

# DESIGNING AND MAKING AN AUTO-SHUTDOWN CIRCUIT

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## WHAT YOU WILL LEARN

**After completing this project you should understand:**

- What an auto-shutdown circuit is and how it is used.
- How to design a shutdown circuit using a block diagram.
- What an electrolytic capacitor is.
- What a power MOSFET is.
- How to use a power MOSFET for electronic switching.

**After completing this unit, you should be able to:**

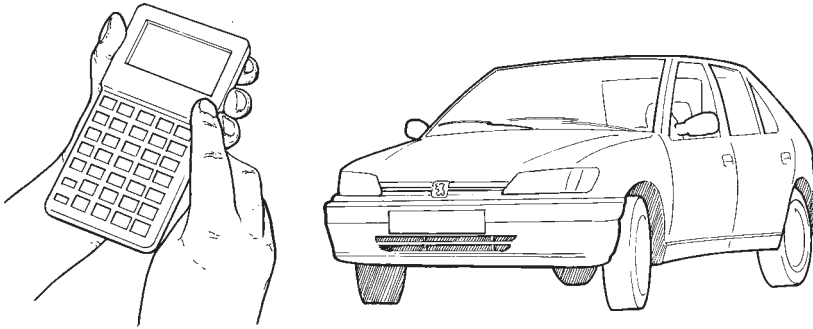
- Use the following components in electronic circuits:
  - IR530 power MOSFET
  - Resistor
  - Electrolytic capacitor
- Select component values to make a circuit work in a desired way

DESIGNING AND MAKING AN AUTO-SHUTDOWN CIRCUIT

There are many examples of electrical products which shut down automatically after a period of time. Examples include calculators, courtesy lights in cars, and some toys. The purpose is usually to conserve battery energy, but there may be other reasons.

◀ NOTE

Research opportunity. List product examples.



Automatic shutdown normally relies on a time-delay circuit. This can be quite complex - for example, using an integrated circuit (IC) to control the time delay before shutdown. On the other hand, it is possible to design and make a time-delay circuit using just two standard components. Such a circuit can be used to control small motors, bulbs or buzzers. It might be used, for example, to conserve battery of a torch, portable fan or child's toy.

DESIGNING AN ELECTRONIC SYSTEM

Electronic circuits are systems - something having several parts working together. In many circuits, there are three basic parts:



**Input Block** - Enters information into the system. E.g., a switch which might be turned 'on' or 'off'.

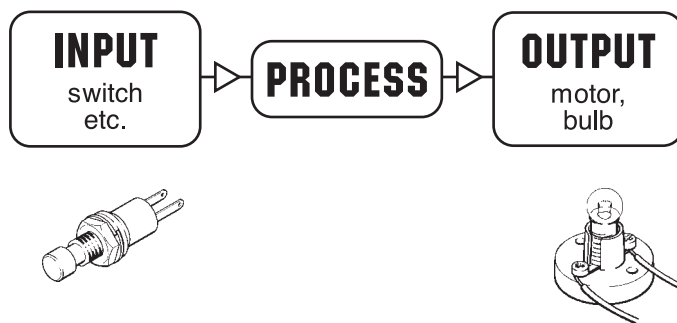
**Process Block** - Uses information from the input to control the output. E.g., an electronic component such as a transistor.

**Output Block** - Makes things happen. E.g., a bulb lighting up or a motor turning on.

## YOUR TASK

*Design and make an auto-shutdown circuit to prevent the battery in a product going flat through being left on. The circuit must answer a need identified by you - e.g. a torch, fan or toy that automatically turns off after a set period.*

You need to design a system that turns something off after a certain time. The block diagram for the system would look like this:



## DESCRIBING YOUR TASK

First, you need to describe in detail what the product will be like, what it will do and who will use it. This is called a **design specification** and will guide your design work and help you to judge how well the outcome works.

