EXXOTEST® EDUCATION

Vehicle training equipment

User's guide for DTM7000
Set of 9 training modules:
LIGHTING & SIGNALLING SYSTEMS

CONTENT

1. INSTALLATION GUIDE

Installing and setting-up all DTM7000 modules

Connect to a 12 to 14 V power supply (not provided), paying careful attention to polarities.

Then interconnect the various modules in accordance with the operating manual supplied with all DTM7000 modules.

Then energised, moving parts remain in their current position.

Operational environment

All DTM7000 modules should be installed in a clean, dry location, free of dust, water vapour and combustion fumes.

The equipment requires a lighting level of approximately 400 to 500 Lux.

The equipment can be installed in a Practical Workshop Classroom, the noise generated will not exceed 70 dBA.

Modules are protected from potential user errors.

Calibration & maintenance of all DTM7000 modules

Calibration: Factory Settings.
Servicing interval: N/A
Cleaning: Use a soft, clean cloth with a window cleaning product.

Number of stations, user position

All DTM7000 modules can be taken as one single workstation.

The various modules are placed on a worktop, and users will remain seated throughout their practical lesson.

Method for removal from service

Turn off power supply, unplug all connecting wires. Check for current by pressing the buttons on each module, if nothing happens, no current is present.

Then store the DTM7030 modules in a contained room with a panel marked "Equipment Removed from Service".

Residual hazards

After extended use of the bulb unit there is a risk of burns.

2. THE BASICS OF ELECTRICITY

Reminder of the Basics of Electricity

Voltage. The Volt is used to measure Voltage (also known as 'potential difference' or 'pd'), which is defined as the work done per unit charge in order to move that charge from one point to another. The symbol used for voltage is V, and its unit is the Volt.

Current. The Amp (or Ampere) is used to measure an electrical current, which is defined as the rate of flow of electrical charges through a point per second. The symbol used for current is I, and its unit is the Ampere.

Resistance. The Ohm is used to measure electrical resistance, which is defined as the opposing force applied, by a component, to the electrical charges in a circulating current. The symbol used for resistance is R and its unit is the Ohm (Ω).

Physical laws

In an electrical circuit, the flow of current is controlled by the following two rules:
- The lower the resistance, the greater the current flowing through the circuit.
- The higher the voltage, the higher the current flowing through a fixed resistance.

These two rules allow us to form fundamental Ohms laws:

$$U = I*R$$ where U is expressed in Volts, R in Ohms & I is in Amperes.

Power is defined by a mathematical formula:

$$P = I*U$$ where P is expressed in Watts, U in Volts & I in Amperes.

Equipment to be used

The Voltmeter used to measure a voltage or potential difference across the terminals of a component in an electrical circuit. The following precautions must be taken during use:
The voltmeter must be connected in parallel with the terminals of the component to be tested.
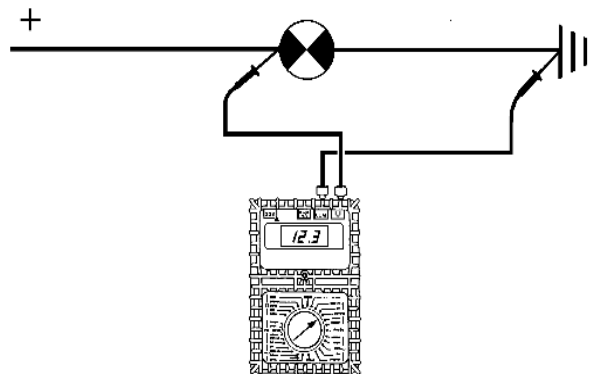

The Ammeter used to measure the current flowing through a circuit. The following precautions must be taken during use:
- Always connect to the circuit to be tested in series.
- Must be associated with a load.
- Pay careful attention to the maximum authorised current for the ammeter in use.
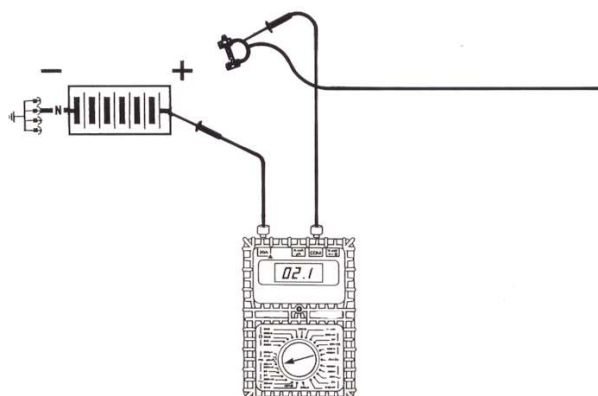
**The Ohmmeter** used to measure the resistance of a conductor. Connects to the terminals of the component to be tested.
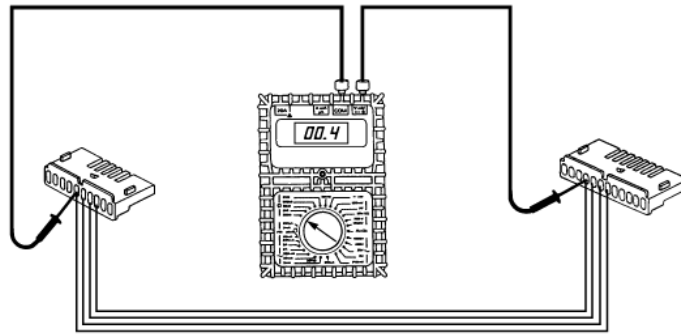
The following precautions must be taken during use:
- The device should never be connected to an external power supply.
- Components to be measured must be disconnected from the circuit and powered-down.
- Avoid disrupting readings by touching the circuit with any part of your body (which is a conductor).
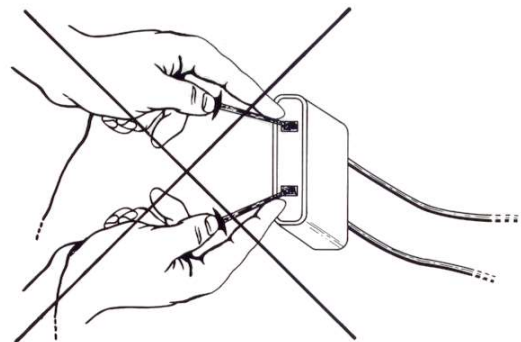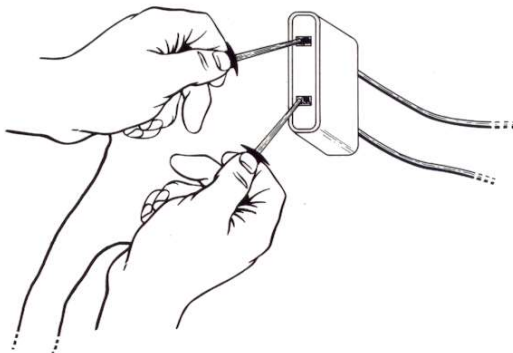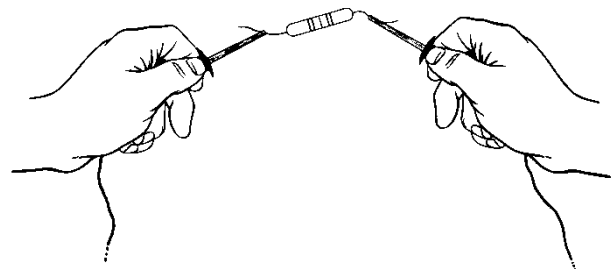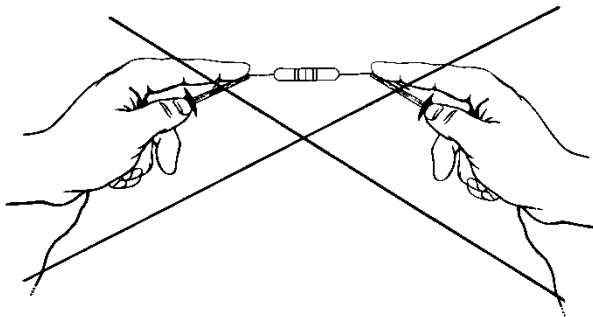
Vehicle power supply

Vehicles are fitted with batteries, which work as chemical storage devices for the electrical energy produced by the vehicle's generator (alternator). The batteries must be capable of providing rapid high current supplies (above all, at low temperatures) when starting the vehicle cold and providing partial or total supply to the other major loads throughout the vehicle's electrical system for a limited period, above all when the vehicle's engine is running at idle or has been stopped. This requirement is generally met by a lead-acid battery (sulphuric acid).

The normal voltage for a battery fitted to a private vehicle is 12V.

The requirements imposed by each of the vehicle's circuits, in terms of starting power, capacity and charging current, apply for a temperature range of between -30 and +70 °C.

The various characteristics of vehicle batteries:
- Voltage - generally 12.5 V for private vehicles.
- Capacity, in Ah (Ampere-Hours), i.e. the number of amps which can be consumed for a period of one hour before the battery is fully discharged (Caution: with a half-charged battery, it may prove difficult to start the vehicle).
- The number of amps supplied at start-up - depending on vehicle type and engine.
- The size and height - different for each vehicle.
- Location of positive and 0 V terminals.

| 0V | + | | + | 0V |

Standardised terminal IDs (taken from DIN 72 552)

A few examples of markings:
| 1 | Ignition - low voltage |
| 15 | Positive when ignition is turned on |

Battery   *Starter*
| 30 | + Battery | 50 Starter motor control
| 31 | Ground 0v |
Relays
| 85 & 86 | Relay control | | 87 | Working |
| 87b | At rest | | 30 | Common |

Connections

Definition:

Connections are used to link two or more components, with the option of disconnecting the link, maintaining a good electrical contact and even waterproofing the connection.

Several different types of shapes exist, all of which are easy to remove.

The best connections are those with the lowest possible electrical resistance.

Be aware of current restrictions!

Examples of types of connector:

          Female flat-lugged connector.

3-way female flat-lugged connector.

Female, 1-7-way connector with or without clip, leak tight (water temperature probe, HV coil, etc. used by PSA and Renault):
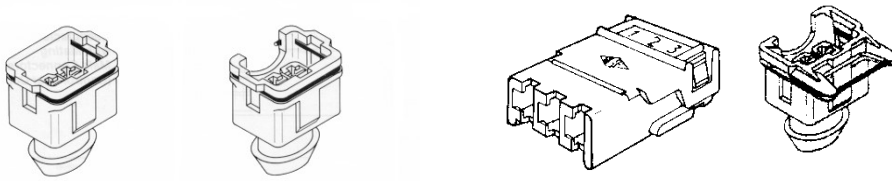
Female connector, 9, 15... way, leak tight (powered ventilation control unit, etc., used by PSA).
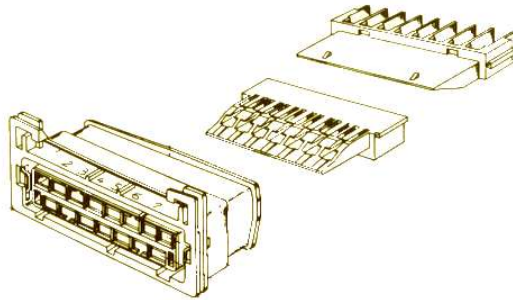
Bulkhead connector, 10, 14, 23, way, leak tight (used by PSA):
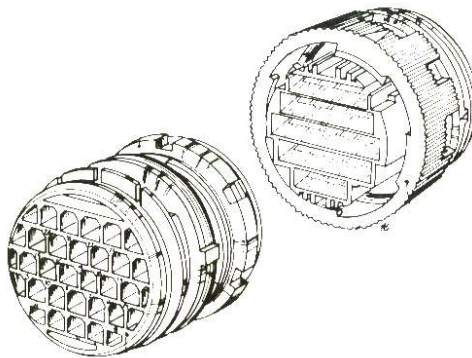
15, 25, 35, 55, way connector, for all types of ECU: injection, ABS, air conditioning, suspension control, etc. on a number of vehicles.

