DURST MM-78B

AUTOMOTIVE MULTIMETER | CAT III 1000V | CAT IV 600V

Instruction Manual

Complete step-by-step electrical systems troubleshooting guide included



Built for EV. Ready for anything.

Read and keep this manual before using the meter.

Designed by Durst Industries Australia

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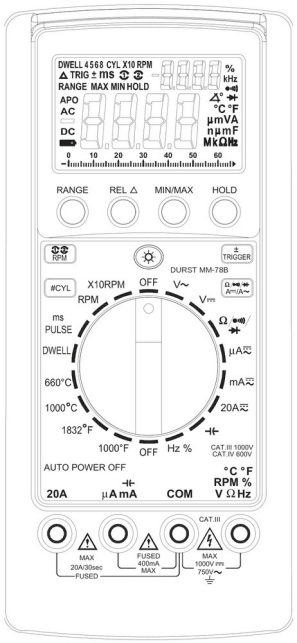
Introduction

The DURST MM-78B is a professional automotive multimeter built for the modern workshop, from conventional engines to electric and hybrid vehicles.

CAT III 1000V. CAT IV 600V. Built for EV and hybrid work.

Safety rated CAT III 1000V and CAT IV 600V to IEC 61010-1, the MM-78B measures up to 1000V DC and 750V AC, giving technicians a confident safety margin on high-voltage vehicle systems. It is suitable for EV and hybrid vehicle work and is used in EV training at technical colleges, including TAFE.

- **Suitable for EV and hybrid vehicles.** Rated CAT III 1000V and CAT IV 600V to IEC 61010-1, Class II double insulated.
- **Engine diagnostics.** RPM, dwell angle, injector pulse width and duty cycle.
- **Full multimeter functions.** Autoranging voltage, AC/DC current to 20A through fused inputs, resistance, capacitance, frequency, diode and continuity testing.
- **K-type temperature** from -20°C to 1000°C.
- **6600-count display** with a 66-segment analogue bar graph, plus MIN/MAX, relative (REL) and data hold.
- **Step-by-step troubleshooting guide.** Systematic battery, voltage drop, starter, charging, ignition and sensor tests.



This chapter covers introductory information and safety precautions.

About this manual

This manual shows you how to use the meter to perform diagnostic tests and to find the likely location of vehicle faults. It does not cover how to correct those faults: for repair procedures, refer to the vehicle service manual. Information, illustrations and specifications are based on the latest information available at the time of publication, and Durst may update them at any time as the product is improved.

Chapter	What it covers
Introduction	About this manual, safety, symbols and safety ratings
Getting started	Meter basics, push-button functions, meter functions, maintenance and troubleshooting
Basic diagnostic testing	Battery, voltage drop, starter motor, charging system and ignition system tests
Basic component testing	Computer controlled systems, input component tests and output component tests
Specifications	General and electrical specifications
Support and warranty	Contact details, warranty and service record

In the box



- DURST MM-78B automotive multimeter
- Red and black test leads with probe tips
- Inductive RPM pickup
- Protective holster
- This instruction manual with step-by-step troubleshooting guide

TIP: For currents above 20A, pair the MM-78B with the DURST MM-CA1000 1000A Clamp Meter (sold separately).

Safety

The MM-78B is built to a high safety standard. Use it correctly and it will serve you safely for years.

Safety rating and standards

Item	Rating
Safety standard	Conforms to IEC 61010-1 (EN 61010-1)
Measurement category	CAT III 1000V, CAT IV 600V
Insulation	Class II (double insulated)
Pollution degree	Pollution degree 2, indoor use
CAT III	For measurements performed in the building installation
EMC	Conforms to EN 61326-1

EV and hybrid vehicles

The MM-78B is suitable for diagnostic work on electric and hybrid vehicle systems. Always follow the vehicle manufacturer's high-voltage safety procedures and keep within the meter's input limits.

Symbols on the meter

The symbols used on this instrument are:

Symbol	Meaning
	Dangerous voltage
	Caution, refer to accompanying documents
	Equipment protected throughout by double insulation (Class II)
	Alternating current (AC)
	Direct current (DC)
	Ground

Vehicle and workshop safety

DANGER	Precaution
	Engines produce carbon monoxide, which is odourless, slows reaction time and can lead to serious injury. When the engine is running, keep service areas well ventilated or connect the vehicle exhaust to the workshop exhaust extraction system.

DANGER	Precaution
	Apply the handbrake and chock the wheels before testing or repairing the vehicle. This is especially important on front-wheel drive vehicles, where the handbrake does not hold the drive wheels.
	Wear eye protection when testing or repairing vehicles.
	Exceeding the limits of this meter is dangerous and can cause serious or fatal injury. Read and understand the cautions and specification limits in this manual.

Electrical safety

DANGER	Avoid electric shock
	Do not touch the test lead tips or the circuit being tested.

DANGER

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

Take care when measuring voltages above 25V AC or DC.

The circuit being tested must be protected by a 20A fuse or circuit breaker.

Do not use the meter if it has been damaged. Do not use test leads with damaged insulation or exposed metal.

Use a current clamp for circuits above 20A.

Never measure voltage with a test lead in the 20A or µA/mA terminal.

Good measurement practice

- When testing for the presence of voltage or current, confirm the meter is working by measuring a known voltage or current before accepting a zero reading.
- Choose the correct function and range. Do not attempt voltage or current measurements that may exceed the ratings marked on the rotary switch or terminals.
- When measuring current, connect the meter in series with the load.
- Connect only one set of test leads to the meter.
- Disconnect the live test lead before disconnecting the common test lead.
- The µA/mA and 20A terminals are fuse protected. Use them only on circuits limited to 400mA (µA/mA terminal) or 20A for 30 seconds (20A terminal). See Fuse and battery replacement.

Accuracy and care

- Replace the battery as soon as the low battery symbol appears, to keep the meter accurate.
- Keep the meter away from spark plug and coil leads to avoid interference.
- Disconnect the test leads from the test points before changing functions.
- Measure resistance only with no power applied to the circuit. The meter is protected to 600V.

Input limits

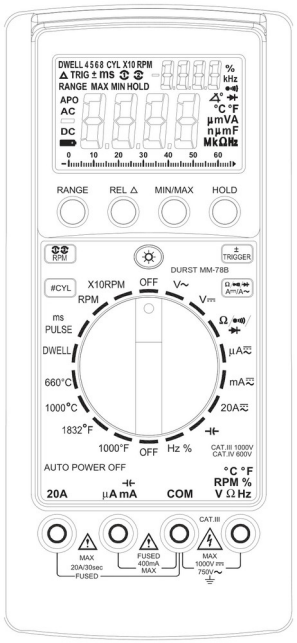
Function	Terminal	Input limit
AC volts	V/Ω/RPM	750V AC rms
DC volts	V/Ω/RPM	1000V DC
Frequency, resistance, diode, capacitance	V/Ω/RPM or µA/mA	600V AC/DC
AC/DC µA, mA	µA/mA	400mA AC/DC
AC/DC 20A	20A	20A AC/DC, 30 seconds maximum
RPM, duty cycle (%), dwell angle, ms pulse width	V/Ω/RPM	600V AC/DC

Getting started

This chapter will help you get started. It describes the basic functions of the meter.

Use this chapter to become familiar with the display, the push buttons and the rotary switch, and to learn each measurement function step by step.

- Meter basics and the digital display
- Function and range selection
- Push-button functions
- Meter functions, from voltage to current
- Maintenance and troubleshooting



Meter basics

1. Digital display. Display features: (a) four-character digital display; (b) symbols to identify the function. The digital display is best for stable inputs.

2. Function buttons. Press a button to select a function. A symbol on the display confirms your choice.

3. Rotary selector switch. Turn the switch to select a function, or to turn the meter OFF.

4. Test lead terminals. The black (-) test lead goes in the COM terminal for all tests. The red (+) test lead is used to measure amps or volts.

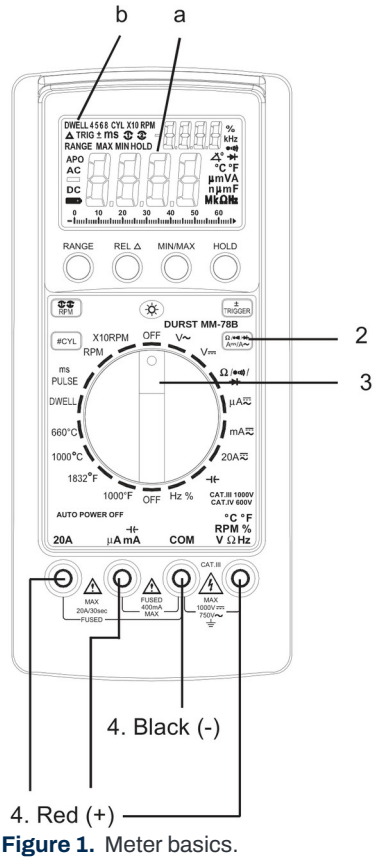


Figure 1. Meter basics.

Digital display

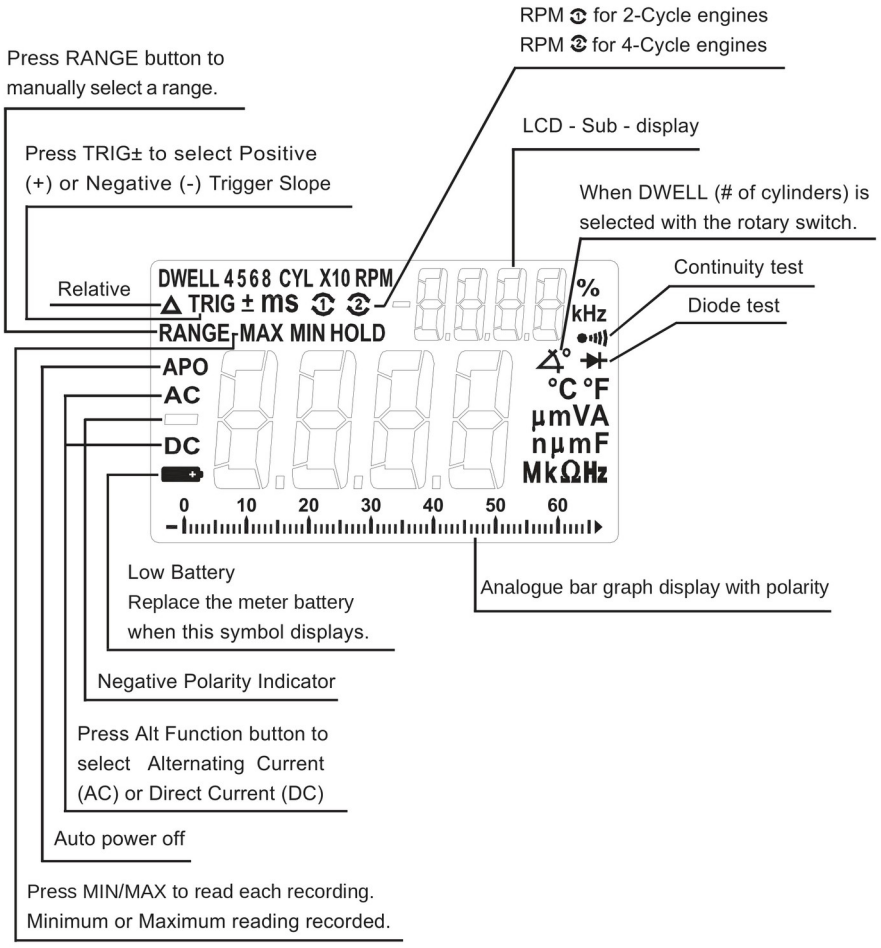


Figure 2. Digital display indicators.

