



Summer Fellowship Report

On

Title

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Bearing in mind previous I am using this opportunity to express my deepest gratitude and special thanks to the MD of [Company name] who in spite of being extraordinarily busy with her/his duties, took time out to hear, guide and keep me on the correct path and allowing me to carry out my project at their esteemed organization and extending during the training.

I express my deepest thanks to [Name Surname], [Position in the Company] for taking part in useful decision & giving necessary advices and guidance and arranged all facilities to make life easier. I choose this moment to acknowledge his/her contribution gratefully.

It is my radiant sentiment to place on record my best regards, deepest sense of gratitude to Mr./Ms. [Name Surname], [Position in the Company], Mr./Ms. [Name Surname], [Position in the Company], Mr./Ms. [Name Surname], [Position in the Company] and Mr./Ms. [Name Surname], [Position in the Company] for their careful and precious guidance which were extremely valuable for my study both theoretically and practically.

I perceive as this opportunity as a big milestone in my career development. I will strive to use gained skills and knowledge in the best possible way, and I will continue to work on their improvement, in order to attain desired career objectives. Hope to continue cooperation with all of you in the future

List of Figures

1.1	Kicad Logo	5
1.2	Kicad PcbNew OpenGL	5
1.3	eSim Logo	6
1.4	eSim Main Window	6
1.5	NgSpice Logo	7
1.6	ngSpice on KDE(Linux)	7
2.1	Required Mockup	8
2.2	Patch Output	9
3.1	Models in ngSpice	11
3.2	LM741	12
3.3	LM741 - Schematic	13
3.4	LM741 - Simulation Output	14
3.5	LM733H - Internal Subcircuit	14
3.6	LM733H - Schematic	15
3.7	LM733H - Simulation Output	16

Contents

1	Introduction	4
1.1	KiCad	5
1.2	eSim	6
1.3	ngSpice	7
2	KiCad Nightly Build (v5)	8
2.1	Building KiCad	8
2.2	Bug : Autoplot PDF when saving projects	8
2.3	Bug : Add hotkey for opening context menu in eeschema	9
2.4	Bug : Ability to open project folder in host operating system	10
2.5	Bug : Inconsistent reference field parsing during editor copy	10
3	Digital Simulation and Component Parser	11
3.1	Digital Simulation in KiCad	11
3.2	Parser to increase supported components in eSim	12
3.2.1	LM741	12
3.2.2	LM733H	14
4	eSim	17
4.1	Increase External Pins for Sub-Circuits	17
4.2	Introduced Rename Project Option	17
4.3	Improve handling of unknown components	17
4.4	Introduced workspace functionality in eSim	17
4.5	Minor Bug Fix and improving code usability	17
5	Standalone Installer for eSim	18
6	Conclusion and future work	19
7	References	20

Chapter 1

Introduction

FOSSEE (Free and Open Source Software in Education) project promotes the use of FOSS tools to improve the quality of education in our country. They aim to reduce dependency on proprietary software in educational institutions. They encourage the use of FOSS tools through various activities to ensure commercial software is replaced by equivalent FOSS tools. They also develop new FOSS tools and upgrade existing tools to meet requirements in academia and research. Incorporated to FOSSEE program, this fellowship's main aim is to introduce students to the FOSS in various engineering fields and to become a part of this big community.

We were selected for this fellowship on the basis of screen task submitted by us. There we got opportunity to work on some of the major open source electronic simulation softwares and are introduced to the Technology Stack they are build on. These technologies include C/C++ Programming, Python, Wxwidget, WxPython, PyQt4,etc.

At the beginning of the fellowship we formulated several learning goals, which we want to achieve:

- To understand the functioning and working conditions of a government organisation
- To see what it is like to work in a professional environment
- To see if this kind of work is a possibility for our future career
- To use our knowledge and skills and to further increase them
- To learn about organising of a open source project
- To enhance our communication skills
- To build a professional and social network

This report is a short description of our 48 days fellowship under FOSSEE. This report contains our activities that have contributed to achieve a number of our stated goals. Following is the description of the softwares we worked on and changes we have done in them, concluding with the experience we gained.