Here are some questions to help you with your specification:

- *Is your circuit to be added to an existing product ?*
- *What is it ?*
- *Why does the product need auto-shutdown?*
- *What time delay is needed ?*

Some additional questions if the product is a new one:

- *Who will use the product ?*
- *What should it cost ?*
- *What battery will it use ?*

◀ DESIGN BRIEF

◀ NOTE

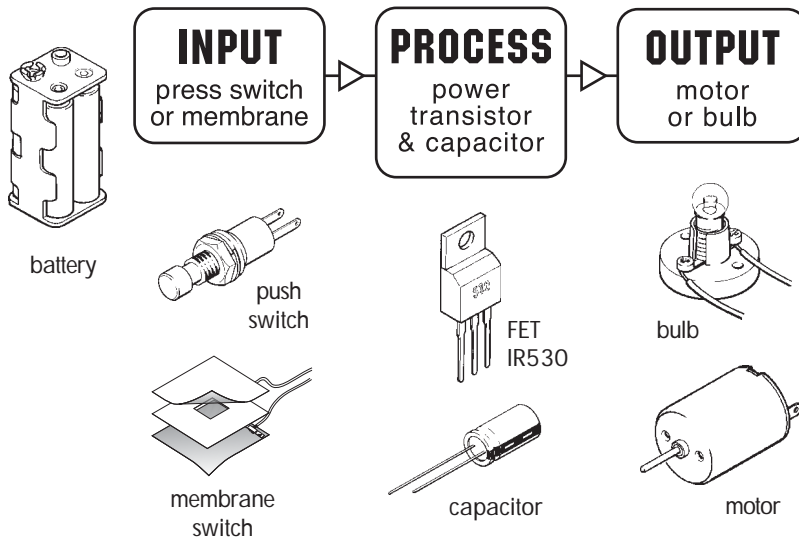
Circuits involving FETs cannot be simulated with Crocodile Clips.

◀ DESIGN SPECIFICATION

MATERIALS AND COMPONENTS PROVIDED

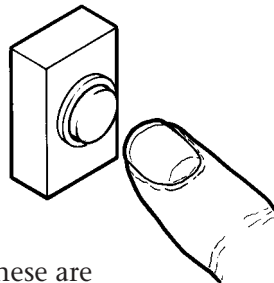
Before you can go ahead with designing the circuit, you need to know what is available. You will also need more information on the components and how they are used.

◀ DESIGNING AND MANUFACTURING CONSTRAINTS



**INPUT BLOCK**

The input to the system will be a switch. There are many different types of switch, but here we need a type which **closes** (makes connection) for only as long as you touch it. An example would be the push-button switch used for door bells or keyboard switches on calculators and computers. These are called **momentary** action switches.

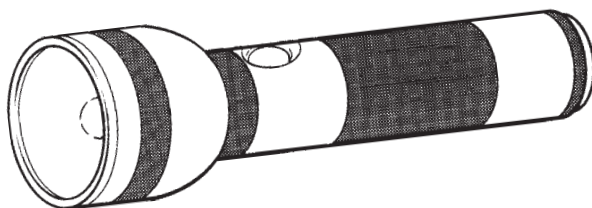


◀ SYSTEM INPUT POSSIBILITIES

◀ NOTE

A 'simple' switch can have many attributes.

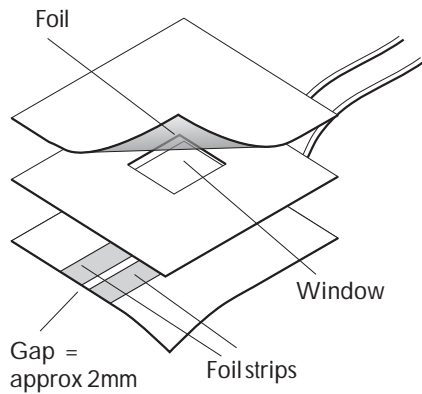
Other familiar types of switch have a **latching** action. When you turn a light switch on, it stays turned on until you move it to the off position. Most torches use a latching switch and that is why the battery goes flat if you forget to turn them off.