Indicator	Meaning
RPM (2-cycle) / RPM (4-cycle)	RPM mode for 2-cycle or 4-cycle engines
RANGE	Press RANGE to select a range manually
Sub-display	Second reading (reference, MIN/MAX, duty cycle and frequency readings)
TRIG ±	Positive (+) or negative (-) trigger slope selected
Cylinder number	Shown when DWELL is selected with the rotary switch
Continuity / diode symbols	Continuity test or diode test selected
REL Δ	Relative mode on
Analogue bar graph	66-segment bar graph with polarity
Low battery	Replace the meter battery when this symbol appears
Minus sign	Negative polarity
AC / DC	Alternating or direct current, selected with the Alternate Function button
Auto power off	Auto power off is active
MIN / MAX	Minimum or maximum recorded reading. Press MIN/MAX to read each recording

Units of measure: dwell degrees (°), duty percent (%), milli (m = 1/1,000), volts (V), mega (M = 1,000,000), kilo (k = 1,000), ohms (Ω), hertz (Hz), nano (n), micro (µ), farads (F), multiplied by 10 (x10), revolutions per minute (RPM).

Function and range selection

Turn the rotary switch in either direction to select a function. The meter selects the range automatically, and you can also select a range within a function by pressing the RANGE button.

Always select a range higher than the current or voltage you expect, then select a lower range if you need better accuracy.

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

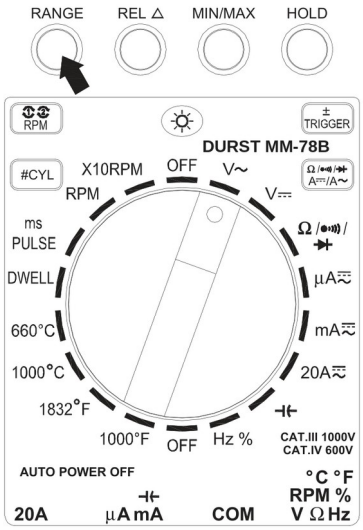
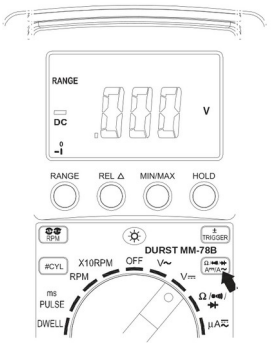


Figure 3. Function and range selection.

Push-button functions

Alternate Function button

Press the Alternate Function button to toggle between DC and AC for voltage and current measurements. With the rotary switch on the resistance, continuity and diode position, press it to toggle between resistance, audible continuity and diode modes.



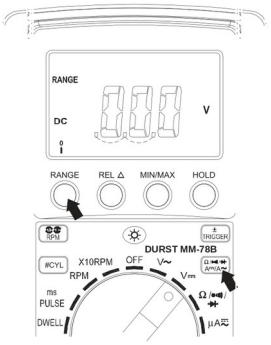
Range select

The meter selects the range automatically. You can also select a range within a function manually by pressing the RANGE button.

Range exit

To exit RANGE mode and return to autoranging, press and hold the RANGE button for 2 seconds.

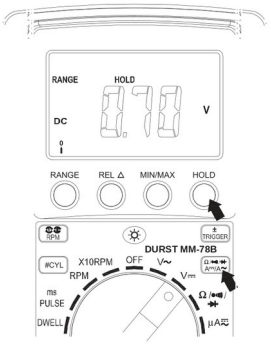
- If the range is too high, readings are less accurate.
- If the range is too low, the meter shows OL (over limit).



Data hold

The data hold feature stores the last reading in memory.

- Press HOLD once to hold the present reading.
- Press HOLD again to exit and resume readings.



REL Δ (relative)

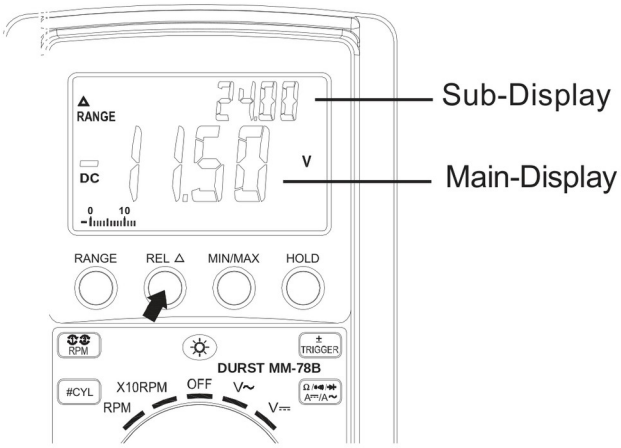


Figure 4. REL mode example.

Press REL Δ to zero the display and store the present reading as a reference value. Press it again to exit. In REL mode the main display shows the difference between the stored value and the present reading. For example, with a

reference value of 24.00V on the sub-display and a present reading of 12.50V, the main display shows -11.50V. If the new reading equals the reference value, the display reads zero.

MIN/MAX (data record)

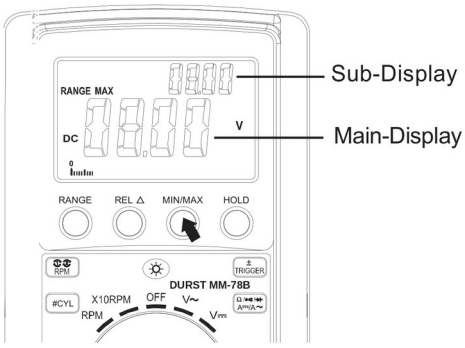


Figure 5. MAX recording.

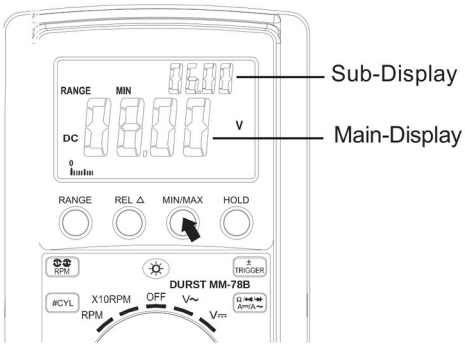
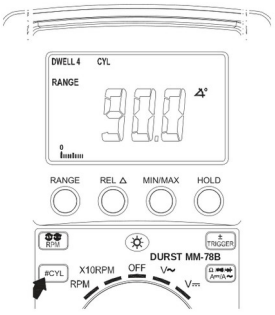


Figure 6. MIN recording.

- Connect the probes to the test points, then press MIN/MAX once to start MAX recording. The maximum reading shows on the sub-display.
- Press MIN/MAX twice to start MIN recording. The minimum reading shows on the sub-display.
- The value being measured shows on the main display.
- Press and hold MIN/MAX for more than 2 seconds to exit.

#CYL (cylinder)

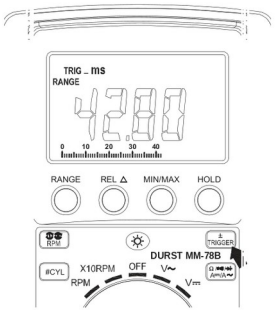
With the dwell function selected, press #CYL to toggle between the 4, 5, 6 and 8 cylinder scales.



± TRIGGER

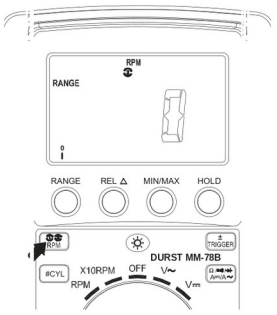
With the duty cycle or pulse width function selected, press ± TRIGGER to toggle between the negative (-) and positive (+) slope.

See also: Meter functions: Duty cycle (%) and ms pulse width; Duty cycle, what is it?



RPM (1) and RPM (2)

In the RPM function the meter defaults to RPM (2) for conventional 4-cycle engines. Press the RPM button to toggle to RPM (1) for 2-cycle engines or waste spark (DIS) 4-cycle engines.



Meter functions

Step-by-step set-up for each measurement function, with the connections shown alongside.

Voltage (V)

WARNING

When measuring voltage, make sure the red test lead is in the terminal marked V. A lead in the 20A or µA/mA terminal can cause injury or damage the meter.

The meter automatically selects the best voltage range. Press the Alternate Function button to select AC or DC.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Touch the black probe to ground or the negative (-) circuit, and the red probe to the circuit coming from the power source. Voltage is always measured in parallel.

Accuracy. Selecting a lower range moves the decimal point one place and increases accuracy. OL (over limit) means the range is too low: select the next higher range.



Figure 7. Voltage (V) measurement

Resistance (Ω)

IMPORTANT: Turn the power OFF to the test circuit and discharge all capacitors. Accurate measurement is not possible with external or residual voltage present.

Select resistance (Ω) with the rotary switch. Press RANGE for a more accurate range if needed.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Touch the test probes across the resistor to be tested.

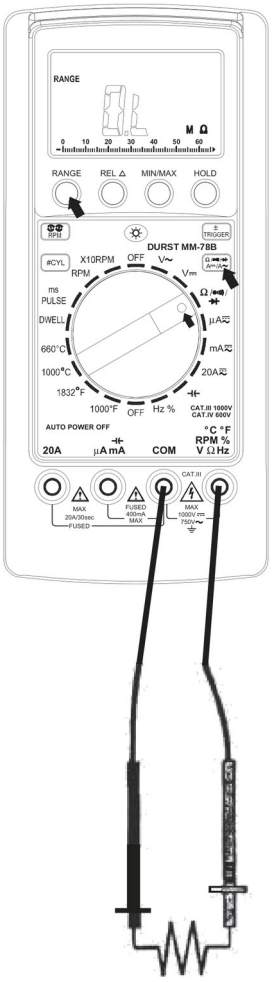


Figure 8. Resistance (Ω) measurement

Audible continuity

IMPORTANT: Turn the power OFF to the test circuit.

Select the audible continuity position with the rotary switch, then press the Alternate Function button to select audible continuity.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Connect one probe to each end of the circuit. If the circuit is complete, the meter beeps. If the circuit is open, there is no beep and the display shows OL.

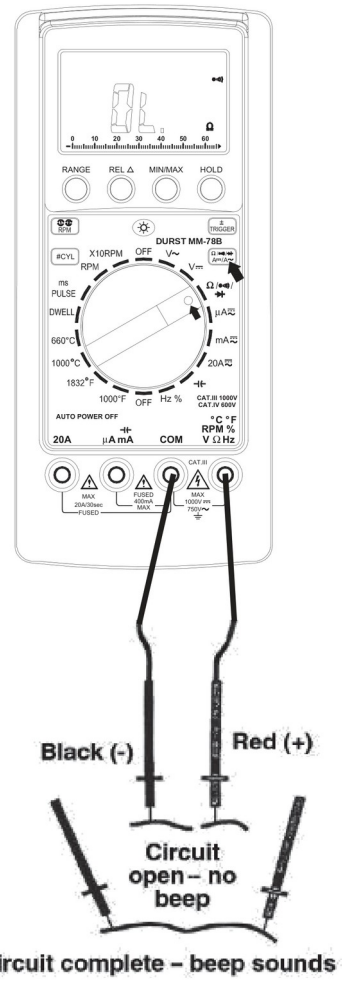


Figure 9. Audible continuity measurement

Diode check

IMPORTANT: Turn the power OFF to the test circuit.

Select the diode position with the rotary switch, then press the Alternate Function button to select diode check.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Touch the black probe to the negative (-) side of the diode and the red probe to the positive (+) side. Then reverse the probes: black to positive (+), red to negative (-).

A good diode reads low in one direction and high (OL) in the other. Readings that match any of the bad rows indicate a defective diode.

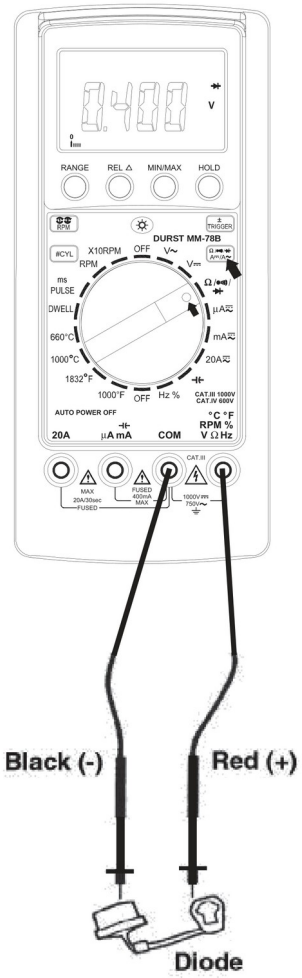


Figure 10. Diode check measurement

Diode	Black to -, red to +	Probes reversed (+ to -)
Good	0.4 to 0.9V	OL
Good	OL	0.4 to 0.9V
Bad	OL	1.0 to 1.999V
Bad	1.0 to 1.999V	OL
Bad	0.4 to 0.9V	0.4 to 0.9V
Bad	OL	OL
Bad	.000V	.000V

Capacitance

IMPORTANT: Turn the power OFF to the vehicle circuit. Discharge the capacitor by shorting its leads together, then confirm with the DC volts function that it is discharged.

