EE230: Lab 4.
Opamp Circuits

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1 Overview of the experiment

1.1 Aim of the experiment

To simulate Schmidt Trigger, Monostable and Astable Multivibrator circuits using Operational Amplifiers on NGSPICE.

1.2 Methods

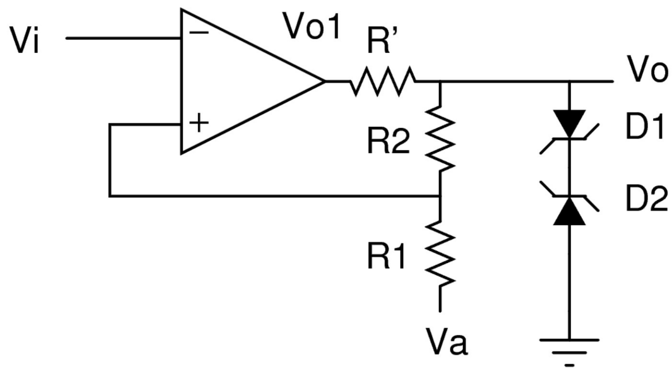
The netlists for Schmidt Trigger, Monostable and Astable Multivibrator were made in NGSPICE.

Subcircuits for Zener Diode and UA741 operational amplifier were directly used in the netlists.

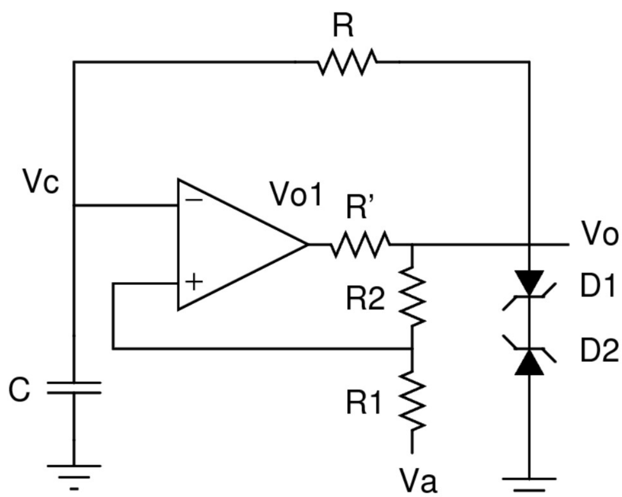
Plots for various waveforms were made as per the handout. The parameters that were supposed to be found as per the handout, were graphically evaluated.

2 Design

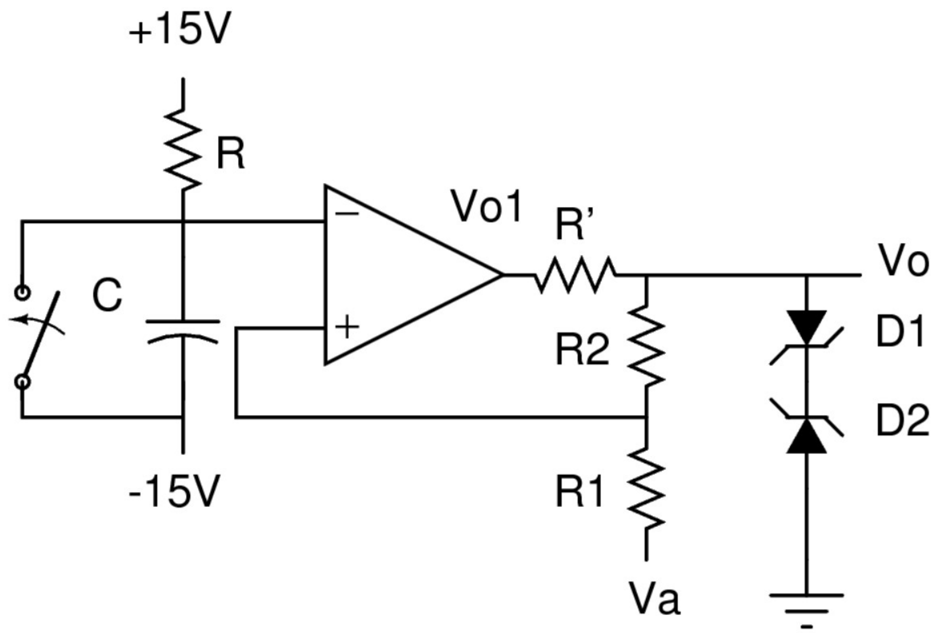
2.1 Circuit Diagrams



Schmidt Trigger



Astable Multivibrator



Monostable Multivibrator

3 Simulation results

3.1 Code snippets

3.1.1 Schmidt Trigger - ($V_a = 0V$)

```
Schmidt Trigger
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
vi 2 0 sin(0 6 1k 0 0)
r3 5 6 1k
r2 6 1 10k
r1 1 7 10k
x2 6 8 ZENER
x3 0 8 ZENER
va 7 0 0

.tran 0.01ms 10ms
.control
run
plot v(6) v(2)
plot v(6) vs v(2)

.endc
.end
```

