circuit.

Clean and inspect the battery cable connections, ground connection and test again.

**Important:**

Repeat this test when the engine is thoroughly warmed up. Heat expansion of metal may cause resistance to increase.
[2] **Negative (-) Chassis Ground**

This test checks for chassis ground efficiency.

- Set the rotary switch to **Voltage**.
- Establish the base voltage that you will compare test voltage against (see base voltage, Volt Drop Test [1] ).
- Connect the positive (+) lead to the point on the fender, fire wall or vehicle frame where the accessory ground is fastened.
- Connect the negative (-) lead to the negative battery terminal.
- Set the Min/Max on the meter.
- Turn ON all the accessories (high beams, A/C fan- high , rear window defroster, windshield wipers , etc.).
- Disable the ignition so the engine doesn't start.
- Crank the engine for 2-3 seconds.

A voltage drop of more than 0.5 volts would indicate a poor ground circuit.

Clean and inspect the battery cable connections and the ground; test again.

[3] **Battery Power to Starter Solenoid (+)**

This test checks battery source efficiency to the starter solenoid.

- Set the rotary switch to **Voltage**.
- Establish the base voltage that you will compare test voltage against (see base voltage, Volt Drop Test [1] ).
- Connect the positive (+) lead to the positive (+) battery terminal.
- Connect the negative (-) lead to the positive (+) terminal on the starter solenoid.
• Set the Min/Max feature on the meter.
• Disable the ignition so the engine doesn’t start; Crank the engine for 2-3 seconds.

A voltage drop of more than 0.3 volts would indicate a poor ground circuit.

Clean and inspect the battery cables and cable connections; test again.

**Important:**
Repeat this test when the engine is thoroughly warmed up. Heat expansion of metal may cause resistance to increase.

[4] **Battery Power to Complete Starter Circuit (+)**
This test checks battery power efficiency to the starter through the starter solenoid.

• Set the rotary switch to **Voltage**.
• Establish the base voltage that you will compare test voltage against (see base voltage, Volt Drop Test [1]).
• Connect the positive (+) lead to the positive (+) battery terminal.
• Connect the negative (-) lead to the positive (+) terminal on the starter motor.
• Set the Min/Max on the meter.
• Disable the ignition so the engine doesn’t start; crank the engine for 2-3 seconds.

The example shown has 4 connectors and 2 wires, and 2 solenoid connections. A voltage drop of more than 0.8 volts would indicate a poor ground circuit.

Clean and inspect the battery and starter cables, solenoid and cable connections; test again.

**Note:**
A defective starter solenoid may cause an excessive voltage drop; check the cables and connections before replacing the solenoid.
9.4 Charging System Tests

[1] Battery (+)
This test checks for alternator output voltage at the battery.

- Set the rotary switch to **Voltage**.
- Connect the positive (+) lead to the positive (+) battery terminal.
- Connect the negative (-) lead to the negative (-) battery terminal.
- Set the Min/Max feature on the meter.
- Mark sure all vehicle accessories are turned OFF.

Start the engine and hold at 1500RPM.

A reading of 13.1~15.5 Volts is an acceptable charging rate, If the voltage is low check for:

- Loose, cracked, or glazed drive belt.
- Loose or faulty wires or connectors.

[2] Alternator Voltage Output (+), Load
This test checks for alternator output voltage. This test is necessary only if the vehicle failed [1] Battery (+) test.

- Set the rotary switch to the Voltage setting.
- Connect the positive (+) lead to the battery (B+) output post on the back of the alternator.
- Connect the negative (-) lead to the negative (-) battery terminal.
- Set the Min/Max feature on the meter.
- Start the engine and hold a 1500RPM.

A reading of 13.1~15.5 Volts is an acceptable Charging rate.
9.5 Ignition System Tests

[1] Ignition Coil, Primary Resistance Test (Ω)
This test the ignition coil primary windings resistance.

**IMPORTANT:** Test the ignition coil cold and hot.

Set the rotary switch to the Resistance (Ω) setting.

**INSERT:**
Black lead in COM terminal.
Red lead in V/Ω/Hz/Cap Terminal.

- Disconnect the coil from the vehicle wiring harness.

