locktronics

Simplifying Electricity

Sensors and control in automotive applications

LK8849

MATRIX

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Worksheet 1

Simple digital sensors

Indicator stalk houses several types of switch

Brake switch component

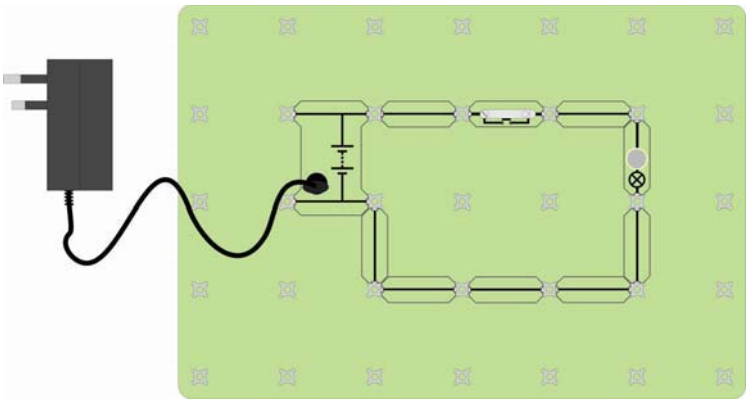
There are many sensors in a modern car. Some are controlled by the driver (like a light switch) and some by factors in the car itself - like the fuel sensor.

Each sensor provides an input signal - often directly into an Electronic Control Unit.

The sensors in a car can be divided into two types ; **analogue** and **digital**
Digital sensors have a two state output, usually either 'on' or 'off'. The car power supply determines the voltages corresponding to these two states - often 12V (on) and 0V (off).

Over to you:

1. Build the circuit shown opposite.
2. Set the power supply to 13.5V, plug into the Locktronics carrier, and switch on.
3. Press the switch to make the bulb light .



1a

w6j

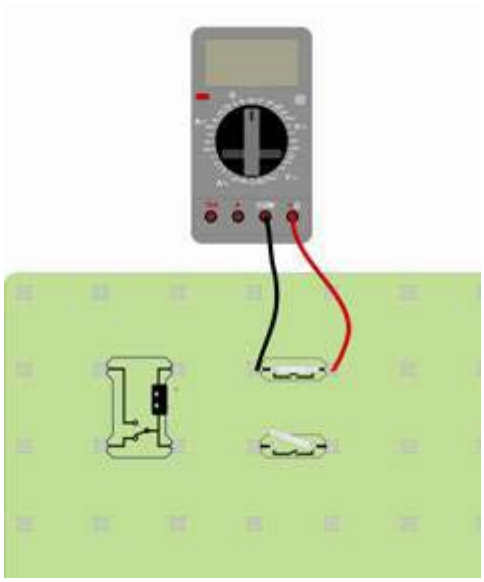
Over to you:

4. Connect a multimeter to read the voltage across the bulb. (A Multimeter Help Sheet is available if you are unsure how to do this.)
5. Select the 20V DC range, and press the red ON/ OFF switch when you want to take a reading.
6. Read the voltage across the bulb when the switch is pressed, and when not pressed.
7. Complete the table with your results:

Switch	Voltage across bulb
Pressed	
Not pressed	

Worksheet 1

Simple digital sensors



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Over to you:

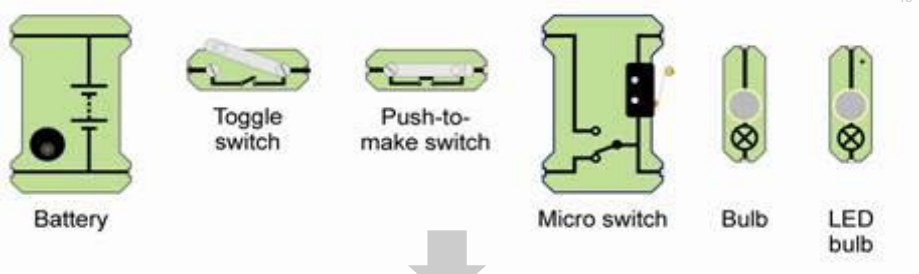
1. Set up the arrangement shown. You will use it to measure the resistance of the three sensors. This must be done when they are not connected in a circuit.
2. Select the 200kΩ range. Make sure that you use the correct sockets on the multimeter. For each of the three components, measure the resistance of the switch when it is open (off) and when it is closed (on).
3. Complete the table with your results.