Select the capacitance position with the rotary switch, then press the Alternate Function button to select capacitance.

- **Black lead** in the COM terminal.
- **Red lead** in the µA/mA terminal.

Attach the red (+) and black (-) probes to the capacitor.

- Holding the probes in your hands can add capacitance and give a false reading.
- Residual charge, poor insulation resistance or poor dielectric absorption can cause measurement errors.
- If dis.c appears on the display, the capacitor still holds a voltage. Discharge it before testing.

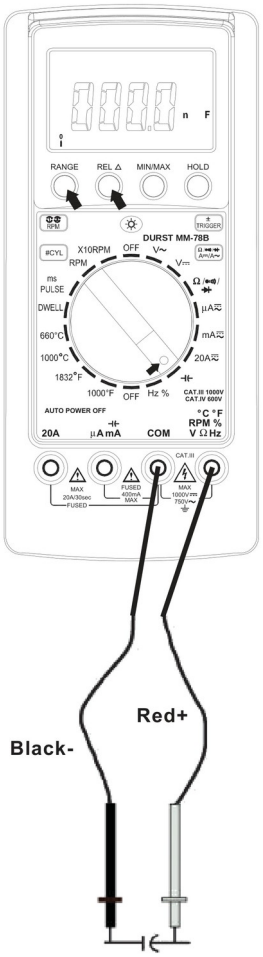


Figure 11. Capacitance measurement

Temperature (°C/°F)

IMPORTANT: Keep the meter away from sources of very high temperature. Very high temperatures also shorten the life of the temperature probe (probe range -20°C to 1000°C, -4°F to 1832°F).

1. Select the unit. Select °C or °F with the rotary switch.

2. Connect the probe. Connect the K-type thermocouple to a TEMP adapter, matching the polarity of the adapter to the thermocouple. Connect the adapter to the V and COM terminals.

3. Measure. Touch the end of the temperature probe to the area or surface to be measured.

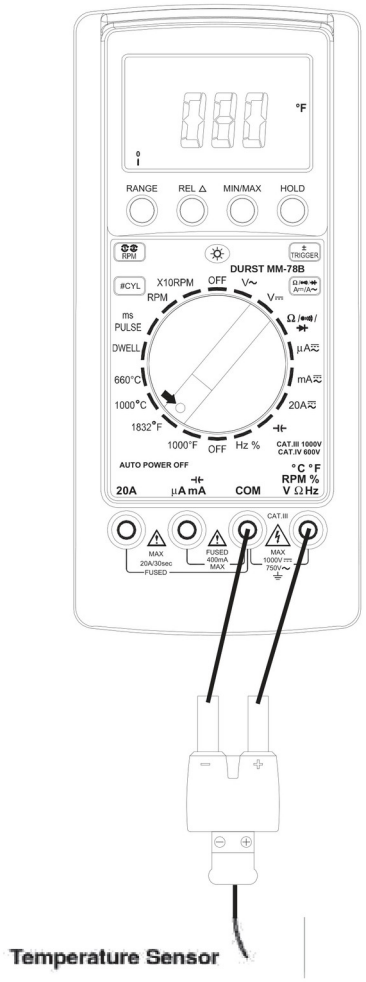


Figure 12. Temperature (°C/°F) measurement

Frequency (Hz)

Set the rotary switch to the frequency range that gives the most accurate reading.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Connect the black probe to ground and the red probe to the signal output wire of the sensor being tested.

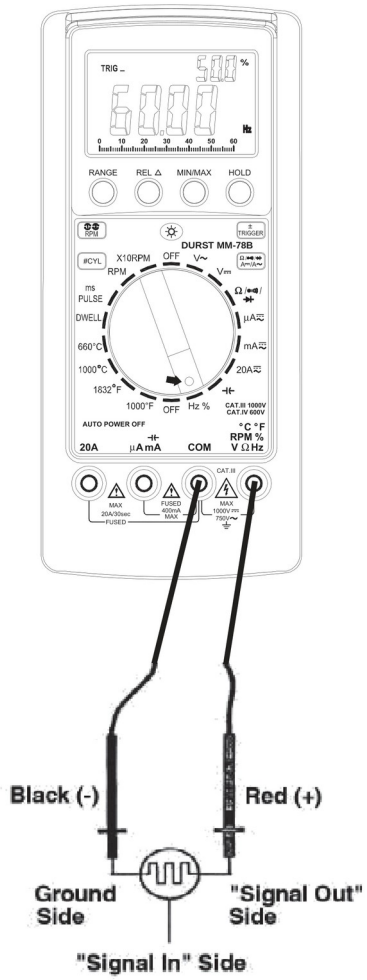


Figure 13. Frequency (Hz) measurement

RPM / x10RPM

Select RPM with the rotary switch, or select x10RPM (1,000 to 12,000 RPM) and multiply the displayed reading by ten for actual RPM.

Plug the inductive pickup into the meter: ground lead in the COM terminal, output lead in the V/Ω/RPM terminal. Clamp the pickup onto a spark plug lead. If there is no reading, unclip the clamp, turn it over and refit it.

Press the RPM button to toggle between RPM for 2-cycle and distributorless ignition system (DIS) engines and RPM for 4-cycle engines.

- Position the pickup as far from the distributor and exhaust manifold as possible.
- Position the pickup within about 150mm (six inches) of the spark plug, or move it to another plug lead if the reading is missing or erratic.

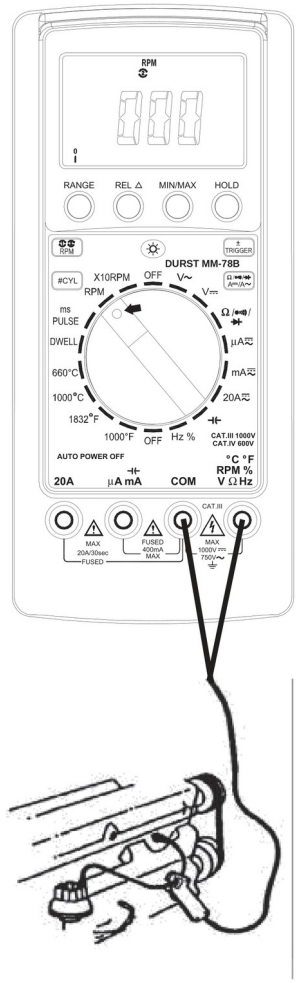


Figure 14. RPM / x10RPM measurement

Duty cycle (%)

Select % duty cycle with the rotary switch.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Connect the black probe to ground and the red probe to the signal wire circuit, for example the signal wire of a mixture control solenoid.

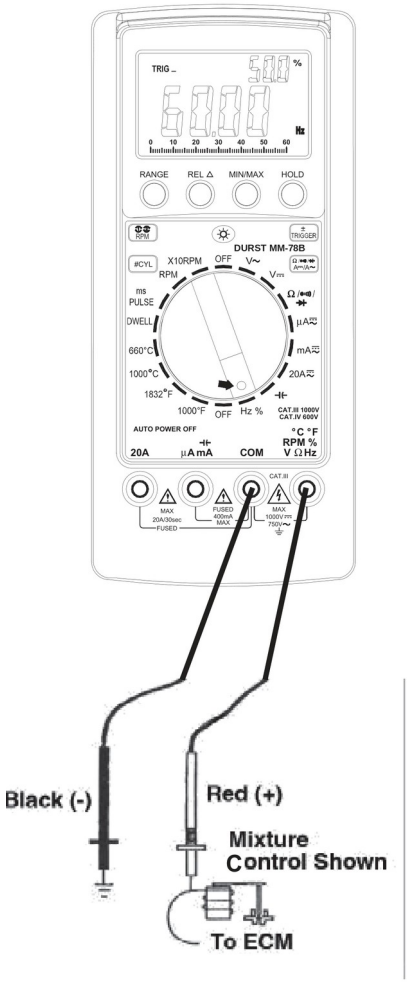


Figure 15. Duty cycle (%) measurement

Dwell

Select the dwell range with the rotary switch.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Connect the black probe to ground and the red probe to the wire that connects to the breaker points.

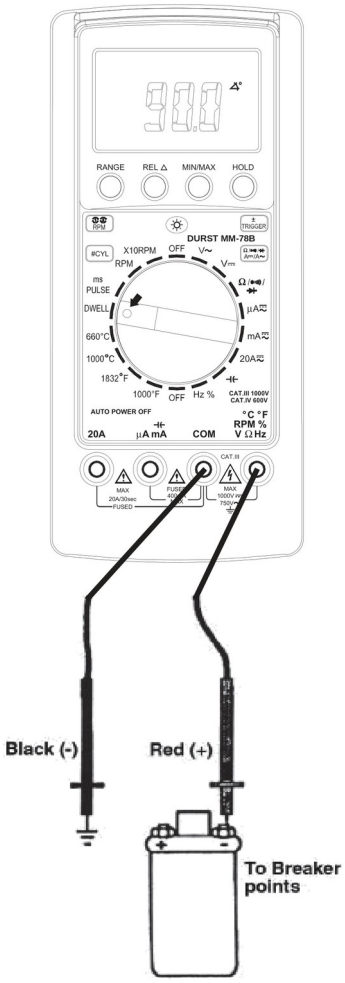


Figure 16. Dwell measurement

ms pulse width

Select ms pulse with the rotary switch.

- **Black lead** in the COM terminal.
- **Red lead** in the V/Ω/RPM terminal.

Connect the black probe to ground and the red probe to the signal wire of the component being measured. Press ± TRIGGER to toggle between the negative (-) and positive (+) slope.

- For most fuel injectors, the on time is displayed on the negative (-) slope.
- With TRIG-ms (negative slope) selected, a small residual value may show before measuring starts. This is normal and does not affect accuracy.

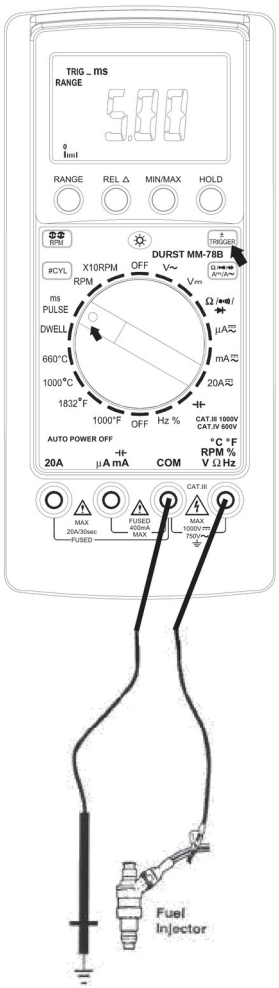


Figure 17. ms pulse width measurement

AC or DC current (A)

IMPORTANT

All measured current flows through the meter.

Do not measure current on circuits above 500V AC or DC with respect to ground.

Between 1A and 20A, measure continuous current for no more than 60 seconds, then allow five minutes to cool down before continuing.

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

Select 20A, mA or µA with the rotary switch, and press the Alternate Function button to select AC or DC.

- **Black lead** in the COM terminal.
- **Red lead** in the 20A or µA/mA terminal. Use 20A if you are unsure of the current draw.

1. Isolate. Turn OFF all power to the circuit, or disconnect the circuit from the power source.

2. Connect in series. Red probe to the side of the circuit closest to the power source, black probe to the side going to ground.