Electrical circuit components

Connecting multi-strand copper wires of various cross-sections, depending on current.

The resistance within the circuit depends on:

- Length:

- Cross section (flow):

- Type of cable:

Table of standard values for electrical conductors:

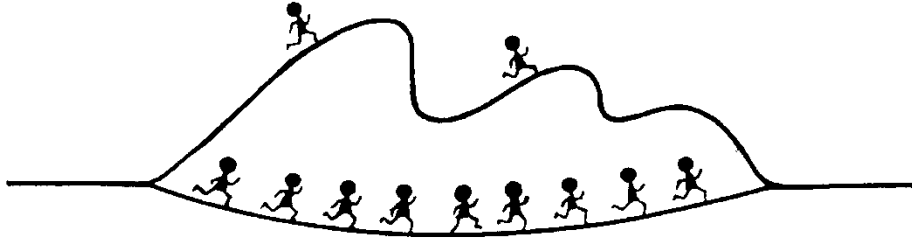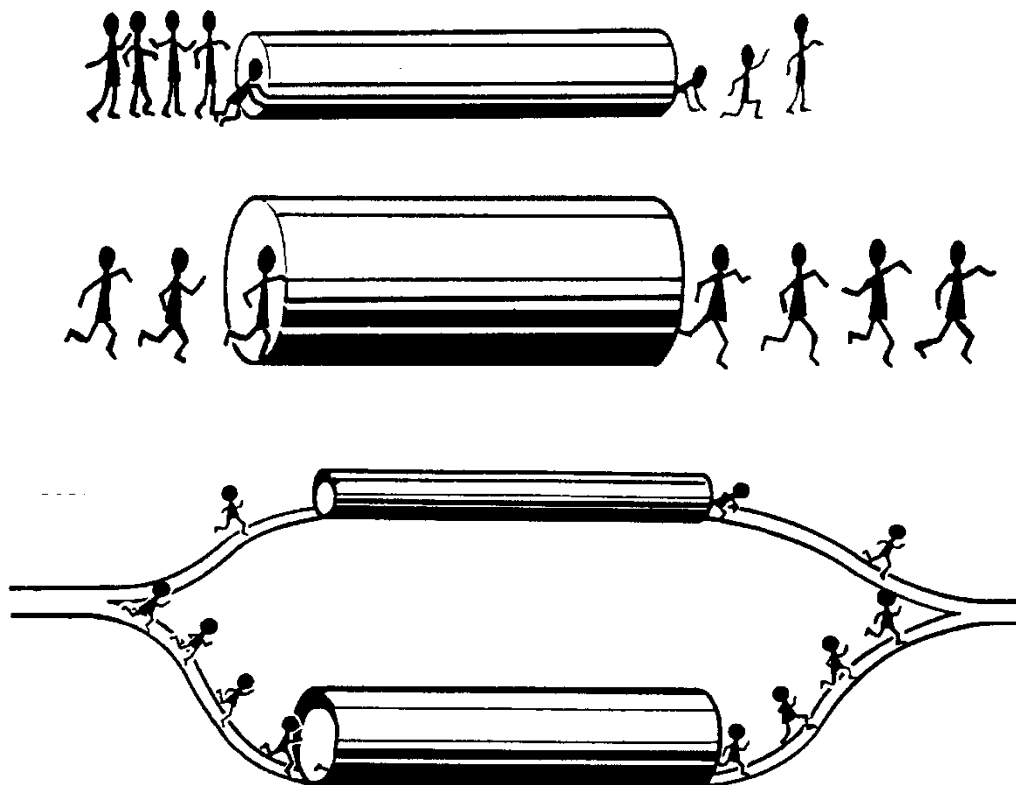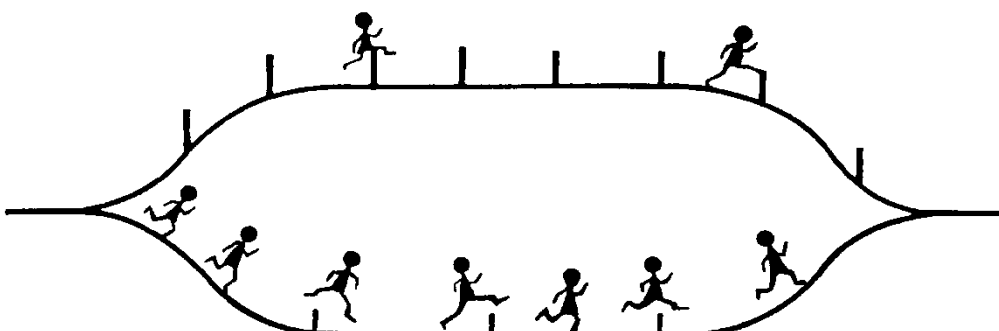| Conductor	Resistivity in Ω.m
Silver	$1,64 .10^{-8}$
Copper	$1,72 .10^{-8}$
Aluminium	$2,69 .10^{-8}$
Nickel	$7,8 .10^{-8}$
Iron	$9,8 .10^{-8}$
Chrome-plated nickel	$108,5 .10^{-8}$

Table showing resistance and weight of copper wiring:

Diameter mm	Cross section mm²	Weight kg/km	Weight kg/km
1,00	0,7854	7	22,28
1,50	1,7671	15,750	9,903
2	3,142	28,00	5,570
2,5	4,909	43,75	3,565
3	7,069	63	2,476

Fuse

A fuse is a safety device, used to protect an electrical circuit from excess current. Generally, fuses comprise a metal strip which melts at a given temperature. If the current flowing through the circuit exceeds a pre-determined value, the fuse metal melts, thus opening the circuit.

A 10A fuse is designed to withstand 10 Amperes at 20°C; however, it will withstand 20A for a period of 10 seconds, 30A for 5 seconds and even 80A for 0.01 seconds.

Here is an example of the time/current curve for a fast blow 10A fuse (time-delayed fuses are also available).

Example of a graph:

Example of curve:
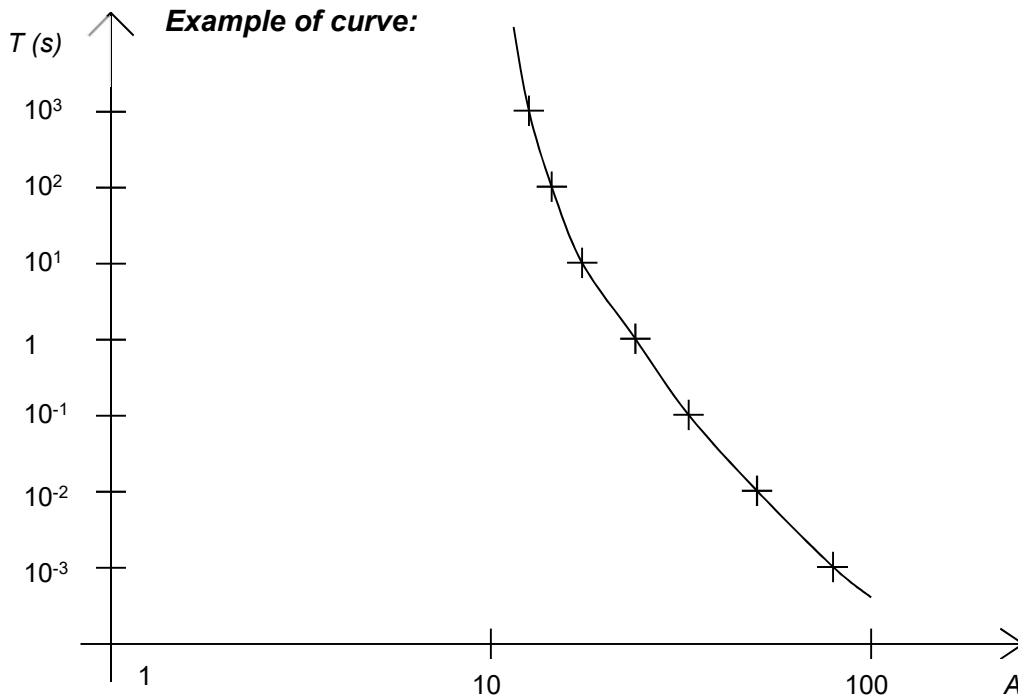
Diodes

They are members of the semi-conductor family and are used to let current flow in one direction whilst blocking it in the other.
The graphical symbol used for the diode is:

The arrow shows the direction in which current may flow.

Current flows

Current cannot flow
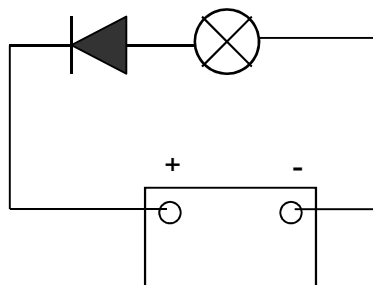
The use of diodes is not restricted to electronic circuits, they can often be found in classical electrical circuits (e.g.: alternators).

Zener diodes

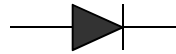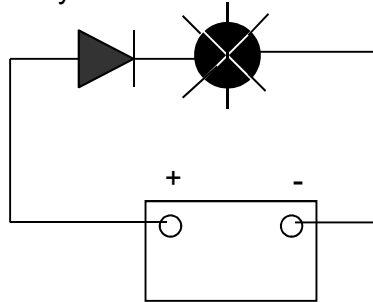Take a standard diode. If one applies too high a voltage in the opposite direction the diode will let current pass, but this will damage it, rendering it unusable.

However, the Zener diode will permit voltages above a certain level to pass through it in the opposite direction without breaking.

Symbol:
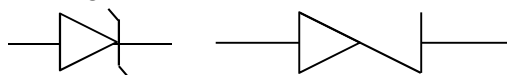
The Zener diode can be found in a wide range of circuits, notably for voltage regulation, load voltage regulators, etc.

Transistors

Members of the semi-conductor family (germanium, silicon, etc.) and can generally be taken as relays.
There are two groups of transistors, as follows:

Type PNP:

B -

E   C
+   -

E   B   C
+   -   -
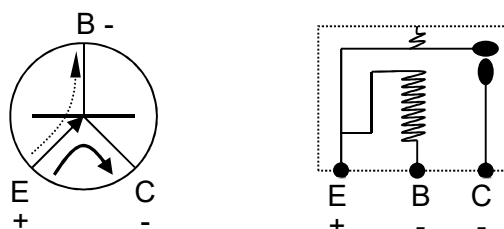
For these transistors to allow current to pass:
The flow of the control current should be from the emitter towards the base
The flow of the current should be from the emitter towards the collector.

Type NPN
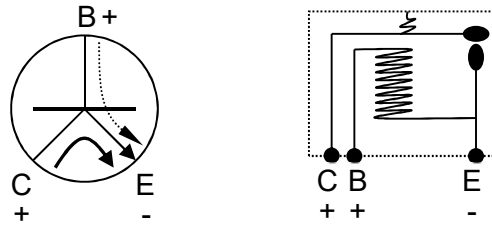
For the transistor to allow current to pass
The flow of the control current should be from the base to the emitter
The flow of the current should be from the collector to the emitter

The advantages of transistors:
- Can be controlled by a frequency of several megahertz
- Practically indestructible
- No induced currents
- Very low control current from emitter to base
- Instant disconnection
- Can be used as an amplifier
- Noiseless

Each transistor is characterised by its gain. This is a coefficient which is used to determine the level of current flowing through the power circuit, from emitter to collector, based upon the current in the control circuit, from emitter to base.

