SECTION 55 - ELECTRICAL SYSTEMS

Chapter 14G - Fault Codes
Semi Powershift Models from Serial No. ACM265009

CONTENT

INTRODUCTION

Fault Codes and Fault Finding

The tractors have an inbuilt self diagnostic facility. This facility utilises the digital display of the Instrument cluster and Gear display to indicate, in coded format, malfunctions in the electrical and electronic circuitry and in the micro-processor. It should be noted that the self diagnostic capability is generally limited to diagnosis of the electrical and electronic circuitry and related components, however, there are some codes, which can be generated if pressure switch circuits are not closed because of an actual lack of hydraulic pressure. Any malfunction of the mechanical and hydraulic components must be diagnosed using conventional techniques, performance characteristics and tooling, such as pressure testing equipment.

Trouble-shooting and fault finding should always be carried out in a logical and planned sequence, many apparent faults associated with electronic components are often hastily diagnosed and result in the replacement of expensive components. An extra few minutes confirming the apparent fault will result in a more positive and cost effective repair.

With the use of micro-processors it is often that this item is blamed for any malfunction but the real truth is that this item is usually sound and that the fault is due to poor contacts in the associated connectors.

Each electrical connector illustrated and identified in the wiring diagrams in Section 55 and referred to in the following fault finding procedures, has the same identification reference. For example, one of the processor connectors is referred to as Connector C537 in the illustration and also referred to as C537 in the fault finding procedure. In the fault finding procedure the connector, pin and wire colour are shown as, C537 pin 25 (U/R/B). If all the wires are the same colour, the circuit number is also included to aid in wire identification. For example, C537 pin 25 (7000T-U/R/B). This is broken down as follows:

C537	Connector number
7000T	Circuit number
U/R/B	Wire colour

All tests are carried out on the harness side of the connector, unless otherwise stated.

Refer to Section 55 Chapter 14C for complete wiring diagrams and how to use them.

Where the fault finding procedure requires checks for continuity a visual inspection of the wiring should be made prior to conducting tests to ensure that obvious ‘mechanical’ damage has not occurred to the harness or the connectors.

A good quality multi-meter is an essential item to perform fault finding. It should be capable of measuring resistance of at least 20,000 ohms and measuring voltage and current. When using the multi-meter it is good practice to select a high range and work downwards to avoid damaging the instrument. Refer to the ’Basic Multi-Meter use’ section of this chapter for further details.

IMPORTANT: *Care should be used when using the multi-meter, only use the instrument as instructed to avoid damage to the internal elements of the micro-processor. When checking the continuity of wiring, sensors or switches it is necessary to isolate the electronic micro-processor and ensure the keystart is turned off to prevent possible further damage. The keystart should only be switched on and the processor connected where specifically instructed in the fault finding procedure.*

If it is found necessary to clean the connectors a contact spray should be used. DO NOT USE ANY OTHER METHOD FOR CLEANING TERMINALS. Do not use a cleaner that contains Trichloro-ethylene, this solvent will damage the plastic body of the connector. It is preferable to use a cleaner with a Freon T.F. base.

SPECIAL TOOLS

Description	Tool No.
Electrical Repair Tool Kit (North America Only)	FNH 01000
Harness Repair Kit (Except North America)	294070
Test Probe Kit (Except North America)	297448

WIRING HARNESS REPAIRS

Temporary Wiring Harness Repair

WARNING

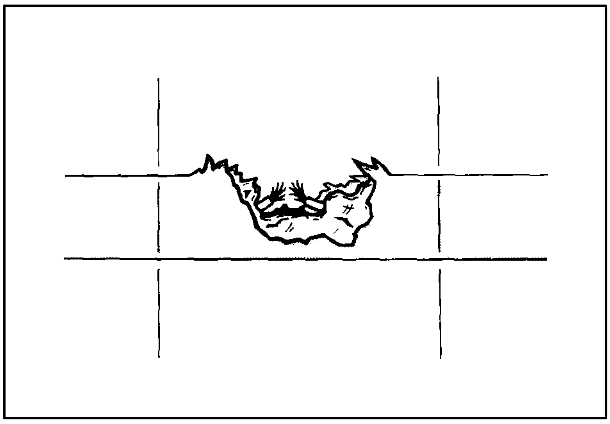
It is acceptable to use the following repair procedure on the CAN BUS wiring. It is important though to ensure that the wire lengths are not altered from the original as this will affect the performance of the CAN BUS system.

The following method to repair wiring is a temporary expedient only. Wiring should be replaced as soon as possible. Do not attempt to repair the wire on any system sensors as these are sealed and should only be replaced with a new component.

NOTE: *When conducting a cable repair it is important that only RESIN CORED SOLDER is used. Use of other types of solder may result in further cable damage.*

To carry out a temporary repair, proceed as follows:-

1. Locate damaged portion of cable then cut away outer protective cover on both sides of the damaged area, Figure 1.



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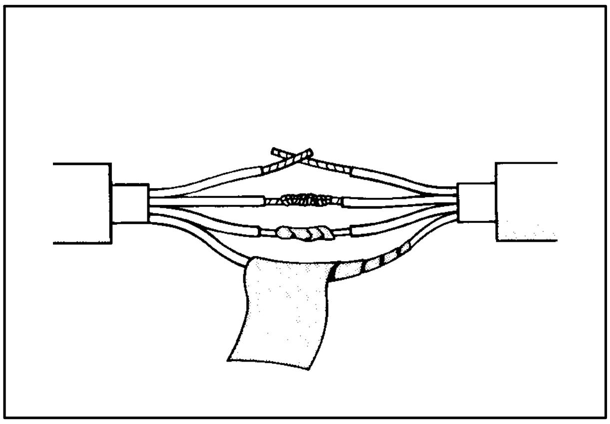
2. Using a suitable solvent, clean about 2 inches (50 mm) from each cover end. Clean the grey cable cover and the individual leads.

3. Twist two bare leads together for each damaged lead, being careful to match wire colours, then solder the leads using resin cored solder. Tape each repaired lead with vinyl insulation tape, Figure 2.



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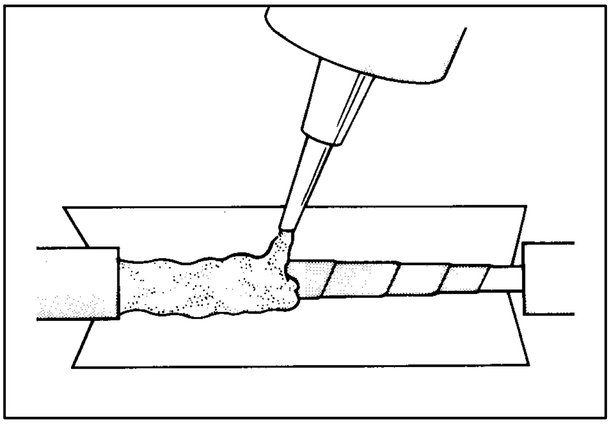
4. Wind a layer of vinyl insulation tape up to the grey cable cover at each end of the repair section. Make a paper trough, Figure 3, then apply silicon rubber compound (non hardening sealant) over the repaired section up to the cover ends. Sufficient sealant must be used to fill the ends of the cut away area.