**NOTE:**
The resistance in the meter leads must be subtracted to an accurate measurement at the 0.50-2.0Ω range.

- Connect the negative (-) lead to the negative (-) terminal on the coil.
- Connect the positive (+) lead to the positive (B+) terminal on the coil.

Typical measurements are between 0.50~2.0Ω. Consult the manufacturer’s specifications for required resistance measurements.

[2] Ignition Coil, Secondary Resistance Test (Ω)
This test checks the ignition coil secondary winding resistance.

**IMPORTANT:** Test the ignition coil cold and hot.

- Set the rotary switch to the Resistance (Ω) setting.
- **INSERT:** Black lead in COM terminal. Red lead in V/Ω Hz/Cap terminal.
- Disconnect the coil from the vehicle wiring harness.
- Connect the negative (-) lead to the high tension terminal on the coil.
- Connect the positive (+) lead to the positive (B+) terminal on the coil.

Typical measurements are between $6\,\text{K}\,\Omega \sim 30\,\text{K}\,\Omega$. Consult the manufacturer’s specifications for required resistance measurements.

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

**IMPORTANT:**
Twist and bend the sparkplug wire while measuring the resistance for this test.

Set the rotary switch to the Resistance (Ω) setting.

**INSERT:**
Black lead in COM terminal.
Red lead in V/Ω/Hz/Cap terminal.
Connect the test probes to opposite ends of the sparkplug wire.

Set the Min/Max feature the meter.

Typical measurements are approximately $1.000\,\Omega\,(1\,\text{K}\,\Omega)$ per inch of wire. For example, 10 inch cable=$10.000\,\Omega\,(10\,\text{K}\,\Omega)$.

This test checks for open circuits or high resistance in the distributor cap and rotor.

- Set the rotary switch to the Resistance (Ω).
- **INSERT:** Black lead in COM terminal. Red lead in V/Ω/Hz/Cap terminal.
[5] **Distributor Cap Center Connector Test:**
Connect the test probes to opposite ends of the distributor cap terminal.

In general, resistance (Ω) should be 5kΩ ~ 10kΩ. Refer to the manufacturer’s specifications.

[6] **Rotor Test:**
Connect the test probes to opposite ends of the rotor contacts.
In general, resistance should be 0.1(Ω) or less. Refer to the Manufacturer’s specifications.

[7] **Pick-up Coil Resistance (Ω)/Voltage Test (V)**
- The Resistance test checks for open circuits or high resistance.
- The Voltage test compares voltage output to resistance.

**Test Procedure**

- Set the rotary switch to the **Resistance(Ω)**.
  
  **INSERT:**
  - Black lead in **COM** terminal.
  - Red lead in **V/Ω/Hz/Cap** terminal.
  - Connect the test probes to the pick-up coil lead.
  - Read the displayed readings.

[8] **Resistance Specifications**
The majority of the pick-up coils will test between 500-1500 Ω’s resistances. See manufacture’s specification for required range.

- Set rotary switch to **Volts**. Press the “SELECT Hz” button to select **AC**.
- Crank engine 10-15 seconds at normal speed; measure voltage.
10.0 RESISTANCE TEST/VOLTAGE OUTPUT

Resistance (Ω) on a “good” pickup coil will match AC output voltage (Ex., 950Ω’s=950mV output). Resistance can be good but voltage low if the magnet has lost magnetism or if the reflector is too far from the stator (Air gap).

[1] Hall Effect Sensor Voltage Test (V)
This test checks for switching action in any Hall Effect sensor (Ignition, RPM, Crankshaft, etc.)

- Set the rotary switch to the Voltage (V) position.
  **INSERT:**
  - Black lead in COM terminal.
  - Red lead in V/Ω/Hz/Cap terminal.
  - Set the Min/Max feature on the meter.
  - Connect the Black test probe to the negative (-) post on the battery.
  - Turn the ignition key ON. Touch the Red (+) test probe to the three test point shown.
  - Ground reading should be the same voltage as the ground (Computer or battery).
  - Supply line reading should be the same voltage as the input source (Computer or battery).

**Signal line** reading should be 0 or the same voltage as the input source (Computer or battery). The reading will toggle high and low as the shutter rotates.

