Summer Fellowship Report

On

Device Modelling in eSim

Submitted by

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Acknowledgment

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We would also like to express our gratitude towards Prof. Mahesh B. Patil for showing us a clear path to the solutions where we were stuck and found ourselves helpless. We would like to thank the eSim team for helping us and providing us all the resources required to work with and guiding us all throughout the project. We are also thankful to our mentors Mr. Sumanto Kar, Mr. Rahul Paknikar, Mr. Nagesh Karmali, Mrs. Madhuri Kadam, Prof. Inderjit Singh Dhanjal, Mrs. Usha Vishwanathan and whole team for the immense support and valuable advices. Their presence and their hard work for us day and night had made our fellowship experience blissful. Moreover, we never forget our fellow friends for assisting us with their fantastic knowledge and superb skills. The work environment is fully energetic and friendly.

We would utilize everything we got from here for our career growth as well as for the betterment of our society.

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Chapter 1

Introduction

FOSSEE (Free/Libre and Open Source Software for Education) project promotes the use of FLOSS tools to improve the quality of education in India. It aims to reduce dependency on proprietary software in educational institutions. It encourages the use of FLOSS tools through various activities to ensure commercial software is replaced by equivalent FLOSS tools. It also develops new FLOSS tools and upgrade existing tools to meet requirements in academia and research. The FOSSEE project is part of the National Mission on Education through Information and Communication Technology (ICT), Ministry of Human Resource Device modelling is one area where measurement and EDA have long collaborated well. The correctness of designs is crucial because they are constructed from device models. However, models are only as good as the measured data that was used to generate them, therefore measurement is essential to obtaining precise and useful device data for modelling. In order to simulate the behaviour of the individual components, they have to be described mathematically. The equations that describe diodes, bipolar (BJT) and a variety of field effect (JFET) and MOS transistors become increasingly complex, sometimes with several equations describing the behaviour of different aspects of device performance in different regions of operation. Different sets of equations may be used to describe devices in the same family of devices, such as MOSFETs, because these sets of equations are heavily depending on the semiconductor physics of devices and the fabrication procedures used to make them. The producer may utilise several sets of equations in order to more accurately or less accurately describe how their products function.In general, the coefficients of the sets of equations are gathered together in the form of a list, even though the equations themselves are deeply buried in a simulator's source code. A list of coefficients, known as a model, can then be used to characterise each individual device in a given device family. The individual coefficients in a model are called the model parameters.

Chapter 2

Problem Statement

Modelling of Electronic Devices in eSim tool, creating the symbols and then simulate the device finally compare the waveforms with the datasheet.

2.1 Approach

There are various ways to model a device some of the ways are:-

- Model Editor tool of eSim

  - Individually add the values of the parameters can be added.

  - Uploading the lib file of the device file in the model editor.

The above operations will create the xml file of the device spice file.

The above method suits well provided that the creator has the spice file with them beforehand. However, it is also possible the spice file/library file is not available in such cases one has to create their own model file for the device, for diode, let say the different parameters can be calculated using the datasheet and and using the pSpice Orcad tool.

Chapter 3

Device Modelling

Device Model means a software model of a specific target architecture device or family of devices used for modeling the internal behavior and programming interfaces of the device(s).

3.1 Diode Family

Diode is a pn junction device, which allows the current to flow in one direction. In this chapter different types of diodes have been discussed.

3.1.1 Si Diode(1N4001)

```
* 1N4001 Diode model
    .MODEL DI-1N4001 D (IS=29.5E-9 RS=73.5E-3 N=1.96 CJO=34.6P
VJ=0.627 M=0.461 BV=60 IBV=10U)
```

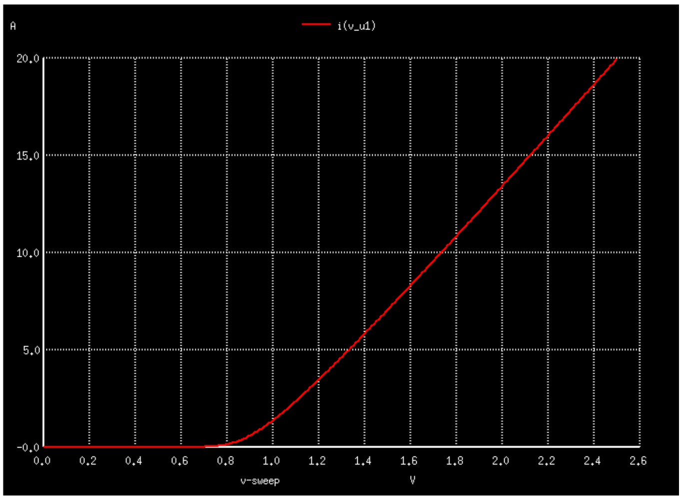

Figure 3.1: Forward Characteristics plotted on eSim

3.1.2 Si Diode(1N4007)

* 1N4007 Diode model
.MODEL DI-1N4007 D (IS=76.9p RS=42.0m BV=1.00k IBV=5.00u $+CJO = 26.5p$ M=0.333 N=1.45 TT=4.32u)

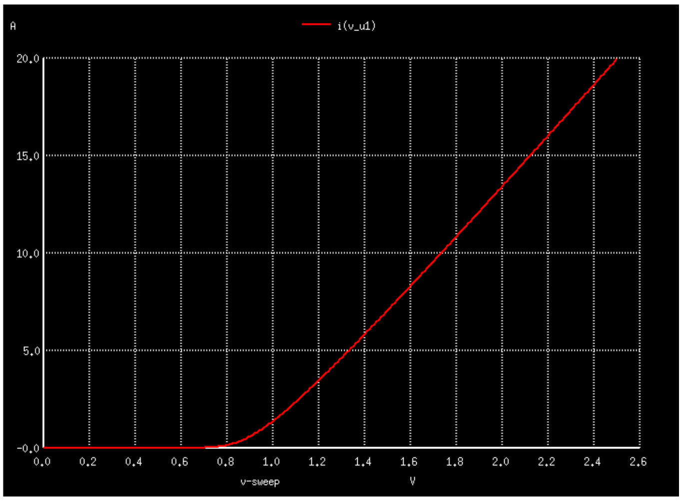

Figure 3.2: Forward Characteristics plotted on eSim

3.1.3 Si Diode(S1B)

* S1B Diode model
.MODEL S1B D (IS=7.31E-018 Rs=42.0m BV=100 IBV=5.00u $+CJO = 42.4p$ M=0.333 N=0.775 TT=4.32u Vj=1)

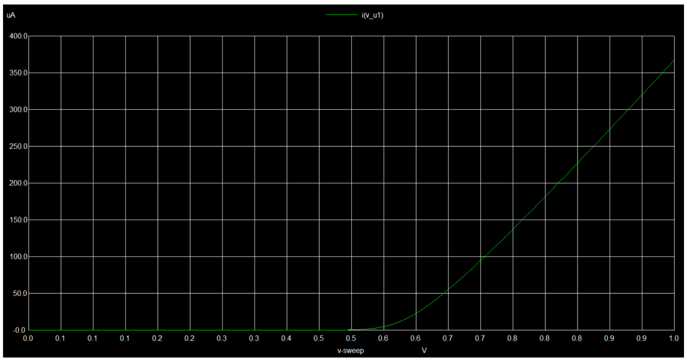

Figure 3.3: Forward Characteristics plotted on eSim

3.1.4 Si Diode(DI_S2M)

* DI_S2M Diode model

.MODEL DI_S2M D (Is=1.30u Rs=8.92m N=2.58 tt=4.32u Cjo=37.0p M=0.333 Vj=0.538 Bv=1.00k Ibv=5.00u)

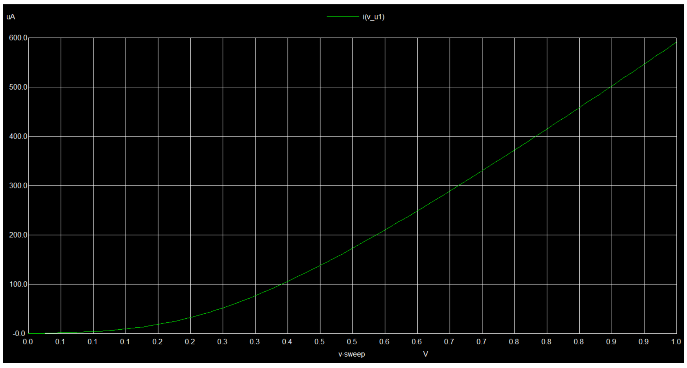

Figure 3.4: Forward Characteristics plotted on eSim

3.1.5 RF Diode(DRN142S)

* DRN142S Diode model

.MODEL DRN142S D (IS=127.76E-12 N=1.7346 RS=.1581 IKF=.14089 CJO=385.59E-15 M=.11823 VJ=.78827 ISR=139.38E-12 NR=3 BV=60 TT=275.00E-9)

3.1.6 Schottky Diode()

* DRN142S Diode model

.MODEL DRN142S D (IS=16.999E-9 N=1.0057 RS=.85033 IKF=49.383E-3 CJO=9.8624E-12 M=1.9579 VJ=9.9900 ISR=170.34E-9 NR=4.9950 BV=30.194 IBV=3.9188E-3 TT=7.2135E-9)

The characteristic of Schottky Diodes is that the threshold voltage is 0.3V unlike 0.7V for silicon diodes.

