Towbar Wiring Essentials

Ryder Towing Equipment Ltd

Training Manual

2008

Quality, Service, Innovation

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The Training Manual For Towbar Electrics

This manual has eight modules, covering key topics relating to Towbar electrics.

Each module except 3 and 4 has a guidance section and a review section.

- Each Guidance section contains information and best practice.
- Each Review section is a form of self-evaluation chart and is to be used by the trainee during their everyday work, to judge their own performance against the standards indicated. The principle of the reviews is to harness the natural enthusiasm most people have to measure their own work against the highest standard.

Modules 3 and 4 do not have review sections because they are concerned with background information. They do, however, contain their own exercises.

Guide To Sections

TB1: Selecting and Fitting Relays: Guidance Notes

12N: Road Lights

Initial Checks

The questions in this section point you at the checks you should do:

Check the operation of all lights and other functions on your check lists
Check that no warning lights are on to begin with (i.e. that there are no existing faults before you start.)
Take individual rear bulbs out, switch on and look for bulb-failure warning - (perhaps not the preferred option if multiplexed)
Look at high level lights, etc. and see if they are original equipment.
Look in the handbook to see if multiplex systems are mentioned.
Tell-tale signs are not obvious but some multiplex junction boxes have few (e.g. three) wires going in, including at least one thick one, and many coming out to feed the lamps. (*Volvo Merc's, Citroen have many cables running in all directions. On the other hand, Honda Fog Lamps show no unusual signs.)*

Reason for choice - Good reason to fit bypass relays are:

To reduce voltage drop and ensure brighter trailer rear lights.
Convenience: you can use the same technique for every car.
Because you detected bulb failure devices.
Because you could not be certain whether there were BFD's.
Because the car has a computer and/or multiplexing.
Because the fuse on the light circuit was shared by something else that you did not want to put at risk. (E.g. The fog light circuit on some Honda Accords shares a fuse with a computer processor unit.)
Because the vehicle wiring size is inadequate to carry additional loads
Because vehicle fuses are already carrying currents close to capacity because of shared functions

For **details of what different relays and monitors do**, see "The Practical Guide for Towbar Fitters" from Ryder Towing. It is included in the CD ROM "Trailing Success".

How did you test?
You should test with a test board with standard bulbs to simulate the conditions with a trailer attached. Test with the engine both running and stopped. Test flasher monitors with the engine both idling and slightly revved.

Current rating of relays: check that it is adequate for the job.

Read the rating on the relay cover.
Check it with your supplier.
Look it up in a catalogue.
Check it with your supervisor.

TB1: Selecting and Fitting Relays: Guidance Notes (2)

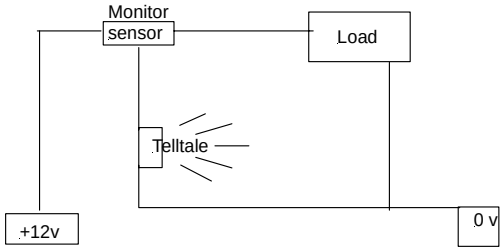
Monitors

Monitors detect current passing through or detect the level of voltage in the circuit they are connected to.

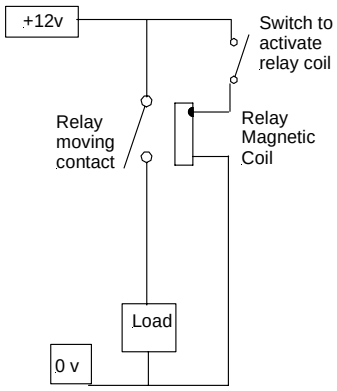
When the predetermined current or voltage is detected, they send out a tell tale (warning) signal.

Monitors are not switches. If you want a monitor to control a circuit you have to attach a relay, in such a way that the tell tale signal energizes the relay coil.

Monitor



Relay



Relays

The relay's moving contact arm has a spring which pushes it away from the coil and an iron pad which is pulled towards the coil when the coil is energized (and becomes a magnet).
Contacts are the most vulnerable part of any relay. Strong currents cause pitting, sticking, etc. Pitting makes sparking worse - relay deteriorates.
Contacts may be Normally Closed (N.C.) that is `ON' when relay coil is NOT energized or Normally Open (NO) that is `OFF' when relay coil is not energized.

Quality

It makes sense to use relays rated sufficiently high to handle expected currents, very easily with capacity to spare, to switch high currents, the relay needs good contacts, a strong spring (to move contacts to `off' position quickly to reduce sparking) and a coil with many windings to make a strong magnet to pull the contacts `ON' quickly.
Small relays suitable for high current often feel hot. This is O.K.

TB1: Selecting and Fitting Relays: Guidance Notes (3)

2S: Supplementary (Caravan) Circuits

Power Supply: Possible sources

A Direct from the battery - ideal (NB. Protect memories etc. don't disconnect battery)
B To a large cable close to battery under fuse box
C To a large cable in rear of vehicle
D To the manufacturer's supplied connection point.

Notes

B/C Check cable has enough capacity (see R2)
Find out what is carrying already. Use an **induction ammeter**

D Check
- Handbook
- Wire size
- Fuse supporting it
- Other circuits.

Fusing and cable runs: See TB2 for reference information.

Testing relay is off when starter motor is cranking:

Use a bulb or a meter on relay output during cranking.

Air conditioning

Warn driver - Explain problems of over consumption
Driver needs to take this into account
Self switching relay should be off if the car's charging circuits are overloaded

Testing a self switching combination relay

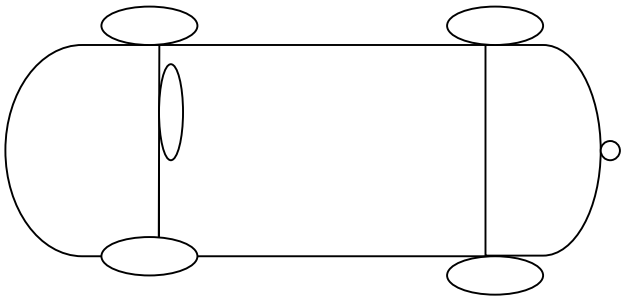
You need to put a significant load on the relay output, Pins 2, 4 and 6 (i.e. approx 10 amps) to test the self-switching relay's operation.
Check:
Did you ensure sufficient air space was available around the self switching relay to ensure adequate cooling? Can you indicate the approximate temperature of a self switching relay under load conditions?

Tb1: Review- Selecting And Fitting Relays
Name: Date

12N: Road Lights –
Vehicle Make & Type:
Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
Initial checks on the car electrics: How did you check:		
That all lamps were working properly		
That no warning lamps were on before you started		
For any special circuits (e.g. Customer add-ons) to take into account		
Whether the car had bulb failure warning devices		
For a computer and/or multiplex circuits controlling lights or accessories		

Where did you fit relays and/or monitors and how did you decide?				
Circuit	**Checks you did**	**Type fitted or "None"**	**What does the relay/monitor do?**	
Flasher				
Stop				
Tail				
Fog				
Reverse				

How did you test your 12N installation?		
When choosing relays that can do the job, how do you check the current rating of the relays you select?		
12S: Supplementary (Caravan) Circuits **Did you fit a 12S System? (*If no:* ignore this section)**		
Where did you pick up your power source?		
How did you prove it was adequate?		
Where did you fuse it? (Connectors, fuses and cables are dealt within their own review)		
 Show cable routes connections, relays, fuses etc:		
Did you fit a relay (If no, give your reasons: normally a relay is essential).		
Did you fit a conventional relay? ***If Yes***: Where did you pick up the trigger current?		

Was the trigger current source "*Off*" • When the ignition was off? • When the starter motor was cranking? • How did you test that?		
Did the car have air conditioning? If yes, how did you deal with the potential conflict (overloading) between the Air Conditioning and the 12S system?		
What reasons did you have for selecting the relay you fitted?		
Describe how you tested the 12S system when you finished fitting it.		

You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award. Total score	

A. Total possible score:	B. Your Score:	A/B x 100= %	%

Start time: End time: Duration (Hrs) .

Tb2: Fuses, Connectors and cables: Guidance Notes

FUSES
Did you use the correct value?

Load calculation: Bulb (5w 10w 21w)

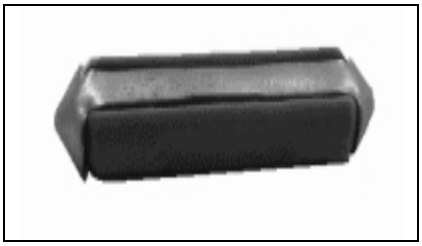
Volts x Amps = Watts
Watts divide by Volts = Amps

Add bulb values together e.g. (5 w + 5w+ 21w +21w = 52w)

Divide the total by the volts e.g. (52 watts divided by 12 Volts = 4.333 Amps)

Did you make the best selection by type?

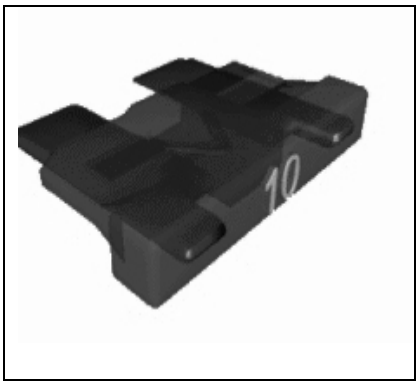
Ceramic inline holder with screw terminals



Advantage: Very neat, quick fitting

Disadvantage: Cheap versions not very accurate
(Use brass type only)

Blade type in fuse holder connected by crimp receptacle

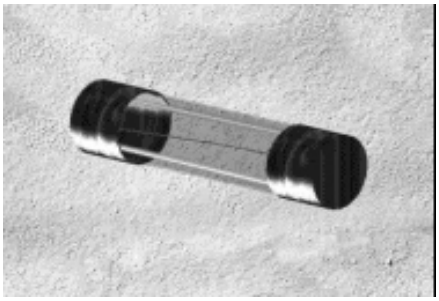


Advantages: accurate available, easy to see/change etc.
Motor Industry standards

Disadvantages: More work to fit (2 crimps)
Slightly more expensive.

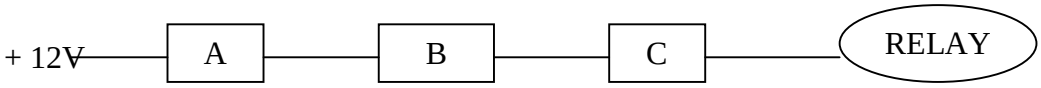
Tb2: Fuses: Guidance Notes(2)

Glass type in holder with flying leads connected by butt connector



Advantages: Cheap
Disadvantages: Not accurate, old fashioned, poor quality control, fuse holder often under-rated

Did you fit the fuse in the right place?

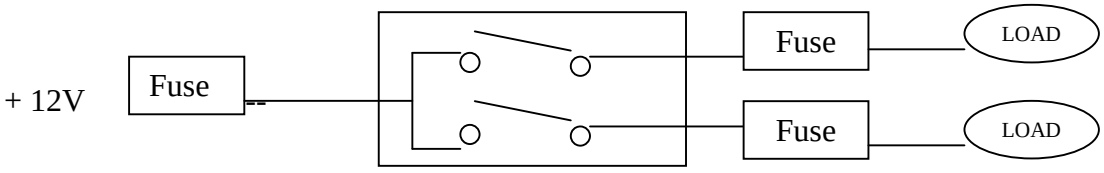


The fuse should be at A to protect the cable run in case of a short. If it is at B or C, a dead short between source and fuse could cause a fire and/or damage the power source.

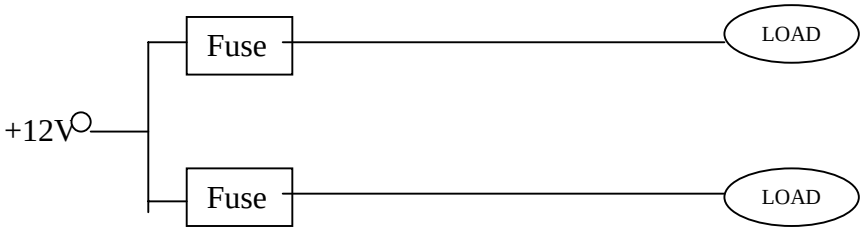
Did you fit the correct configuration?

Some configurations use more fuses than others. Accessibility could be a factor in your decision to which configuration to use. Examples A, B + C show acceptable configurations.

