PIR SENSOR

Group 13

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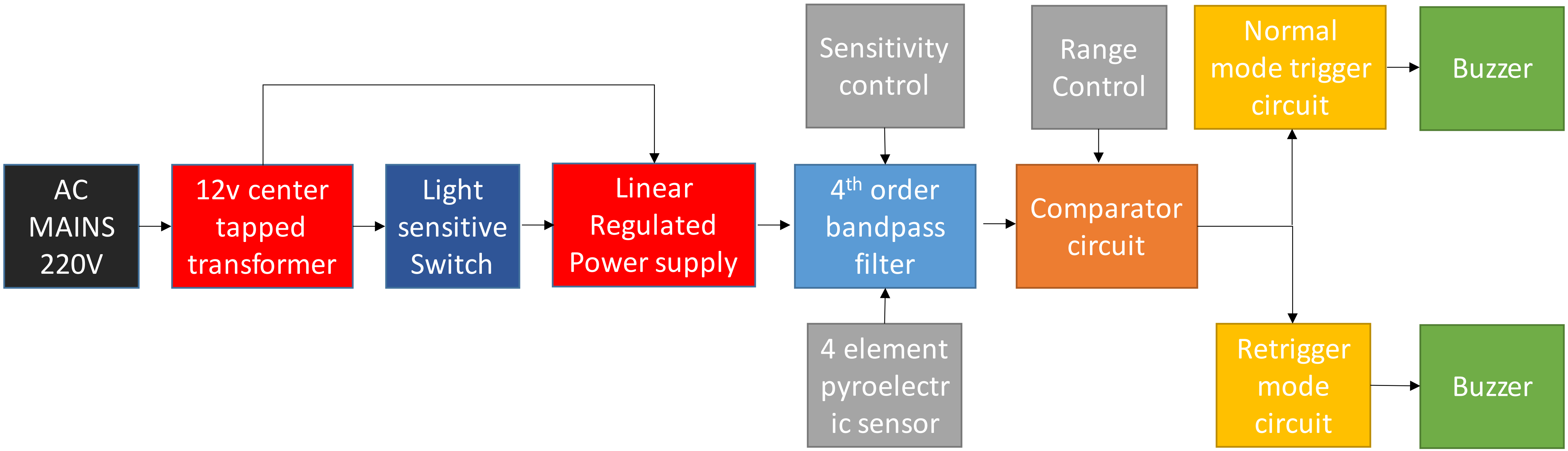
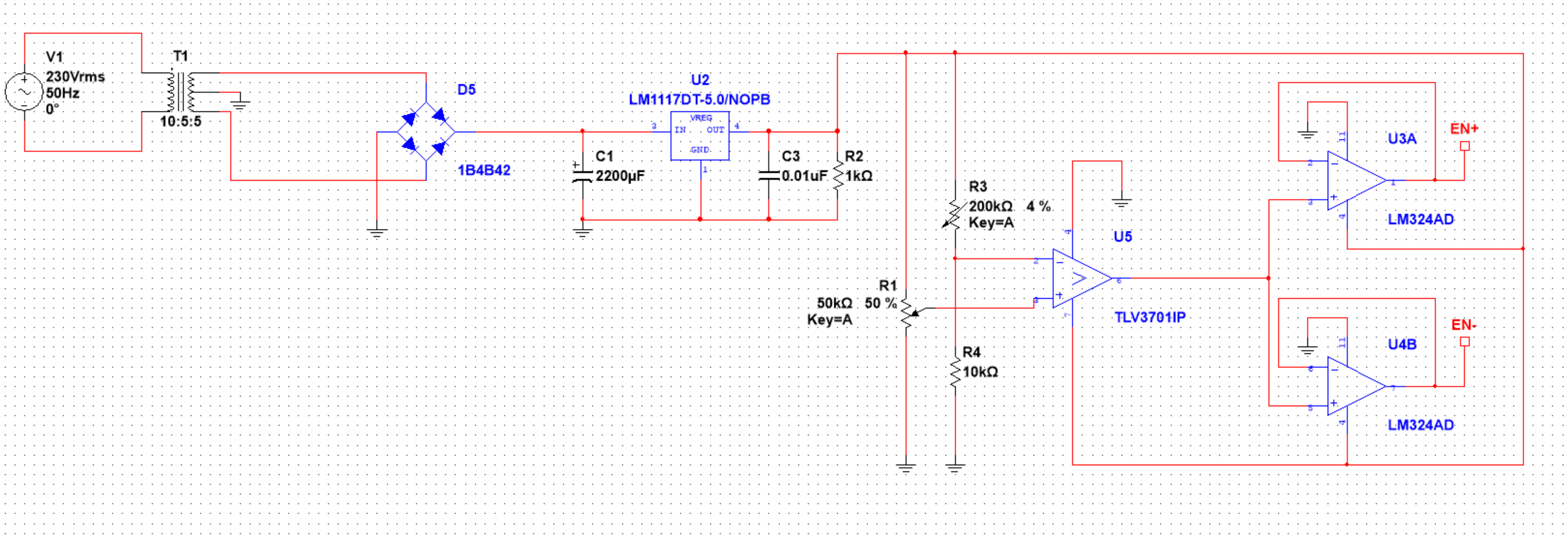
Method of Implementation



Light Sensitive Switch

Light sensitive Switch Circuit

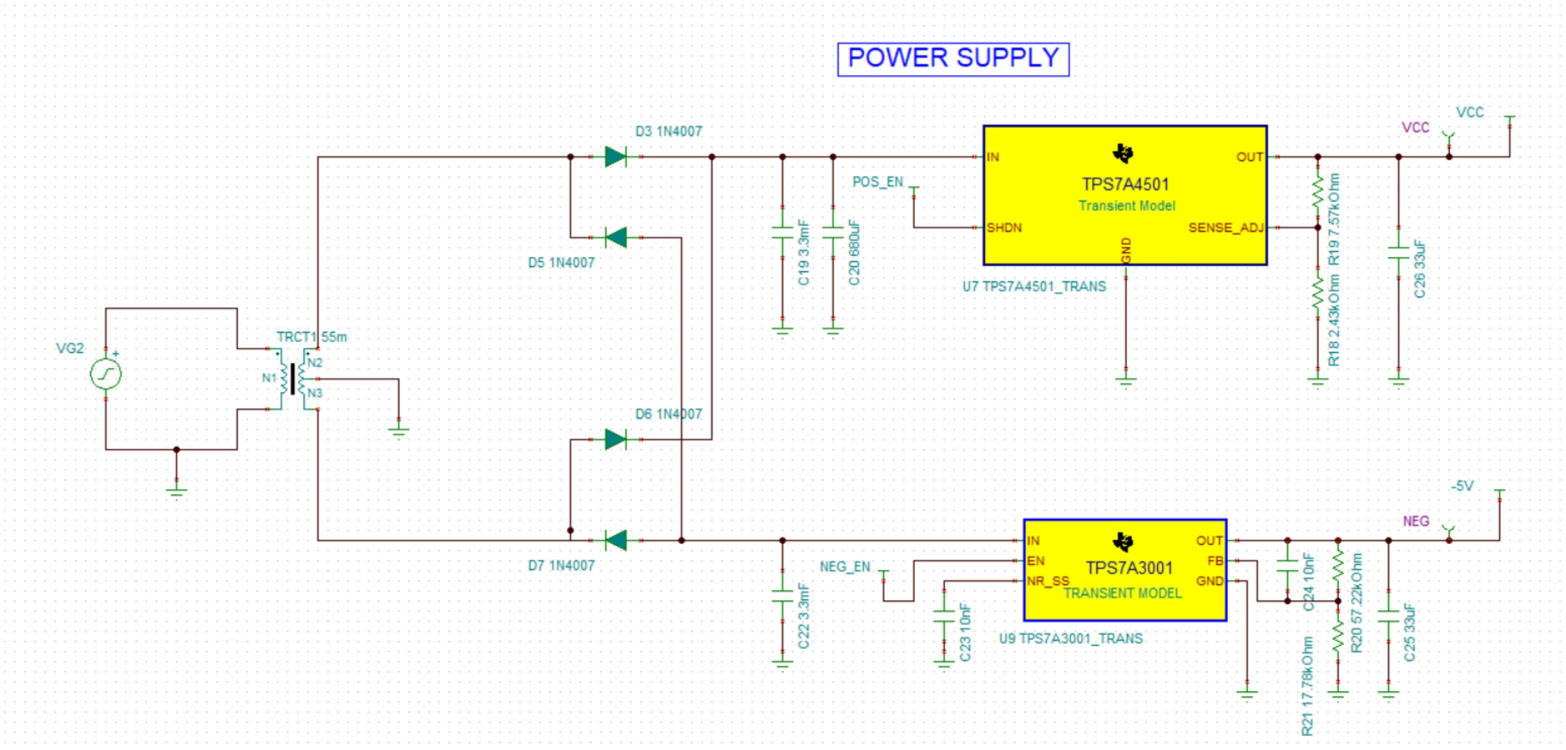


The Enable pins of the two voltage regulators used in the rest of the circuit are driven using this circuit.
The LDR is represented by the R3 variable resistor.
Two buffer amplifiers are used to keep the two enable inputs of the regulators decoupled.

Power Supply Unit

Power Supply Unit

- For our circuits, we need +5V and -5V.
- So, we use 12-0-12 Center tapped transformer.
- PIR sensor output voltage is in micro-volt range. Regulators that produce low noise as much as possible.



- Therefore, we use Low-Dropout Voltage Regulators other than the LM7805 or LM7905 regulators.
- After full wave rectifier, we use low value capacitors to minimize ripples.
- The TPS7A4501 regulator has an adjustable output voltage range of 1.21 to 20 V.
- The TPS7A3001 regulator has an output voltage range of –1.174 to –35V.

