EE40 Final Project-2   Light Sensor

Name & SID 1 :

Name & SID 2 :

Introduction

In this Project you will implement a light sensing circuit. When there is no light shining on the detection part of the circuit, the green LED will be flashing. At the presence of light the red LED will start flashing instead of the green one.
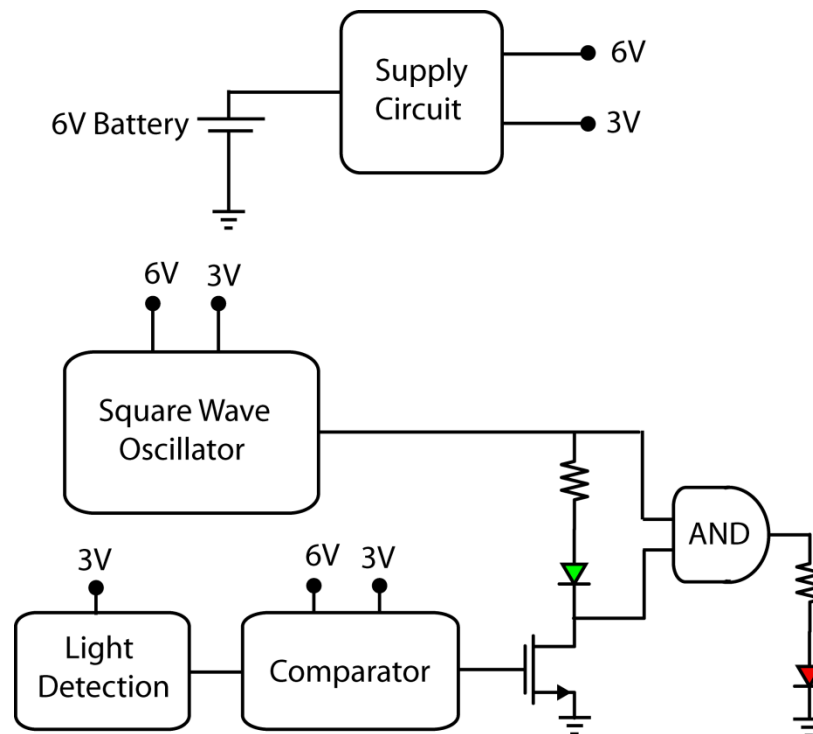
Block Diagram

Figure 1 . Block diagram of the light sensing circuit

Block diagram of the light sensor is depicted in Figure 1. We are using a single 6V battery for this project, but for different building blocks we need both 3V and 6V as supply voltages. Therefore through the "Supply Circuit" block we generate this additional 3V supply voltage.

A "Square Wave Oscillator" generates a 0-6V square wave signal required for making LEDs flash.

A "Light Detection" block detects if there is any light being shined on the detection part or no. When there is no light the output of the detection circuit is 0 and in the presence of light it goes up, close to 3V.

A comparator compares the output of detection block with a threshold. When the detection signal is higher than the threshold (there is light) the output of comparator is low and when the detection output is lower than the threshold (no light) the output of comparator is high.

The comparator output needs to be connected to a MOSFET to be able to drive (provide enough current) for subsequent blocks and LEDs. When comparator output is high(6V), drain of the MOSFET is low(0V) and when the comparator output is low, MOSFET's drain is set to 6V.

LEDs will emit light when their anodes (longer leads) are connected to higher voltages with respect to their cathodes(shorter leads). Therefore to make the green LED flash when there is no light at the input, its anode should be connected to square wave generator output while its cathode being connected to the drain of the MOSFET. Anode of the red LED can be connected to ANDed signal of 1-square wave generator output and 2- drain of the MOSFET while its cathode being grounded, hence when there is light the red LED flashes instead of the green one. LEDs never should be directly connected to a voltage source or output of a logic circuit(or output of any other circuit that can be approximated as a voltage source in series with a low impedance). Because if a voltage is directly applied to anode-cathode of the LED, it draws a huge current which burns the LED. So LEDs should always be in series with a resistor (in the range of KΩ) to limit the current.

Supply Circuit
The circuit will be powered by a 6V battery. But lower DC voltages are also needed for other building blocks. This additional voltage is generated through the circuit which its schematic is depicted in Figure-2.