A



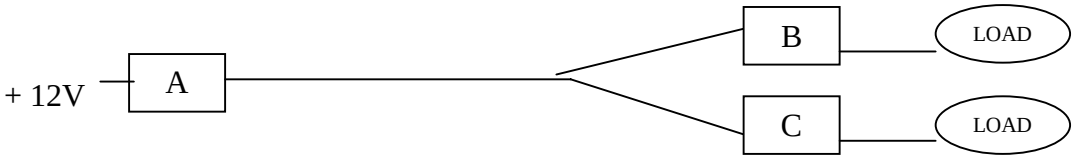
B



Circuit B only requires two fuses but needs two long runs of cable

Tb2: Fuses: Guidance Notes(3)

C



Circuit C requires three fuses because the long single cable run has to be protected by Fuse A

Connectors

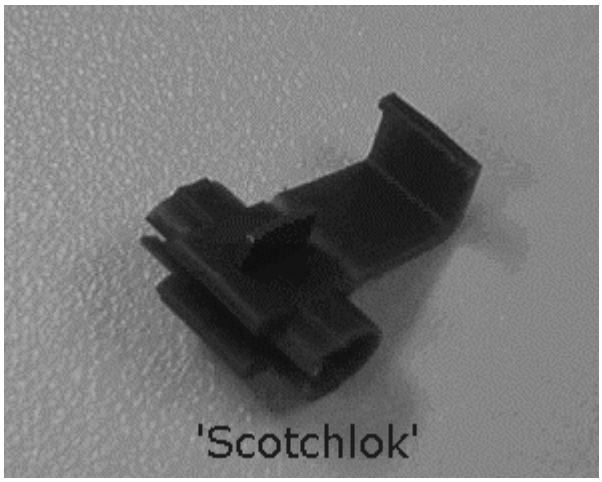
Introduction

There are many views about connectors and a good deal of misunderstanding. Basically, most connectors can be used safely if they are properly fitted, used for their designed purpose and used in the appropriate environment.

In the notes that follow, the phrase "gas tight" refers to the finished connection. This means that the compression achieved between the connector and the strands of cable is sufficient to prevent the ingress of air and the consequent development of electro-chemical reactions which will, in due course, degrade the connection. It also inevitably implies a good electrical connection.

Scotchloks (and imitations)

A Scotchlok connector, comprises of an insulated polypropylene case enclosing a 'U' grip blade providing a uniform conducting area: the side slot makes insertion of the 'run' cable easier and the hinged cover provides extra protection.



Scotchlok devices are quick to fit, requiring only a pair of pliers to close them onto and around the cables they join; they are designed to give a gas tight connection.

They should be used in a dry environment.

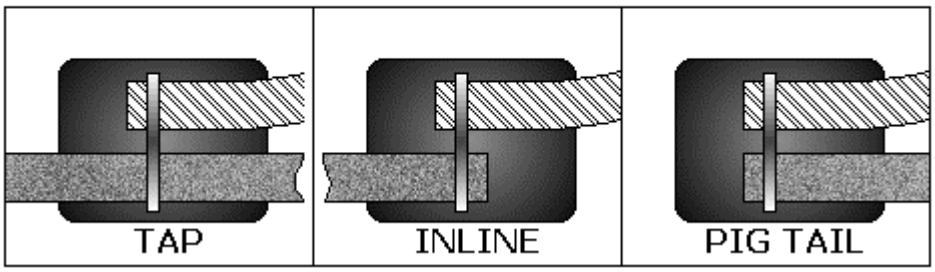
Successful use of these connectors is very much dependent upon the correct matching of connector and cable; clear guides for this purpose are available. The failure to match connector and cable and the common habit of removing and refitting, leaving open breaks in the cable insulation, is probably the chief cause of mistrust of this type of connector.

Large Scotchloks (Brown, Yellow) can be useful for making connections for power sources.

Scotchlok specifications

Colour	Reference	Main Cable mm^2	Tap Cable mm^2
Red	**0569**	**0.65 - 2.00**	**0.65**
Blue	**0560**	**0.65 - 2.00**	**0.65 - 2.00**
Brown	**0561**	**3.00 - 4.50**	**0.65 - 2.00**
Yellow	**0562**	**3.00 - 4.50**	**3.00 - 4.50**

Installation arrangements for Scotchloks.



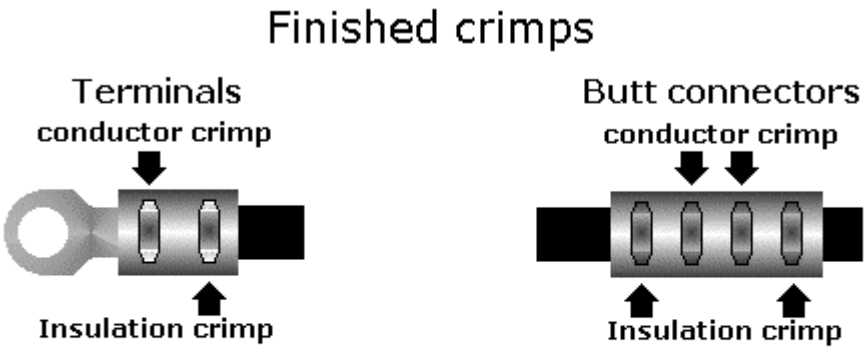
Crimp Terminals

Specifications

Red crimp connectors: for conductor sizes 0.5mm^2 to 1.5mm^2

Blue crimp connectors: for conductor sizes 1.5 mm^2 to 2.5 mm^2

Yellow crimp connectors: for conductor sizes 3.0 mm^2 to 6.0 mm^2



Soldered Connections

Most fitters who are in the car alarm industry solder all joints, as this is a requirement in that industry. The consequence of this has been the growth of soldering as a technique in the towbar industry. We have limited advice to give on this subject except to say the soldering is a skill that must be practised thoroughly. Poor soldered joints can be very unreliable.

Newly stripped wires are usually clean enough to solder directly together if the soldering iron is large enough and hot enough to heat all the strands of both wires quickly. If the wires are dirty, both cables to be joined must be thoroughly tinned before the connection is made so that true connection is achieved. (Without effective tinning, a kind of laying on effect can be achieved between the wire and the solder and this does not give good electrical or mechanical connection.)

The application of solder to a section of cable can make it brittle and liable to break at the point where the solder tapers off. Again, this is down to the practised skill of the operator and to the use of the correct soldering tools.

Finally, it is obvious that great care has to be taken by an operator soldering joints in the confined spaces of a motor vehicle. Precautions should certainly be taken against the risk of heat damage to plastics, seats, etc, as well as the risk of fire.

Protecting the cable

Routing cable safely within the car requires common sense. If there are points along the route where the cable might be subject to damage, adequate precautions must be taken. Examples:

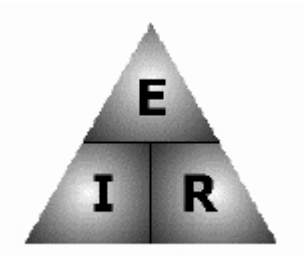
1. Passing through bulkheads: make sure the cable will not come into contact with sharp edges. A suitable grommet will afford protection. ***Where a wire passes from the passenger compartment to the engine compartment or the underneath of the car, care must be taken to avoid creating an entry point for fumes and gases to enter the passenger compartment.***
2. Inside the luggage compartment. Make sure that cables cannot be damaged by luggage etc.
3. Behind removable trims. Remember that you should make sure that your cables do not impede access to any areas that are designed to be accessible, and that they are protected within such areas.
4. In the engine compartment. Make sure cables are well secured, protected from heat and not interfering with access to service points, etc.
5. Under the vehicle. If you run cables under the vehicle, protect them with suitable sheathing, run them in protected places and secure them well. Do not tie them to fuel lines.
6. Mark your cables so others can recognise them
7. Use cables with suitable protection (e.g. double-insulated).

Calculating resistances: OHM'S LAW

Ohm's law states that electrical current flowing in a conductor is directly proportional to the voltage and inversely proportional to the resistance. In simple English this means that if you increase the voltage by a certain percentage, you will increase the current by the same percentage if the resistance stays the same. If you increase the resistance by a certain percentage and the voltage stays the same, the current will drop proportionally as you increase the resistance.

There is a formula to use to calculate these values. At first sight it makes it look mysterious but if you use it you will find it efficient. The formula is:

$$\frac{\text{Voltage (E)}}{\text{Current (I) x Resistance(R)}}$$



The value of any item results from the relationship between the other two items. If you know two values, you can find the third.
In the case of voltage, the value you get is the voltage "used up" or the voltage drop.

If you want **voltage dro**p, its value is current times resistance (I x R).

If you want **resistanc**e, its value is voltage divided by current, (V/I)

If you want **maximum curren**t, its value is voltage divided by resistance (V/R).
(If you could achieve maximum current, it would reduce voltage to zero and no doubt make the wire burn!)
More extensive details of Ohm's law can be found in Module TB3

Cable selection

Always use the correct size of cable. Attempting to supply large currents through cables of insufficient size is bad practice and should be avoided. **Use the chart below for guidance.** (When measuring cable length, remember that the length of any insulated earth return cables has to be taken into account) Always protect circuits with suitable fuses. Calculate the required fuse value and fit that value. If you put in too large a fuse you risk damaging the device protected or even the cable. To calculate the value of fuse required, add together the wattage of the lamps or other devices that form the load and divide this total by the voltage (12 or 24 volts).

Strands and diameter (mm)	Nominal cross-sectional area (mm^2)	Resistance per metre (Ohms) at 20^oC.	Maximum desired continuous current at 12 volts to give less than 0.5v drop over 5m.(*** see note)**
9/030	0.65	0.0294	3.4 amps
14/030	1	0.0189	5.29 amps
21/030	1.5	0.0125	8 amps
28/030	2	0.0094	10.64 amps
35/030	2.5	0.0075	13.33 amps
44/030	3	0.0060	16.66 amps

Calculation is: ***Max desired voltage drop divided by total resistance***
(Max desired voltage drop is 0.5 (volts)
(Total resistance is resistance per metre times length (metres)

e.g. 5 metres of 35/030 cable, 0.5 / (0.0075 x5) = 13.33 amps
10 metres of 35/030 cable, 0.5 / (0.0075 x10) = 6.67 amps

**Note: These are guide figures. In some circumstances, larger voltage drops may be acceptable. Also cars run approx. 14.2 volts which will affect the performance of the cable.*

Example using different selection criteria

35/0.30 Cable has a max recommended current rating of 21.75 amps
resistance of this cable is 0.0075 ohms/meter

Load applied (e.g. s/switch, combi for fridge + battery charge) 16 amps
Voltage provided at source 14.2 v
Acceptable voltage drop 10%
Cable run 5 metres
Calculation

Voltage drop = Current + Resistance, 16 A x (0.0075 x 5) = 0.6 v

This is well within a target of 10% drop (i.e. 1.42v), is acceptable for the s/switching relay requirements and will deliver in excess of 12 v to the caravan.

When might a towbar fitter use these calculations?

The calculations that are of interest to you as a towbar fitter are:

- Finding the voltage drop (when you are planning an installation)
- Finding the real resistance in a circuit when you are trouble shooting an installation. If, you found a voltage drop greater than there should be in a circuit, you would look for faults in the circuit such as poor connections, faulty wire or a failing battery).

Try this on a car:
Selecting a wire to make the 12S feed.

Try this on a car, using a loaded test board (i.e. a test board with additional lamps to simulate the heavy current
drawn by a caravan 12S circuit).

1. With a 12S socket at the rear of the car, rig different wires directly from the battery to the 12S socket.
(*Do not forget to put an in-line fuse in the line, by the battery*.)

2. With the power off, measure the voltage at the battery.

3. With the power on and your loaded board connected, measure the voltage at the 12S socket.

4. Take the second value from the first to find the voltage drop.

From this, using the guidance given above, you will see which cable is best suited to your job.

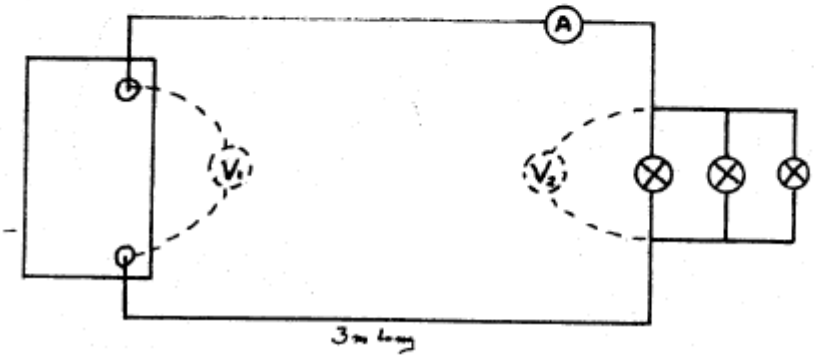
Workshop test:

WIRE CURRENT CARRYING CAPACITY

OBJECT

To establish how much current can be carried in 6 m lengths of wire, with various cross sectional areas (C.S.A.) and a minimum of 0.5 volts and 1 volt drop.

METHOD



Set up the wiring as above diagram and change the bulb sizes to obtain either 0.5 vd or 1.0 vd and take note of the current flowing. Repeat with other wire sizes.