3.1.2 Schmidt Trigger - ($V_a = 3V$)

```
Schmidt Trigger
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
vi 2 0 sin(0 6 1k 0 0)
r3 5 6 1k
r2 6 1 10k
r1 1 7 10k
x2 6 8 ZENER
x3 0 8 ZENER
va 7 0 3 dc

.tran 0.01ms 10ms
.control
run
plot v(6) v(2)
plot v(6) vs v(2)

.endc
.end
```

3.1.3 Schmidt Trigger - ($V_a = -3V$)

```
Schmidt Trigger
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
vi 2 0 sin(0 6 1k 0 0)
r3 5 6 1k
r2 6 1 10k
r1 1 7 10k
x2 6 8 ZENER
x3 0 8 ZENER
va 7 0 -3 dc

.tran 0.01ms 10ms
.control
run
plot v(6) v(2)
plot v(6) vs v(2)

.endc
.end
```

3.1.4 Astable Multivibrator - Without Zener Diode

```
Astable Multivibrator
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
*vi 2 0 sin(0 6 1k 0 0)
c1 2 0 0.01u
r4 2 6 50k
r3 5 6 0
r2 6 1 35k
r1 1 0 30k
*x2 6 8 ZENER
*x3 0 8 ZENER
*va 7 0 0 dc

.tran 0.01ms 10ms
.control
run
plot v(2) v(6)
.endc
.end
```

3.1.5 Astable Multivibrator - With Zener Diode

```
Astable Multivibrator
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
c1 2 0 0.01u
r4 2 6 50k
r3 5 6 1k
r2 6 1 30k
r1 1 7 35k
x2 6 8 ZENER
x3 0 8 ZENER
va 7 0 -3 dc

.tran 0.01ms 10ms
.control
run
plot v(2) v(6) v(5)
.endc
.end
```

3.1.6 Monostable Multivibrator - Push Button Closed and Released

```
Monostable Multivibrator
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00
M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

.SUBCKT pushbutton 1 2
S1 1 2 c 0 switch1
V1 c 0 pulse(0 10 0.10 0.02 0.02 1000 1000)
.model switch1 sw vt=1 vh=0.2 ron=1 roff=1000MEG
.ENDS pushbutton

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
r4 3 2 10k
c1 2 4 10u
x4 2 4 pushbutton
r3 5 6 1k
r2 6 1 10k
r1 1 0 10k
x2 6 8 ZENER
x3 0 8 ZENER

.tran 1ms 2s
.control
run
plot v(6)
.endc
.end
```

3.1.7 Monostable Multivibrator - Push Button pressed for Short Duration

```
Monostable Multivibrator
*Rohan Rajesh Kalbag - 20D170033

.include ua741.txt

.SUBCKT ZENER 1 2
D1 1 2 DF
DZ 3 1 DR
VZ 2 3 3.5
.MODEL DF D(IS =27.5p RS=0.620 N=1.10 CJO =78.3p VJ=1.00 M =0.330 TT =50.1n)
.MODEL DR D(IS =5.49f RS=50 N=1.77 )
.ENDS

.SUBCKT pushbutton 1 2
S1 1 2 c 0 switch1
V1 c 0 pulse(0 10 0.10 0.02 0.02 0.05 1000)
.model switch1 sw vt=1 vh=0.2 ron=1 roff=1000MEG
.ENDS pushbutton

v1 3 0 15 dc
v2 4 0 -15 dc
x1 1 2 3 4 5 ua741
r4 3 2 10k
c1 2 4 10u
x4 2 4 pushbutton
r3 5 6 1k
r2 6 1 10k
r1 1 0 10k
x2 6 8 ZENER
x3 0 8 ZENER

.tran 1ms 2s
.control
run
plot v(6) v(2)
.endc
.end
```

3.2 Simulation Results

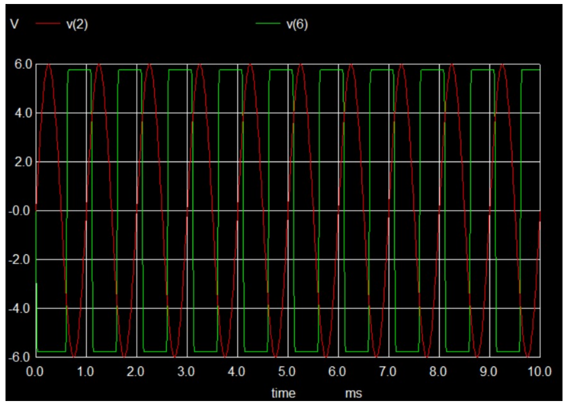


Fig 1.1
Output waveform for Schmidt Trigger - $V_a = 0V$
v(6): Output Voltage V_o, v(2): Input Voltage V_i