- Equations for calculating the R18 and R19 resistors of the Positive regulator (from the Datasheet) :

$$V_{OUT} = 1.21V\left(1 + \frac{R19}{R18}\right) + I_{ADJ} \times R19$$

and

$$R18 + R19 = 10\ kOhm$$

- We need +5V output. So, $V_{OUT} = 5V$
- For better work $I_{ADJ} = 0.5mA$

$$5V = 1.21V\left(1 + \frac{R19}{R18}\right) + 0.5 \times 10^{-3} \times R19$$

- After solving two equations :

$$R18 = 2.43\ kOhm$$
$$R19 = 7.57\ kOhm$$

- Equations for calculating the R20 and R21 resistors of the Negative regulator (from the Datasheet) :

$$R20 = R21\left(\frac{V_{Out}}{V_{REF}} - 1\right)$$

and

$$R20 + R21 = 75kOhm$$

- We need -5V output. So, $V_{OUT} = -5V$
- For better work $V_{REF} = -0.584V$ (from the Datasheet)

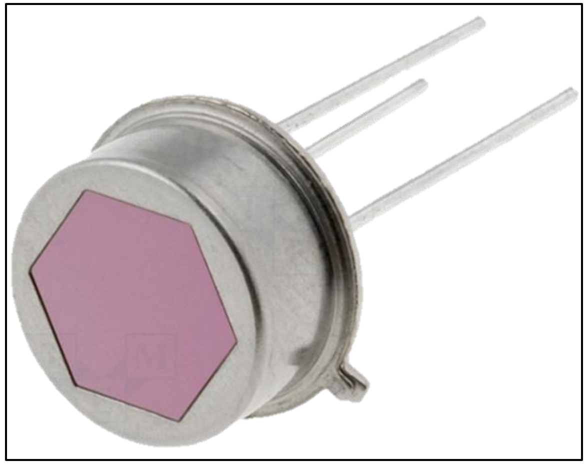
$$R20 = R21\left(\frac{-5V}{-1.184V} - 1\right)$$

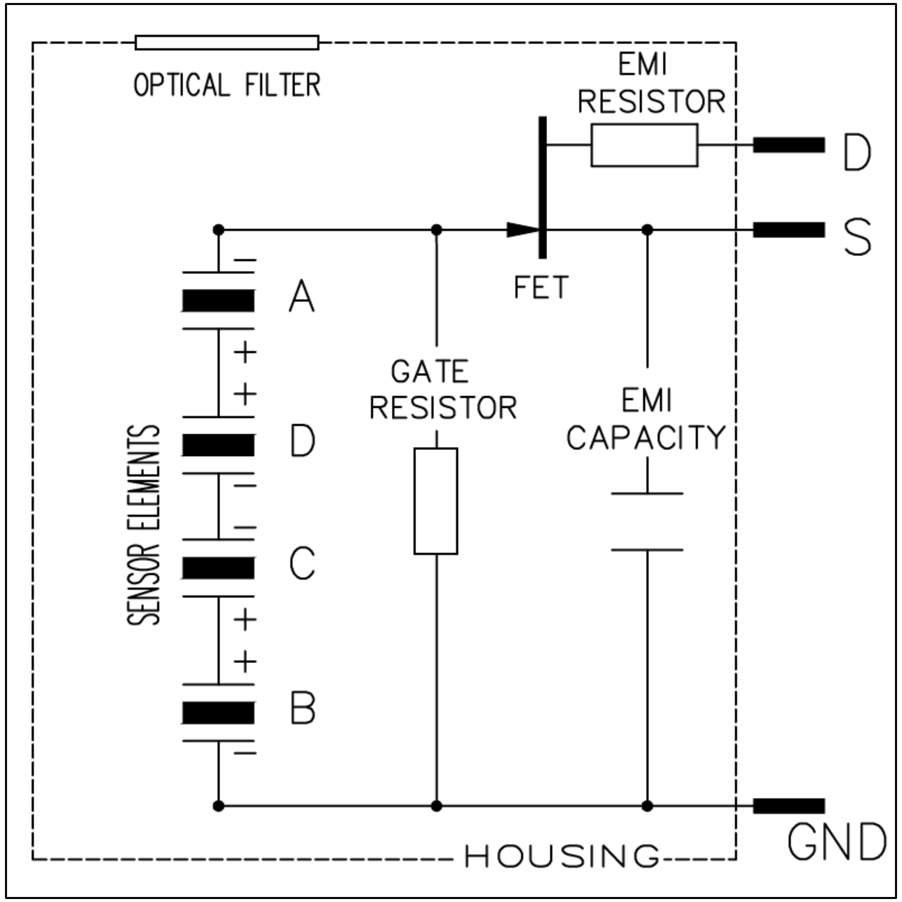
- After solving two equations :

$$R20 = 57.22\ kOhm$$
$$R21 = 7.57\ kOhm$$

LHi-1128 Pyroelectric Sensor

- 156 degrees of horizontal Field of View
- Generates an AC signal due to moving objects
- Symmetrically fabricated two pairs of pyroelectric elements with a single channel output-{eliminate false triggering}
- Built-in capacitor option to reduce Electromagnetic Interference(EMI)-{eliminate false triggering}
- Built-in FET to amplify the signal
- Amplified output signal is in the range of 100uV(p-p) to low mV(p-p)
- Optical filter which allows only Infrared Rays



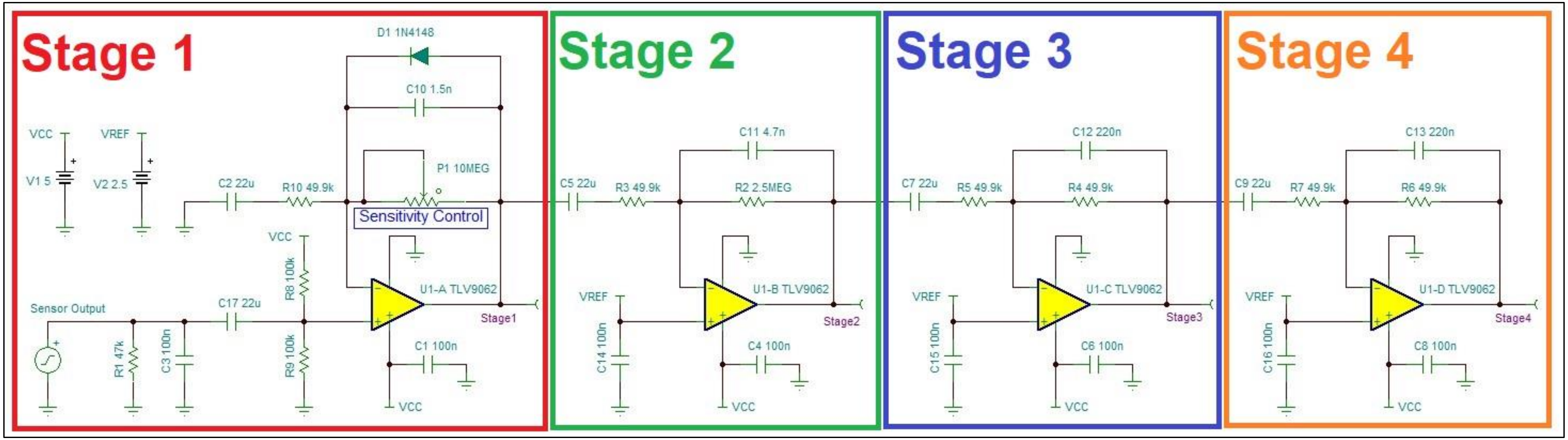


Target Frequency range of filter to eliminate false triggering

- Frequency range depends on the assumed maximum and minimum moving speed of an average human in the Field of View.
- Values were taken by a reference design provided by Texas Instruments

Speed of the Human	Approximated frequency of the generated signal by Pyroelectric sensor
1 m/s	0.3 Hz
10 m/s	6.5 Hz