RESULTS

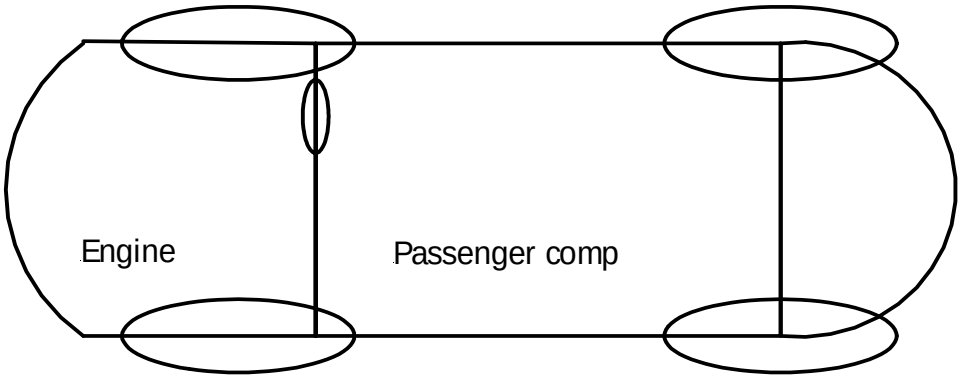
SIZE	C.S.A mm²	BATTERY VOLTAGE	LAMP VOLTAGE	AMPS 0.5 vd	BATTERY VOLTAGE	LAMP VOLTAGE	AMPS 1.0 vd
9 / .30							
14 / .30	1.0						
THIN WALL	1.0						
21 / .30	1.5						
28 / .30	2.0						
35 / .30	2.5						
44 / .30	3.0						

TB2 Review: Fuses, Cables And Connectors

Vehicle Make & Type:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
CHOICE OF FUSE RATING How did you calculate the load that the fuse(s) would protect?	Show your calculation	
What type of fuse did you fit and why did you select that type as suitable?		
What value fuse(s) did you fit?		
Sketch how you configured the fuse(s). Battery Load(s)		
Where you fitted the fuse(s) in the vehicle? Show: Battery, load/relay route of cable(s) location and value of fuse(s). Identify cable(s) (marked 1 / 2 etc. if more than one)		



Where the components and fuses are installed.

POWER CABLE (S) INSTALLED	

State cable length and specification • Strands/gauge • Cross sectional area mm?	1:	2:	3:

Voltage drop

In relation to the cables you fitted, what was the maximum current rating to achieve less than 0.5v drop over 5 metres? (Refer to cable selection chart in the *Practical guide to Towbar Electrics*)
Fill in the chart below to show whether the cables you selected were adequately rated.

A		B	C	D	E		See notes in guidance about variations
Load in amps		**Length of Cable installed**	**Max. rating over 5m**	**Max. rating over length you installed: (5/BxC=D)**	**If the figure at D is less than the figure at "A" the cable is inadequate. Is D equal to or more than "A"? Yes/No**		
1							
2							
3							

CONNECTORS USED
Did you: (a) solder your connection or (b) use connectors?

If (a) how did you ensure the solder connection was perfect?		

If (b) describe the connections you used as follows:

Type (E.g. self-stripping, insulated crimp, etc.)	**A** **Colour of connector used + cable rating(mm^2) of connector**	**B** **Main cable & tap cable**	**Was the cable rating (mm^2) at A suitable for the cable used at B?**	Which tool did you use to get a good connection? (e.g. ratchet crimper,)	

You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	

A. Total possible score:	B. Your Score:	A/B x 100= %	%

Start time: End time: Duration (Hrs)

TB3 Instruments & testing, Guidance Notes

Reference only

- **The Multi Meter**
- **The Ammeter and the Induction Ammeter**
- **Ohm's Law**
- **The Power Rating of a Resistance**

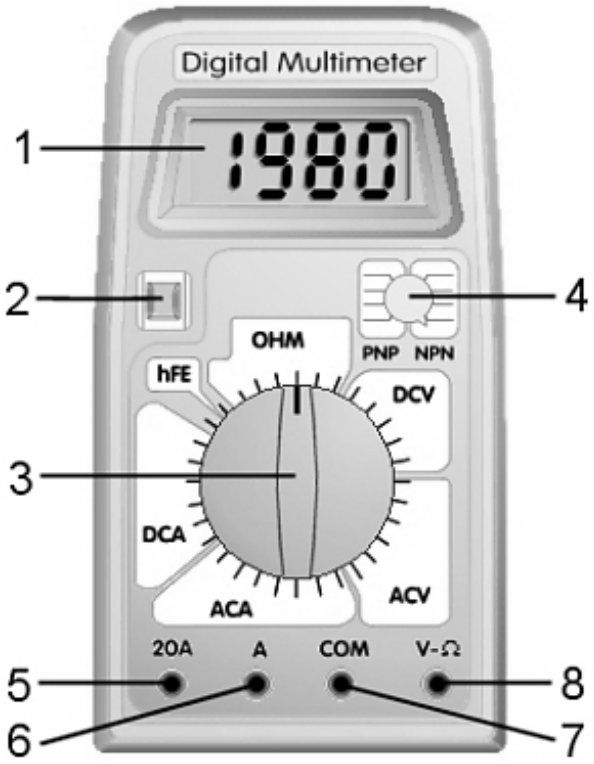
Introduction

Due to the rapid advances that have been made in the field of vehicle electronics, modem technicians need to be highly skilled. Systems that are fitted to the modern vehicle include anti-lock braking, engine management, multiplexing, electrically operated seats etc. When trouble shooting these complex systems, technicians must have a good sound knowledge of circuit diagrams, and must be aware of the various types of faults likely to be confronted. These faults would include short circuits, high resistance, open circuits and so on. Along with all the skills previously mentioned a good working knowledge of the various items of test equipment available is of paramount importance.

The Multimeter

Apart from specialist equipment the Multimeter and the test light or continuity tester are perhaps the most versatile instruments. A good Multimeter can be used to carry out a wide range of diagnostic checks on an electrical system. The Multimeter allows circuits to be tested for continuity, voltage present, resistance and current flow.

Features of a typical Digital Multimeter



1: Liquid Crystal Display LCD

2: Power on/off switch

3: Function range

4: TR socket (transistor to FE measurement only)

5: 20 amp terminal

6: A terminal

7: COM terminal

8: v/Ω terminal

Avoiding damage to a Digital Multimeter

To avoid damage to the meter and/or injury the following must be observed.

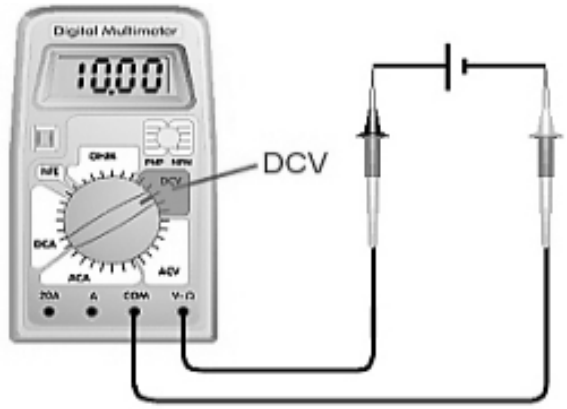
(i) Do not exceed the input limits.
(ii) Disconnect test leads from test points before changing the function range switch.
(iii) Do not touch the test lead tips or the circuit under measurement whilst power is turned on.
(iv) Ensure the test leads are in good condition.
(v) Do not get the meter and/or test leads wet.

And finally,

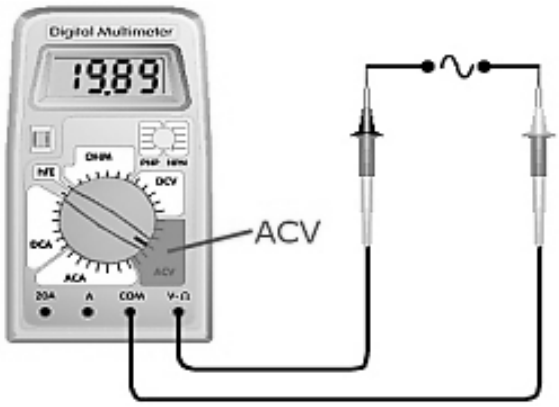
(vi) When making current measurements, make sure that the multimeter is connected in series with the load in which current is being measured. *Never* connect the meter across a voltage source in this setting, to do so may damage the device or circuit under test, or blow the overload protection fuse in the meter.

Set ups when using a Digital Multimeter.

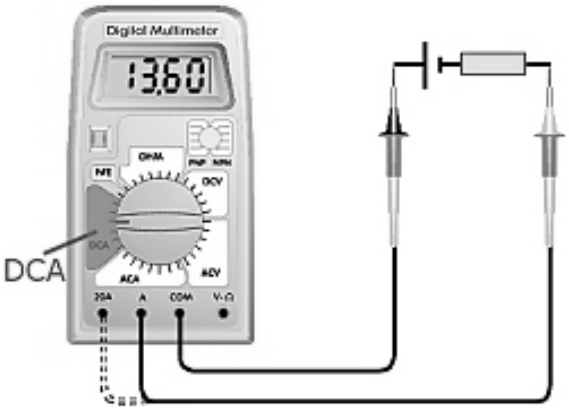
The meter/circuit set ups are illustrated below



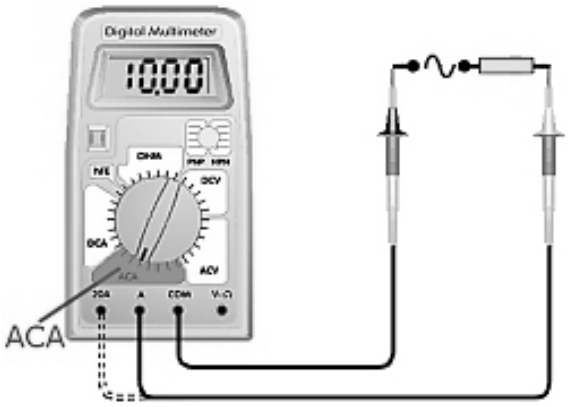
(i) DC Voltage measurement



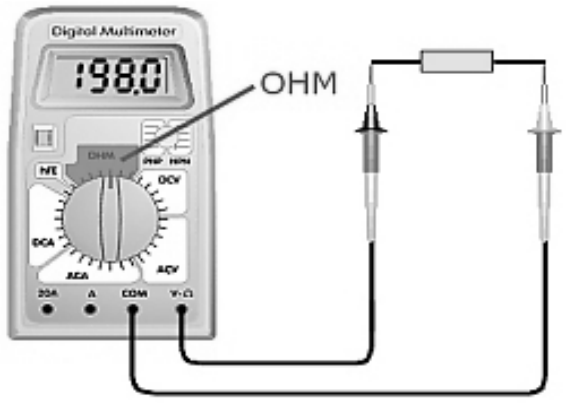
(ii) AC Voltage measurement



(iii) DC Current measurement



(iv) AC Current measurement

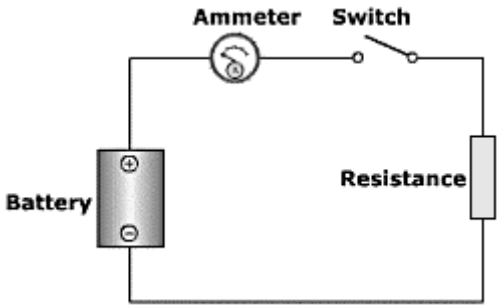


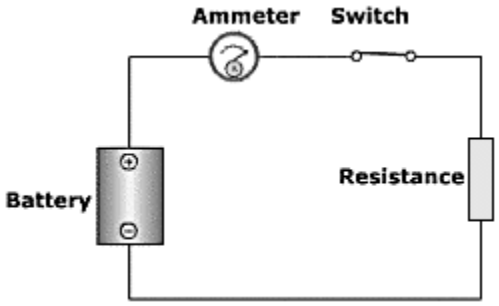
(v) Resistance measurement

The Ammeter and the Induction Ammeter

This instrument is used to measure the amount of current flowing in a circuit. They are connected in series with the circuit thus ensuring all of the current flowing passes through the meter.

An ammeter can be positioned on either the positive or negative side of the circuit. A perfect ammeter would itself have no resistance whatsoever. However, in practice, this is never realised.

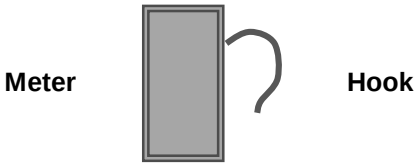




Remember: An *ammeter* must be positioned in *series* in the circuit

Induction Ammeter:

An induction ammeter can read the current flowing in a circuit without the need to be in series. Instead, the instrument has a hook device on it which is simply placed around the wire being investigated. When in place, the instrument will read the current in the wire. Accuracy varies according to the cost of the meter but even a simple version is invaluable to the towbar fitter looking for suitable power cables in sensitive vehicles.



Ohm's Law

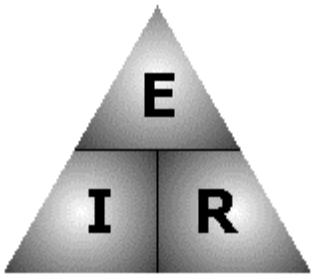
A German physicist, George Ohm, made a careful study of the behaviour of electric currents flowing in conductors and in 1826 he published his findings including his "law".

Ohm's Law describes the relationship between electrical currents, voltages and the 'resistance' of the conductors carrying them.

Ohm's Law states that the electric current flowing in a conductor is directly proportional to the voltage and inversely proportional to the resistance.

The "ohm" is the standard unit of resistance and is defined as the resistance acting when one amp flows through a potential difference of one volt. The Greek symbol omega "Ω" is used to represent resistance in ohms, 50 ohms is usually written as 50 Ω.

