FACTFILE:
GCE TECHNOLOGY & DESIGN

1.17 ELECTRONIC SYSTEMS: PART 3

Rewarding Learning

Flip Flop

Learning Outcomes:

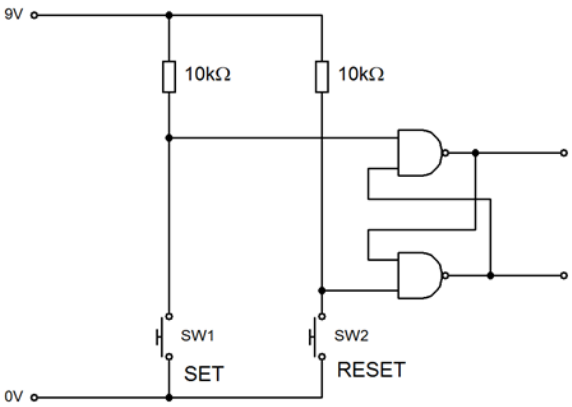
Students should be able to:

- demonstrate knowledge and understanding of the following system:
  - flip flop, set–reset (SR) based on NAND gates only;
  - incorporate these devices into applications to meet specified criteria.

Course Content

A flip-flop (also known as a bistable multivibrator, latch or memory cell) has 2 stable states and so can be used to store information as either a “0” or a “1”.

One way to construct a flip-flop is by using a pair of cross-coupled NAND gates as shown in the diagram – the output of each gate is connected to one of the inputs of the other. This is known as an S R flip flop (pronounced S-bar R-bar). The letters S and R are abbreviations for the Set and Reset inputs. The inputs are triggered by a falling edge or a voltage which is changing from high to low.



In this circuit, the inputs are held high using pull-up resistors. Pressing switch SW1 causes the voltage at the input to the upper NAND gate to fall, triggering the Set input. Pressing switch SW2 causes the voltage at the input to the lower NAND gate to fall, triggering the Reset input.

In order to determine the outputs, it is useful to consult the truth table for a NAND gate.

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

This truth table for a NAND gate could be summarized as follows:

If any input is a “0”, the output is a “1”.
If both inputs are “1”, the output is a “0”.

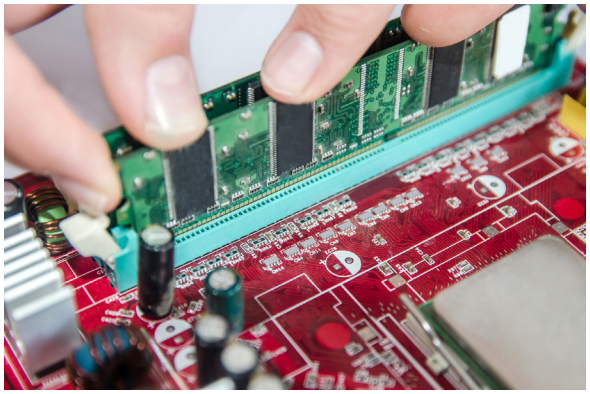
Using this, it can be seen that the truth table for the flip flop is as follows:

S	R	Q	Q
0	1	1	0
1	1	1	0
1	0	0	1
1	1	0	1
0	1	1	0
1	1	1	0

Note that the inputs are changed in a particular sequence, with one of the inputs becoming low, and then returning to high. It is important to note that when the inputs are both high, the output can be either high or low. This depends on the previous combination of inputs. Hence this is a sequential logic circuit - the output depends on the sequence of events. This can be used as a simple memory cell. Input S can momentarily be brought low, thus setting Q to “1”. Q will remain at “1”when the input returns high. The circuit will remain in that state until it is reset by momentarily bringing R low.
In normal use, the output Q is opposite to Q. (The input combination S = R = 0 is not normally used since in this instance, Q = Q = 1).

Applications

Computer memory. In order to store an eight bit binary number, eight flip flops may be used as memory cells. The processor may write a “0” or “1” to each of the cells.



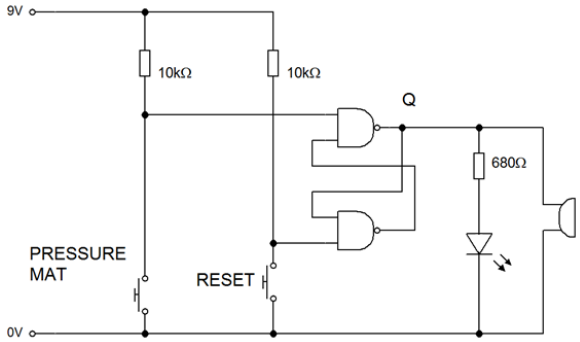
Latching circuits and alarms
In a steady hand game, if the handle touches the wire track, a circuit is completed and this may cause a buzzer to sound or an LED to light. However, the game will be more effective if the buzzer or LED continue until a reset switch is pressed. This may be achieved using a flip flop which latches or “remembers” that the handle has touched the wire track, even after it has been removed.

Source: Leisureking Ltd

Similarly, if an intruder alarm is triggered, the alarm should continue until the owner has pressed the reset.

Worked Example
Design an intruder alarm based on a flip flop.