1.1 KiCad

KiCad is a free software suite for electronic design automation (EDA). It facilitates the design of schematics for electronic circuits and their conversion to PCB designs. KiCad was originally developed by Jean-Pierre Charras. It features an integrated environment for schematic capture and PCB layout design. Tools exist within the package to create a bill of materials, artwork, Gerber files, and 3D views of the PCB and its components.

The Kicad suit has 5 main parts:

- KiCad the project manager.
- Eeschema the schematic capture editor.
- Pcbnew the PCB layout program. It also has a 3D view.
- GerbView the Gerber viewer.
- Bitmap2Component tool to convert images to footprints for PCB artwork.



Figure 1.1: Kicad Logo

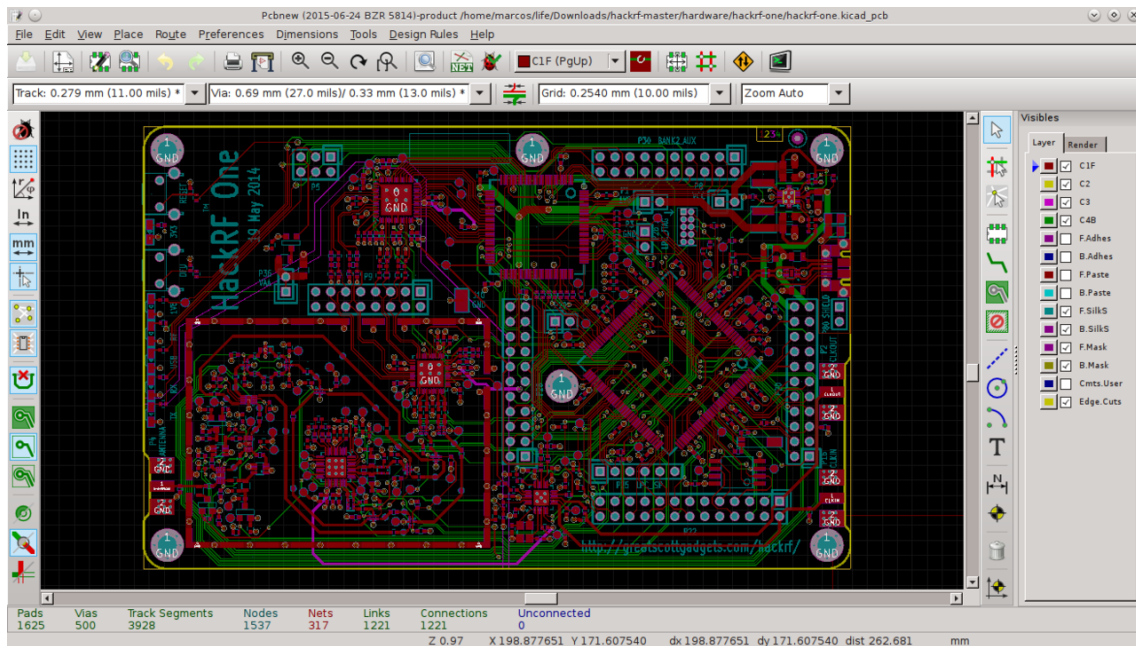


Figure 1.2: Kicad PcbNew OpenGL

1.2 eSim

eSim (previously known as Oscad / FreeEDA) is an open source EDA tool for circuit design, simulation, analysis and PCB design. It is an integrated tool built using open source software such as **KiCad** and **NgSpice**. eSim is released under GPL.

eSim offers similar capabilities and ease of use as any equivalent proprietary software for schematic creation, simulation and PCB design, without having to pay a huge amount of money to procure licenses. Hence it can be an affordable alternative to educational institutions and SMEs. It can serve as an alternative to commercially available/ licensed software tools like OrCAD, Xpedition and HSPICE. The eSim suit Includes:

- KiCad the complete KiCad suit.
- KiCadtoNgSpice - Generate Ngspice netlist.
- NgSpice Simulation - Simulate Circuit using NgSpice backend
- Model Editor
- Subcircuit Editor - Design subcircuit from IC's
- NGHDL - Convert VHDL to Ngspice
- Modelica Converter - Convert Modelica files to Schematic
- Modelica Optimization



Figure 1.3: eSim Logo



Figure 1.4: eSim Main Window

1.3 ngSpice

Ngspice is a mixed-level/mixed-signal circuit simulator. It is the open-source successor of Spice3f5. A small group of maintainers and the community of motivated users contribute to the ngspice project by providing new features, enhancements and bug fixes.

Ngspice is based on three free-software packages: Spice3f5, Xspice and Cider1b1:

- SPICE is the origin of all electronic circuit simulators, its successors are widely used in the electronics community.
- Xspice is an extension to Spice3 that provides additional C language code models to support analog behavioral modeling and co-simulation of digital components through a fast event-driven algorithm.
- Cider adds a numerical device simulator to ngspice. It couples the circuit-level simulator to the device simulator to provide enhanced simulation accuracy (at the expense of increased simulation time). Critical devices can be described with their technology parameters (numerical models), all others may use the original ngspice compact models.

Ngspice is, anyway, more than the simple sum of the packages above, as many people are contributing to the project with their experience, their bug fixes and their improvements giving ngspice additional features and improved robustness.



Figure 1.5: NgSpice Logo

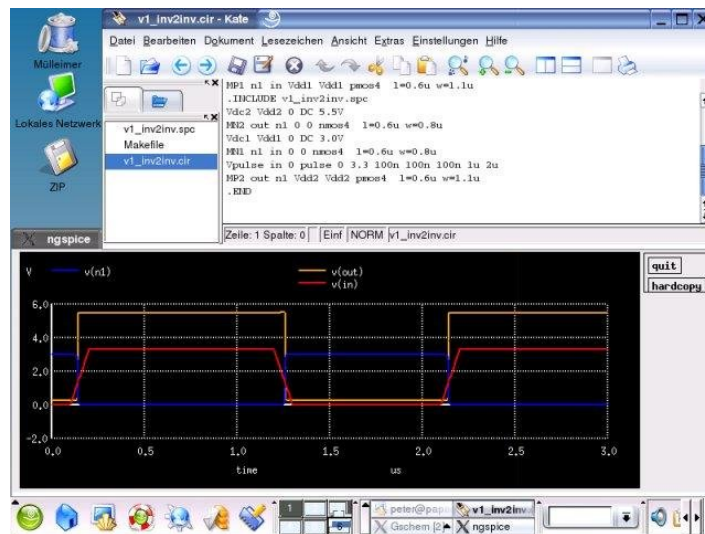


Figure 1.6: ngSpice on KDE(Linux)

Chapter 2

KiCad Nightly Build (v5)

2.1 Building KiCad

2.2 Bug : Autoplot PDF when saving projects

This Bug : # 1636549 is a feature addition in Kicad which is requested by a user of Kicad. It is sometime necessary to have the schematic in a handy format (like pdf) which can be easily accesed by other non-electric background people. So the requirement is to automatically plot the schematic in PDF format whenever the user saves the schematic, as the default plot method is time consuming.