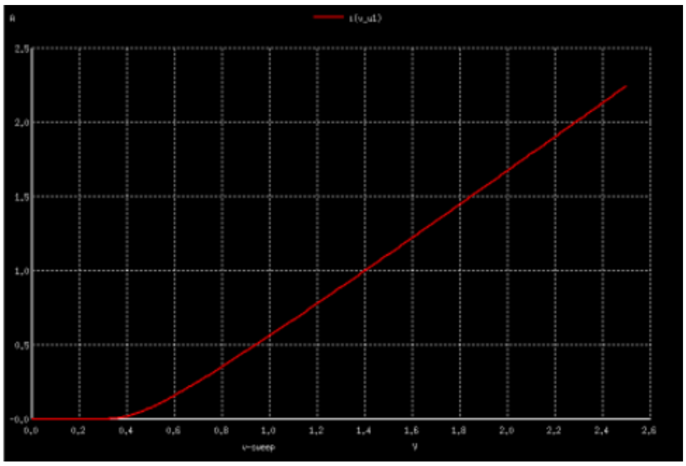

Figure 3.5: Forward Characteristics plotted on eSim

3.2 Light Emitting Diodes (LEDs)

Just like diode the process to model blue led is also the same, it is to be noted here that the forward voltage of the LEDs are higher than the normal diode.

3.2.1 Red LED

.MODEL eSim$_{R}edLED\ D(Is = 1e{-}10\ Rs = 0.1\ N = 4.09\ tt = 4.0e{-}6\ Cjo = 3e - 12\ M = 0.5\ Vj = 0.7\ Bv = 5\ Ibv = 10e - 6\ Fc = 0.5\ Isr = 0.0\ Nr = 2.0\ Kf = 0.0\ Af = 1.0\ Ffe = 1.0\ Xti = 3.0\ Eg = 1.11\ Tbv = 0.0\ Trs = 0.0)$

NOTE: The name of the above LED is set as `eSim_Red_LED` the same name of the LED must be given to the subcircuit while creating the symbol for LED. While the D is the designator for the diode.

3.2.2 Blue LED

Just like diode the process to model blue led is also the same, it is to be noted here that the forward voltage of the LEDs are higher than the normal diode.

3.2.3 Red LED

.MODEL eSim-BlueLED D (Is=1e-10 Rs=0.1 N=6.68 tt=4e-6 Cjo=3e-12 M=0.5 Vj=0.7 Bv=5 Ibv=10e-6 Fc=0.5 Cp=0.0e-12 Isr=0.0 Nr=2.0 Temp=26.85 Kf=0.0 Af=1.0 Ffe=1.0 Xti=3.0 Eg=1.11 Tbv=0.0 Trs=0.0 Ttt1=0.0 Ttt2=0.0 Tm1=0.0 Tm2=0.0 Tnom=26.85 Area=1.0)

3.3 Creation of symbol for diodes

After the generation of model files for the diodes it is equally important to create the symbols so that user can search for them in the place component under eschema window.

The symbol of the diode can be drawn in Library Editor under the eschema window. By clicking the library editor tab and drawing the desired shape the symbols can be made and after the symbol is created pins of the device have to inserted, the pins are available in the right side of the library editor. When the design part is done it is then updated and exported so that it can be found under symbol subcircuit section.

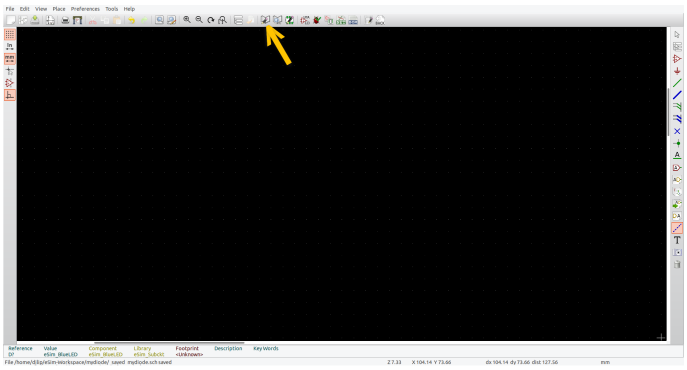

Figure 3.6: Library Editor.

The symbols for Blue LED is shown below.

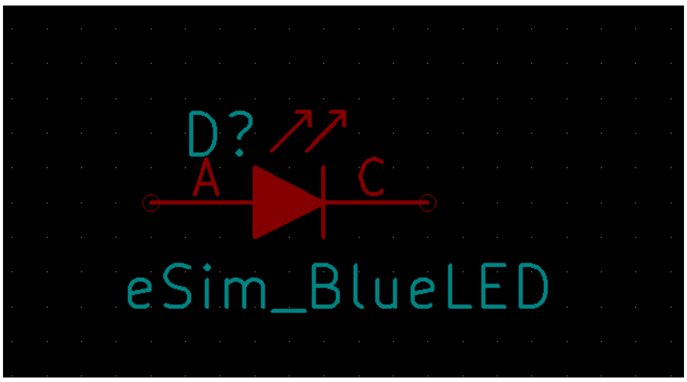

Figure 3.7: Symbol of Blue LED.

The symbols for Red LED is shown below.

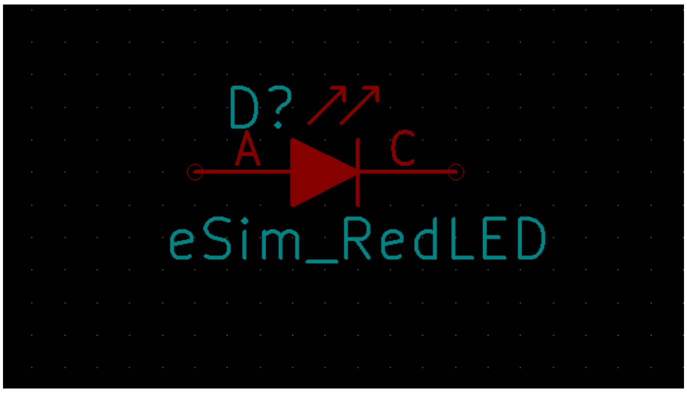

Figure 3.8: Symbol of RED LED.

The symbols for Green LED is shown below.

Figure 3.9: Symbol of Green LED.

The symbols for Yellow LED is shown below.

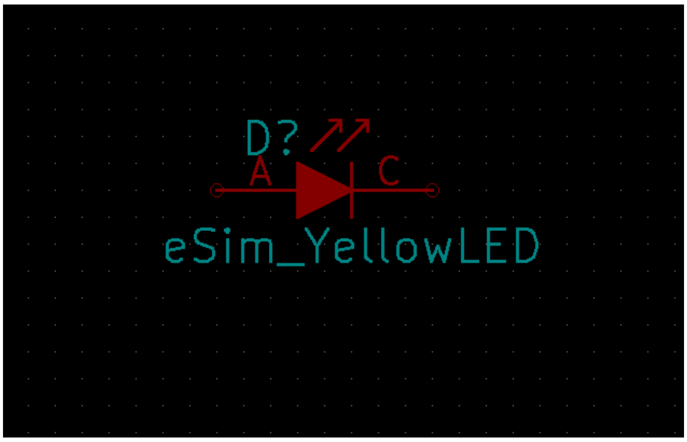

Figure 3.10: Symbol of Yellow LED.

Chapter 4

Device Modelling

4.1 Voltage Controlled Switch

The Voltage Controlled Switch block represents the electrical characteristics of a switch whose state is controlled by the voltage across the input ports (the controlling voltage).

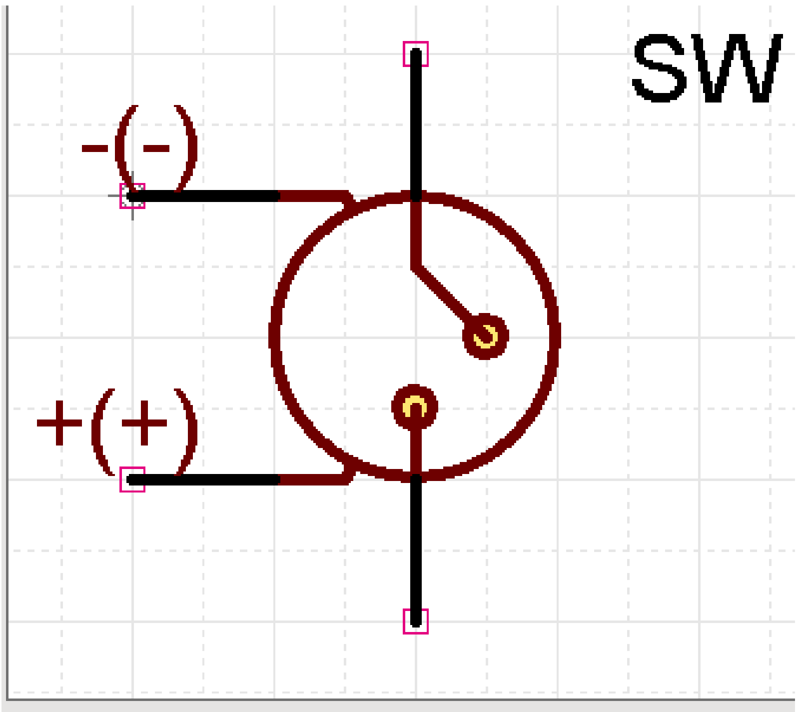

Figure 4.1: Symbol of voltage controlled switch.