3. Test. Turn the power ON and take the reading.

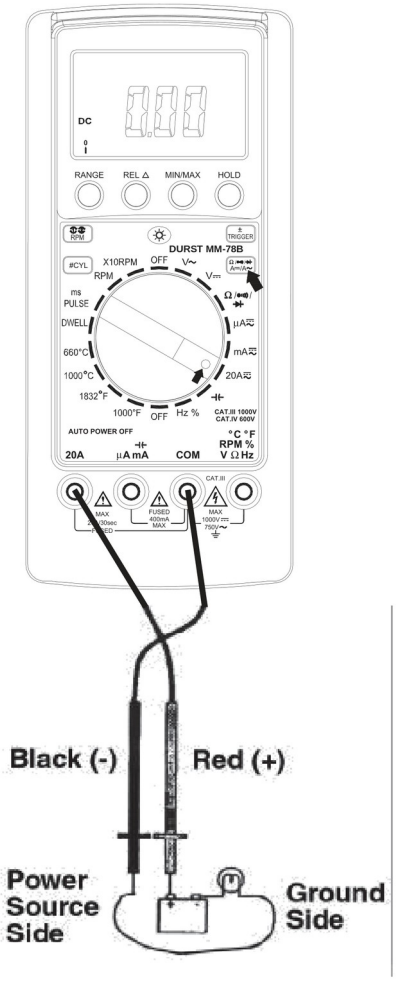


Figure 18. AC or DC current (A) measurement

Maintenance

Fuse and battery replacement

WARNING

Remove the test leads before opening the case.

Do not operate the meter or turn the rotary switch while the case is open.

1. **Open the case.** Loosen the three screws in the case back and lift off the front case.
2. **Replace the battery.** Fit a 9V battery (NEDA 1604, IEC 6F22).
3. **Check the fuses.** If current measurements are not possible, check for a blown overload protection fuse. Replace fuses only with the same type: 20A terminal F20A 600V high energy, fast acting; µA/mA terminal F500mA 1000V fast acting. Make sure the fuse is centred in its holder.
4. **Reassemble.** Refit the case and tighten the three screws.

IMPORTANT: Keep the circuit board clean: make sure your hands are clean and hold the board by its edges.

General maintenance

- Wipe the case with a dry, soft cloth. Keep the input terminals clean.
- Before each use, check the case, test leads, probe tips and inductive pickup for damage. Replace damaged leads before use.
- Store the meter in its holster, switched OFF.
- Keep in a dry place, within the storage environment of -20°C to 60°C at less than 80% relative humidity.
- Replace the battery as soon as the low battery symbol appears. Remove the battery if the meter will not be used for an extended period.

Extreme environment maintenance

For hot, cold, dusty or humid workshops and roadside work. Follow this in addition to General maintenance.

Condition	Care
Heat	Use the meter between 0°C and 50°C. Do not leave it on a dashboard, in direct sun or near hot engine parts and exhausts.
Cold	Let the meter warm to its 0°C to 50°C operating range before use, for best accuracy.
Humidity and moisture	Keep in a dry place. Operate at less than 70% relative humidity. If the meter gets damp or shows condensation, switch it off and let it dry fully before use.
Dust and grime	Keep the terminals and rotary switch clean. Wipe dust and oil from the case and leads after use, and store in the holster.
Vibration and transport	Carry the meter in its holster and secure it in the vehicle or toolbox so it cannot fall.
Altitude	Rated for use up to 2000m.

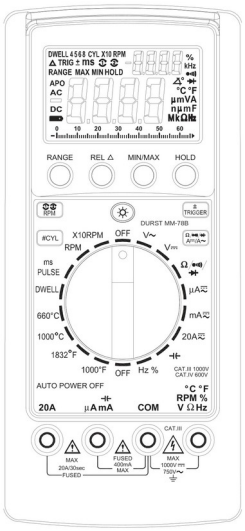
Troubleshooting

Problem	Checks
Meter will not turn on	Check the battery contacts are a tight fit. Check the battery is at least 8.0V.
Current reading is erratic or missing	Open the back cover and test the fuses for continuity.
Meter reading is erratic	Circuit board contaminated from handling; low battery; open circuit in a test lead (frayed or broken wire); wrong range selected; blown fuse.
Reading does not change	HOLD is still on.

Basic diagnostic testing

This chapter leads you through a systematic series of tests that check the vehicle electrical system. Perform these before testing individual components.

- Battery testing
- Voltage drop testing
- Starter motor testing
- Charging system tests
- Ignition system tests



Electrical system diagnostics

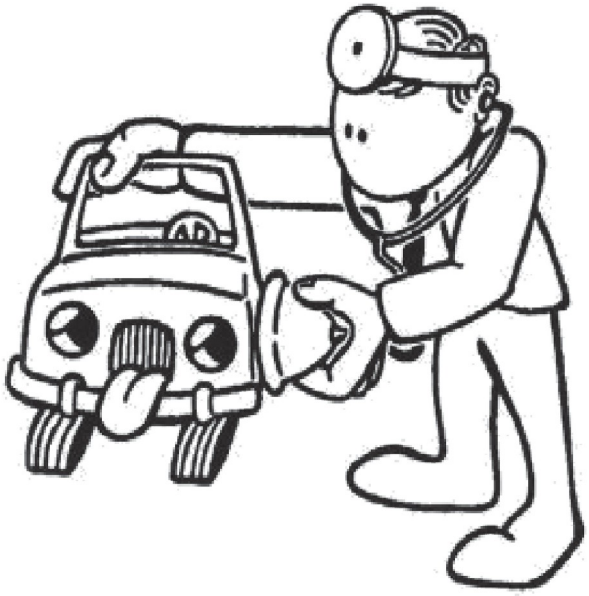


Figure 19. The vehicle electrical system.

Diagnose vehicle electrical problems thoroughly and efficiently. The tests that follow check the primary areas responsible for most electrical problems in a vehicle.

Perform these basic tests first, even if the vehicle computer has a trouble code set. A component fault detected by the computer can be caused by a basic ground problem, and replacing a failed component will not fix the problem if a poor ground caused the failure.

The tests begin with the main power source and the chassis ground connections. Ground circuits are one of the least understood and most troublesome areas of automotive electronics: excessive voltage drop in a ground circuit affects the entire circuit. Make sure the basic circuits are in good shape before checking trouble codes and components.

Battery testing

NOTE

Remove the positive and negative battery cables and thoroughly clean the cable terminals and battery posts. Reassemble, then begin testing.

The ignition switch must be OFF when connecting or disconnecting battery cables, to protect the vehicle computer.

[1] Battery test (surface discharge)

Checks for low current discharge across the battery case.

- Set the rotary switch to voltage.
- Connect the negative (-) lead to the negative battery post.
- Touch the positive (+) lead to the battery case around the positive (+) post. Do not touch the post.

A reading above 0.5V indicates excessive surface discharge. Dirt, moisture and corrosion cause surface discharge. Clean the battery with a bicarbonate of soda and water solution, keeping the solution out of the battery.

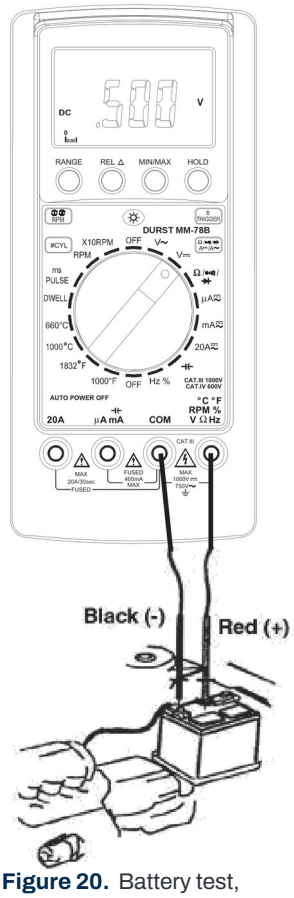


Figure 20. Battery test, surface discharge

[2] Static battery test (no load)

Checks the battery state of charge.

- Turn the headlights on for 15 seconds to remove surface charge.
- With the ignition OFF, disconnect the negative (-) battery terminal.
- Set the rotary switch to voltage.
- Connect the positive (+) lead to the positive (+) post and the negative (-) lead to the negative (-) post.

A reading below 12.4V indicates an undercharged battery. Recharge before testing.

Leave the battery cable disconnected and continue with the next test.

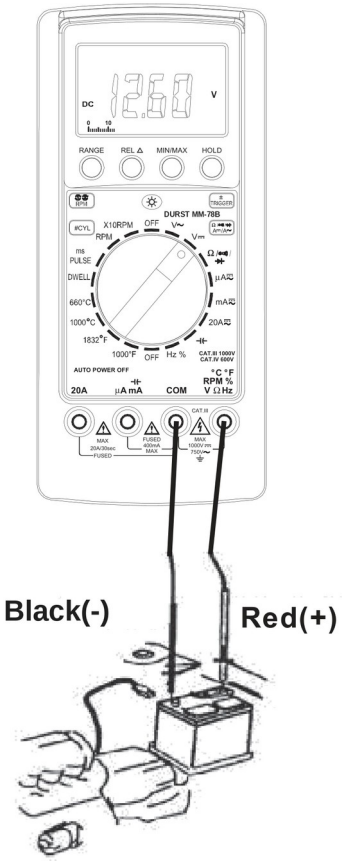


Figure 21. Static battery test, no load

Reading	Battery charge
12.6V	100%
12.4V	75%
12.2V	50%
12.0V	25%

[3] Battery test (parasitic load)

IMPORTANT: Do not start the vehicle during this test, or the meter may be damaged.

Checks for excessive parasitic drain on the battery.

- Turn the ignition and all accessories OFF.
- Set the rotary switch to 20A and insert the positive (+) lead into the 20A terminal.
- Disconnect the battery positive (+) cable.
- Connect the positive (+) lead to the positive (+) battery terminal and the negative (-) lead to the disconnected positive (+) cable terminal.

Parasitic draw should not exceed 100mA. If draw is excessive, remove the circuit fuses one at a time until you find it. Also check non-fused items such as headlights, computer relays and capacitors in the instrument panel. Reconnect the battery cable for the next test.

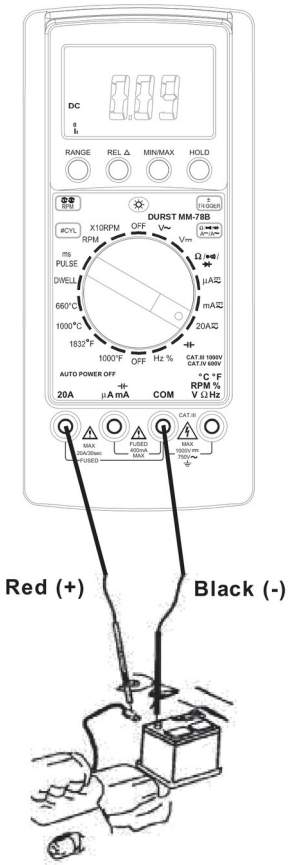


Figure 22. Battery test, parasitic load

[4] Battery test (load)

Checks the battery's capacity to deliver enough cranking voltage.

- Set the rotary switch to voltage.
- Connect the positive (+) lead to the positive (+) terminal and the negative (-) lead to the negative (-) terminal.
- Disable the ignition and crank the engine for 15 seconds.

A reading below 9.6V at 21°C (70°F) indicates a weak battery. Recharge or replace before testing.

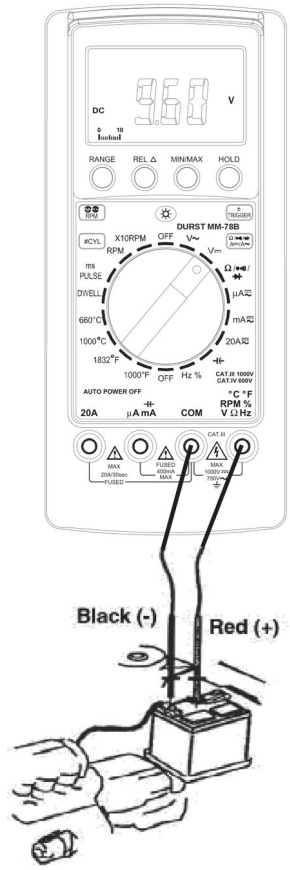


Figure 23. Battery test, load

Minimum reading	Battery / air temperature
10.0V	33°C (90°F)
9.8V	27°C (80°F)
9.6V	21°C (70°F)
9.4V	16°C (60°F)
9.2V	10°C (50°F)
9.0V	4°C (40°F)
8.8V	-1°C (30°F)
8.6V	-7°C (20°F)

For each 10°F (about 5.5°C) above or below 21°C, add or subtract 0.1V. Check battery temperature with the meter's temperature probe.