Since 3V is half of the 6V supply, R_1 and R_2 are equal. C_1 and C_2 are filtering capacitors which are usually placed in parallel with the DC power supplies to remove any AC signal and high-frequency noise.
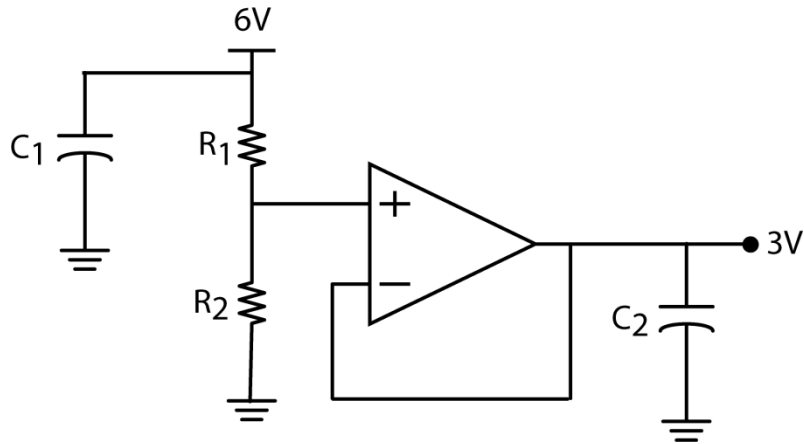
Figure 2. Builing block for generating additional 3V DC supply voltage
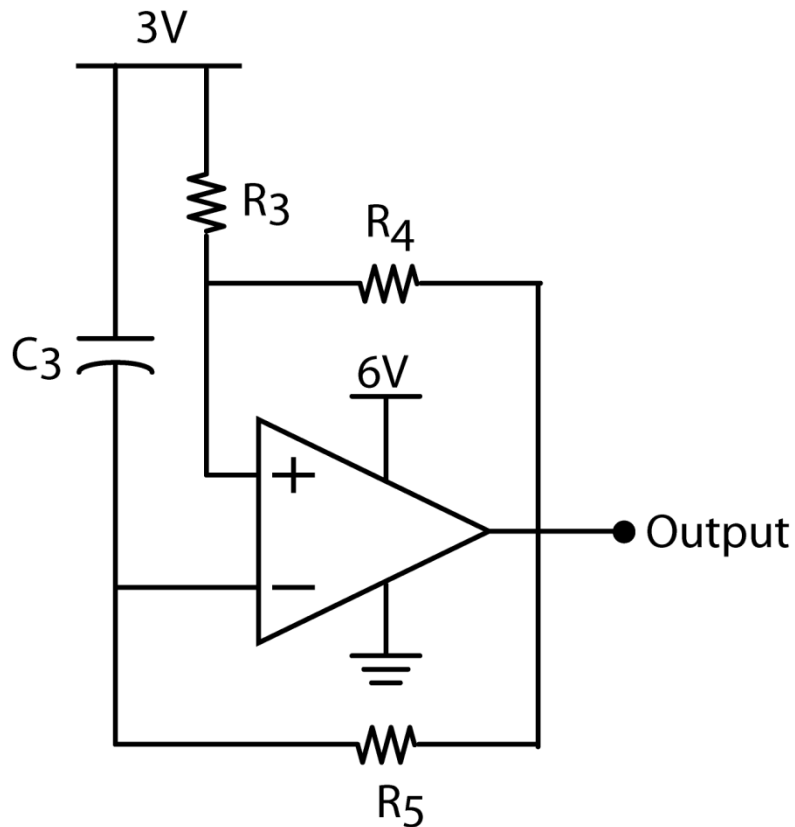
Square Wave Generator

Figure 3. Square wave generator

   The op-amp feedback is positive, which means that the output voltage is either Vss=0 or Vcc=6V. The output voltage toggles between these two values through the charge and discharge of the capacitor (C_3).

Initially there is no charge on the capacitor (Q=CV) hence the voltage drop across the cap is zero and the negative terminal of the op-amp is at 3V ($V\_=3V$). Since V_{out} is at zero potential at the beginning, the positive terminal of the op-amp will be determined through a voltage division. $V_+=3 \times R_4 / (R_3+R_4) < V\_$. Because the negative terminal of the op-amp is greater than the positive terminal of the op-amp the output of the ap-amp will go down to Vss (zero potential in this case).

