EE230: Experiment No.04
Opamps circuits-2

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1 Overview of the experiment

1.1 Aim of the experiment

Aim of this experiment is using Opamp to make half wave , full wave rectifier and improving them from that made using diodes (bridge rectifier).

1.2 Methods

I used ngspice software to write code for schmitt trigger,astable multivibrator,monostable multivibrator and performed transient analysis, plotted time vs v_{in}, v_{out} for all three circuits for different inputs and then extracted output files from each .cir ngspice file in .txt format and then used matplotlib to visualise this data from text file .

2 Design

2.1 Schmitt Trigger

connect a 6v peak sinusodial voltage as shown below and measure v_{out}.
for $v_{in} = 6sin(wt)$:
when $v_{in} = v_-$ is lesser than v_+,v_{out} goes to v_{th} similarly when it is greater than v_-,v_{out} goes to $-v_{th}$ because as $v_{out} = A(v_+ - v_-)$ if $v_+ - v_-$ is slighlty positive too v_{out} goes to v_{th} because of multiplication of A which is large number and it happen commulatively. similar things happens for $v_a = 3v$,$v_a = -3v$. where $v_{th} = v_0R_2/(R_1 + R_2)$

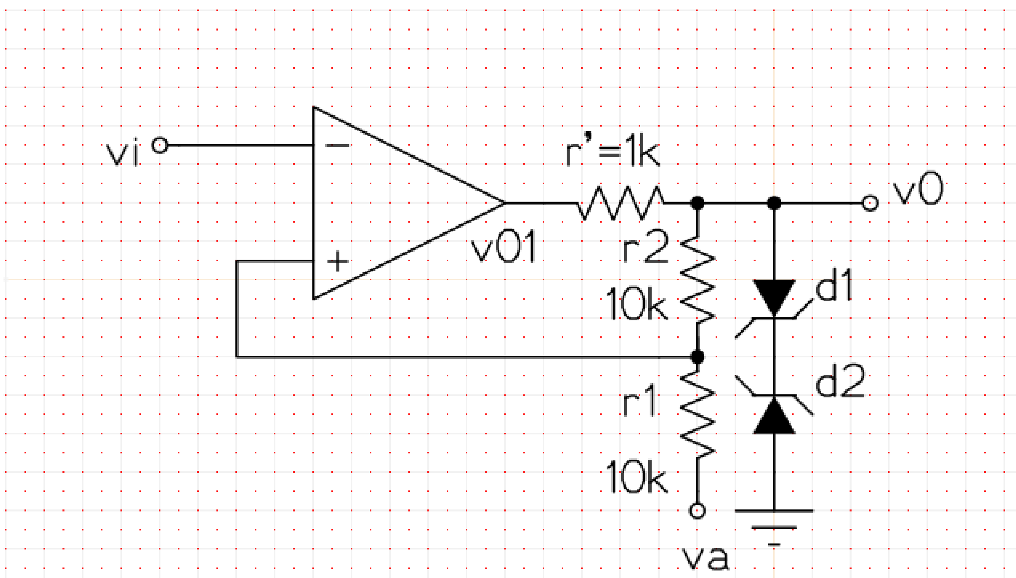
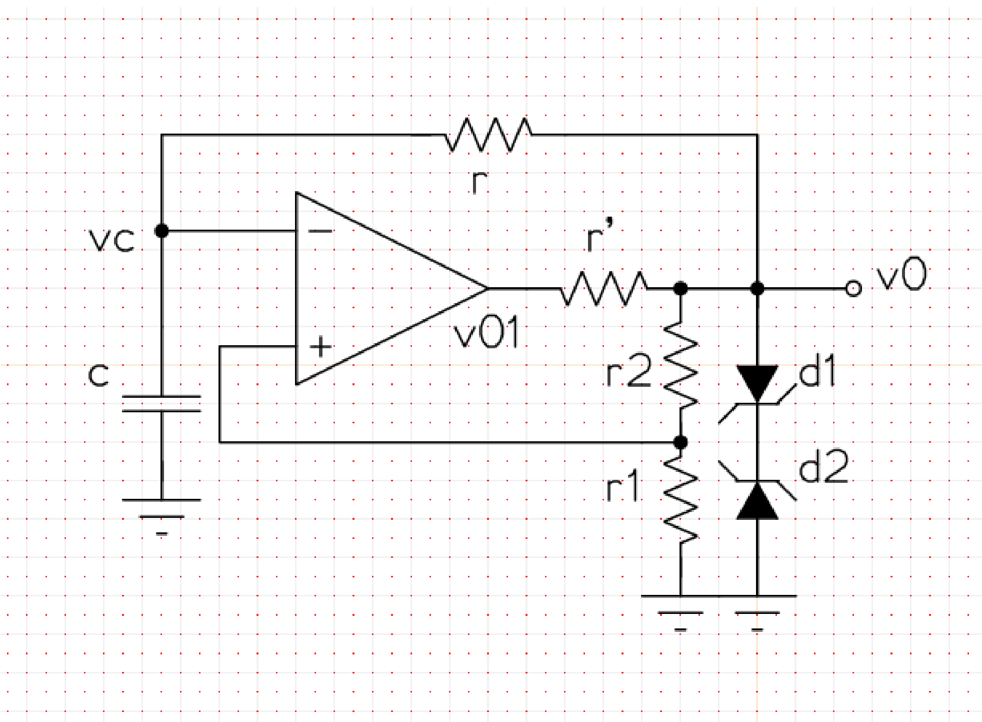


