

ELG3331: DESIGN OF LOGIC CIRCUIT

Suppose we intend to design a remote door lock which is operated by an electrical relay that requires 15 mA to operate. The relay may be opened by two switches A or B or both. The information from the switches is combined in a logic circuit. The logic levels are 0 to 0.5 V for a digital 0 and 4.5 to 5 V for a digital 1. A transistor is used to operate the relay and the logic circuit controls the transistor.

The following steps should be followed while designing any circuit using logic gates.

1. Define the problem.
2. Write logic statements
3. Write Boolean expression.
4. Simplify and minimize the Boolean expressions, if possible.
5. Write all realizations of gates in order to minimize the number of required logic gate IC components.
6. Draw the logic schematic for the electronic realization of the circuit.

Define the problem

We want a remote door lock which is operated by an electrical relay that requires 15 mA to operate. The relay may be opened by two switches A or B or both. The information from the switches is combined in a logic circuit. A transistor is used to operate the relay. The relay will function when a current 15 mA or more will flow through the inductor and R_C . Accordingly, the user should be familiar with the following operating states:

1. An active state where the relay will close if either switch A or B or both switches are on.
2. A disabled state where the relay will not close if both switches are off.

Write Logic Statements

We translate the word statements into logic-like statements. Activate the relay if either or both switches are on. In such case, the output should be zero. This means that enough current (15 mA) will flow through the relay and R_C . When both inputs are zero, the relay should not operate and the output voltage should be 5 V (logic 1). Accordingly, we need a NOR gate with two inputs and four possible input combinations for A and B, which we have listed in the following truth table (Figure 1)

A	B	C
0	0	1
0	1	0
1	0	0
1	1	0

Figure 1 Truth table for the NOR function

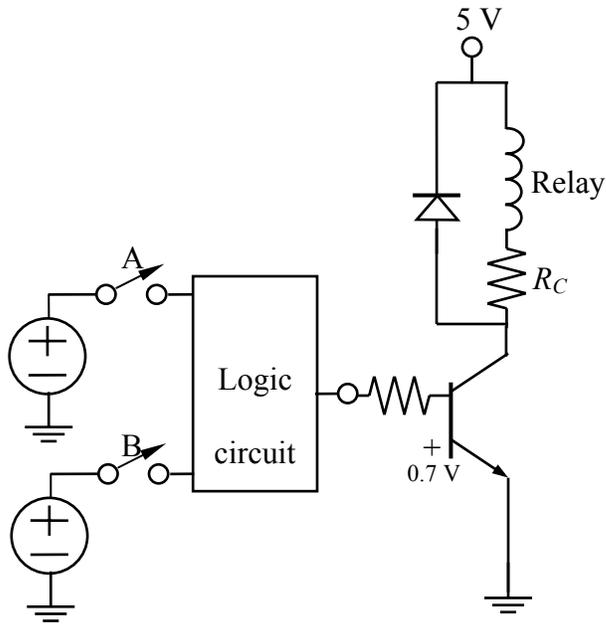


Figure 2 Realization of a remote door lock.

Write the Logic Expressions

Now we may write the Boolean expression based on the logic statement.

	$Y = \overline{A + B}$	
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Once the expression is realized, the preferred type of gate will be selected (for example, NOR gate or an OR gate with inverter).

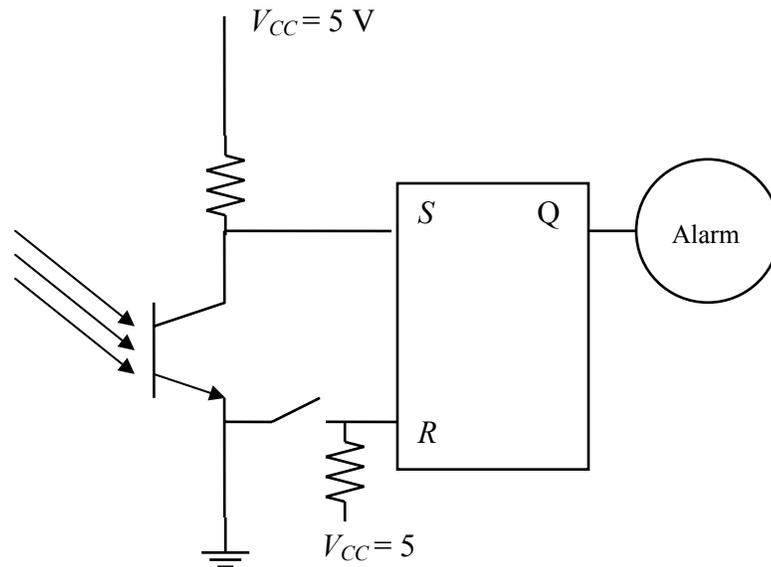
Circuit Diagram

Now it is relatively straightforward to draw the circuit using two switches with a NOR gate and connecting them to a transistor circuit as shown in Figure 2. Usually logic gates come packaged on integrated circuit chips (logic ICs). Since we need one NOR gate, the circuit may be constructed with one IC: 1 quad 2-input gate (e.g., the 4000), which contains four NOR gates. The solution just presented is known as a hardware solution because it uses integrated circuit gates and transistor circuit to provide the desired logic.

DESIGN OF SEQUENTIAL LOGIC CIRCUITS

Simple Alarm System Using *SR* Flip Flop

The alarm is to sound when a beam of light is interrupted and will remain sounding even when the beam is no longer interrupted. A photo transistor might be used as a sensor and so connected that when illuminated it gives 0 V input to *S* but when the illumination ceases it gives about 5 V input to *S*. When the light beam is interrupted *S* becomes 1 and the output from the flip flop becomes 1 and the alarm sound. The output will remain as 1 even when *S* changes to 0. The alarm can only be stopped if the reset switch is momentarily opened to produce a 5 V input to *R*.



SR (set-rest) flip flop is constructed by NOR gates

<i>S</i>	<i>R</i>	<i>Q</i>
0	0	Present state
0	1	Reset
1	0	Set
1	1	Disallowed

Simple Alarm System Using SR Flip Flop

The following figure shows a system that could be used to show a green light when the sensor input is low and a red light when it goes high and sound an alarm. The red light is to remain on as long as the sensor input is high but the alarm can be switched off. This might be monitoring system for the temperature in some processes. The sensor and signal conditioning giving a low signal when the temperature is below the safe level and a high signal when it is above. The flip-flop has a high input. When a low input is applied to the CK input and the sensor input is low, the green light goes on. When the sensor input changes to high, the green light goes out, the red light goes on and the alarm sounds. The alarm may be cancelled by applying a high signal to the CK input, but the red light remains on as the sensor input is high. You may use a 7474 D flip flop and an integrated circuit giving three NAND gates to construct this alarm.

D flip-flop, also called a data flip flop has a single input D whose value is stored and presented at the output Q at the edge of a clock pulse, for example a positive edge triggered D flip-flop.

