

GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester-III

Course Title: Circuit Design Tools

(Course Code: 4341104)

Diploma programme in which this course is offered	Semester in which offered
Electronics and Communication Engineering	4 th Semester

1. RATIONALE

Simulation techniques are an essential part of electronic circuit design, providing an insight into the operation of a designed circuit prior to its being built. This allows circuit design changes and device optimization. Circuit simulations are an easy, powerful way to “check your work”. You can also play “what if” – trying different values of components to see what effect they have on circuit operation. As you do that, try to predict, based on your knowledge of circuits, what the circuit behavior will be.

Printed Circuit Boards (PCBs) are the building block of most modern electronic devices. PCBs are installed in various electronic products, ranging from consumer gadgets, such as PCs, tablets, smart phones and gaming consoles to industrial and high-tech products.

It is advisable to use electronic circuit simulation for cost-effective better design electronics circuit and PCB design software to fabricate the PCB in the era of miniature electronic gadgets.

This course aims to teach students how to simulate the electronic circuit using available circuit simulation software, how to design PCB layout of given circuit using PCB layout design tools (free or licensed) and build their career in PCB Designer for PCB manufacturing industries.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- **Simulate/test the electronic circuit using Circuit Simulation Tools.**
- **Prepare PCB layout of electronic circuits by using PCB layout design tools**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

- a. Simulate simple electronic circuit using simulation software.
- b. Make schematic of electronic circuits in the software.
- c. Design and develop layout of PCB using PCB layout design tool (free or licensed).
- d. Fabrication of PCB of miniature electronics circuit with hardware soldered on it.

TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
0	0	2	1	0	0	25	25	50

Legends: **L**-Lecture; **T** – Tutorial/Teacher Guided Theory Practice; **P** -Practical; **C** – Credit, **CA** - Continuous Assessment; **ESE** -End Semester Examination.

Note: It is the responsibility of the institute heads that marks for PA of theory & ESE and PA of practical for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU.

5. SUGGESTED PRACTICAL EXERCISES

Following practical outcomes (PrOs) are the sub-components of the Course Outcomes (Cos). Some of the **PrOs** marked “*” are compulsory, as they are crucial for that CO at the ‘Precision Level’ of Dave’s Taxonomy related to ‘Psychomotor Domain’.

Sr. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Create and save new schematic file identify different options like wire, Bus, junction, AC and DC voltage source, current source, probe, Pulse generator, ground, probe etc. of circuit simulation software library.	1	02
2	Make a given circuit by adding and connecting different electronic components to the schematic file from the library of simulation software.	1	02
3	Simulate the Voltage Divider, RC, LC, and RLC based electronic circuit using circuit simulation software in DC Simulation.	2	02
4	Simulate and test characteristics of Diode, Transistor and MOSFET using circuit simulation software in DC Simulation.	2	02
5	Simulate and test Diode, Transistor, MOSFET and IC based electronic circuit using circuit simulation software in DC Simulation.	2	02
6	Plot time domain waveforms for a RC filter/Diode/Transistor based circuit using circuit simulation software in Transient simulation.	2	02
7	Plot time domain waveforms for a given Analog IC/OP-AMP/555 based circuit using circuit simulation software in Transient simulation.	2	02
8	Plot the frequency response curve to check the functionality of RC, LC and RLC based filter circuit using circuit simulation software in AC Simulation.	2	02
9	Demonstrate any Circuit Simulation Android/iOS Application on mobile.	2	02
10	Installation and introduction of PCB designing software, along with study of basic PCB Terminologies - grid, top & bottom copper, pads, vias, netlists, silkscreen, etc.	3	02
11	Create schematic of simple electronics circuitry in PCB designing software or export net-list of the same from simulation software.	3	02
12	Perform Component arrangement for Board Layout & perform Manual	3	02