figure 1. schmitt trigger

2.2 Astable multivibrator

The circuit for astable multivibrator is connected as shown in figure it has no external input. then i perormed transient analysis. output of opamp produces nearly rectangular pulse because intially $v_+ > v_-$ thus $v_{out} = v_{th}$ because of schmitt trigger effect therefore it charges capacitor for some time when voltage across input increases as it increases in rc circuit that is $v_c = v_o(1 - e^{-t/rc})$,when v_{out} becomes negative because as voltage across capacitor builds up $v_+ < v_-$ thus $v_{out} = -v_{th}$,tus voltage across capacitor becomes $v_c = v_o(e^{-t/rc})$ that is voltage decreases exponentially.Where $v_{th} = v_0 R_2/(R_1 + R_2)$



2.3 Monostable multivibrator

connect the circuit for monostable multivibrator is shown below.when switch is closed the capacitor gets shorted thus input for inverting terminal for opamp becomes 15v as shown but when opened voltage across inverting terminal becomes voltage across a capacitor in a rc circuit that is $v_c = v_o(1 - e^{-t/rc})$ thus intially v_- becomes 0 slowly it starts building voltage ,thus intially as voltage across v_+ greater than v_- thus v_{out} becomes v_{th} but as v_- increases it becomes greater than v_+ eventually then v_{out} becomes $-v_{th}$. Where $v_{th} = v_0 R_2/(R_1 + R_2)$.