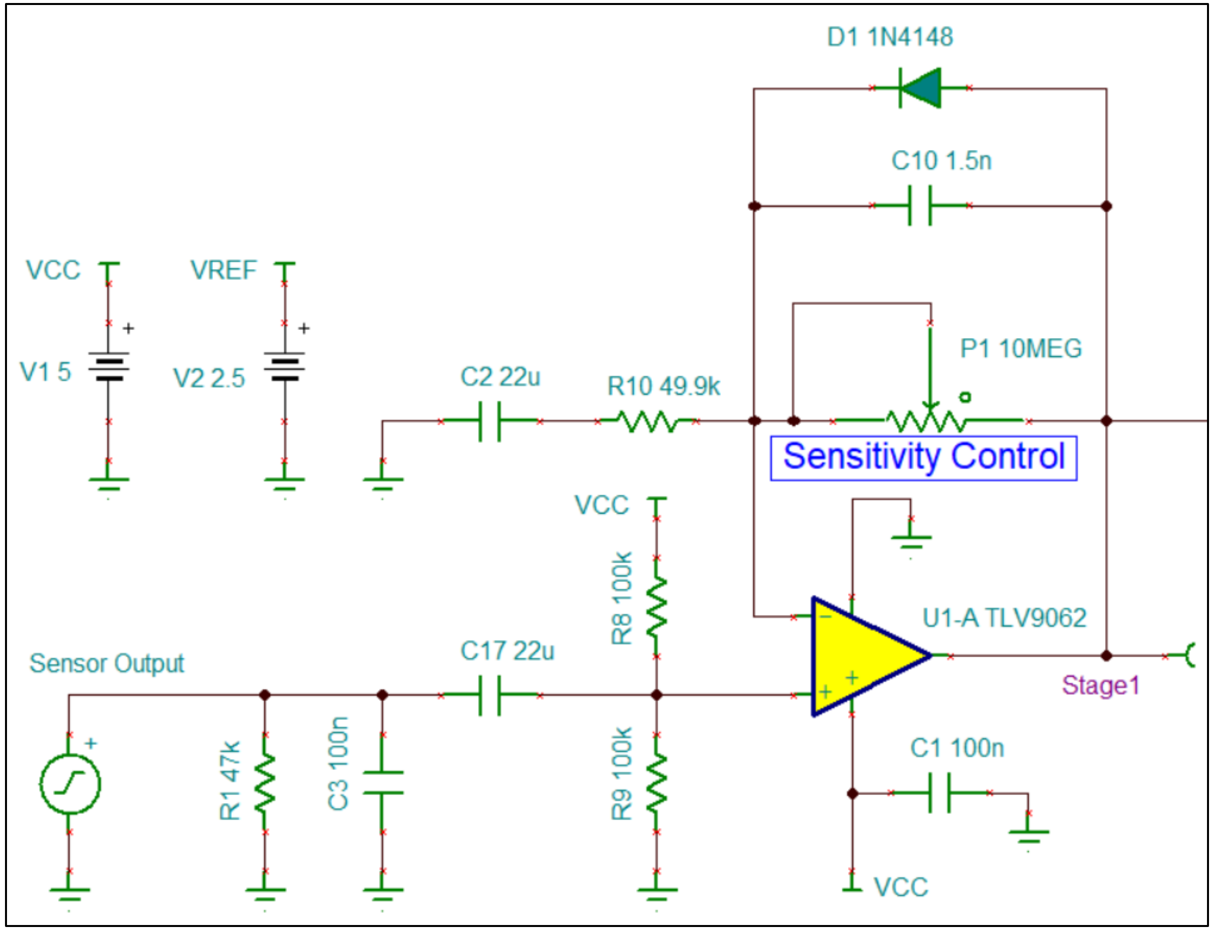
Four-Stage Signal Conditioning Circuitry



- All four stages together provide a band-pass filter with lower cutoff frequency – (0.072Hz - 0.145Hz) and upper cutoff frequency – (14.5Hz - 13.55Hz)
- First two stages amplifies the signal with a gain around 77.58 dB-{can be controlled using variable resistor}
- Latter two stages with unity gains filter unwanted frequency components furthermore sharply.

Stage 1

Calculations are done keeping the variable resistor P1 at 7.5 MΩ



- High Pass Filter cutoff frequency :

$$f_{C1} = \frac{1}{2\pi.C17.R9} = \frac{1}{2\pi.22\mu.100k}$$
$$= 0.072Hz$$

- Low Pass Filter cutoff frequency :

$$f_{C2} = \frac{1}{2\pi.P1.C10} = \frac{1}{2\pi * 7.5M\Omega * 1.5nF}$$
$$= 14.147Hz$$

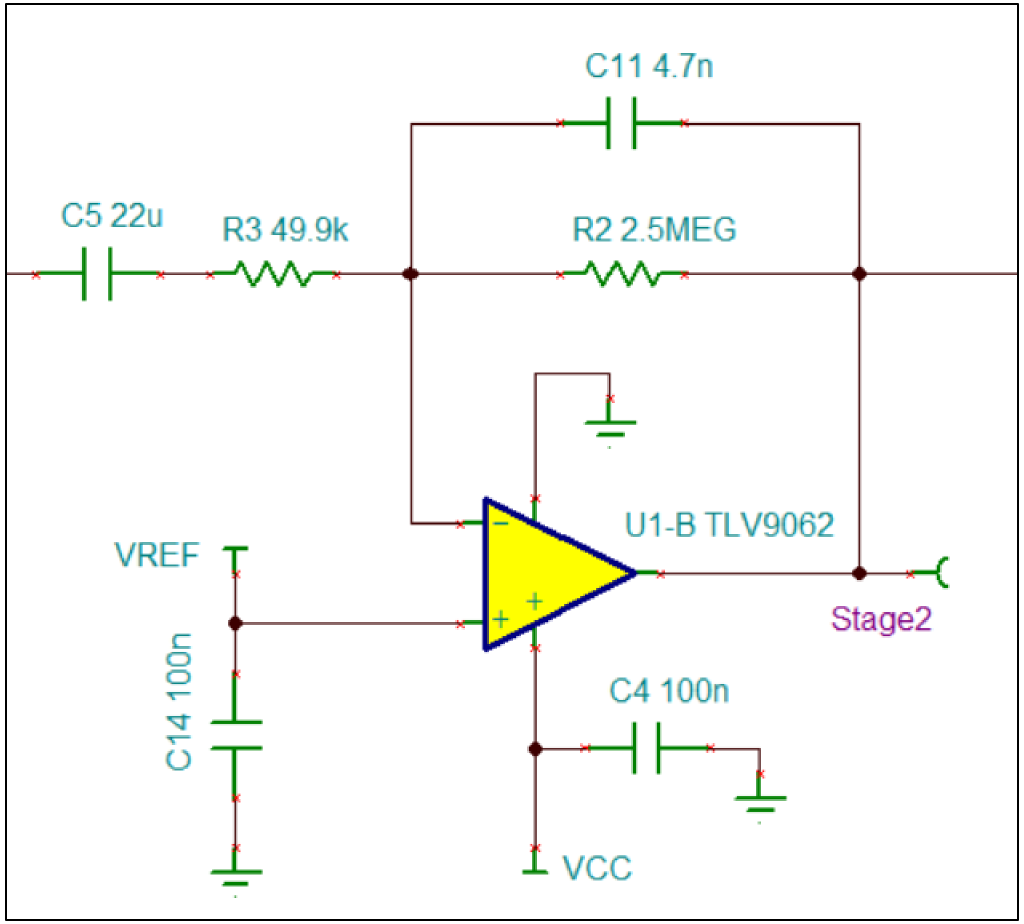
- Target frequency range :

0.072 Hz – 14.147Hz

- Effect of the capacitive reactance of *C10* to the gain can be negligible
- Non Inv. Amplifier Gain

$$A_V = 1 + \frac{P1(Var.\ Res.)}{R10}$$
$$A_V = 1 + 7.5M\Omega/49.9k = 151.3$$
$$A_V = 20.log_{10}(151.3) = 49.59\text{dB}$$

Stage 2



- High Pass Filter cutoff frequency :

$$f_{C1} = \frac{1}{2\pi . C5 . R3} = \frac{1}{2\pi * 22\mu * 49.9k}$$
$$= 0.145Hz$$

- Low Pass Filter cutoff frequency :

$$f_{C2} = \frac{1}{2\pi . R2 . C11} = \frac{1}{2\pi * (2.5M\Omega) * 4.7nF}$$
$$= 13.55Hz$$

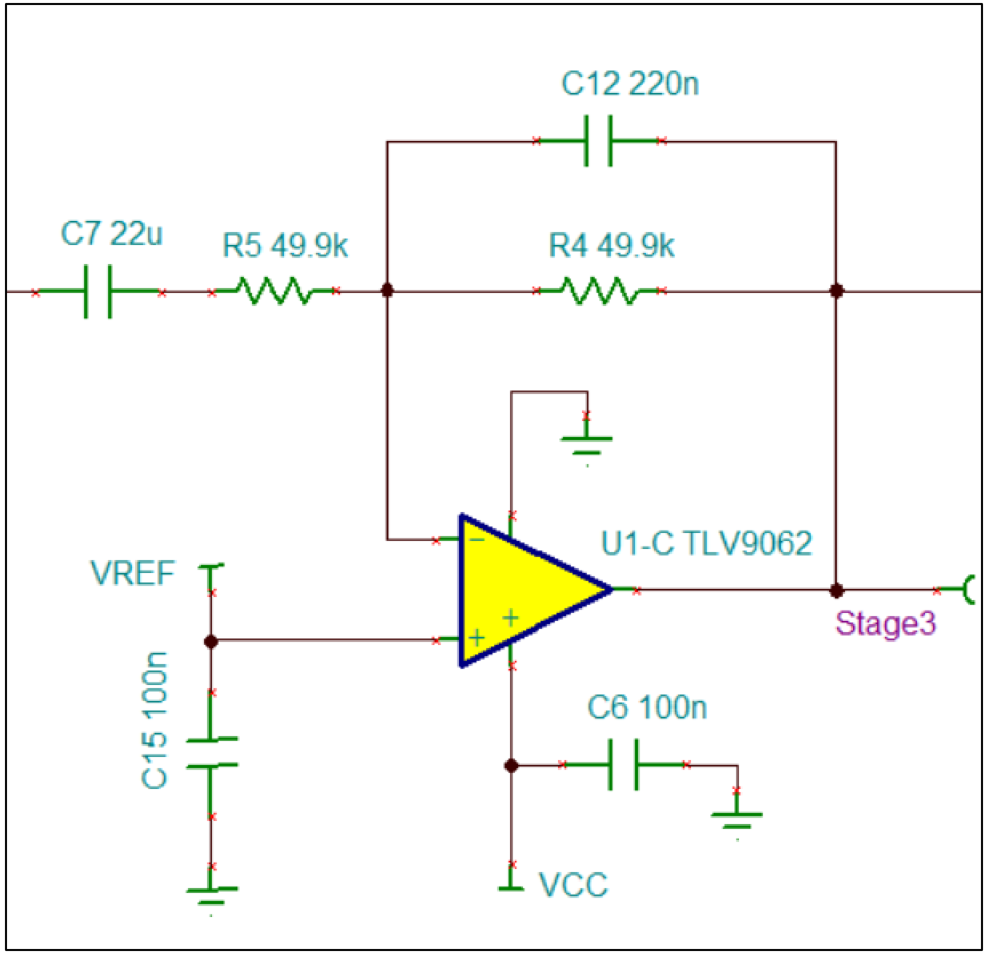
- Target frequency range :

