Operations On Signal generated from the sound detected.

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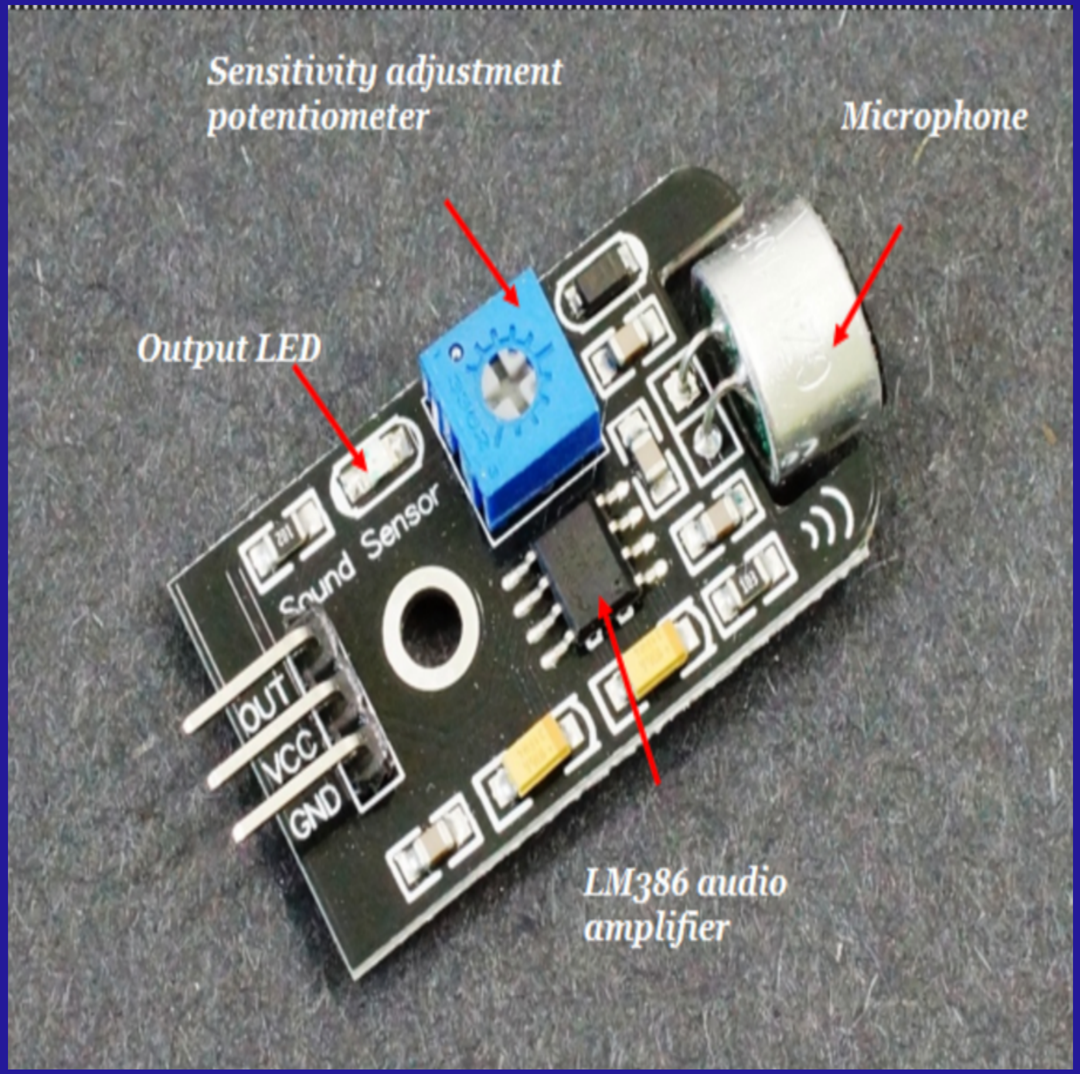
WORKING OF A SOUND SENSOR