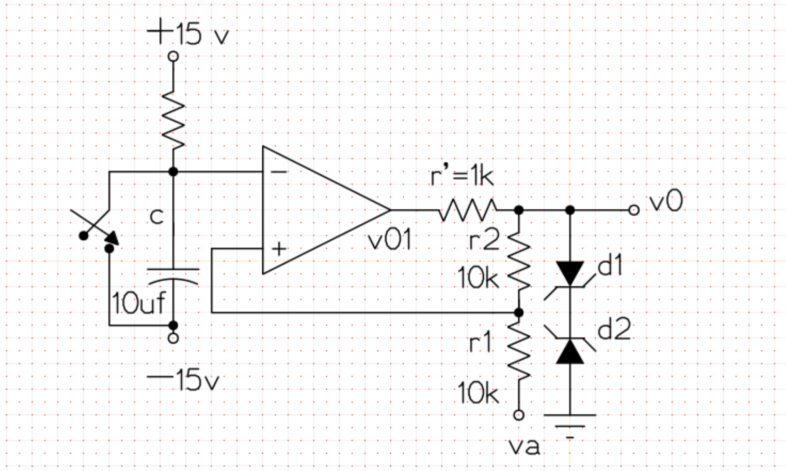


figure 3 monostable multivibrator

3 Simulation results

3.1 Code snippet

3.1.1 schmitt trigger

```
schmitt trigger circuit
.subckt ua741 1 2 3 4 5
c1 11 12 8.661E-12
c2 6 7 30.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 5.961E-9
iee 10 4 dc 15.16E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 5.305E3
rc2 3 12 5.305E3
re1 13 10 1.836E3
re2 14 10 1.836E3
ree 10 99 13.19E6
ro1 8 5 50
ro2 7 99 100
rp 3 4 18.16E3
vb 9 0 dc 0
vc 3 53 dc 1
ve 54 4 dc 1
vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
```

```
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends
```

```
.subckt ZENER_12 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
vin 1 0 sin(0 6 1k 0 0)
x1 5 1 6 7 2 ua741
ro 2 3 1k
r2 3 5 10k
r1 5 8 10k
va 8 0 -3v
x2 3 4 ZENER_12
x3 0 4 ZENER_12
vdd1 6 0 15v
vdd2 7 0 -15v
.tran 0.01u 4m
.control
run
plot v(3) v(1)
.endc
.end
```

3.1.2 Astable multivibrator

without r' and zener diode

```
astable multivibrator
.subckt ua741 1 2 3 4 5
c1 11 12 8.661E-12
c2 6 7 30.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 5.961E-9
iee 10 4 dc 15.16E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 5.305E3
rc2 3 12 5.305E3
re1 13 10 1.836E3
re2 14 10 1.836E3
ree 10 99 13.19E6
ro1 8 5 50
ro2 7 99 100
rp 3 4 18.16E3
vb 9 0 dc 0
vc 3 53 dc 1
ve 54 4 dc 1
```

```
    vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends
x1 1 2 3 4 5 ua741
r2 5 1 35k
r1 1 0 30k
c1 2 0 0.01u
r 5 2 50k
vdd1 3 0 15v
vdd2 4 0 -15v
.tran 0.1u 10m
.control
run
plot v(2) v(5)
.endc
.end
```

with r' and zener diode

```
astable multivibrator with r' and diodes
.subckt ua741 1 2 3 4 5
c1 11 12 8.661E-12
c2 6 7 30.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 5.961E-9
iee 10 4 dc 15.16E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 5.305E3
rc2 3 12 5.305E3
re1 13 10 1.836E3
re2 14 10 1.836E3
ree 10 99 13.19E6
ro1 8 5 50
ro2 7 99 100
rp 3 4 18.16E3
vb 9 0 dc 0
vc 3 53 dc 1
ve 54 4 dc 1
vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends
```

.subckt ZENER_12 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
x1 1 2 3 4 5 ua741
rd 5 6 1k
r2 6 1 35k
r1 1 0 30k
c1 2 0 0.01u
r 6 2 50k
x2 6 7 ZENER$_1$2
$x307ZENER_12$
$vdd13015v$
$vdd240-15v$
$.tran0.1u10m$
$.control$
run
$plotv(2)v(5)v(6)$
$.endc$
$.end$

3.1.3 Monostable multivibrator

```
monostable multivibrator part a
.subckt ua741 1 2 3 4 5
c1 11 12 8.661E-12
c2 6 7 30.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 5.961E-9
iee 10 4 dc 15.16E-6
hlim 90 0 vlim 1K
q1 11 2 13 qx
q2 12 1 14 qx
r2 6 9 100.0E3
rc1 3 11 5.305E3
rc2 3 12 5.305E3
re1 13 10 1.836E3
re2 14 10 1.836E3
ree 10 99 13.19E6
ro1 8 5 50
ro2 7 99 100
rp 3 4 18.16E3
vb 9 0 dc 0
vc 3 53 dc 1
ve 54 4 dc 1
```

```
vlim 7 8 dc 0
vlp 91 0 dc 40
vln 0 92 dc 40
.model dx D(Is=800.0E-18 Rs=1)
.model qx NPN(Is=800.0E-18 Bf=93.75)
.ends
.subckt ZENER_12 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 button_sw 1 2
s1 1 2 c 0 b_sw1
v1 c 0 pulse(0 10 0.10 0.02 0.02 0.05 100)
.model b_sw1 sw vt=1 vh=0.2 ron=1 roff=1000MEG
.ends
```