Voltage drop testing

Resistance, what is it? Resistance is an opposing force, created by a circuit or component, to the flow of electrical current. Wires, switches, grounds and connections all have a small natural resistance. It rises beyond acceptable limits when corrosion develops, fittings loosen or wires fray, and it increases with each wire, switch, connection or ground added to the circuit.

Voltage drop, what is it? Voltage drop is the difference in voltage measured across a circuit or component that creates resistance. Resistance reduces the voltage available: if voltage is too low, a bulb will not light or a motor will not turn.

Maximum voltage drop. No more than 0.1V per wire, ground, connection, switch or solenoid. Total for a circuit should be no more than 0.4V, as in the example below.

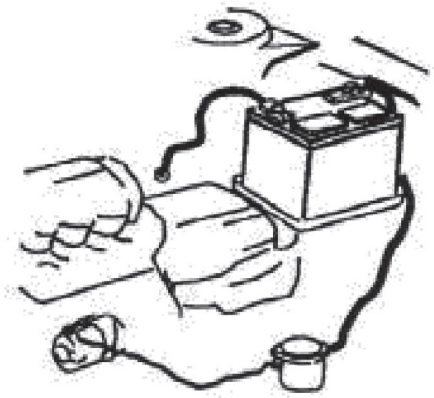


Figure 24. Resistance and voltage drop in a circuit.

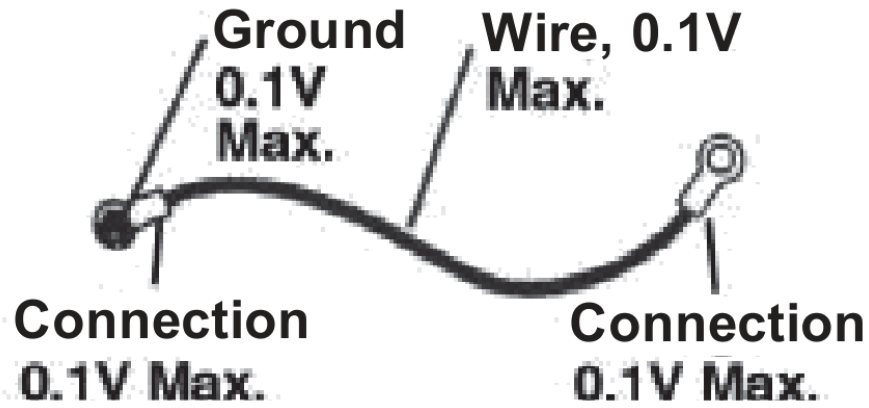


Figure 25. Maximum voltage drop example, 0.4V total.

What should be tested? Each wire, ground, connection, switch, solenoid and the complete circuit. Every connection point is a potential source of extra resistance.

IMPORTANT: Repeat each voltage drop test when the engine is fully warmed up. Heat expansion of metal can increase resistance.

[1] Negative (-) engine ground

Checks 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 (-) post. Note the reading: this is the base voltage for comparison.
- Connect the positive (+) lead to a clean spot on the engine block and the negative (-) lead to the negative battery post.
- Disable the ignition so the engine does not start, and crank for 2 to 3 seconds.

In the example circuit (2 connectors, 1 wire, 1 ground and 1 terminal to the battery post), a drop of more than 0.5V indicates a poor ground circuit. Clean and inspect the battery cable connections and the ground, then test again.

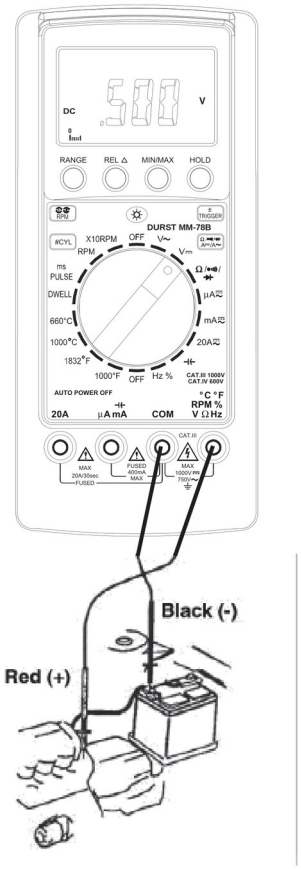


Figure 26. Negative (-) engine ground test

[2] Negative (-) chassis ground

Checks chassis ground efficiency.

- Set the rotary switch to voltage and establish the base voltage (see test [1]).
- Connect the positive (+) lead to the point on the guard, firewall or chassis where the accessory ground is fastened, and the negative (-) lead to the negative (-) battery terminal.
- Turn all accessories ON (high beam, A/C fan on high, rear window demister, windscreen wipers and so on).
- Disable the ignition and crank for 2 to 3 seconds.

In the example circuit (2 connectors, 1 wire, 1 ground and 1 terminal to the battery post), a drop of more than 0.5V indicates a poor ground circuit. Clean and inspect the battery cable connections and the ground, then test again.

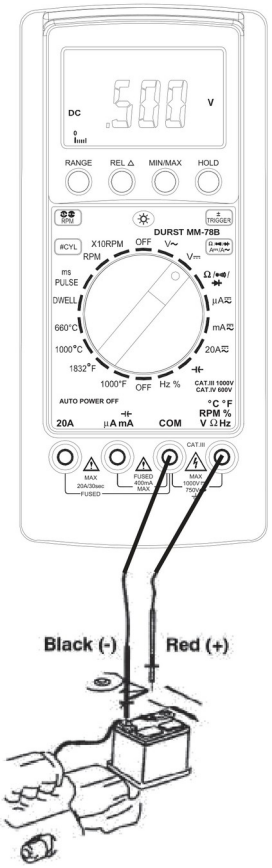


Figure 27. Negative (-) chassis ground test

[3] Battery power to starter solenoid (+)

Checks battery supply efficiency to the starter solenoid.

- Set the rotary switch to voltage and establish the base voltage (see test [1]).
- Connect the positive (+) lead to the positive (+) battery terminal and the negative (-) lead to the positive (+) terminal on the starter solenoid.
- Disable the ignition and crank for 2 to 3 seconds.

In the example circuit (2 connectors and 1 wire), a drop of more than 0.3V indicates a poor circuit. Clean and inspect the battery cables and connections, then test again.

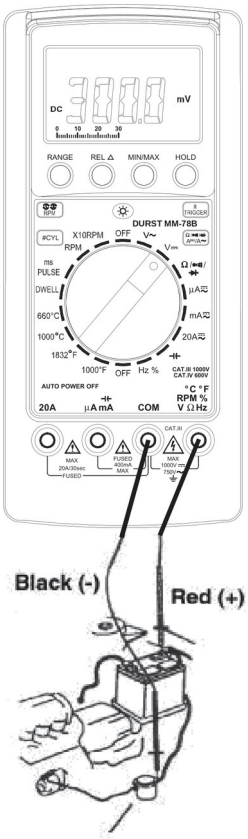


Figure 28. Battery power to starter solenoid test

[4] Battery power to complete starter circuit (+)

Checks battery power efficiency to the starter through the starter solenoid.

- Set the rotary switch to voltage and establish the base voltage (see test [1]).
- Connect the positive (+) lead to the positive (+) battery terminal and the negative (-) lead to the positive (+) terminal on the starter motor.
- Disable the ignition and crank for 2 to 3 seconds.

In the example circuit (4 connectors, 2 wires and 2 solenoid connections), a drop of more than 0.8V indicates a poor circuit. Clean and inspect the battery and starter cables, solenoid and connections, then test again. A defective solenoid can cause excessive voltage drop: check the cables and connections before replacing the solenoid.

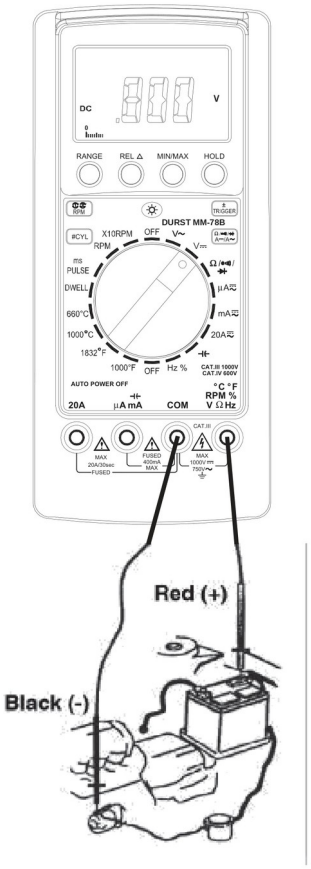


Figure 29. Complete starter circuit test

Starter motor testing

Starter current test

With battery and voltage drop tests confirming adequate voltage at the starter, check for excessive starter current draw.

- Fit a current clamp (not included) around the negative (-) or positive (+) battery cable and connect it to the meter.
- Set the rotary switch to voltage. With a 1mV per amp clamp, 1mV = 1A.
- Disable the ignition and crank for 2 to 3 seconds.

The current clamp measures in the direction of current flow. Make sure the arrow on the clamp points in the direction of current flow in the cable.

Quick test. Turn the ignition and all accessories OFF. Fit the clamp on the battery cable and turn the headlights on. If the reading is not negative, remove the clamp, turn it over and refit it.

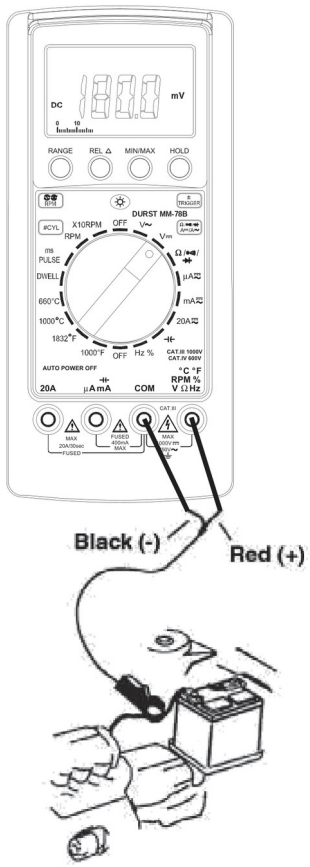


Figure 30. Starter current test

Engine	Approximate maximum draw
4 cylinder	150 to 180A
6 to 8 cylinder, under 300 CID (approx. 4.9L)	180 to 210A
6 to 8 cylinder, over 300 CID (approx. 4.9L)	250A

Charging system tests

[1] Battery (+)

Checks alternator output voltage at the battery.

- Set the rotary switch to voltage.
- Connect the positive (+) lead to the positive (+) battery terminal and the negative (-) lead to the negative (-) terminal.
- Turn all accessories OFF. Start the engine and hold at 1500 RPM.

A reading of 13.1 to 15.5V is an acceptable charging rate. If voltage is low, check for a loose, cracked or glazed drive belt, loose or faulty wires or connectors, or a faulty alternator or regulator. See [2] Alternator voltage output (+), loaded.

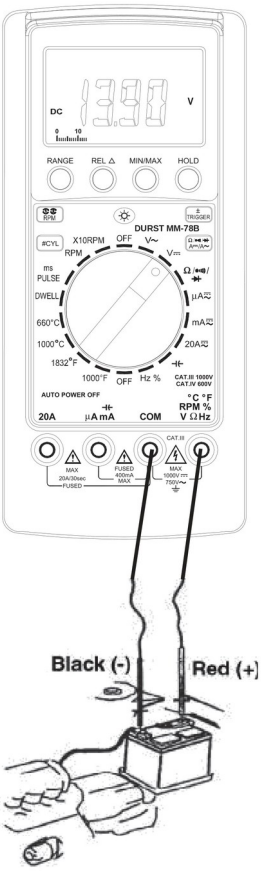


Figure 31. Charging system test, battery (+)

[2] Alternator voltage output (+), loaded

Checks alternator output voltage. Only needed if the vehicle failed test [1] Battery (+).

- Set the rotary switch to voltage.
- Connect the positive (+) lead to the battery (B+) output post on the back of the alternator and the negative (-) lead to the negative (-) battery terminal.
- Start the engine and hold at 1500 RPM.

A reading of 13.1 to 15.5V is an acceptable charging rate.