11.0 BASIC DIAGNOSTIC TESTING

This chapter describes a computer controlled sensor and actuator system typically found on today’s automobile.
Test procedures are also provided for the basic ground of electrical input and output components commonly found in a computer controlled automotive system.

The test procedures are general theory tests due to the complexity of components. Be sure to consult the vehicle service manual for component schematics and test specifications.

12.0 COMPUTER CONTROLLED SYSTEMS

A need for better fuel economy and lower emissions resulted in today’s automobiles utilizing computer controlled functions that were previously activated by Mechanical, Electrical and Vacuum devices. Computerized vehicle control systems are made up of three basic component groups. These groups are:

1. **Sensors:**
   They are input devices that supply information about engine operating conditions and the surrounding environment to the vehicle computer.

2. **Engine Control Module:**
   A vehicle computer that processes the information supplied by the sensors then sends an electronic command to the appropriate components actuators.

3. **Actuators:**
   These are output devices that may be electrical, mechanical or vacuum components controlled by the vehicle computer.
13.0 BASIC COMPUTER CONTROLLED ENGINE DIAGNOSTICS

There are two important steps that must always be followed when diagnosing and repairing vehicles with computer controls.

- Perform basic engine diagnostics first. Many problems can be traced to lack of routine maintenance on components such as plug wires, filters and spark plugs. Also check for vacuum leaks on any vehicle whether new or old.

A complete engine diagnosis should precede any electrical system diagnostics.

- Follow exactly the described diagnostic procedures in the service manual to perform repair on the computer component.
14.0 SELF-DIAGNOSTIC COMPUTER SYSTEMS

One of the functions of the vehicle computer is to record fault codes produced when a sensor or actuator fails. These failures are usually displayed as a “Current Code” or as an “Intermittent Failures”.

Be aware, however, that some vehicle manufacturers use different terminology and older vehicles do not have all of ground of codes described.

**Current Codes** are faults that are active.

- **Hard Failure** causes the dash “check engine” light to remain ON.
- **Intermittent Failure** causes the dash “check engine” light to flicker and then go OFF after a short period of time.

Generally the trouble code stays in the computer memory.

**History Codes** are stored codes for faults that have occurred in the past.

**Failure Codes**

When a failure is detected by the computer, it stores the information in the form of “Fault Codes” (also known as Trouble Codes or Service Codes).

These Fault Codes are usually a two or three digit number that identifies the electrical circuit affected.

Once these codes have been read the vehicle repair can be started. Be sure to follow closely the vehicle service manual, diagnostic procedures, repairs and specifications.
15.0 COMPONENT TESTING

Component testing with a meter generally requires detailed schematics and specifications that are provided by the car manufacturer.

The following section provides general information for the main groups of sensors (input) devices and actuators (output) devices.

The primary input devices (sensors) are:

- Temperature sensors
- 2-wire devices
- 3-wire devices
- Oxygen sensor
- Pressure sensors

Primary output devices (actuators) are a form of an electromagnet that is either ON or OFF.

The ON/OFF signal, in general, will be in one of three configurations:

- ON of OFF only (switch).
- Pulse width in a specified length of time (fuel injector).
- Duty cycle measured in percent of high or low time or dwell degrees (mixture control solenoid).
What is Duty Cycle?

Duty cycle is the **percentage (%) of time** a voltage is positive compared to negative: ON compared to OFF. For example; Duty Cycle measurements are used for Mixture control solenoids. The amount of ON time is measured as a percent of the total ON/OFF cycle. The meter can read the negative (-) or positive (+) slope and display it as a percent (%) of the total cycle.

What is Frequency (Hz)?

Frequency is the number of times a voltage cycle repeats positive compared to negative: ON compared to OFF, during one (1) second of time.

For example:
Frequency (Hz) measurements are specified for digitally controlled manifold Absolute Pressure sensors.
The frequency of the ON/OFF signals per second are measured and displayed.

Frequency (Hz) is shown as:

**Analog:** A continuous positive to negative cycle.
**Digital:** A positive to negative (ON to OFF) cycle.
What is Pulse Width?

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. 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).

Throttle Body Injection fuel injectors (TBI) operate with a single ON or OFF electrical pulse.