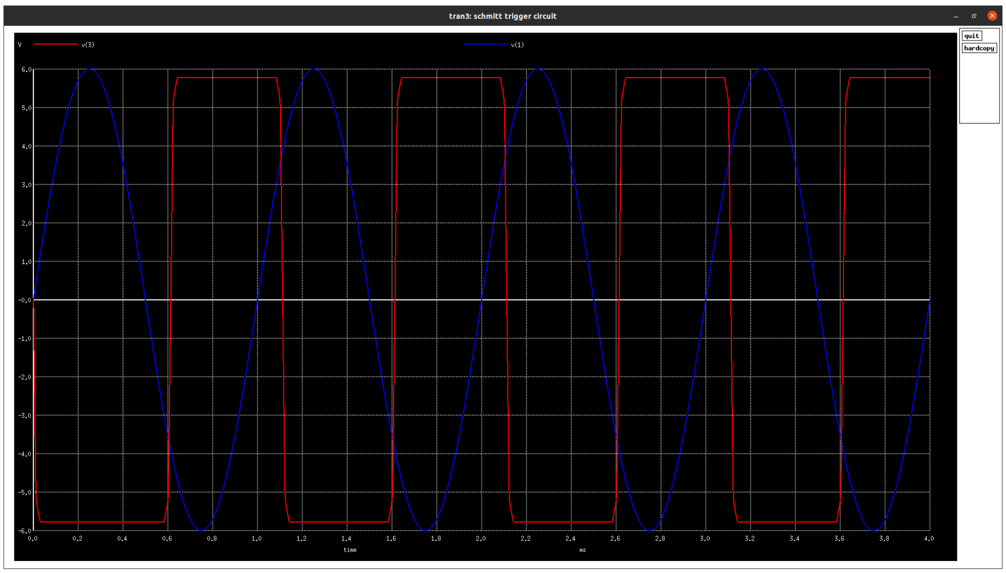
x1 1 2 3 4 5 ua741
x2 2 6 button$_s w$
$v160-15v$
$c12610u$
$r2710k$
$v27015v$
$v33015v$
$v440-15v$
$rd581k$
$r28110k$
$r11010k$
$x389ZENER\_12$
$x409ZENER\_12$
$.tran0.1m2s$
$.control$
run
$plotv(8)$
$plotv(2)v(8)v(2)-v(6)$
$.endc$
$.end$

