EE230: Lab 3
Precision Rectifiers

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January 27, 2022

1 Overview of the experiment

1.1 Aim of the experiment

1. Creating and Simulating two models for a Half-Wave Precision Rectifier, finding V_{out} and comparing it with experimental results.

2. Creating and Simulating a model for a Full-Wave Precision Rectifier, finding V_{out} and comparing it with experimental results.

1.2 Methods

The circuit diagrams for the Half-Wave and Full-Wave Precision Rectifiers were provided in the lab handout, using which I created and simulated them in NGSpice.

2 Design & Working

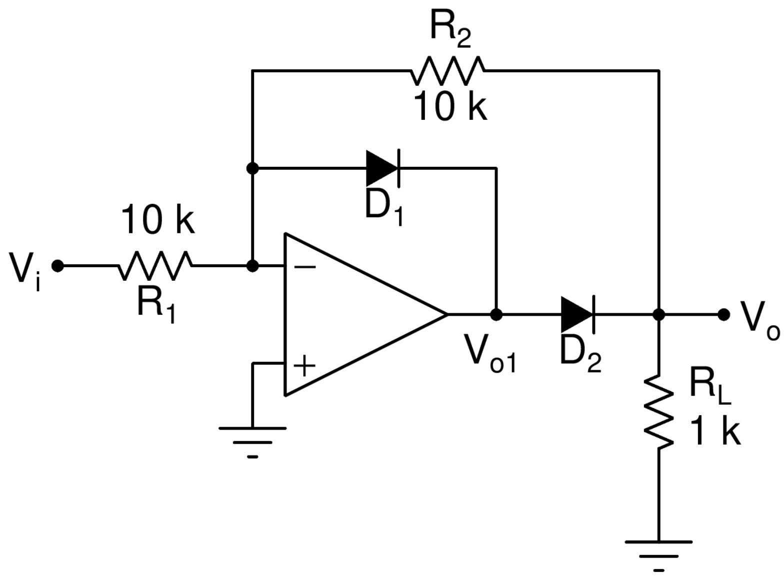


Fig. Half-Wave Precision Rectifier - A

In the above circuit, we can see that the diode D_1 will conduct if the positive half of the sinusoidal input is applied as an input i.e. V_i is positive. In this case no current will flow through R_2 and V_{o_1} will be equal to the negative diode drop i.e. $-0.7V$. Since D_2 is now reverse biased, $V_o = V_- = 0V$. Therefore we get $0V$ output for the positive input cycle. For the negative input cycle, D_1 is now reverse biased and thus current flows through R_2 and the Op-Amp acts as an Inverting Amplifier. Therefore $V_o = V_i(\frac{-R_2}{R_1}) = -V_i$ and we get rectification for the negative input cycle.