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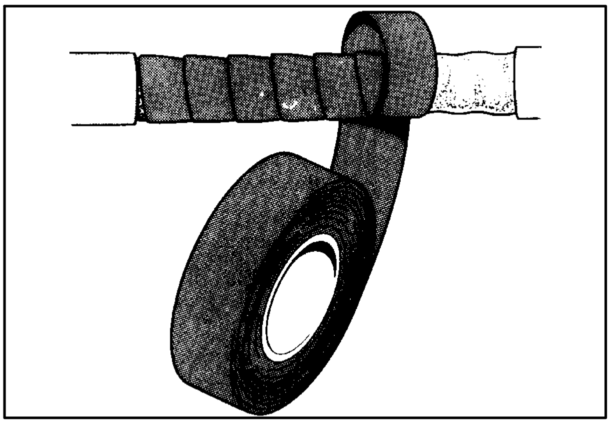
5. Allow the compound to cure then cover the area with insulating tape taking the tape well over each end of the repair. An overlap of at least 2 inches (50 mm) of tape at each end is necessary, Figure 4.

6. Check to ensure the repair is satisfactory and secure the repaired cable so that repeat damage is avoided.

NOTE: *This is a temporary repair only. Ensure the damaged cable is replaced as soon as possible to prevent ingress of water or chemicals.*



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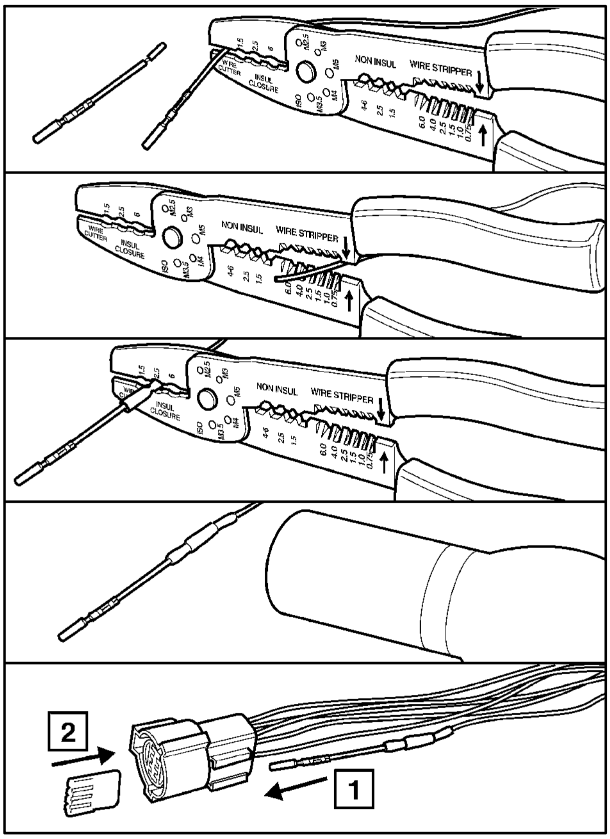
Harness Wire Replacement

If a wire within the harness is found to be beyond repair or is open circuit, a jumper wire may be installed as a temporary repair until such time when a new harness assembly can be installed. Use the following procedure to install an additional wire:

1. Locate the faulty wire using the procedures described in the fault code charts.
2. Disconnect the affected connectors.
3. If fitted carefully roll back the seal between the connector and harness outer covering.
4. Remove the pins from the connector blocks of the affected wire using the appropriate removal tool found in the harness repair kit.

NOTE: *Use the instructions supplied with the kit to ensure correct pin removal.*



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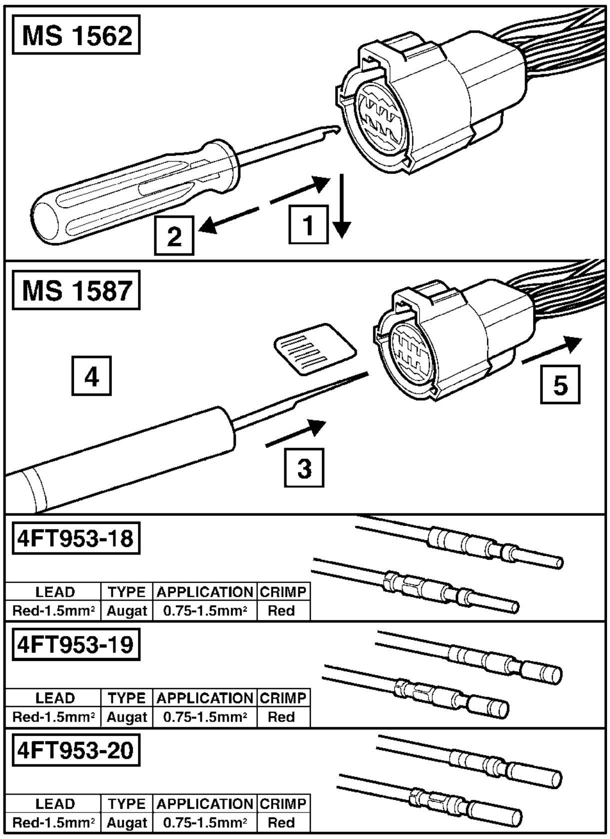
5. From the harness repair kit select the correct pin for the connectors. Obtain locally the correct cross-sectional size wire and measure out the length required by following the harness routing.
6. Join the new wire to the new pins as described in the harness repair kit and install one of the pins into its connector.
7. If possible attempt to run the new wire within the existing harness outer covering, if this is not possible run the wire along the harness, securing regularly with suitable ties. With the wire correctly routed instal the second terminal into its connector block. Replace the connector seal if removed.
8. To ensure that the repair has been effective check for continuity of the new wire using a suitable multi-meter.

NOTE: *This is a temporary repair only. Ensure the damaged cable is replaced as soon as possible to prevent ingress of water or chemicals.*



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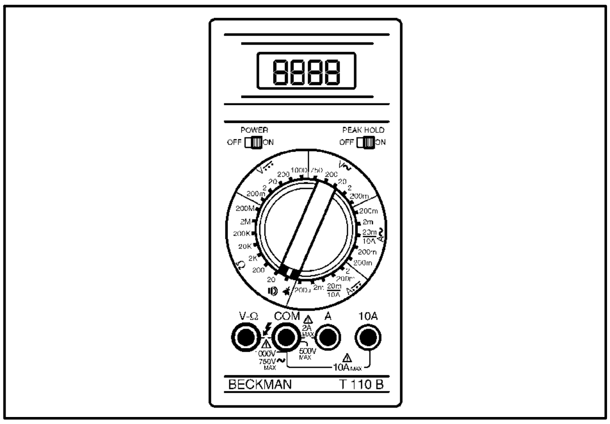
THE DIGITAL MULTI-METER

NOTE: *This section is only intended as a general guide to using a digital multimeter.*
Always refer to the manufactures operators manual for correct operation

A multimeter is an electronic measuring device. The different types of measurement that can be made depend upon the make and model of the multimeter. Most types of multimeter have the capacity to measure:

- Current (A) ac or dc
- Resistance (Ω)
- Voltage (V) ac or dc
- Continuity (Buzz test)

More expensive multimeters have other functions, such as the capacity to measure frequency (Hz) and test diodes.