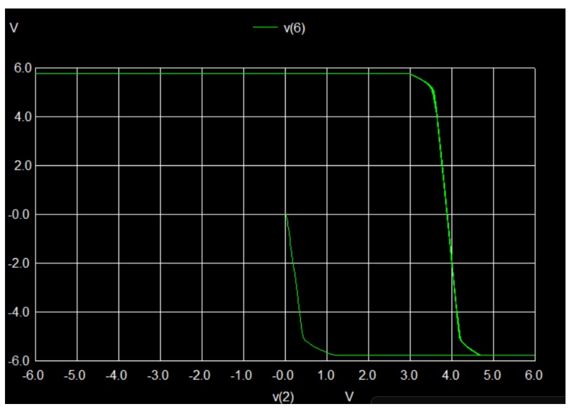


Fig 1.2
V_{out} vs V_{in} for sinusoidal input in Schmidt Trigger - $V_a = 0V$
v(6): Output Voltage V_o, v(2): Input Voltage V_i

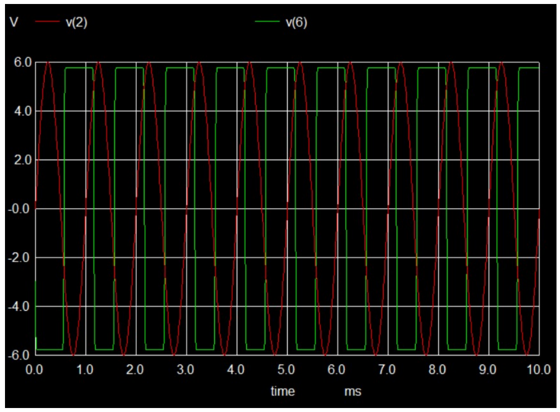


Fig 1.3

Output waveform for Schmidt Trigger - $V_a = 3V$

v(6): Output Voltage V_o, v(2): Input Voltage V_i

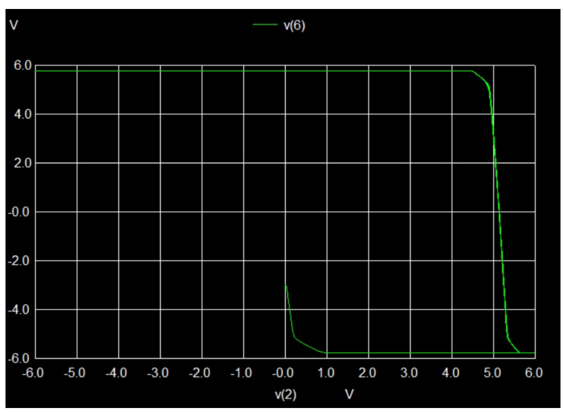


Fig 1.4

V_{out} vs V_{in} for sinusoidal input in Schmidt Trigger - $V_a = 3V$

v(6): Output Voltage V_o, v(2): Input Voltage V_i

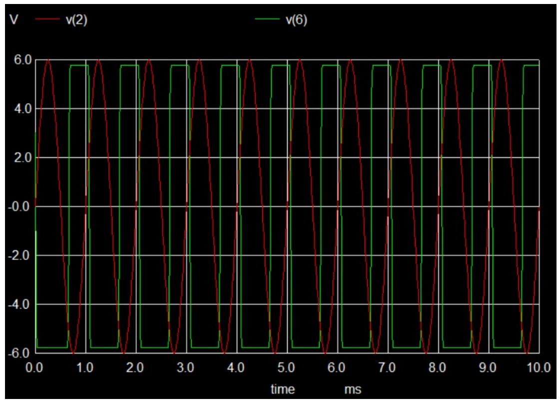


Fig 1.5
Output waveform for Schmidt Trigger - $V_a = -3V$
v(6): Output Voltage V_o, v(2): Input Voltage V_i

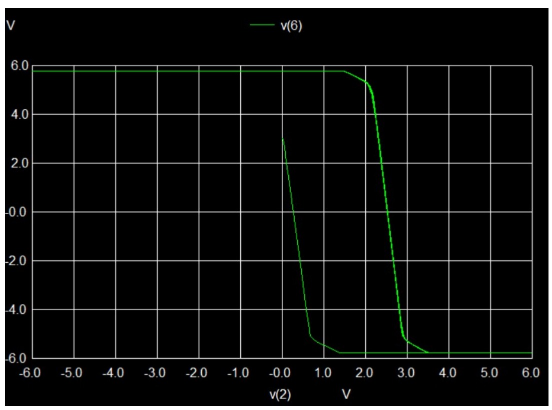


Fig 1.6
V_{out} vs V_{in} for sinusoidal input in Schmidt Trigger - $V_a = -3V$
v(6): Output Voltage V_o, v(2): Input Voltage V_i

