EE236 : Electronic Devices Lab
Lab 0 [Tuesday Batch]

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1 Objectives

- Installing NGSPICE and getting familiar with using it.
- Learning the basic commands to design circuits, transient analysis, including external files and using them as a component in a larger circuit and plotting graphs
- Using NanoHub for analysis of characterisitcs of PN junctions.

2 Circuit analysis using NGSPICE

2.1 Transient analysis of RC Circuit

2.1.1 Circuit

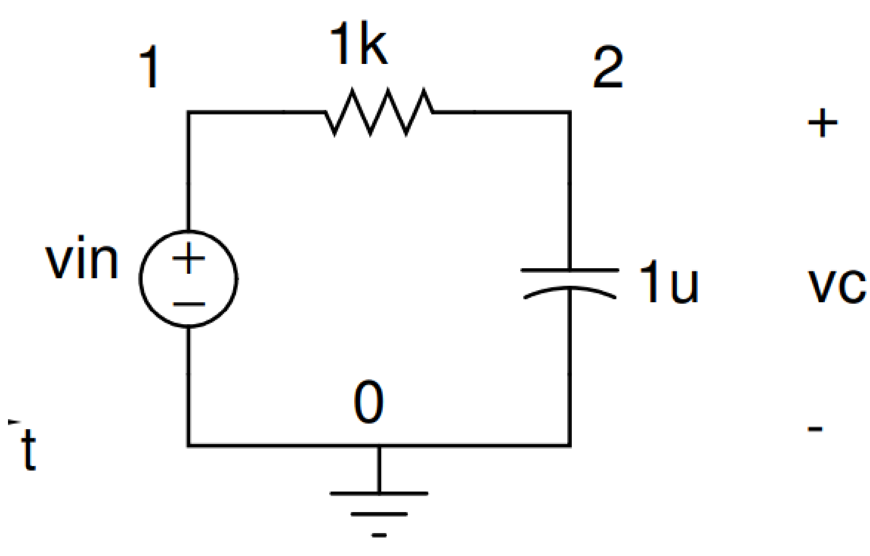
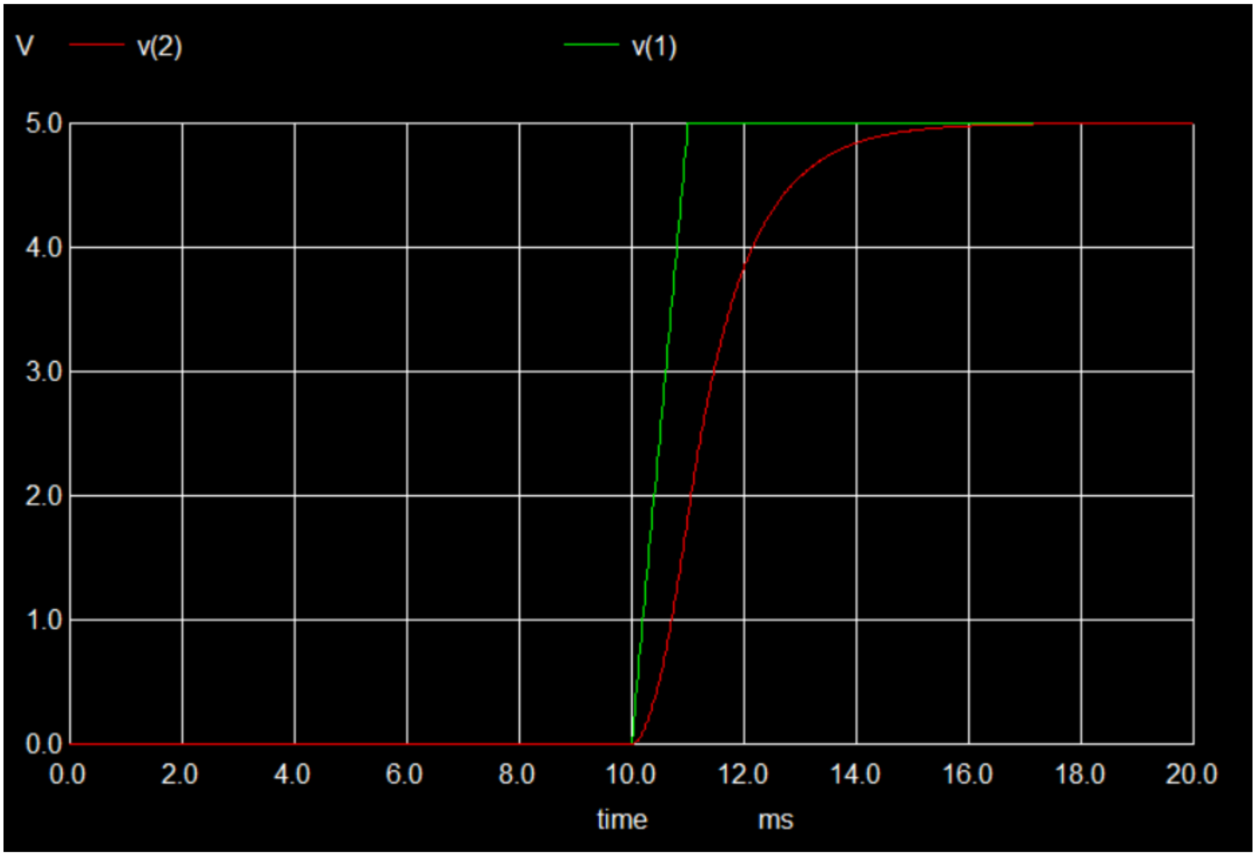


Figure 1: RC Circuit

2.1.2 Code

```
RC Circuit Transient Response
*resistor connected between nodes 1 and 2
r1 1 2 1k
*capacitor connected between nodes 2 and 0
c1 2 0 1u
*piecewise linear input voltage
vin 1 0 pwl (0 0 10ms 0 11ms 5v 20ms 5v)
*transient analysis for 20ms, step size 0.02ms
.tran 0.02ms 20ms
*defining the run-time control functions
.control
run
*plotting input and output voltages
plot v(1) v(2)
.endc
.end
```