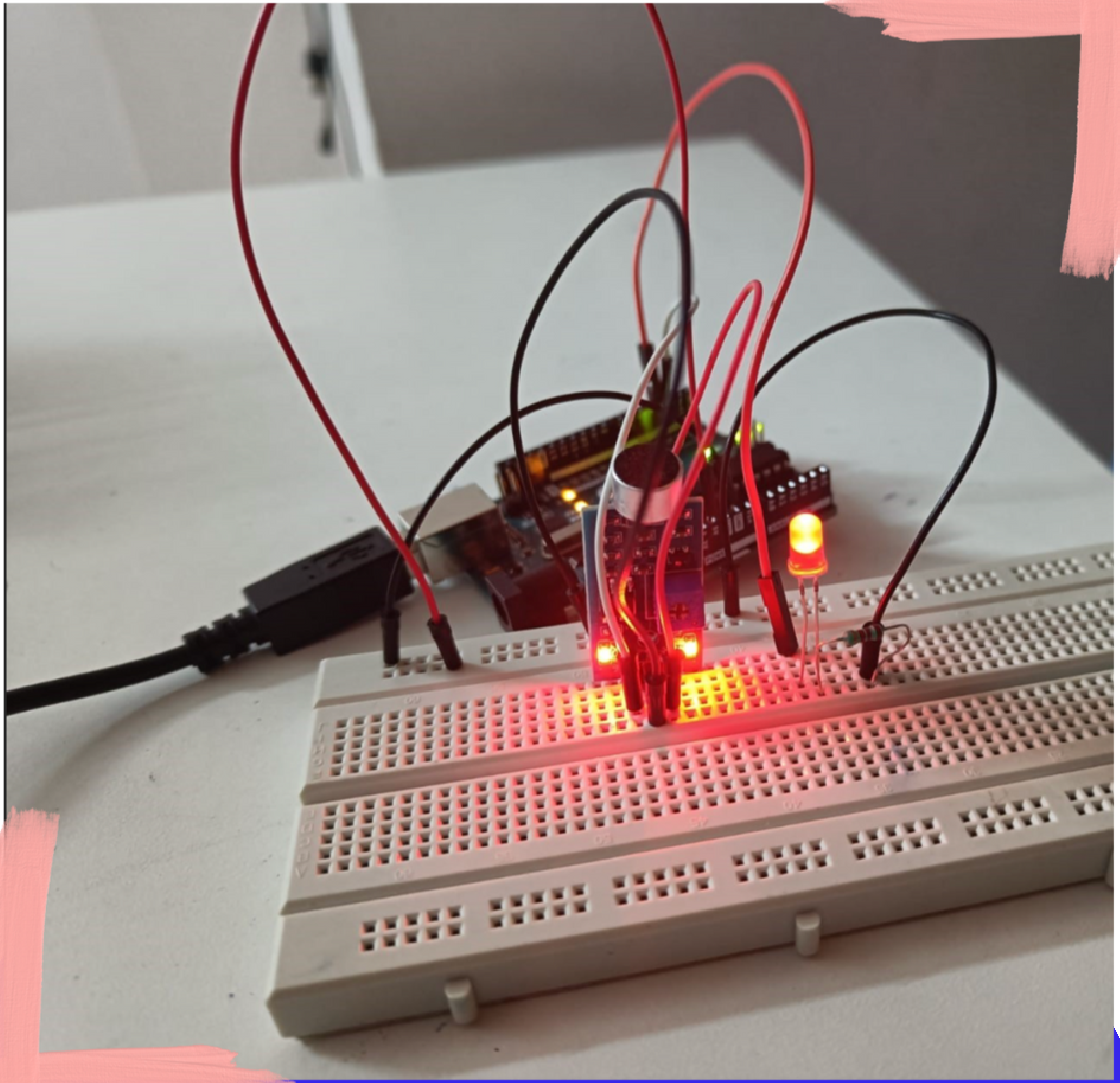
The sound sensor consist of Microphone as a transducer, potentionmeter to adjust the intensity, LM386 low power audio amlifier, LED and other passive components like resistors and capacitors.
You can set a threshold value using a potentiometer so that when the amplitude of the sound exceeds the threshold value, the module will output LOW otherwise HIGH.
This sensor includes 3 pins and they are,

- Pin1 (VCC): 3.3V DC to 5V DC
- Pin2 (GND): This is a ground pin
- Pin3 (OUT): This is an output pin. It provides high signal when there is no sound and goes LOW when sound is detected. You can connect it to any digital pin on an Arduino or directly to a 5V relay or similar device.

It works similar to our ears. Our Ears have a diaphragm which converts the detected the vibration and converts it in the signal. Similarly, the sound sensors convert the vibration into audio signal (voltage and current proportional) with the help of a microphone.
This microphone has an inbuilt diaphragm, made up of magnets which are coiled by metal wire. Whenever sound waves hits the diaphragm, magnets vibrate and at the same time coil induces the current.