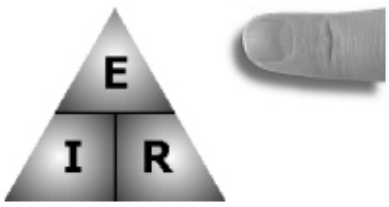
You will find it useful to remember Ohm's Law and the following triangular graphic is commonly employed.



In the graphic, E is the symbol for voltage (volts V)
I is the symbol for current (amperes A)
R is the symbol for resistance (ohms Ω)

The horizontal line in the triangle indicates division and the vertical line multiplication.

To find voltage 'E', we cover 'E' on the diagram.



Hence we have:

Voltage (E) = Current (I) x Resistance (R)

To find current 'I', we cover 'I' on the diagram.

Hence we have:

$$\text{Current (I)} = \frac{\text{Voltage (E)}}{\text{Resistance (R)}}$$

To find resistance 'R', we cover 'R' on the diagram.

Hence we have:

$$\text{Resistance (R)} = \frac{\text{Voltage (E)}}{\text{Current (I)}}$$

Example 1

A current of 0.3 amps (A) flows through a resistance of 40 ohms (Ω) determine the voltage (E) across the resistor.

Solution

Using:	Voltage	=	Current x Resistance
		=	0.3 (A) x 40 (Ω)
	∴ Voltage E	=	12 volts (V)

Don't worry at this stage if you find this area of work a little difficult. You will find that as you progress through the package the Examples and Exercises will help you to develop your understanding and the skills necessary to handle such calculations.

Resistor power rating

When a resistor opposes the electron flow a certain amount of power is expended which is indicated in the form of heat. Resistors are rated by the amount of power they can safely dissipate without being damaged.

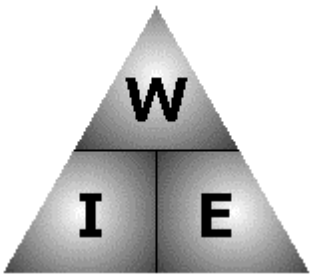
This power rating is expressed in units called watts, the symbol for which is W

To calculate how much power a resistor in a circuit will dissipate we use the formula:

watts = volts x amps

i.e.
Power (W) = Voltage across the resistor (E) x Current flowing through resistor (I)

Again a triangular graphic, as shown below, is often used.



You can see that the triangular graphic is very similar to the one we used for Ohms Law. Use the covering up procedure again, from this you should be able to write:

Power (W) = Current (I) x Voltage (E)

and, Current (I) = $\frac{\text{Power (W)}}{\text{Voltage (E)}}$

and, Voltage (E) = $\frac{\text{Power (W)}}{\text{Current (I)}}$

Electrical Units and Measurement

CURRENT is the measurement of electrons in a closed electrical circuit.
It is measured with an ammeter in AMPS (A)
The ammeter must only be connected in SERIES
It must also be connected with the correct polarity: RED = POSITIVE (+)

VOLTAGE is the pressure which forces the electrons through the electrical conductor.
It is measured with a voltmeter in VOLTS (V)
The voltmeter must only be connected in PARALLEL and the correct polarity must be observed.

RESISTANCE is the obstruction to electron flow in a circuit.
It measured with an ohmmeter in OHMS (Ω)
Important – Any component or circuit to be tested must not be energised, otherwise the Ohmmeter will be damaged.

DIGITAL METER – because it has a very high input impedance (resistance) it can take a reading UNSEEN by the circuit or computer.
In electronics measurements are usually expressed in milliamps (mA) millivolts (mV) and Kilo ohms (K)

Revision Exercises

1. What must be borne in mind when connecting measuring instruments.
(*Tick the right box)*

Voltmeter

☐ The instrument is connected in parallel to the voltage source

☐ The instrument is connected in series in the circuit

Ammeter

☐ The instrument is connected in parallel to the voltage source

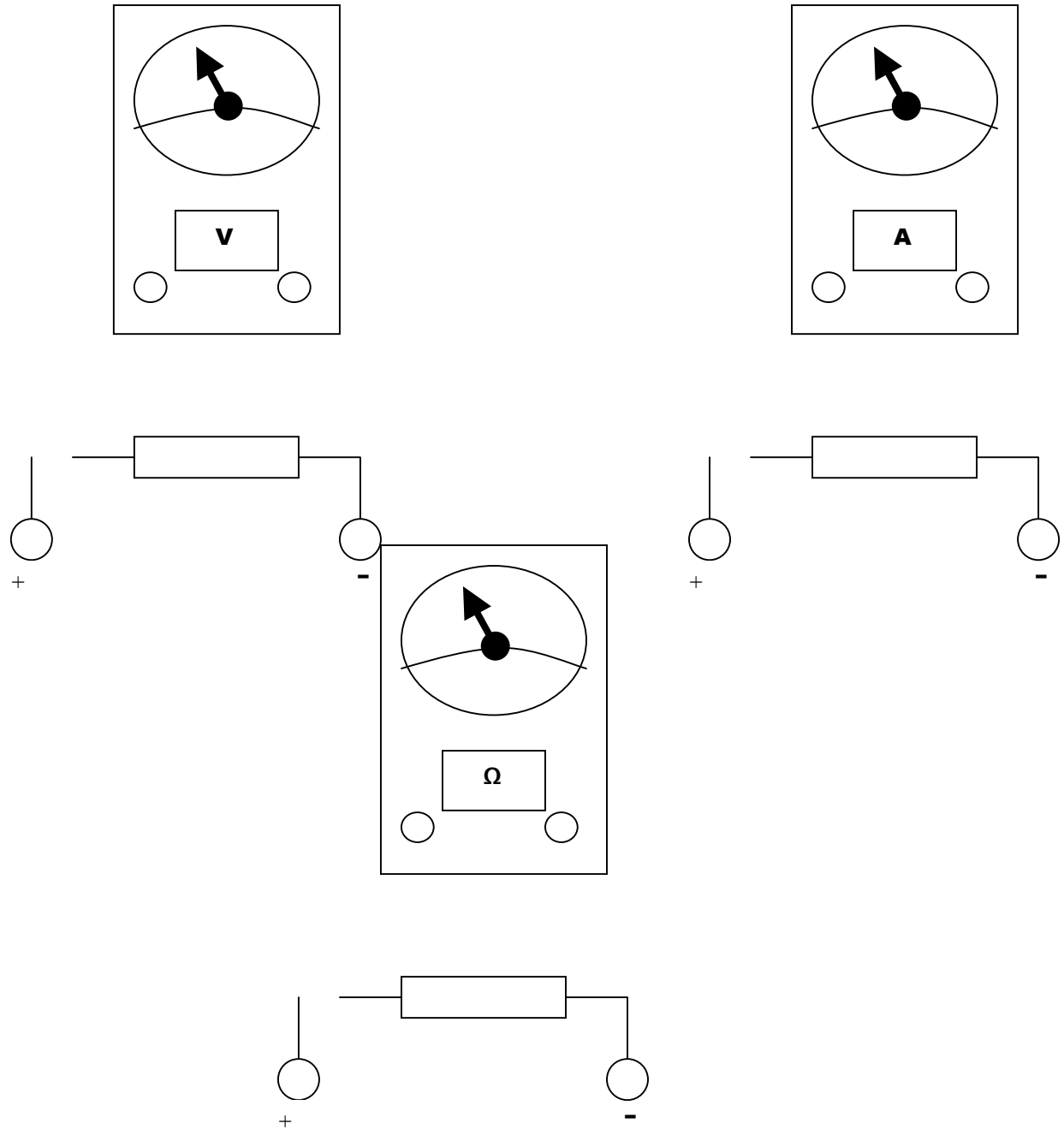
☐ The instrument is connected in series in the circuit

Ohmmeter

☐ The components and circuits to be measured must not carry voltage

☐ The components and circuits to be measured must be under voltage

2. Draw in the multimeter connections for measuring voltage, current and resistance in the illustrations on the next page.


V
A
Ω
+
-
+
-
+
-

Current Calculations

1. Wiper Motor

What current would the wiper motor consume?

2. Relays

What current is required to switch on the relays?

a. 30A 28RA relay

b. 4-way bypass relay

3. Ignition Coil

What are the primary and secondary resistances?

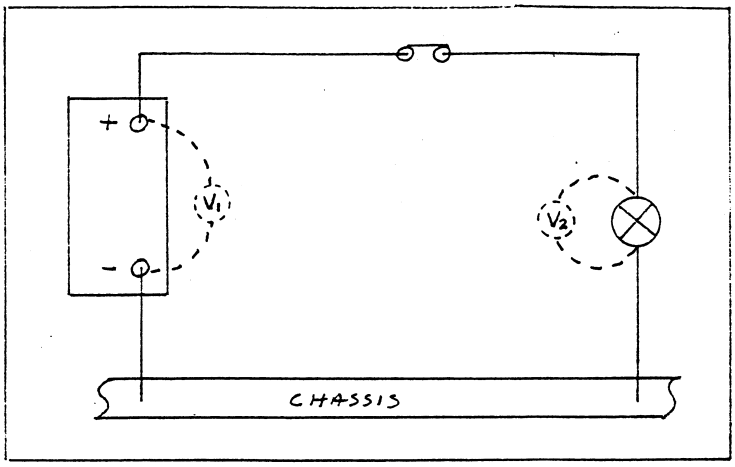
What is the primary winding current consumption?

4. Caravan running lights

What current must the main feed wire to the six-way bypass relay be able to carry to supply all the lights?

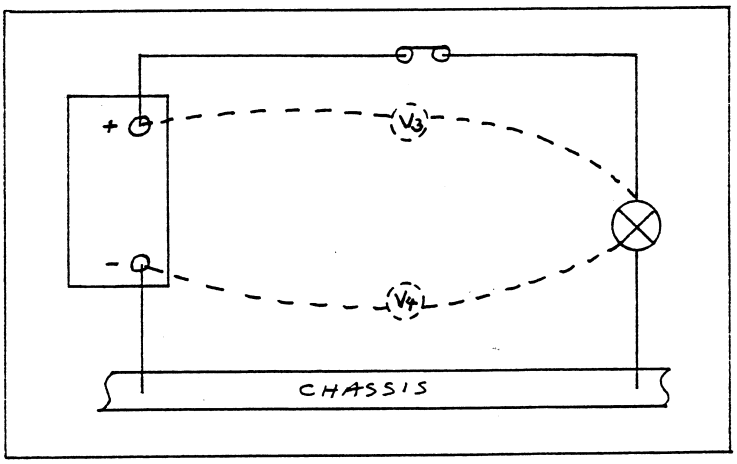
Appendix:

TESTING FOR VOLT DROP IN A CIRCUIT



With circuit energised measure voltage at battery (V1) and voltage at component or bulb (V2).

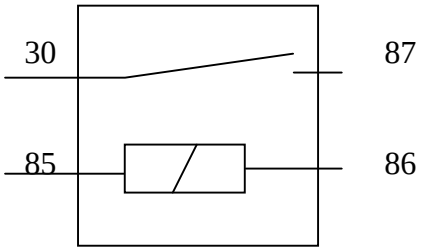
If the difference is less than 1 volt no further test is required. If more than 1 volt move to next test to locate the lost volts.



If the voltage at (V3) is between zero and 0.5 volts there is no fault on the insulated side.

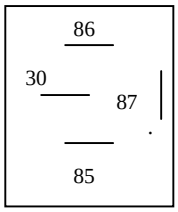
If the voltage at (V4) is between zero and 0.5 volts there is no fault on the earth return side of the circuit.

RELAYS: OPERATING AND TRIGGERING CURRENTS

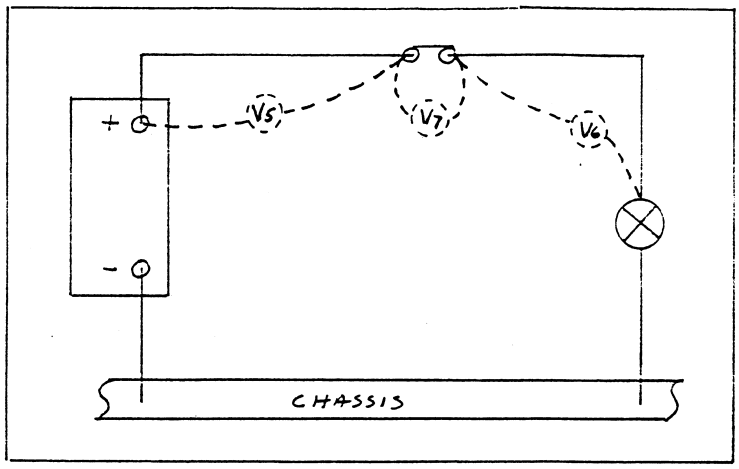


A relay is an electro magnetic switch that will switch a large current with minimal voltage drop and is triggered by a small current.

Examine the various relays and measure the resistance of the operating coils and then, using Ohms Law, calculate the current required to operate the various relays.