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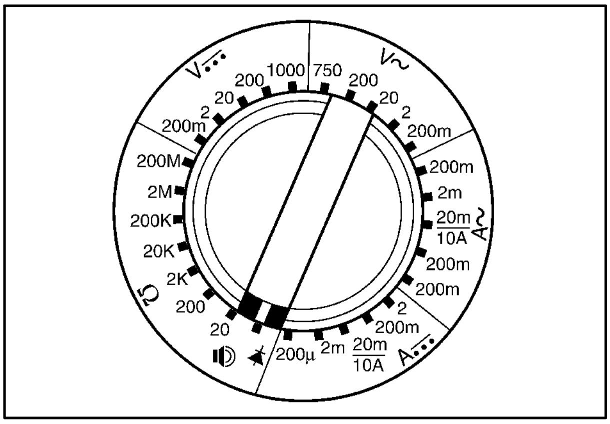
General Operation:

Before proceeding with a test, decide on what is going to be measured (Voltage, Current etc.). Rotate the dial until the pointer is within the relevant zone. Within each zone there are different scales. The scale that is selected will represent the maximum value that the multimeter will read. Always select a scale which is greater than the value that you intend to measure. If you are unsure of the value to be measured, always select the highest scale and then reduce the scale once you have an idea of the measured value.



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Why are there different scales ?

The closer that the scale is to the measured value, the more accurate the reading will be
e.g. If measuring the voltage of a battery with the scale set at 200V, the display may read 12V. However, if the scale was set to 20V the display may read a more accurate reading of 12.27V

Giga	G	1,000,000,000	10^{9}
Mega	M	1,000,000	10^{6}
Kilo	K	1,000	10^{3}
milli	m	0.001	10^{-3}
micro	µ	0.000 001	10^{-6}
nano	n	0.000 000 001	10^{-9}
pico	p	0.000 000 000 001	10^{-12}

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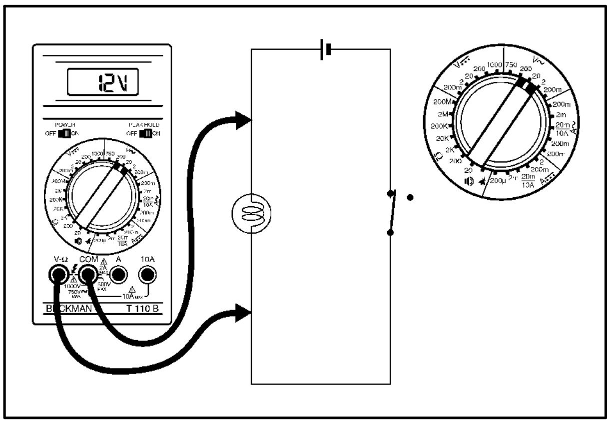
Measuring Voltage (Volts):

Set the range dial to either ac or dc volts. Connect the Black test probe to the "COM" terminal and the Red test probe to the "V/Ω" terminal. Place the test probes across the component to be measured with the circuit complete (closed). Read off the display value



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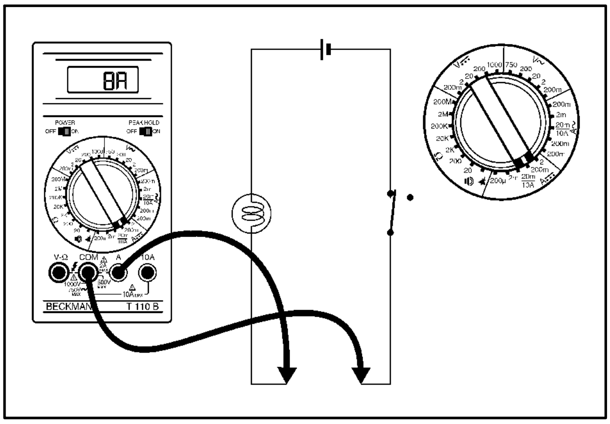
Measuring Current (Amps):

Set the range dial to either ac or dc current. When measuring current up to 2 amps, connect the Red test probe to the "A" terminal. When measuring current up to 10 amps, connect the Red test probe to the 10 "A" terminal. Always connect the Black test probe to the "COM" terminal. When taking measurement of current, always break the circuit and connect the multi meter in series with the circuit. Read off the display value.

NOTE: For protection, multi meters are usually fused at 1OA.



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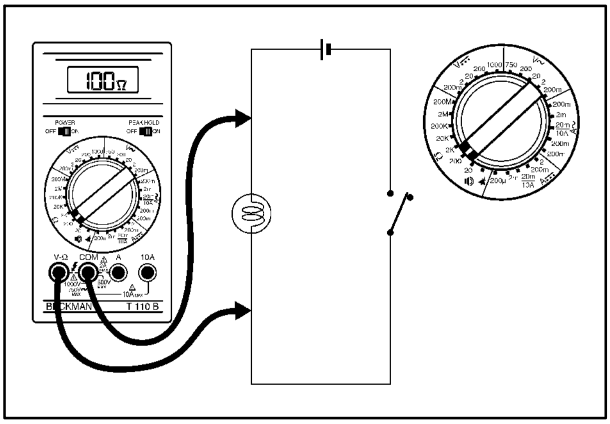
Measuring Resistance (Ohms):

Set the range dial to the desired Q position. Connect the Red test probe to the "V/Ω" terminal. Connect the Black test probe to the "COM" terminal. If the resistance being measured is connected in a circuit, then turn off the power to the circuit. Connect the test probes to the measuring point and read off the display value.



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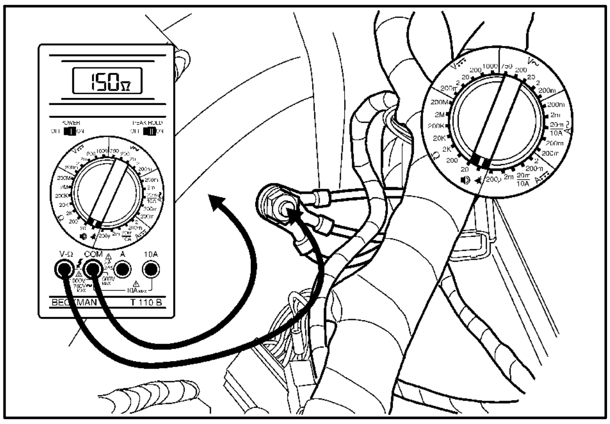
Continuity (Buzzer) test:

Set the range dial to the “Buzz” position. Connect the Red test probe to the “V/Ω” terminal. Connect the Black test probe to the “COM” terminal. Connect the test probes to the measuring point. In general, if the resistance is less than 50Ω then the buzzer will sound, indicating continuity.



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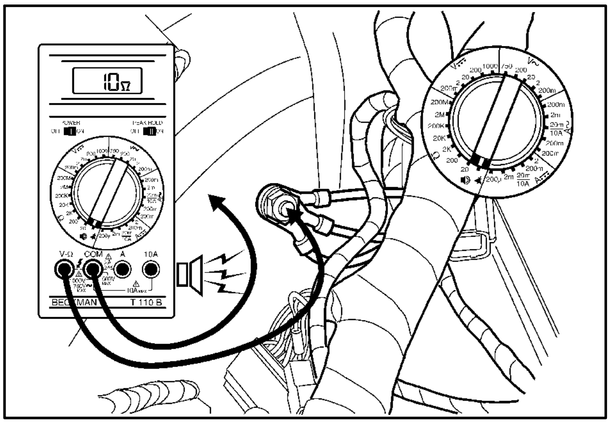
Note: Buzzers on different multi meters will sound at different ohmic values, depending on the quality of the meter. This can often be misleading. For example, when checking a corroded earth point. A poor quality multi meter may buzz at 150Ω, indicating continuity and no problem. When using a higher quality multi meter for the same test, it would not buzz due to the high resistance. When carrying out such tests, we should always check the value of resistance as well as listening out for the buzz.