E.g.: for a gain of 100, if I_{EB} = 0.1 A, then I_{EC} will be 10A.

The transistor does not allow current to flow.

L.E.D.

The transistor allows current to flow

L.E.D.
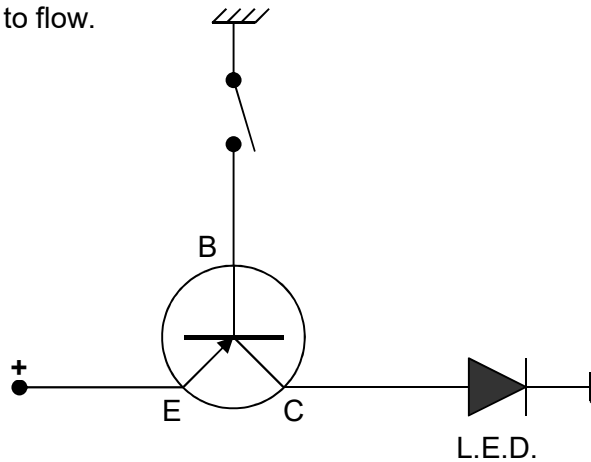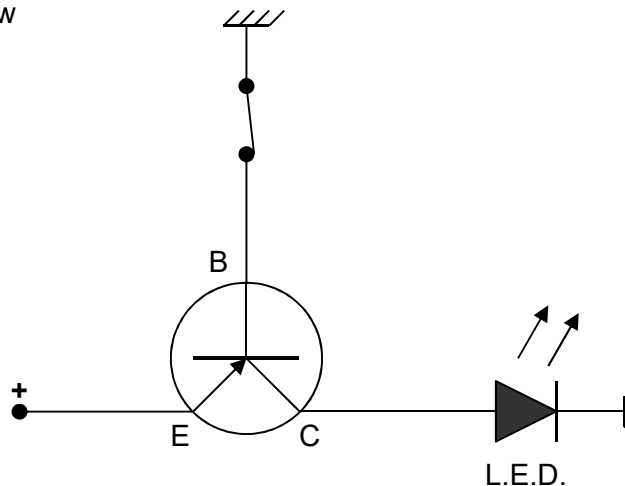
The transistor does not allow current to flow (blocked)
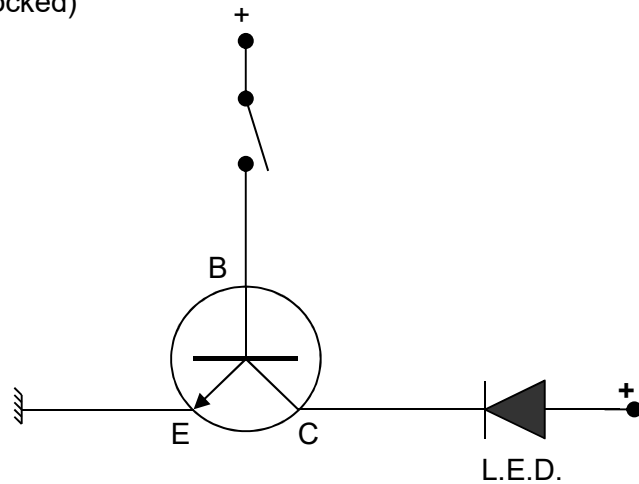
The transistor allows current to flow
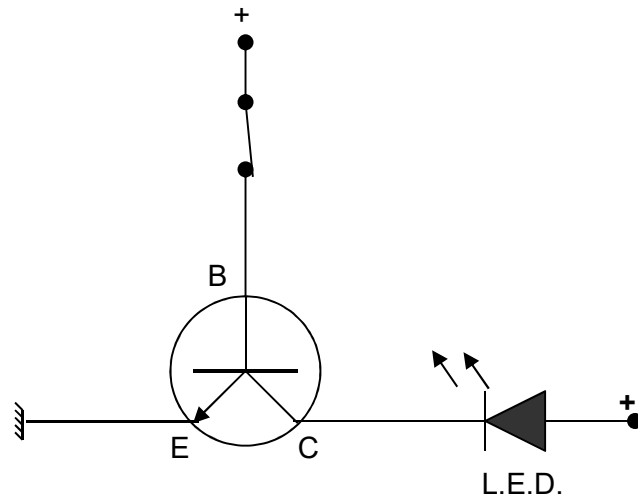
Consumers

These are components which consume current. There are two types of consumer, Active & Passive.

Passive Consumers: bulbs, resistors, etc.

Active Consumers: motors, injectors, retarding valves, etc.

Attention, certain consumers are polarized, whereas others are not.

The notion of Watts Consumed is important when dealing with consumers, as, for a given voltage one can determine the absorbed current.
Example of the various modules along with their consumers:

Relays

A relay is made up of two parts, the control circuit and the power circuit.

The control circuit:
You provide a supply of a few milliamps to a coil, which will create a magnetic field.

The power circuit:
The magnetic field created by the control circuit is used to open and close the power circuit, which may have a current flow of around 10 A.

Within a relay, the control circuit is **isolated** from the power circuit.

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Example - **Module DTM7004** with two relays:

The first relay is a standard, commonly used work/rest relay.

The second is a polarised relay with a 'free-wheeling' diode designed to protect the control circuits from the induction effects of the relay coils.
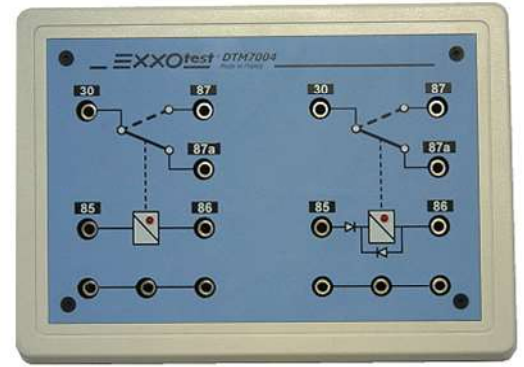
3. DETAILS OF THE DTM7000 SERIES OF MODULES

Module DTM7001D

This module represents the rear lighting cluster on the right hand side and includes the indicator, rear light, fog lamp and brake light.

Brake light bulb Rear R 21W

Rear light Rear R 5W

Fog light bulb Rear R 21 W

Indicator bulb Rear R 21W

Connection point for common earth

Connector terminals
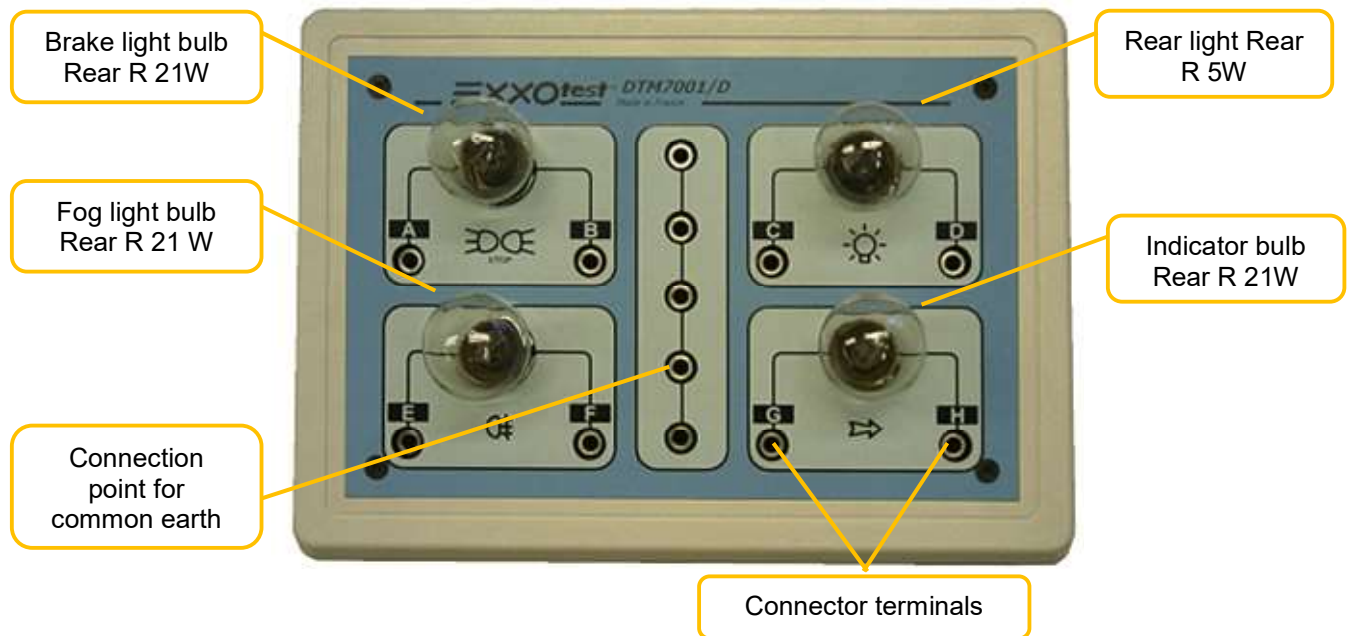
Module DTM7001G:

This module represents the rear lighting cluster on the left hand side and includes the indicator, rear light, reversing light and brake light.

Rear light Rear L 5W

Brake light bulb Rear L 21W

Indicator bulb Rear L 21W

Fog lamp bulb Rear L 21W

Connection point for common earth

Connector terminals
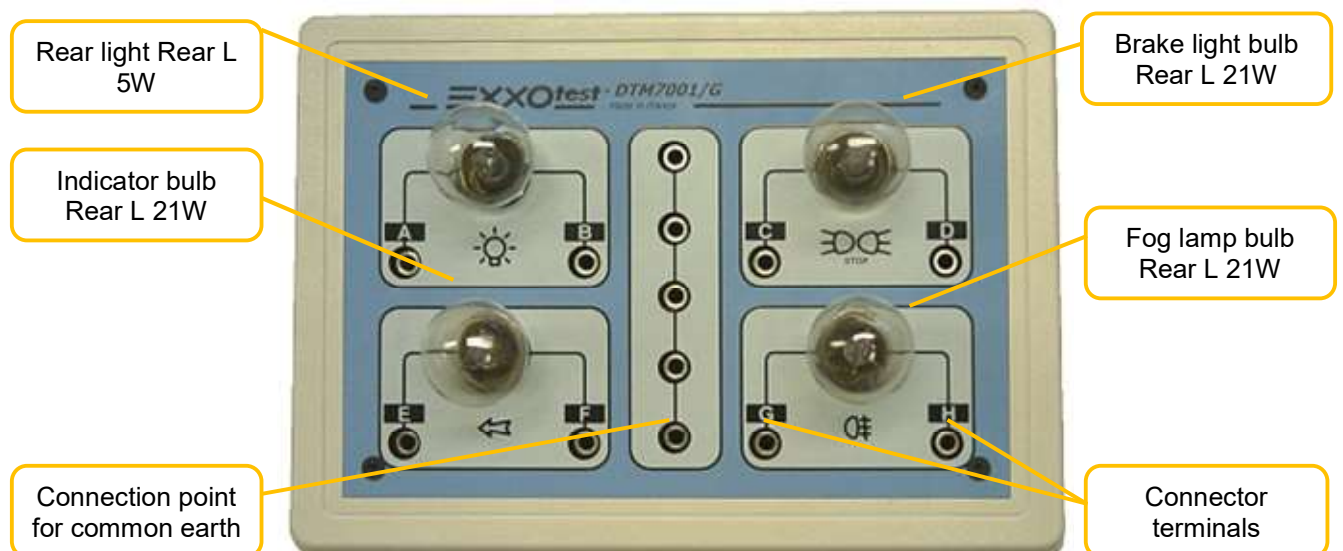
Module DTM7002D

This module represents the front lighting unit on the right hand side and includes the indicator, side light and dipped/main beam headlights.