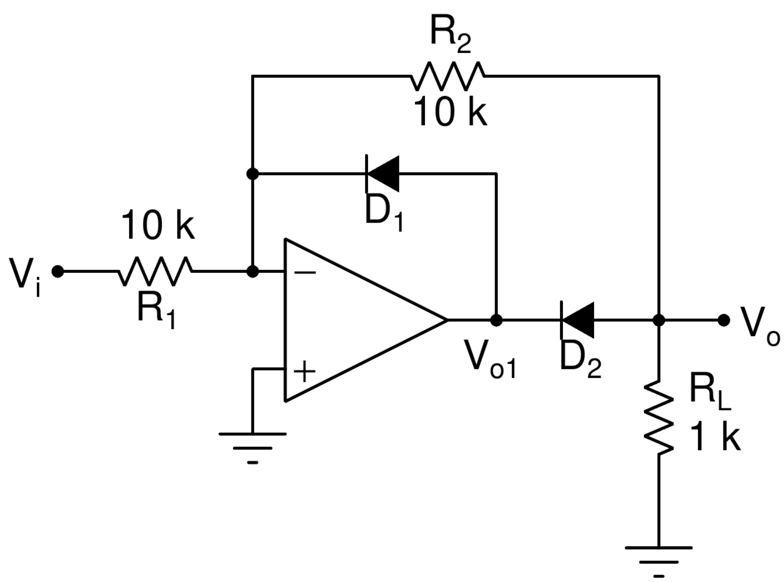


Fig. Half-Wave Precision Rectifier - B

In the above circuit, we can see that the diode D_1 will conduct if the negative half of the sinusoidal input is applied as an input i.e. V_i is negative. In this case no current will flow through R_2 and V_{o_1} will be equal to the positive diode drop i.e. $+0.7V$. Since D_2 is now reverse biased, $V_o = V_- = 0V$. Therefore we get $0V$ output for the negative input cycle. For the positive input cycle, D_1 is now reverse biased and thus current flows through R_2 and the Op-Amp acts as an Inverting Amplifier. Therefore $V_o = V_i(\frac{-R_2}{R_1}) = -V_i$ and we get negative rectification for the positive input cycle.

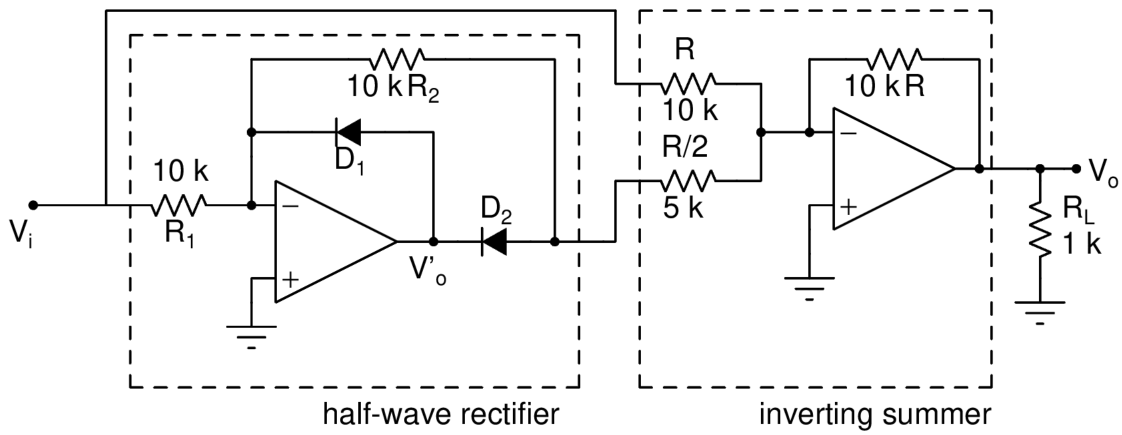


Fig. Full-Wave Precision Rectifier

The latter half of the above circuit is an Inverting summer whose V_o is given by $-V_i - 2V_o'$. For the negative input cycle, $V_o' = 0V$, therefore $V_o = -V_i$. For the positive input cycle, $V_o' = -V_i$, therefore $V_o = V_i$. Therefore we get a final fully rectified output for the given sinusoidal signal.