Now capacitor C_3 starts to be charged, So there will be a positive voltage difference between top and bottom plates of the capacitor. The top-plate stays at 3V and bottom plate($V\_$) moves down to reach to the zero potential (the potential of the other side of the resistor R_5). This charging happens with the time-constant of ($R_5 C_3$). Whenever the bottom plate($V\_$) that is moving down towards zero reaches and slightly goes below the voltage level of the ($V_+=3 \times R_4 / (R_3+R_4)$) then the condition will be ($V_+ > V\_$) and the output toggles to V_{CC}(6V).

When the output is at 6V, we use the superposition to find the V_+ :

$V_+ = 3 \times R_4 / (R_3+R_4) + 6 \times R_3 / (R_3+R_4) = 3 \times (R_4+2R_3)/(R_3+R_4)$

Now the capacitor C_3 will be discharged so that the bottom plate ($V\_$) rises toward the voltage value of the other side of the resistor (6V). In this scenario when $V\_$ is moving up from $3 \times R_4 / (R_3+R_4)$ towards 6V with time constant of ($R_5 C_3$) at some point it reaches and goes slightly above $V_+= 3 \times (R_4+2R_3)/(R_3+R_4)$ and that's the point where again ($V_+ < V\_$) and the output toggles to 0.

Hence the negative terminal of op-amp charges and discharges between $3 \times R_4 / (R_3+R_4)$ and $3 \times (R_4+2R_3)/(R_3+R_4)$ with the time constant of ($R_5 C_3$) and the output toggles between 0 and 6V, generating a square wave.

Human eyes can differentiate frequencies below 30Hz. Based on the explanation above calculate the frequency of the square wave based on R and C values and choose R and C values in such a way that the frequency of the square wave is almost 4Hz.
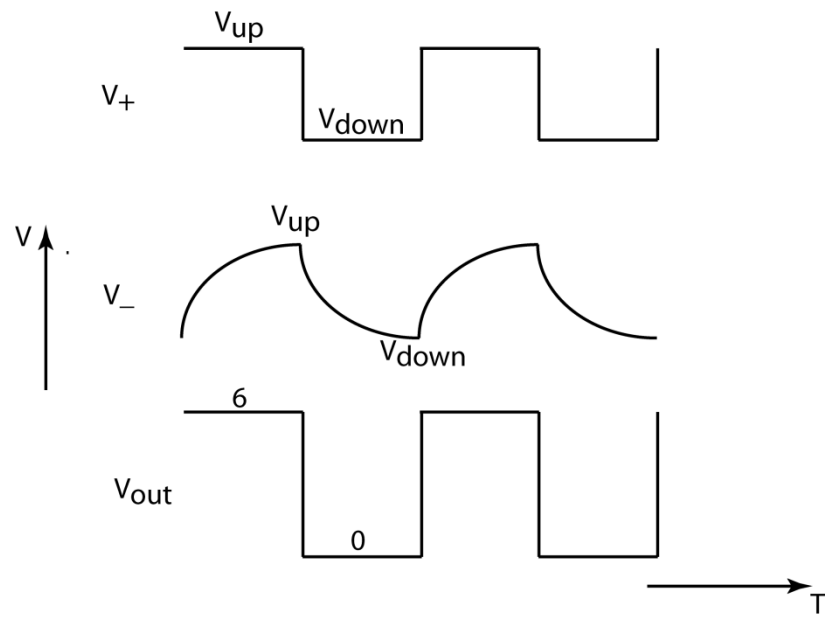
$V_{up} = 3 \times (2R_3 + R_4) / (R_3 + R_4)$

$V_{down} = 3 \times R_4 / (R_3 + R_4)$

Figure 4. Plot of V_ ,V+ and V_out
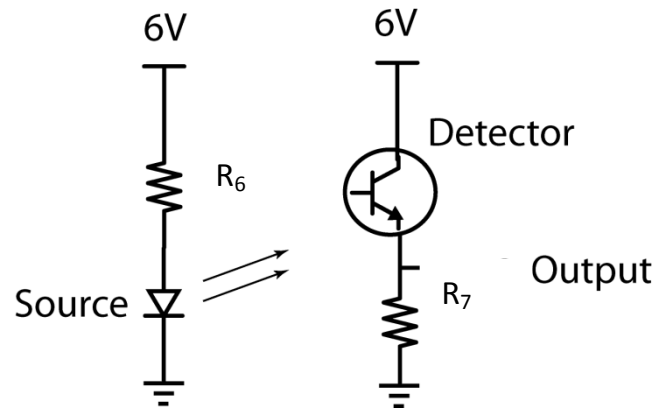
Light Detection

Figure 5. Light generation and detection circuitry

Light generation can be done via visible LED, room light or infrared(IR) LED. Light source intensity is determined by the sensitivity of the detector. Photo transistor can be used as detector. Light exposure causes an increase in the current flow of phototransistor and pulls up the output voltage of the detection block. Here are the list of choices that you have.