Sidelight bulb Front R 5 W

Headlamp bulb Front R

Indicator bulb Front R 21 W

Connector terminals

Connection point for common earth

Bulb earth

Module DTM7002G

This module represents the front lighting unit on the left hand side and includes the indicator, side light and dipped/main beam headlights.

Headlamp bulb Front L 40/45 W

Sidelight bulb Front L 5 W

Connection point for common earth

Indicator bulb Front L 21 W

Bulb earth

Connector terminals

Module DTM7003

This module is a fuse panel, used to protect each of the circuits, dependant on the calibre of the fuse fitted.

Sockets for fuses

Input terminal e.g. for fuse **F7**

Output terminal e.g.: for fuse **F7**
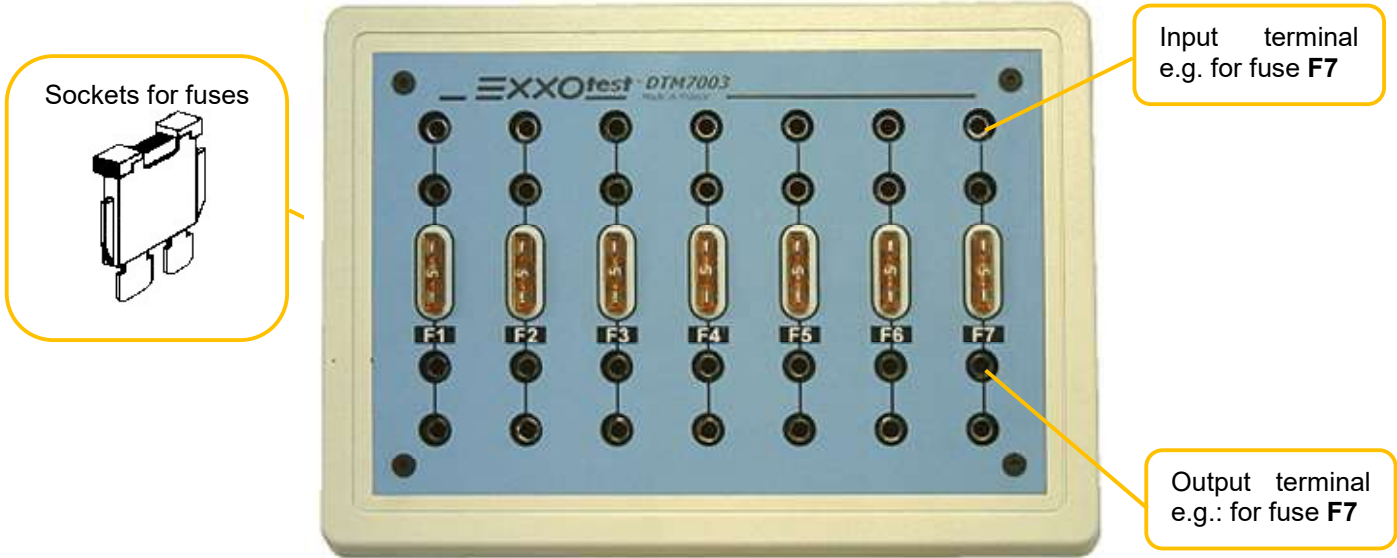
Module DTM7004

This module includes two relays, the first a standard relay, the second a polarised relay fitted with a 'free-wheeling' diode.

Power circuit
30: common
87a: rest position
87: active position

85 & 86
Control circuit

Connection point for common earth (E.g.: Earth)

Power circuit
30: common
87a: rest position
87: active position

85 & 86
Control circuit

Polarisation diode

Free-wheeling diode
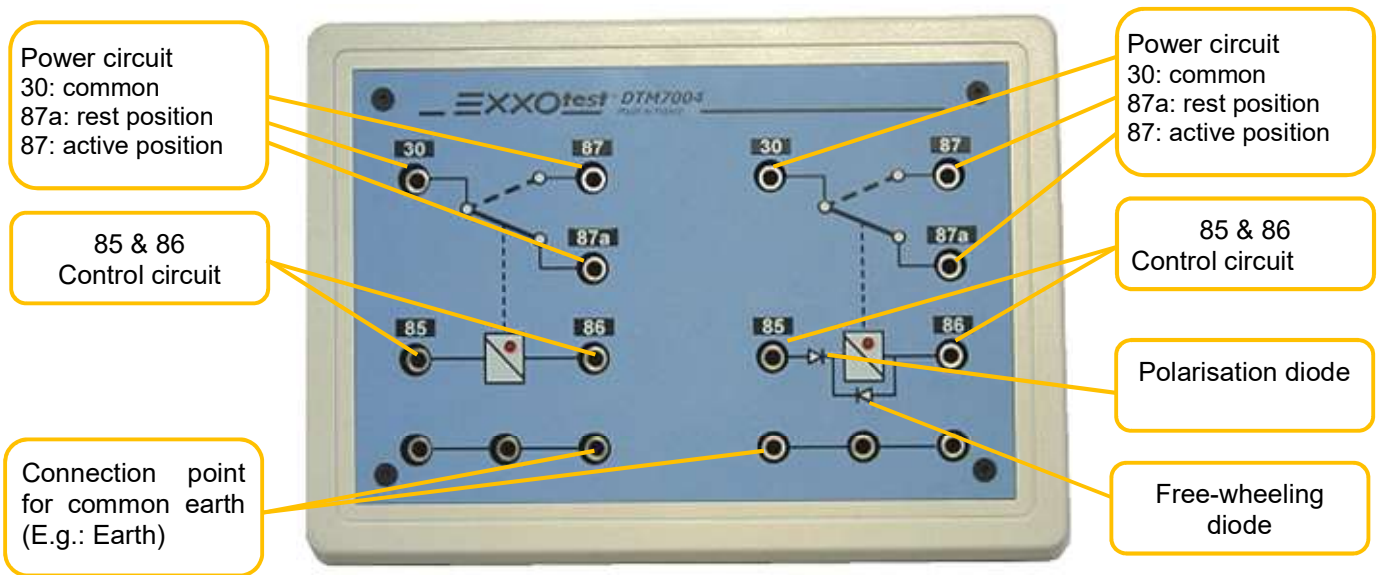
Left-hand relay:

ID	Description	Functionalities
85 or 2 86 or 1	Control circuit	If one connects 85 & 86 to positive and 0v respectively, the coil generates a magnetic field which will, in turn, activate the power circuit.
30 or 3 87b or 4 87 or 5	At rest Active — Common Power circuit	Coil de-energized: Terminal 30 is connected to Terminal 87b (at rest position) Coil energized: Terminal 30 is connected to Terminal 87 (at active)

Right hand relay, caution, the control circuit is polarised

ID	Description	Functionalities
85 or 2 86 or 1	Control circuit	If one connects terminal 86 to positive and terminal 85 to 0v, the coil generates a magnetic field which will, in turn, activate the power circuit.
30 or 3 87b or 4 87 or 5	At rest Active — Common Power circuit	Coil de-energized: Terminal 30 is connected to Terminal 87b (at rest position) Coil energized: Terminal 30 is connected to Terminal 87 (active)

Module DTM7005

This module represents the instrument panel.

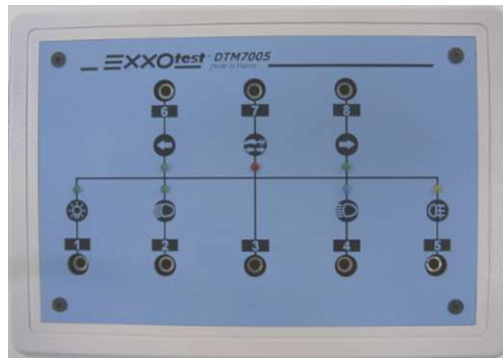| ID	Description	ID	Description
1	Side lights	5	Rear fog lamp
2	Dipped beams	6	Indicator - LHS
3	Earth	7	Brake lights
4	Main beams	8	Indicator - RHS

Module DTM7006

This module represents the lighting control stem switch, including switches for the side lights, dipped beams, main beams, rear fog lamp and indicators.

Power supply battery

Output - Main beams

Output - Main beams

Output - rear fog lamps

Main beam flash control

Output - sidelights

Control for horn

Control for rear fog lamp

Indicator control

Lighting controller sidelights, dipped & main beams
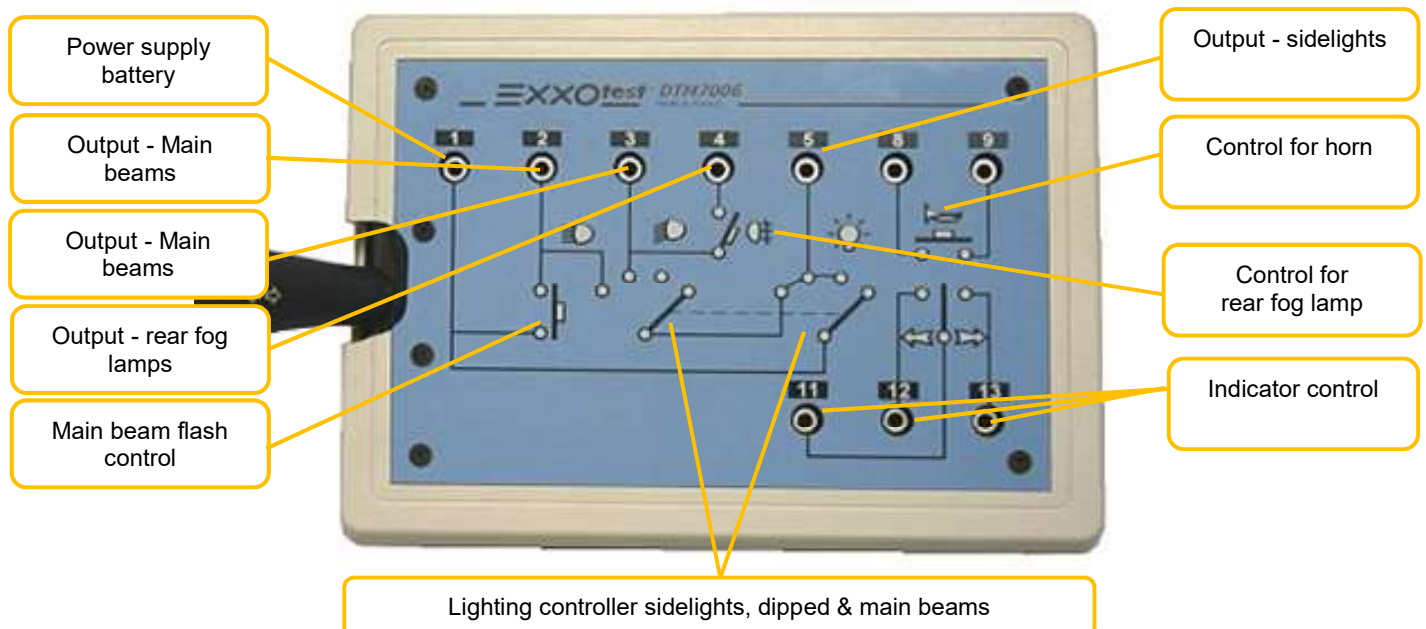
The lighting controller has four positions:
- 1st position: OFF
- 2nd position: side lights ON
- 3rd position: dipped beams ON
- 4th position: main beams ON