A good connection gives low resistance.

A bad connection gives high resistance.



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SUMMARY:

When measuring -

Voltage (V):
Connect across the component with the circuit closed.

Current (A):
Connect in series with the circuit. Circuit closed.

Resistance (Ω):
Connect across the component with the circuit open.

Continuity (Buzz):
Connect the meter across the component with the circuit open. (Always check the value of resistance as well!!)

ELECTRICAL TEST PROCEDURES

Four electrical tests will be required to properly troubleshoot electrical concerns on the vehicle.

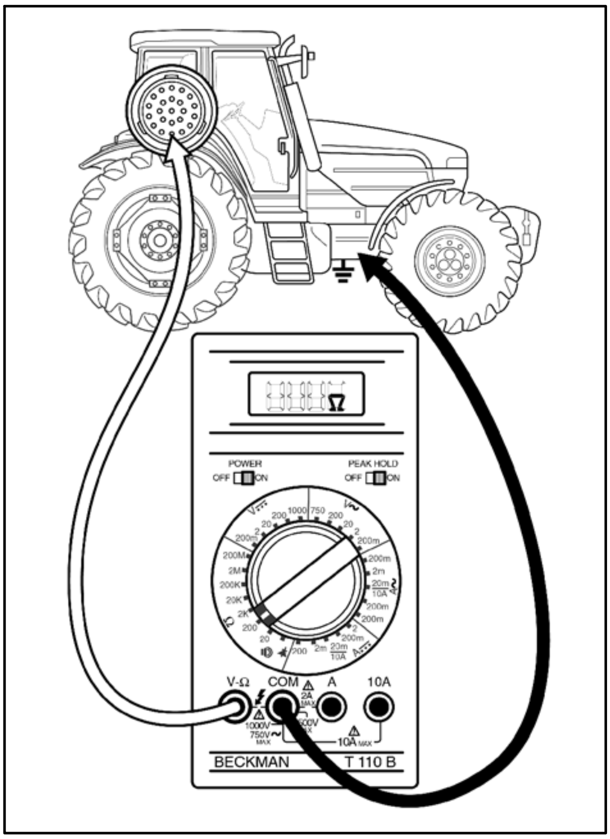
Each test is described in detail. Ensure that all steps are reviewed and followed when testing.

1. Continuity Test, Short to ground
2. Voltage measurement, short to 12 volts
3. Resistance test for components
4. Continuity test, Open circuits

ELECTRICAL TEST PROCEDURE 1: CONTINUITY TEST - SHORT TO GROUND

CONDITIONS FOR PERFORMING TESTS:

1. Power OFF, Keyswitch OFF, (sometimes battery disconnected or fuse pulled out if specified in procedure).
2. Connectors at each end or ends of circuit disconnected to prevent false readings.
3. Set meter to measure resistance or ohms, and measure circuit resistance. Use black lead to make contact with a plated metal part on the chassis such as a jump start post if fitted. Make sure the surface of the part is not corroded. Use the red meter lead to touch the connector pins, one pin at a time, and avoid contact with the case of metal connectors.
4. Determine if measured resistance falls within guidelines specified in the procedure. 3 to 4 ohms indicates a direct short to chassis ground and must be located and repaired. Higher resistances usually indicate circuit paths through modules, and that an additional connector needs to be disconnected to perform the test. More than 100K ohms indicates that the circuit is free of shorts to ground.



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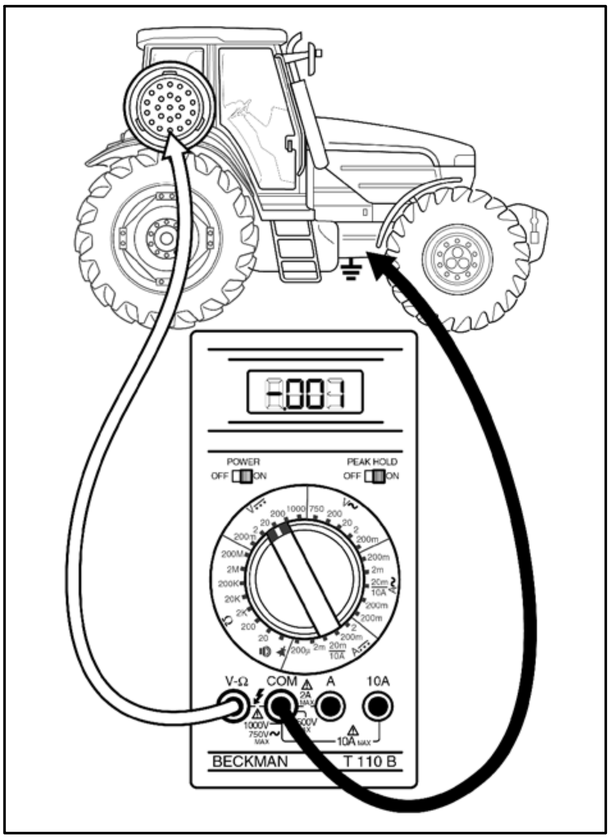
ELECTRICAL TEST PROCEDURE 2: VOLTAGE MEASUREMENT OR SHORT TO POSITIVE SUPPLY VOLTS

CONDITIONS FOR PERFORMING SHORT TO POSITIVE SUPPLY TESTS:

1. Keyswitch ON (sometimes OFF, if specified in procedure).
2. Connectors at sensor, switch or potentiometer end disconnected. All other connectors must be reconnected to perform test.
3. Set meter to measure DC VOLTS, and measure circuit voltage as illustrated. Use the red meter lead to touch the connector pins, one pin at a time, and avoid contact with the case of metal connectors. Use the black lead to make contact with a plated metal part on the chassis such as a jump start post if fitted. Make sure the surface of the part is not corroded.
4. Determine if measured voltage falls within guidelines specified in the procedure.



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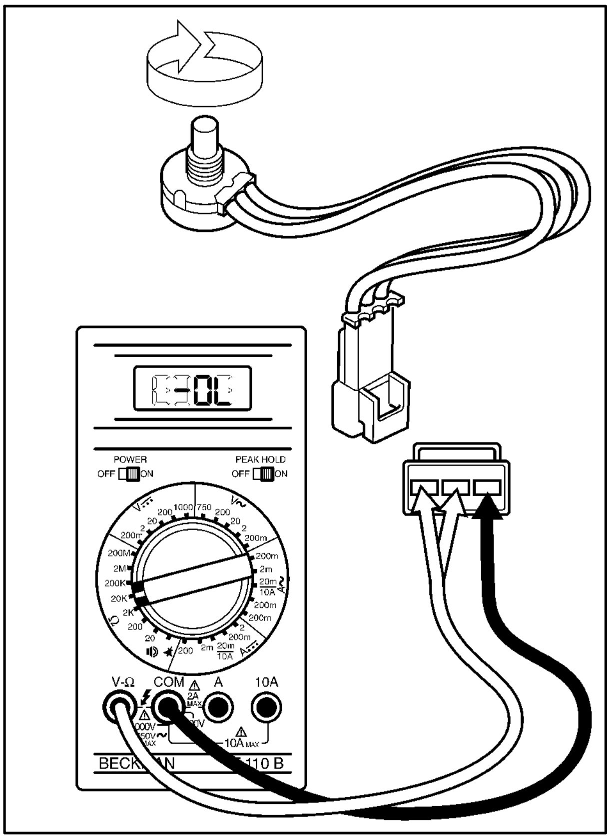
ELECTRICAL TEST PROCEDURE 3: RESISTANCE TEST FOR ELECTRICAL PARTS

CONDITIONS FOR PERFORMING RESISTANCE TEST

1. Disconnect tractor part by unplugging electrical connectors to expose the part assembly connector for testing.
2. Set electrical meter to measure resistance or Ohms and insert test probes into connector terminals specified in procedure. When checking potentiometers, measure from wiper terminal to each of the other terminals while TURNING THE POT SHAFT. This will ensure no open spots escape detection. When checking rocker or rotary switches, actuate the switch while measuring for opens and shorts.
3. Compare measured values to values specified in the fault code procedures. Allow plus or minus 5 percent of range tolerance for all measurements.