Bug Link : <https://bugs.launchpad.net/kicad/+bug/1636549>

Patch Link : <https://launchpadlibrarian.net/375310564/0001-Eeschema-Adding-Autoplot-Patch>

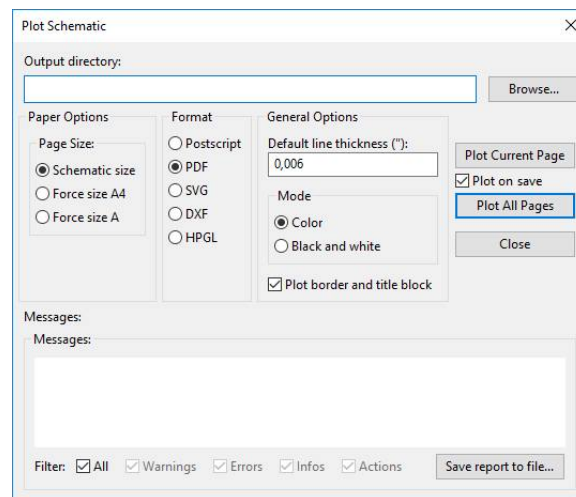


Figure 2.1: Required Mockup

The schematic will be plot in PDF format and with scaling the color and the wire width will be taken from the previous setting keeping in mind that they are user defined property i.e. every user might have different requirement of PDF

2.3 Bug : Add hotkey for opening context menu in eeschema

This Bug : # 1663595 is also a feature addition in eeschema in which the user wanted to have a shortcut to open the context menu for fast use of the software. The assigned hotkey for this function is 'D'. The context menu open a bit below the cursor position.

Bug Link : <https://bugs.launchpad.net/kicad/+bug/1663595>

Patch Link : <https://bugs.launchpad.net/kicad/+bug/1663595/+attachment/5159628/+files/0001-Eeschema-Add-shortcut-for-opening-context-menu.patch>

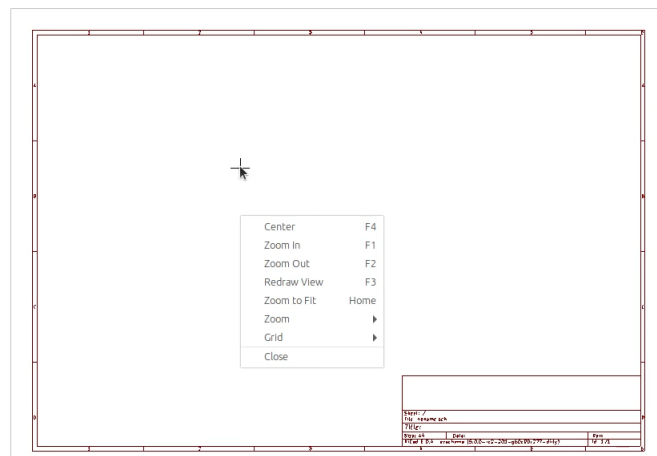


Figure 2.2: Patch Output

Solution : Following is the Code snippet to generate context menu

```
case HK_RIGHT_CLICK:
{
    wxMenu MasterMenu;
    wxPoint pos1 = wxGetMousePosition() , pos2 = GetScreenPosition();
    wxPoint pos = pos1 - pos2;

    if( !OnRightClick( aPosition, &MasterMenu ) )
        return false;

    AddMenuZoomAndGrid( &MasterMenu );

    m_canvas->SetIgnoreMouseEvents(true);
    PopupMenu( &MasterMenu, pos );
    m_canvas->SetIgnoreMouseEvents(false);
}
```

- 2.4 Bug : Ability to open project folder in host operating system
- 2.5 Bug : Inconsistent reference field parsing during editor copy

Chapter 3

Digital Simulation and Component Parser

This Chapter describes about the simulation in ngspice and about the component libraries of Kicad and eSim , similarities and differences between them. Problem description is to find out the reason behind the failure of ngspice in simulating the digital circuits and some analog circuits in Kicad and to find out if we can use the components of kicad in eSim to increase the eSim library.