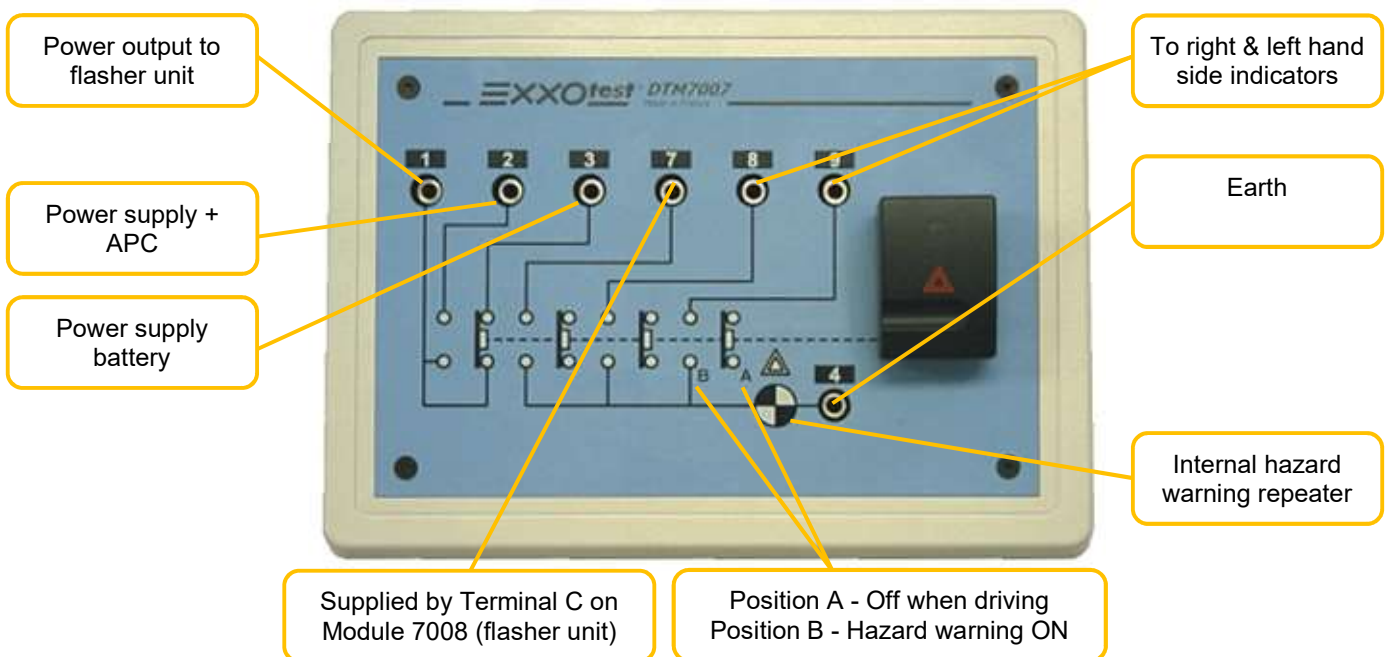| ID	Description	Functionalities
1	Permanent power supply	
2	Output - Main beams	Two different controls - main beam flasher control and lighting controller in position 4
3	Output - Main beams	Selector in Position 3
4	Output - Fog lamps	Selector in Position 2
5	Output - sidelights	Selector in Position 1
8	Horn control input or output	Actuates horn control
9	Horn control input or output	Actuates horn control
11	Common	
12	Indicator - LHS	Indicator switch - left
13	Indicator - RHS	Indicator switch - right

Module DTM7007

This module represents the hazard warning selector

ID	Description	Functionalities
1	Power supply output for flasher unit (module DTM7008)	Constant supply + APC at rest and battery positive when active.
2	Power supply + APC	+ APC
3	Battery supply (+30)	Permanent positive
4	Earth connection	Earth
7	Supply for Terminal C on Module 7008 (flasher unit)	Control signal from flasher unit module (DTM7008)
8 9	To right & left hand side indicators	Hazard warning button pressed
◓	Internal hazard warning repeater light	Flashes when the hazard warning switch is pressed.

Module DTM7008:

This module represents the flasher unit, which actuates the instrument panel repeaters, the internal hazard warning button and the indicators themselves.
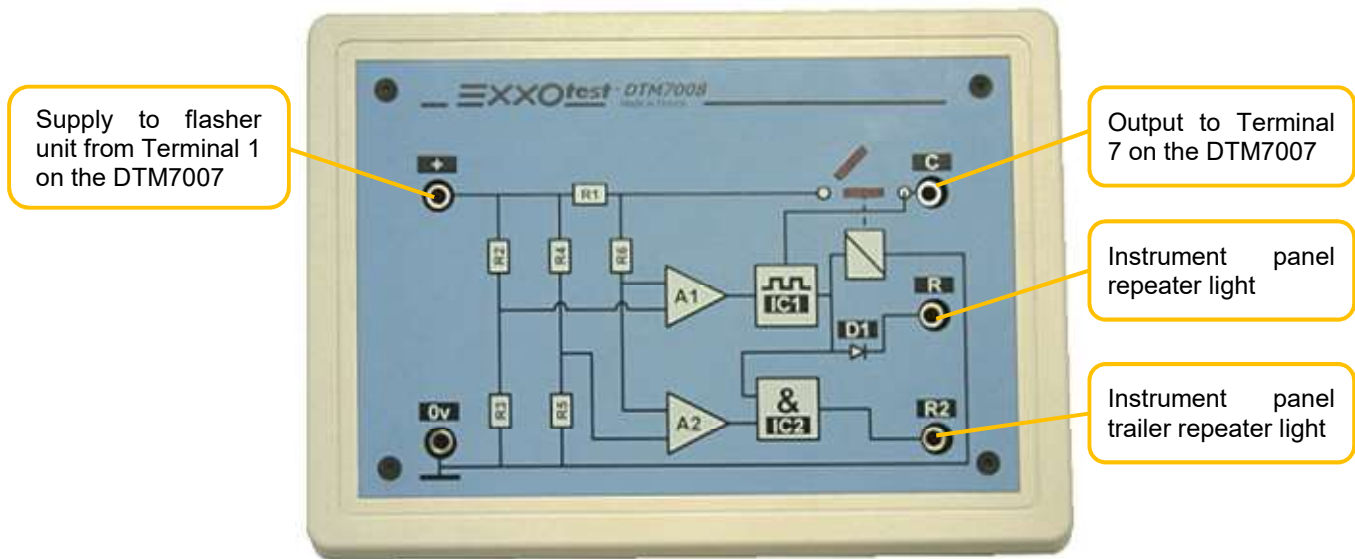
ID	Description	Functionalities
positive	Unit supply	Supply with APC at rest and positive from battery when active
0v	System earth	Earth
C	Output to Terminal 7 on the DTM7007	When à current is drawn through terminal C to the DTM7007 a square wave signal will be created.
R	Instrument panel repeater light	When the hazard warning switch is pressed the instrument panel indicator is supplied.

4. WIRING EXAMPLES

Wiring example: indicator lights
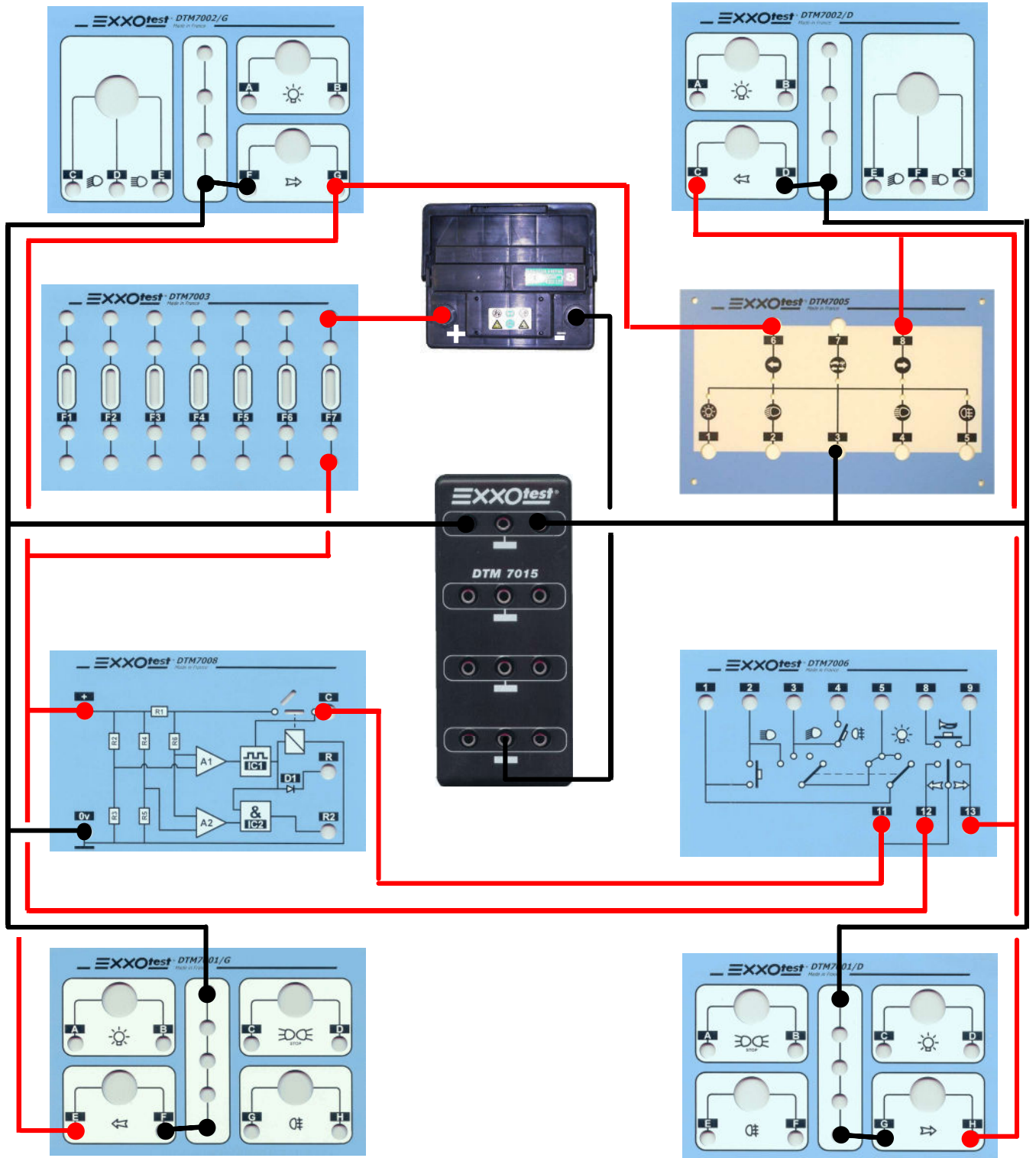
Wiring example: indicators and hazard warning lights