This block models either a variable-resistance or a short-transition switch. For a variable-resistance switch, set the Switch model parameter to Smooth transition between Von and Voff. For a short-transition switch, set Switch model to Abrupt transition after delay.

4.1.1 Short-transition Switch

In a short-transition switch, the transition between the off and on states is instantaneous:

When the controlling voltage is greater than or equal to the sum of the

- Threshold voltage=VT and
- Hysteresis voltage=VH parameter values,

the switch is closed and has a resistance equal to the

- On resistance=RON parameter value.

When the controlling voltage is less than the Threshold voltage, VT parameter value minus the Hysteresis voltage, VH parameter value, the switch is open and has a resistance equal to the Off resistance, ROFF parameter value.

When the controlling voltage is greater than or less than the Threshold voltage, VT parameter value by an amount less than or equal to the Hysteresis voltage, VH parameter value, the voltage is in the crossover region and the state of the switch remains unchanged.

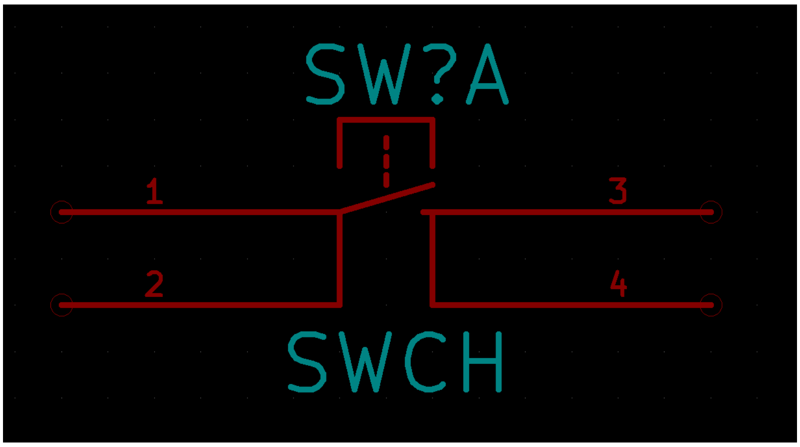

Figure 4.2: Symbol of voltage controlled switch.

The schematic to test the proposed voltage controlled switch is shown below. It is a simple circuit where a pulse source is connected to the switch followed by a resistor.

When the switch is turned ON, then at the Vout the source voltage can be obtained, however, the switch model is given some value for Ron meaning the amount of ron will be offered by the switch when it is turned ON.

Similarly, when it is turned off then it will offer the resistance set in roff. Refer switch1 model file below.

4.1.2 switch circuit

.model	switch1	sw(vt=0.05	vh=1	ron=1	roff=1e12)

The schematic diagram for switch circuit is shown below.

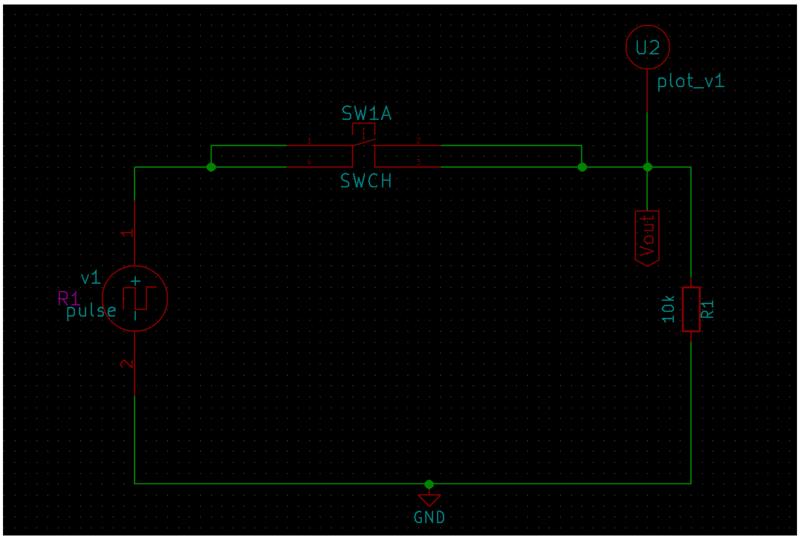

Figure 4.3: Schematic diagram of switch circuit.

The cir.out file of the switch is shown below-

```
* /home/dilip/esim-workspace/switch_testbed/switch_testbed.cir

.include switch1.lib
v1 net-_sw1-pad1_ gnd pulse(0 5 5n 1n 1n 20n 40n)
r1 vout gnd 10k
* u2 vout plot_v1
sw1 net-_sw1-pad1_ vout vout net-_sw1-pad1_ switch1 on
.tran 1e-09 70e-09 50e-09

* Control Statements
.control
run
print allv > plot_data_v.txt
print alli > plot_data_i.txt
plot v(vout)
.endc
.end
```

The corresponding output wave is shown below.

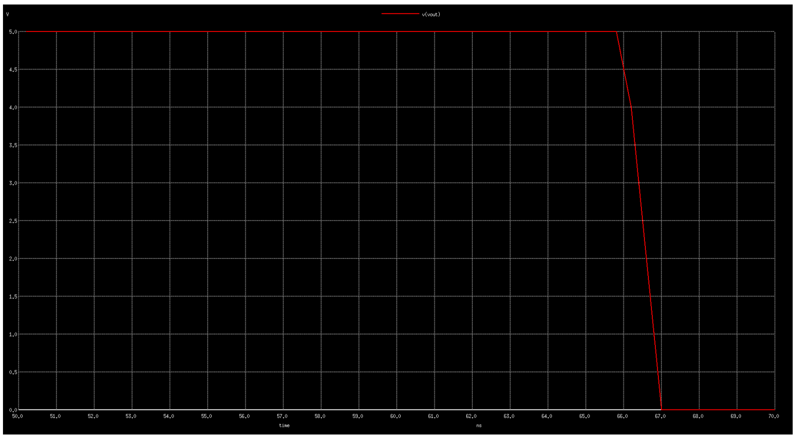

Figure 4.4: Output waveform.

Chapter 5

Transmission Line

Transmision lines are used to carry Radio Frequency(RF) power from one place to another, and to do this as efficiently as possible.

In this section the lossless and lossy transmission lines will be discussed along with the simulation results.

5.1 Lossless transmission line

A transmission line having no line resistance or no dielectric loss is said to be a lossless transmission line. It means that the conductor would behave as a superconductor and dielectric would be made of perfect dielectric medium. In a lossless transmission line, power sent from a generating point would be equal to power received at the load end. There is no power dissipation in the line itself.

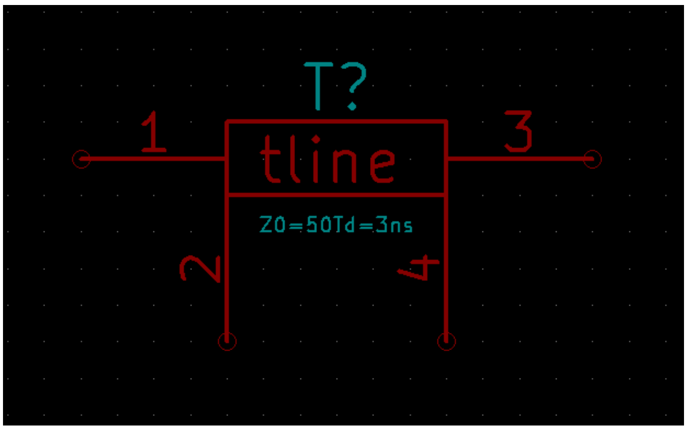

Figure 5.1: Symbol of lossless transmission line.

NOTE: We have to put one space between Z0=50 and Td=3ns
This can be done in the cir.out file after creating the circuits and converting kiCad to NgSpice.

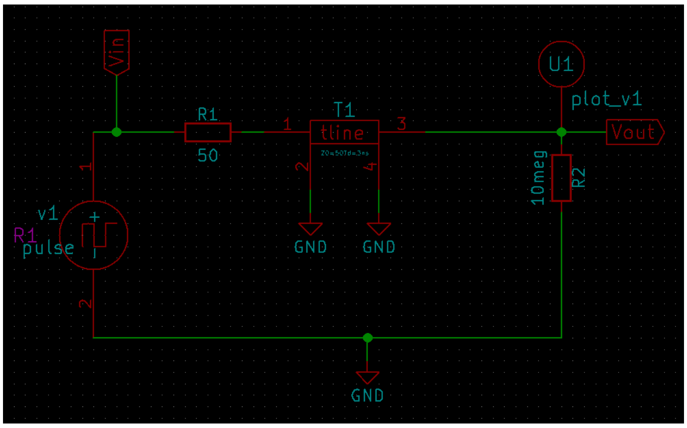

Figure 5.2: Schematic diagram of lossless transmission line for transient analysis.