2.1.3 Plots

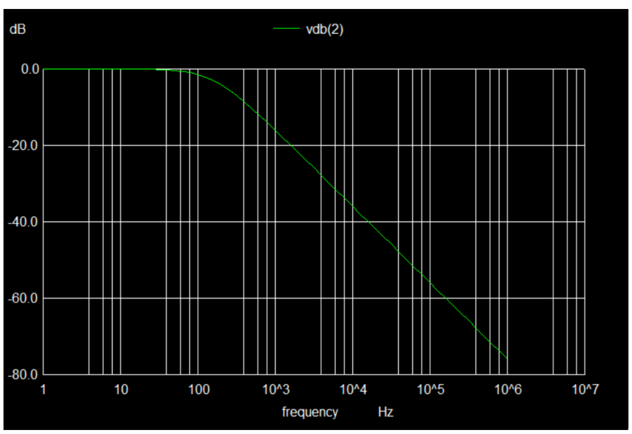


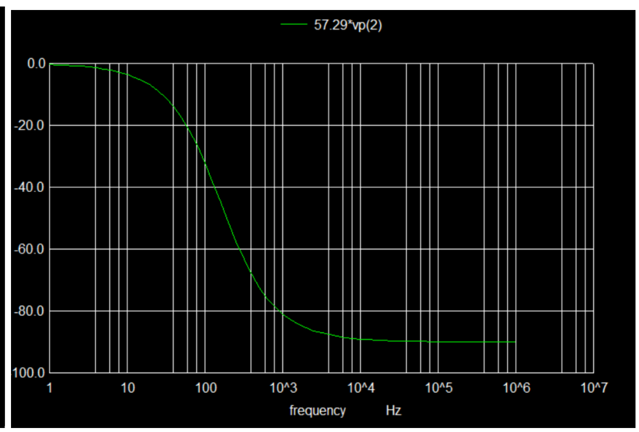
2.2 AC analysis of RC Circuit

2.2.1 Code

```
RC Circuit Frequency Response
r1 1 2 1k
c1 2 0 1u
*Specifying an AC source with zero dc
vin 1 0 dc 0 ac 1
*AC analysis for 1 Hz to 1MHz, 10 points per decade
.ac dec 10 1 1Meg
.control
run
*Magnitude dB plot for v(2) on log scale
plot vdb(2) xlog
*Phase degrees plot for v(2) on log scale
plot {57.29*vp(2)} xlog
.endc
.end
```

2.2.2 Plots



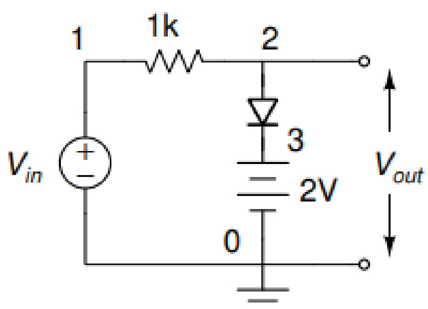


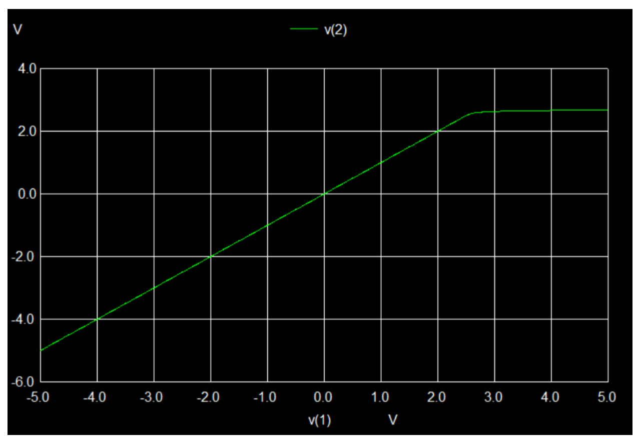
2.3 DC Analysis of Shunt Clipper

2.3.1 Code

```
Shunt Clipper DC analysis
r1 1 2 1k
*Specifying a default diode p n
d1 2 3 di
.model di D()
*Independent DC source of 2V
vdc 3 0 dc 2
*Independent DC source whose voltage is to be varied
vin 1 0 dc 0
*DC Analysis on source vin, to vary from -5 to +5V
.dc vin -5 5 0.01
.control
run
plot v(2) vs v(1)
.endc
```

2.3.2 Circuit and Plot





2.4 Using Subcircuits

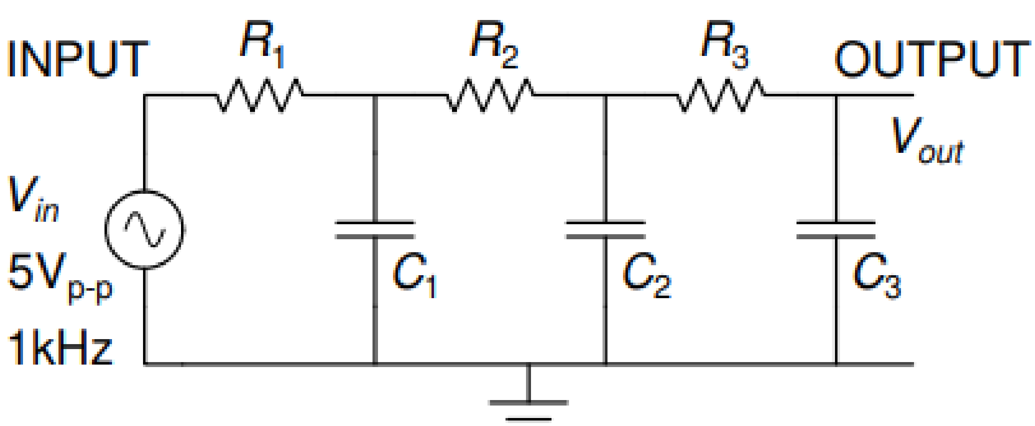
2.4.1 Code

```
*Defining the Subcircuit RC subcircuit: <name> <pin1> <pin2> <pin3>
.subckt RC_subcircuit IN OUT COM
r IN OUT 1K
c OUT com 1u
.ends
```