Determining fuse calibres and cross sectional areas of wiring
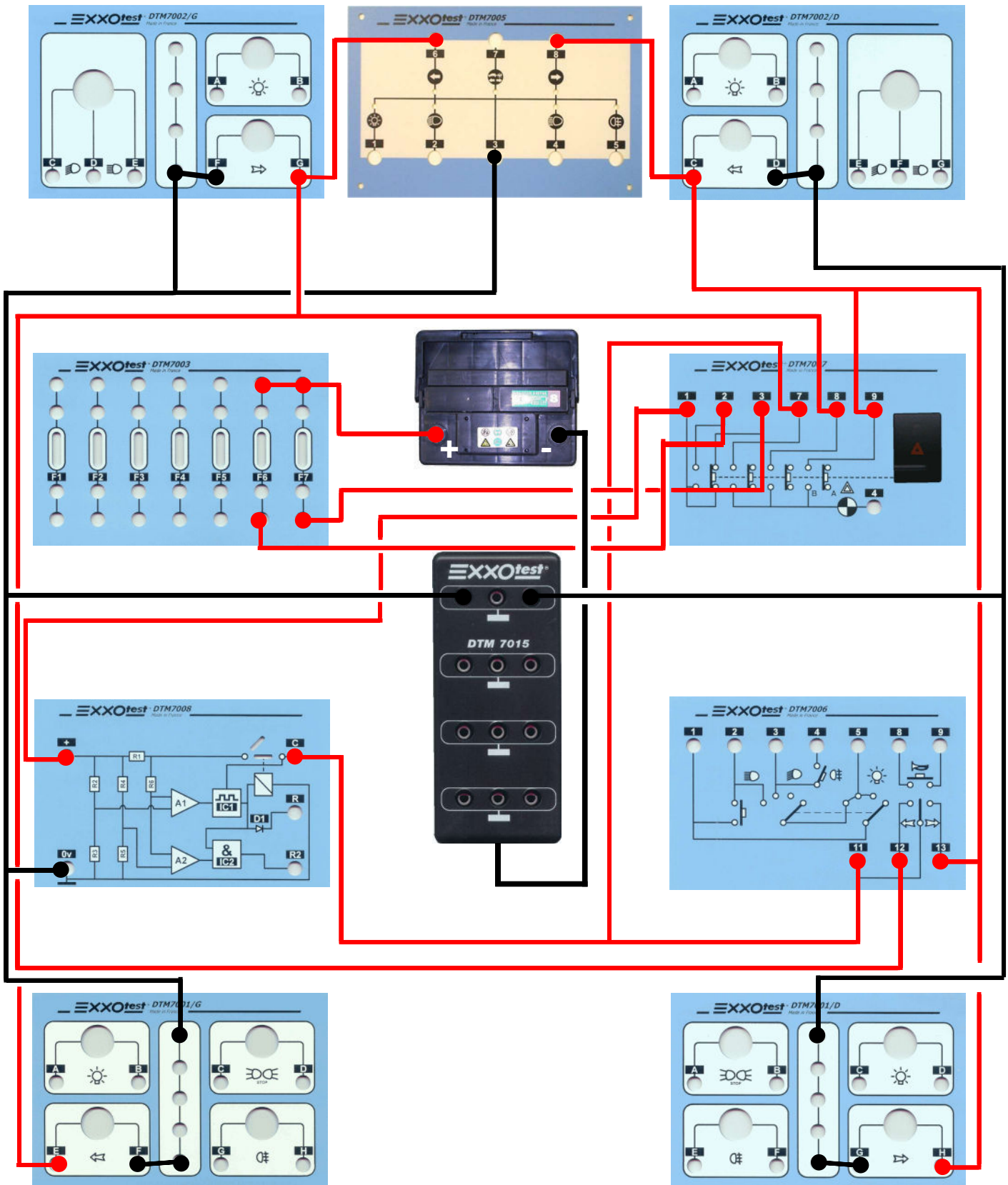
Calculate the current absorbed by an indicator bulb:

The standard values are 21W for 12.5 V, giving an absorbed current, per bulb, of 1.68 A under normal operating conditions.

The consumption of the flasher unit is 2W.
The instrument panel repeaters themselves consume 5W.

Determining the choice of Fuse F7 to protect the hazard warning circuit:

- 4 x lamps at 21 W, the flasher unit at 2 W and the two lamps with a total of 5 W: giving an overall current of 7.3 A.

- The safety coefficient is 2, giving a fuse rating of 15 A.

- Determining the choice of indicator fuse:

- 2 x lamps at 21 W, the flasher unit at 2W and an instrument panel repeater at 2.5W giving a current of 3.72 A.

- The safety coefficient used is 1.5, meaning a fuse of at least 5.58 A should be used; the next available fuse is 7.5 A, making the safety coefficient 2.2.

Determining the diameter of the wire for the rear right brake light:

Hypotheses:

- The length of the power supply wire is assumed to be three metres (the earth being connected to the chassis in the immediate vicinity of the brake light) this copper wire has a resistance value ρ of 1.72×10^{-8} Ω per metre.

- The indicator bulb consumes 21W at 12.5V.

- The maximum tolerated voltage drop is set at 1V.

Calculations:

The current flowing through the circuit is 21/12.5 = 1.68 A

The voltage drop of 1 V forces a maximum resistance of:

$$U = IR, \text{ therefore } R = U/I \text{ or } 1/1.68 = 0.5952. \Omega$$

The resistance of a conductor can be found using the following equation:

$R = \rho * L / S$

$S = (L \rho) / R = (3 \times 1.72 \times 10^{-8}) / 0.5952 = 8.669 \times 10^{-8} M^2 \text{ giving } 0.9 \text{ mm}^2$

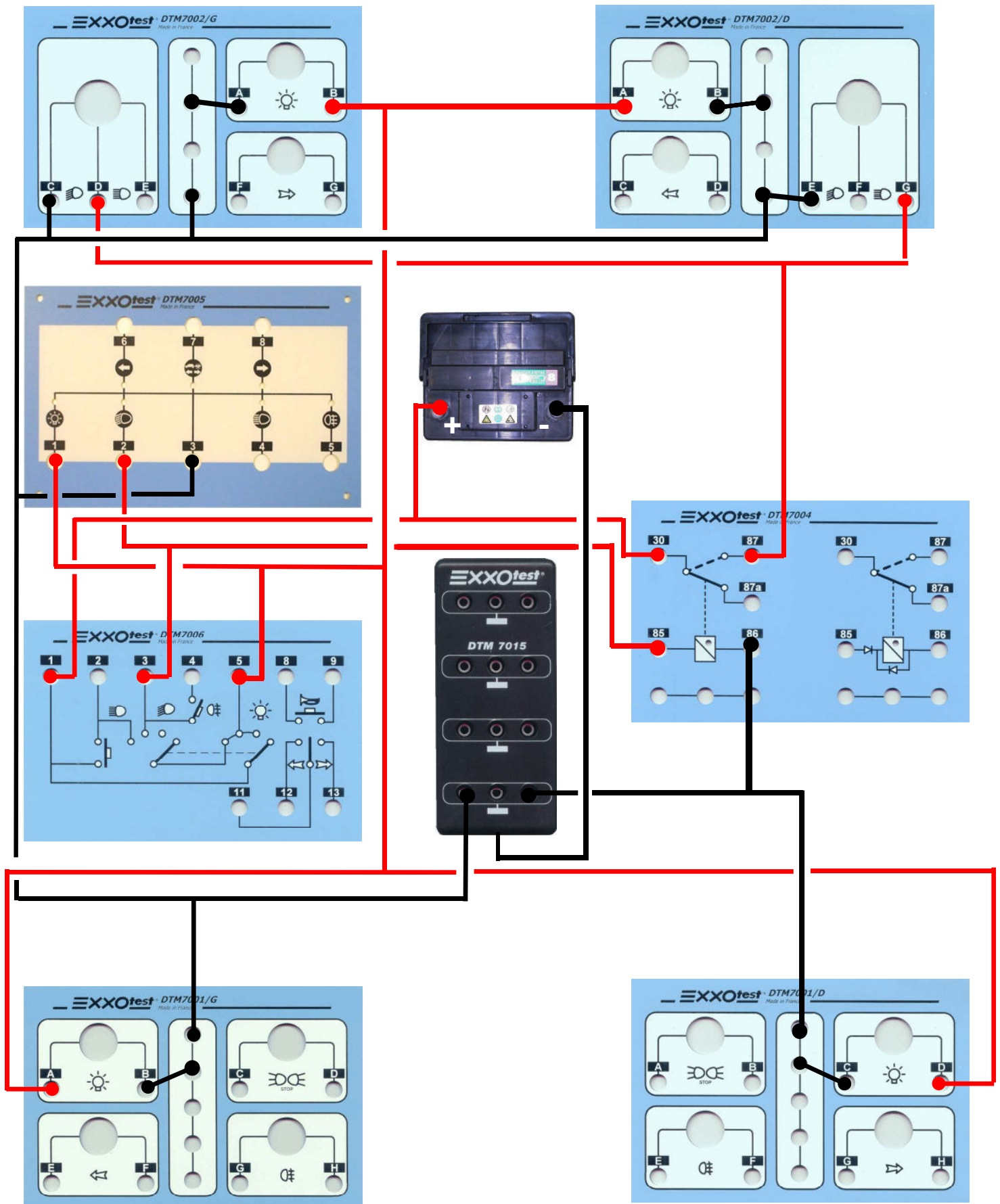The diameter, as a function of the cross section, is found using the following equation:

$S = (\Pi * D^2) / 4$

$D = (4 S / \Pi)^{0.5}$

$D = ((4 \times 0.9)/ \Pi)^{0.5} = 1.07 \text{ mm}$

Wiring for side lights & dipped beams with a relay

What is a relay?

A relay is an electrically controlled disconnector switch, used to control a power circuit using a lower current control circuit.

Justify the use of a relay for the main and dipped beam lighting circuits:

The power absorbed by these consumers would lead to the switches and wiring being over dimensioned for the current levels if the control and power circuits were not separated.

What happens if one adds an additional two 55W driving lights, linked to the existing headlamps (of 55W) without a separate power circuit?

The current will be doubled; however the power and earth-return circuits are not designed to handle this power. There will therefore be a drop of voltage through the conductors, leading to heating and a voltage drop at the consumer terminals, which will not work at their optimum level, with ensuing operational problems.

Calculations for wire cross-sections:

The aim of this study is to show the cross-section of the wires to be used to connect an additional set of driving lights, assuming they are to be controlled from a relay in the vicinity of the battery, approximately 1.2m from the right hand light.

The earth from the bulbs will be connected 20 cm from the bulbs, for this reason we can assume the same cross section as used for the bulb supply.

The characteristics of the bulb: minimal voltage 12.5V

Power absorbed at 12.5V: 55W

Calculate, using the previous method, the cross-section of the supply wire to prevent a voltage drop of greater than 0.5 V.

I at 12.5V = 4.4A
U = IR therefore R = U/I giving an R_{max} = 0.11.Ω
R = ρ * L / S giving S = Lρ / R = 1.87 mm^2
S = (Π * D^2) / 4 giving D = (4 S / Π)$^{0.5}$ = 1.54 mm

The corresponding diameter is 1.54 mm.

What can be deduced from the positioning of the relays?

The position should be chosen to minimalize the length of the power cabling.

Showing the resistance of a wire:

Connect the earths from the bulbs on the DTM7002G&D modules, link to a selector switch for the parallel bulbs, using wires of 2 mm^2, and set up a power supply battery.

Prepare two wires with a different cross section, e.g.: 0.4 mm & 2 mm, with a length of 2 m.

Connect the consumers successively with the two wires after having first connected their terminals to a voltmeter.