The simulation results of the above tline is shown below:-

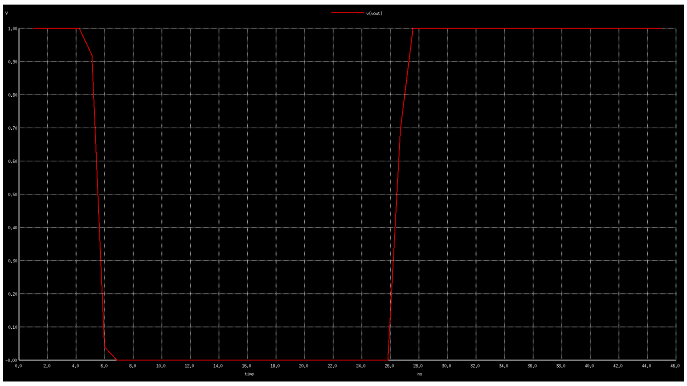

Figure 5.3: Output waveform

5.2 Single Lossy Transmission Line

An appreciable value of series resistance and shunt conductance make up a lossy transmission line, which allows different frequencies to transmit at various speeds. In contrast, on a lossless transmission line, wave propagation rates are constant across all frequencies. As waves move towards the load end of the lossy transmission line, distortion is caused by a change in speed.

The symbol for Single Lossy Transmission Lines(SLTL) is shown below-

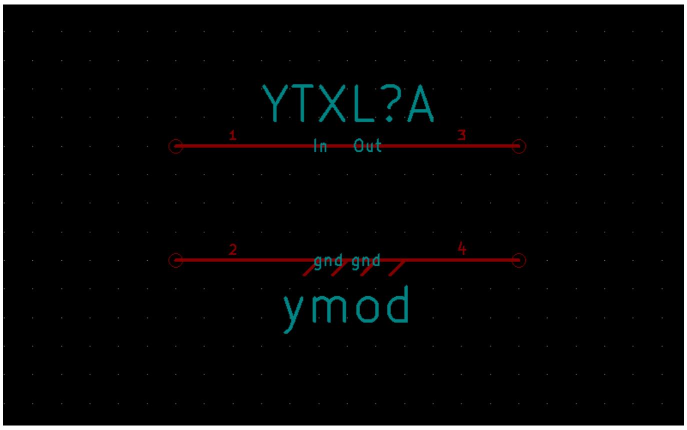

Figure 5.4: Symbol of SLTL.

The cir.out file of single lossy transmission line is shown below:-

```
* /home/dilip/esim-workspace/sltl_testbed/sltl_testbed.cir

.include ymod.lib
v1  net-_r1-pad1_ gnd pulse(0 1 5n 1n 1n 20n 40n)
r2  output gnd 10meg
r1  net-_r1-pad1_ input 50
ytxl1 input gnd output gnd ymod
* u1  input plot_v1
* u2  output plot_v1
.tran 0.1e-09 45e-09 0e-09

* Control Statements
.control
run
print allv > plot_data_v.txt
print alli > plot_data_i.txt
plot v(input) v(output)
.endc
.end )
```

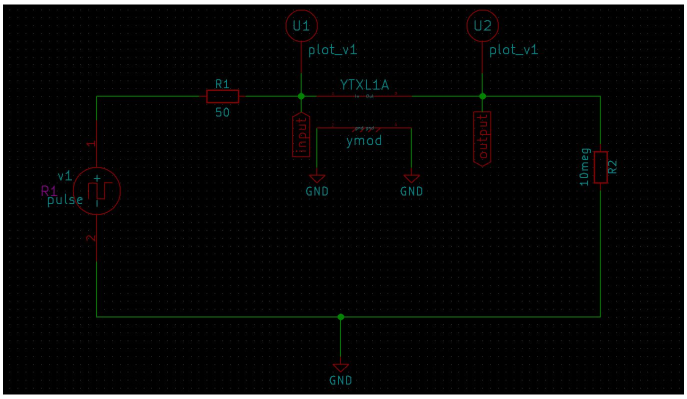

Figure 5.5: Schematic diagram of lossy transmission line for transient analysis.

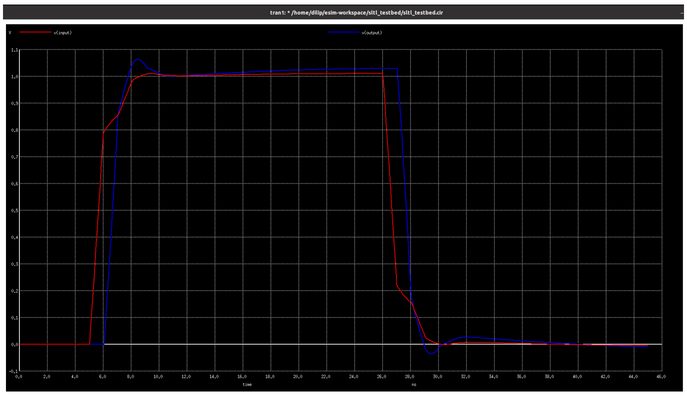

Figure 5.6: Output waveform.

Chapter 6

Resonant Circuit for Gallium Nitride Gunn Diode

Gunn diodes are two-terminal negative differential resistance (NDR) devices that, when coupled to a suitably tuned ac resonator, generate RF power.

"Gunn Diode" is not a device in SPICE, so needed an equivalent subcircuit that exhibits the negative differential resistance(NDR) V-I curve. This project's goal is to simulate a circuit that the Gunn Diode fits into, that produce oscillation. Place that subcircuit into a simple resonant circuit and demonstrate oscillation.

6.1 Gunn diode

Gunn diode consists of a uniformly doped n-type III-V material (e.g., GaAs, InP) sandwiched between heavily doped regions at each termina If the diode is placed in a cavity or resonant circuit so that its negative resistance cancels the resistance of the resonator, then the circuit oscillates without attenuation and emits electromagnetic radiation.

The subcircuit for Gunn diode is designed and simulated in the eSim tool and the results are obtained.

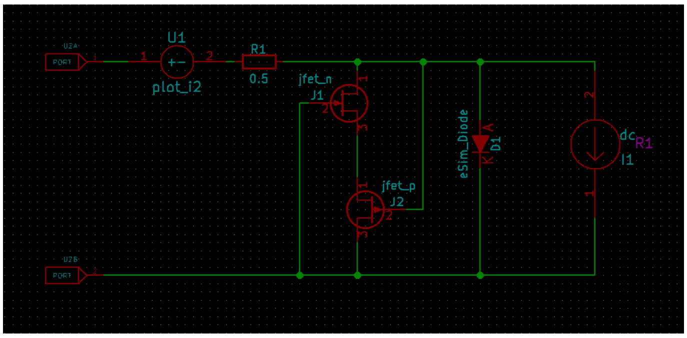

Figure 6.1: Subcircuit of gunn diode.

The schematic diagram of Gunn diode for IV characteristics is shown below-

The cir.out file of the project is shown below

*

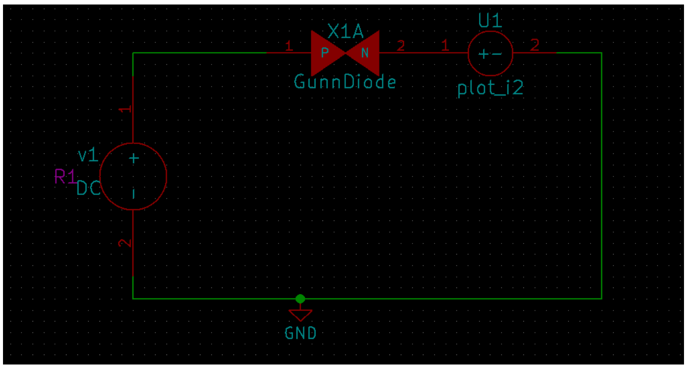

Figure 6.2: Schematic diagram of Gunn diode IV characteristics circuit.

```
.include GunnDiode.sub
v1 net-_x1-pad1_ gnd dc 11
* u1 net-_u1-pad1_ gnd plot_i2
x1 net-_x1-pad1_ net-_u1-pad1_ GunnDiode
v_u1 net-_u1-pad1_ gnd 0
.dc v1 0e-00 11e-00 0.1e-00

* Control Statements
.control
run
print allv > plot_data_v.txt
print alli > plot_data_i.txt
plot i(v_u1)
.endc
.end
```

The below waveform shows the I vs V characteristics of the Gunn diode.