There are many switches to choose from including panel-mounting switches which are secured in a cut-out in a panel or printed circuit board (PCB) mounting switches which are soldered directly to a printed circuit board. It is also possible to make a make a momentary-action push-switch using card and foil. This is called a membrane panel switch.

◀ NOTE

See Study File 11 (membrane switches).



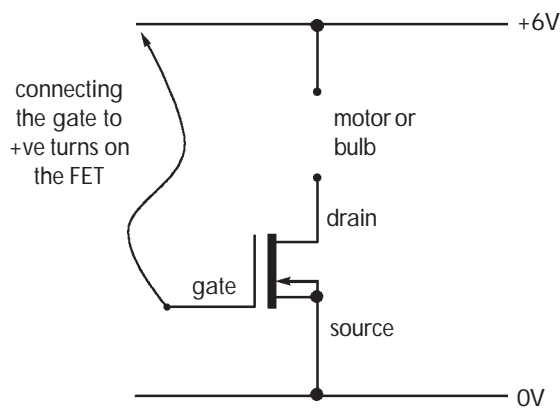
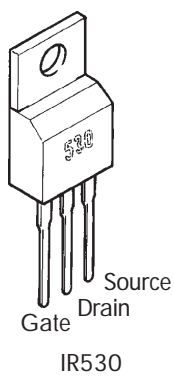
**PROCESS BLOCK**

The main component used in the process block is a field effect transistor (FET). This is an electronic switch which is turned on and off by a small voltage. It has three legs and is connected in a sample circuit to switch on a bulb. When the voltage at the gate is more than 3v, the FET switches on; when it is less the FET switches off. Connecting the gate to +ve, turns the FET on.

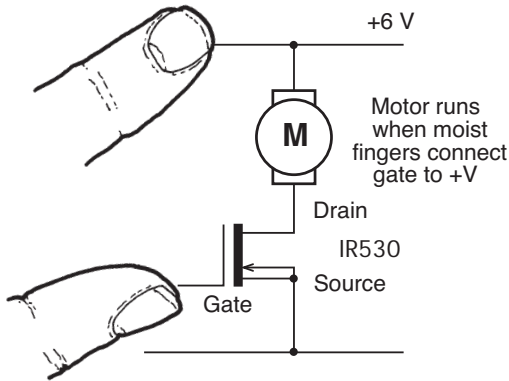
◀ SYSTEM PROCESSING POSSIBILITIES

◀ NOTE

See Study File 15 (Transistors)



Why not just use an ordinary switch to turn the light on ? The answer is that the FET can switch a very high current between source and drain - without arcing between switch contacts. It is also possible to switch on the FET by bridging across between the gate and +ve with a poor conductor such as a damp finger ! (e.g. the FET becomes a touch control switch.)

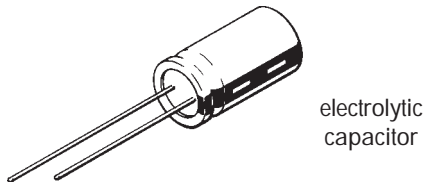


◀ NOTE

The FET is presented as an electronic switch. It is one of the most useful devices for single active component circuits.

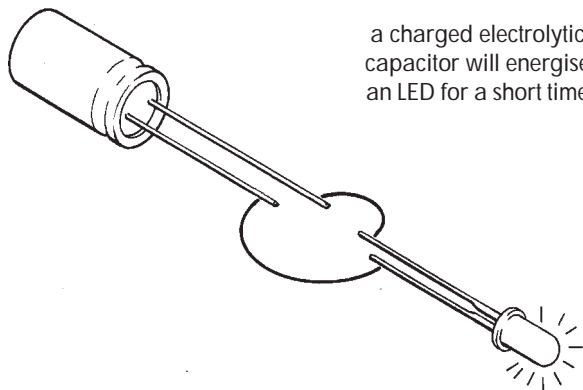
The other components used in the process block are a capacitor and resistor. A capacitor is a component that stores electrical charge. When connected to the supply, it **charges up** (fills up) almost instantly. The capacity is measured in Farads. Because most capacitors used in electronics are only a fraction of one Farad, even the larger ones are measured in micro-farads ( $\mu\text{F}$ ).