The circuit

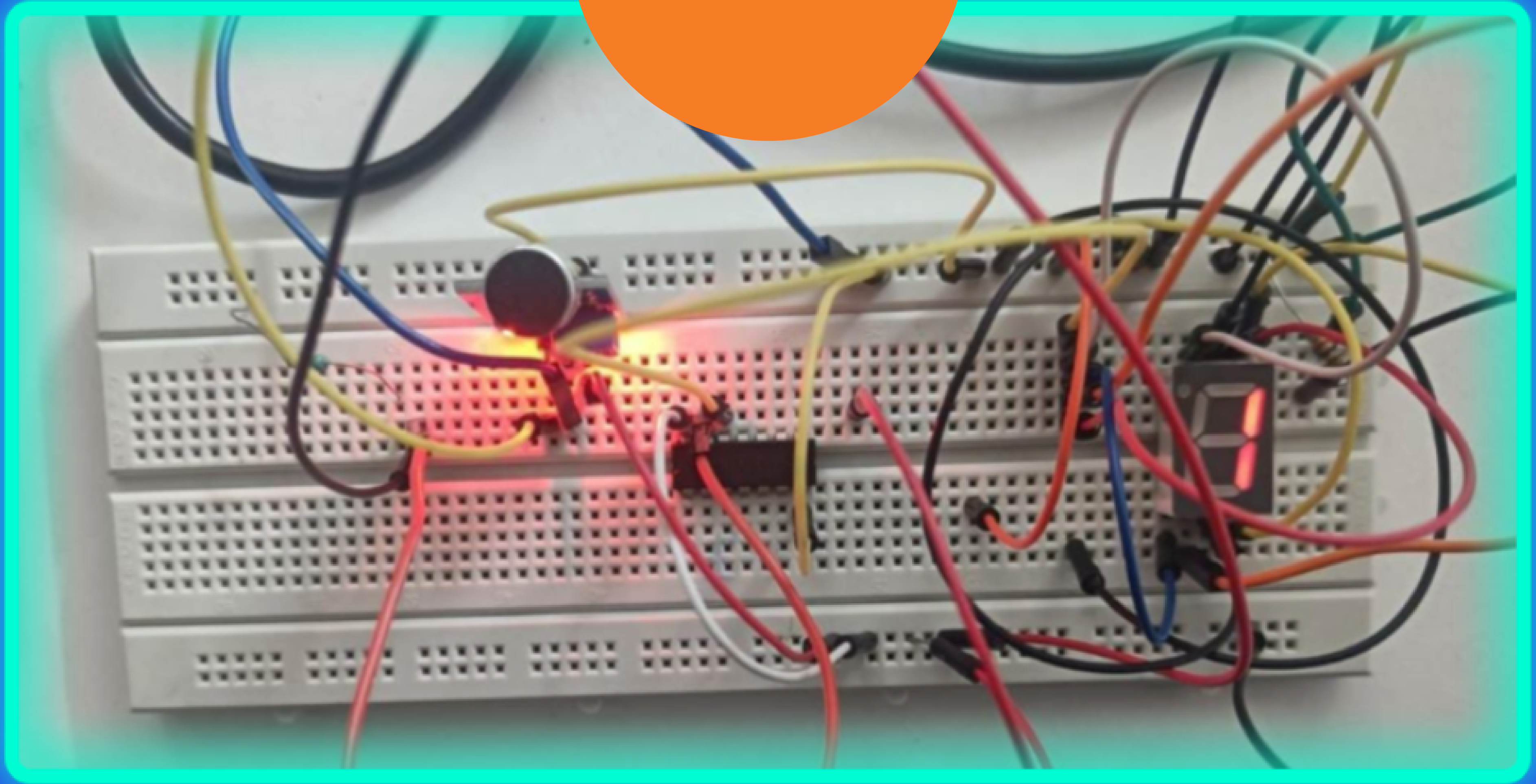


Validating the sound sensor using a seven segment display

The display shows 1 when no sound above the threshold value is detected and it displays 0 when a sound above the threshold value is detected.

Link for the video demo:

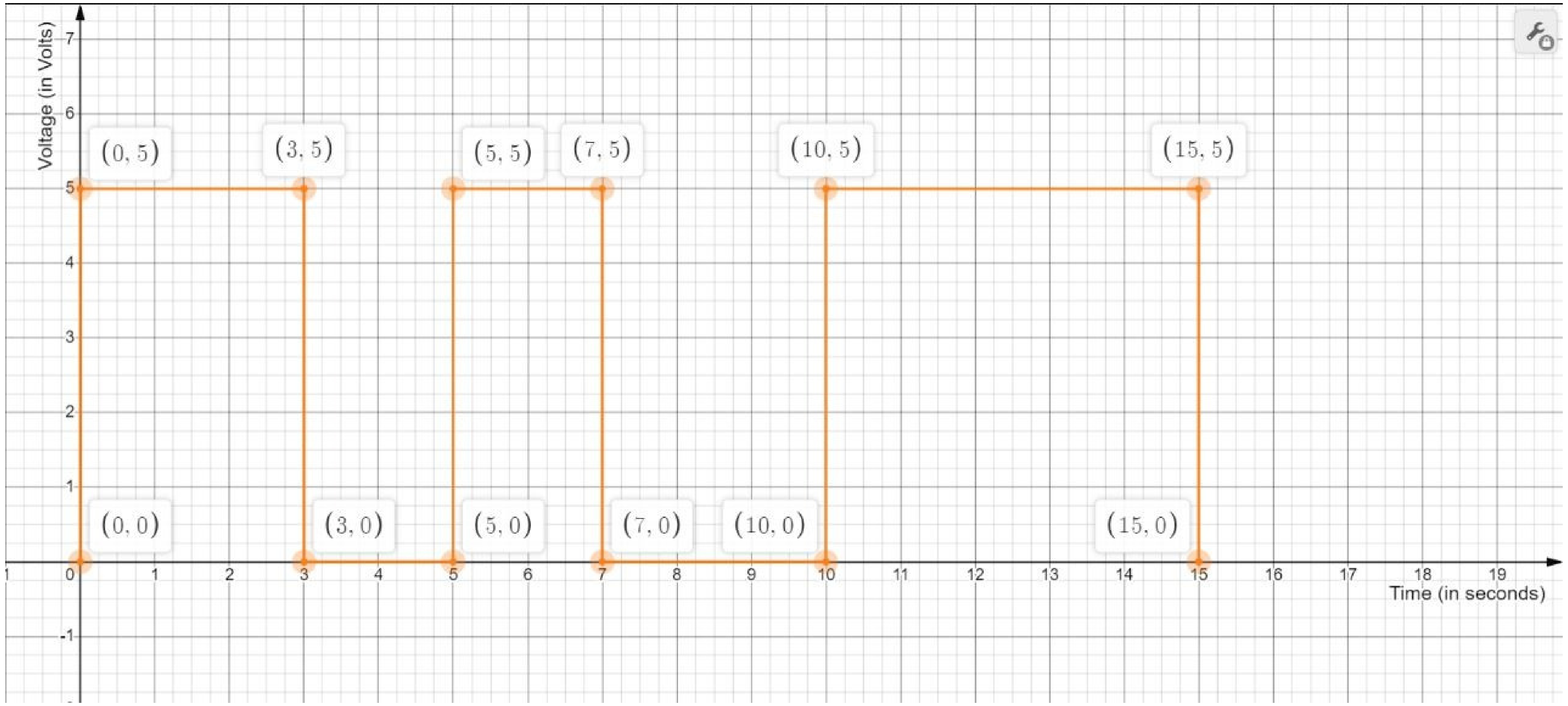
https://iiitbac-my.sharepoint.com/:v:/g/personal/shashank_lal_iiitb_ac_in/EfCnxkHJmJtlrVQwAC93jawBRrtv2iDXUL2VW4e16hTcGg?e=H5baXP