0.145 Hz – 13.55Hz

- Inv. Amplifier Gain

$$A_V = -(R2/R3)$$
$$A_V = -2.5M\Omega/49.9k = -50.1$$
$$A_V = 20.\, log_{10}(|\text{-}50.1|) = 33.99\text{dB}$$

Stages 3 & 4



- High Pass Filter cutoff frequency :

$$f_{C1} = \frac{1}{2\pi.C7.R5} = \frac{1}{2\pi * 22\mu * 49.9k}$$
$$= 0.145Hz$$

- Low Pass Filter cutoff frequency :

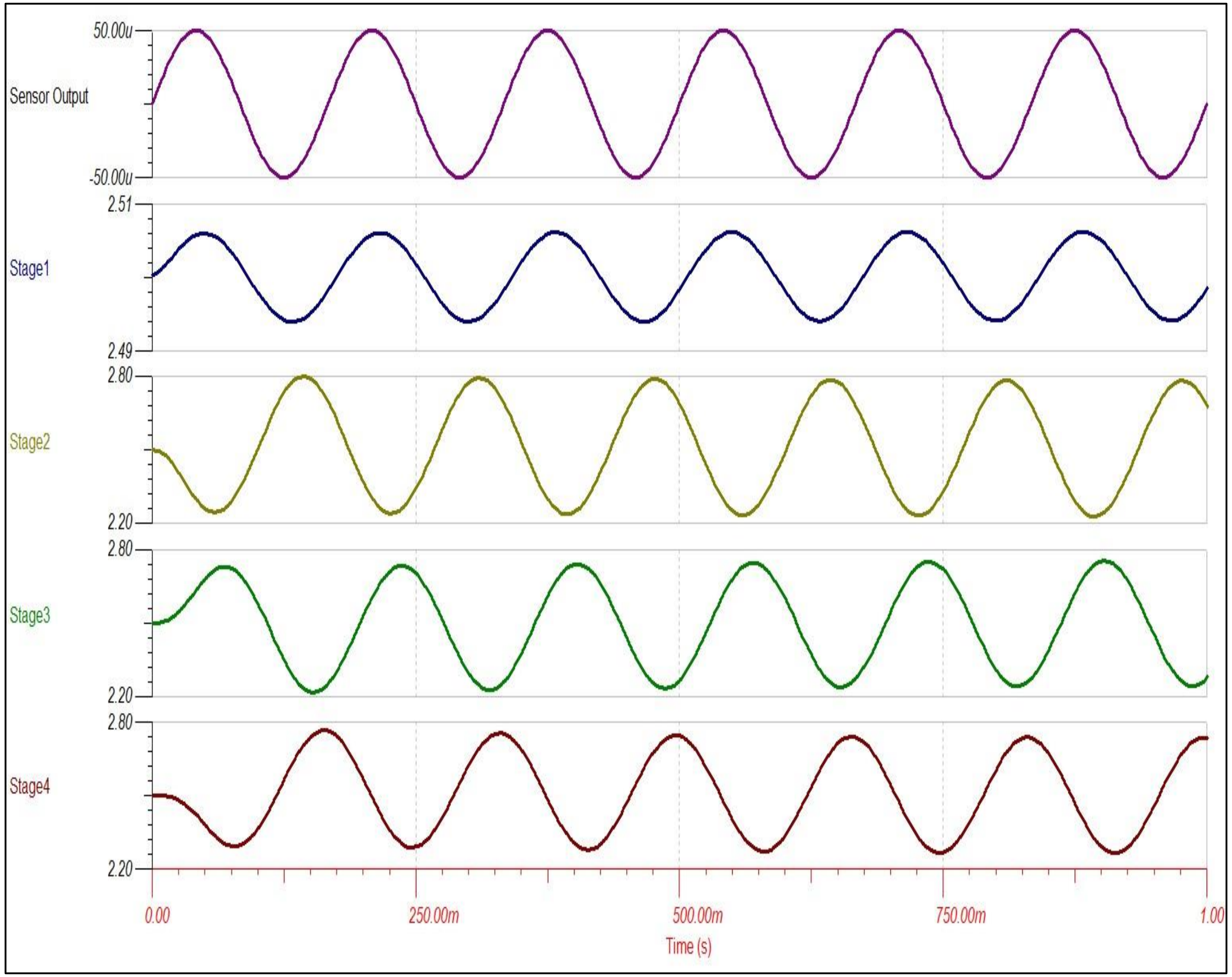
$$f_{C2} = \frac{1}{2\pi.R4.C12} = \frac{1}{2\pi * (49.9k) * 220nF}$$
$$= 14.5Hz$$

- Target frequency range :

  0.145 Hz – 14.5Hz

- Inv. Amplifiers have unity Gains
- Purpose is to filter unwanted frequency components further more steeply

Simulation Results : var. res. at 7.5MΩ and Signal of 5Hz to imitate Pyroelectric Sensor output



Expected AC signal from the pyroelectric Sensor In the range 100µV p-p.

49.59dB gain is provided by the stage 1

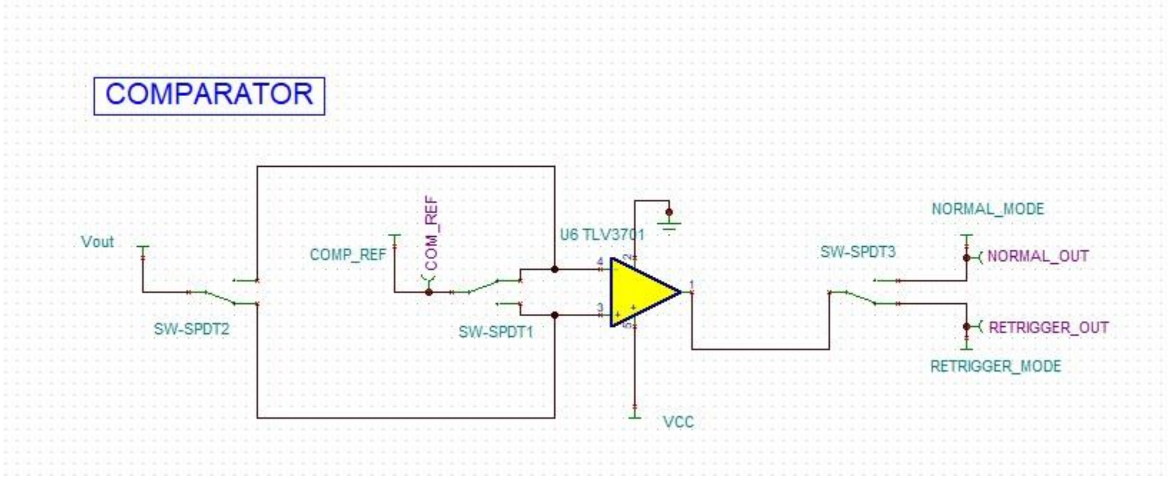
33.99dB gain is provided by the stage 2

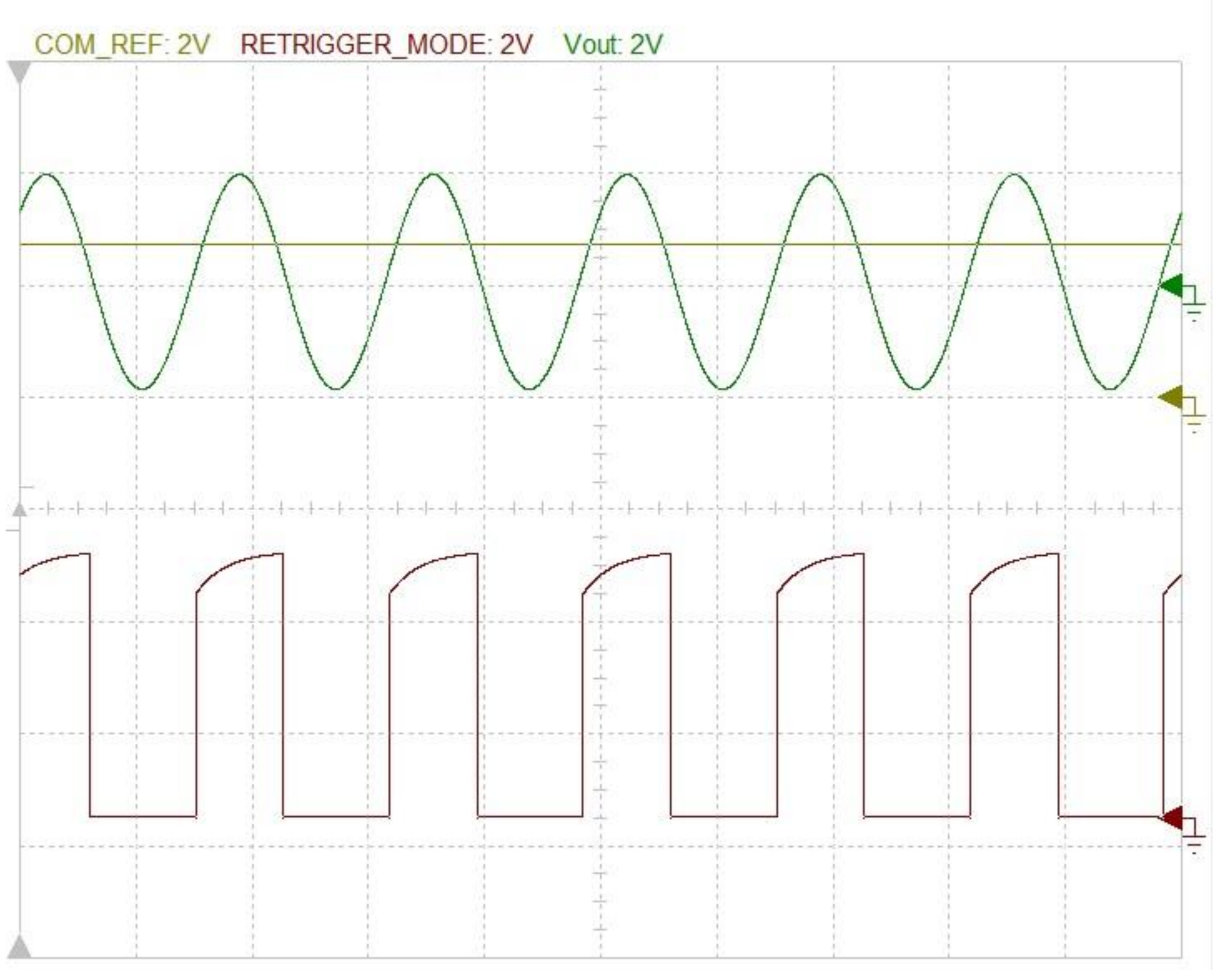
Unity gain at stage 3 : filter unwanted noise further