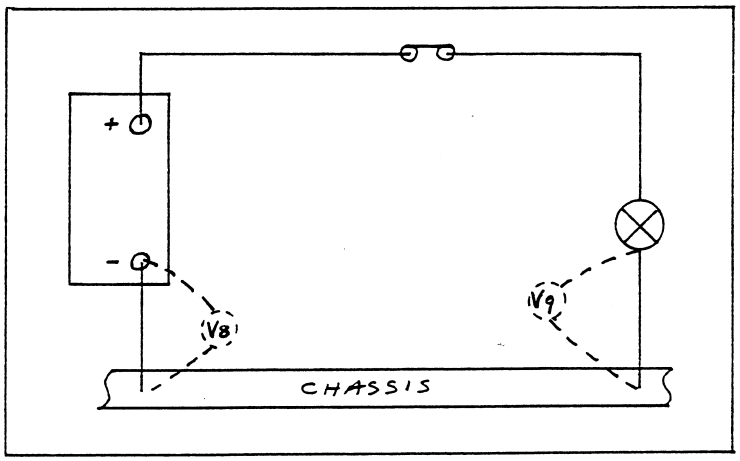
	Pin Location and Number	Switched Current	Energising Coil Ω	I=E R	Energising Current
1		70A	60Ω	$I = {}^{E}/_{R} = {}^{12}/_{60} =$	0.2A
2					
3					
4					
5					

Testing for volt-drop (2)



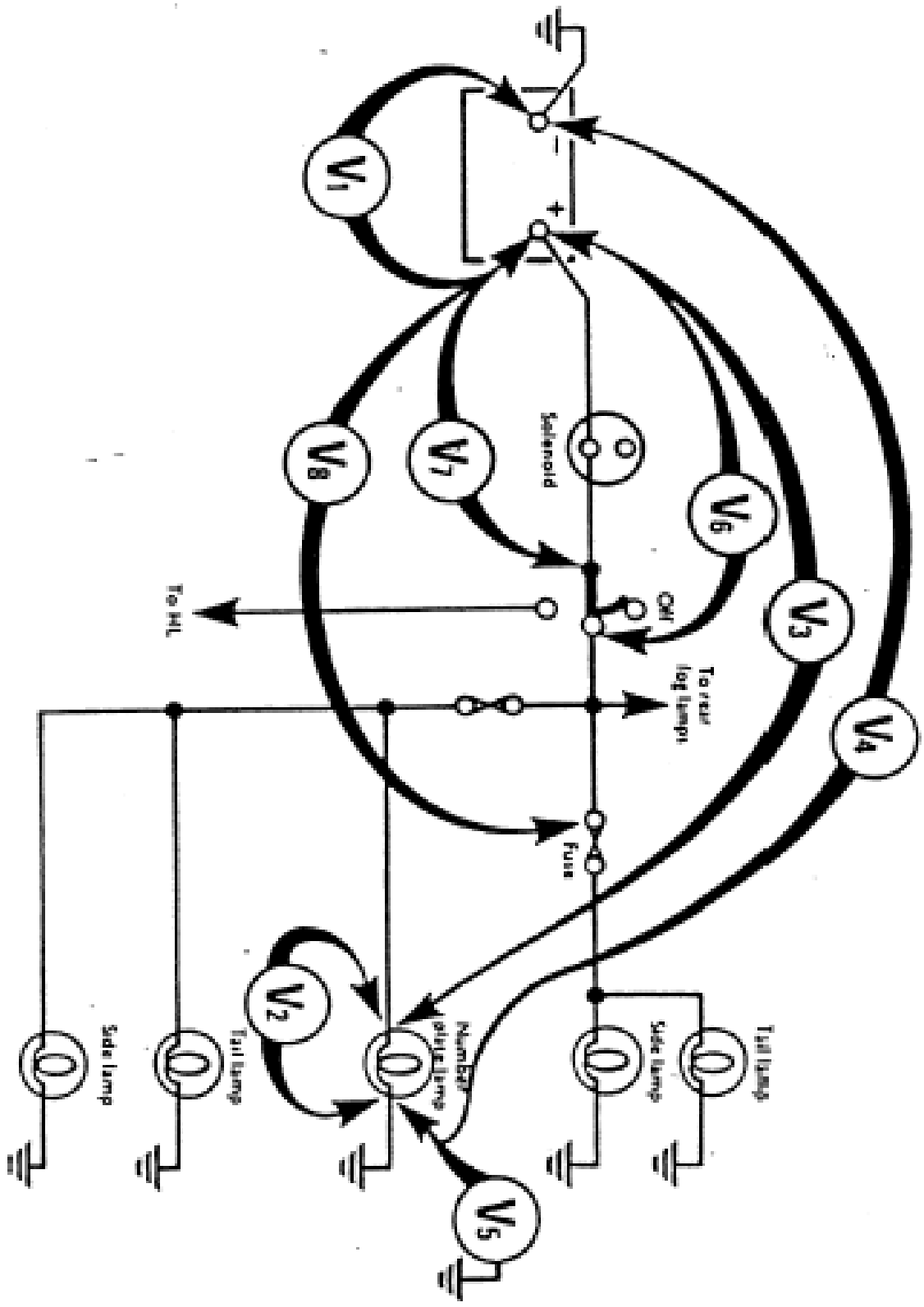
If the voltage at (V3) is above 1 volt this is volt drop and must be located.

Tests (V5) (V6) (V7) should locate the point of high resistance, which could be cleaned, repaired or replaced as necessary.



If the volt drop is not on the insulated side (V8) (V9) etc can be used to check the earth return side of the circuit.

Voltage Drop issues



Testing for volt-drop (3)

OBJECT

To measure volt drop and current consumed in a circuit using wire of different size and length.

EQUIPMENT

3 – 60 watt x 12 volt bulbs and board, long and short lengths of 14/30 wire, including lengths of 44/30 wire, voltmeter and ammeter.

METHOD 1

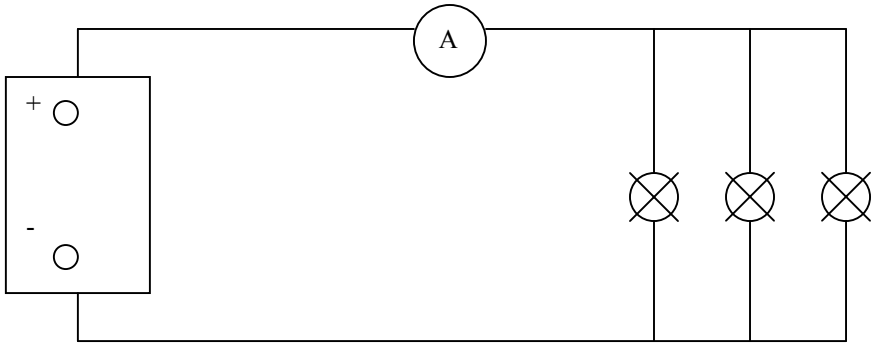
Wire up the bulb and board in parallel with the short 14/30 wire, measure voltage at the battery and bulb board, also measure the current consumed.

METHOD 2

Repeat with long 14/30 wire.

METHOD 3

Repeat with 44/30 wire.



		Battery Voltage	Bulb Voltage	Voltage Drop	Current
5m	Short 14/30				
1m	Long 14/30				
5m	44/30				AMPS

Conclusion

TB4: Batteries, Guidance Notes

Battery maintenance is not a part of towbar fitting but poor batteries can cause you problems. A basic understanding of batteries is, therefore, likely to be useful.

Most common type
Most batteries currently used on motor vehicles are of the lead-acid variety. Their plates are made of Antimonial lead and the electrolyte is sulphuric acid and distilled water.

Specific Gravity
When the battery is charged the Specific Gravity (SG) of the electrolyte increases so SG can be used to measure the state of charge of the battery. This is done with a hydrometer.

Explosive gases
The electrolytic action of charging changes the distilled water (H_20) into Hydrogen and Oxygen gas which is an explosive mixture, so no naked flames or sparks must be allowed near a battery that is being charged or has just been charged.

Sealed for life type
The latest batteries are sealed for life. Cadmium lead is used for the plate and this reduces the battery gassing. These batteries, therefore, need no topping up.

14.4 volts max
Batteries should not be recharged at anything above 14.4 volts.

Temperature
Batteries achieve their maximum capacity at 26^{o}C and only 65% is available at 0^{o}C.

Ideal Charging Rate
The ideal charging rate for batteries is one tenth of their amp-hour capacity.
E.g. 45A/hr = 4.5 amps; 90A/hr = 9 amps.

BATTERY CAPACITY

This is a measure of the amount of current a battery can supply for a given time. It is determined by the number of plates and the cross-sectional area of the plates. As the capacity rises so does the thickness of the plates so, for example, a light car battery might have 3mm plates whilst a traction battery might have 6mm.
Thicker plates have a better resistance to buckling when a high current is drawn.

Different measures of capacity:

AMP HOUR A/hr
This has been the traditional way of rating battery capacity.
A **65 A/hr** battery could deliver ***6.5 amps for 10 hours***.
It could **not**, however, deliver 65 amps for 1 hour.

COLD CRANK AMPS (CCA) I.E.C. BS3911
This is the amount of current supplied for 1 minute at a temperature of –18^{o}C before the battery voltage drops to 8.4 volts
SAE - 30sec - 7.2V
D.I.N. - 30sec - 8.0V.

RESERVE CAPACITY (RC)
The time taken in minutes for the battery voltage to drop to 10.5 volts when discharged at 25 amps running load at 25^{o}C.

BATTERY TESTING

There are two tests to check the state of charge and condition of a battery.

HYDROMETER TEST

This must always be the first check. The object is to check both the state of the charge and the comparison between the cells, which must be within 0.020 of each other.

Specific Gravity Reading	Condition
1.270 - 1.290	Fully charged
1.900 - 1.210	Half discharged
1.100 – 1.200	Discharged

VOLTMETER

If the battery is a sealed for life type, a digital volt meter can be used. If the battery has been on charge, let it stand for 30 minutes or switch the headlamps on for 20 seconds before carrying out the check.

Reading	Battery condition
12.7 - 12.9V	Fully charged
12.4V	Half discharged
12.0V	Discharged

HEAVY DISCHARGE TEST (FIXED CURRENT TESTER)

The battery must be above half-charged.

Use the meter for only 10 to 15 seconds.

a. The needle should be steady without falling (7-10V). The voltage reading will vary according to A/hr capacity.
b. If the needle falls and bubbling occurs at a cell, that cell is faulty and the battery should be replaced.
c. Low volt meter readings could mean a sulphated battery.
d. No voltage reading possibly accompanied by hissing could mean an internal bad connection.

BATTERY SERVICING

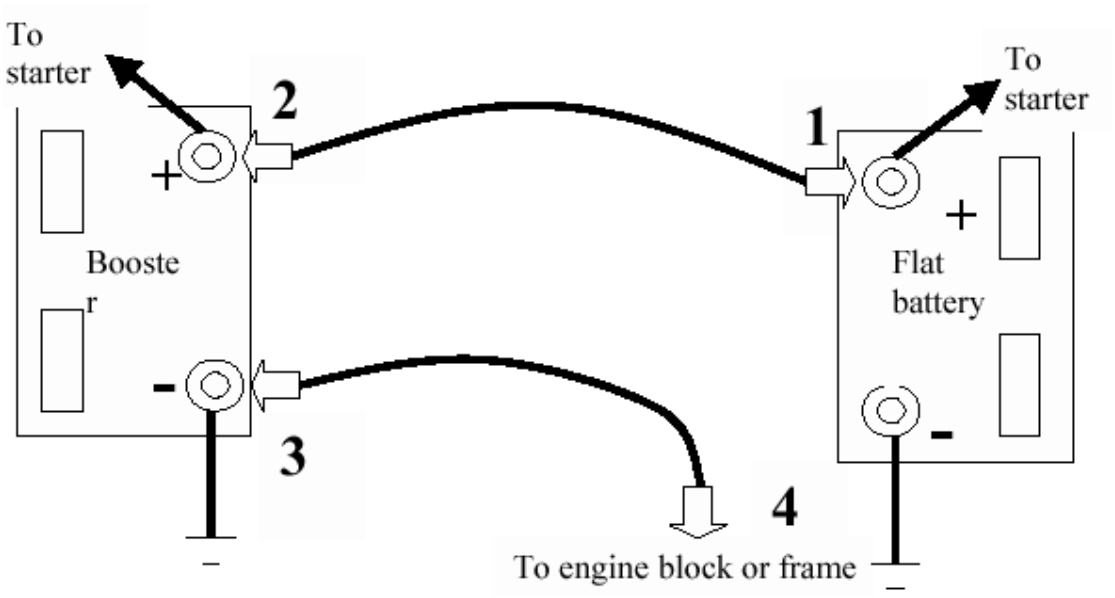
1. Top up with distilled water only
2. When removing a battery, disconnect the earth connection first and connect this last when replacing the battery.
3. If the battery terminal has a green/blue/white verdigris deposit it can be leaned off with boiling water or with ammonia. Cleaned terminals can be smeared with petroleum jelly.
4. The battery must be clamped down in its compartment but not over tightened.