Wiring diagram
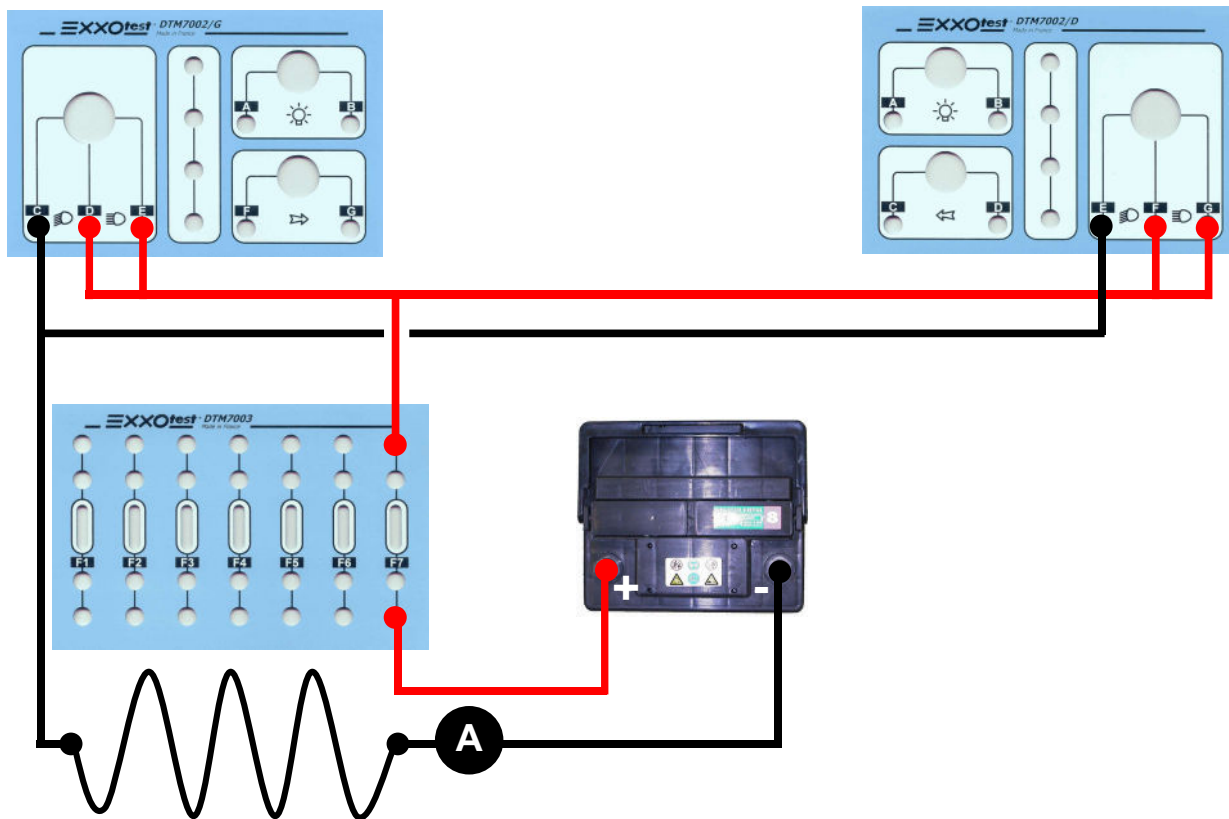
The two metre wire is represented by the curved wire; its role is to supply the circuit. At the terminals the voltmeter measures the voltage across the terminals of the wire.

What happens when a voltage is applied?

The bulbs light and the test conductor heats up.

Carry out a test with each wire, what can be deduced?

The longer and thinner the wire the greater the voltage drop across the terminals.

How does the voltage change once the circuit has been energised?

The voltage reaches a peak then first connected, then decreases over time.

How could one define the resistivity of the wire?

The resistivity of the wire has a positive temperature coefficient.

**What impact will this change in resistivity have on the voltage and current in the line?**

The voltage across the terminals of the wire reaches a peak when first connected then decreases over time. The current follows the same curve.

Acquisition & Comments

Take a reading of the battery voltage, the voltage across the wire terminals and the current passing through it, by means of a Reflet® and MI 25A. Display these readings as curves, recording the data from the moment of initial energising until the voltage across the wire terminals stabilises.
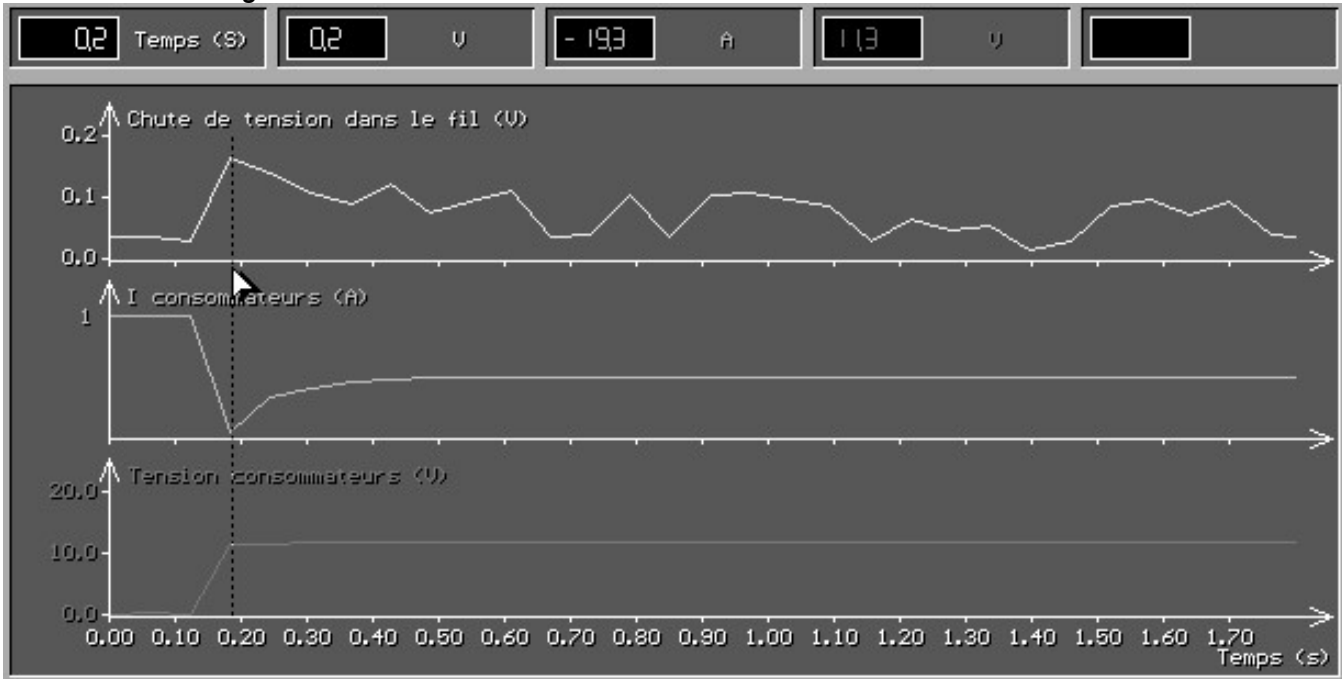
Examples of measurements taken from smaller cross-section wires:
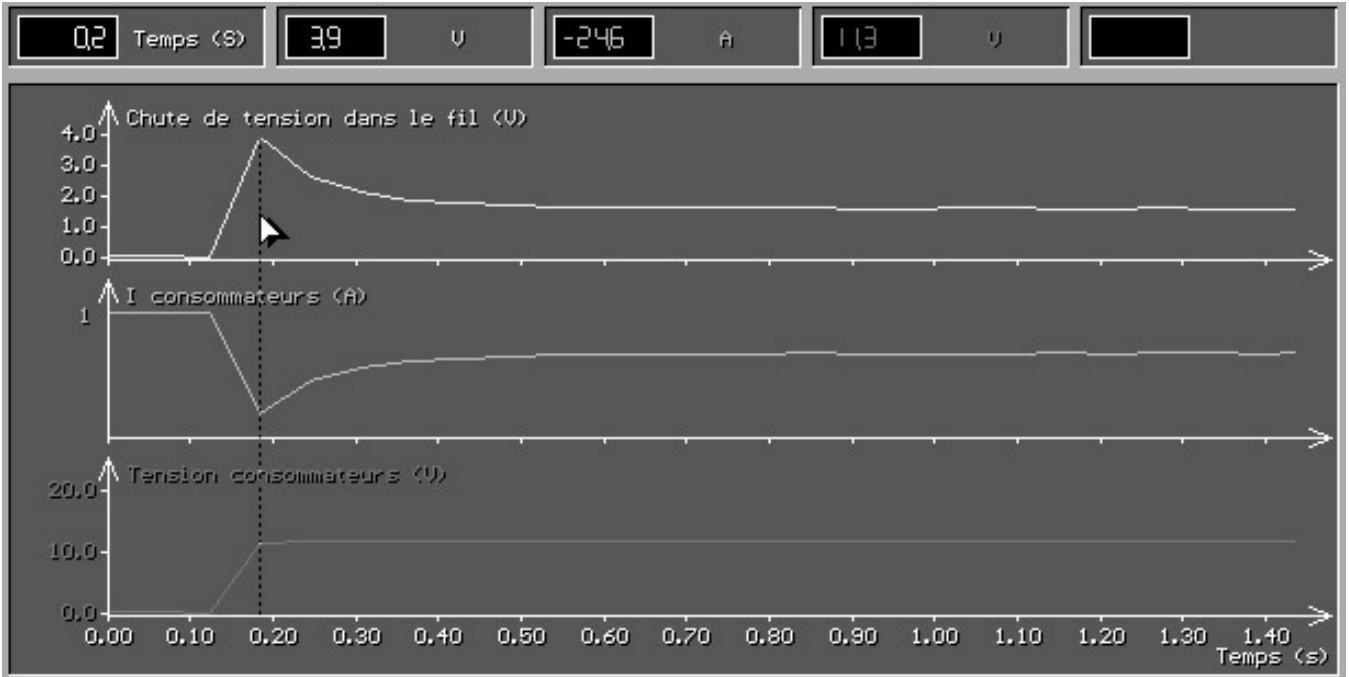
Second test with an average cross-section wire:
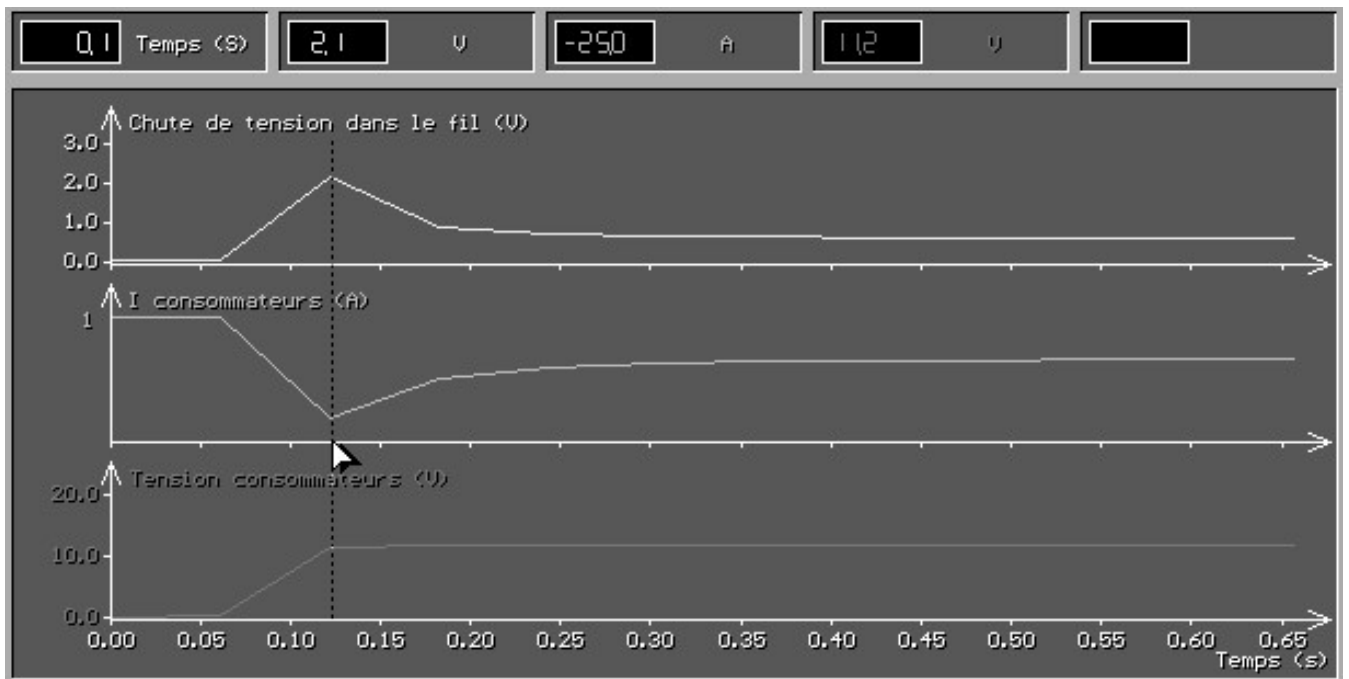
Third test with a large cross-section wire:

Comments on the changing parameters:

On initial energising, the switches let a peak current flow as the lower temperature means a lower resistance.