Component	State	Resistance
Push-to-make switch	Open (Off)	
	Closed (On)	
Slide switch	Open	
	Closed	
Microswitch	Open	
	Closed	

- These simple digital sensors have a two-state output - either open (off) or closed (on).
- When open, they have a very high resistance.
- When closed, they have a very small resistance.
- When open, they output a 0V signal to the rest of the circuit.
- When closed, they output the full power supply voltage to the rest of the circuit.

(We will see that the last two results can be swapped round by changing the circuit.)

The circuit symbols for the components can be seen clearly on the carriers. The selection below demonstrates this. Notice that there are two types of bulb in your pack, a traditional filament bulb and a LED bulb. You can use either, but when using the LED bulbs, make sure you connect them the right way round, in the circuit.



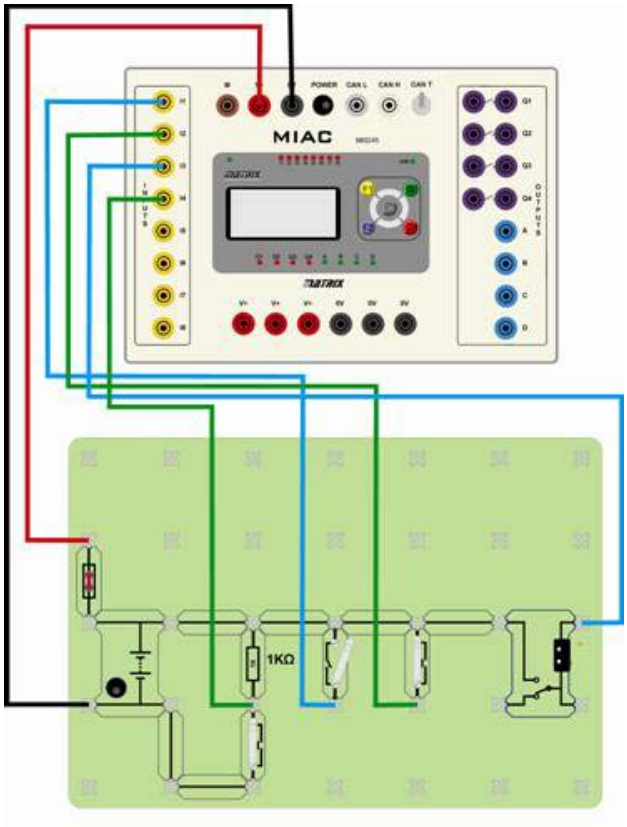
1b

Worksheet 1

Simple digital sensors

Simple digital sensors, such as switches, can output a high voltage when activated or a low voltage - depending on the circuit. Software inside an ECU can be programmed to recognise a high input voltage as the switch being either ‘on’ or ‘off’.

Over to you:



1. Build the circuit shown opposite. This connects a number of simple digital sensors to a MIAC (Matrix Industrial Automotive Controller.) The MIAC inputs sit at 0V when there is no external input.
2. Plug the power supply (13.5V) into the Locktronics carrier. It will provide power for the full system.
3. If the correct program is loaded, you will see the words ‘Sense and Control 1’ on the MIAC screen
4. Use the Up / Down arrows on the MIAC to select program 1.
5. Connect a multimeter, set to the 20V DC range, to measure the signal voltage on input I1.
6. Close the slide switch attached to this input.
7. Complete the first row of the table below with the signal voltage from the switch before and after you closed it, and the message displayed on the MIAC screen.
8. Repeat steps 5, 6 and 7 for inputs I2, I3 and I4 and the switches connected to them.
9. Complete the table with your results.
10. For any switch measure the input current: To do this replace the lead from the switch to the MIAC with the multimeter, set to the 2A DC range. Note your reading in the table.