Unity gain at stage 4 : filter unwanted noise further

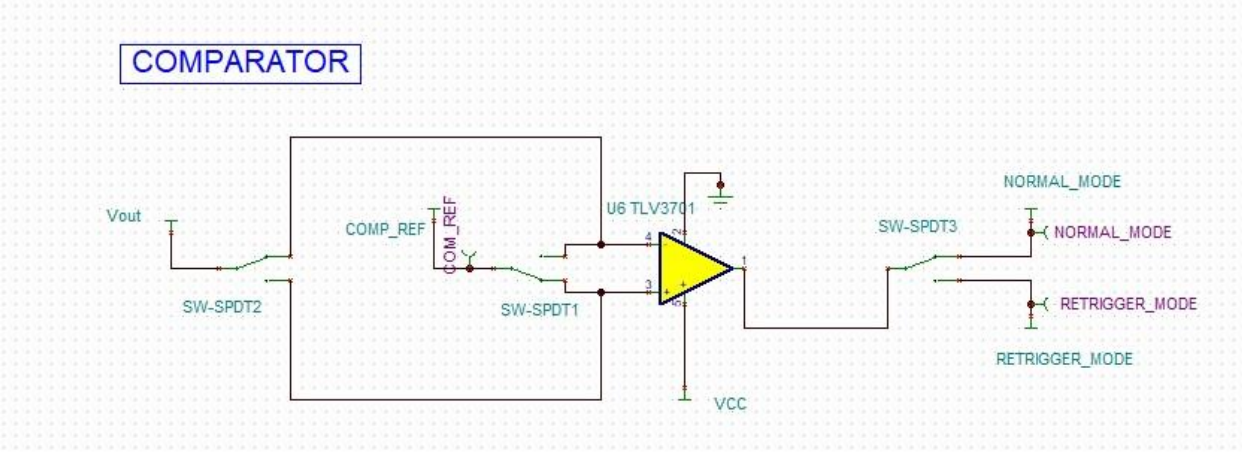
Comparator circuit

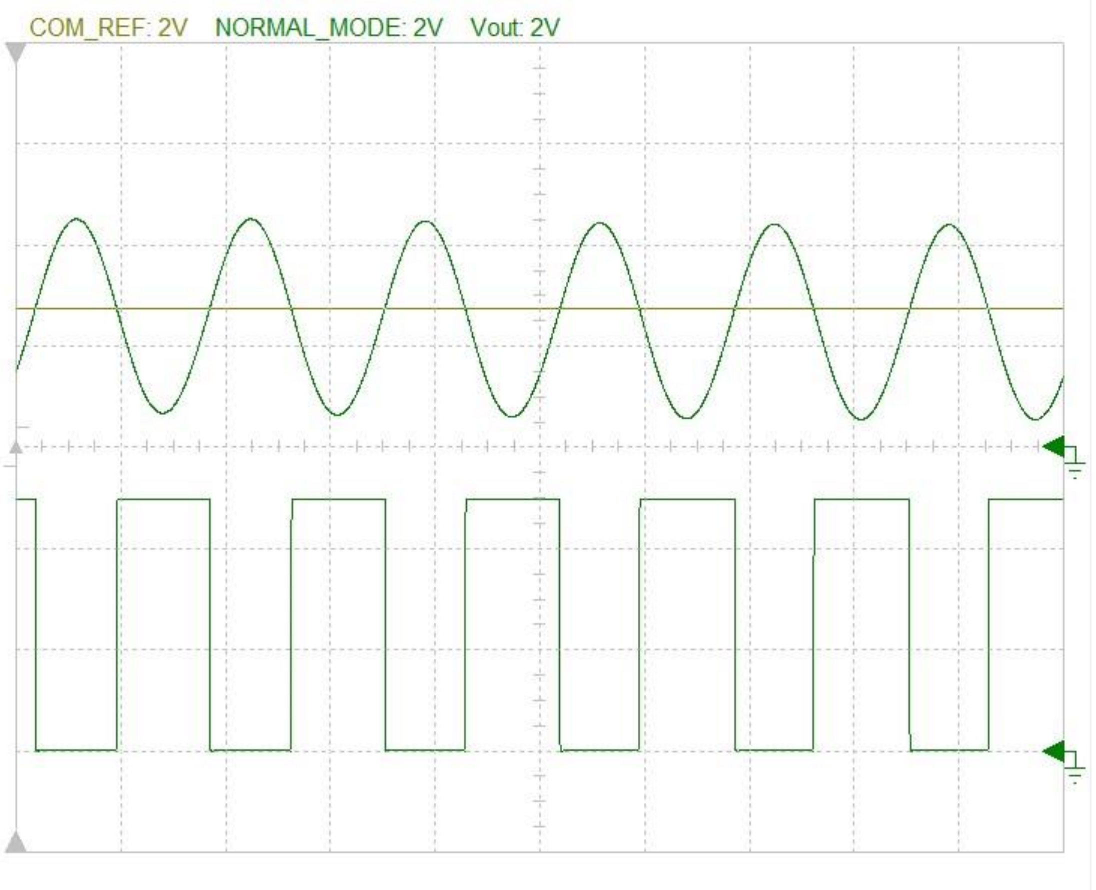
- The main purpose of the comparator circuit is to make negative and positive pulses that are used in normal mode and retrigger mode.
- In the retriggering mode we use positive pulses. So, we use non-inverting comparator.





- In normal mode negative pulses are used. So we use inverting comparator to make the pulse.

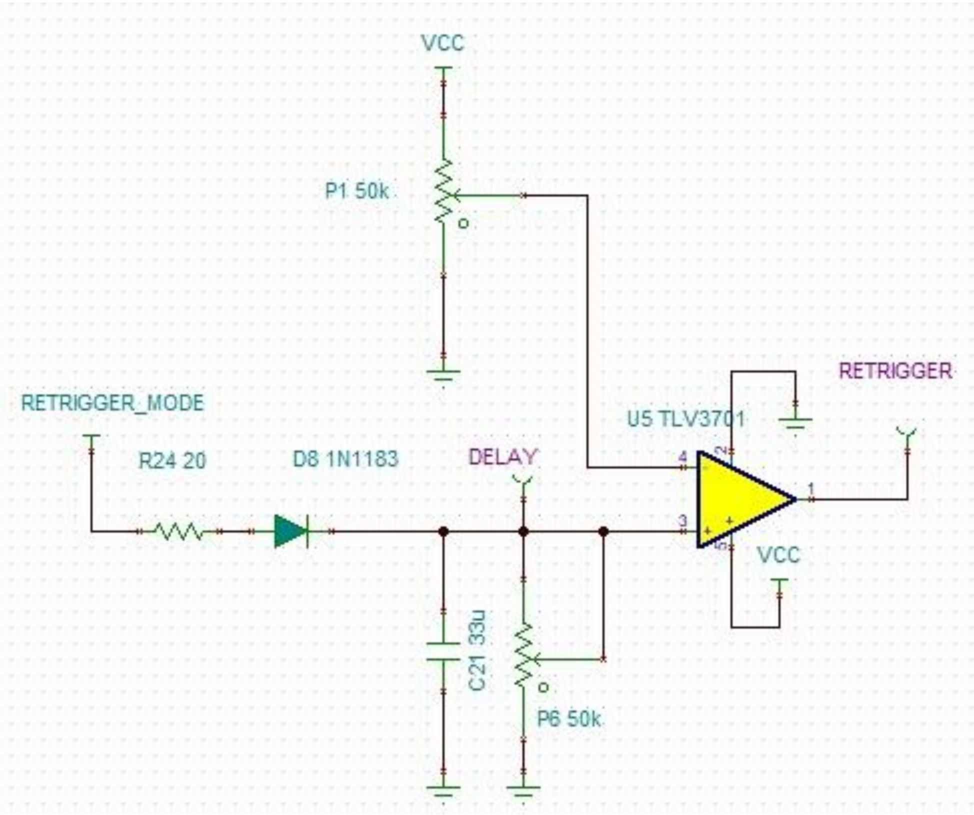




- Switching between Normal mode and Retrigger mode is done by using a triple pole-double throw(3PDT) switch. It will change the state of all the switches simultaneously.