![Diagram of pulse width measurement](image)

This method creates a double electrical “spike”. An oscilloscope is required to measure this type of pulse.

16.0 COMPONENT TESTS (INPUT)

[1] **Temperature Tests**

Many components that regulate temperature can be tested by measuring the surface temperature of the area surrounding the component.
• Connect the temperature probe to the meter.
• Set the rotary switch to the **Temperature** position.
• Set the Min/Max feature on the meter.
• Touch the end of the temperature probe directly to the surface of the component to be tested.

Compare the readings with the manufacturer manual.

**Specifications:**

The temperature should be within $±10°F (±5°C)$ of the data stream values.

Some of the components that can be tested for Temperature variation are:

- Radiators
- Transmission
- Heaters
- A/C Condensers
- A/C Evaporators
- Engine Coolant Sensors
- Air Temperature Sensors

**[2] Thermistor (Variable Resistance, 2-wire) Tests**

Thermistors are variable resistors that are sensitive to temperature level changes. As the temperature changes, the thermistor's resistance value changes.

- Select the **Ohms** ($\Omega$) range the rotary switch.
- Connect the test probes to the sensor terminals.

The Ohms reading should match the temperature of the sensor (see manufacturer’s specifications).

Typical thermistor applications are:

- Engine Coolant Temp. (ECT)
- Air Charge Temp. (ACT)
- Manifold Air Temp. (MAT)
- Vane Air Temp. (VAT)
- Throttle Body Temp. (TBT)
A. Voltage Presence Test

- Disconnect the vehicle wiring harness at the sensor.
- Select the Voltage range with the rotary switch.
- Insert Black lead in COM terminal.
- Insert Red lead in V/Ω/Hz/Cap terminal.
- Connect the test probes in parallel:
  - Positive (+) to the circuit coming from the power source,
  - Negative (-) to the negative circuit from the sensor.
- Turn the ignition switch ON; do not start the engine.

Measurement should be 5~9 Volts (check the manufacturer’s specifications).

B. Voltage Change Test

Connect jumper wires between the connector and the sensor.
- Connect the test probes in parallel:
  - Positive (+) to the circuit coming from the power source,
  - Negative (-) to the Negative circuit from the sensor.
- Start the engine.
- Set the Min/Max feature on the meter.

The voltage should change as the temperature changes. This is the signal that is sent to the computer for processing. Refer to the manufacturer’s specifications. If the voltage change is not within specifications, look for sources of resistance due to poor connectors, connections or breaks in the wiring.

The potentiometer is a variable resistor. The signal it generates is used by the vehicle computer to determine position and direction of movement of a device within the component.

A. Resistance Test

- Set the rotary switch to the Resistance (Ω) setting.
- Disconnect the sensor.
- Connect the test probes to the signal line and to the ground (refer to manufacturer’s schematic).
- Set the Min/Max feature on the meter.

Watch the reading display. The Ohms reading should change as the signal arm on the potentiometer is move (signal sweep).

Typical potentiometer applications are:

- Throttle Position Sensor (TPS)
- Exhaust Gas Recirculation Valve position Sensor (EGR)
- Volumetric Air Flow Sensor (VAF) or MAF

B. Reference Voltage Test

- Disconnect the vehicle wiring harness at the sensor.
- Select the Voltage range with the rotary switch.
- Insert Black lead in COM terminal.
- Insert Red lead in V/Ω/Hz/Cap terminal.
- Connect the test probes in parallel:
  - Positive (+) to the computer reference voltage circuit,
  - Negative (-) to the negative system ground circuit from the sensor.
- Turn the ignition switch ON. Do not start the engine.

Watch the reading display. Reading should be 5~9 volts (check the manufacturer’s specifications).
C. **Voltage Change Test**

- Connect jumper wires between the connector and the sensor.
- Connect the test probe in parallel:
  - Positive (+) to the signal line, Negative (-) to the ground circuit.
- Turn the ignition key ON, do not start the engine.
- Set the Min/Max feature on the meter.
- Observe the display reading.

The voltage should change as the position of the signal on the potentiometer moves (signal sweep). Refer to the manufacturer’s specifications.

If the voltage change is not within specifications, look for sources of resistance due to poor connectors, connections or breaks in the wiring.