Input number	Signal voltage - switch closed	Signal voltage - switch open	MIAC message
1			
2			
3			
4			
.....	Input current = ...		

Worksheet 2

Lamps and simple actuators

Typical light cluster

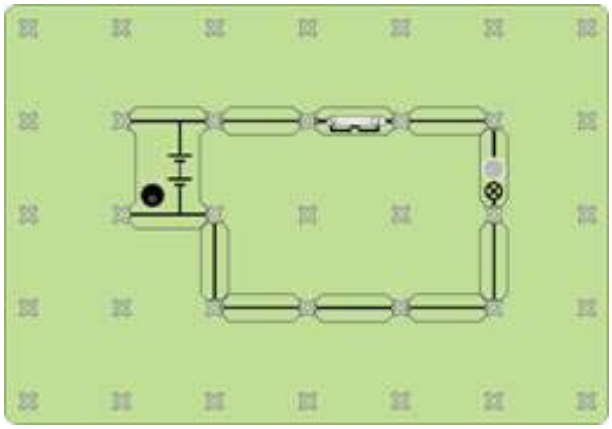
Wiper motor and linkage

There are many different kinds of lamps and actuators in an automotive system.

Collectively these are known as ‘output devices’.

Output devices need widely varying amounts of current.
As a result, there are a number of different circuits used to deliver current to, and control, (‘drive’) these output devices.

Over to you:



2a

1. Build the circuit shown opposite.
2. Set the power supply to 13.5V, plug into the Locktronics carrier, and switch on.
3. Press the switch to check that the bulb lights.
4. Connect a multimeter to read the current through the bulb. (A Multimeter Help Sheet is available if you are unsure how to do this.)
5. Select the 2A DC range, and press the red ON/OFF switch when you want to take a reading.
6. Press the switch and read the current through the bulb. Record the result in the table.

Component	Current	Polarised?
Bulb		
Buzzer		
LED		
LED Bulb		
Motor		
Solenoid		

7. Replace the bulb with the other components listed in the table, in turn.
8. Some components work only when connected the right way round. Try each component both ways round in the circuit, and note which ones have this polarity.
10. Measure the current needed to drive each of these components.
11. Complete the table with your results.

There are several different types of bulbs and lamps in an automotive system.
Each has different electrical properties and needs different circuitry.
Confusingly, wiring diagram can use the same symbol for all of them.

Here are three examples:

Standard bulb

LED with current limiting resistor

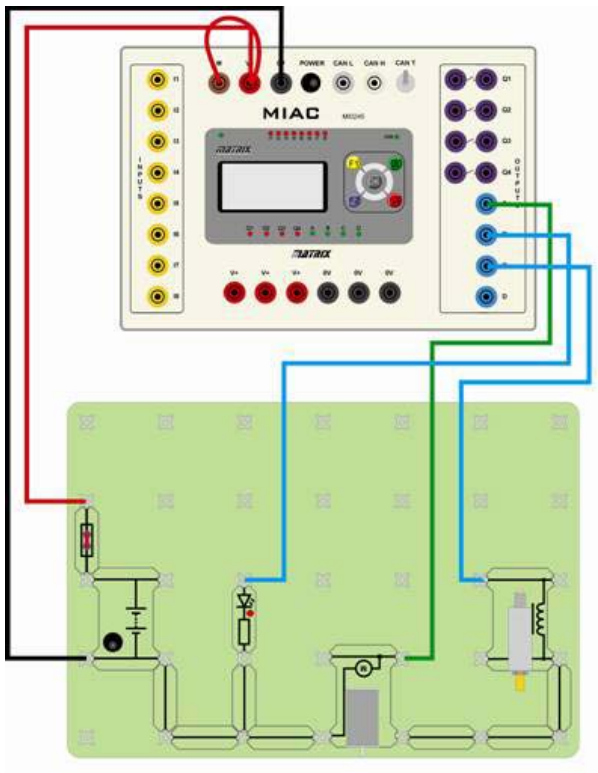
LED bulb with internal current limiting resistor