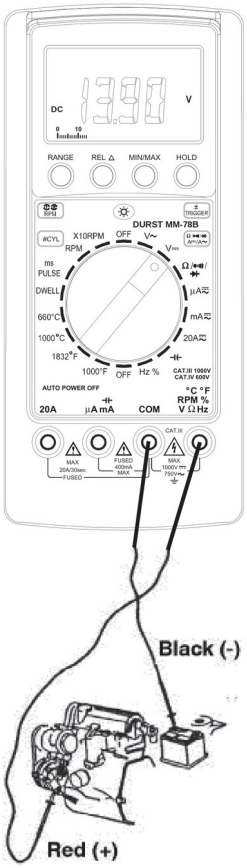


Figure 32. Alternator voltage output test, loaded

[3] Alternator current output, battery

Checks alternator charging rate efficiency at the battery.

- Connect the current clamp leads to the meter and fit the clamp around the negative (-) or positive (+) battery cable.
- Set the rotary switch to voltage. With a 1mV per amp clamp, 1mV = 1A.
- Turn all accessories OFF. Start the engine and hold at 1500 RPM.

The reading should be 5A or more. Make sure the arrow on the clamp points in the direction of current flow.

Quick test. Fit the clamp on the battery cable and turn the headlights on. If the reading is not negative, remove the clamp, turn it over and refit it.

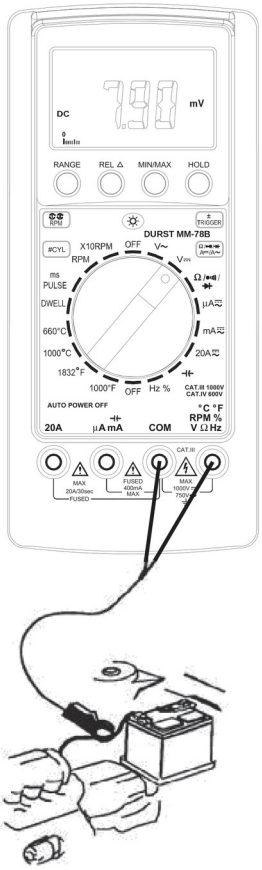


Figure 33. Alternator current output test

Ignition system tests

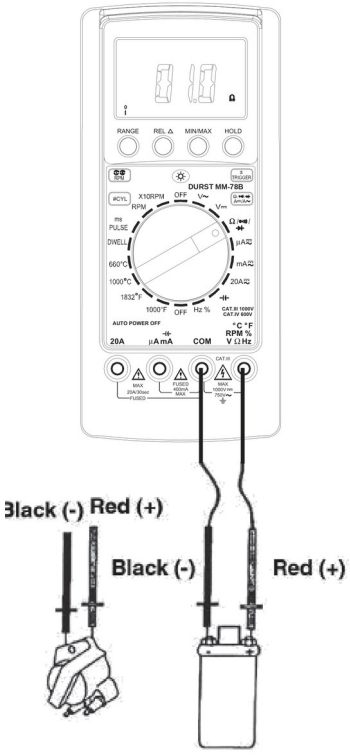
NOTE: For all ignition resistance tests: set the rotary switch to resistance (Ω), black lead in COM and red lead in V/Ω/RPM.

[1] Ignition coil, primary resistance (Ω)

Checks primary winding resistance. Test the coil both cold and hot.

- Disconnect the coil from the vehicle wiring harness.
- Connect the negative (-) lead to the negative (-) coil terminal and the positive (+) lead to the positive (B+) coil terminal.
- Subtract the resistance of the meter leads for an accurate reading in the 1.0 to 2.0Ω range.

Typical readings are 1.0 to 2.0Ω. Check the manufacturer's specifications. The illustration shows a GM DIS coil, Type II, with both primaries located on the back of the coil.



GM DIS Coil, Type II - Both primaries located on back of coil.

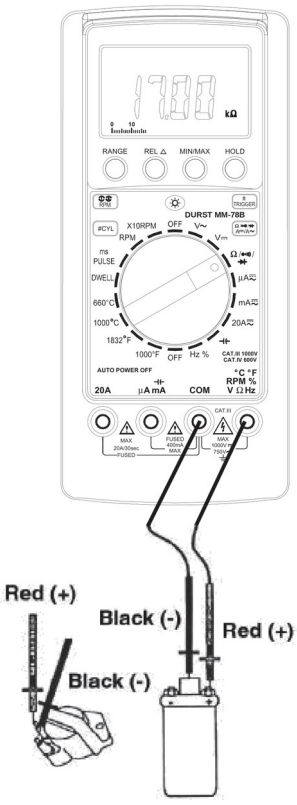
Figure 34. Ignition coil primary resistance test (GM DIS coil, Type II)

[2] Ignition coil, secondary resistance (Ω)

Checks secondary winding resistance. Test the coil both cold and hot.

- Disconnect the coil from the vehicle wiring harness.
- Connect the negative (-) lead to the high tension terminal and the positive (+) lead to the positive (B+) terminal.

Typical readings are 6,000 to 30,000Ω. Check the manufacturer's specifications.



GM DIS Coil,
Type II

Figure 35. Ignition coil secondary resistance test

[3] Secondary ignition lead resistance (Ω)

Checks for open circuits or high resistance in the spark plug leads. Twist and bend the lead while measuring.

- Connect the probes to opposite ends of the spark plug lead.

Typical readings are about 1,000Ω per inch (25mm) of lead. For example, a 10 inch (250mm) lead reads about 10,000Ω.

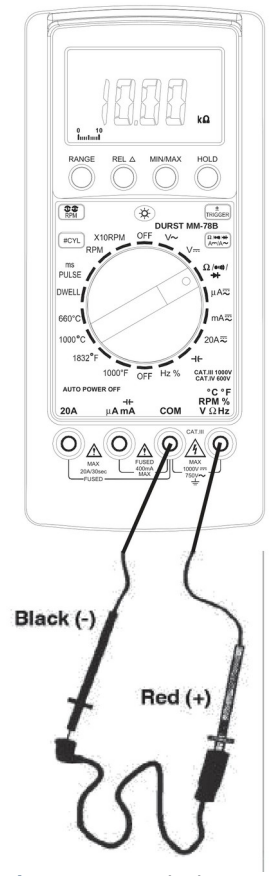


Figure 36. Spark plug lead resistance test

[4] Distributor cap and rotor resistance (Ω)

Checks for open circuits or high resistance in the distributor cap and rotor.

- **Cap centre connector:** connect the probes to opposite ends of the cap terminal. Resistance is generally 5k to 10kΩ.
- **Rotor:** connect the probes to opposite ends of the rotor contacts. Resistance is generally 0.1Ω or less.

Refer to the manufacturer's specifications.

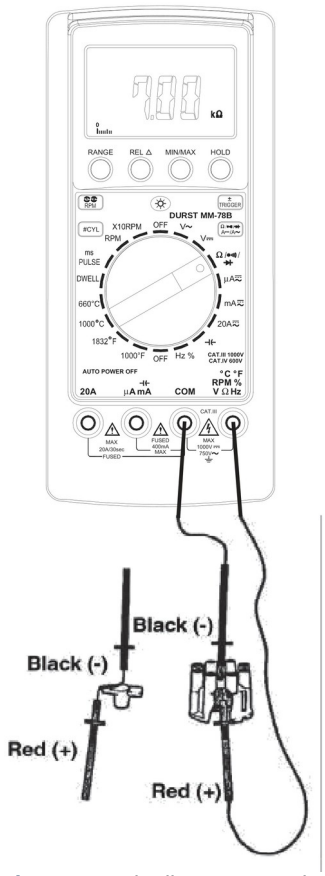


Figure 37. Distributor cap and rotor resistance test

[5] Pick-up coil resistance (Ω) and voltage (V)

The resistance test checks for open circuits or high resistance. The voltage test compares voltage output to resistance.

- Connect the probes to the pick-up coil leads. Most pick-up coils read 500 to 1500Ω. See the manufacturer's specification.
- Set the rotary switch to volts and press the Alternate Function button to select AC.
- Crank the engine for 10 to 15 seconds at normal speed and measure the voltage.

On a good pick-up coil, resistance matches AC output voltage (for example 950Ω = 950mV output). Resistance can be good but voltage low if the magnet has lost magnetism or the reluctor is too far from the stator (air gap).

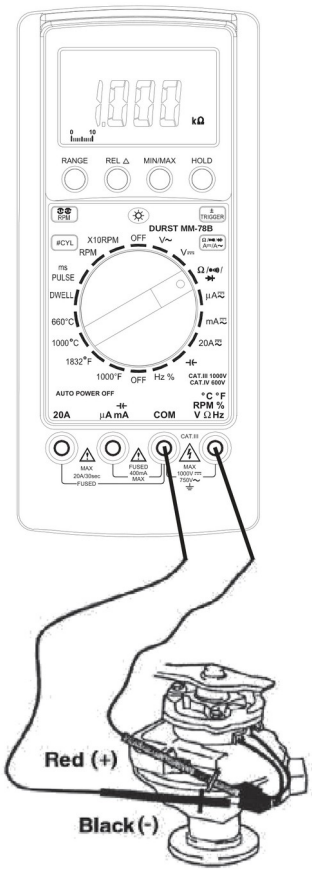


Figure 38. Pick-up coil test

[6] Hall effect sensor voltage (V)

Checks switching action in any Hall effect sensor (ignition, RPM, crankshaft and so on).

- Set the rotary switch to voltage. Black lead in COM, red lead in V/Ω/RPM.
- Connect the black (-) probe to the negative (-) battery post.
- Turn the ignition ON and touch the red (+) probe to each of the three test points.

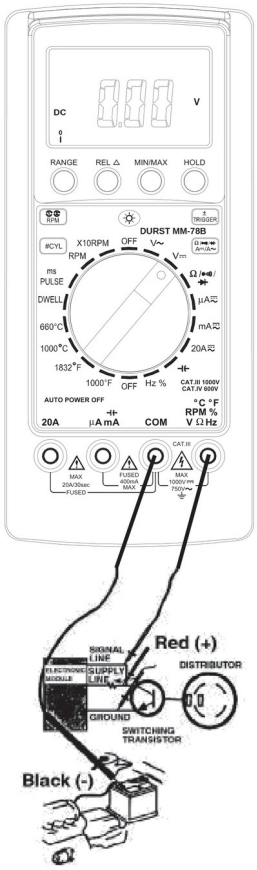


Figure 39. Hall effect sensor test

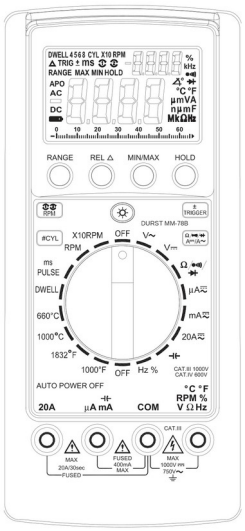
Test point	Expected reading
Ground	Same voltage as ground (computer or battery)
Supply line	Same voltage as the input source (computer or battery)
Signal line	0V or the input source voltage, toggling high and low as the shutter rotates

Basic component testing

Test procedures for the main groups of electrical input and output components in a computer controlled vehicle.

This chapter describes a computer controlled sensor and actuator system typically found in today's vehicles.

Because of the complexity of these components, the procedures are general theory tests. Consult the vehicle service manual for component schematics and test specifications.



Computer controlled systems

The need for better fuel economy and lower emissions led to computer control of functions that were once handled by mechanical, electrical and vacuum devices. Computerised vehicle control systems have three basic component groups:

1. **Sensors.** Input devices that give the vehicle computer information about engine operating conditions and the surrounding environment.
2. **Engine control module.** The vehicle computer processes sensor information and sends electronic commands to the appropriate actuators.
3. **Actuators.** Output devices (electrical, mechanical or vacuum) controlled by the vehicle computer.