3 Simulation results

3.1 Half-Wave Precision Rectifier - A

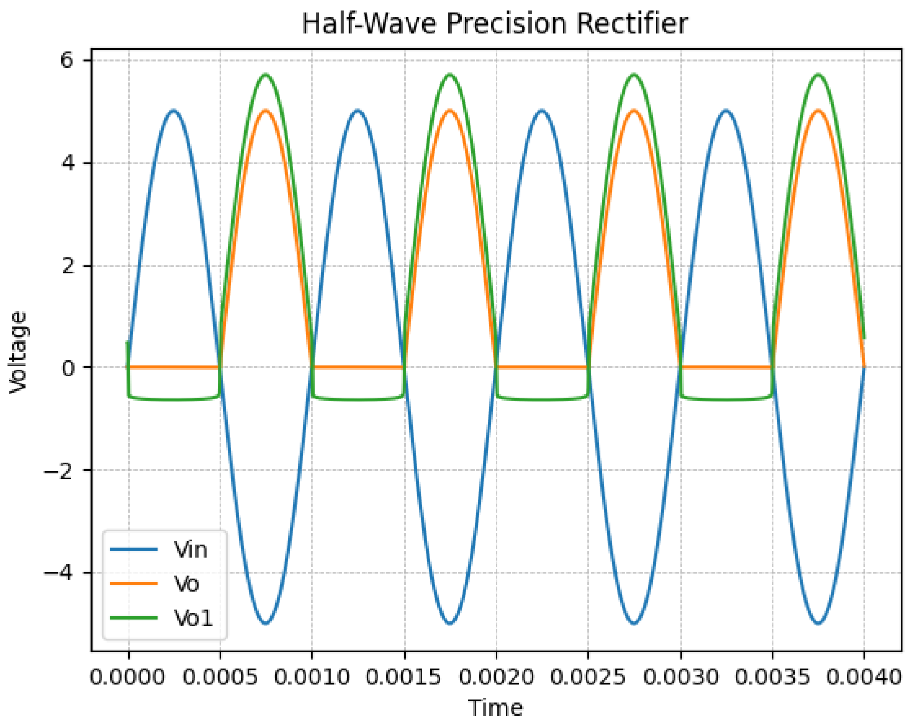
3.1.1 Code snippet

```
Half-Wave Precision Rectifier - A
*Including the predefined op-amp subcircuit file
.include uA741.txt
R1 1 2 10k
R2 2 3 10k
Rl 3 0 1k
D1 2 4
D2 4 3
VCC 5 0 dc 15
VEE 6 0 dc -15
x1 0 2 5 6 4 uA741
Vi 1 0 sin(0 5 1k 0 0)
.tran 0.0001m 10m
.control
```

```
run
plot v(1) v(3) v(4)
.endc
.end
```

3.1.2 Simulation results

Given below is the plot for V_{out} waveform obtained from the transient analysis of the circuit:



We can observe in the graph above that negative half of the sinusoidal input waveform has been rectified.

3.2 Half-Wave Precision Rectifier - B

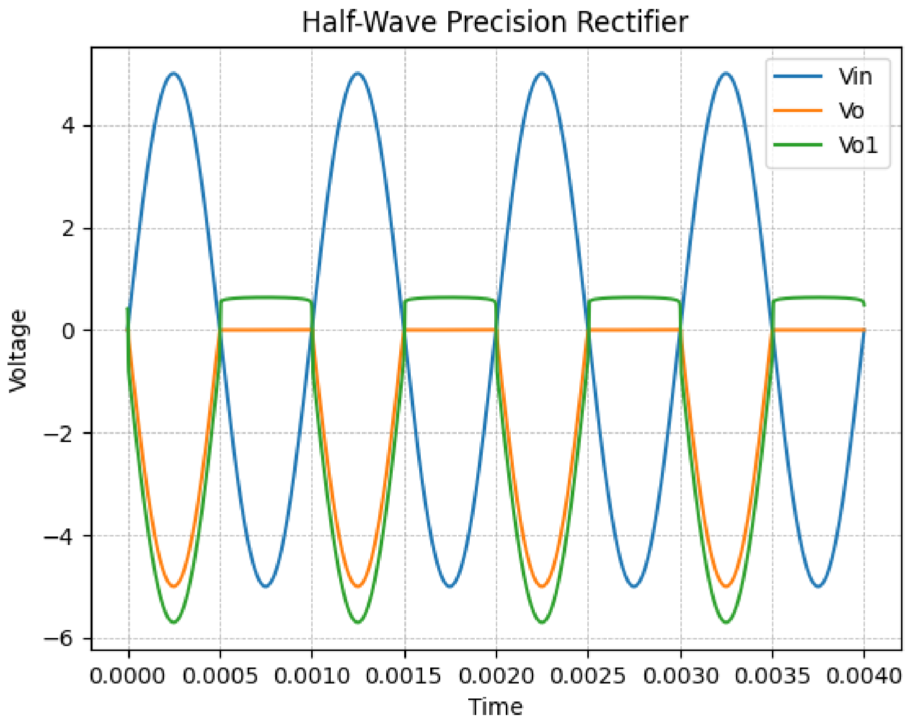
3.2.1 Code snippet

```
Half-Wave Precision Rectifier - B
```

```
*Including the predefined op-amp subcircuit file
.include uA741.txt
R1 1 2 10k
R2 2 3 10k
Rl 3 0 1k
D1 4 2
D2 3 4
VCC 5 0 dc 15
VEE 6 0 dc -15
x1 0 2 5 6 4 uA741
Vi 1 0 sin(0 5 1k 0 0)
.tran 0.0001m 10m
.control
run
plot v(1) v(3) v(4)
.endc
.end
```