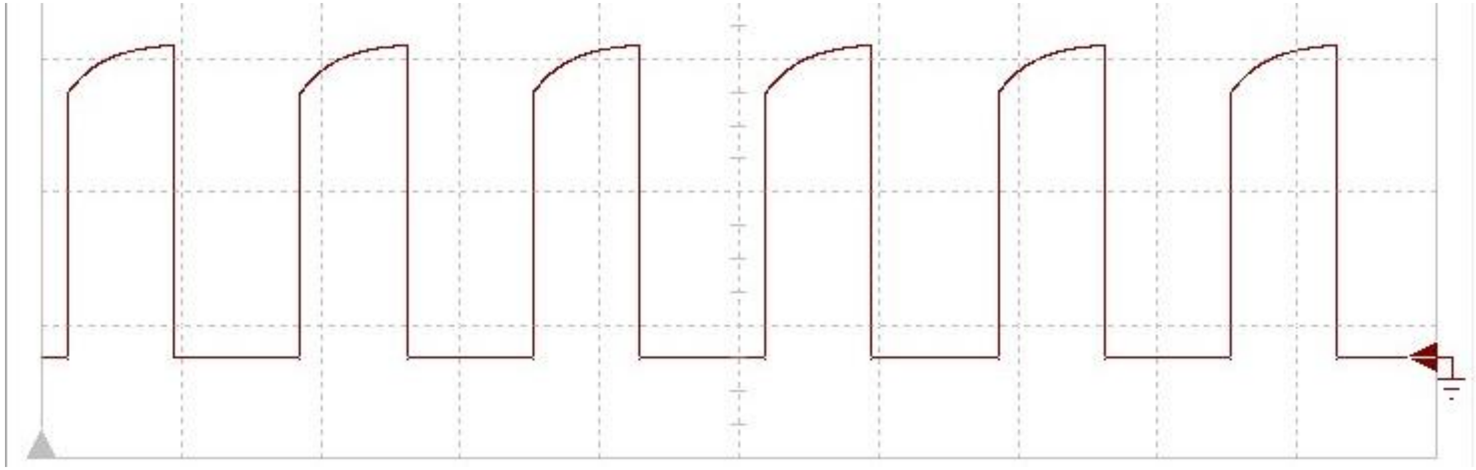
- The comparator IC is used in here is TLV3701 by Texas instruments.

Retrigger mode circuit



- When the comparator output become high, capacitor starts charging. It's charging take small time because RC time constant of the resistor and the capacitor is very low. $(R*C = 20*33*10^{-6} = 0.66ms)$

- When the comparator output become low, capacitor starts discharging. Discharging through R24 resistor is avoided by using diode. We use a potentiometer to control the capacitor discharging time. Then the voltage at the delay probe will compared with (-) input of the comparator IC. If it is greater than that voltage, then output will be the positive saturation voltage of the comparator. Otherwise it will become zero.



- Another way that we can do that is replace P6 by a large resistor and changing the negative input voltage by a variable resistor.

CALCULATIONS

Assume comparator voltage = P = $5 \times \frac{5}{100}$ = 0.25v

Peak voltage of the comparator output = 5v

So,

$0.25 = 5 \times e^{-\frac{t}{RC}}$

$0.05 = e^{-\frac{t}{RC}}$

$\ln 0.05 = \ln e^{-\frac{t}{RC}}$

$-\frac{t}{RC}$ = -2.995732

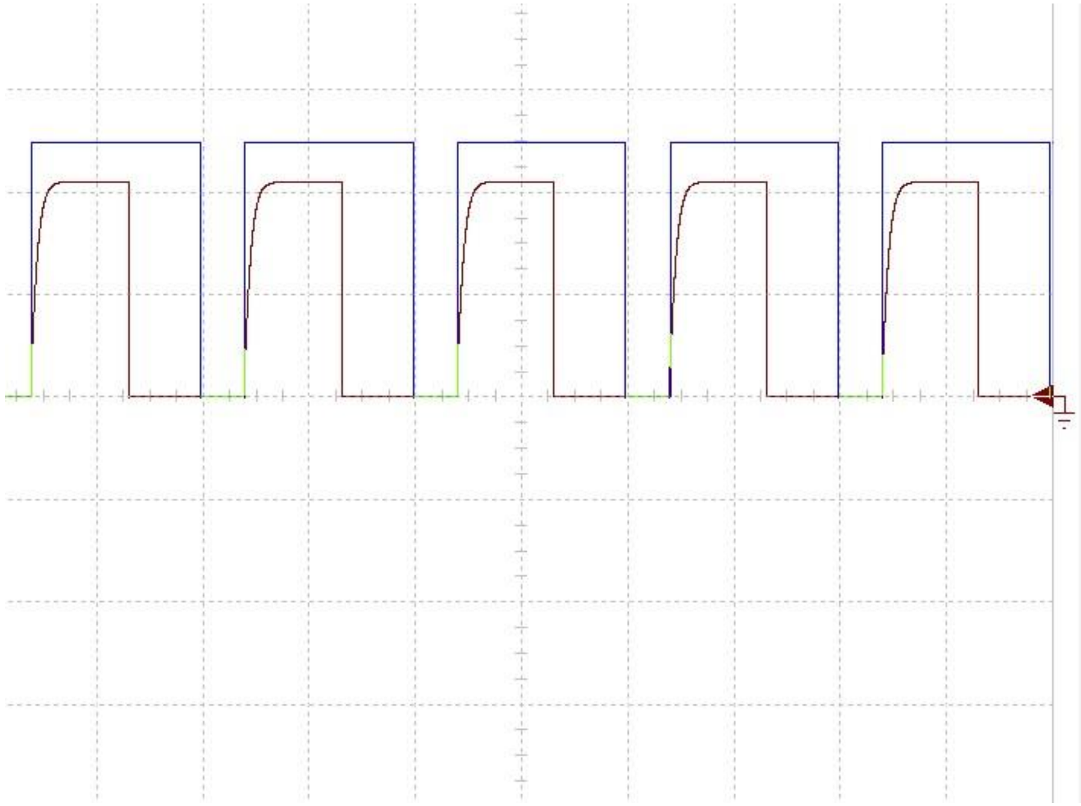
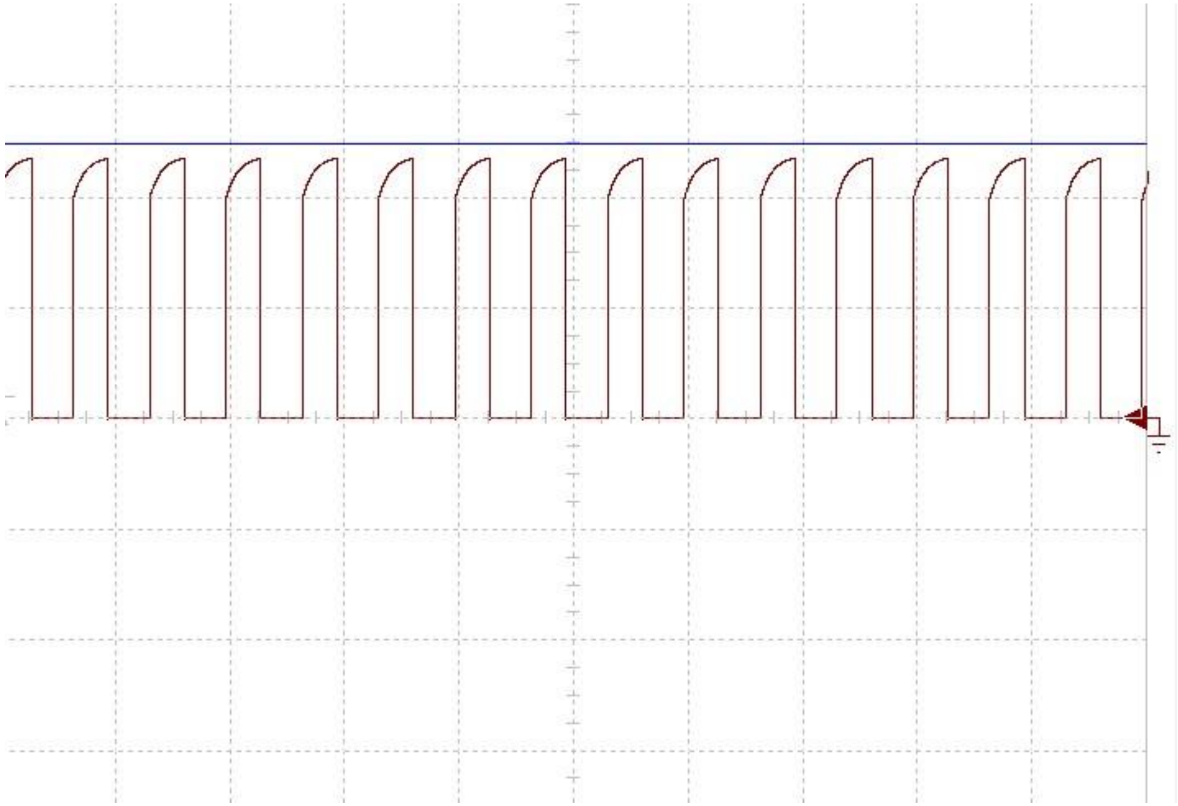
$\frac{t}{R \times 33 \times 10^{-6}} = 2.995732$