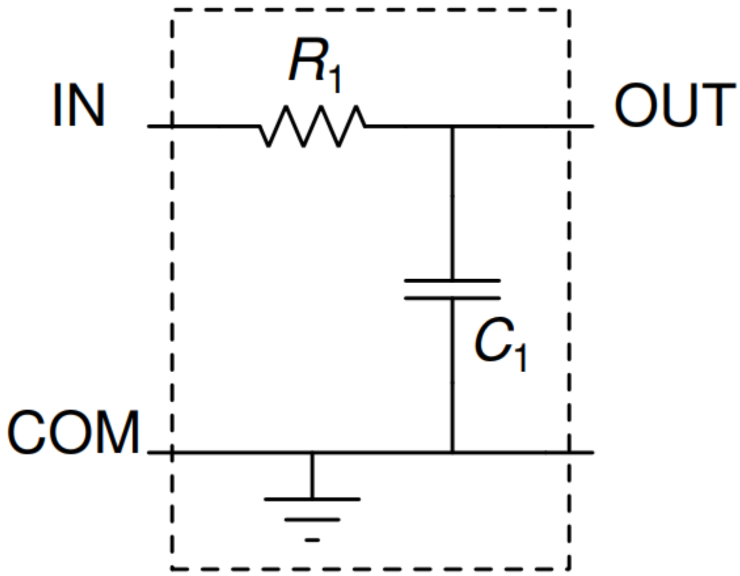
```
*Subcircuit definition ends here
vsin INPUT gnd sin(0 2.5 1K 0 0)
*Invoking RC_subcircuit with an
xrc1 INPUT 1 gnd RC_subcircuit
xrc2 1 2 gnd RC_subcircuit
xrc3 2 OUTPUT gnd RC_subcircuit
.control
tran 0.02m 40m
plot v(INPUT) v(OUTPUT)
.endc
.end
```

```
RC Circuit Transient Analysis using Subcircuits
*Providing some default component values
.subckt RC_subcircuit IN OUT COM r1 = 1k c1 = 1u
r IN OUT {r1}
c OUT COM {c1}
.ends
vsin INPUT gnd sin(0 2.5 1k 0 0)
xrc1 INPUT 1 gnd RC_subcircuit
*Instantiating component values for 2nd subcircuit
xrc2 1 2 gnd RC_subcircuit r1 = 100 c1 = 0.1u
xrc3 2 OUTPUT gnd RC_subcircuit
.control
tran 0.02m 40m
plot v(INPUT) v(OUTPUT)
.endc
.end
```