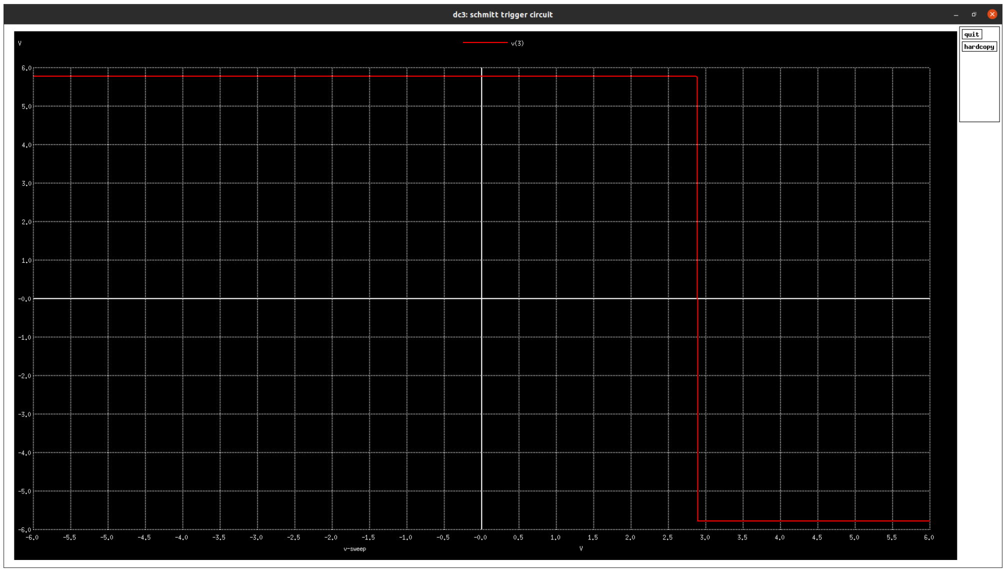
3.2 Simulation results

3.2.1 schmitt trigger

Va=gnd

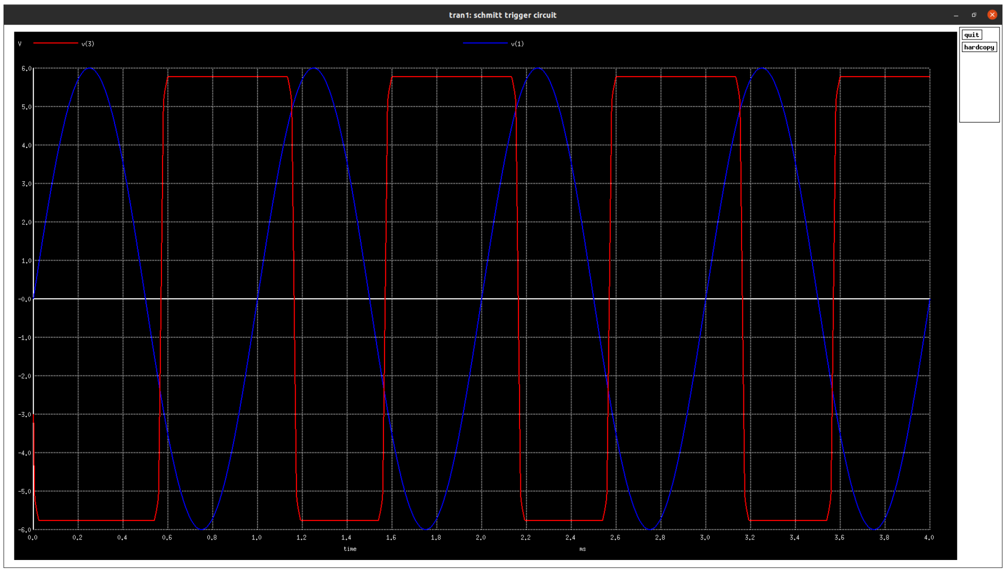
X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that when V_{in} is sinusodial V_{out} becomes nearly rectangular wave of amplitude +5.8v and -5.8v and frequency 900 Hz .