CONNECTING A BOOSTER BATTERY

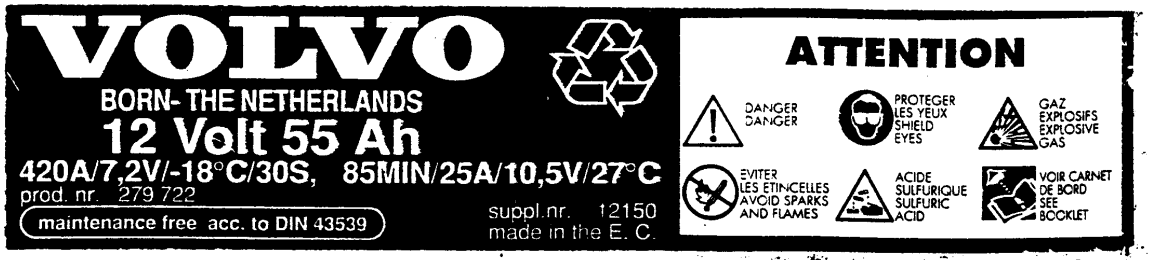
SHIELD EYES AND FACE FROM THE BATTERIES AT ALL TIMES. Be sure vent caps are tight and level. Place damp cloths over vent caps on both batteries. Make sure vehicles do not touch.

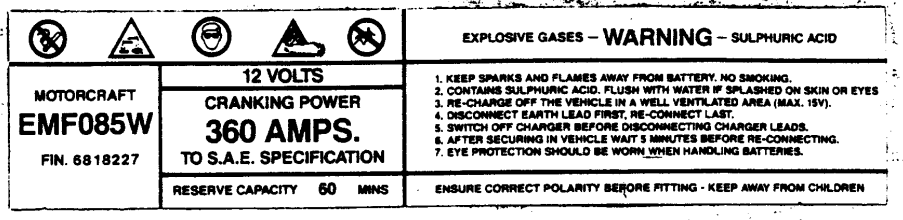
1. Connect the positive cable to the positive (+) post of the discharged battery.
2. Connect the same wire to the positive (+) post of the booster battery.
3. Connect the negative cable to the negative (-)post of the booster battery.
4. MAKE THE FINAL CONNECTION TO THE ENGINE BLOCK OF THE STALLED VEHICLE AWAY FROM THE BATTERY. STAND BACK.
5. Start the vehicle and remove the cables in reverse order of connection.

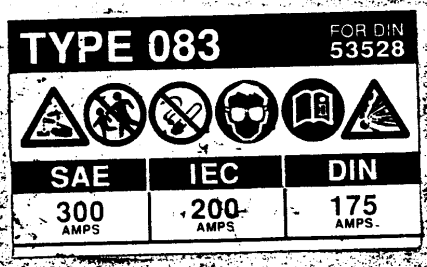
HOOK UP FOR NEGATIVE EARTH VEHICLES

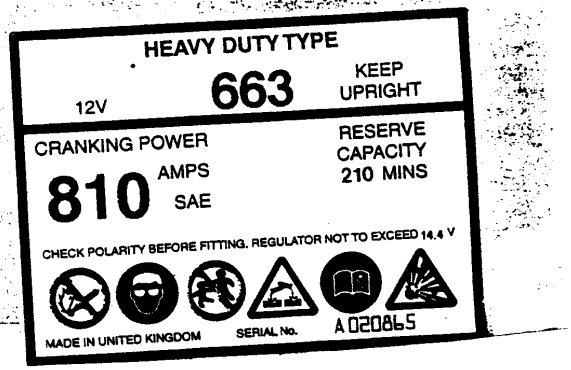


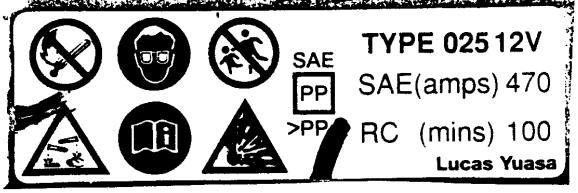
Typical Battery Labels **40**











TB5: Bulb Failure, Computers, Multiplexing - Guidance Notes

Bulb-failure Warning Systems

Some vehicles have bulb-failure warning devices to give a warning if a bulb on a road light circuit fails. These may be relatively simple sensors, like flasher relays, or more complex, perhaps forming part of a larger computer-controlled system. Unlike conventional flasher relays which can usually support extra lamps, most other bulb-failure warning systems would be activated by the simple connection of additional lamp circuits for the trailer directly to the vehicle's own lamp circuits.

Bypass Relays

Bypass relays were first developed and introduced by Ryder Towing Equipment Ltd. Since their introduction, other manufacturers have broadly copied the Ryder designs, Bypass relays allow trouble-free fitting on vehicles with complex electrics and electronics. They are designed to operate trailer road lamps in unison with the towing vehicle's road lamps without drawing any significant current from the vehicle's road lamp circuits.

Not detected

Bypass relays employ miniature relays to switch the trailer lamps on and off. Connection is made to the vehicle's lamp circuits but only for the purpose of energising the coils of the relays. The current drawn by each relay is less than 40 milliamps (0.04amps). This current is so small that it can be drawn from the vehicle's lamp circuits without bulb-failure warning devices in the vehicle detecting its loss because the normal tolerances found in typical vehicle lighting circuits are greater than 0.04 amps.

Power direct from the battery

Power for the trailer lamps is taken directly from the vehicle's battery and merely switched by these relays. No significant load is put on the vehicle's own lamp circuits.

Easily handle currents

Although the coil currents are tiny, the switching capacity of each relay is 10 amps. This means they can easily handle the currents found in typical trailer/caravan road light systems.

Bypass Relays available from Ryder Towing Equipment Ltd.

TF1011	Single
TF1012	Double
TF1013	Three way
TF1014	Four way

All the relays below incorporate flasher monitoring

TF1016	Six way
TF2117	Seven way with built-in buzzer
TF2117X	Seven way with anti-chatter and built-in buzzer
TF2117	Seven way with anti-chatter, built-in buzzer and double fog cut-out
TF110R	Two way (Flasher booster)

Computers and Multiplex Wiring Systems

Multiplexing is a method of transferring many data signals along a single "bus"cable to switch relays drawing their power from a single power cable. Using this method, many devices can be controlled without a mass of individual interconnecting wires. Multiplexing is associated with computer control units, these being the source of the control signals.

Basic Principles

The multiplex system used on vehicles has a large supply cable running around the vehicle. Connected to this are electrical system units i.e. relays, lamps, actuators, motors and other electrical equipment. By transmitting a coded digital signal, either electrical or optical around a second cable known as a data line or "bus", the electrical system units can be made to operate.

Fitted to each consumer unit is a decoder, which recognises when a given signal is being transmitted along the data bus. On receipt of the message by the decoder following the recognition of its call-up code, a relay is operated by the decoder as instructed and thus the consumer unit is actuated. One data bus can carry a number of messages by allocating a time

slot for each instruction. The process for dividing the time is known as time division multiplexing (MUX).

Since each burst of data is sent many times a second, the response of the system appears to be instantaneous as far as the driver is concerned, just as if the switches were wired directly to the electrical system units.

A practical multiplex system would incorporate many sending and receiving units, located at strategic points around the vehicle, all connected to the same data bus.

Because the signal current needed to operate a multiplex system is very low (10 mA) good connections are important. Furthermore, precautions must be taken to reduce electrical noise (interference) in the line, since this can interfere with the digital signals in a manner that would affect the operation of the system. Fibre optic cables are unaffected by electrical fields especially those radiated from HT ignition systems.

The additional cost of multiplex systems, along with design conservatism, has meant that relatively few systems have reached the market and multiplexing has tended to be confined to just part of electrical system such as door sub harnesses. This situation appears to be changing, with many manufacturers introducing multiplexing elements into an increasing range of models.

Advantages of multiplexing

- Wiring harnesses are small and simpler providing a saving on cost and weight.
- Faster harness installation time.
- Reliability through the reduction in the number of wires being used.
- Self-diagnosis can be built into the system.

How will the use of computers and multiplexing affect the towbar fitter?

There is some concern in the industry that the introduction of these systems will drive towbar fitting into the workshops of vehicle main dealers and away from the specialist fitter. These concerns centre on the provision by some manufacturers

Multiplexing etc. Contd.

such as Volvo for computer downloads associated with the fitting of manufacturers' towing kits, engine management and on-board diagnostics.

The questions and answers are:

Will computer downloads be required, to modify engine management systems to allow cars to tow?

Unlikely. Engine management systems are carefully set up to cope with all likely conditions and will already handle towing. There is no likelihood, at least in the foreseeable future, that it would ever be appropriate for manufacturers would introduce downloads for towing, related to the management of engine performance. Such downloads as exist perform much more humble tasks such as the commissioning of the fog cut-out system.

Will the addition of towbar electrical systems that are not supplied by the manufacturer cause problems for any diagnostic systems installed in the vehicle.

No. On-board diagnostic systems are designed to take into account the normal conditions that apply in a vehicle. These include a lighting system that has bulbs. Bulbs are variable. The resistances found in different bulbs of the same type and wattage will vary considerably. In determining what is normal, any OBD system has to take into account these possible variations. They do this by being set up to respond to fairly large variances,

outside defined ranges. If towbar electrical systems create variances that do not stray out of these ranges, they will, effectively, be invisible to OBD systems.

Will the fitting of bypass relays prevent malfunctions and alarms caused by the towbar electrical installation?

Normally, even without bypass relays, direct towbar electrical connections should be invisible to on-board diagnostics at the time these are used. Since, presumably, no trailer is present during diagnosis and servicing to provide loads on the towing electrical circuits, these circuits, unless they are faulty, will be "invisible". Problems may arise, however, if the car detects and records faults in the trailer lighting system and these are investigated under the vehicle's service regime. Because the servicing dealer is required to look into such faults, there is a potential for some expensive confusion. The fitting and clear labelling of bypass relays should virtually eliminate this possibility.

Provided that bypass relays are correctly installed, their electromagnetic coils do not draw sufficient current to be detectable by monitoring systems in vehicles or to add significantly to the load on the individual circuits to which their signal wires are attached.

The rules for correct installation are:

- If the vehicle has conventional feed wires leading to the light units or clusters and these wires supply 12+ volts and sufficient current to drive the lamps, the coil signal wires of bypass relays can safely be attached to these feed wires.
- Connect the bypass relay coil signal wires to the appropriate vehicle light feed wire
- Connect the relay's power input terminal to the battery, using a suitable gauge of wire and fusing it appropriately, close to the battery.

If bypass relays are not installed, any loads generated by the trailer lights will fall directly onto the vehicle's systems. Monitoring systems will be alerted if they are in place. Circuit overloads can also be created by such direct connection.

Detecting multiplex systems

Tell-tale signs are not obvious but multiplex junction boxes typically have few (e.g. three) wires going in, including at least one thick one, and many coming out to feed the various devices. Experience tell that identifying multiplexing is not at all simple. Some vehicles have junction boxes with large numbers of wires coming out in all directions. The Honda Accord has partial multiplexing which is virtually undetectable, despite being quite critical to towbar fitters.

Can you tap into the multiplex feed wire?

There will be a thick power feed wire associated with any multiplex system. It is unwise to tap into this feed wire as a source of power for bypass relays, because of the likelihood of interfering with the multiplex signaling and this fact should be taken into account by any fitter looking for a suitable power source other than the battery.

TB5 Review: Bulb-failure, Computer control, Multiplexing
Name: Date:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	Answer	Score/10
Bulb-failure bypass relays		
Conventional flasher relays cause no problems for towbar electrics installers. Bulb-failure warning systems on other circuits in the car do. What makes the difference?		
Why are bypass relays not detected by bulb-failure warning systems?		
Typically, what currents are drawn by the coils of bypass relays?		
What hazards might you encounter if you looked for a power source for your bypass relay(s) other than the battery?		
What key characteristics of good bypass relays enable them to handle the currents found in typical trailer/caravan road light systems?		
Computer Control and Multiplexing		
What is multiplexing?		
Why would car manufacturers wish to introduce it?		
How does multiplexing reduce the amount of cabling in a car?		
Multiplex systems switch relays. What is different about the way they do this compared with conventional relay switching?		

***Computer Control and Multiplexing** (Contd.)*		
Will computer downloads modify engine management systems to accommodate towing and thus be essential? If not, why not?		
Will the addition of towbar electrical systems that are not supplied by the manufacturer cause problems for any diagnostic systems installed in the vehicle? If not, why not?		
Will the fitting of bypass relays always prevent malfunctions and alarms caused by the towbar electrical installation?		
What essential condition must be present for the bypass relay to work successfully?		
Why should you not tap into the multiplex system power cable?		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.		Total score
A. Total possible score:	B. Your Score:	A/B x 100= %

TB6: Vehicle Preparation, Guidance Notes

1. Identify Hazards

Look up your company records on each model
or
Examine the vehicle
In either event refer to the vehicle handbook, dealer, etc. On the vehicle itself, check the following:

- Are any warning lights operating before you start?
- Have you instructions for any alarm system / immobilizer?
- Is there multiplexing? If so what does it affect? (See TB5 for guidance.)
- Is there a computer? If so, what does it control?
- Are there bulb failure devices? If so, on which circuits?
    - Check the lights:
        - Check the handbook
        - Examine dash for symbols lit when ignition is switched on
        - As a last resort, remove bulbs and see the effect
    - Look out for bulbs "taking over" from failed bulbs (e.g. Rover 75, BMW)
- Fuse configurations
    - Don't load a circuit that shares a fuse with something vital like a CPU
    - Don't load a circuit with a low value fuse
    - Don't up rate the existing fuse
- Does the vehicle have lamp status checking that accommodates trailer lights and monitors them?
- Can you recognise Airbag and ABS circuits when looking for power sources?
- If you are fitting a bypass or caravan relay, use an induction ammeter to identify a power source other than the battery (if you are not going direct to the battery).
- Use other checks, e.g.:
    - Fuse ratings
    - Trace wires to make sure where they come from and where they go.