3.1 Digital Simulation in KiCad

Digital simulation is a problem coming in Kicad on simulating the circuits which works perfectly on eSim. Initially it was suggested that there must be some problem in the way Kicad converts the schematic to its respective generic netlist. On studying the kicad code base it is found that there are some changes in the way kicad identifies the connections from v4 (used in eSim) to v5 (new stable version of kicad). But it is not the only problem, because on changing the connection accordingly the same error pops i.e. `Error:model not found...` On referring to [ngSpice manual](#), it is found that there are some specific components which are identified as models in ngSpice which are shown.

Code	Model Type
R	Semiconductor resistor model
C	Semiconductor capacitor model
L	Inductor model
SW	Voltage controlled switch
CSW	Current controlled switch
URC	Uniform distributed RC model
LTRA	Lossy transmission line model
D	Diode model
NPN	NPN BJT model
PNP	PNP BJT model
NJF	N-channel JFET model
PJF	P-channel JFET model
NMOS	N-channel MOSFET model
PMOS	P-channel MOSFET model
NMF	N-channel MESFET model
PMF	P-channel MESFET model
VDMOS	Power MOS model

Figure 3.1: Models in ngSpice

The problem found out is that for models other than those mentioned above ngSpice is not able to identify them, and hence error. For such case ngSpice uses its feature of subcircuit to make internal

circuits for these components. Also among the shown components, basic components like R,C,L are automatically identified by ngSpice but for others i.e. Diodes and Transistors you have to specify them using `.model` function.

In eSim, the Kicad to ngSpice Converter uses some of the hardcoded values for these models (stored in `.xml` format) specified in program and add these lines to the generic spice netlist. Also, in eSim for the models not specified in it, will fail to simulate. So the user have to make subcircuits for these models in order to make them work.

Even from the discussion in official [KiCad Forum](#), it is suggested to make the subcircuits for the components, to make them work.

3.2 Parser to increase supported components in eSim

This section discuss about the suggestion to increase the no of components in eSim from Kicad by making a parser which convert the symbols from Kicad format to eSim format. It is suggested to take help from the [Pspice to Kicad parser](#) made earlier. On research it is found that the component files of Kicad and eSim are almost same. In fact eSim uses the eeschema software of kicad suit for schematic designing, so the components of kicad can be easily run on eSim, there might be only warning to uses a newer version of eeschema but it does not have any such effect in the running of the prorgam. And even the parser which was made earlier converts files from pspice to kicad which are two completely different softwares (infact competitors), whereas eSim is made on Kicad.

Hence, it is conclude that there is no need to make a parser. In support to our conclusion , few components are added to eSim from Kicad which earlier dont work in eSim. These components include LM741, LM733H.

3.2.1 LM741



Figure 3.2: LM741

The LM741 series are general-purpose operational amplifiers which feature improved performance over industry standards like the LM709. They are direct, plug-in replacements for the 709C, LM201, MC1439, and 748 in most applications.

The amplifiers offer many features which make their application nearly foolproof: overload protection on the input and output, no latch-up when the common-mode range is exceeded, as well as freedom from oscillations.

Subcircuit file of LM741

```

* OPAMP MACRO MODEL (INTREMEDATE LEVEL)
*
      IN-  IN+  VEE    OUT  VCC
.SUBCKT lm741    18 2    1    102 19 81    101 20
Q1 5 1 7 NPN
Q2 6 2 8 NPN
RC1 101 5 95.49
RC2 101 6 95.49
RE1 7 4 43.79
RE2 8 4 43.79
I1 4 102 0.001
* OPEN-LOOP GAIN, FIRST POLE AND SLEW RATE
G1 100 10 6 5 0.0104719
RP1 10 100 9.549MEG
CP1 10 100 0.0016667UF
*OUTPUT STAGE
EOUT 80 100 10 100 1
RO 80 81 100
* INTERNAL REFERENCE
RREF1 101 103 100K
RREF2 103 102 100K
EREF 100 0 103 0 1
R100 100 0 1MEG
.model NPN NPN(BF=50000)
.ENDS lm741