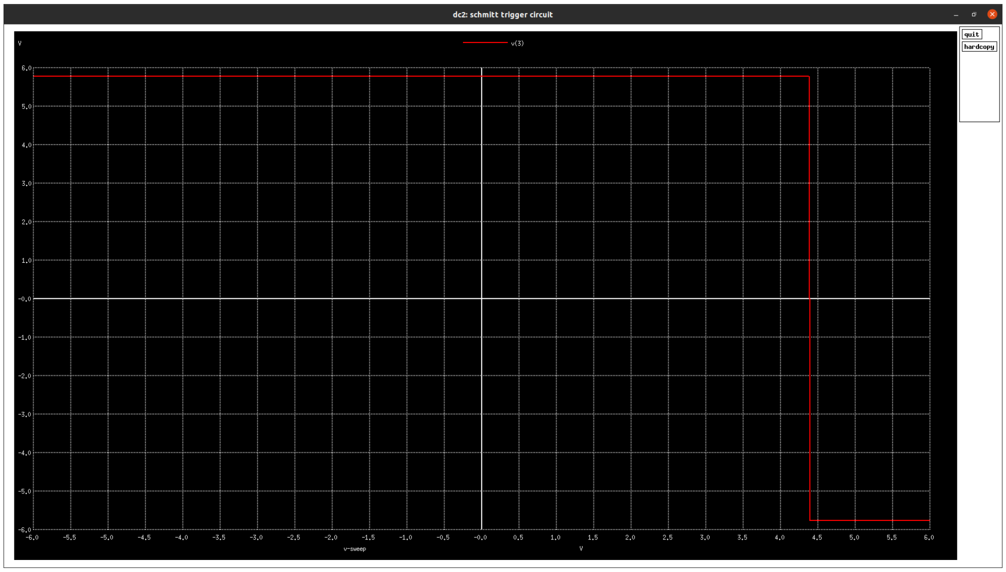



dc3: schmitt trigger circuit
quit
hardcopy
v(3)
V
v-sweep
V

Va=3v

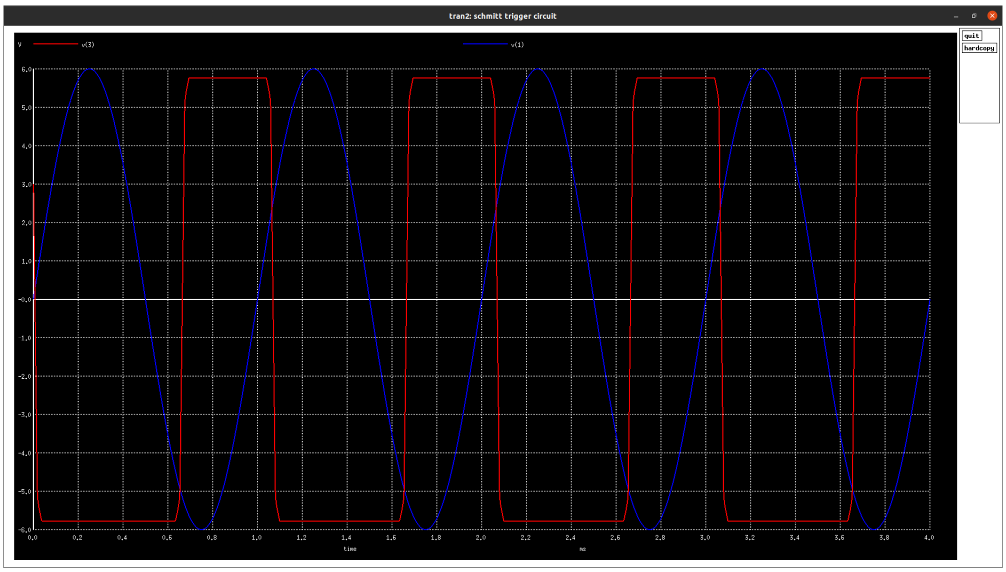
X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that when V_{in} is sinusodial V_{out} becomes nearly rectangular wave of amplitude +5.8v and -5.8v and frequency 1000 Hz .