s

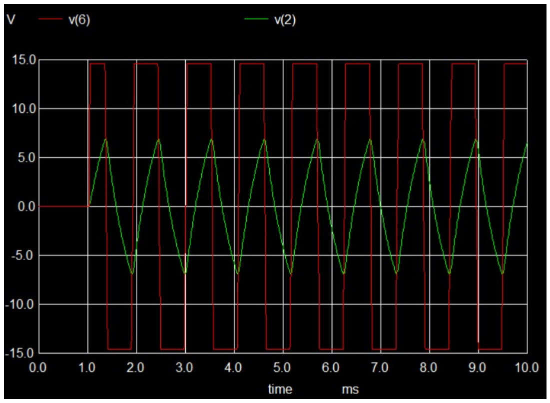


Fig 2.1
Astable Multivibrator without Zener Diodes
v(2): Capacitor Voltage, v(6): V_o

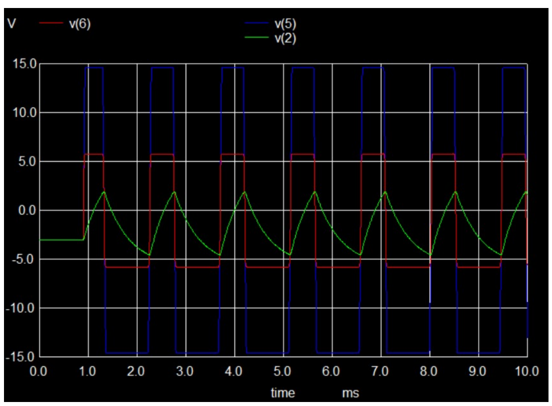


Fig 2.2
Astable Multivibrator with Zener Diodes
v(2): Capacitor Voltage, v(6): V_o*, v(5):* V_{o1}

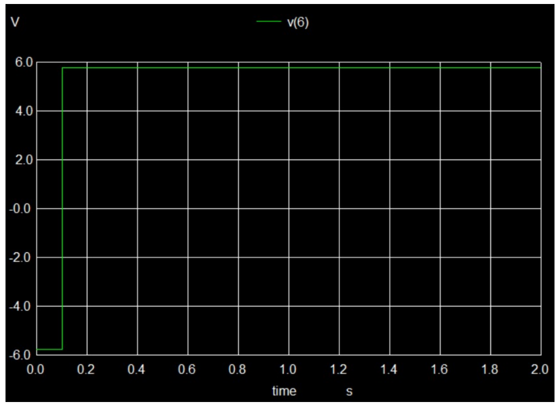


Fig 3.1
Waveform for Monostable Multivibrator (Long Push on Button)
v(6): Output Pulse

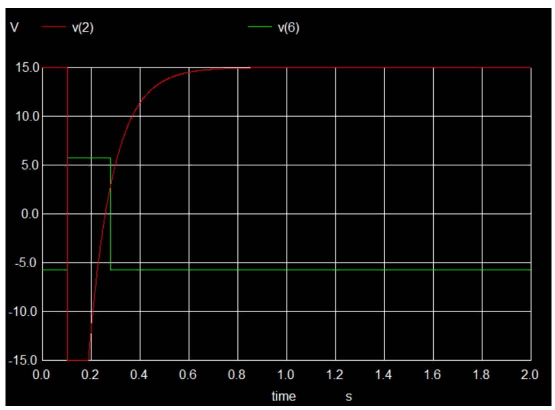


Fig 3.3
Waveform for Monostable Multivibrator (Short Push on Button
v(2): Inverting Terminal Voltage, v(6): Output Pulse

4 Experimental results

4.1 Answers to Questions in Handout

4.1.1 1(c)

For $V_a = 0V$, Experimental $V_{TL}, V_{TH} = 0V, 4V$
For $V_a = 3V$, Experimental $V_{TL}, V_{TH} = -0.5V, 5V$
For $V_a = -3V$, Experimental $V_{TL}, V_{TH} = 0.5V, 2.5V$

4.1.2 2(e)

The frequency of the obtained waveform is $\approx \frac{1}{1ms} = 1kHz$ (w/o Zener)

4.1.3 2(g)

The voltage at V_{o1} and V_o have different amplitude but similar waveform. This is because the peak voltage of $V_{o1} \approx 15V$ is regulated to $\approx 5V$ because of the two zener diodes present.

4.1.4 2(h)

The frequency of the obtained waveform is slightly lesser than 1kHz (with Zener), the time period is > 1ms. There is a minor change in frequency as compared with 2(e).

4.1.5 3(a)

The pulse width can be graphically calculated as $\approx 0.1s$.