2. Considerations before disconnecting the battery

- Do you have the radio security code?
- Engine management system - will it reset after battery has been disconnected?
- Will the vehicle alarm system be affected?
- Do you have a battery keeper to preserve memory?

3. Can you get to the wiring?

- Keep and renew records of how to remove trim, etc
- Collect the right tools
- Have a stock of trim clips

Detecting multiplex systems

Tell-tale signs are not obvious but multiplex junction boxes typically have few

(e.g. three) wires going in, including at least one thick one, and many coming out to feed the various devices. Experience tell that identifying multiplexing is not at all

simple. Some vehicles have junction boxes with large numbers of wires coming out in all directions. The Honda Accord to 2001 had partial multiplexing which was virtually undetectable, despite being quite critical to towbar fitters.

Can you tap into the multiplex feed wire?

There will be a thick power feed wire associated with any multiplex system. It is unwise to tap into this feed wire as a source of power for bypass relays, because of the likelihood of interfering with the multiplex signaling and this fact should be taken into account by any fitter looking for a suitable power source other than the battery.

Section TB5 has a detailed section on multiplex systems

TB6 Review: Vehicle Preparation
Vehicle Make & Type:

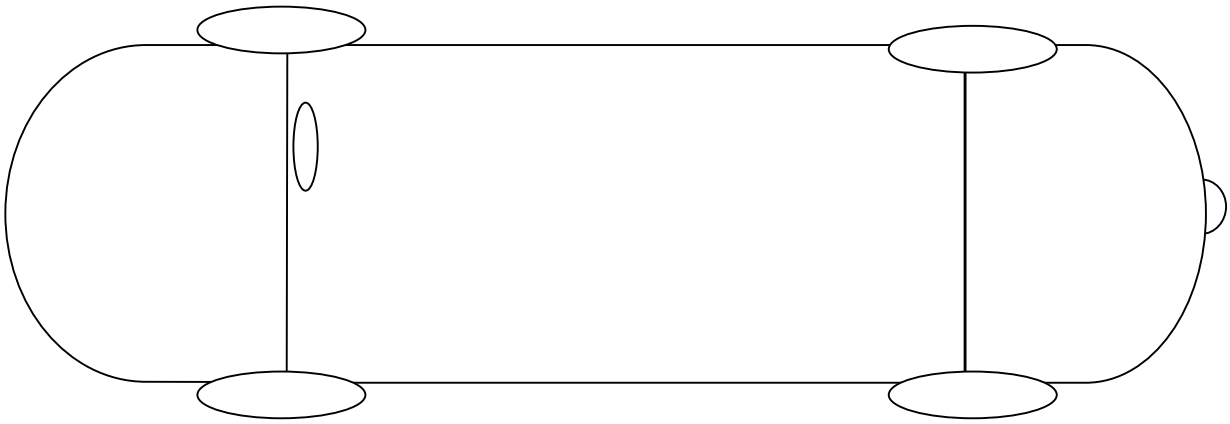
Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
Hazards Answer the questions and describe what you did. **Did you:**		
Check your company records for details of this car?		
Check other records, newsletters etc?		
Examine the vehicle (including the handbook).		
Do bulb failure devices and other light checks		
Check warning lights before starting		
Identify circuits at risk from battery disconnection		
Selecting power sources making connections - did you check: *Answer the questions and describe what you did.*		
Fuse configurations		
For the presence of airbag and ABS circuits		
Existing loads on any cable you used as power source		

Did you up rate an existing fuse? If yes justify your decision, giving a clear explanation of what checks were carried out and in what areas		

Routing cables

- On the diagram below show cable routes
- Show points where cable needed additional protection



Getting to the wiring: Removing trims

Answer the questions and describe what you had or did.

Did you have a record of how to remove trim on this vehicle? Did you have all necessary tools, bits and components at the start of the job?		

Trims, (Contd.) What particular problems, if any, did you encounter removing trims?		
List any clips broken, seals damage etc. Did you have replacements in case you broke any?		
What new details (if any) did you add to your company's records on completion of this job?		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	
A. Total possible score:	B. Your Score:	A/B x 100= %

TB7 Installing the Towbar Electrics. Guidance

For detailed data on fuses, connectors and cables, refer to Section TB2 Guidance.

Considerations when deciding whether to disconnect the battery

- Do you have the radio security code?
- Engine management system - will it reset after battery has been disconnected?
- Will disconnection affect the vehicle's alarm system?
- Do you have a battery keeper to preserve memory?

Power Supply: Possible sources

A Battery - ideal (NB. Protect memories etc. don't disconnect battery)
B Large cable close to battery under fuse box
C Large cable in rear of vehicle
D Manufacturer's supplied connection point.

Notes

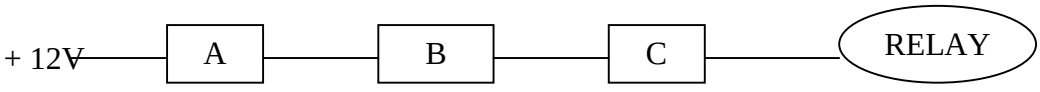
B/C Check cable has enough capacity (see TB2)
Find out what is carrying already. Use an **induction ammeter**

D Check

- Handbook
- Wire size
- Fuse supporting it
- Other circuits.

Fuses

Fit the fuse in the right place: where should this fuse be? A, B or C?

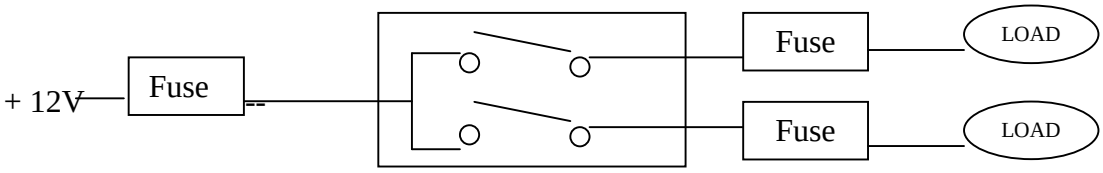


The fuse should be at A to protect the cable run in case of a short. If it is at B or C, a dead short between source and fuse could cause a fire and/or damage the power source.

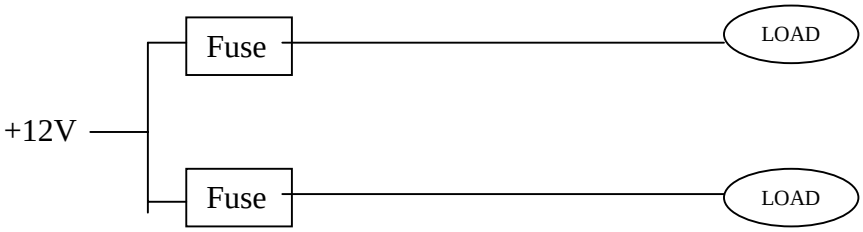
Did you fit the correct configuration?

Some configurations use more fuses than others. Accessibility could be a factor in your decision to which configuration to use.

A

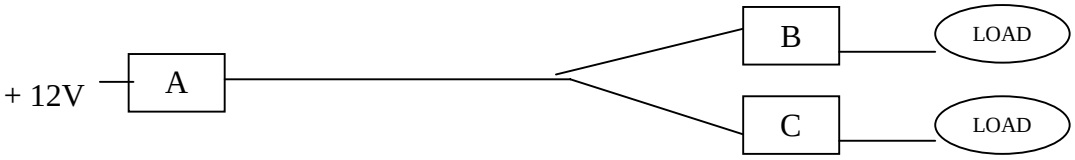


B



Circuit B only requires two fuses but needs two long runs of cable

C



Circuit C requires three fuses because the long single cable run has to be protected by Fuse A

CABLE SELECTION.

Always use the correct size of cable. Attempting to supply large currents through cables of insufficient size is bad practice and should be avoided. **Use the chart in section TB2 for guidance.** (When measuring cable length, remember that the length of any insulated earth return cables has to be taken into account)

The chart on the next page tells you how to calculate loads.

How much power does each lamp use?

This table tells you.

Function and Wattage			
Pin number	Supply to	Wire colour (UK)	Typical Watts
12N			
1	LH Flasher	Yellow	21
2	Fog lamp	Blue	21
3	Earth for 1, 2, 4, 5, 6 & 7	White	Return current equals all working output currents
4	RH Flasher	Green	21
5	RH tail	Brown	5
6	Brake lights	Red	42
7	LH tail	Black	5
12S			
1	Reverse light	Yellow	21
2	Battery (pre ’98)	Blue	96
3	Earth for pins 2 & 4	White	Return current equals all working output currents
4	Unswitched live	Green	21 pre 98 96 post 98
5	Spare	Brown	0
6	Fridge	Red	96
7	Earth for pin 6	Black	96

More lights may be fitted to any of the above circuits, depending on the design of the trailer. Longer trailers may have several extra lights on the tail circuits.

How to calculate the correct cable gauge to use.

Load calculation: Bulb (5w 10w 21w)

Volts x Amps = Watts
Watts divide by Volts = Amps

Add bulb values together e.g. (21w +21w = 42w) (Brake lights)

Divide the total by the volts e.g. (42 watts divided by 12 Volts = 3.5 Amps)

Testing

Before you do any work.
Test the vehicle. Check that its lights work and that no other devices in or on it are malfunctioning. If you do find problems, inform the owner before commencing any installation.

On completion

1. Test your installation, using a suitable test board or other device.

2. Test with the alternator charging at different rates and with the engine off.

3. Pay close attention to what is happening when you test, both the functioning of the loads on your tester and the condition of any warning lights in the vehicle.

4. Tick off all functions against the checklist you used when you checked the vehicle in.

5. To be a true test your test device should simulate the conditions in a trailer or caravan. If you use a test board with lights providing the load, you should have enough lights to create the loads listed in the *Function and Wattage* table above.

TB7 Review: Fitting and Testing
Name: Date

Vehicle Make & Type:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
Did you need to disconnect the battery?		
If you did not disconnect the battery, what commonsense precautions did you take?		
If you disconnected the battery why did you do so and what precautions did you take to safeguard the vehicle?		
How and why did you select your power source?		
How did you connect to your power source?		
What tools did you use?		
At which points, if any, in the installation, did you have to protect your wires from being cut, pierced, crushed or otherwise damaged?		
Where did you locate your fuse(s) to give maximum protection to the cable and the components you fitted?		

Cable selection

Fill in the chart below with the colours and functions of the wires and give the standard cross sectional areas (mm^2) of the wires you used. Different pins need different size wires.

12N pin	Colour	Function	CSA (mm^2)	12S pin	Colour	Function	CSA (mm^2)
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			

Score for cable selection	

Testing

Describe how you tested your installation.		

In a test board, approximately what <u>minimum</u> load do you need to put on each circuit to simulate the trailer or caravan?

12N Pin 1 2 4 5 6 7 12S Pin 1 2 <<Pin 4, pre and post 1996>> 4 5 6 7		

How many amps, approximately, do the earth wires for the following have to carry?		
Earth from: 12N pin3 Pre1996 12S pin 3 Post 1996 12S pin 3 Post 1996 12S pin 7		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	
A. Total possible score:	B. Your Score:	A/B x 100= %

Time spent on this training

In workshop	
Completing review form	
Checking answers	
Looking up information	

Time started …….. Time finished……. Duration (hrs.)……

TB8: Trouble Shooting & Component Evaluation

Guidance Notes

Trouble Shooting

If you have problems with your installation, refer to the *Practical Guide to Towbar Electrics*, which has trouble-shooting sections for all common towing relays.
You should keep notes for your own reference when you encounter problems.

Component Evaluation

You should reasonably expect your suppliers to ensure that the products they supply to you are fit for their purpose. In an industry where new problems and solutions are constantly being presented, it is also reasonable for you to examine the products you are offered, to satisfy yourself that they are built to an acceptable standard.

Build quality

1. Appearance
2. Robust construction
3. Protection of electrical conductors against accidental shorting
4. Provision for mounting, securing cables, etc.

Components used

1. Relays - will they handle the currents they are expected to switch?
2. Open relays - are they properly protected?
3. Connectors - will they handle the cables you will connect?

Design and support

1. Is the product clearly well designed to do its job?
2. Will the product be compatible with other systems in the vehicle?
3. Is there protection against overheating?
4. Do the product instructions give you clear guidance about its use?
5. Is there technical backup when you have problems?

Performance

1. Is the product up-to-date for fitting in new vehicles?
2. Is the product easy to fit?
3. Does the product do the job reliably over a long period?

TB8 Review: Trouble shooting & component evaluation.