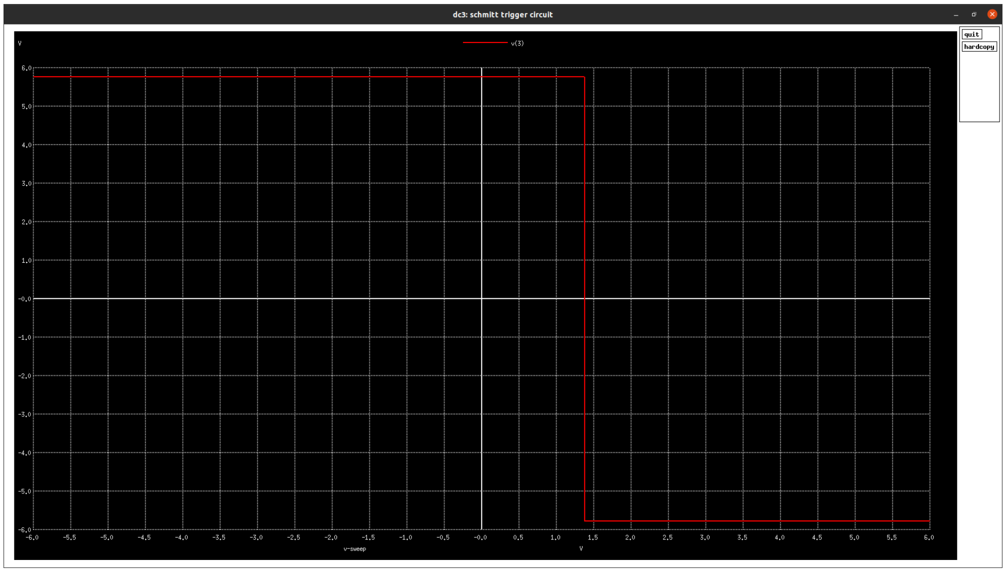



dc2: schmitt trigger circuit
v(3)
quit
hardcopy
v-sweep

Va=-3v

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that when V_{in} is sinusodial V_{out} becomes nearly rectangular wave of amplitude +5.8v and -5.8v and frequency 1000 Hz .

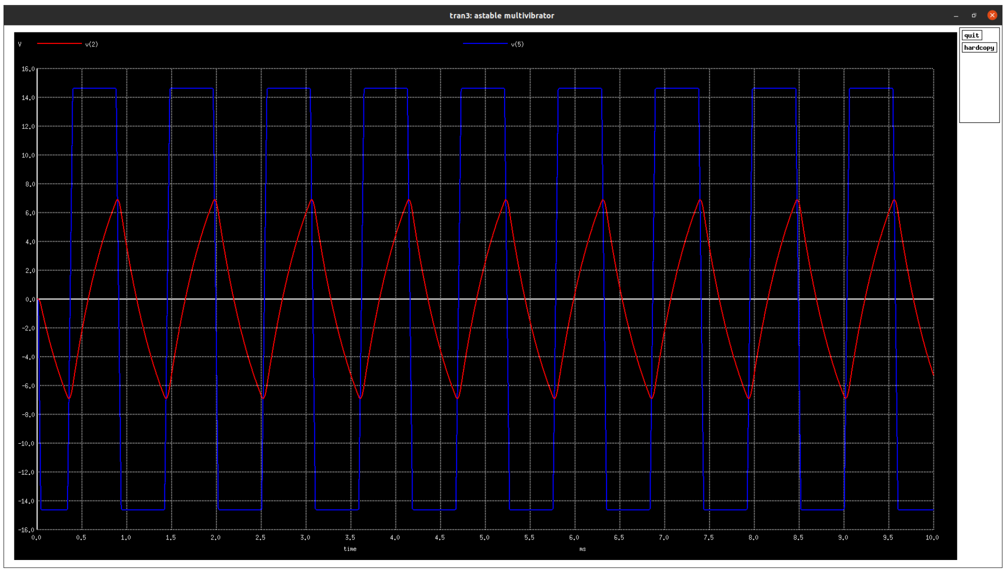



dc3: schmitt trigger circuit
quit
hardcopy
V
v(3)
6.0
5.0
4.0
3.0
2.0
1.0
-0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-6.0 -5.5 -5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 -0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
v-sweep
V