```

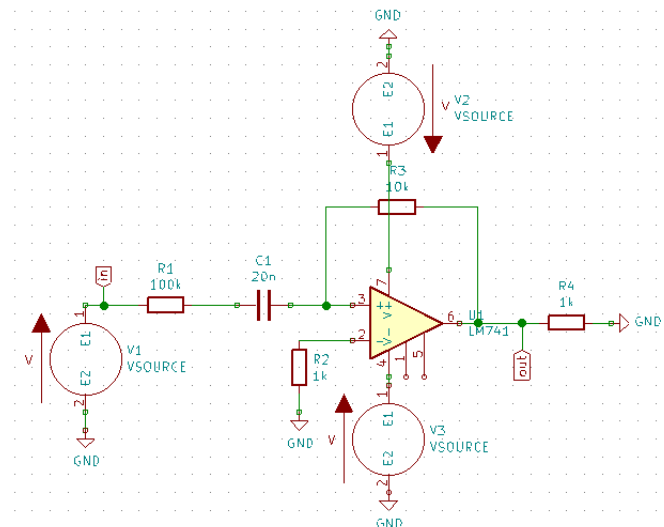
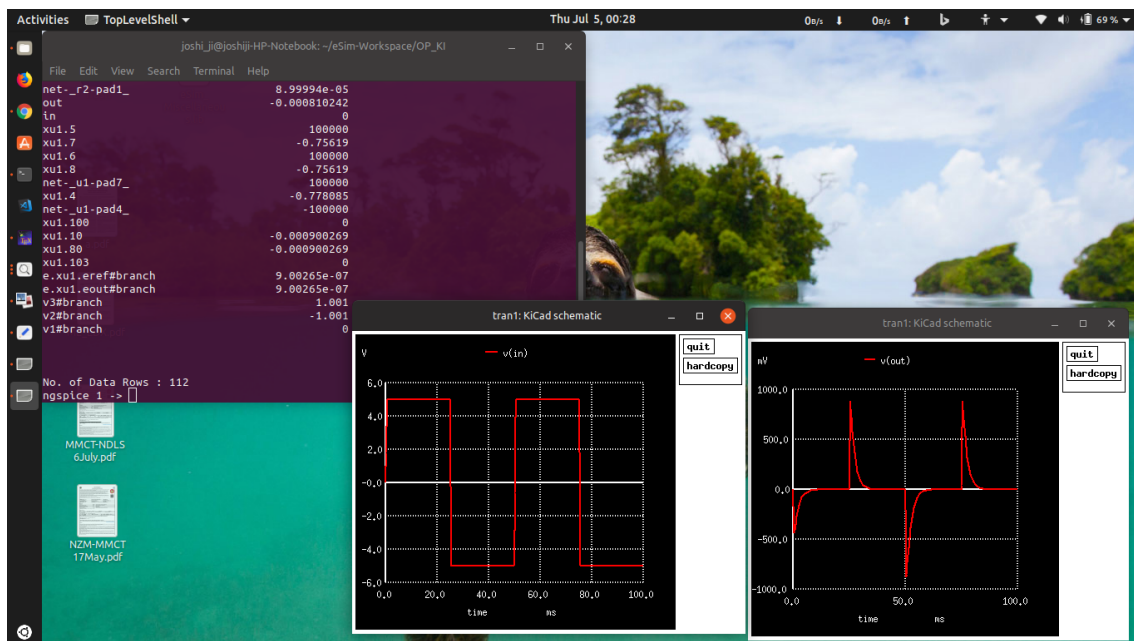