$t = 98.859154 \times 10^{-6} \times R$

EX: Assume R =25k ohms

$t = 98.859154 \times 10^{-6} \times 25 \times 10^{3}$

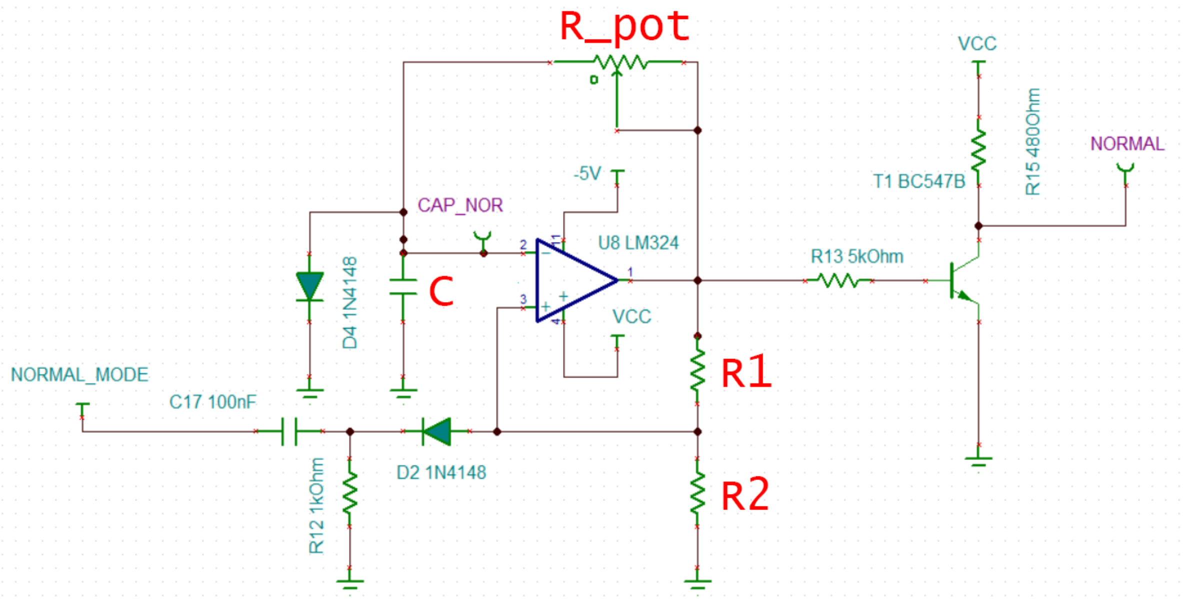
$t = 2.47147885\ s$

- When load is at about 50%, then the delay time created will be large enough to fill the gap between comparator output. So the output voltage will remain at 5v. It is shown in figure in right hand side.

Normal Mode

Normal Mode Trigger circuit



Monostable multi-vibrator using Operational Amplifier

OPAMP is configured as a schimitt trigger using positive feedback.

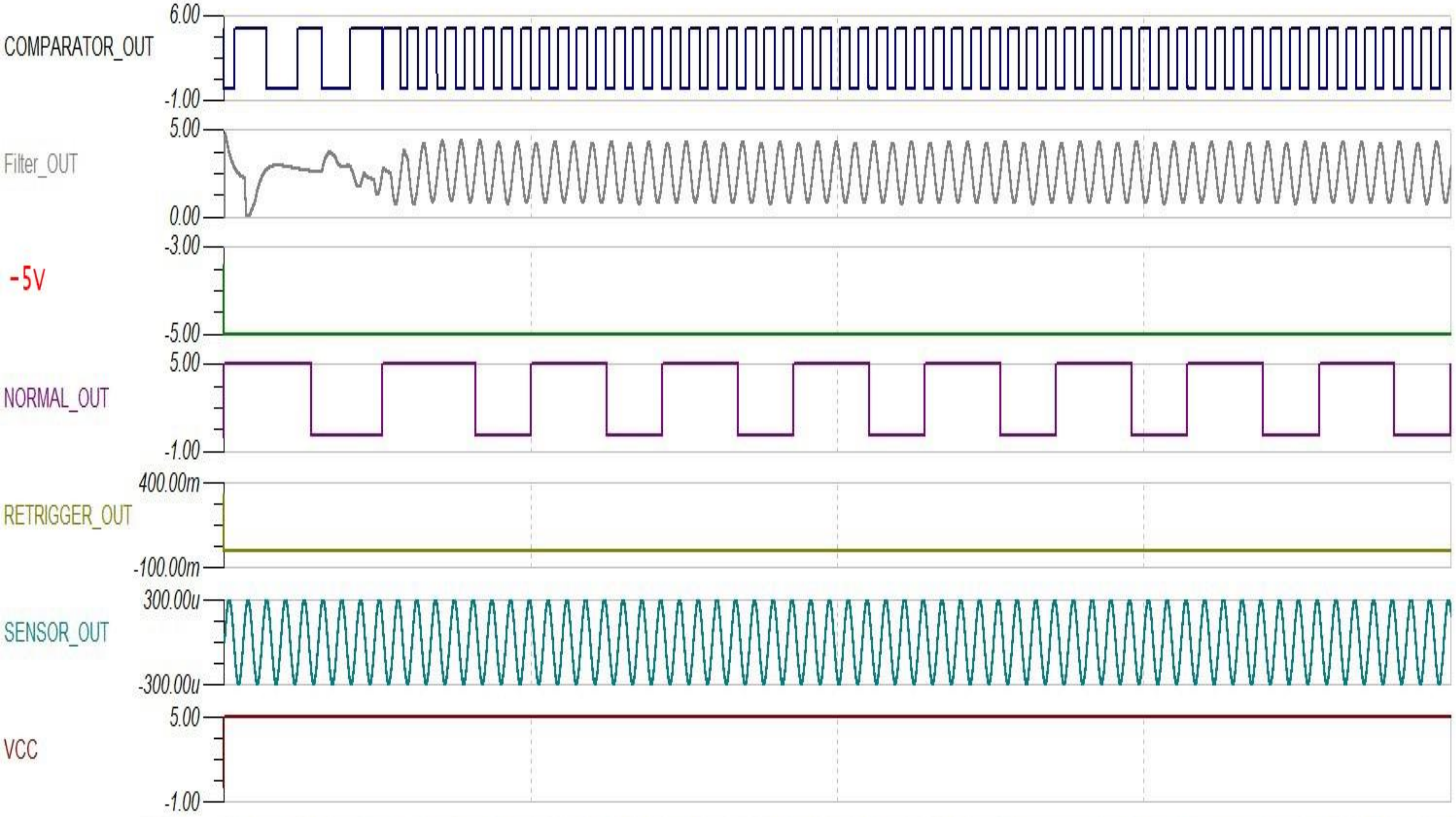
The delay time for triggering is given by the equation

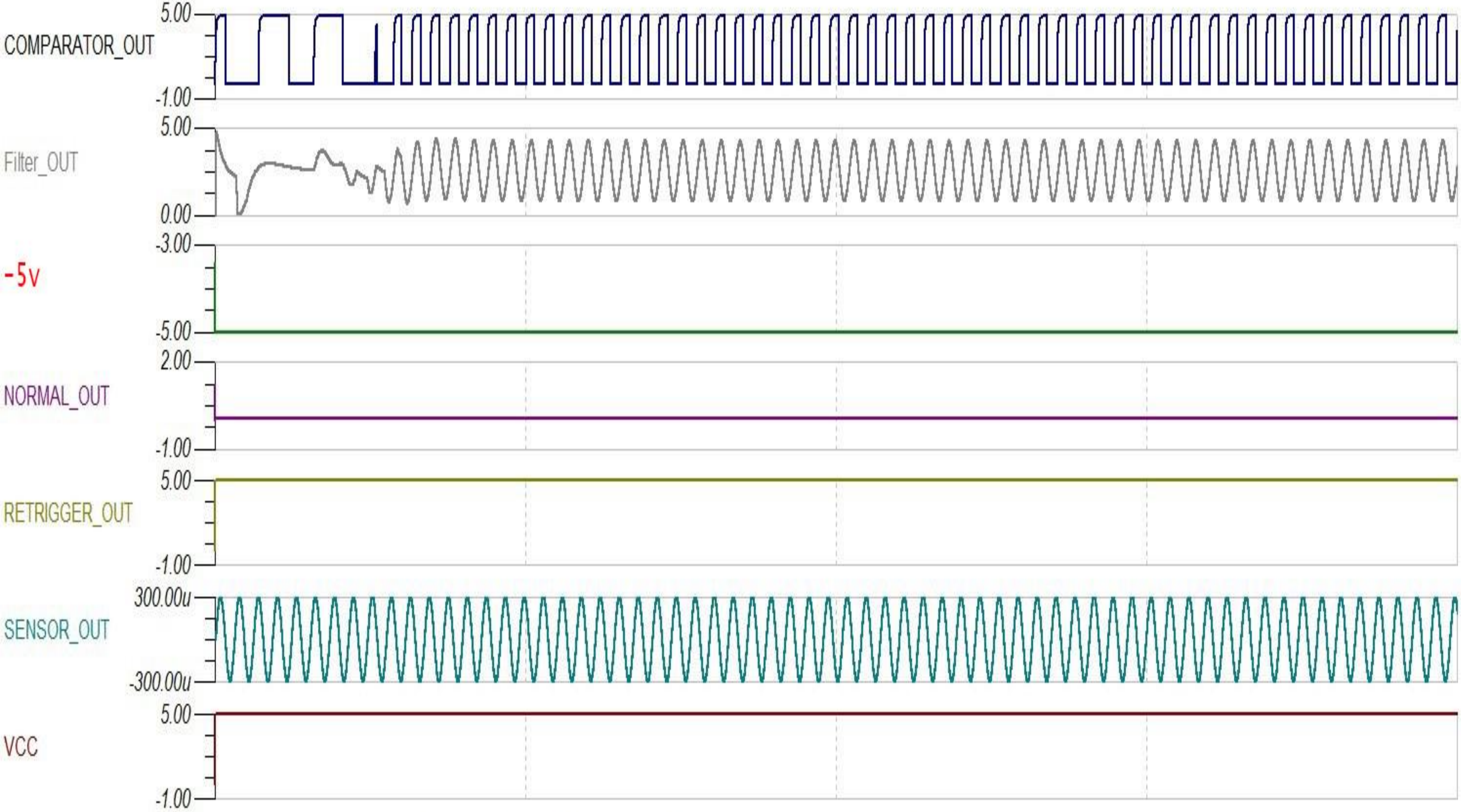
$$T = R\_pot \times C \ \ln \frac{R1 + R2}{R1}$$