THE ARDUINO CODE.

```
int SoundSensor=2; // LM393 Sound Sensor Digital Pin D0 connected to pin 2

int LED=3; // LED connected to pin 3

boolean LEDStatus=false;

void setup() {
pinMode(SoundSensor,INPUT);
pinMode(LED,OUTPUT);
Serial.begin(9600); //initialize serial
}

void loop() {

  int SensorData=digitalRead(SoundSensor);

  serial.println(SensorData);//print the value

  if(SensorData==1){
    if(LEDStatus==false){
        LEDStatus=true;
        digitalWrite(LED,HIGH);
     }
     else if(LEDStatus==true){
          LEDStatus=false;
          digitalWrite(LED,LOW);
      }
  }
}
```

Based on the code, when the sound sensor detects an amplitude above the threshold value (the sound sensor has been connected to input pin 2 of Arduino), the Arduino gives a low voltage value on output pin 3 (the led is connected to the output pin 3) if the variable led status is high and it gives a high voltage value on output pin 3 if the variable ledstatus is low. (In the code the variable led status is changed every time we detect a sound above the threshold value). Thus the value given to output pin 3 changes only on the detection of a sound above the threshold value. An example of the voltage v/s time graph produced :



Here the sound is detected at time stamps 3s,7s,10s and 15s (at the timestamps where the voltage value changes either from 5V to 0V or form 0V to 5V)

DEMONSTRATION OF THE SIGNAL GENERATED

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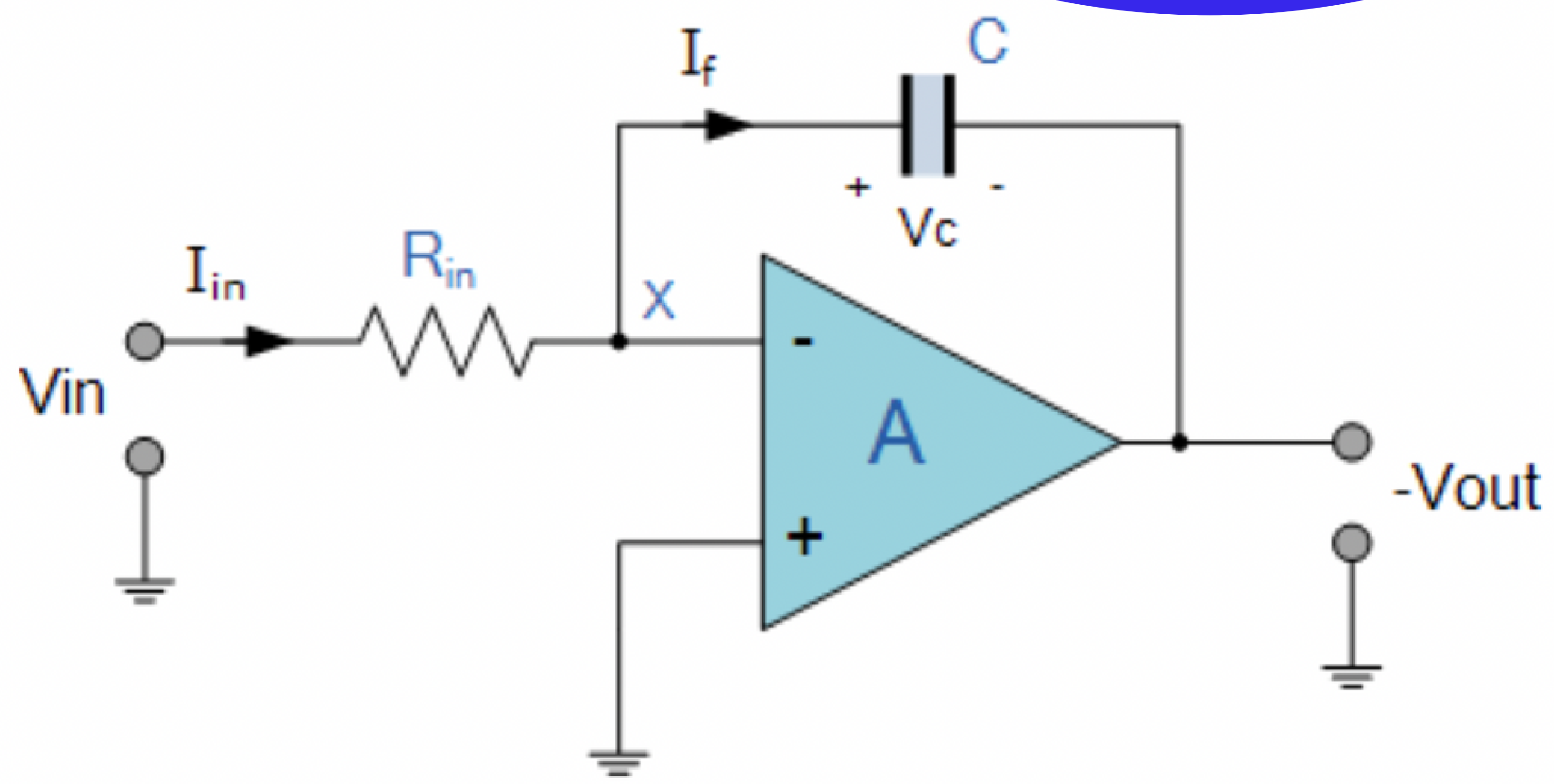
USING THE SIGNAL GENERATED TO DEMONSTRATE