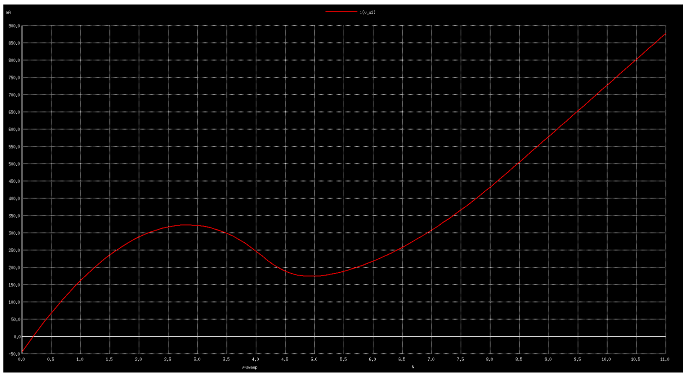

Figure 6.3: Characteristic of Gunn diode.

Chapter 7

Bipolar Junction Transistors (BJTs)

Bipolar Junction Transistors (BJTs) are three terminal semiconductor devices used to amplify signals. They consist of 2 PN Junction diodes attached side by side helping to get an amplifying effect on input signals. There are two types of BJTs - PNP and NPN as shown in the figure below.

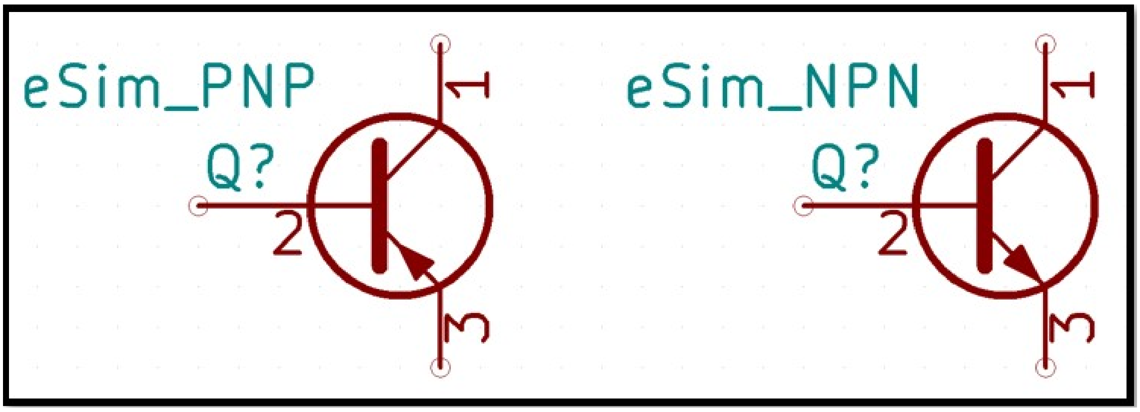

Figure 7.1: PNP and NPN BJTs

Several characteristic graphs can be used to determine aspects a BJT model. Some of the standard graphs are given below. The parameter beta which is the ratio of collector current to base current is important in deciding the gain of a BJT amplifier

7.1 NPN Transistors

The construction and terminal voltages for a bipolar NPN transistor are shown below. The voltage between the Base and Emitter (VBE), is positive at the Base and negative at the Emitter because for an NPN transistor, the Base terminal is always positive with respect to the Emitter

The following circuits are used to test characteristics and small signal gains of various transistors.

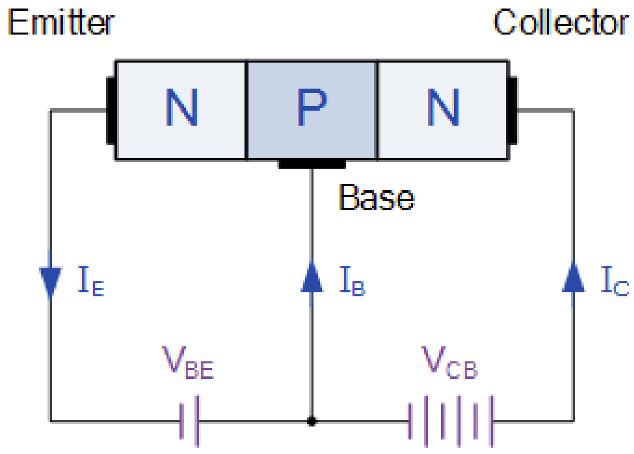

Figure 7.2: NPN Transistor Connections

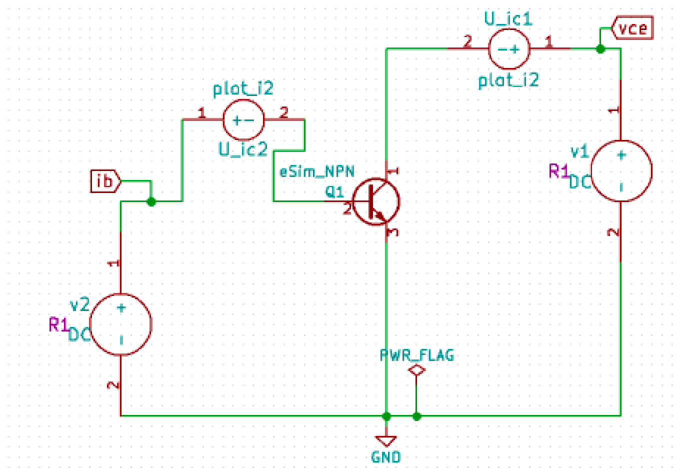

Figure 7.3: To test DC characteristics

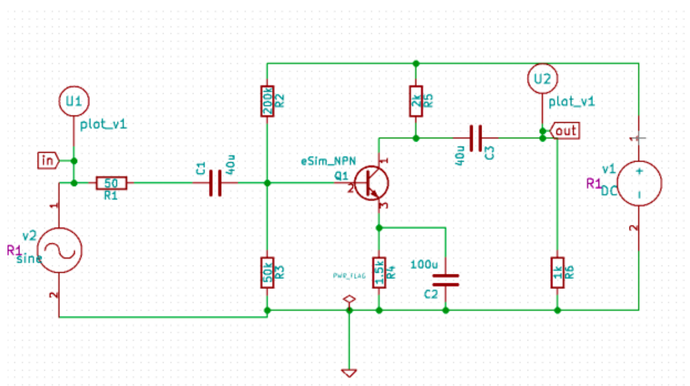

Figure 7.4: To test small signal gain

7.1.1 BJT BC141

BJT BC 141 is a general purpose transistor with beta > 100.

* BC141 model

.MODEL sm_NPN NPN (IS=11.1f NF=1.00 BF=95.8 VAF=139 IKF=0.364 ISE=46.8p NE=2.00 BR=4.00 NR=1.00 VAR=28.0 IKR=0.900 RE=0.120 RB=0.482 RC=48.2m XTB=1.5 CJE=193p VJE=1.10 MJE=0.500 CJC=22.4p VJC=0.300 MJC=0.300 TF=3.03n TR=1.39u EG=1.12)

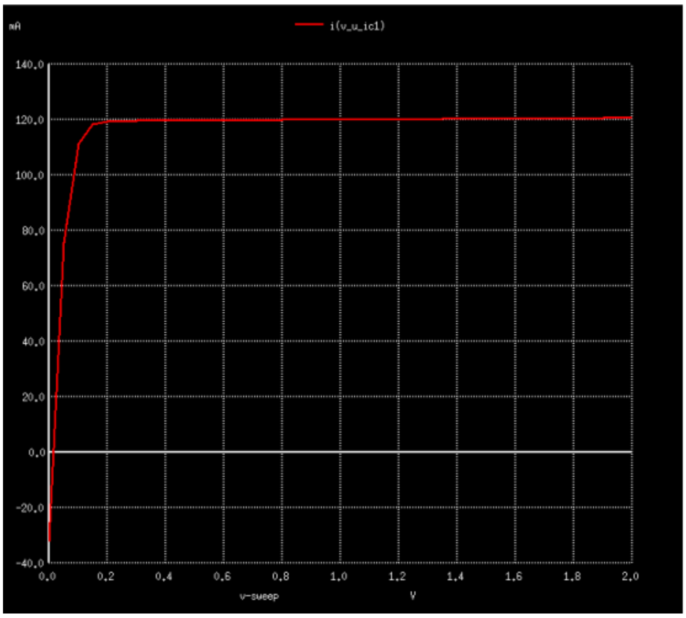

Figure 7.5: Ic vs Vce BJT BC141

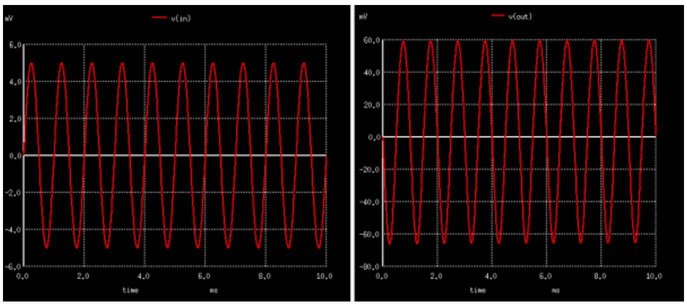

Figure 7.6: Small Signal Amplification using BJT BC141 (gain 10

7.1.2 BJT BC864A

BJT BC141 is a general purpose NPN planar transistor. It is a surface mounted device and works for larger Vce voltages