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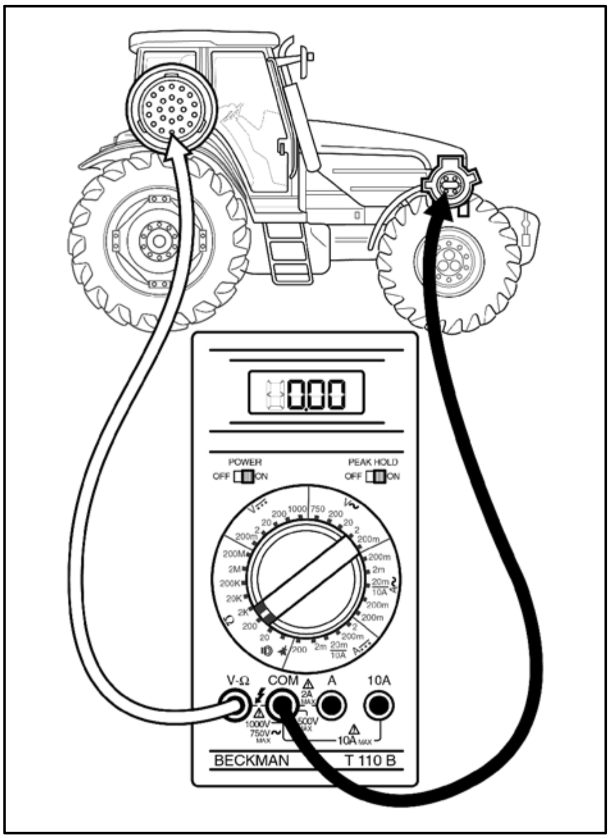
ELECTRICAL TEST PROCEDURE 4: CONTINUITY TEST - CHECK FOR OPEN CIRCUITS

CONDITIONS FOR PERFORMING CONTINUITY TESTS:

1. Keyswitch OFF (sometimes disconnect battery or pull fuses).
2. Connectors at both ends of the circuit disconnected. All other connectors must be reconnected to perform test.
3. Set meter to measure resistance or ohms, and measure circuit resistance as illustrated.
   Use the red meter lead to touch the connector pins, one pin at a time, and avoid contact with the case of metal connectors.
   Use the black lead to make contact with the connector pin at the other end of the circuit. Avoid contact with other pins in the connector and the connector case, if it is metal.
4. Determine if measured resistance falls within guidelines specified in the procedure. If the resistance is no more than 3 to 4 ohms, the circuit is continuous. More resistance usually indicates dirty or corroded terminals in connectors, and 100K ohms indicates an open circuit.



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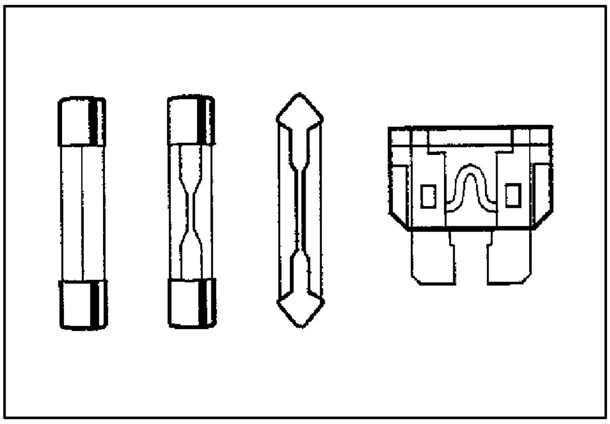
CIRCUIT COMPONENTS - BASIC DESCRIPTION

CIRCUIT PROTECTION DEVICES

Circuit protection devices are used to protect wiring and components from excessive current. Three different types of protection are fitted in tractors. Two of them (fuses and fusible links) are currently used, while circuit breakers are no longer used.



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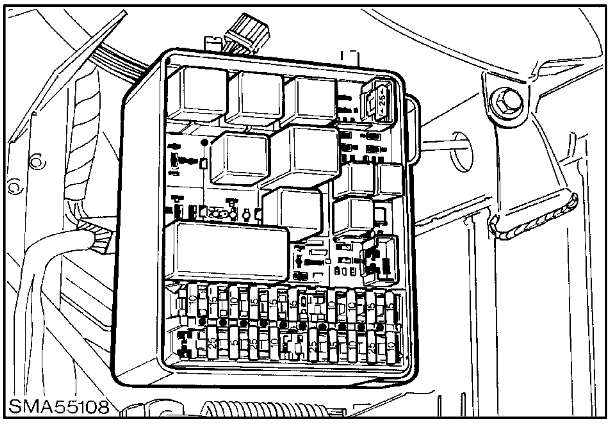
FUSES, FUSIBLE LINKS

Fuses and fusible links protect circuits with thin pieces of metal and wire which heat up and melt to open up the circuit when too much current flows through them.



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Fuses are used to protect the circuit from overload. This can occur in the event of a short circuit or by connecting equipment which demands a current greater than the circuit is designed to carry.

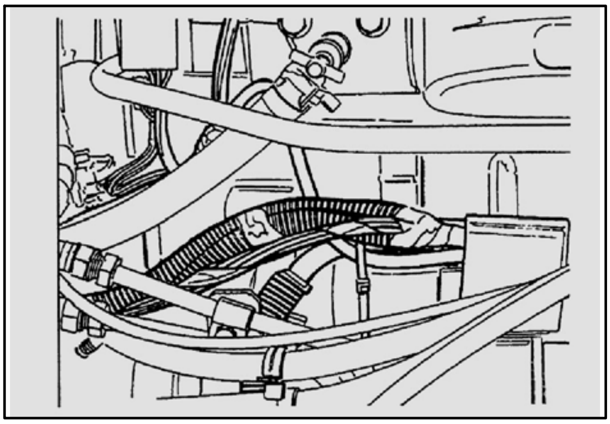
There are several types of fuses, but they all consist of a metal conductor which is capable of carrying a limited current. If the specified current is exceeded then the metal conductor will overheat, causing it to melt and break. This will in turn cause an open circuit.

The rating of the fuse relates to the current that the fuse can carry continuously.

If a fuse blows, it must be replaced with a fuse of the correct rating, and if it blows again, then the cause must be investigated.

FUSE LINKS

A fuse link is a wire that acts like a fuse, breaking down and causing an open circuit when the current that passes through it exceeds a certain amperage. For primary fuse protection the main supplies from the starter solenoid are fitted with fuse links.