3.2.2 Simulation results

Given below is the plot for V_{out} waveform obtained from the transient analysis of the circuit:



We can observe in the graph above that positive half of the sinusoidal input waveform has been rectified.

3.3 Full-Wave Precision Rectifier

3.3.1 Code snippet

```
Full—Wave Precision Rectifier
*Including the predefined op—amp subcircuit file
.include HWPR_B_S.txt
.include uA741.txt
x1 1 2 HWPR
R1 1 3 10k
R2 2 3 5k
R3 3 4 10k
Rl 4 0 1k
VCC 5 0 dc 15
```

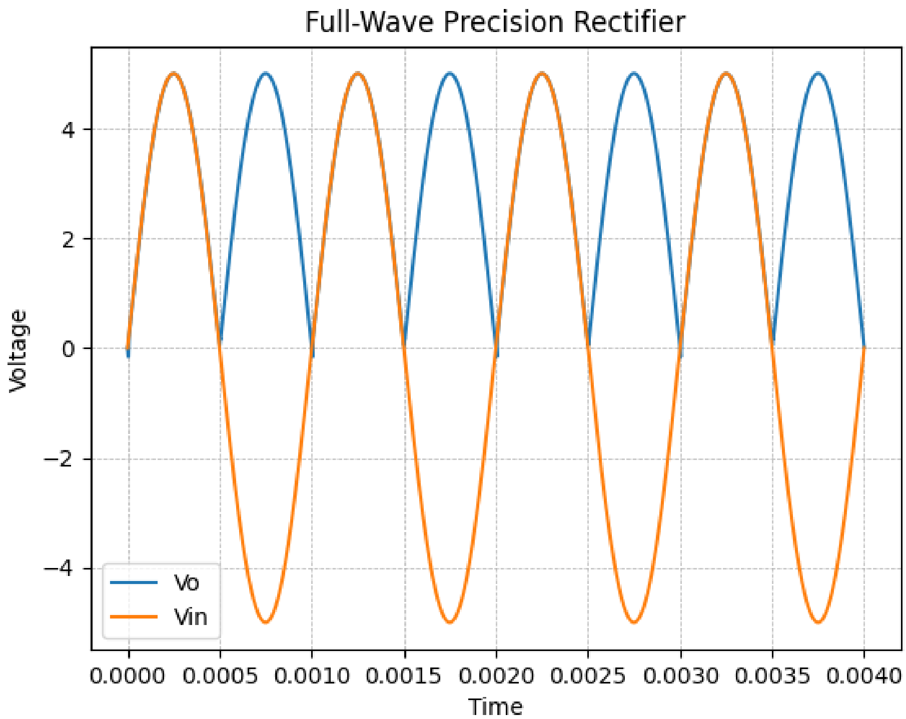
```
VEE 6 0 dc -15
x2 0 3 5 6 4 uA741
Vi 1 0 sin(0 5 1k 0 0)
.tran 0.0001m 4m
.control
run
print v(4) v(1)
.endc
.end
```

The subcircuit file used for the Half-Wave Precision Rectifier - B circuit is as follows:

```
*Half-Wave Precision Rectifier - B
*Including the predefined op-amp subcircuit file
.include uA741.txt
.subckt HWPR in out
R1 in 2 10k
R2 2 out 10k
D1 4 2
D2 out 4
VCC 5 0 dc 15
VEE 6 0 dc -15
x1 0 2 5 6 4 uA741
.ends
```

3.3.2 Simulation results

Given below is the plot for the V_{out} waveform obtained from the transient analysis of the circuit:

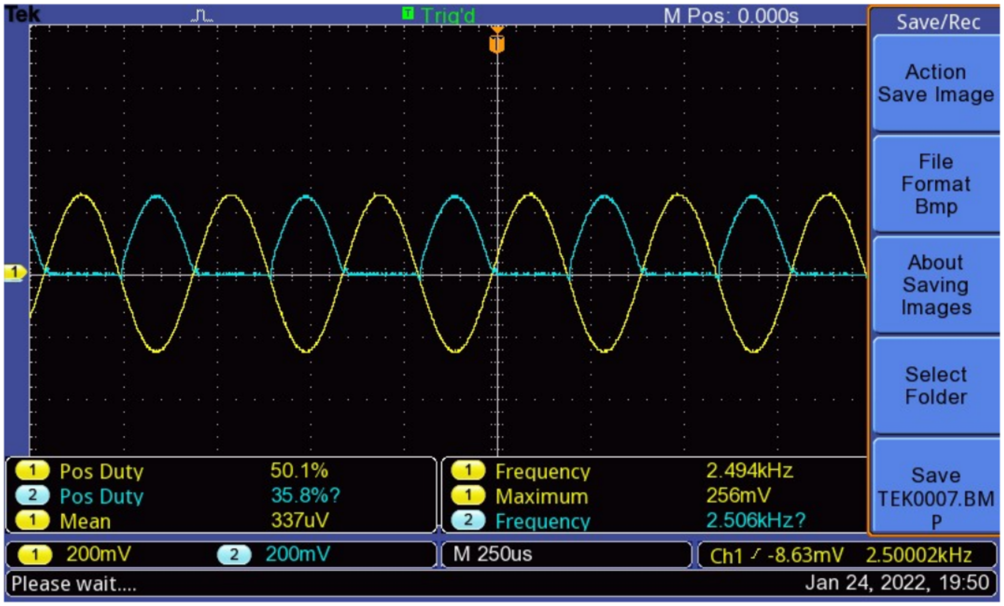


We can observe in the graph above that the sinusoidal input waveform has been fully rectified.

4 Experimental results

4.1 Half-Wave Precision Rectifier - A

Given below are the Experimental Results for the given circuit:



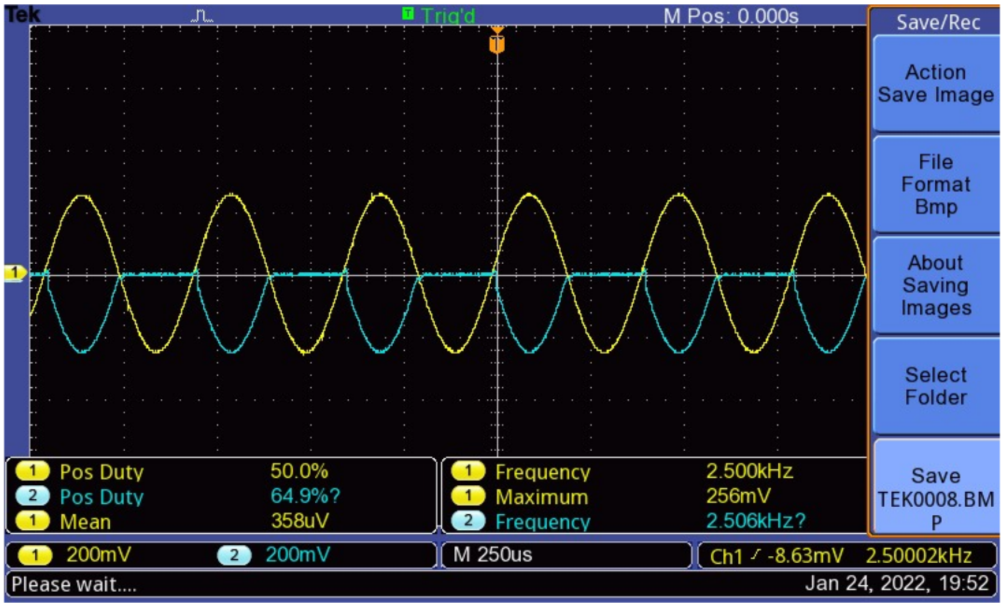
We can observe that the experimental values are in line with the simulation results from NGSpice.