At a stable operating temperature both voltage and current stabilise.

The changing voltage across the test wire terminals is inversely proportional to the cross-section of the wire used but is directly proportional to its length as its resistance is characterised by the following formula:
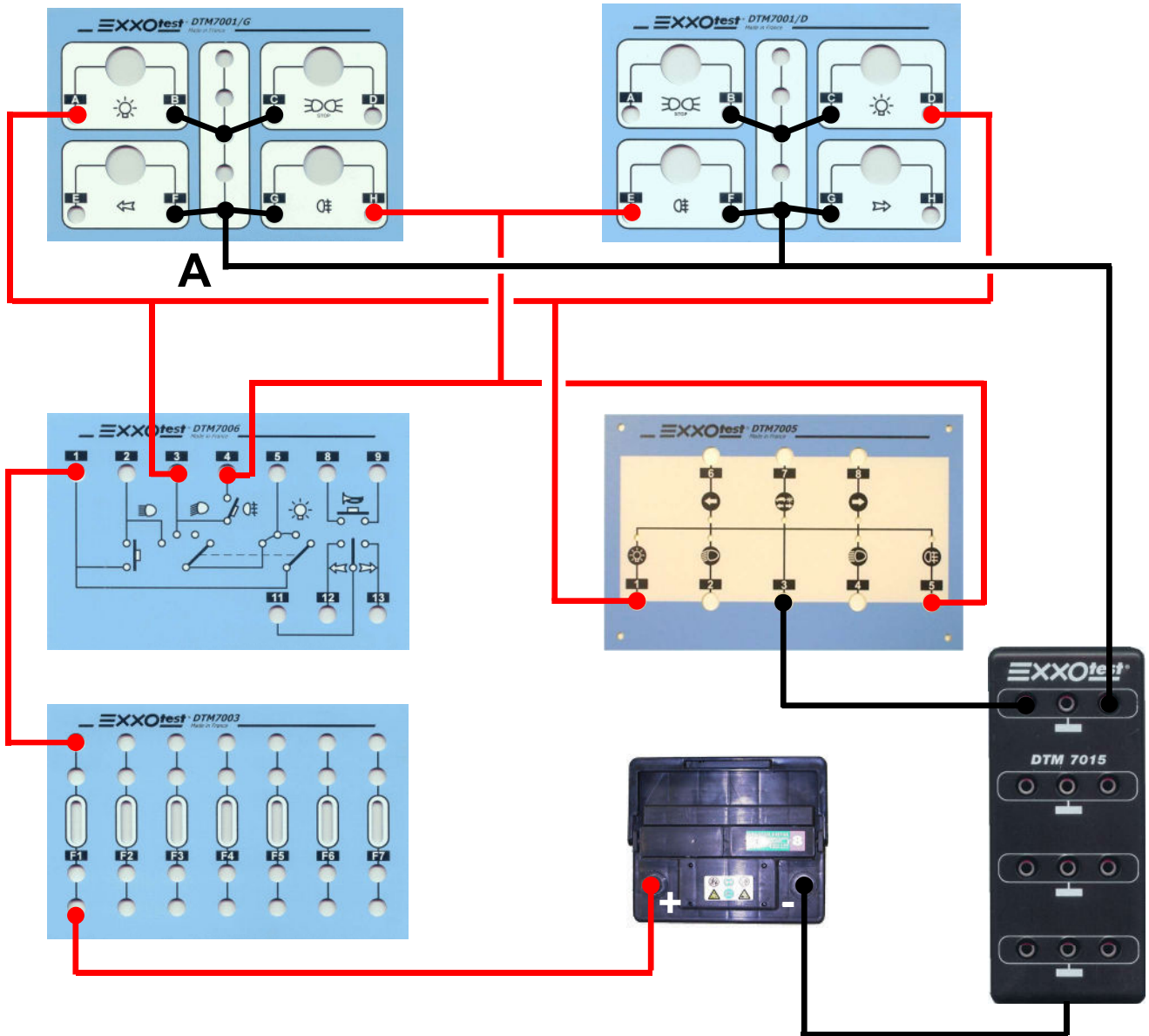
$$R = \rho * L / S$$

Propose a method for fitting dipped & main beams which causes no operational inconveniences:
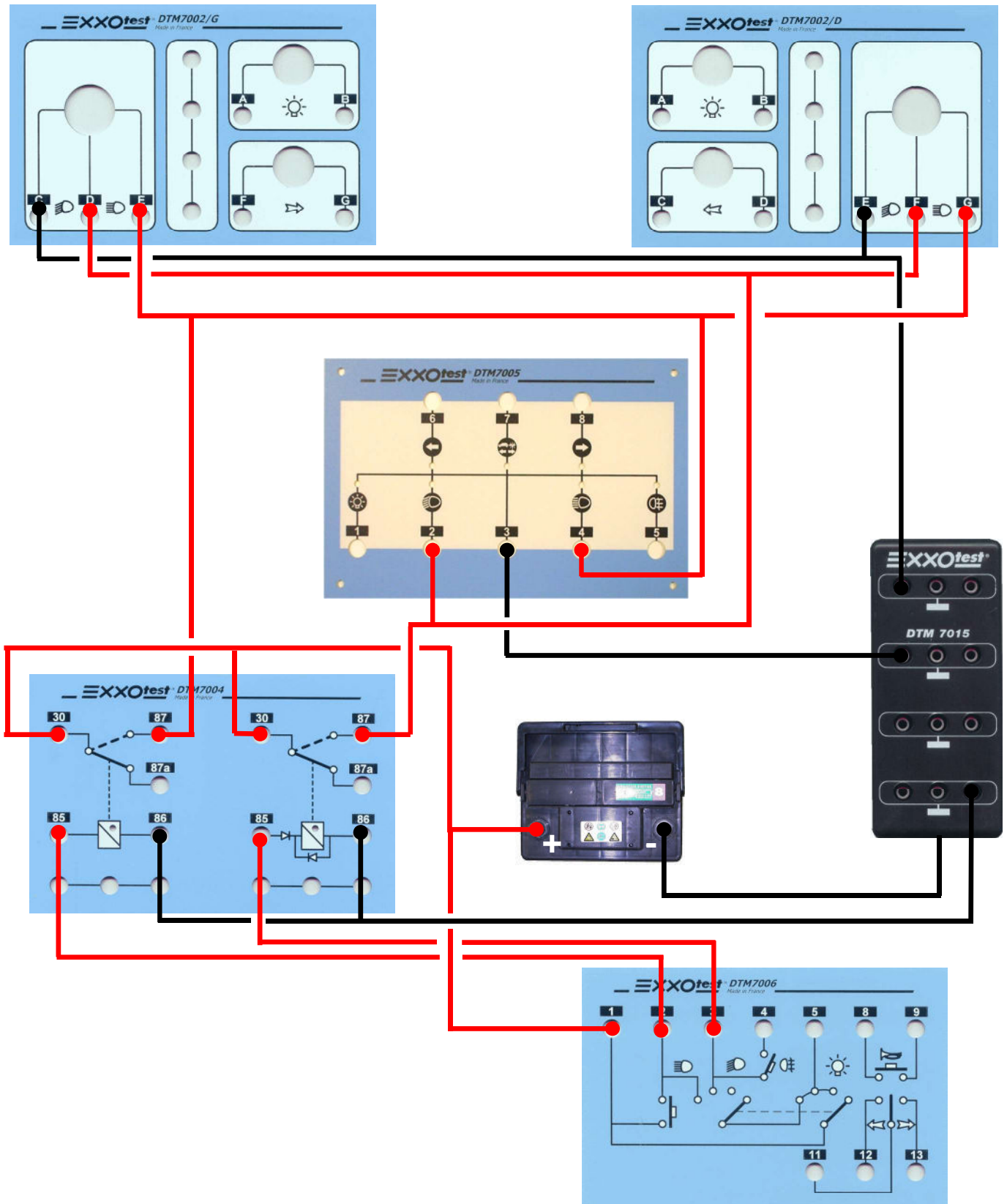
Common earth circuits: example of the rear lights fitted to a vehicle

The following diagram shows the wiring for the rear fog lamps and rear lights with the earths for the bulbs regrouped at a point A.

Wire the circuit and operate it.

Disconnect the rear left hand light from the earth at A and turn on the lights. What happens?

The left hand rear light and fog lamp light up dimly.

Trace the circuit the current is flowing along. What can one deduce from the voltage across the bulb terminals?

The rear right light and left hand lights are in series, dropping their supply voltage to just 4V.

Turn on the rear lights and fog lamps. What happens?

Only the right hand bulbs light up.

Why?

The two left hand lights are supplied from two positive terminals, making a zero potential difference across their terminals.

DECLARATION CE *OF CONFORMITY*

By means of this declaration of conformity, as defined by the European Directive on Electromagnetic Conformity 2004/108/EC, the company:

ANNECY ELECTRONIQUE S.A.S.
Parc Altaïs – 1, rue Callisto
F-74650 CHAVANOD

Declares that the following product:

Brand	Model	Description
EXXOTEST	**DTM7000 model**	**TRAINING MODEL: automatically controlled vehicle air conditioning**

I - Has been manufactured in accordance with the requirements of the following European Directives:

'
- LV Directive 2006/95/EC - 12 December 2006
- Machinery Directive 98/37/EC - 22 June 1998
- EMC Directive 2004/108/EC - 15 December 2004

and satisfies the requirements of the following standard:

- NF EN 61326-1 dated 07/1997 +A1 of 10/1998 +A2 of 09/2001
  Electrical measurement, control and laboratory equipment, EMC-related requirements.

II - Has been manufactured in accordance with the requirements of the European Directives relating to EEE design and WEEE management for the EU. :

- Directive 2002/96/EC dated 27 January 2003 on Waste Electronic and Electrical Equipment (WEEE)
- Directive 2002/95/EC dated 27 January 2003 on the limitations for the use of certain hazardous substances in the construction of Electronic and Electrical Equipment (EEE).

Drawn up in Saint-Jorioz on 12 December 2011.

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