1. integrator
2. differentiator

INTEGRATOR

As its name implies, the Op-amp Integrator is an operational amplifier circuit that performs the mathematical operation of Integration, that is we can cause the output to respond to changes in the input voltage over time as the op-amp integrator produces an output voltage which is proportional to the integral of the input voltage.



INTEGRATOR DERIVATION

We know from first principals that the voltage on the plates of a capacitor is equal to the charge on the capacitor divided by its capacitance giving Q/C. Then the voltage across the capacitor is output Vout therefore: -Vout = Q/C. If the capacitor is charging and discharging, the rate of charge of voltage across the capacitor is given as:

$$V_c = \frac{Q}{C}, \qquad V_c = V_x - V_{out} = 0 - V_{out}$$

$$\therefore -\frac{dV_{out}}{dt} = \frac{dQ}{Cdt} = \frac{1}{C}\frac{dQ}{dt}$$

But dQ/dt is electric current and since the node voltage of the integrating op-amp at its inverting input terminal is zero, X = 0, the input current I(in) flowing through the input resistor, Rin is given as:

$$I_{in} = \frac{V_{in} - 0}{R_{in}} = \frac{V_{in}}{R_{in}}$$

The current flowing through the feedback capacitor C is given as:

$$I_f = C\frac{dV_{out}}{dt} = C\frac{dQ}{Cdt} = \frac{dQ}{dt} = \frac{dV_{out}.C}{dt}$$

Assuming that the input impedance of the op-amp is infinite (ideal op-amp), no current flows into the op-amp terminal. Therefore, the nodal equation at the inverting input terminal is given as:

$$I_{in} = I_f = \frac{V_{in}}{R_{in}} = \frac{dV_{out}.C}{dt}$$

$$\therefore \frac{V_{in}}{V_{out}} \times \frac{dt}{R_{in}C} = 1$$

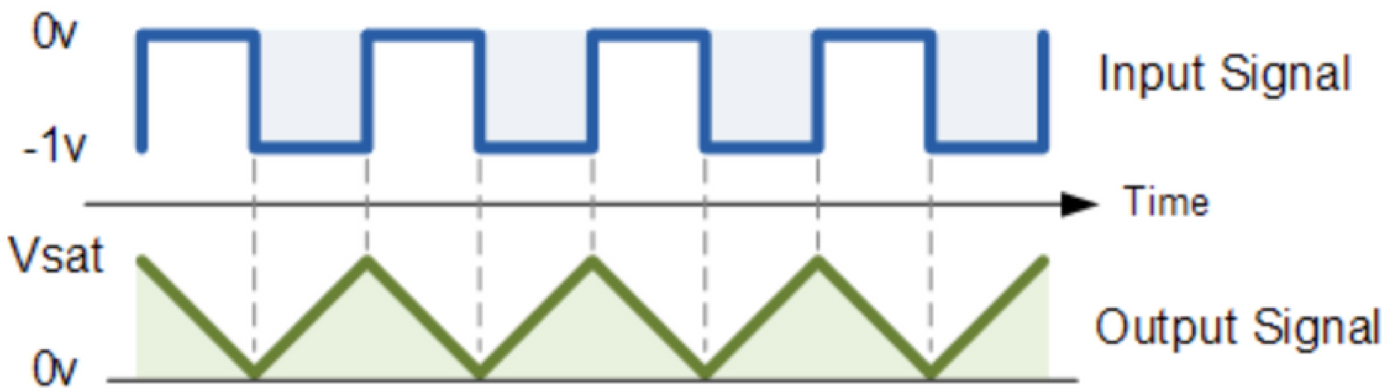
From which we derive an ideal voltage output for the Op-amp Integrator as:

$$V_{out} = -\frac{1}{R_{in}C}\int_0^t V_{in}\,dt = -\int_0^t V_{in}\frac{dt}{R_{in}.C}$$