[4] **Oxygen Sensor (02) Test**

The Oxygen sensor samples the amount of Oxygen in the exhaust system. The voltage produced by the 02 sensor is in direct proportion to the oxygen level in the exhaust stream. This voltage is used by the computer to change the air/fuel mixture.

This test will check oxygen sensor signal output levels.

- Disconnect the vehicle wiring harness at the sensor. Install a jumper wire.
- Select the voltage range with the rotary switch.
- Insert Black lead in COM terminal.
- Insert Red lead in V/Ω/Hz/Cap terminal.
- Connect the test probes in parallel:
  - Positive lead (+) to the jumper wire and Negative lead (-) to the engine ground.
- Set the Min/Max feature on the meter.
- Vehicle engine must be running at operating temperature (fast idle at 2000RPM for two minutes).

Voltage readings should move between 0.2V (lean) and 0.8V (rich). The average DC voltage should be around 0.50V.
[5] **Pressure sensor Test**

The electrical tests for pressure sensor such as the Manifold Absolute Pressure (MAP) and Barometric Pressure (BARO) vary greatly depending upon the type and manufacturer. Consult the vehicle service manual for the schematic, specifications and test procedures.

**17.0 GENERAL TESTING PROCEDURES**

**Note:** Do not perform a resistance (Ω) test on pressure sensor.

**Analog Sensor**

An analog sensor can be tested with the same procedure in voltage (V) tests suggested for 3-wire potentiometer voltage tests.

In place of “sweeping” the sensor, a vacuum pump is generally used to vary the pressure on the sensor. In all cases, refer to a vehicle service manual for the correct procedure.

**18.0 COMPONENT TEST (OUTPUT)**

**Output Devices**

The electrical tests for output devices vary greatly, depending upon type and manufacturer. Consult the vehicle service manual for the schematic, specifications and test procedures.

Primary output devices (actuators) are in the form of electromagnet that is either ON/OFF.
The ON/OFF signal, in general, will be in one of three configurations:

- **ON/OFF only (switch)**
  Perform continuity check with the switch in the ON and OFF position.

- **Pulse width (fuel injector)**
  Measure the ON time (Pulse) in mS.

- **Duty cycle (Mixture Control Solenoid)**
  Measure the percentage of High (+) or Low (-) Time in Duty Cycle mode. In most cases the Low (-) Time is the ON all the time.

### 19.0 MAINTENANCE:

#### Fuse and Battery Replacement

⚠️ **WARNING:**

- To avoid electrical shock, remove test leads before opening case.

- Do not operate the meter or rotate the meter switch when the case is open.

1. To replace a battery or fuse, loosen the three screws at the back cover and remove the cover by lifting it up and forward.

- The battery should be 9V Normal or Rechargeable type.

2. To replace fuse, firmly grasp the printed circuit board (PC boards by the edges and lift the fuse up and out of the holder.
IMPORTANT:

- To prevent contamination of the circuits, handling must be clean and hold the printed circuit board by the edges.
- Replace the fuse with the same type and ratings.
  - © 20A is a F20A, 500V high energy, fast acting fuse.
  - © mA is a F500mA, 250v high energy, fast acting fuse.
- Be sure the replaced fuse is firmly secured in the center in the fuse holder.

3. Carefully place the PC boards back into the casing and reassemble the case cover with the three screws.

20.0 TROUBLE SHOOTING GUIDE

1. Meter will not turn ON.
   - Check the battery contacts for a tightly fit.
   - Check for a minimum battery voltage of 8.0 volts. If not, replace battery.
   - Mark sure the battery wire, are not pinched in the case cover.

2. Ampere reading is erratic or there is no reading at all.
   - Disassemble the meter back cover and test the fuses for continuity.

3. Meter reading is erratic.
   - Printed circuit board contaminated with dirt from handling. Wipe with clean cloth.
   - Low battery voltage. Replace battery.
   - Open circuit in a test lead (frayed or broken wire).
   - Wrong range selected.
   - For frequencies below 1Hz, the display will show 00.00Hz.
   - “Blown” fuse. Replace Fuse.

4. Meter reading does not change.
   - “Hold” feature is still toggled ON. Press “Hold” again to release.