Name: Date:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
If you had problems with the installation, what advice was available to you? (Tick/comment) • Your own notes • Company notes • Instruction sheets • Practical Guide • Supervisor • Telephone help line • Website		
How do you record details of problem-solving in vehicles?		
Did you evaluate relays used in terms of: • Handling the current (Show current and relay rating) • Protection of relays and terminals from damage or shorting • Compatibility with other systems in the vehicle		
For any crimp or self-stripping connectors you used, write down their cable range and the cable size you fitted them to.	Connector Range Cable size	
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award. Total score		
A. Total possible score:	B. Your Score:	A/B x 100= %

Time spent on this training

In workshop	
Completing review form	
Checking answers	
Looking up information	

Review Sheets Pack

Tb1: Review- Selecting And Fitting Relays

Name: Date

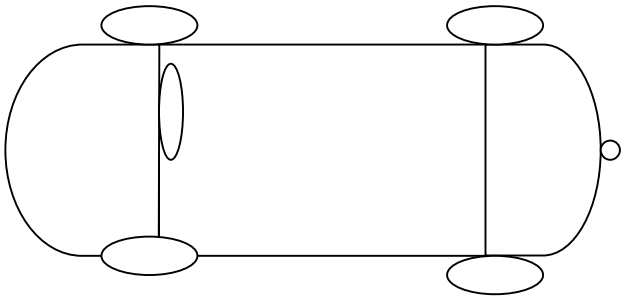
12N: Road Lights –

Vehicle Make & Type:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	**What you did**	**Score/10**
Initial checks on the car electrics: How did you check:		
That all lamps were working properly		
That no warning lamps were on before you started		
For any special circuits (e.g. Customer add-ons) to take into account		
Whether the car had bulb failure warning devices		
For a computer and/or multiplex circuits controlling lights or accessories		

Where did you fit relays and/or monitors and how did you decide?				
Circuit	**Checks you did**	**Type fitted or "None"**	**What does the relay/monitor do?**	
Flasher				
Stop				
Tail				
Fog				
Reverse				

How did you test your 12N installation?		
When choosing relays that can do the job, how do you check the current rating of the relays you select?		
12S: Supplementary (Caravan) Circuits **Did you fit a 12S System? (*If no:* ignore this section)**		
Where did you pick up your power source?		
How did you prove it was adequate?		
Where did you fuse it? (Connectors, fuses and cables are dealt within their own review)		
 Show cable routes connections, relays, fuses etc:		
Did you fit a relay (If no, give your reasons: normally a relay is essential).		
Did you fit a conventional relay? ***If Yes***: Where did you pick up the trigger current?		

Was the trigger current source "*Off*" • When the ignition was off? • When the starter motor was cranking? • How did you test that?		
Did the car have air conditioning? If yes, how did you deal with the potential conflict (overloading) between the Air Conditioning and the 12S system?		
What reasons did you have for selecting the relay you fitted?		
Describe how you tested the 12S system when you finished fitting it.		

You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award. Total score	

A. Total possible score:	B. Your Score:	A/B x 100= %	%

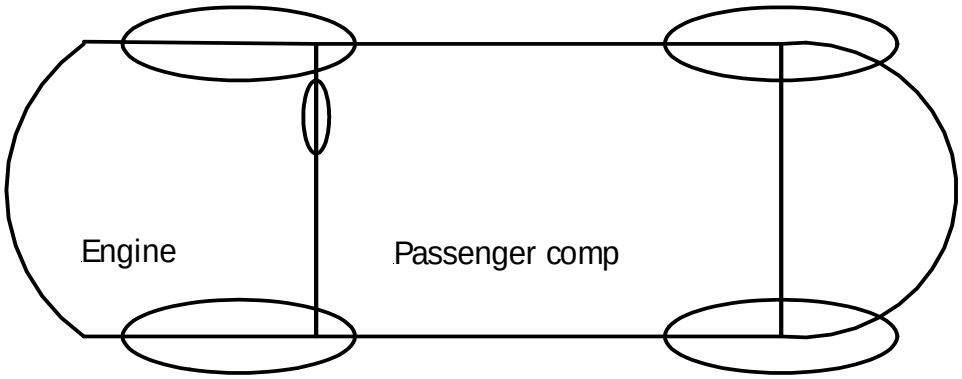
Start time: End time: Duration (Hrs) .

TB2 Review: Fuses, Cables And Connectors

Vehicle Make & Type:
Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
CHOICE OF FUSE RATING How did you calculate the load that the fuse(s) would protect?	Show your calculation	
What type of fuse did you fit and why did you select that type as suitable?		
What value fuse(s) did you fit?		
Sketch how you configured the fuse(s). Battery Load(s)		

Where you fitted the fuse(s) in the vehicle?
Show: Battery, load/relay route of cable(s) location and value of fuse(s).
Identify cable(s) (marked 1 / 2 etc. if more than one)



Where the components and fuses are installed.

POWER CABLE (S) INSTALLED			
State cable length and specification • Strands/gauge • Cross sectional area mm?	1:	2:	3:

Voltage drop

In relation to the cables you fitted, what was the maximum current rating to achieve less than 0.5v drop over 5 metres? (Refer to cable selection chart in the *Practical guide to Towbar Electrics*)
Fill in the chart below to show whether the cables you selected were adequately rated.

A		B	C	D	E		See notes in guidance about variations
Load in amps		**Length of Cable installed**	**Max. rating over 5m**	**Max. rating over length you installed: (5/BxC=D)**	**If the figure at D is less than the figure at "A" the cable is inadequate. Is D equal to or more than "A"? Yes/No**		
1							
2							
3							

CONNECTORS USED

Did you: (a) solder your connection or (b) use connectors?

If (a) how did you ensure the solder connection was perfect?		

If (b) describe the connections you used as follows:

Type (E.g. self-stripping, insulated crimp, etc.)	**A** **Colour of connector used + cable rating(mm^2) of connector**	**B** **Main cable & tap cable**	**Was the cable rating (mm^2) at A suitable for the cable used at B?**	Which tool did you use to get a good connection? (e.g. ratchet crimper,)	

You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	

A. Total possible score:	B. Your Score:	A/B x 100= %	%

Start time: End time: Duration (Hrs)

Verified by:……Position……. Date……

TB5 Review: Bulb-failure, Computer control, Multiplexing

Name: Date:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	Answer	Score/10
Bulb-failure bypass relays		
Conventional flasher relays cause no problems for towbar electrics installers. Bulb-failure warning systems on other circuits in the car do. What makes the difference?		
Why are bypass relays not detected by bulb-failure warning systems?		
Typically, what currents are drawn by the coils of bypass relays?		
What hazards might you encounter if you looked for a power source for your bypass relay(s) other than the battery?		
What key characteristics of good bypass relays enable them to handle the currents found in typical trailer/caravan road light systems?		
Computer Control and Multiplexing		
What is multiplexing?		
Why would car manufacturers wish to introduce it?		
How does multiplexing reduce the amount of cabling in a car?		
Multiplex systems switch relays. What is different about the way they do this compared with conventional relay switching?		

Computer Control and Multiplexing (Contd.)		
Will computer downloads modify engine management systems to accommodate towing and thus be essential? If not, why not?		
Will the addition of towbar electrical systems that are not supplied by the manufacturer cause problems for any diagnostic systems installed in the vehicle? If not, why not?		
Will the fitting of bypass relays always prevent malfunctions and alarms caused by the towbar electrical installation?		
What essential condition must be present for the bypass relay to work successfully?		
Why should you not tap into the multiplex system power cable?		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	
A. Total possible score:	B. Your Score:	A/B x 100= %

TB6 Review: Vehicle Preparation

Vehicle Make & Type:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

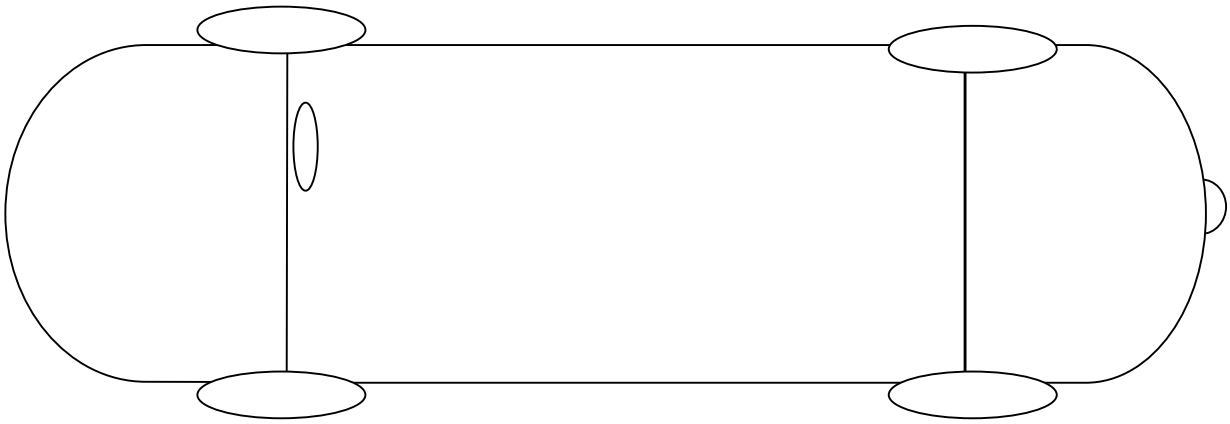
Question	What you did	Score/10
Hazards Answer the questions and describe what you did. **Did you:**		
Check your company records for details of this car?		
Check other records, newsletters etc?		
Examine the vehicle (including the handbook).		
Do bulb failure devices and other light checks		
Check warning lights before starting		
Identify circuits at risk from battery disconnection		
Selecting power sources making connections - did you check: *Answer the questions and describe what you did.*		
Fuse configurations		
For the presence of airbag and ABS circuits		
Existing loads on any cable you used as power source		

Verified by:……Position…… Date……..

Did you up rate an existing fuse? If yes justify your decision, giving a clear explanation of what checks were carried out and in what areas		

Routing cables

- On the diagram below show cable routes
- Show points where cable needed additional protection



Getting to the wiring: Removing trims

Answer the questions and describe what you had or did.

Did you have a record of how to remove trim on this vehicle? Did you have all necessary tools, bits and components at the start of the job?		

Verified by:……Position…… Date……..

Trims, (Contd.) What particular problems, if any, did you encounter removing trims?		
List any clips broken, seals damage etc. Did you have replacements in case you broke any?		
What new details (if any) did you add to your company's records on completion of this job?		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	
A. Total possible score:	B. Your Score:	A/B x 100= %

Verified by:……Position…… Date……..

TB7 Review: Fitting and Testing

Name: Date

Vehicle Make & Type:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
Did you need to disconnect the battery?		
If you did not disconnect the battery, what commonsense precautions did you take?		
If you disconnected the battery why did you do so and what precautions did you take to safeguard the vehicle?		
How and why did you select your power source?		
How did you connect to your power source?		
What tools did you use?		
At which points, if any, in the installation, did you have to protect your wires from being cut, pierced, crushed or otherwise damaged?		
Where did you locate your fuse(s) to give maximum protection to the cable and the components you fitted?		

Verified by:……Position……
Date……..

Cable selection
Fill in the chart below with the colours and functions of the wires and give the standard cross sectional areas (mm^2) of the wires you used. Different pins need different size wires.

12N pin	Colour	Function	CSA (mm^2)	12S pin	Colour	Function	CSA (mm^2)
1				1			
2				2			
3				3			
4				4			
5				5			
6				6			
7				7			

Score for cable selection	

Testing

Describe how you tested your installation.		

In a test board, approximately what <u>minimum</u> load do you need to put on each circuit to simulate the trailer or caravan?

12N Pin 1 2 4 5 6 7 12S Pin 1 2 <<Pin 4, pre and post 1996>> 4 5 6 7		

Verified by:……Position……
Date……..

How many amps, approximately, do the earth wires for the following have to carry?		
Earth from: 12N pin3 Pre1996 12S pin 3 Post 1996 12S pin 3 Post 1996 12S pin 7		
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award.	Total score	
A. Total possible score:	B. Your Score:	A/B x 100= %

Time spent on this training

In workshop	
Completing review form	
Checking answers	
Looking up information	

Time started …….. Time finished……. Duration (hrs.)……

Verified by:……Position……
Date……..

TB8 Review: Trouble shooting & component evaluation.

Name: Date:

Self Evaluation: Fill this in as you work and check your answers against those given in the Guide File

Question	What you did	Score/10
If you had problems with the installation, what advice was available to you? (Tick/comment) • Your own notes • Company notes • Instruction sheets • Practical Guide • Supervisor • Telephone help line • Website		
How do you record details of problem-solving in vehicles?		
Did you evaluate relays used in terms of: • Handling the current (Show current and relay rating) • Protection of relays and terminals from damage or shorting • Compatibility with other systems in the vehicle		
For any crimp or self-stripping connectors you used, write down their cable range and the cable size you fitted them to.	Connector Range Cable size	
You need to record 100% scores in each element and be able to demonstrate them to an assessor for your unit award. Total score		
A. Total possible score:	B. Your Score:	A/B x 100= %

Time spent on this training

In workshop	
Completing review form	
Checking answers	
Looking up information	

Verified by:……Position……
Date……..