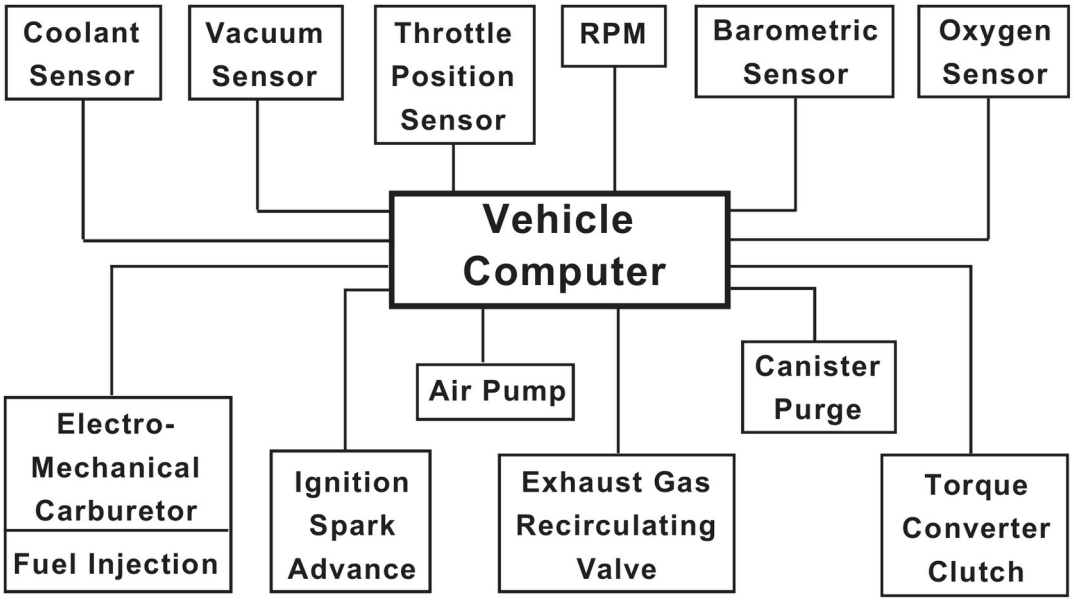


Figure 40. Computer controlled system: typical sensors and actuators.

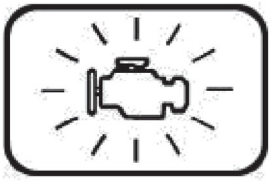
Typical sensors	Typical actuators
Coolant sensor, vacuum sensor, throttle position sensor, barometric sensor, oxygen sensor	Canister purge, air pump, electromechanical carburettor, fuel injection, ignition spark advance, exhaust gas recirculation valve, torque converter clutch

Basic diagnostics for the computer controlled engine

- Do basic engine diagnostics first. Many problems come from missed routine maintenance on plug leads, filters and spark plugs. Check for vacuum leaks on any vehicle, new or old. A complete engine diagnosis should come before any electrical diagnosis.
- Follow the published diagnostic charts exactly, through every step, to repair a computer component.

Self-diagnostic computer systems

When a sensor or actuator fails, the Check Engine light on the instrument panel alerts the driver and the vehicle computer stores a fault code.



The vehicle computer records fault codes when a sensor or actuator fails, usually as a current code or a history code. Current codes are further grouped into hard failures and intermittent failures. Some manufacturers use different terms, and older vehicles may not have every group.

- **Current codes** are active faults. A hard failure keeps the Check Engine light ON. An intermittent failure makes the light flicker and then go OFF after a short time; the code generally stays in memory.
- **History codes** are stored codes for past faults.

These fault codes (also called trouble codes or service codes) are usually two or three digit numbers that identify the affected circuit. Once read, the repair can begin. Follow the vehicle service manual diagnostic procedures, repairs and specifications closely.

Code	Description (typical examples only)
13	O2 sensor circuit
14	Coolant temp high
15	Coolant sensor low temp
21	TPS voltage high
22	TPS voltage low
23	Manifold air temp high
24	VSS low
25	Manifold air temp low
32	EGR vacuum error
33	MAP error
34	MAP sensor high
41	Cylinder select error
42	EST grounded
44	O2 sensor lean
45	O2 sensor high
51	PROM error

Component testing

Component testing with a meter generally needs the manufacturer's detailed schematics and specifications. The following gives general information for the main groups of sensors (input devices) and actuators (output devices).

Primary input devices (sensors): temperature sensors, 2-wire devices, 3-wire devices, oxygen sensors and pressure sensors.

Primary output devices (actuators) are a form of electromagnet that is either ON or OFF. The ON/OFF signal generally takes the form of ON or OFF only (switch), or duty cycle measured in percent of high or low time, or dwell degrees (mixture control solenoid).

Duty cycle, what is it? Duty cycle is the percentage of time a voltage is positive compared with negative: ON compared with OFF. For example, it is used for mixture control solenoids, where ON time is measured as a percentage of the total ON/OFF cycle. The meter reads the negative (-) or positive (+) slope and shows it as a percentage of the total cycle.

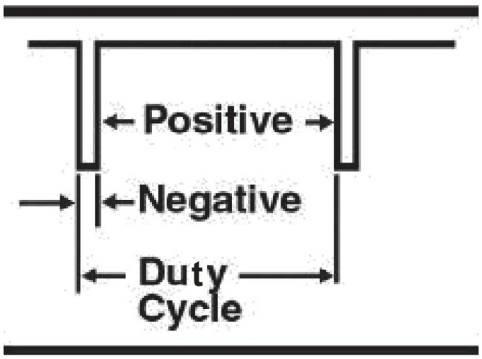


Figure 41. Duty cycle.

Frequency (Hz), what is it? Frequency is the number of times a voltage pattern repeats positive to negative (ON to OFF) in one second. For example, frequency is specified for digitally controlled manifold absolute pressure sensors. Frequency can be analogue (a continuous positive to negative cycle) or digital (a positive to negative, ON to OFF cycle).

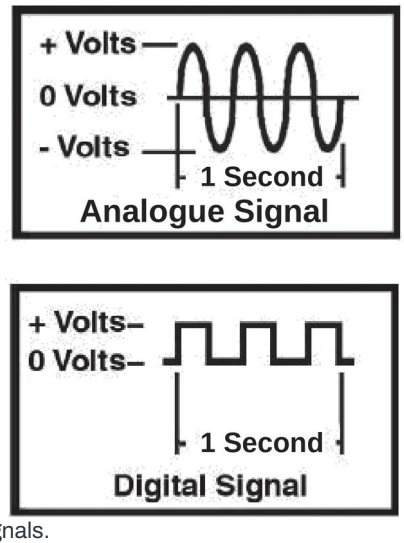


Figure 42. Analogue and digital frequency signals.

Component tests (input)

[1] Temperature tests

Many temperature-regulating components can be tested by measuring the surface temperature around them.

- Connect the K-type thermocouple to a TEMP adapter, matching polarity, and connect the adapter to the V and COM terminals.
- Set the rotary switch to the temperature range required.
- Touch the probe tip directly to the surface of the component.

Compare with the manufacturer's specifications. Temperature should be within ±5°C (±10°F) of the data stream values. Components you can check include radiators, transmissions, heaters, A/C condensers, A/C evaporators, engine coolant sensors, coolant temperature switches and air temperature sensors.

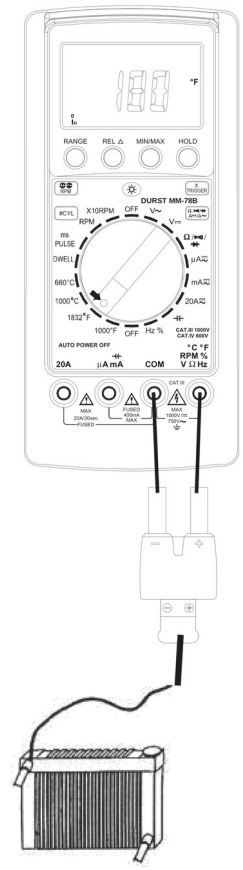


Figure 43.
Temperature test

[2] Thermistor tests (variable resistance, 2-wire)

Thermistors are variable resistors whose resistance changes with temperature. Typical applications: engine coolant temp (ECT), air charge temp (ACT), manifold air temp (MAT), vane air temp (VAT) and throttle body temp (TBT).

Resistance. Select ohms (Ω) and connect the probes to the sensor terminals. The reading should match the sensor temperature (see the manufacturer's specifications).

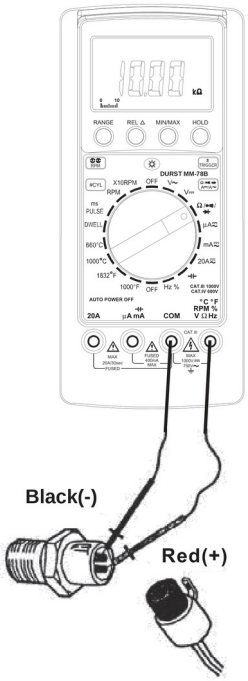


Figure 44. Thermistor resistance test

Voltage presence. Disconnect the wiring harness at the sensor and select voltage (black lead in COM, red lead in V/Ω/RPM). Connect in parallel: positive (+) to the circuit from the power source, negative (-) to the sensor's negative circuit. Turn the ignition ON without starting the engine. The reading should be 5 to 9V (check the manufacturer's specifications).

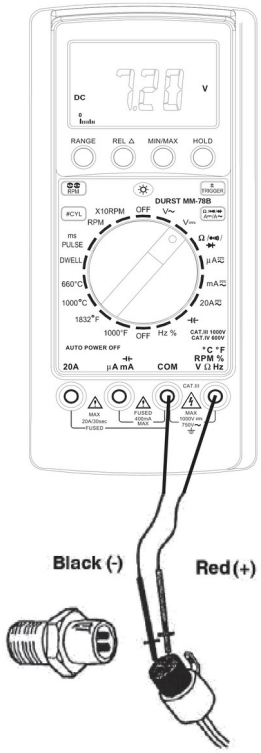


Figure 45. Thermistor voltage presence test

Voltage change. Connect jumper wires between the connector and the sensor and connect the probes in parallel as above. Start the engine. Voltage should change as the temperature changes: this is the signal sent to the computer. If the change is outside specification, look for resistance from poor connectors, connections or broken wiring.

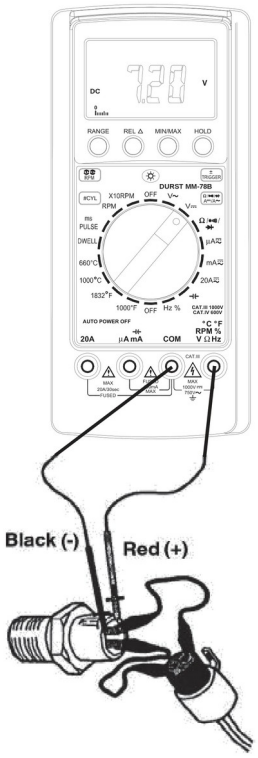


Figure 46. Thermistor voltage change test

[3] Potentiometer tests (variable resistance, 3-wire)

A potentiometer is a variable resistor. Its signal tells the vehicle computer the position and direction of movement of a device within the component. Typical applications: throttle position sensor (TPS), EGR valve position sensor (EVP) and vane air flow meter (VAF).

Resistance. Select ohms (Ω) and disconnect the sensor. Connect the probes to the signal line and ground (see the manufacturer's schematic). The reading should change smoothly as the signal arm moves (signal sweep).

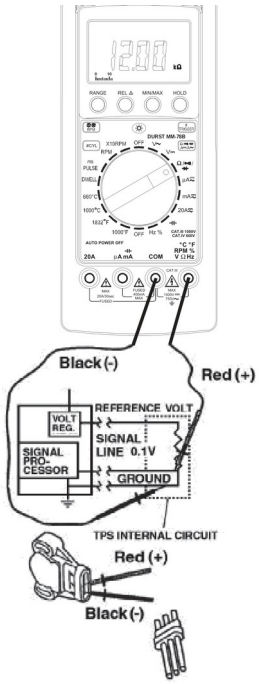


Figure 47. Potentiometer resistance test

Reference voltage. Disconnect the harness at the sensor and select voltage (black lead in COM, red lead in V/Ω/RPM). Connect in parallel: positive (+) to the computer reference voltage circuit, negative (-) to the system ground circuit from the sensor. Turn the ignition ON without starting the engine. The reading should be 5 to 9V (check the manufacturer's specifications).