Results of the Voltage readings for the given circuit are as follows:

S. No.	Time	V_i	V_o	V_{o1}
1	6.651971e-04	-4.30686e+00	4.302195e+00	4.997520e+00
2	1.331616e-03	4.356846e+00	-3.73526e-07	-6.33628e-01
3	2.015429e-03	4.839643e-01	2.871277e-05	-5.76399e-01
4	2.694029e-03	-4.69399e+00	4.691065e+00	5.388627e+00
5	3.406829e-03	2.762709e+00	-3.39687e-06	-6.21877e-01

4.2 Half-Wave Precision Rectifier - B

Given below are the Experimental Results for the given circuit:



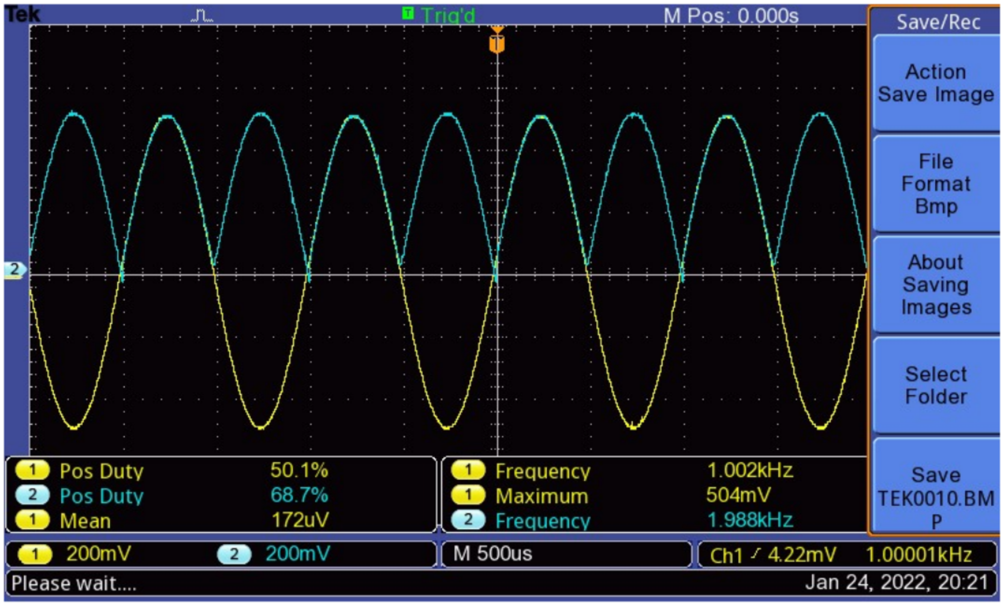
We can observe that the experimental values are in line with the simulation results from NGSpice.

Results of the Voltage readings for the given circuit are as follows:

S. No.	Time	V_i	V_o	V_{o1}
1	6.651772e-04	-4.30654e+00	-1.11631e-06	6.333204e-01
2	1.332177e-03	4.348173e+00	-4.35254e+00	-5.04816e+00
3	1.998577e-03	-4.47048e-02	2.145641e-04	5.204540e-01
4	2.664977e-03	-4.30334e+00	-1.12274e-06	6.333011e-01
5	3.331977e-03	4.351277e+00	-4.35563e+00	-5.05127e+00

4.3 Full-Wave Precision Rectifier

Given below are the Experimental Results for the given circuit:



We can observe that the experimental values are in line with the simulation results from NGSpice.

Results of the Voltage readings for the given circuit are as follows:

S. No.	Time	V_i	V_o
1	6.647233e-04	4.292817e+00	-4.29928e+00
2	1.331553e-03	4.377114e+00	4.357815e+00
3	1.997752e-03	8.460059e-02	-7.06050e-02
4	2.663786e-03	4.277631e+00	-4.28416e+00
5	3.330597e-03	4.391543e+00	4.372465e+00