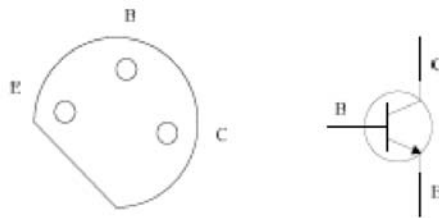| Source/Detector	R6 (Ω)	R7(Ω)	Output(V)
Flash light/Photoresistor	-	10K	0-5
Room light/Photoresistor	-	1K	2-4
IR LED/IR detector (Phototransistor)	50	100K	0-4

Figure 6. Light generation and detection, phototransistor FPT100 pinout
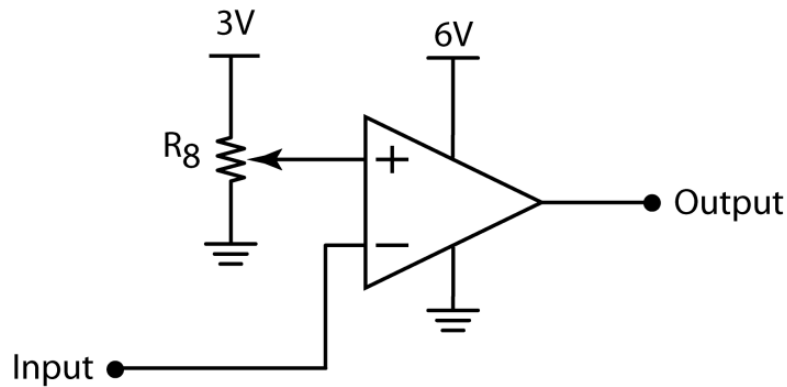
Comparator

Figure 7. Comparator Schematic

An open loop op-amp as shown above can be used as a comparator. Since the input (V_-) is the output of the detection circuit and varies from close to 0 to a voltage close to 3V, by connecting V_+ to the middle point of a potentiometer this V_+(in other words the threshold voltage) will be set in the mid-range of 0-3V. therefore in the presence of light the comparator output will be low and when there is no light it will be high(6V).

AND

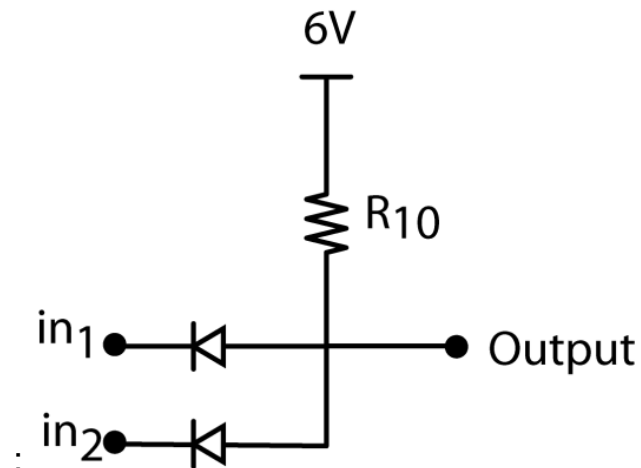The easiest way to implement an AND function is via two diodes and a resistor as shown below

Figure 8. Schematic of the AND gate, two flashing LEDs and the driver MOSFET

Component list

Component	Value	Quantity
Resistor	10 kΩ	8
	1 kΩ	3
	510 Ω	3
	200 Ω	1
Pot	10 kΩ	2
	5 kΩ	1
Capacitor	10 μF	3
	0.1 μF	1

Component	Model	Quantity
Op-amp	LMC 6482	2
NMOS	BS170	3
PMOS	ZVP2106A	1
Diode	1N4148	2
LED	Green, Yellow, Red	3
IR LED	512-QED423	1
IR detector	512-QSD723	1
Photoresistor	-	1
Buzzer		1
Battery	6v	1
Breadboard	-	1