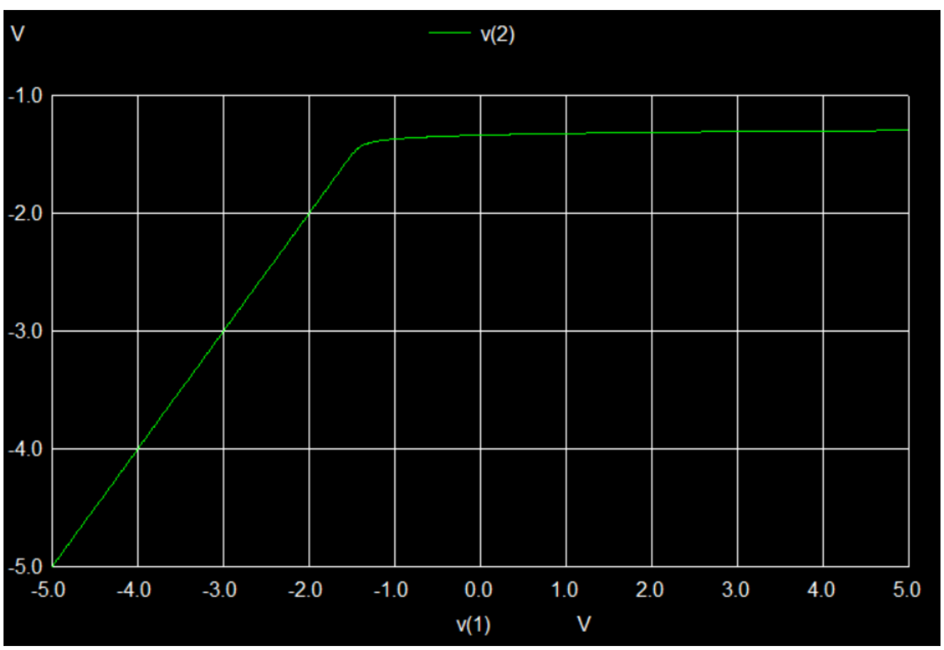
2.4.2 Circuit



2.4.3 RC subcircuit

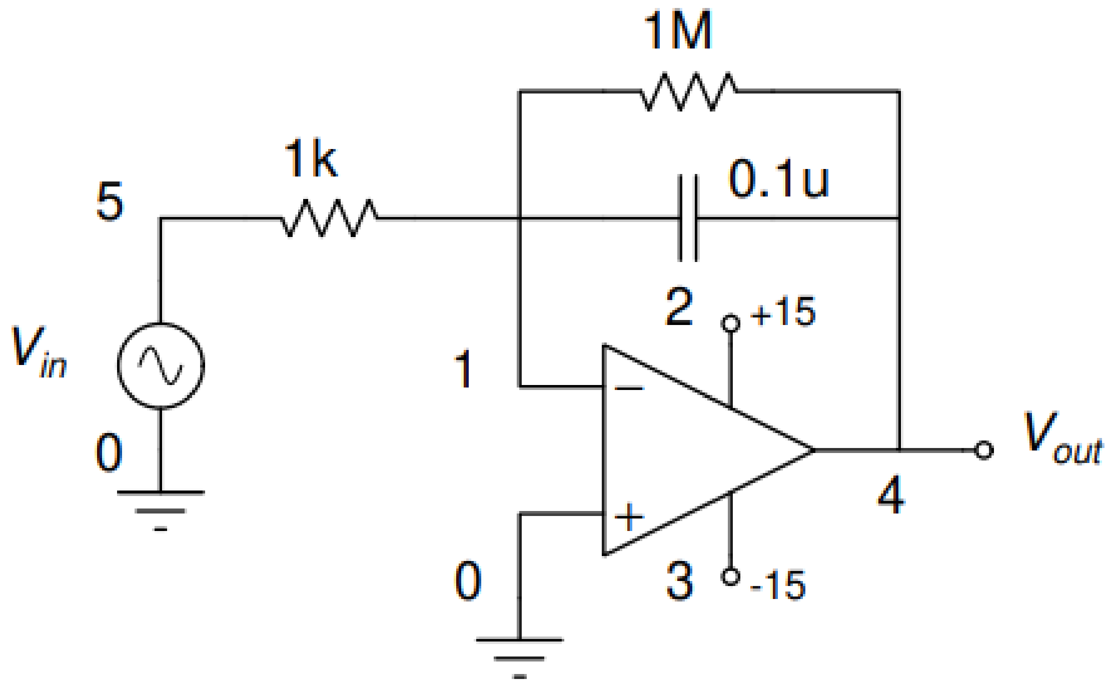


2.4.4 Plot



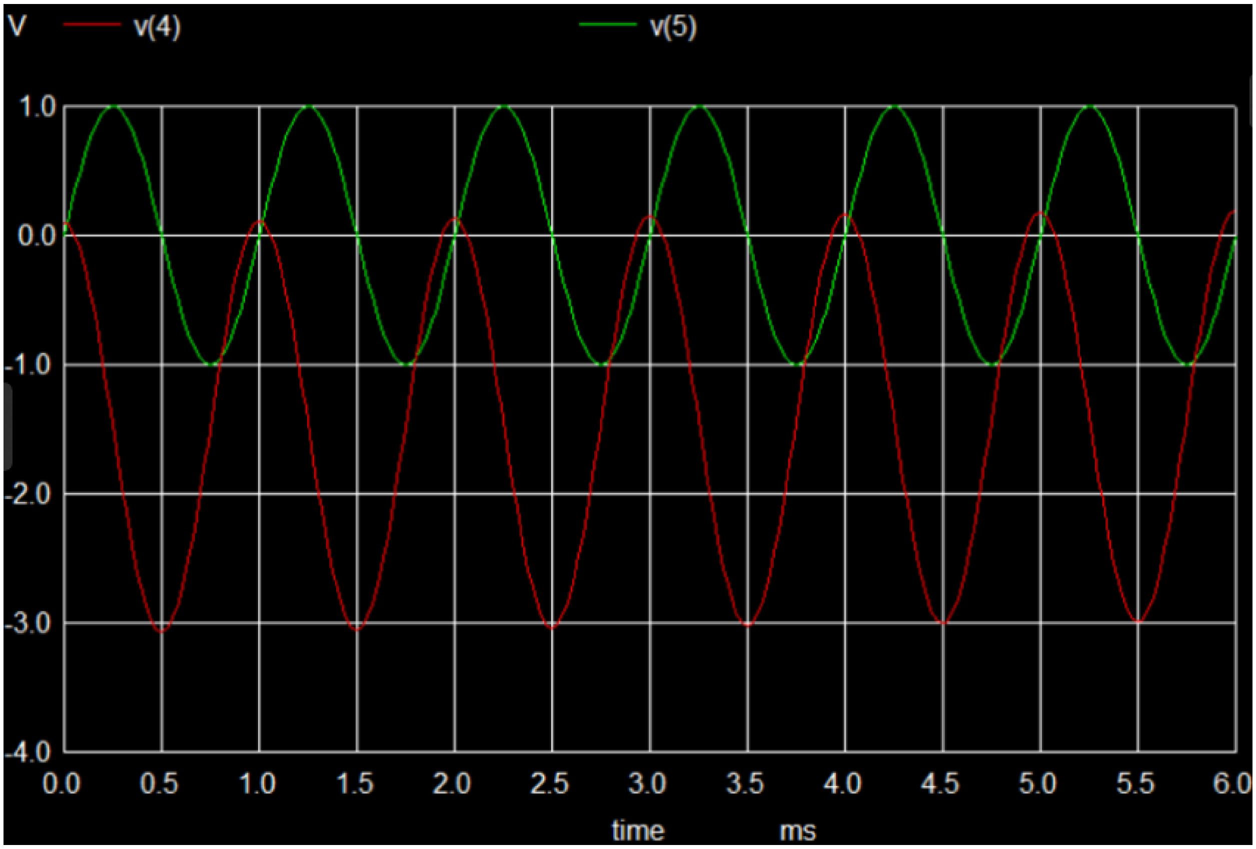
2.5 Using component defined in an external file

2.5.1 Circuit



2.5.2 Code

```
RC Circuit Transient Analysis using Subcircuits
*Providing some default component values
.subckt RC_subcircuit IN OUT COM r1 = 1k c1 = 1u
r IN OUT {r1}
c OUT COM {c1}
.ends
vsin INPUT gnd sin(0 2.5 1k 0 0)
xrc1 INPUT 1 gnd RC_subcircuit
*Instantiating component values for 2nd subcircuit
xrc2 1 2 gnd RC_subcircuit r1 = 100 c1 = 0.1u
xrc3 2 OUTPUT gnd RC_subcircuit
.control
tran 0.02m 40m
plot v(INPUT) v(OUTPUT)
.endc
.end
```



