EE230: Experiment No.03
Opamps circuits

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January 29, 2022

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).

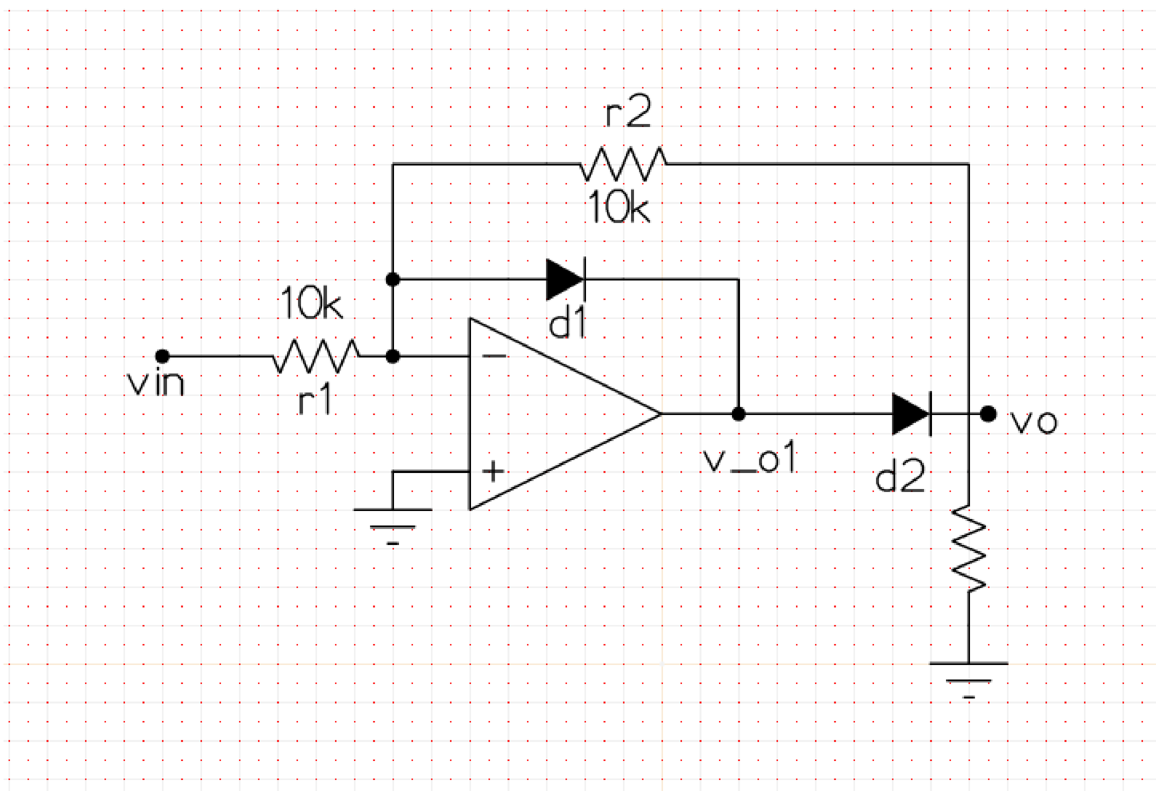
1.2 Methods

I used ngspice software to write code for half wave precision rectifier and improved half wave precision rectifier,full wave rectifier and performed transient analysis, plotted time vs v_{in}, v_{out} for all three circuits for a sinusodial input 10pp 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 Half-wave Precision rectifier

connect a 10v peak to peak sinusodial voltage as shown below and measure vout at load resistance (R_l).
for $v_{in} = 5sin(wt)$:
when v_{in} is positive both diodes get forward biased and resistance R_2 gets shorted thus voltage across v_{out} goes to zero, when v_{in} is negative diodes gets reverse biaseda nd thus no current flows through diodes thus whole circuit behaves as inverting amplifier with gain unity thus we get $v_{out} = -v_{in}$.