Worksheet 2

Simple lamps and actuators

Over to you:

1. Build the system shown opposite.
2. Plug the power supply (set to 13.5V) into the Locktronics carrier, to power the full system.
3. Press the reset switch on the MIAC and select program 2.
4. Measure the current and complete the first row of the table.
5. Replace the LED with each of the two other types of lamp and measure the current.
6. Measure the current in the solenoid when the MIAC unit turns it on.



Component	Current
LED	
LED Bulb	
Standard bulb	
Solenoid	

ECUs have different types of outputs for driving devices with differing current demands.

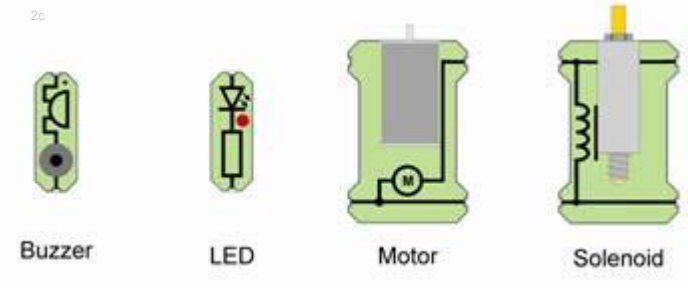
This circuit uses the MIAC low current transistor outputs (labelled A to D).
Higher current devices will need to use the relay outputs, (labelled Q_1 to Q_4).

Transistor outputs can vary the current delivered, which means they can alter lamp brightness and motor speed. Relay outputs are either on or off, and so cannot.

More symbols and components

The motor, LED and buzzer are familiar objects. You may not have met the solenoid.

It consists of a electromagnet which pushes out the rod at its core when activated.



There are two sets of circuit symbols in common use:

- the European (DIN) symbols;
- the American (ANSI) symbols.

Many Locktronics components are available in either format.

Worksheet 3

Using transistors

Car radio

Transistors -
they come in a variety of shapes and sizes!

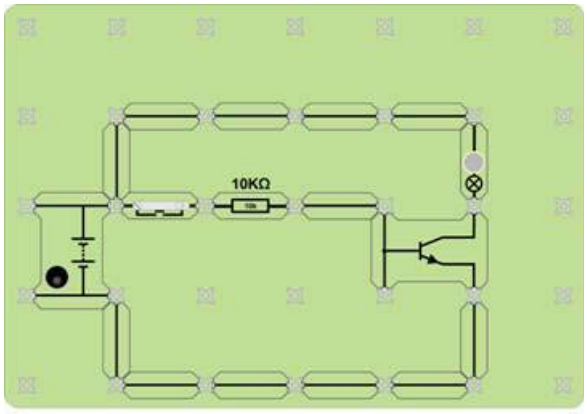
The transistor is the building block of modern electronics.

You will not often see a ‘stand alone’ transistor in an automotive application, but they are there, embedded in radios, ECUs and other subsystems.

It is useful to understand how they work, and what their limitations are.

The most basic use of a transistor is to amplify current.
The ratio of output current to input current is known as the transistor current ‘gain’.

Over to you:



9a

1. Build the circuit shown opposite.
2. Set the power supply to 13.5V, plug into the Locktronics carrier, and switch on.
3. Press the switch to check that the bulb lights.
4. Connect a multimeter, on the 2A DC range, to read the current through the 10kΩ resistor when the bulb is lit. This is the transistor **input** current
5. Move the multimeter to measure the current through the bulb. This is the transistor **output** current.
6. Press the switch and read the current through the bulb.
7. Record your results in the table.