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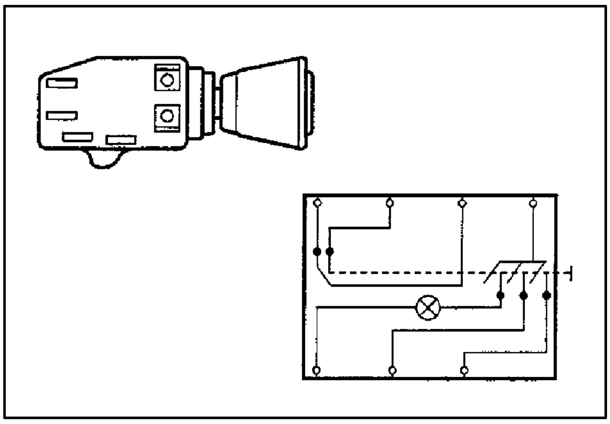
CIRCUIT CONTROL DEVICES

Some of the components in a circuit are used to interrupt and direct current flow either through an action of the operator or automatically. The current interrupters you are probably most familiar with are switches.



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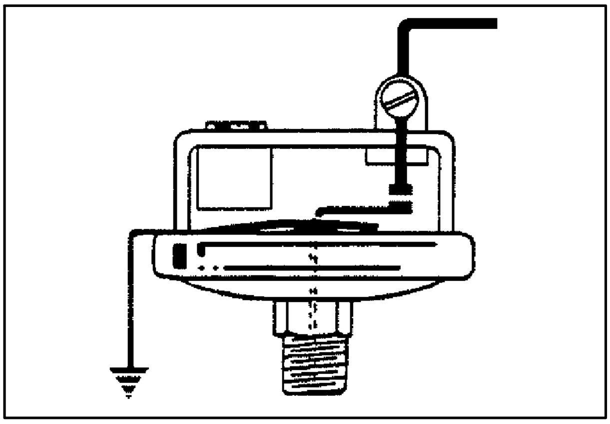
SWITCHES

Switches are a vital part of an electric circuit, providing a method of controlling the circuit itself. One switch can control a number of different circuits at the same time. This is achieved by having several separate connections and/or multi-connector switches (several switch 'positions').

There are several types of switch, and they may incorporate a warning light.

Switches can be as simple as that used to turn on an implement lamp or as complex as the ones used to operate the starting and lighting systems. Checking the operation of switches is usually just a matter of testing for power going into the switch and for power leaving the switch at the appropriate contacts when the switch is operated.

One of the most common type of switches is the pressure switch (Fig. 23), a switch opened or closed by a fluid pressure. An example of this type of switch is the engine oil pressure switch, a simple on/off device that opens (or closes) when oil pressure rises above 10 psi.



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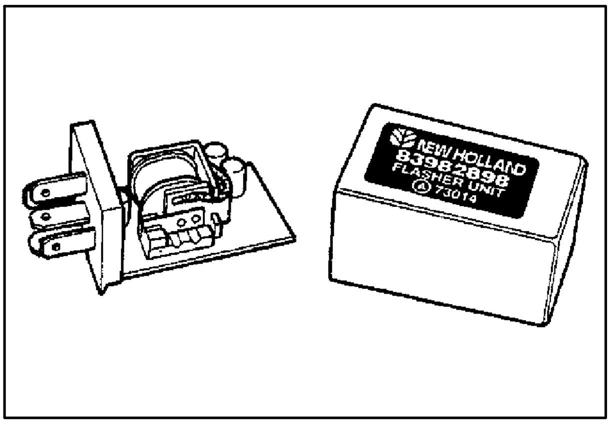
FLASHERS

Flashers work automatically to interrupt and connect the flow of current. Their operation is similar to that of the circuit breaker described earlier.

In the flasher, a heating element warms a bimetallic strip. The strip bends, breaking contact with the power source. When it cools, the bimetallic strip once again makes contact and the process begins again.



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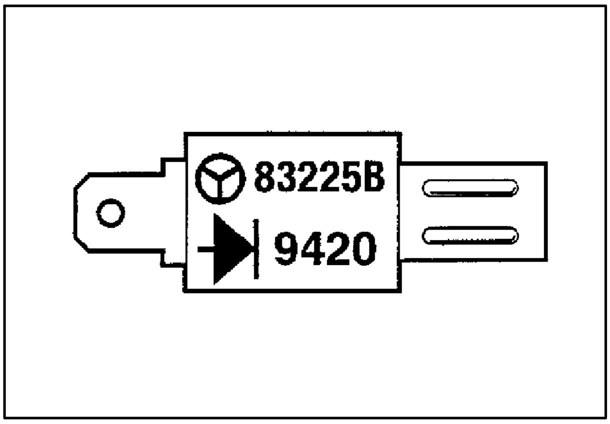
DIODES

Some components use a semiconductor material instead of moving parts to direct current. Diodes for example, allow current flow in one direction only.

They are essential in converting the alternating current that an alternator produces to the direct current that the tractor electrical system components use.



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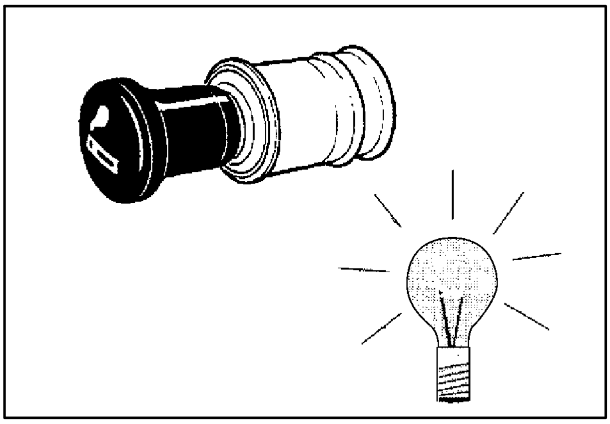
RESISTANCE DEVICES

A number of electrical components alter or make use of electricity through their resistance to current flow. Resistors are components which are generally used to regulate the supply of voltage and current to other electrical components.

In some cases, the purpose of resistance in an electrical circuit is to provide light or heat. Lamps and cigar lighters are examples. Lamps convert electricity into light, and cigar lighters convert it into heat. Both lamps and lighters make use of the same physical principle, that is Ohms Law.



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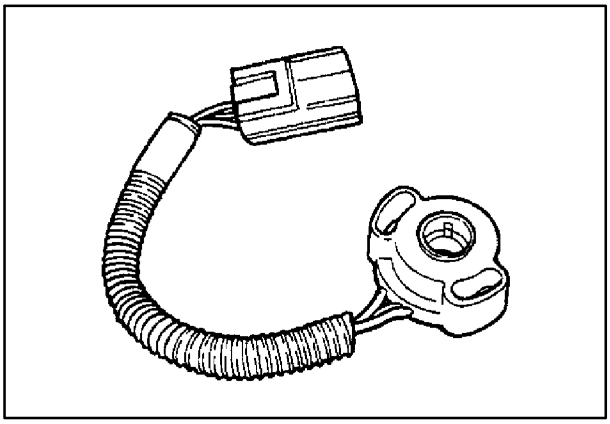
POTENTIOMETERS

Potentiometers are variable resistors which are dependant on mechanical movement, i.e. Lateral float movement, to vary the resistance of the component and therefore alter the output voltage.

In order to verify the correct operation of a potentiometer, the resistance should be measured at the minimum and maximum positions and a smooth and continuous change of resistance should be observed between. As the resistance varies with temperature, the test specifications are usually given at 20 °C.



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ELECTROMAGNETIC DEVICES

In general, they use the magnetic field created by flowing current to move metal parts within the components.

RELAYS

The relay is an electromagnetic switch that uses a small amount of current to switch a larger amount on and off.