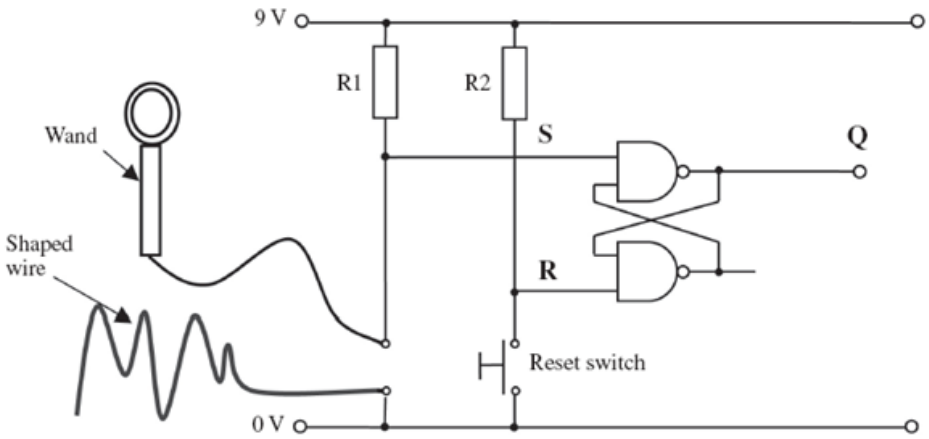
If a burglar triggers an alarm, say, by opening a door and standing on a pressure mat, then some simple memory circuit is usually necessary to keep the alarm sounding after the intruder has stepped off the mat. In this application the Set input would be connected to a sensor or switch such as the pressure mat. The Reset switch may only be accessed by the householder. The output Q will operate an output device such as an LED or a siren, if necessary, driven by a suitable circuit.



ACTION	S	R	Q
Owner presses reset	1	0	0
Owner releases reset	1	1	0
Intruder steps on pressure mat	0	1	1
Intruder steps off pressure mat	1	1	1
Owner presses reset	1	0	0

Revision Questions

1 (a) A student has designed a "steady hand game" which consists of a shaped wire and a metal wand. Part of the circuit to control the game is shown in the figure below. If the wand touches the shaped wire momentarily the output Q will be "high". The output will remain high until the reset switch is pressed.



(i) Name the arrangement of logic gates shown in the figure above.

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(ii) The table below b) shows the sequence of operations from Stage 1 to Stage 4 when using the circuit in the figure above. Deduce the missing logic states for S, R and Q respectively.

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Source: CCEA AS June 2006 Paper 3 Q1

Stage	Wand and shaped wire contact? Yes/No	Reset switch	S Logic state	R Logic state	Q Logic state
1	No	Open	1	1	0
2	Yes	Open	0	1	?
3	No	Open	?	1	1
4	No	Closed	1	?	0

Figure 1b

Revision Questions

2 The circuit shown in the figure below has been designed to indicate if a security door in a building has been opened.

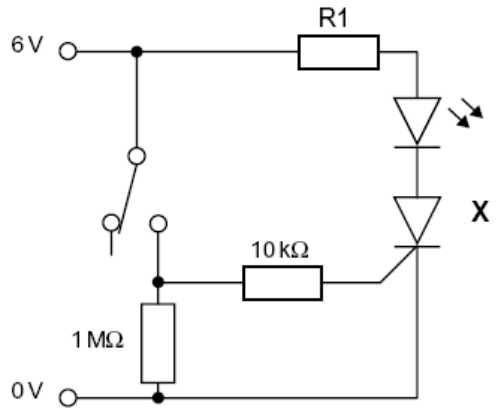

Figure 2

The circuit shown in the figure above is to be replaced by one using an SR flip flop.

(a) Draw a circuit diagram of an SR flip flop.

(b) Add components to the SR flip flop and explain how it could be used to indicate if the security door was last opened from the inside or outside.

Source: CCEA AS May 2009 Q9

3 A logic circuit that could be used as a simple tamper alarm for a trophy display stand is shown in the figure below. Sw A is a micro switch which is kept in the closed position as shown when the trophy is resting on it.

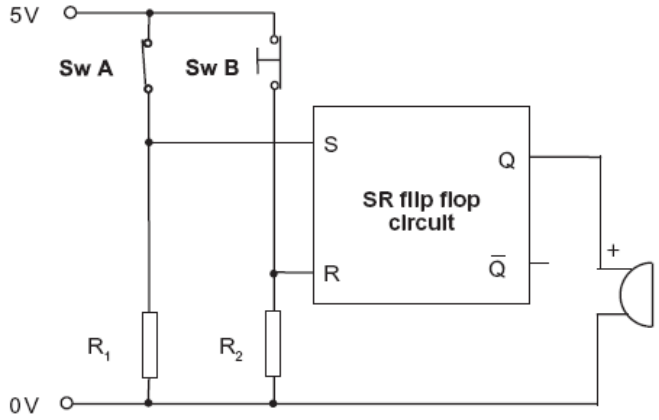

Figure 3

(i) State the type of logic gate that could be used to make the SR flip flop circuit shown in Figure 3.

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(ii) Explain why the resistors R1 and R2 are used in conjunction with each of the switches shown in Figure 3.

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(iii) Draw using logic gates, the SR flip flop circuit in Figure 3. Add labels S, R, Q and Q̄ and describe the operation of the circuit including how the tamper alarm is reset.

Source: CCEA AS June 2011 Q10