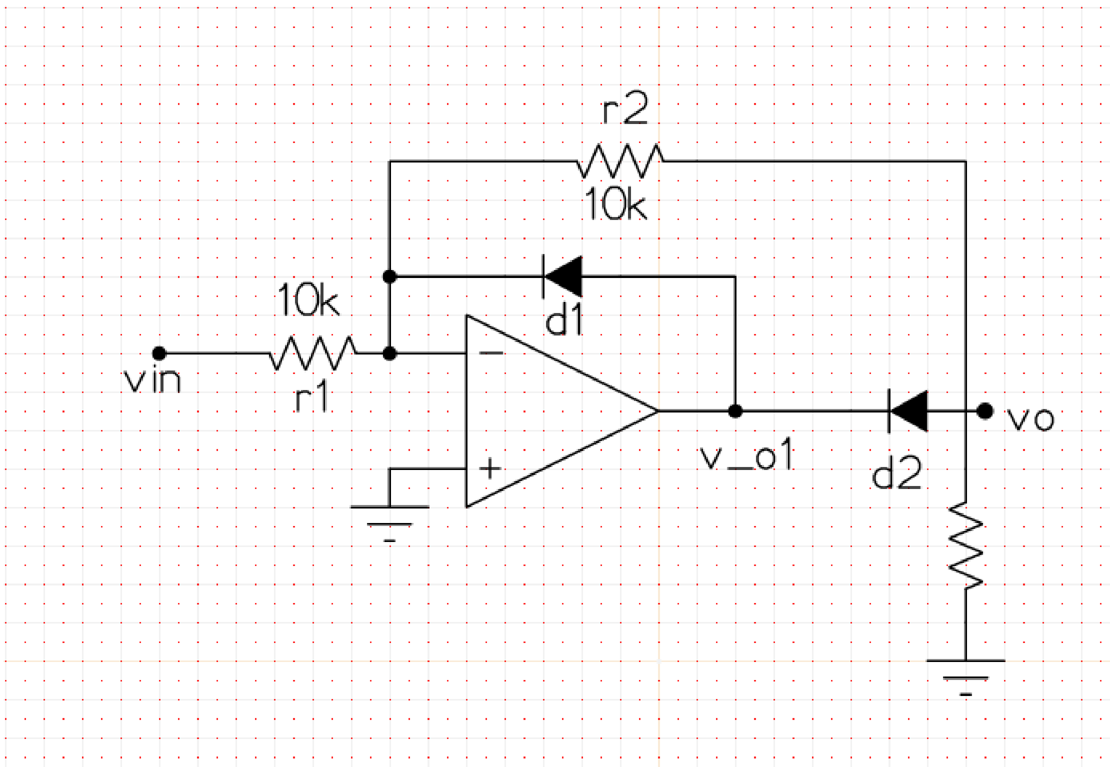


2.2 Improved Half-wave Precision rectifier

connect a 10v peak to peak sinusodial voltage as shown below and measure vout at load resistance (R_l).

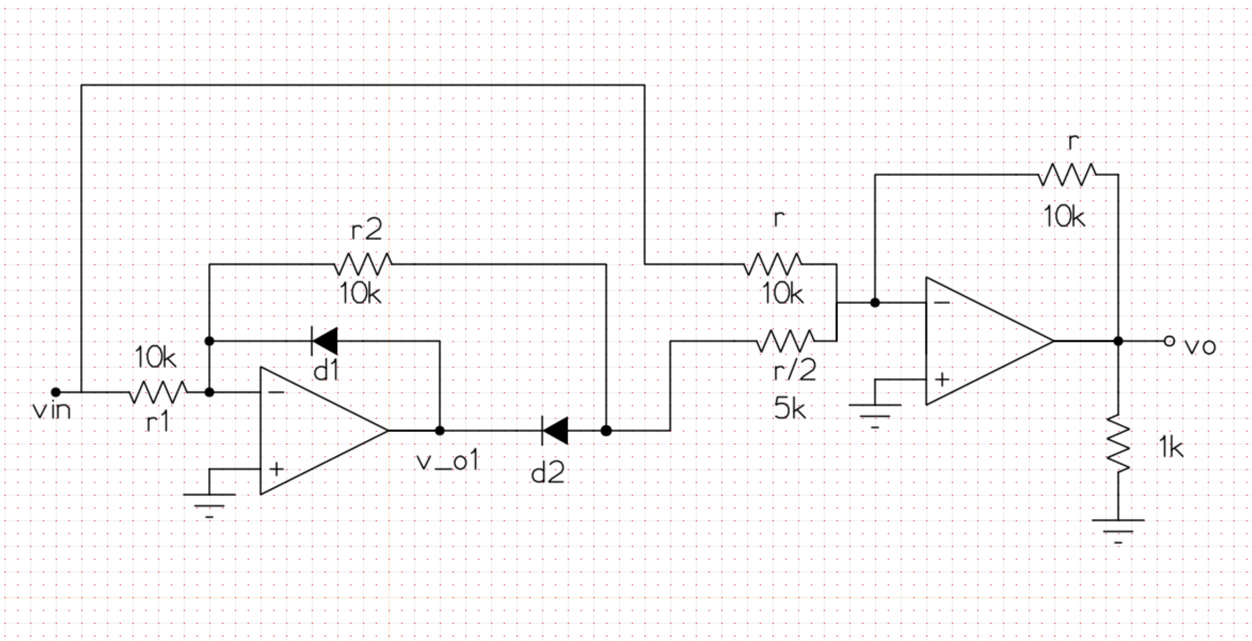
for $v_{in} = 5sin(wt)$:

when v_{in} is positive both diodes get reverse biased and thus no current flows through diodes thus whole circuit behaves as inverting amplifier with gain unity thus we get $v_{out} = -v_{in}$and when v_{in} is negative diodes gets forward biased ,resistance R_2 gets shorted thus voltage across v_{out} goes to zero,



2.3 Full-wave Precision rectifier

connect a 10v peak to peak sinusodial voltage as shown below and measure vout at load resistance (R_l).
for $v_{in} = 5sin(wt)$:
when v_{in} is positive both diodes get reverse biased and thus no current flows through diodes thus Improved half wave rectifier part of the circuit behaves as inverting amplifier with gain unit thus we get $v_{Improved-half-rectifier} = -v_{in}$ thus $v_{out} = V_{in}$ and when v_{in} is negative diodes gets forward biased ,resistance R_2 gets shorted thus voltage across $v_{Improved-half-rectifier}$ goes to zero thus $v_{out} = V_{in}$.



3 Simulation results

3.1 Code snippet

3.1.1 Half-wave rectifier

```
Half wave precision rectifier
.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
.include Diode_1N914.txt
x1 0 2 6 7 4 ua741
d2 2 4 1N914
d3 4 3 1N914
vin 1 0 sin(0 5 1k 0 0)
vcc1 6 0 15v
vcc2 7 0 -15v
r1 1 2 10k
r2 2 3 10k
rl 3 0 1k
.tran 1us 4ms
.control
run
plot v(3) v(4) v(1)
print v(3) v(4) v(1)
.endc
.end
```

3.1.2 Improved half-wave rectifier

```
Improved Half wave precision rectifier
.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
.include Diode_1N914.txt
x1 0 2 6 7 4 ua741
d2 4 2 1N914
d3 3 4 1N914
vin 1 0 sin(0 5 1k 0 0)
vcc1 6 0 15v
vcc2 7 0 -15v
r1 1 2 10k
r2 2 3 10k
rl 3 0 1k
.tran 1us 4ms
.control
run
plot v(3) v(4) v(1)
print v(3) v(4) v(1)
.endc
.end
```

3.1.3 full-wave rectifier

```
full wave precision rectifier
.subckt imprect 1 3
.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
.include Diode_1N914.txt
x1 0 2 6 7 4 ua741
d2 4 2 1N914
d3 3 4 1N914
r1 1 2 10k
r2 2 3 10k
vcc1 6 0 15v
vcc2 7 0 -15v
.ends
```