**1  $\mu\text{F}$  = 0.000001 Farads**



electrolytic capacitor

A large capacitor is a bit like a rechargeable battery. If you connect an LED and resistor to a large charged capacitor, current will flow and the LED will glow until the capacitor has lost most of its charge.



a charged electrolytic capacitor will energise an LED for a short time

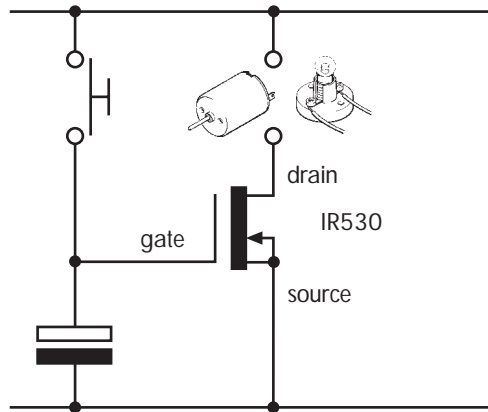
◀ NOTE

See Study File 18 (Capacitors)

◀ NOTE

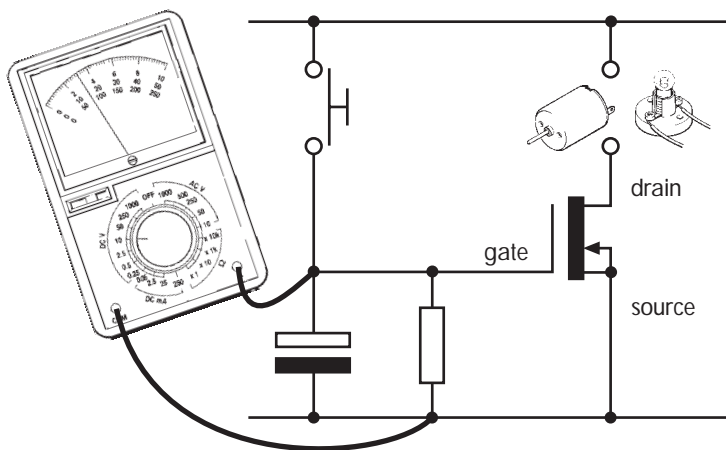
Maths/science opportunity for plotting capacitor discharge.

For the auto-shutdown circuit, the capacitor is connected to the FET as shown. When the press switch is closed briefly, the capacitor charges up and the FET is also turned on. When the switch is released the charged capacitor keeps the FET turned on until it loses most of its charge. Normally this would happen very slowly through **leakage** within the capacitor. (Low leakage capacitors can keep their charge for many hours.)



However, if a resistor is added to the circuit as shown, the capacitor will discharge more rapidly. The lower the value of the resistor, the faster the capacitor discharges. Also, the smaller the capacitor, the faster it will discharge. For a required time delay, you can experiment with the values of both the resistor and capacitor using a multimeter as shown.

◀ NOTE  
Maths and science opportunity

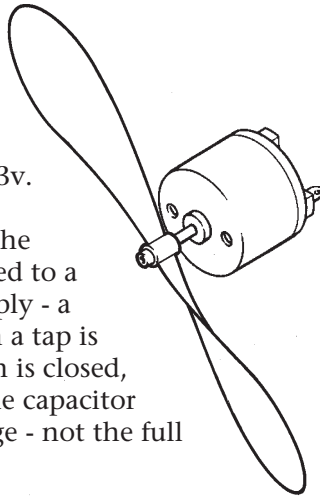


If the correct values of capacitor and resistor are selected, we can obtain the required time delay for the auto-shutdown. As a guide, a 100  $\mu\text{F}$  capacitor and 1M resistor will give a time delay of approximately 30 seconds - using a 6v battery.

**OUTPUT BLOCK**

A small bulb (torch) or motor (fan) can be connected to the FET and will turn on when the switch is closed - and remain on until the capacitor has discharged below about 3v.