* BC864A model

.MODEL BC846A NPN (IS=17.466E-15 BF=75 VAF=7.0819 IKF=23.987E-3 ISE=1.5775E-12 NE=2 BR=14.747 VAR=100 IKR=3.9712 ISC=17.673E-15 NC=1.1027 NK=.3263 RB=8.9231 RC=.80911 CJE=16.519E-12 VJE=.35 MJE=.45959 CJC=4.6028E-12 VJC=.35 MJC=.45463 TF=332.69E-12 XTF=43.018 VTF=17.355 ITF=158.43 TR=5.8334E-9)

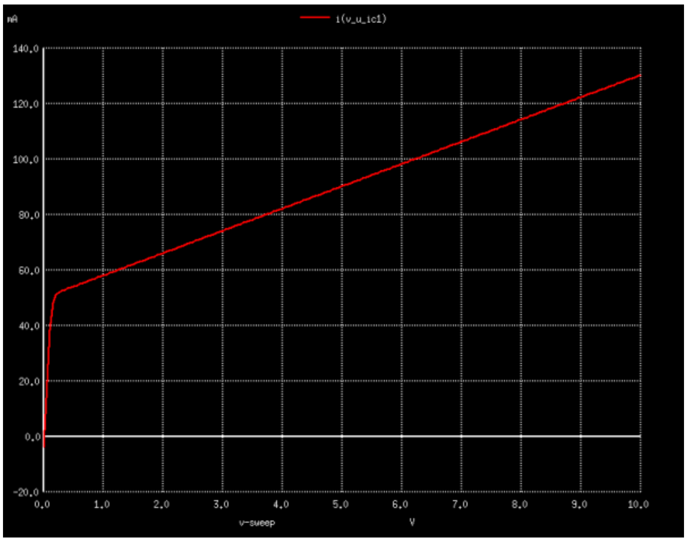

Figure 7.7: Ic vs Vce BJT BC864A

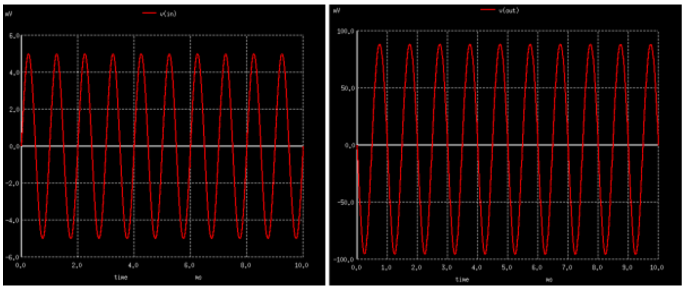

Figure 7.8: Small Signal Amplification using BJT BC864A (gain 20

7.1.3 BJT BCV72

BJY BCV72 is a general purpose NPN transistor with beta as 200

* BCV72 model

.MODEL BCV72 NPN (IS=18.500E-15 BF=232 VAF=210 IKF=1.0500 ISE=1.0000E-15 NE=1.7500 BR=6.4500 VAR=100 IKR=.5 ISC=8.0000E-15 NC=1.1827 NK=.75 RB=21 RC=.98586 CJE=14.168E-12 VJE=.8126 MJE=.38593 CJC=5.1317E-12 VJC=.5341 MJC=.41426 TF=1.1700E-9 XTF=2.0000E3 VTF=3.5000 ITF=4 TR=87.500E-9)

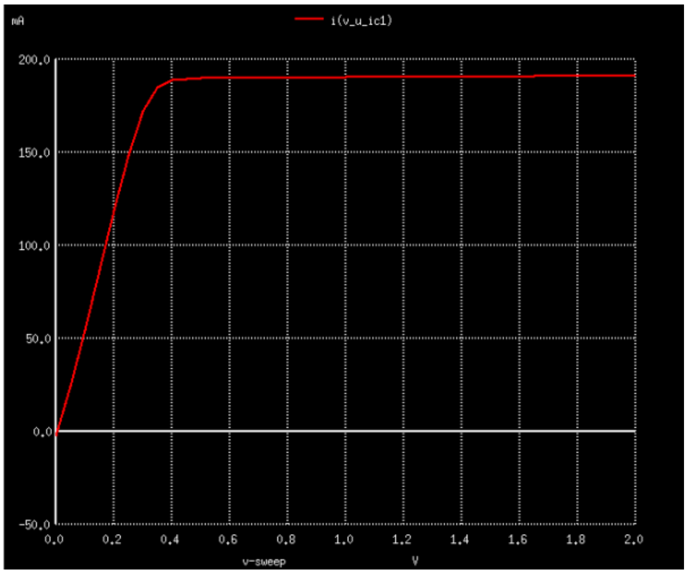

Figure 7.9: Ic vs Vce BJT BCV72

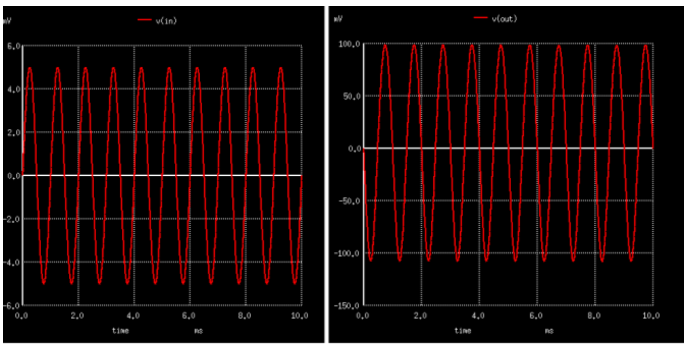

Figure 7.10: Small Signal Amplification using BJT BCV72 (gain 20)

7.1.4 BJT 2N3904

2N3904 BJT is a NPN transistor which has high gain and low saturation voltage.

* 2N3904 model

.MODEL 2N3904 NPN(IS=1.4E-14 BF=300 VAF=100 IKF=0.025 ISE=3E-13 BR=7.5 RC=2.4 CJE=4.5E-12 TF=4E-10 CJC=3.5E-12 TR=2.1E-8 XTB=1.5 KF=9E-16)

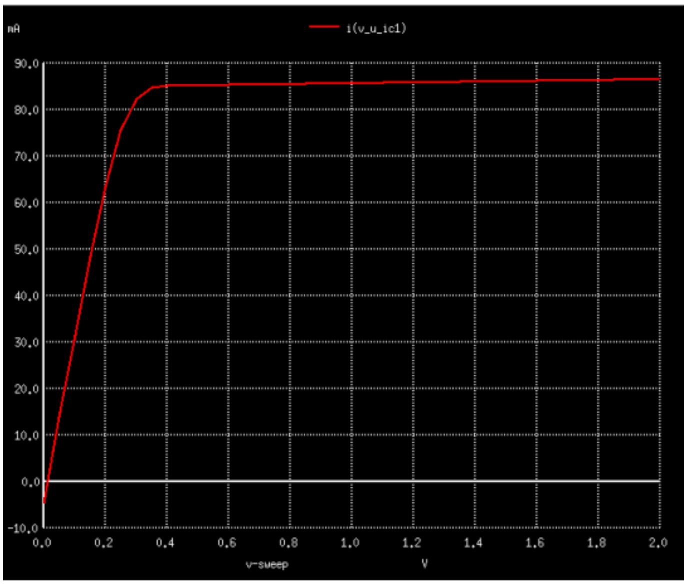

Figure 7.11: Ic vs Vce BJT 2N3904

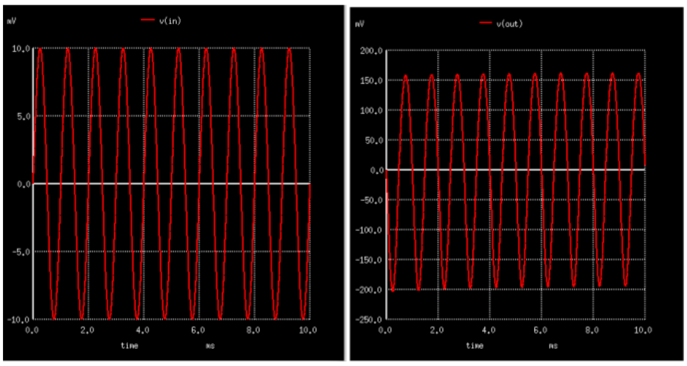

Figure 7.12: Small Signal Amplification using BJT 2N3904 (gain 20)

7.1.5 BJT BC557

BC 557 BJT is a PNP transistor which has High-Voltage.