When the operator closes a switch, current flows through the relay's control circuit. In this circuit there are windings surrounding an iron core which is fixed in place (see Fig. 28).

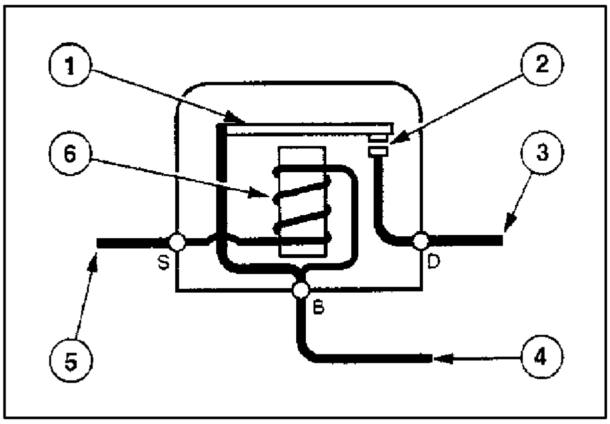
Current turns the iron core into an electromagnet. The core then attracts an arm which has a contact point on it. When the point on the arm contacts the stationary point, current flows through the power circuit.

Relays are basically electrically operated switches. They are used to switch a circuit on/off in similar way to a manual switch.

Two circuits are connected to the relay:

- A work circuit, which is switched on/off by the relay, and provides the supply for the equipment to be operated, i.e., bulbs, solenoids, etc.;
- A control circuit, switched on/off by manual switches, used to operate the relay.

The part of the relay which is connected to the control circuit consists of the winding of an electro-magnet. When the control circuit is switched off, the contacts are kept apart by a return spring. When the control circuit is switched on, a current flows through the coil and a magnetic force is produced. This force, which is stronger than the spring pressure, pulls the contacts of the relay together, causing the work circuit to operate.



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A switch-relay system has two main advantages over a simple switch:

- The current that flows through the switch is not the same as all the current requested by the equipment to be operated, but usually by a smaller current: this allows the usage of smaller and less expensive switches;
- The distance from the supply, to the equipment, can be made as short as possible to minimise voltage drop.

There are several types of relays. They can be normally open or normally closed. They may have internal electronic circuits to give special operating features. For example, they can turn the switch on/off at timed intervals (flasher relay), be sensitive to current, temperature, etc. The relay cover usually gives information about the features of the relay.

On the relay cover there are usually 4 or 5 terminal markings :

- 30: input terminal direct from battery positive, normally live.
- 85: winding output terminal, usually to ground.
- 86: winding input terminal.
- 87: output terminal for normally closed contact.
- 87a: output terminal for normally open contact.

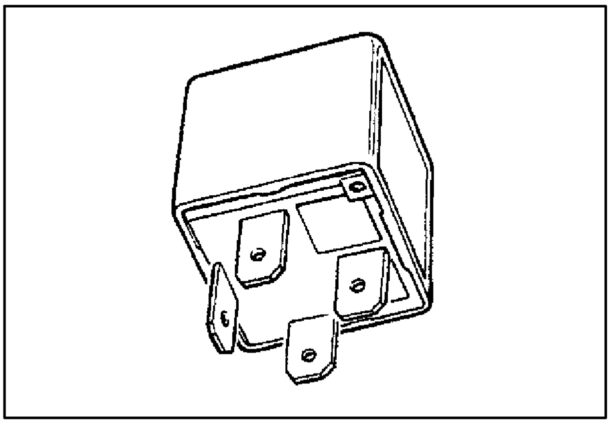
Brown relays are normally open relays, blue ones are normally closed.

SOLENOIDS

Solenoids (Fig. 30) work in much the same way as relays, except that the iron core is not fixed in place. As a result, the windings in the control circuit cause the iron core to move.

In the starting system, for example, the movement of this core is used to send large amounts of current to the starter motor.

A solenoid is basically a winding around an iron core. In the centre of the core there is a plunger which is free to move through the core. When an electrical current passes through the winding an electro-magnetic force is produced which causes the plunger to move through the core. If the current is switched off, the magnetic force is stopped and the plunger is returned by a spring.



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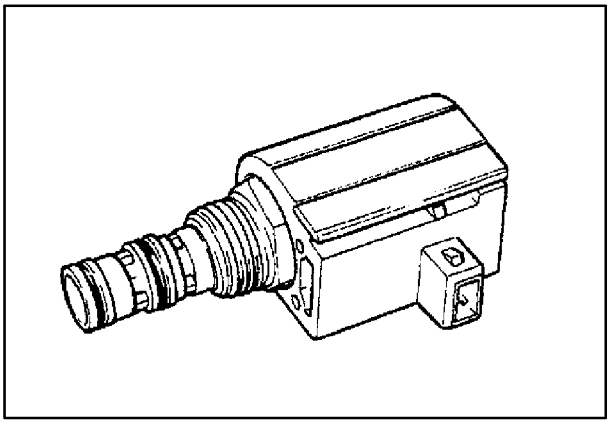

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The solenoid plunger may have different uses: the most common are moving a hydraulic spool or a mechanical lever.

The use of solenoids to control hydraulic pressure instead of the hydraulic valves is highly recommended wherever there is a long distance between the control panel and the valve (more than 10 meters) or a fast action is required.

A coil should:

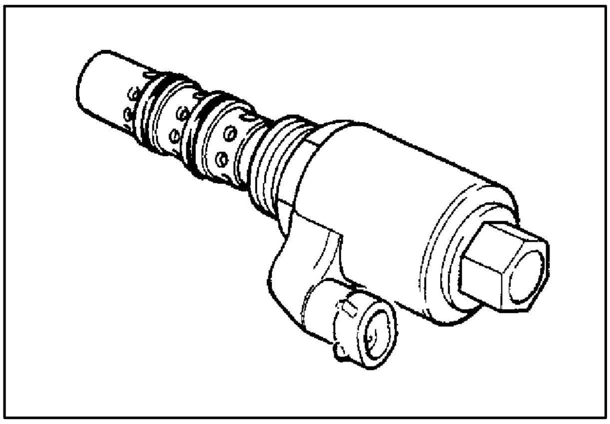
- Be non-sensitive to vibrations;
- Be silent in operation
- Have large frequency of activation (30-35 times per second)
- It should be possible to fit it in any position.
- Be insulated, in order to function correctly for a wide range of temperatures (-40 to +85°C), and with high humidity conditions.

The MOST COMMON FAULTS that can occur are:

- Short circuit winding: if a section of the winding allows the current to pass directly from positive (+) to negative (-) terminals without passing through the winding, this will cause the relevant circuit fuse to blow.
- Broken winding: causing an open circuit, it will not allow the current to pass through the winding, so the solenoid will not operate.
- Seized plunger (and/or connected components): the solenoid will only move the plunger if all components are free to move.

PWM SOLENOID VALVES

Whenever it is necessary to provide proportional control to the solenoid valves, it is much better to use a principle of operation called pulse width modulation (PWM). PWM is a variable DC voltage signal that is used to control the solenoid valves. The voltage signal is pulsed on and off many times a second (at a constant frequency of 500 Hz) at a constant supply voltage of 12 V.