Figure 3.3: LM741 - Schematic



3.2.2 LM733H

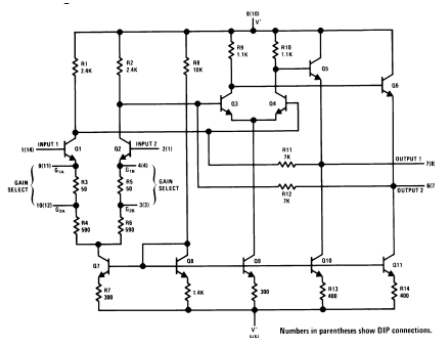


Figure 3.5: LM733H - Internal Subcircuit

The LM733/LM733C is a two-stage, differential input, differential output, wide-band video amplifier. The use of internal series-shunt feedback gives wide bandwidth with low phase distortion and high gain stability. Emitter-follower outputs provide a high current drive, low impedance capability. Its 120 MHz bandwidth and selectable gains of 10, 100 and 400, without need for frequency compensation, make it a very useful circuit for memory element drivers, pulse amplifiers, and wide band linear gain stages.

Subcircuit file of LM733H

* Subcircuit LM733H

```
.subckt LM733H net-_q1-pad2_ net-_q1-pad3_ net-_r2-pad2_ net-_q3-pad3_
net-_r6-pad2_ net-_q3-pad2_ net-_r11-pad2_ net-_q10-pad1_ net-_q8-pad1_
net-_q10-pad3_
```

```
r2 net-_q1-pad3_ net-_r2-pad2_ 50
r6 net-_q3-pad3_ net-_r6-pad2_ 50
r3 net-_r2-pad2_ net-_q2-pad1_ 590
```

```

r7  net-_r6-pad2_ net-_q2-pad1_ 590
r4  net-_q2-pad3_ net-_r11-pad2_ 300
r9  net-_q4-pad3_ net-_r11-pad2_ 1.4k
r11 net-_q6-pad3_ net-_r11-pad2_ 300
r15 net-_q8-pad3_ net-_r11-pad2_ 400
r16 net-_q11-pad3_ net-_r11-pad2_ 400
r1  net-_q10-pad1_ net-_q1-pad1_ 2.4k
r5  net-_q10-pad1_ net-_q3-pad1_ 2.4k
r10 net-_q10-pad1_ net-_q10-pad2_ 1.1k
r14 net-_q10-pad1_ net-_q7-pad1_ 1.1k
r8  net-_q10-pad1_ net-_q11-pad2_ 10k
r12 net-_q8-pad1_ net-_q1-pad1_ 7k
r13 net-_q10-pad3_ net-_q3-pad1_ 7k
q1  net-_q1-pad1_ net-_q1-pad2_ net-_q1-pad3_ npn
q3  net-_q3-pad1_ net-_q3-pad2_ net-_q3-pad3_ npn
q7  net-_q7-pad1_ net-_q1-pad1_ net-_q5-pad3_ npn
q5  net-_q10-pad2_ net-_q3-pad1_ net-_q5-pad3_ npn
q9  net-_q10-pad1_ net-_q7-pad1_ net-_q8-pad1_ npn
q10 net-_q10-pad1_ net-_q10-pad2_ net-_q10-pad3_ npn
q11 net-_q10-pad3_ net-_q11-pad2_ net-_q11-pad3_ npn
q8  net-_q8-pad1_ net-_q11-pad2_ net-_q8-pad3_ npn
q6  net-_q5-pad3_ net-_q11-pad2_ net-_q6-pad3_ npn
q4  net-_q11-pad2_ net-_q11-pad2_ net-_q4-pad3_ npn
q2  net-_q2-pad1_ net-_q11-pad2_ net-_q2-pad3_ npn

.model npn  NPN( Is=14.34f Xti=3 Eg=1.11 Vaf=74.03 Bf=400 Ne=1.307
Ise=14.34f Ikf=.2847 Xtb=1.5 Br=6.092 Nc=2 Isc=0 Ikr=0 Rc=1 Cjc=7.306p
Mjc=.3416 Vjc=.75 Fc=.5 Cje=22.01p Mje=.377 Vje=.75 Tr=46.91n Tf=411.1p
Itf=.6 Vtf=1.7 Xtf=3 Rb=10)

.ends LM733H