Thus the circuit has the transfer function of an inverting integrator with the gain constant of -1/RC. The minus sign (–) indicates a 180 degree phase shift because the input signal is connected directly to the inverting input terminal of the operational amplifier.

RAMP GENERATOR

The integrator gives output signal as ramp for a square input signal.



OBTAINED GRAPH

The blue plot represents the input signal and the yellow plot represents the output signal.

DEMONSTRATION OF INTEGRATOR

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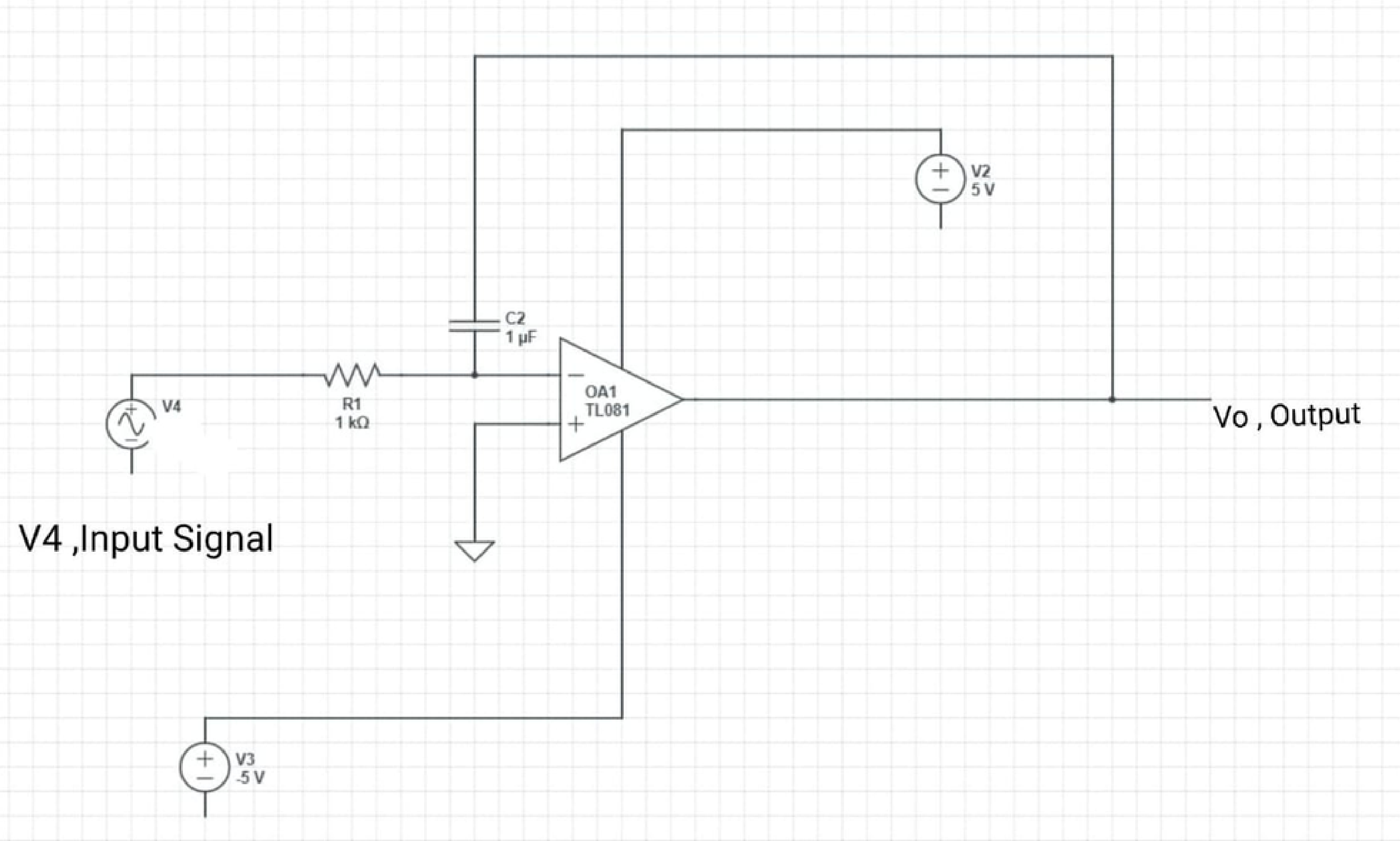
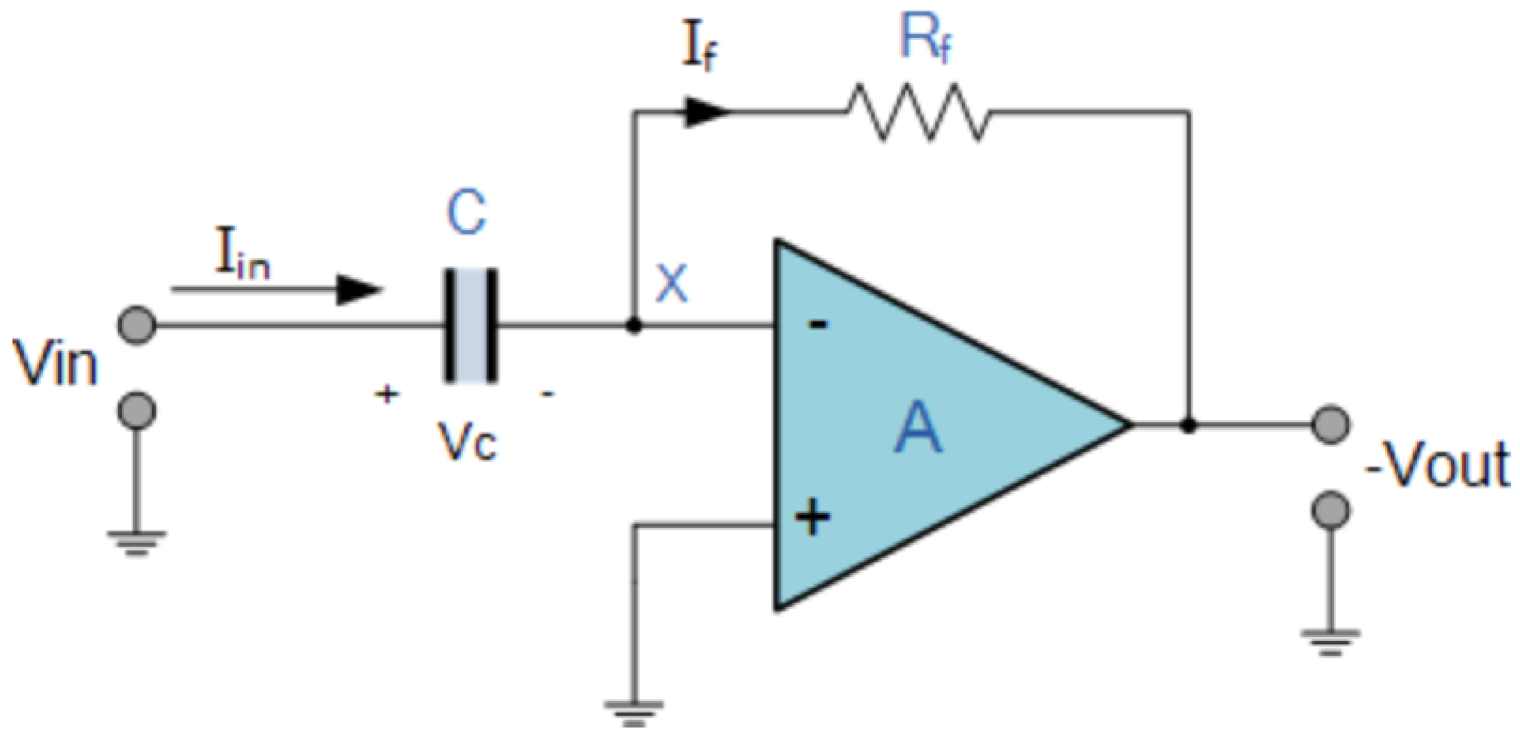
CIRCUIT USED IN DEMO