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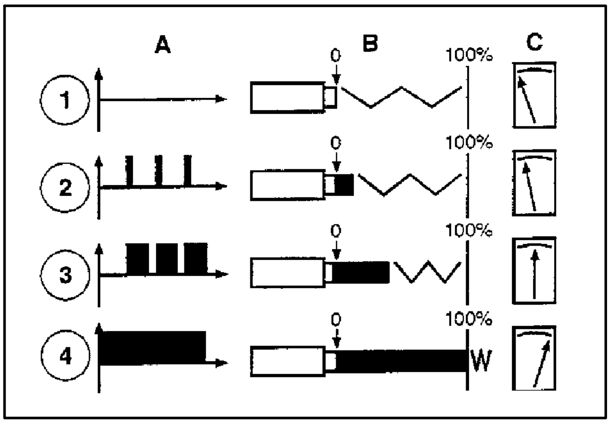
The processors contain transistors that are supplied with a constant input voltage which is switched on and off to achieve the variable input range. In this way the control module is able to limit the armature movement, so the hydraulic output flow of the solenoid is proportional to the average DC voltage. The lower voltage also allows the solenoid to operate with less residual magnetism and so the entire circuit will operate smoother.

The variable DC voltage signal level is determined by varying the duration of the ON pulse relative to the OFF pulse (see Fig. 32). The ratio between the ON time and the cycle time is called duty cycle and is stated as a percentage of one complete cycle.

With reference to Fig. 32, diagrams 1 to 3 show the normal operating range of the PWM valve, and diagram 4 shows the initial 12V programming and fill time only. The diagrams in column A show the voltage signal that is sent to the valve, whereas column B shows the relevant spring pressure and column C the reading on a voltmeter connected to the solenoid valve.

Diagram 1 shows the OFF position: no signal is directed to the valve, which means no spring pressure in the valve at all and results in a zero voltage reading. Increasing the duty cycle causes some pressure to be made on the circuit (Diagram 2), which results in a voltmeter reading increase. Diagram 3 shows the maximum signal that is used during the normal activity of the valve: its duty cycle is around 0.5, which results in a spring pressure for the half of its run and in an indication of a 6 volt average DC current.

The electrical circuit to the solenoids can be checked by using a digital or analogue DC voltmeter, which will indicate the average voltage readings.



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SENSORS

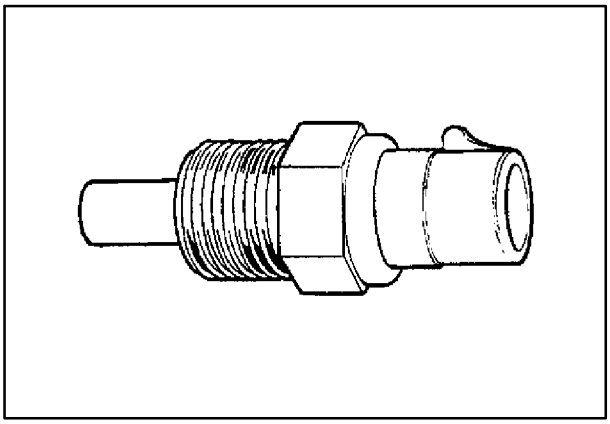
A sensor is the primary component of a measurement chain that converts the input variable (temperature, capacitance, reluctance) into a signal suitable for measurement. The relationship between the input variable and the measured signal is a characteristic of the sensor.

In the above mentioned measurement chain the signal is filtered and treated in order to adapt it to its use. It consists of three elements: the sensor itself; the converter, which converts the output signal from the sensor (in most of the cases into an electric signal); and the conditioner, which transforms the output signal from the converter in the most suitable form. Generally the term sensor indicates the entire measurement chain.

TEMPERATURE SENSORS

Generally based on a simple circuit with a thermistor. A thermistor is a resistor that changes its resistance according to the temperature.

There are two groups of thermistors: NTC (Negative Temperature Coefficient) and PTC (positive Temperature Coefficient). In the first case the higher the temperature, the lower is the resistance, and for the PTC the higher the temperature, the higher the resistance. The NTC are often used as sensors to indicate temperature change in fluids, such as the engine coolant fluid.



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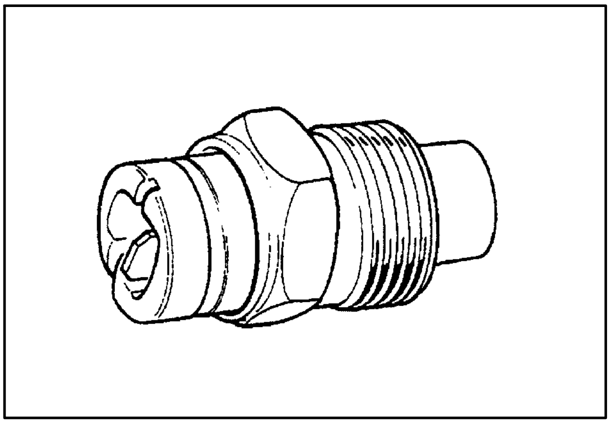
An example of these type of senders is the coolant temperature sender. The changes in its resistance (which varies with temperature) are relayed to the Instrument Cluster, which operates the bargraph and the warning indicators accordingly.

PRESSURE SENDER

A pressure sender receives a supply signal and it varies it according to the (oil) pressure. An example is the oil pressure sender, which receives a 5 volt signal and varies it according to the oil pressure. The Instrument Cluster keeps track of these variations and changes its readouts and warnings accordingly.



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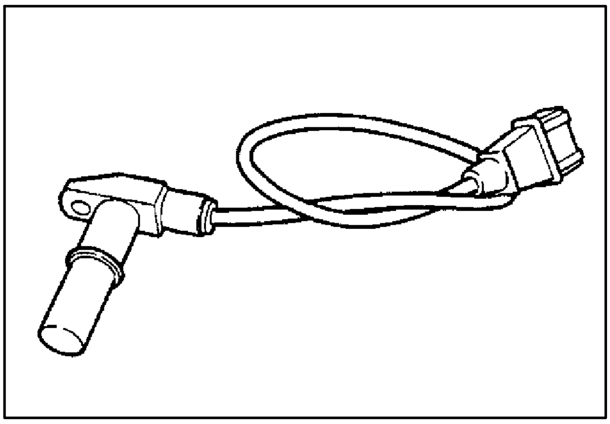
SPEED SENSOR

The speed sensor is typically a reluctance sensor. An example is the axle speed sender, which is fitted into the transmission and gets pulses off the gears, counting the gear teeth. The sender uses a pickup coil close to four wheel drive coupling. The action of the gear close to the pickup creates pulses which are relayed to the Instrument Cluster. The Instrument Cluster converts the frequency of the pulses into ground speed.

Possible failures are due to vibration, open circuits.



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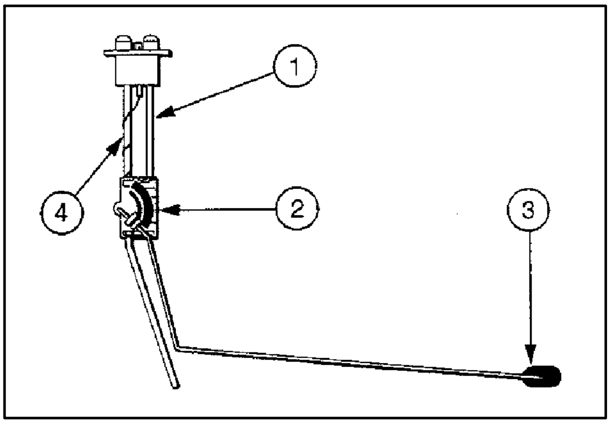
FLUID LEVEL SENDER

It operates by varying resistance through the movement of a float. An example is the fuel level sender.



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