* BC$_5$57*model*

.MODEL BC557 PNP(Is=3.834E-14 Xti=3 Eg=1.11 Vaf=21.11 Bf=800 Ne=1.528 Ise=1.219E-14 Ikf=0.08039 Xtb=0 Br=14.84 Nc=1.28 Isc=2.852E-13 Ikr=0.047 Rc=0.5713 Cjc=1.084E-11 Mjc=0.3563 Vjc=0.1022 Fc=0.8027 Cje=1.23E-11 Mje=0.378 Vje=0.6106 Tr=1E-32 Tf=5.595E-10 Itf=0.1483 Vtf=5.23 Xtf=3.414 Rb=1)

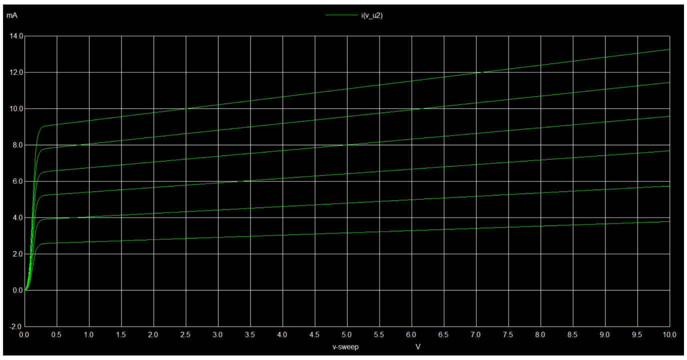

Figure 7.13: Ic vs Vce BJT BC557

7.1.6 BJT BC547B

BC 547 BJT is a NPN transistor.

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* BC$_5$47*model*

.MODEL BC547B NPN(IS=1.8E-14 BF=400 NF=0.9955 VAF=80 IKF=0.14 ISE=5E-14 NE=1.46 BR=35.5 NR=1.005 VAR=12.5 IKR=0.03 ISC=1.72E-13 NC=1.27 RB=0.56 RE=0.6 RC=0.25 CJE=1.3E-11 TF=6.4E-10 CJC=4E-12 VJC=0.54 TR=5.072E-8)

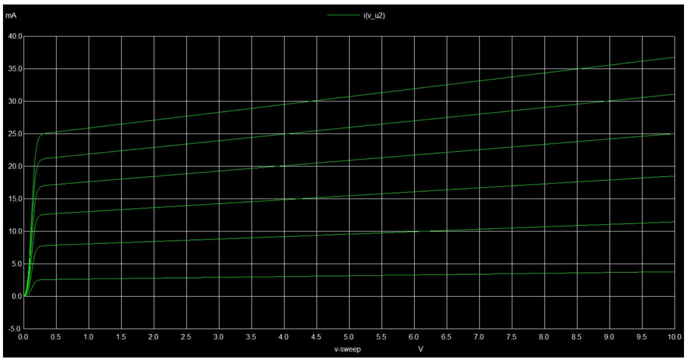

Figure 7.14: Ic vs Vce BJT BC547B

Chapter 8

Junction field-effect transistor(JFET)

Junction Field Effect Transistor is one of the simplest types of field-effect transistor. It is opposite to the Bipolar Junction Transistor(BJT), It is a voltage-controlled devices. In JFET, the current flow is due to the majority of charge carriers, however, in BJTs, the current flow is due to both minority and majority charge carriers. Since only the majority of charge carriers are responsible for the current flow, JFETs are unidirectional. There are two types of JFETs - N-Channel and P-Channel as shown in the figure below.

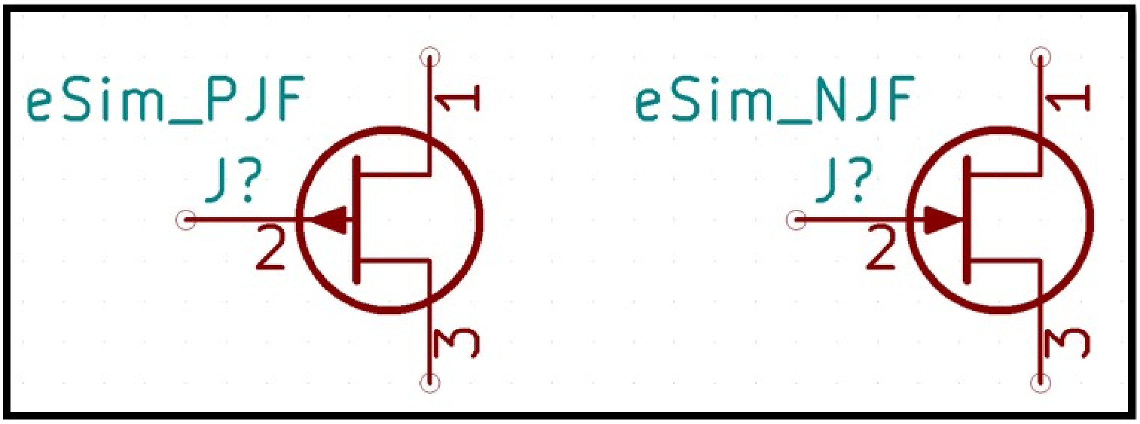

Figure 8.1: P-Channel and N-Channel JFET's

Several characteristic graphs can be used to determine aspects a JFET model. Some of the standard graphs are given below.

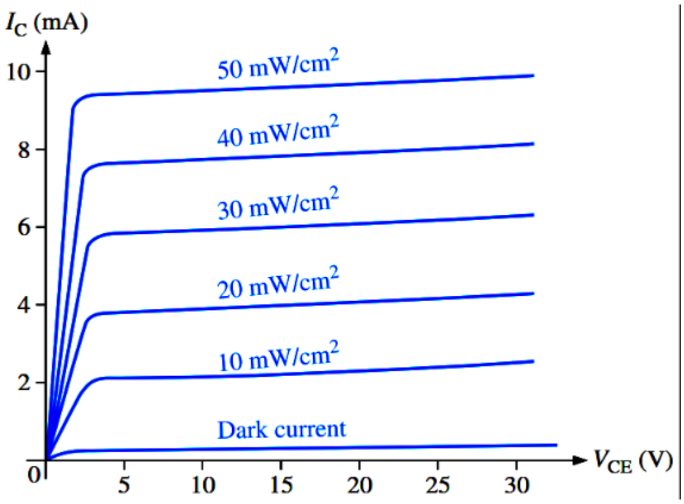

Figure 8.2: Ic vs Vbe for JFET

Some JFET Spice Models are given in the next sections

8.1 N-Channel Transistors

The JFET contains a large number of electrons, it is called an N-type JFET. This means that when the transistor is turned on, it is primarily the movement of electrons which constitutes the current flow. The construction and terminal current for a N-Channel are shown below.

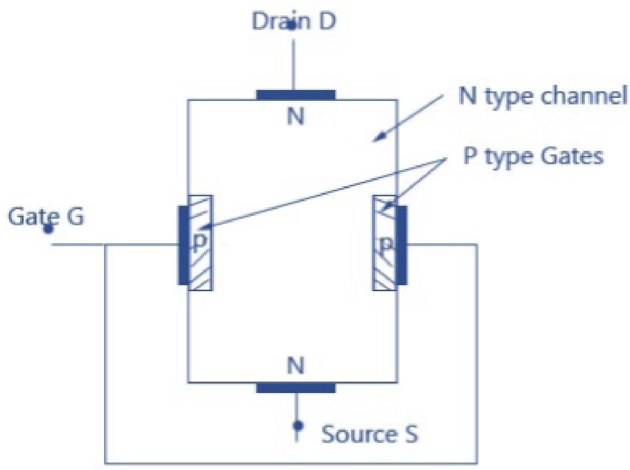

Figure 8.3: N-Channel Transistor Connections

The following circuits are used to test characteristics of various transistors.

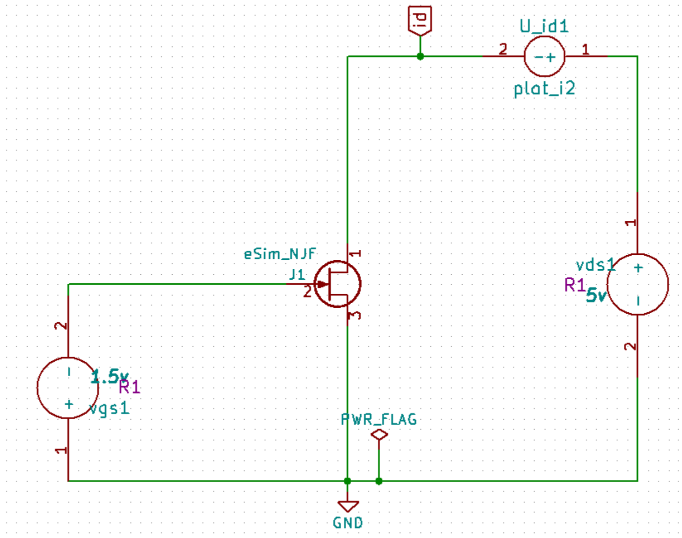

Figure 8.4: To test DC characteristics

8.1.1 JFET J204

JFET J204 is a general purpose transistor with Low Cutoff Voltage: J201 <1.5 V.