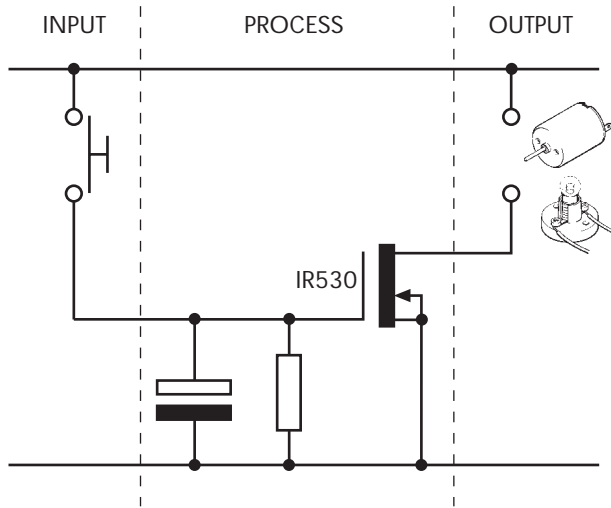
The type of output device will affect the time delay. A motor or bulb connected to a supply reduces the voltage of the supply - a bit like water pressure dropping when a tap is opened. The moment the start switch is closed, the motor or bulb will turn on and the capacitor will only charge to the reduced voltage - not the full voltage of the battery.



◀ SYSTEM OUTPUT  
POSSIBILITIES

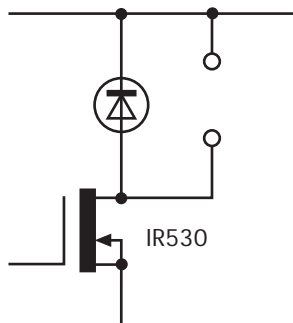
**PUTTING IT ALL TOGETHER**

The circuit diagram for the complete auto-shutdown circuit is shown below. The output might be a bulb, buzzer or anything else - providing that it does not take more current that the FET can safely provide (15 amps !).

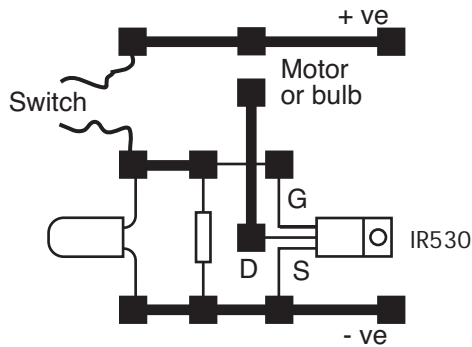


◀ SYSTEM SYNTHESIS

When connecting a motor or any other output which has a wound coil, a diode must be added as shown. This protects the FET against any high voltages that the coil will produce when the current in the coil changes.



You need to make a printed circuit board (PCB) on which to mount the components, A possible layout is shown here with the components in position.



## TESTING

When you have built the circuit, you will need to test it. If the circuit does not work, do the following:

- Check the PCB layout is correct and that no tracks are bridged or broken.
- Check that all soldered joints are good.
- Check that all components are correctly connected - especially the FET.
- If the light or motor comes on when you close the start switch but rapidly turn off, make sure the resistor value is high enough and that the capacitor is large enough.

◀ SYSTEM DIAGNOSTICS

## EVALUATING THE AUTO-SHUTDOWN CIRCUIT

There are a number of things to consider depending on whether you have made something to add to an existing product - or designed the whole thing.

- How well does the auto-shutdown work ? Is the time delay correct ?
- Will it work for the use for which it was intended ?
- Did you choose the most appropriate components and methods of manufacture ?
- What did others think of your design ?

◀ EVALUATION

**Note:** Do not be disappointed if the bulb (torch) or Motor (fan) do not switch off instantly. As the capacitor discharges, it will keep the FET fully switched on for most of the time and then the FET will switch off slowly - dimming the bulb or slowing down the motor.

◀ NOTE

Maths/science opportunity for plotting capacitor discharge curve