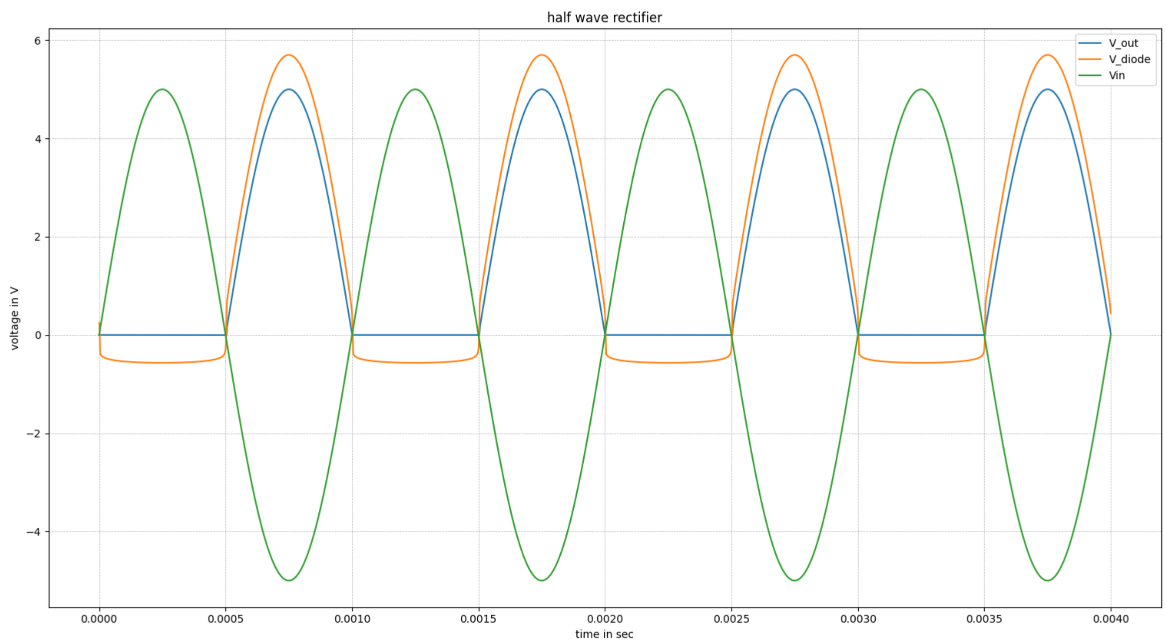
```
.subckt ua741 1 2 3 4 5
c1 11 12 8.661E-12
c2 6 7 30.00E-12
dc 5 53 dx
de 54 5 dx
dlp 90 91 dx
dln 92 90 dx
dp 4 3 dx
egnd 99 0 poly(2) (3,0) (4,0) 0 .5 .5
fb 7 99 poly(5) vb vc ve vlp vln 0 10.61E6 -10E6 10E6 10E6 -10E6
ga 6 0 11 12 188.5E-6
gcm 0 6 10 99 5.961E-9
iee 10 4 dc 15.16E-6
hlim 90 0 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
xx1 1 2 imprect
xx2 0 3 6 7 4 ua741
vin 1 0 sin(0 5 1k 0 0)
vcc1 6 0 15
vcc2 7 0 -15
r1 1 3 10k
r2 2 3 5k
r3 3 4 10k
rl 4 0 1k
.tran 1us 4ms
.control
run
plot v(4) v(1)
print v(4) v(1)
.endc
.end
```