3.2.2 astable multivibrator

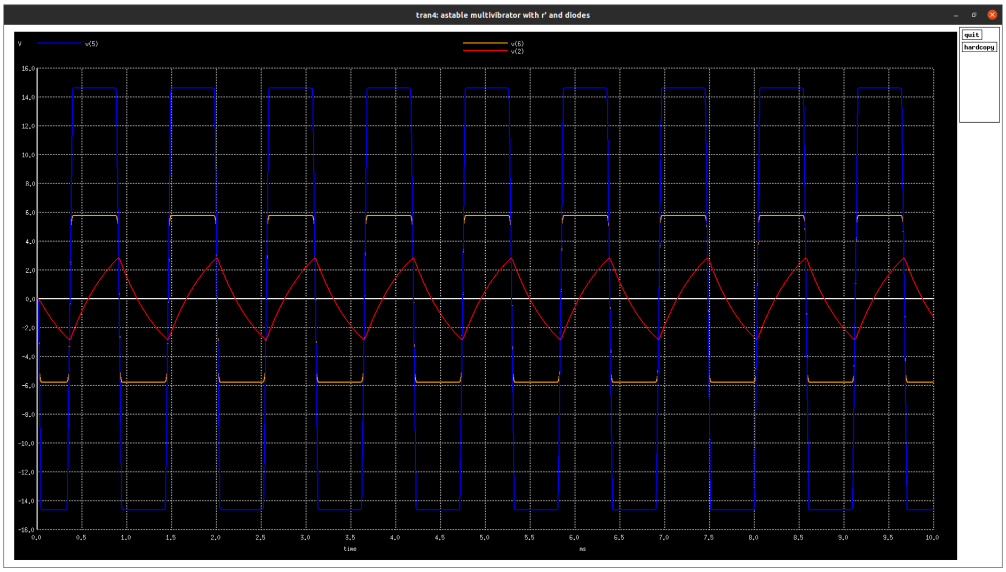
with no r' and diode

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that V_{in} increases with $V_{out} = v_{th}$ and decreases with $V_{out} = -v_{th}$. Frequency of this plot is 952 Hz.



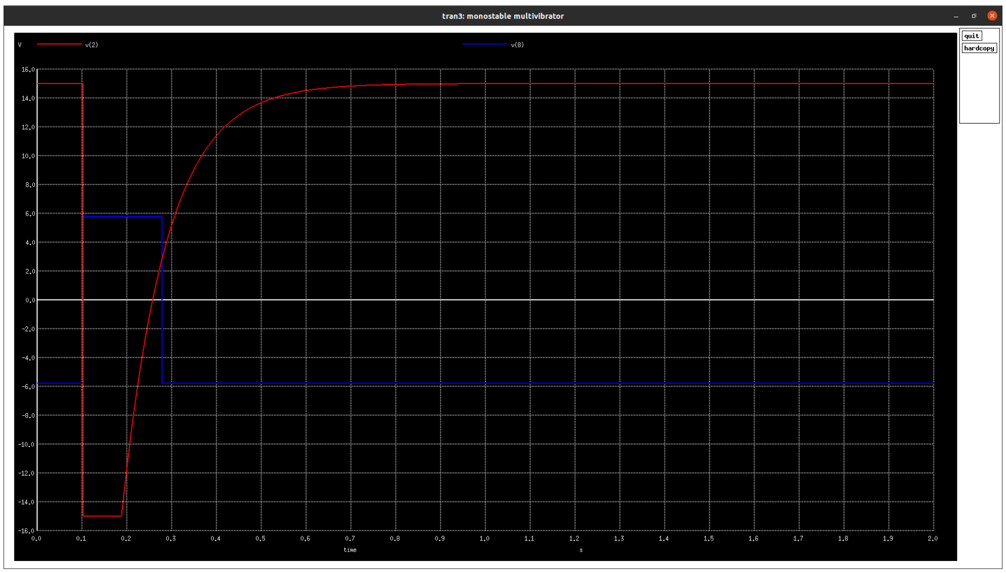
with r' and diode

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that V_{in} increases with $V_{out} = v_{th}$ and decreases with $V_{out} = -v_{th}$. Frequency of this plot is 909 Hz.



3.2.3 Monostable multivibrator

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out} is plotted below . plot shows that intially V_{in} is 15v as it is shorted thus V_{out} becomes $-V_{th}$ but as switch is opened V_{in} becomes 0 thus V_{out} becomes V_{th} and capacitor charges and as V_{in} increases V_{out} becomes $-V_{th}$. Thus width of plot should be nearly equal to 0.18 seconds.



4 Experiment completion status

I have completed all sections in Lab only.