DIFFERENTIATOR

The basic operational amplifier differentiator circuit produces an output signal which is the first derivative of the input signal



DIFFERENTIATOR DERIVATION

Since the node voltage of the operational amplifier at its inverting input terminal is zero, the current, i flowing through the capacitor will be given as:

$$I_{IN} = I_F \quad \text{and} \quad I_F = -\frac{V_{OUT}}{R_F}$$

The charge on the capacitor equals Capacitance times Voltage across the capacitor

$$Q = C \times V_{IN}$$

Thus the rate of change of this charge is:

$$\frac{dQ}{dt} = C\frac{dV_{IN}}{dt}$$

but dQ/dt is the capacitor current, i

$$I_{IN} = C\frac{dV_{IN}}{dt} = I_F$$

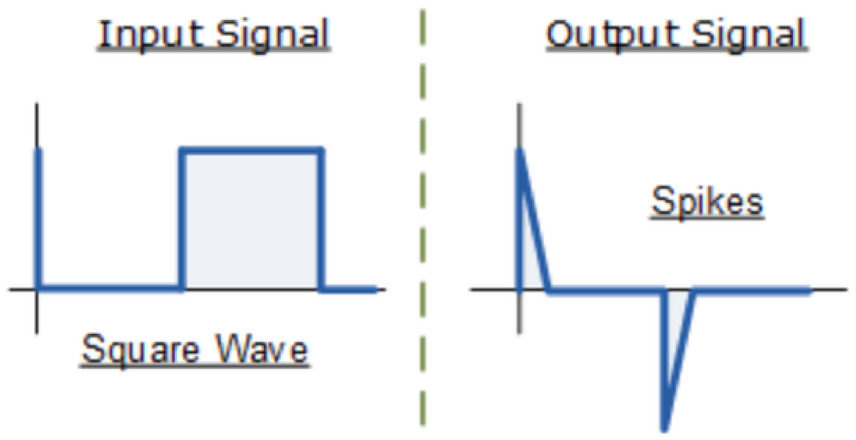
$$\therefore -\frac{V_{OUT}}{R_F} = C\frac{dV_{IN}}{dt}$$