* J204 model

.MODEL J204 NJF(Beta=1.004m Betatce=-.5 Rd=1 Rs=1 Lambda=3.333m Vto=-1.139 Vtotc=-2.5m Is=29.04f Isr=281.9f N=1 Nr=2 Xti=3 Alpha=698u Vk=270.4 Cgd=3.58p M=.3601 Pb=1 Fc=.5 Cgs=5.4p Kf=165E-18 Af=1)

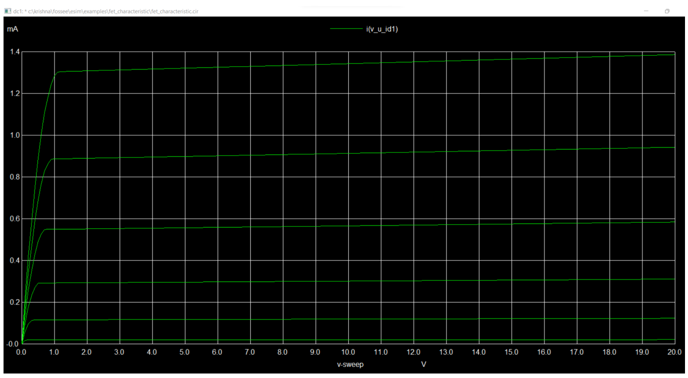

Figure 8.5: DC characteristics JFET J204

8.1.2 JFET J2N3822

JFET J2N3822 is used Low Cutoff Voltage.

* J2N3822 model

.MODEL J2N3822 NJF(Beta=1.1m Betatce=-.5 Rd=1 Rs=1 Lambda=4.09m Vto=-1.962 Vtotc=-2.5m Is=181.3f Isr=1.747p N=1 Nr=2 Xti=3 Alpha=2.543u Vk=152.2 Cgd=4p M=.3114 Pb=0.5 Fc=.5 Cgs=4.627p Kf=10.2E-18 Af=1)

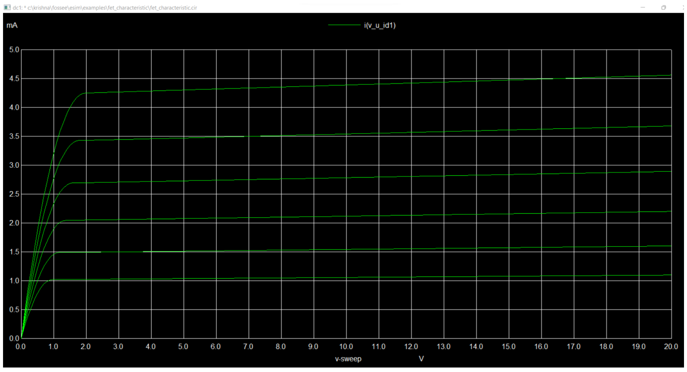

Figure 8.6: DC characteristics JFET J2N3822

8.1.3 JFET BF244B

JFET BF244B is used Low Cutoff Voltage.

* BF244B model

.MODEL BF244B NJF(Beta=1.6m Betatce=-.5 Rd=1 Rs=1 Lambda=3.1m Vto=-2.29 Vtotc=-2.5m Is=33.57f Isr=322.4f N=1 Nr=2 Xti=3 Alpha=311.7u Vk=243.6 Cgd=3.35p M=.3622 Pb=1 Fc=.5 Cgs=3.736p Kf=13.56E-18 Af=1)

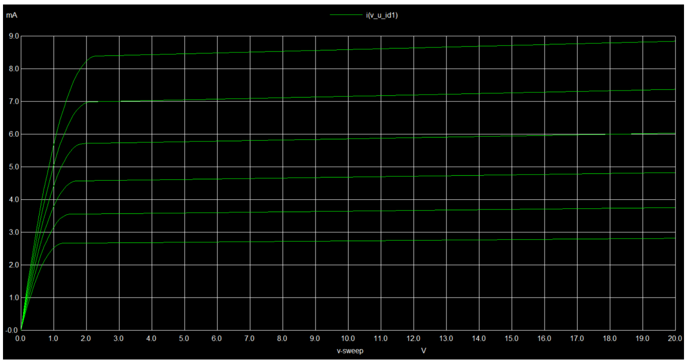

Figure 8.7: DC characteristics JFET BF244B

Chapter 9

Challenges Faced During the Journey

9.1 Installation Issue in Ubtunu

Based on the usage of eSim from past few years, it has been noticed that it runs like butter, works efficiently in Ubuntu as compared to windows. However while installing the tool in Ubuntu issue has been encountered like **saltmakrel package** issue in Ubuntu so it has been removed after many hours of struggle.

9.2 Difficulties finding Opensource Spice model files

During initial days finding opensource spice model files was a real challenge because without data proceeding further was NOT possible.

9.3 No access for commercial tool to model device

Yeah, because there is license issue regarding spice model files, therefore one has to look in different way, like one can create their own spice model files from the datasheet and for that there exists few commercial tools and they are quite expensive at the same time.

9.4 Error in including model files in Device Modelling tab

The other issue faced was a nerve-wracking it is because my NgSpice code was running well in terminals but it was throwing errors in eSim, the solution lies somewhere in DeviceModel.py file that has been edited, learnt that to add new device it is required to include that model file while converting kiCad to NgSpice file - for this reason the DeviceModel.py file needs to be coded accordingly. In the below figures code snippet have been shown.

```python
elif eachline[0] == 'ytxl':
    # print("Device Model ymod:", words[0])
    self.devicemodel_dict_beg[words[0]] = self.count
    ymodbox = QtWidgets.QGroupBox()
    ymodhgrid = QtWidgets.QGridLayout()
    ymodbox.setTitle(
        "Add library for ymod " +
        words[0] +
        " : " +
        words[4])
    self.entry_var[self.count] = QtWidgets.QLineEdit()
    self.entry_var[self.count].setText("")
    # global path_name
    try:
        for child in root:
            if child.tag == words[0]:
                # print("DEVICE MODEL MATCHING---", \
                #       child.tag, words[0])
                try:
                    if child[0].text \
                       and os.path.exists(child[0].text):
                        path_name = child[0].text
                        self.entry_var[self.count] \
                            .setText(child[0].text)
                    else:
                        self.entry_var[self.count].setText("")
                except BaseException as e:
                    print("Error when set text of device " +
                          "model ymod :", str(e))
    except BaseException:
        pass

    ymodgrid.addWidget(self.entry_var[self.count], self.row, 1)
    self.addbtn = QtWidgets.QPushButton("Add")
    self.addbtn.setObjectName("%d" % self.count)
    self.addbtn.clicked.connect(self.trackLibrary)
    self.deviceDetail[self.count] = words[0]

    if self.entry_var[self.count].text() == "":
        pass
    else:
        self.trackLibraryWithoutButton(self.count, path_name)

    ymodgrid.addWidget(self.addbtn, self.row, 2)
    ymodbox.setLayout(ymodgrid)

    # CSS
    ymodbox.setStyleSheet(" \
    QGroupBox { border: 1px solid gray; border-radius: \
    9px; margin-top: 0.5em; } \
    QGroupBox::title { subcontrol-origin: margin; left:\
     10px; padding: 0 3px 0 3px; } \
    ")

    self.grid.addWidget(ymodbox)



    # Adding Device Details #

    # Increment row and widget count
    self.row = self.row + 1
    self.devicemodel_dict_end[words[0]] = self.count
    self.count = self.count + 1
```

Figure 9.1: Code snippet in transmission lines.

```python
elif eachline[0] == 's':
    # print("Device Model Switch:", words[0])
    self.devicemodel_dict_beg[words[0]] = self.count
    switchbox = QtWidgets.QGroupBox()
    switchgrid = QtWidgets.QGridLayout()
    switchbox.setTitle(
        "Add library for Switch " +
        words[0] +
        " : " +
        words[5])
    self.entry_var[self.count] = QtWidgets.QLineEdit()
    self.entry_var[self.count].setText("")
    # global path_name
    try:
        for child in root:
            if child.tag == words[0]:
                # print("DEVICE MODEL MATCHING---", \
                #       child.tag, words[0])
                try:
                    if child[0].text \
                       and os.path.exists(child[0].text):
                        path_name = child[0].text
                        self.entry_var[self.count] \
                            .setText(child[0].text)
                    else:
                        self.entry_var[self.count].setText("")
                except BaseException as e:
                    print("Error when set text of device " +
                          "model switch :", str(e))
    except BaseException:
        pass

    switchgrid.addWidget(self.entry_var[self.count], self.row, 1)
    self.addbtn = QtWidgets.QPushButton("Add")
    self.addbtn.setObjectName("%d" % self.count)
    self.addbtn.clicked.connect(self.trackLibrary)
    self.deviceDetail[self.count] = words[0]

    if self.entry_var[self.count].text() == "":
        pass
    else:
        self.trackLibraryWithoutButton(self.count, path_name)

    switchgrid.addWidget(self.addbtn, self.row, 2)
    switchbox.setLayout(switchgrid)

    # CSS
    switchbox.setStyleSheet(" \
    QGroupBox { border: 1px solid gray; border-radius: \
    9px; margin-top: 0.5em; } \
    QGroupBox::title { subcontrol-origin: margin; left:\
     10px; padding: 0 3px 0 3px; } \
    ")

    self.grid.addWidget(switchbox)
```

Figure 9.2: Code snippet in switch.

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