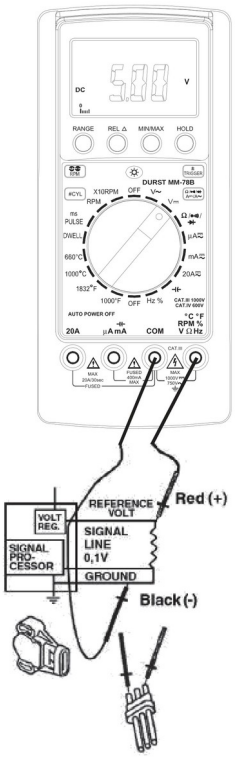


Figure 48. Potentiometer reference voltage test

Voltage change. Connect jumper wires between the connector and the sensor. Connect in parallel: positive (+) to the signal line, negative (-) to the ground circuit. Turn the ignition ON without starting the engine. The voltage should change as the signal arm moves (signal sweep). If it is outside specification, look for resistance from poor connectors, connections or broken wiring.

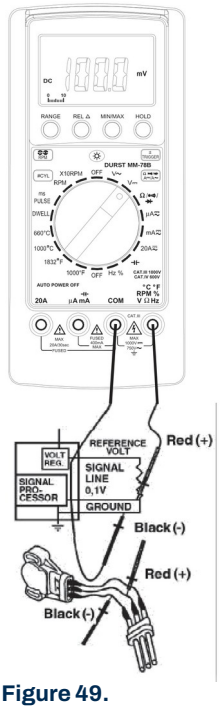


Figure 49.
Potentiometer voltage change test

[4] Oxygen sensor (O_2) test

The oxygen sensor samples the oxygen in the exhaust stream and produces a voltage in direct ratio to it, which the computer uses to adjust the air/fuel mixture. This test checks the sensor's signal output.

- Disconnect the harness at the sensor and fit a jumper wire.
- Select voltage (black lead in COM, red lead in V/Ω/RPM).
- Connect in parallel: positive (+) to the jumper wire, negative (-) to engine ground.
- Run the engine at operating temperature (fast idle at 2,000 RPM for two minutes).

Readings should move between 0.2V (lean) and 0.8V (rich), averaging about 0.50V DC.

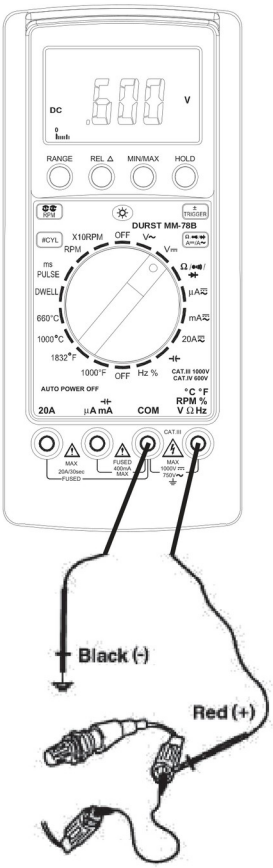


Figure 50. Oxygen sensor test

[5] Pressure sensor tests

Electrical tests for pressure sensors such as manifold absolute pressure (MAP) and barometric pressure (BARO) sensors vary greatly by type and manufacturer. Consult the vehicle service manual for the schematic, specifications and test procedures. Resistance (Ω) tests cannot be used on pressure sensors.

Analogue sensor. Use the same voltage tests as for 3-wire potentiometers, using a vacuum pump to vary the pressure in place of sweeping the sensor.

Digital sensor. Set the rotary switch to Hz and use the same tests as for 3-wire potentiometer voltage, generally using a vacuum pump to vary the pressure. Always refer to the vehicle service manual for the correct procedure.

Component tests (output)

Electrical tests for output devices vary greatly by type and manufacturer. Consult the vehicle service manual for the schematic, specifications and test procedures. Output devices (actuators) are a form of electromagnet that is either ON or OFF, generally in one of these configurations:

- **ON or OFF only (switch).** Check continuity with the switch ON and OFF.
- **Duty cycle (mixture control solenoid).** Measure the percentage of high (+) or low (-) time in one duty cycle. In most cases the low (-) time is the ON time.

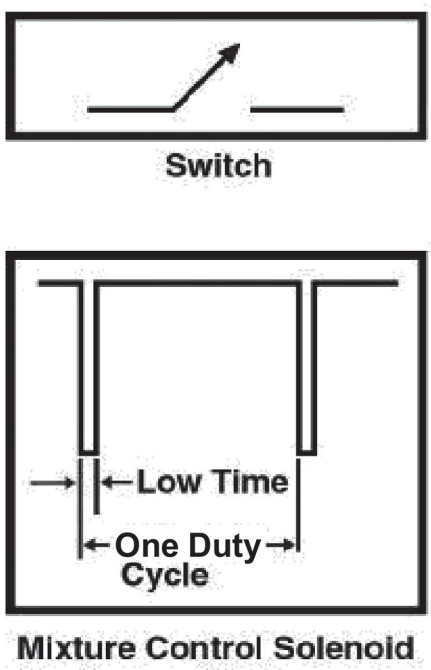


Figure 51. Output devices

Specifications

General specifications

Specification	Value
Model	DURST MM-78B
Safety	IEC 61010-1 (EN 61010-1), CAT III 1000V, CAT IV 600V, Class II, pollution degree 2
EMC	EN 61326-1
Display	6600 counts, 66-segment analogue bar graph
Polarity	Automatic, negative polarity indication
Over-range indication	OL
Zero	Automatic
Low battery indication	Battery symbol shows when battery voltage drops below the operating level
Measurement rate	2.8 times per second, nominal
Auto power off	Approx. 30 minutes
Operating environment	0°C to 50°C (32°F to 122°F) at less than 70% RH
Storage environment	-20°C to 60°C (-4°F to 140°F) at less than 80% RH
Accuracy conditions	Stated accuracy at 23°C ±5°C, less than 75% RH
Temperature coefficient	0.1 x (specified accuracy) per °C (0°C to 18°C, 28°C to 50°C)
Altitude	2000m (6561.7 ft)
Power	Single standard 9V battery (NEDA 1604, IEC 6F22)
Battery life	75 hours typical with carbon-zinc
Fuses	F500mA 1000V and F20A 600V fast acting ceramic
Dimensions	198mm (H) x 90mm (W) x 44mm (D)
Weight	Approx. 400g including holster
Warranty	1 year

Electrical specifications

Accuracy is given as ±([% of reading] + [number of least significant digits]) at 18°C to 28°C (65°F to 83°F), relative humidity up to 70%. Overload protection on every function below except current: 1000V DC or 750V AC rms.

Function	Specification
RPM (tach)	Range: 600 to 6600, 6600 to 12,000 (x10RPM) Resolution: 1 RPM. Effective reading: above 600 RPM Accuracy: ±(2% rdg + 5 dgts)
ms pulse width	Range: 0.1ms to 10.0ms Accuracy: ±(2.0% rdg + 0.2ms) The on time for most fuel injectors is displayed on the negative (-) slope.
% duty cycle	Range: 5.0% to 95.0%. Resolution: 0.1% Pulse width: above 100µs, below 100ms. Frequency range: 40Hz to 10kHz Accuracy: ±(2% rdg + 10 dgts). Readings show on the sub-display.

Function	Specification
Dwell angle	Cylinders: 4, 5, 6, 8 Range: 0 to 90.0° (4 cyl), 0 to 72.0° (5 cyl), 0 to 60.0° (6 cyl), 0 to 45.0° (8 cyl) Resolution: 0.1°. Accuracy: ±(2% rdg + 5 dgts)
Temperature	Ranges: -20°C to 1000°C, -4°F to 1832°F. Resolution: 0.1°C, 0.1°F Accuracy: ±(2.0% + 4°C) -20°C to 10°C; ±(1.0% + 3°C) 10°C to 200°C; ±(3.0% + 2°C) 200°C to 1000°C ±(2.0% + 8°F) -4°F to 50°F; ±(1.0% + 6°F) 50°F to 400°F; ±(3.0% + 4°F) 400°F to 1832°F Sensor: K-type thermocouple
DC voltage (autoranging)	Ranges: 660mV, 6.6V, 66V, 660V, 1000V. Resolution: 0.1mV Accuracy: ±(0.5% rdg + 2 dgts) Input impedance: 660mV above 100MΩ; 6.6V 10MΩ; 66V to 1000V 9.1MΩ
AC voltage (autoranging)	Ranges: 660mV, 6.6V, 66V, 660V, 750V. Resolution: 0.1mV Frequency response: 50Hz to 500Hz Accuracy: ±(2.0% rdg + 5 dgts) (660mV range at 50 to 100Hz) Input impedance: 660mV above 100MΩ; 6.6V 10MΩ; 66V to 750V 9.1MΩ Frequency (in AC V): 50Hz to 1kHz, ±(0.1% rdg + 5 dgts), minimum input above 500 dgts, shown on the sub-display
Current	Ranges: 660µA, 6600µA, 66mA, 400mA, 20A. Resolution: 0.1µA DC accuracy: ±(1.0% rdg + 4 dgts) 660µA to 66mA; ±(1.5% rdg + 4 dgts) 400mA; ±(3.0% rdg + 5 dgts) 20A AC accuracy: ±(1.5% rdg + 8 dgts) 660µA to 66mA; ±(2.0% rdg + 8 dgts) 400mA; ±(3.5% rdg + 8 dgts) 20A Frequency response: 50Hz to 500Hz. Frequency (in AC A): 50Hz to 1kHz, ±(0.1% rdg + 5 dgts), minimum input above 500 dgts, shown on the sub-display Voltage burden: 0.5V on 660µA, 66mA ranges; 2V on 6600µA, 400mA ranges Input protection: 0.5A/1000V fast acting ceramic fuse on µA/mA; 20A/600V fast acting ceramic fuse on 20A
Resistance (autoranging)	Ranges: 660Ω, 6.6kΩ, 66kΩ, 660kΩ, 6.6MΩ, 66MΩ. Resolution: 0.1Ω Accuracy: ±(1.0% rdg + 8 dgts) 660Ω, 6.6kΩ; ±(1.0% rdg + 5 dgts) 66kΩ, 660kΩ; ±(2.0% rdg + 5 dgts) 6.6MΩ; ±(3.5% rdg + 5 dgts) 66MΩ Open circuit volts: -1.1V DC (-3.2V DC on 660Ω range)
Capacitance (autoranging)	Ranges: 6.6nF, 66nF, 660nF, 6.6µF, 66µF, 660µF, 6.6mF. Resolution: 1pF Accuracy: ±(3.0% rdg + 30 dgts) 6.6nF, 660nF; ±(3.0% rdg + 10 dgts) 66nF, 6.6µF, 66µF, 660µF; ±(5.0% rdg + 10 dgts) 6.6mF
Frequency (autoranging)	Ranges: 66Hz, 660Hz, 6.6kHz, 66kHz, 200kHz. Resolution: 0.01Hz Accuracy: ±(0.1% rdg + 5 dgts) Sensitivity: 10Hz to 200kHz, above 3.5V rms. Minimum pulse width: above 5µs. Duty cycle limits: above 30% and below 70%
Diode test	Test current: approx. 0.8mA. Accuracy: ±(1.5% rdg + 5 dgts). Resolution: 1mV Audible indication: below 0.03V. Open circuit volts: 3.2V DC typical
Audible continuity	Audible indication: less than 30Ω Response time: 100ms

Support and warranty

Contact	Details
Company	Durst Industries (Aust.) Pty Ltd
Address	1/11 Packard Ave, Castle Hill NSW 2154, Australia
Phone	+61 2 9660 1755
Email	sales@durst.com.au
Website	durst.com.au
Support and warranty enquiries	durst.com.au/pages/contact

Warranty information

The DURST MM-78B carries a 1-year warranty from Durst. Contact Durst to confirm the coverage and claim procedure. This warranty is in addition to your rights under Australian Consumer Law.

Before requesting support

Have the model (MM-78B), proof of purchase and a description of the fault ready, including the function and range in use. Contact Durst before returning the meter so the correct return or service process can be arranged.

Service record

Record	Details
Model	DURST MM-78B
Serial number	
Purchase date and invoice	
Manual	DURST MM-78B Instruction Manual, revised November 2026

Date	Battery, fuse or check done	Findings and action taken	Name