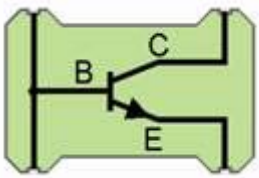
Transistor	Current
Input	
Output	

8. Calculate the current gain. (Divide the output current by the input current.)

Current gain = _____

New symbols and components

Transistor



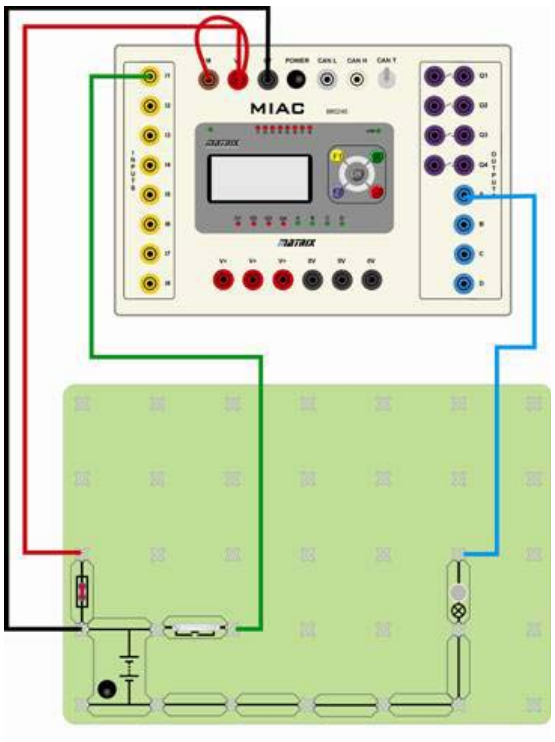
There are many types of transistor. This one is a ‘NPN’ transistor. The three terminals, shown on the symbol by the letters ‘B’, ‘C’ and ‘E’, are the base, collector and emitter.

Worksheet 3

Using transistors

Over to you:

1. Build the system shown opposite.
   This is effectively the same circuit as on the previous page, but it uses a transistor found inside the MIAC.
2. Plug the power supply (set to 13.5V) into the Locktronics carrier, to power the full system.
3. Press the reset switch on the MIAC and select program 3.
4. Use a multimeter to measure the current through the switch, (transistor **input** current,) and then through the bulb (transistor **output** current.)
5. Record your results in the table.



9c

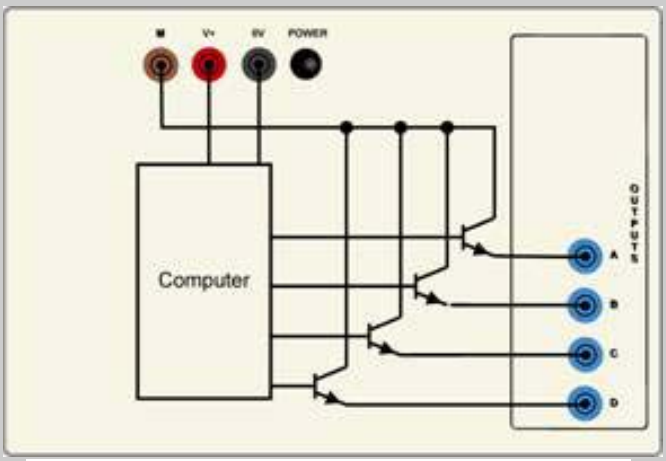
Transistor	Current
Input	
Output	

6. Compare these results with those you obtained for the stand-alone transistor on the previous page.

Inside the MIAC, each of the outputs A, B, C, D is controlled by an internal computer, connected to a power transistor.
The power supply for the computer is comes from the V+ terminals.
The power supply for the transistor outputs comes from the 'M' terminal.
For this reason you always need to connect the M terminal to V+ when you want to use the transistor outputs.

In practice the circuitry inside the MIAC, (and an ECU,) is more complicated. The outputs have protection against short circuits, and against high voltages caused by inductive loads, such as motors and coils.

The 'M' terminal can be connected to any voltage supply, and does not have to use the MIAC power supply. This allows the transistors to switch higher voltages, such as the 24V supply found in a truck.



Wiring of the transistor outputs inside the MIAC.

9d