3.2 Simulation results

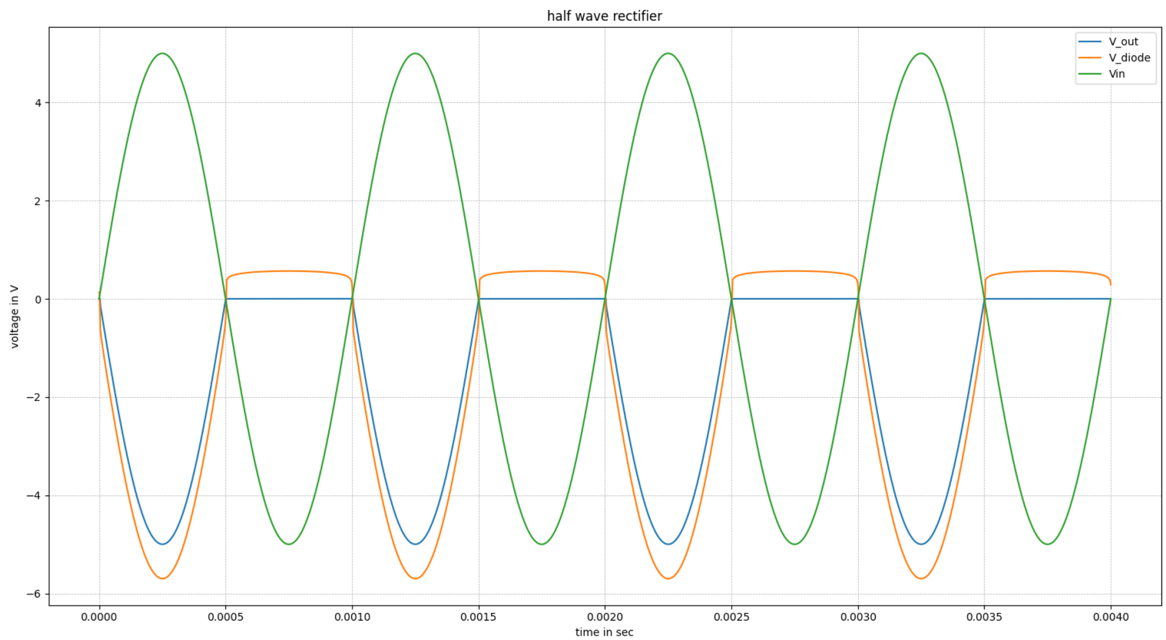
3.2.1 half wave precision rectifier

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out},V_{diode} is plotted below . plot shows that when V_{in} is sinusodial at V_{out} negative part of sinusodial curve is inverted and positive part of vin is returned as 0v .



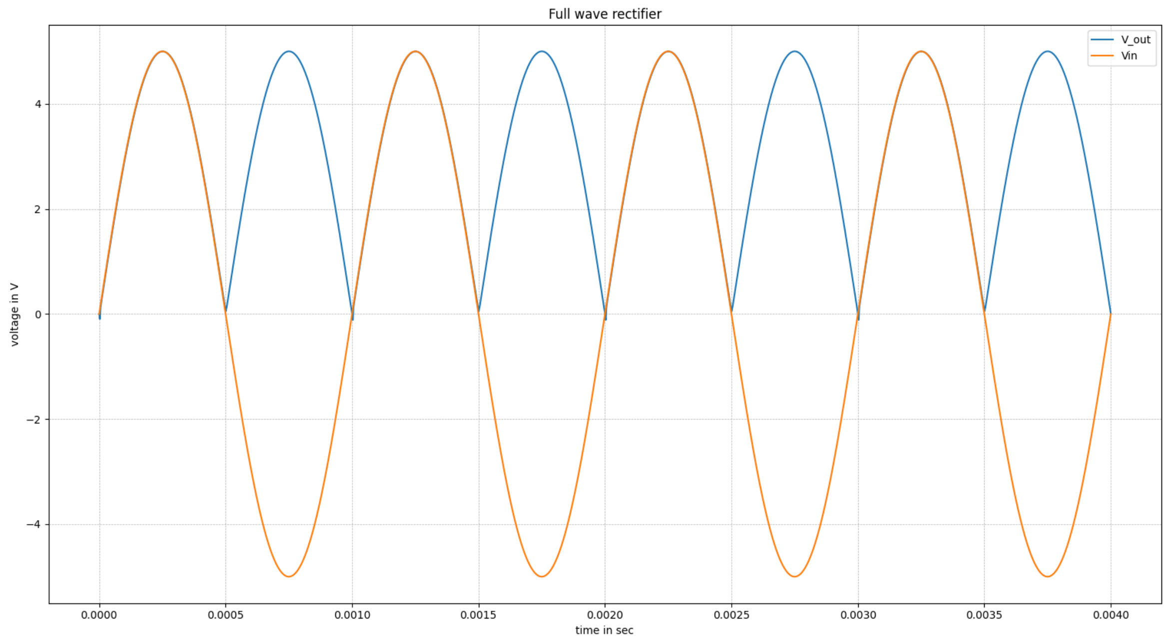
3.2.2 improved half wave rectifier

X-axis is time axis, Y-axis is voltage axis , time vs V_{in}, V_{out},V_{diode} is plotted below. plot shows that when V_{in} is sinusodial , at V_{out} positive part of sinusodial curve is inverted and negative part of vin is returned as 0v .



3.2.3 full wave rectifier

X-axis is time axis, Y-axis is voltage axis time vs V_{in}, V_{out},V_{diode} is plotted below. plot shows that when V_{in} is sinusodial , at V_{out} for both positive and negative part of sinusodial curve V_{out} remains positive , $V_{out} = |V_{in}|$



4 Experiment completion status

I have completed all sections in Lab only.