from which we have an ideal voltage output for the op-amp differentiator is given as:

$$V_{OUT} = -R_F C\frac{dV_{IN}}{dt}$$

Therefore, the output voltage Vout is a constant −Rƒ*C times the derivative of the input voltage Vin with respect to time. The minus sign (−) indicates a 180o phase shift because the input signal is connected to the inverting input terminal of the operational amplifier.

The differentiator gives spikes for an input signal of the square wave.



OBTAINED GRAPH

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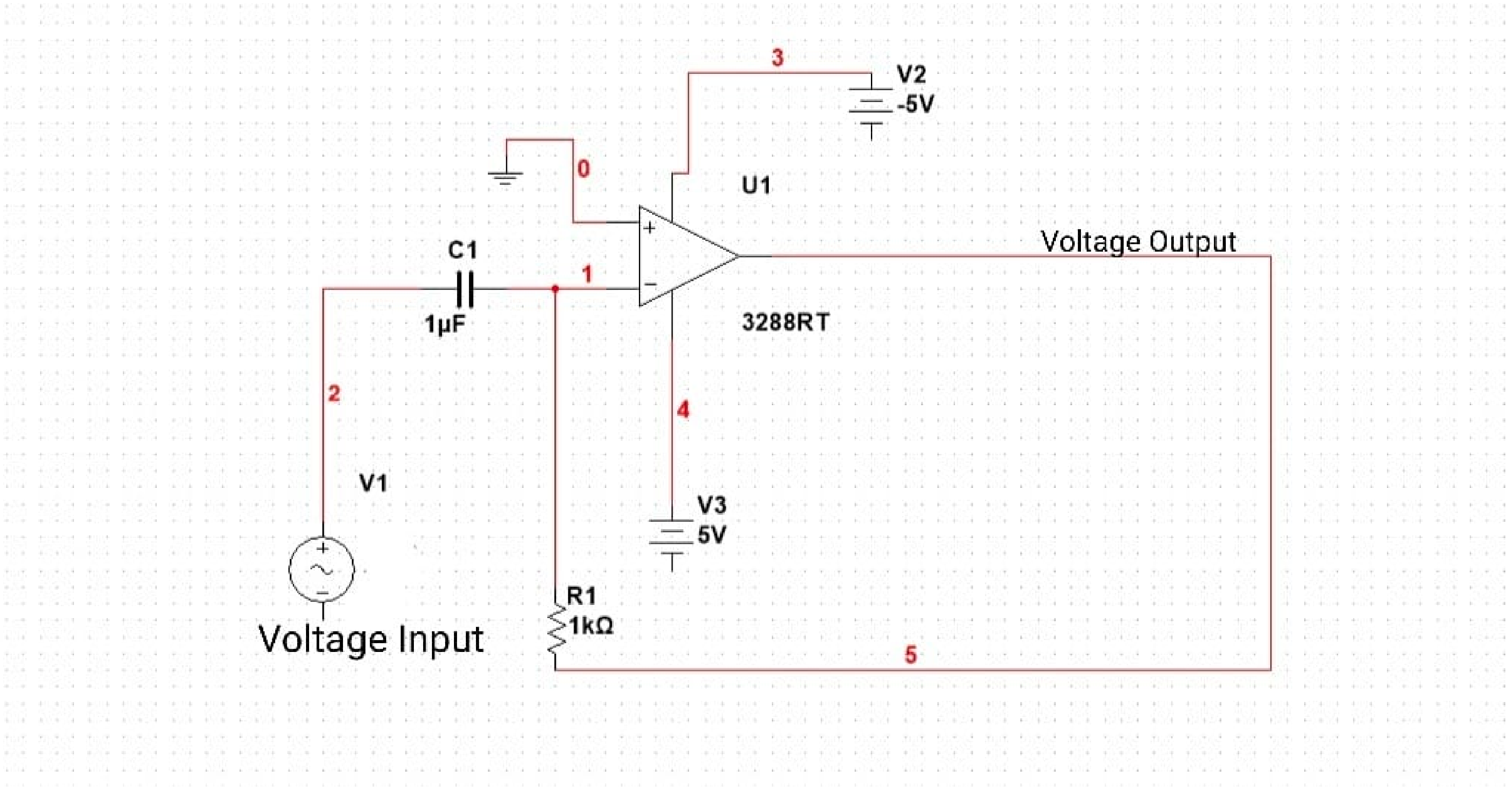
CIRCUIT USED IN DEMO



DEMONSTRATION OF DIFFERENTIATOR

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Thank you!