```

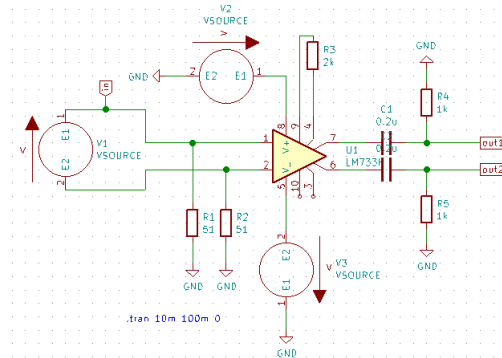


Figure 3.6: LM733H - Schematic

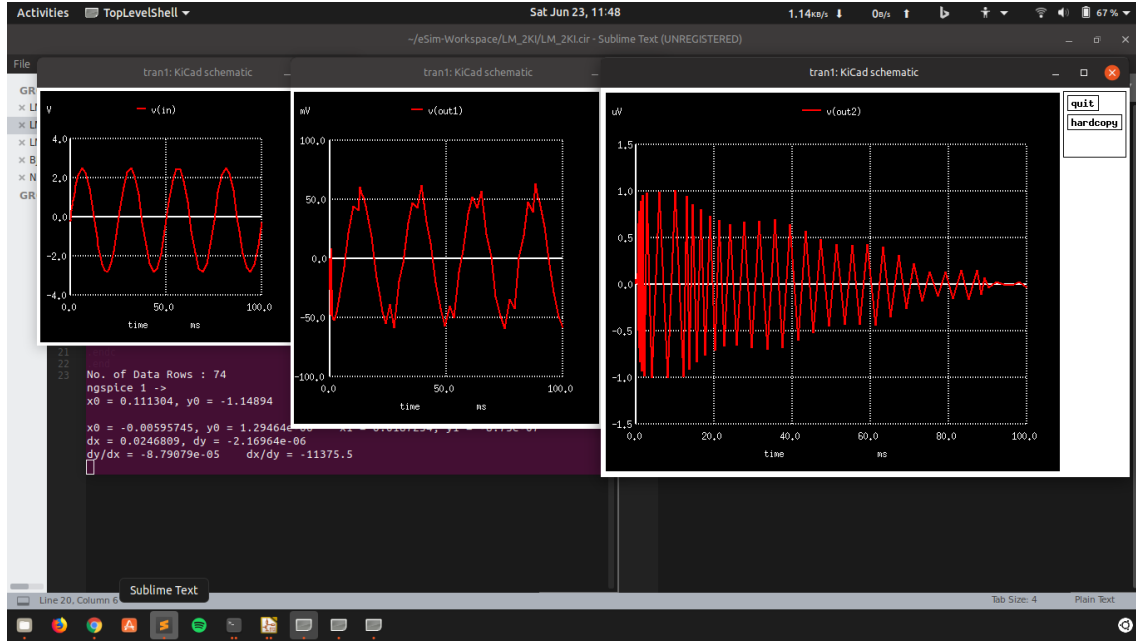


Figure 3.7: LM733H - Simulation Output

Conclusion

So after all research and discussion it is concluded that the solution for both digital simulation and parser problem is to make the subcircuit for every components required in the circuit. Also, Kicad being a PCB designing focused software give more preference to the shape of IC and the positioning of pins in the IC rather than what is the internal circuitory of the component. Also the above subcircuits for LM741 and LM733H support the solution. But the problem which arised in this case is the limited no of ports to represent pins of the subcircuit (which is only 8), whose solution is discussed in the next chapter.

Chapter 4

eSim

- 4.1 Increase External Pins for Sub-Circuits
- 4.2 Introduced Rename Project Option
- 4.3 Improve handling of unknown components
- 4.4 Introduced workspace functionality in eSim
- 4.5 Minor Bug Fix and improving code usability

Chapter 5

Standalone Installer for eSim

Chapter 6

Conclusion and future work

Chapter 7

References