2.5.3 Plot

2.6 Exercises

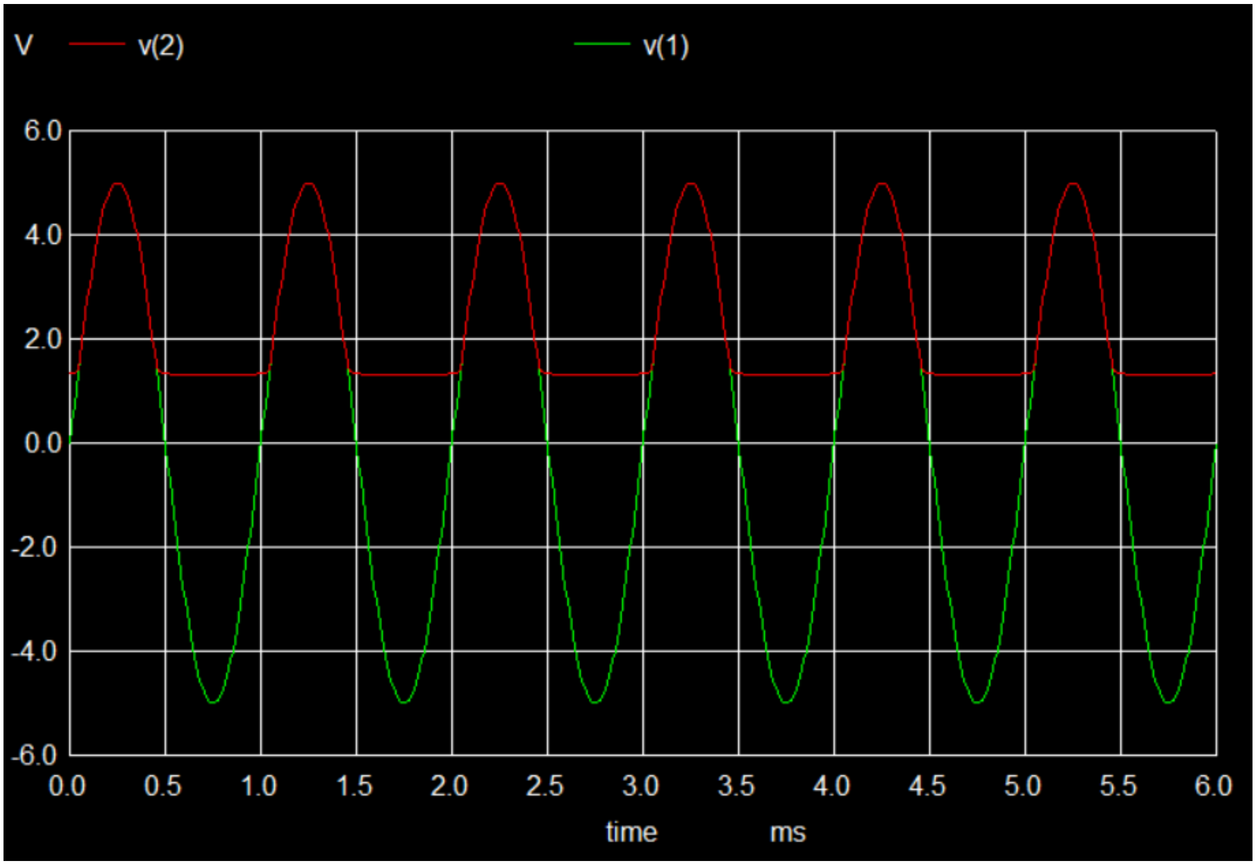
1. **Consider the shunt clipper shown in Example III. Change the following and and simulate to observe Vout v/s Vin variation. For each case, give a 1 kHz sinusoidal input and observe the output waveform (six cycles).:**

   (a) **The diode connections**
   Solution:
   Code:

```
Shunt Clipper DC analysis
r1 1 2 1k
*Specifying a default diode p n
d1 3 2 di
.model di D()
*Independent DC source of 2V
vdc 3 0 dc 2
*Independent DC source whose voltage is to be varied
vin 1 0 sin (0 5v 1k 0 0)
.tran 0.01m 6m
.control
```

```
run
plot v(1) v(2)
.endc
```

Plot:

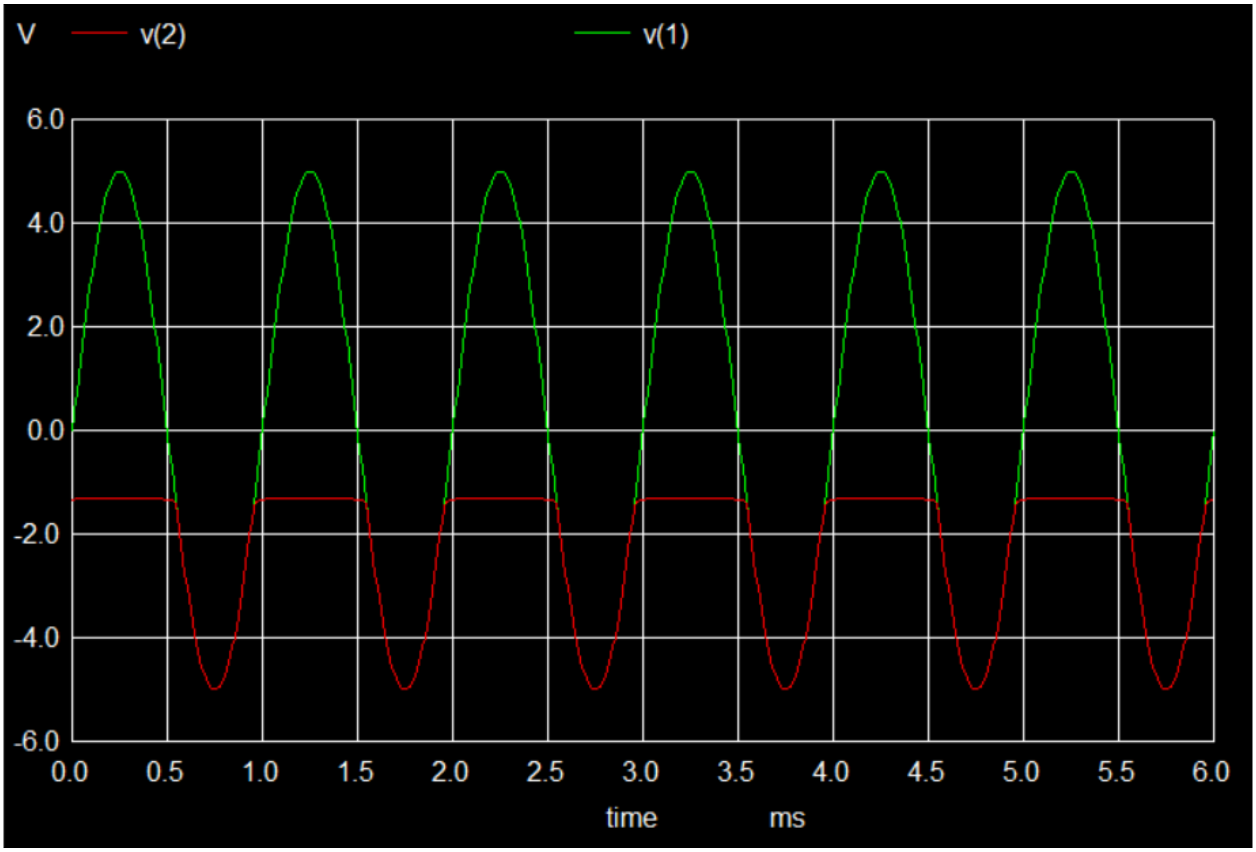


(b) **The 2 V battery polarity Solution:**
Code:

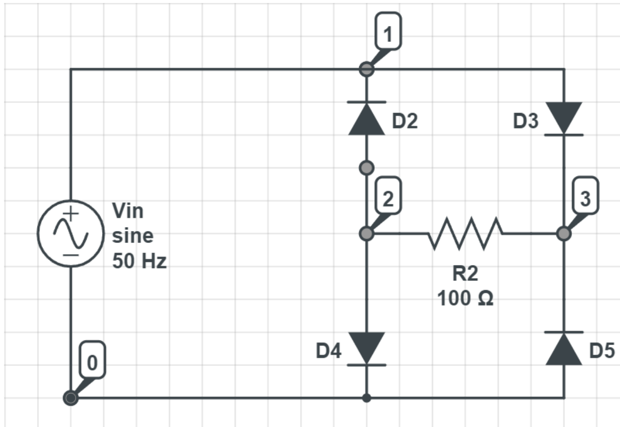
```
Shunt Clipper DC analysis
r1 1 2 1k
*Specifying a default diode p n
d1 2 3 di
.model di D()
*Independent DC source of 2V
vdc 0 3 dc 2
*Independent DC source whose voltage is to be varied
vin 1 0 sin (0 5v 1k 0 0)
.tran 0.01m 6m
.control
run
plot v(1) v(2)
```

```
.endc
```

Plot:



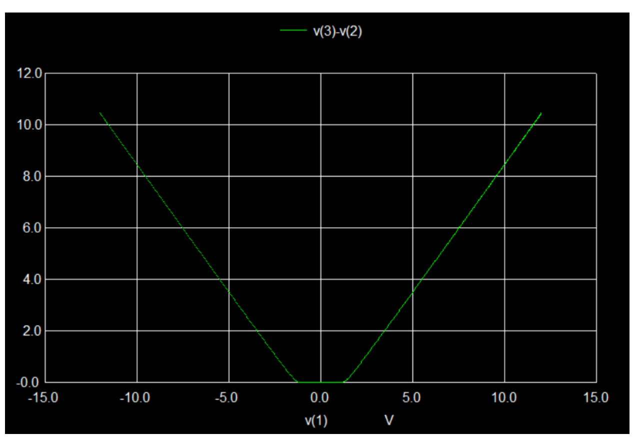
2. **Write an NGSPICE netlist for a diode-based bridge rectifier and simulate it to observe the rectified voltage across a load resistor, by giving a 12 V, 50 Hz input. Also, observe the V_{out} v/s V_{in} transfer characteristics.**
   Circuit:



Code:

```
Bridge rectifier
d0 2 1 a
d1 2 0 a
d2 1 3 a
d3 0 3 a
.model a D()
r1 2 3 100
vin 1 0 sin (0 12v 50 0 0)
.tran 0.01m 100m
.control
run
plot v(3)-v(2) vs v(1)
.endc
```

Plot:



3 NanoHub

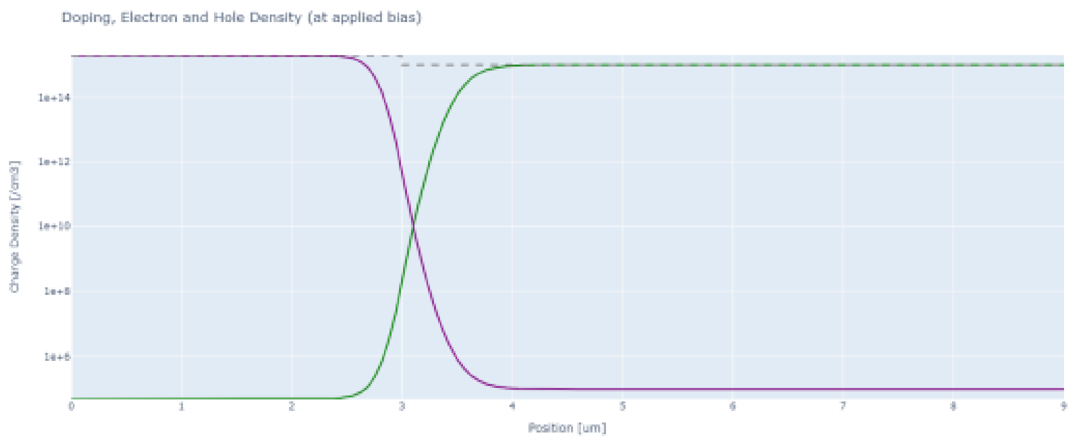


Figure 2: equilbrium

At non equilibrium, these are the plots:

1. Fermi level is different for holes and electrons
2. The electric field is reduced in magnitude due to reduction in depletion region
3. Number of minority carriers has increased on both p and n sides
4. There are 4 graphs each for equilibrium and non equilibrium

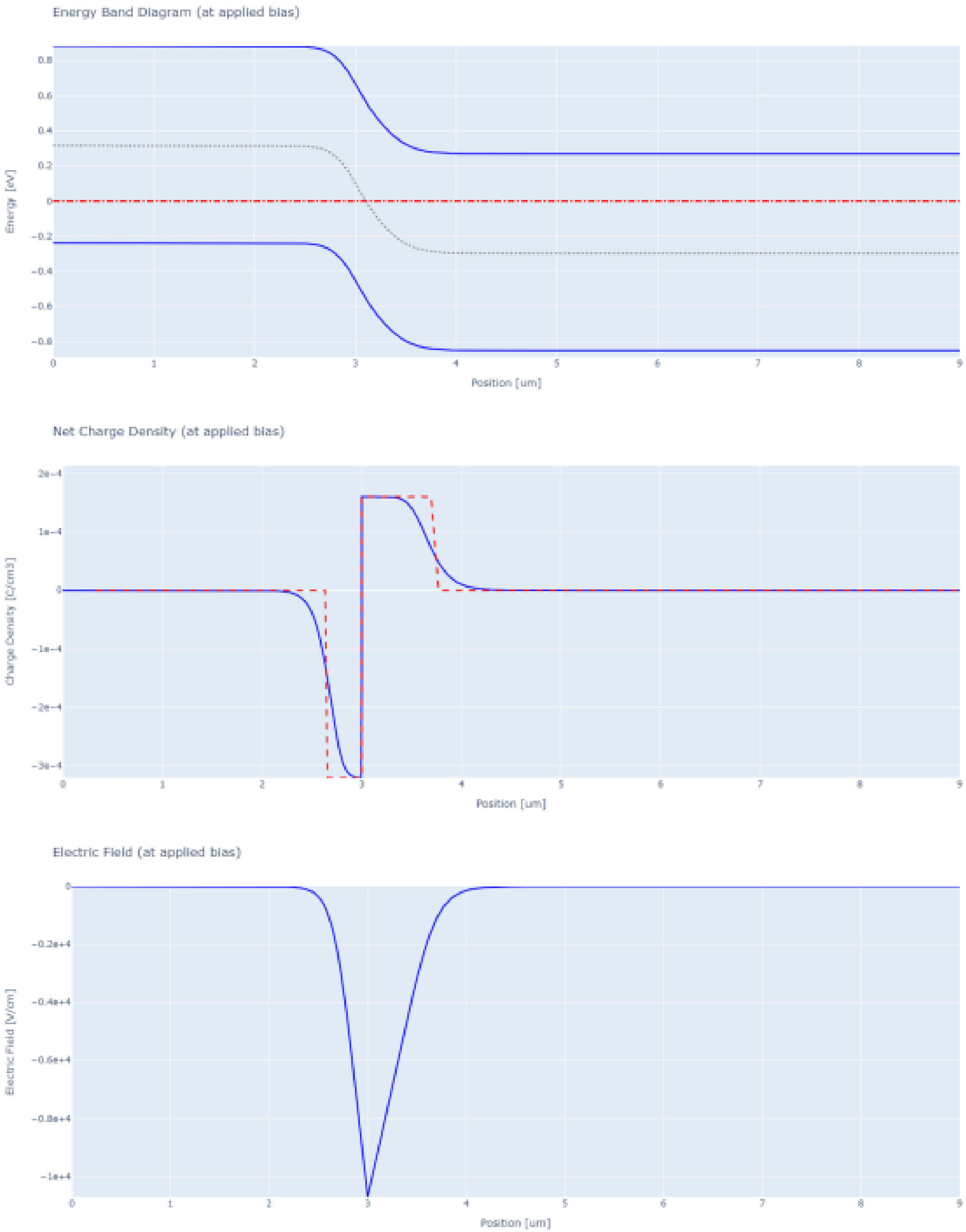


Figure 3: equilbrium

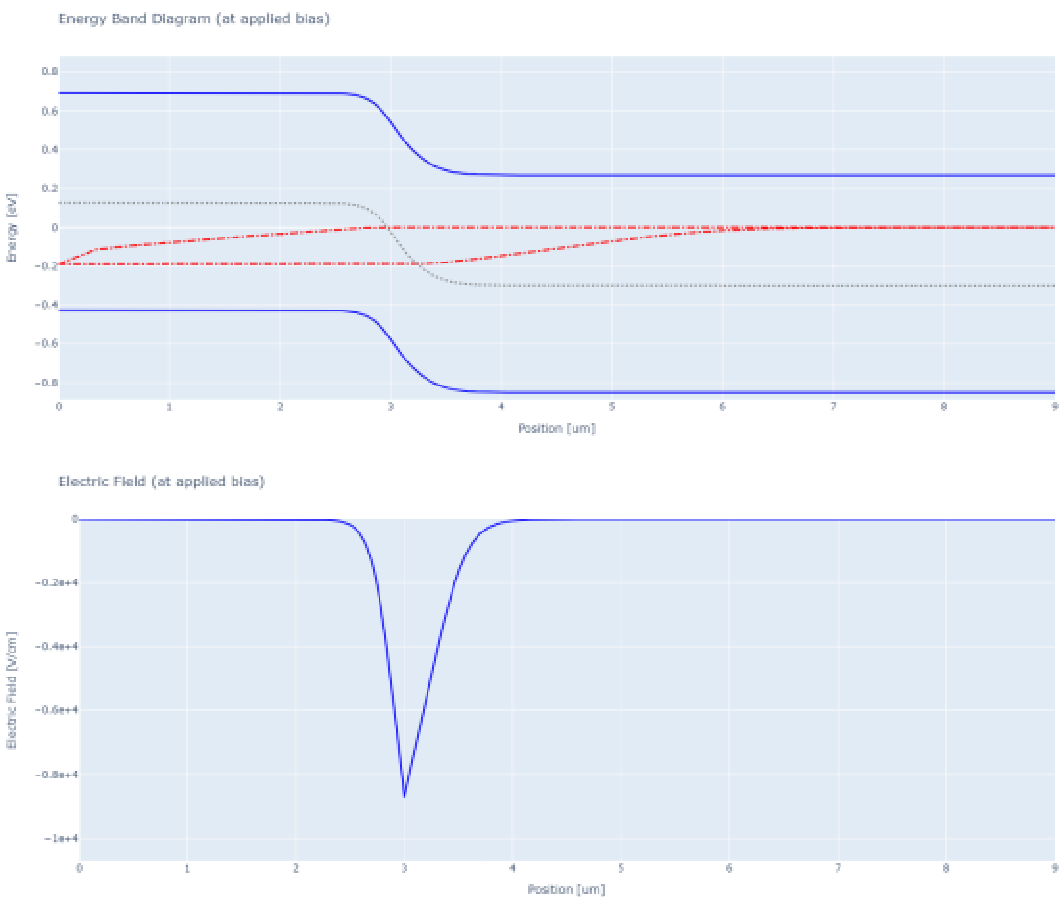


Figure 4: non equilbrium

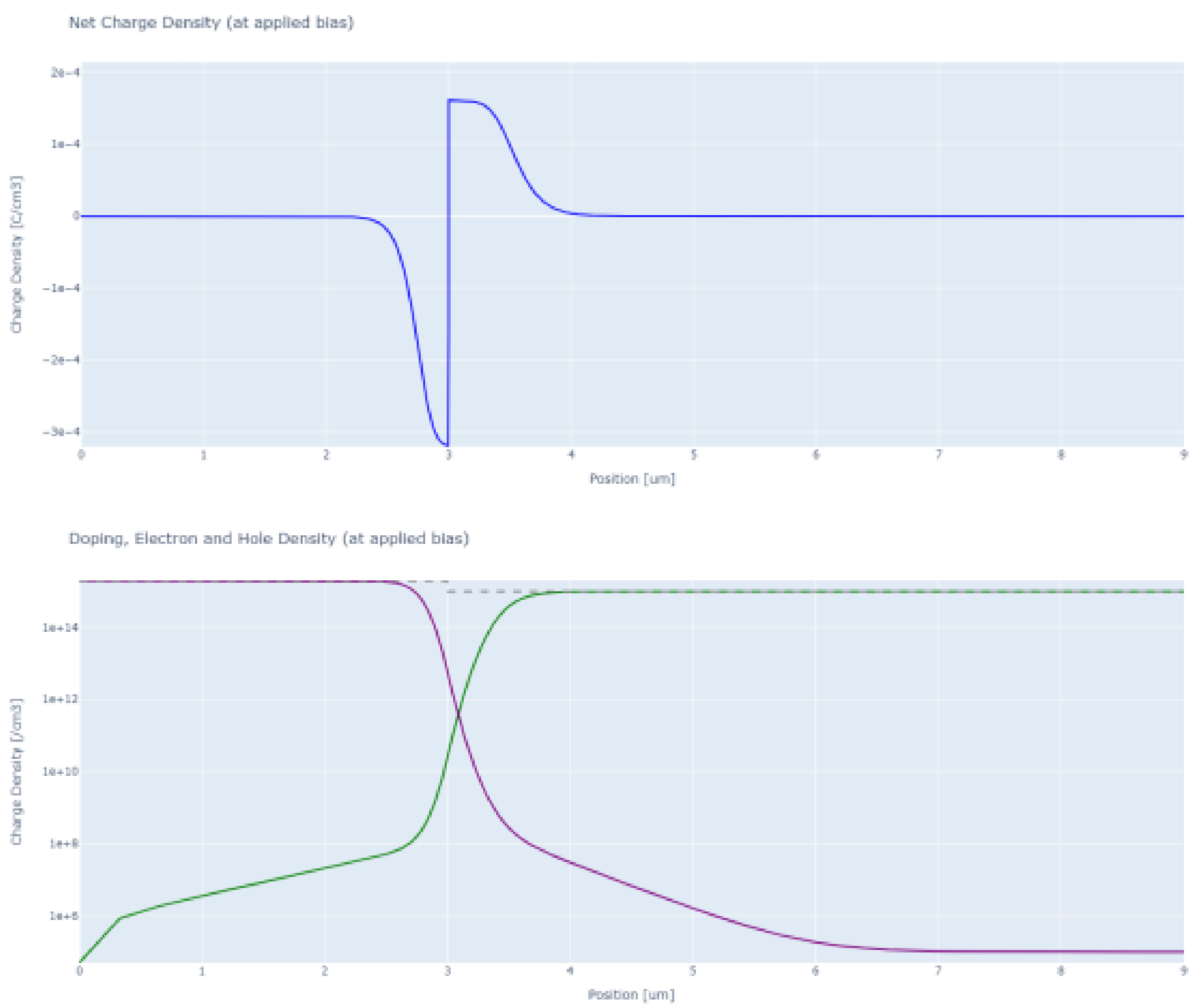


Figure 5: non equilbrium