NOT gate at the output to invert the negative output pulses.

$$T = 300 \times 10^3 \times 220 \times 10^{-6} \times \ln \frac{30k + 10k}{30k} = \mathbf{18.98}\ seconds$$

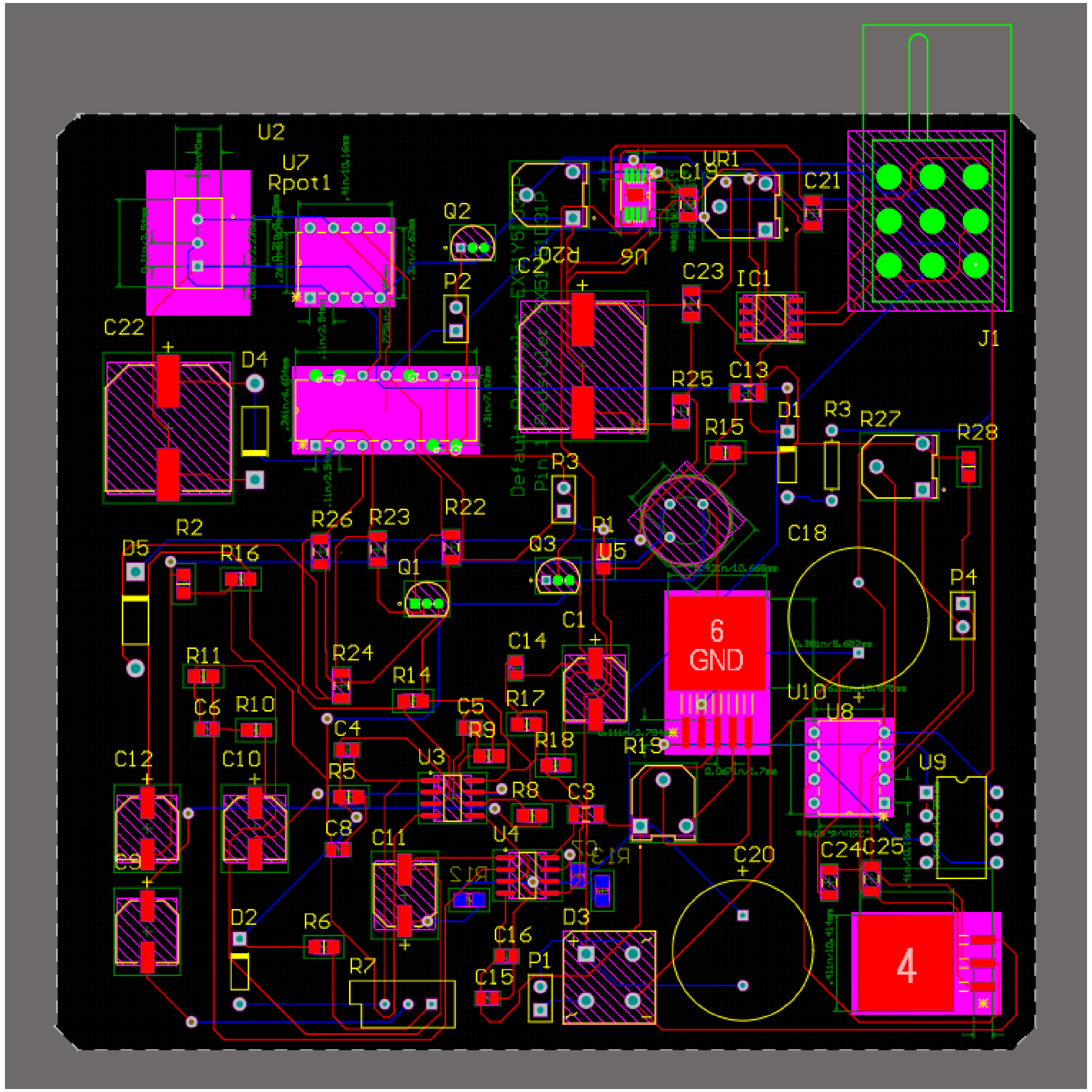
Simulation Results

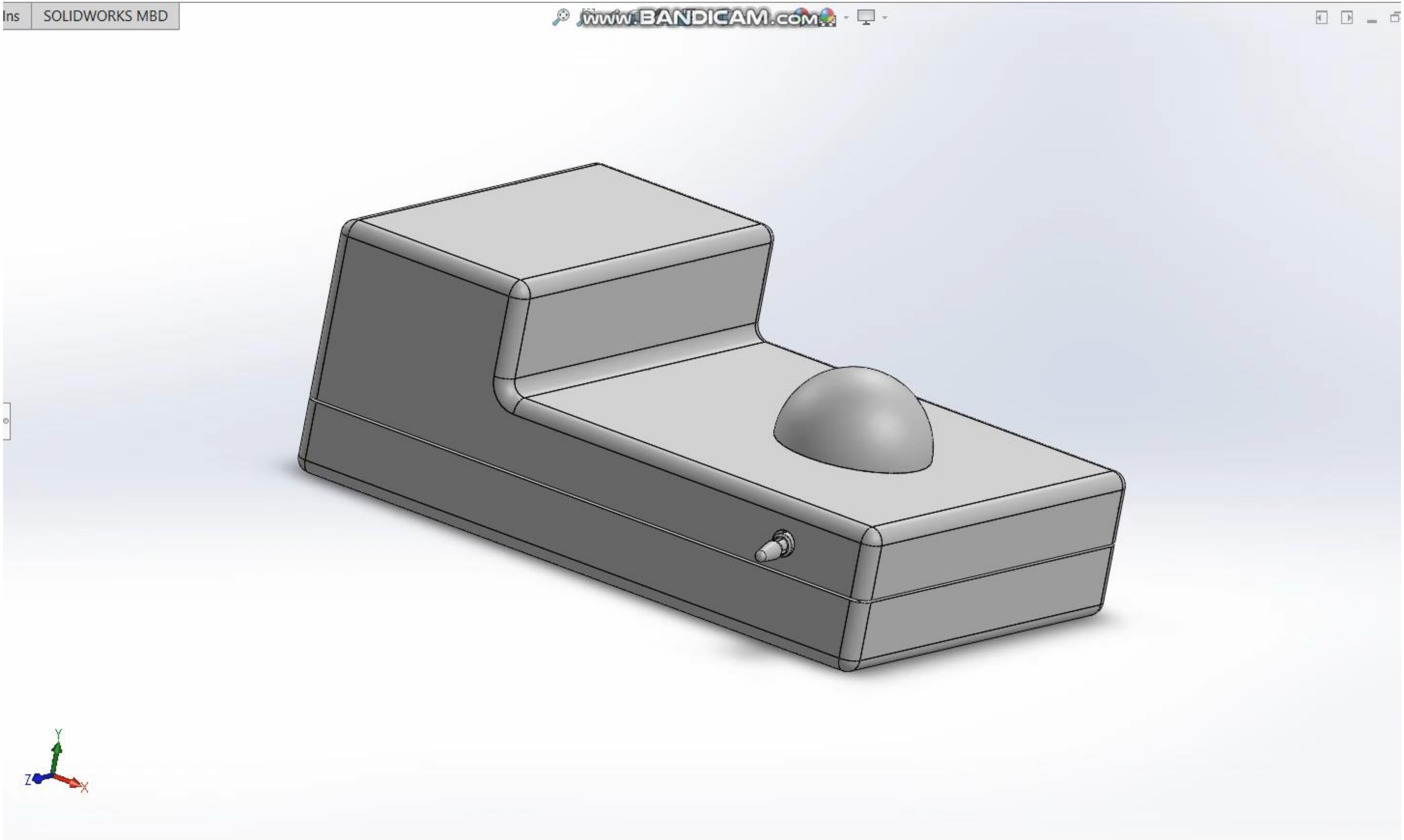

COMPARATOR_OUT
6.00
-1.00
Filter_OUT
5.00
0.00
-5V
-3.00
-5.00
NORMAL_OUT
5.00
-1.00
RETRIGGER_OUT
400.00m
-100.00m
SENSOR_OUT
300.00u
-300.00u
VCC
5.00
-1.00


COMPARATOR_OUT
5.00
-1.00
Filter_OUT
5.00
0.00
-5v
-3.00
-5.00
NORMAL_OUT
2.00
-1.00
RETRIGGER_OUT
5.00
-1.00
SENSOR_OUT
300.00u
-300.00u
VCC
5.00
-1.00

CAD Designs

PCB Layout


U2
U7
Rpot1
Q2
P2
C22
D4
UR1
C19
C21
C2
R20
U6
C23
IC1
J1
R25
C13
D1
R3
R27
R28
R15
P3
R26
R23
R22
R2
D5
R16
Q1
Q3
R1
U5
C18
P4
R11
R24
R14
C14
C1
6
GND
U10
U8
C6
R10
C5
R9
R17
R18
R19
C4
C12
C10
R5
U3
R8
C3
U9
C8
C11
U4
R13
C24
C25
C20
C9
R12
D2
R6
C16
D3
R7
P1
C15
4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Thank you