Sr. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
	Routing of the Board.		
13	Perform Design Rule Check (DRC) and Electrical Rule Check (ERC) of your board and apply finishing touches to the board by adding copper pours, silkscreen, mounting holes, etc.	3	02
14	Generate design files (Gerber files) & Bill of Materials (BOM). Preview your completed PCB design using the online preview tool.	3	02
15	Study various PCB fabrication techniques, fabricate PCB using Gerber Files and prepare complete PCB assembly by soldering hardware components, test your board for desired functionality.	4	02
16	Make Custom Library component of one PTH (Plating Through Hole) & one SMD (Surface Mount Device) IC.	3, 4	02
17	Make a chart or presentation on E-Waste management, Electronic Waste Recycling and its Disposal.	4	02
18	Mini Project: Fabricate a complex electronic circuit (SMD components desirable) on PCB. (Apply all skills learned in this course: Schematic Design, Simulation, PCB Layout, Fabrication, Soldering of component & Functionality Testing)	1,2,3, 4	06
	Total		40

Note

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.

The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Practical Exercises** of this course required which are embedded in the COs and ultimately the competency.

S. No.	Sample Performance Indicators for the PrOs	Weightage in %
1	Find Best Simulation Software/PCB Design Software	10
2	Design Schematic	10
3	Simulate and Analyze circuit.	40
4	Prepare PCB Layout	30
5	Prepare PCB.	10
Total		100

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrO's is a guide to procure them by the administrators to user in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Personal Computer (i3, 4GB RAM, 500GB HDD/SDD) with Internet Facility	1 to 14,16,17
2.	Open Source/Licensed Electronic Circuit Simulation Software	1 to 8
3.	Open Source/Licensed PCB Layout Design Software	10 to 16,18
4.	Micro Soldering station (5 -15 Watt)	15,18
5.	3 in 1 SMD Rework station	15,18
6.	Printer, FeCl ₃ , GPPCB, Silicon liquid Flux , Silicon Spray, white solder flux	15,18
7.	Soldering Iron (variable wattage) , De-soldering Iron (30 watt) with Stand, Soldering pen	15,18
8.	Digital /Portable/ Optical Microscope with LED Lights	15,18
9.	PCB Making Instruments, Drill Machine, Hand Held electric power drill	15,18
10.	Android/iOS Mobile	9

7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

- Work as a leader/a team member.
- Follow safety practices while using electrical, electronics, pneumatic instruments and tools.
- Realize importance of E-waste management. (Environment related)

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organization Level' in 2nd year.
- 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit – I Simulation of Electronic Circuits Using Simulation Software	1a. State the features of different circuit simulation tools (Open source or free or licensed) used for electronic circuit simulation. 1b. Define the general terms used in circuit simulation software. 1c. Create new project, make schematic and save it. 1d. Use 'Search', 'add' or 'create' an electronics component to the schematic file of the simulation software. 1e. Design an electronics circuit using circuit simulation software.	1.1 Introduction to different types of Circuit simulation software 1.2 Wire, bus, junction, probe, voltage source, current source, and ground etc. used in circuit simulation software. 1.3 Create new project, and schematic file. 1.4 Search, Add or Create an electronic part. 1.5 Edit, Connect, or wire the circuit.
Unit – II Analyze Electronic Circuits Using Simulation Software	2a. Simulate and test the passive components like RC, LC, or RLC based electronic circuit using circuit simulation software. 2b. Simulate and test the active components like diode, transistor or MOSFET based electronic circuit using circuit simulation software. 2c. Simulate and test the analog or digital IC based electronic circuit using circuit simulation software. 2d. Find the transient analysis of RC, LC, or RLC based circuit using circuit simulation software. 2e. Find the bias point analysis of diode, transistor or MOSFET based circuit using circuit simulation	2.1 Test Passive components RC, LC or RLC based electronic circuit. 2.2 Test DC simulation of active components like diode, transistor or MOSFET based electronic circuit. 2.3 Test DC Simulation of analog/digital IC based electronic circuit. 2.4 Transient simulation of RC, LC, or RLC based electronic circuit. 2.5 Bias point analysis or characteristic curve of diode, transistor or MOSFET based electronic circuit. 2.6 Transient simulation of diode, transistor or MOSFET etc. based electronic circuit.

	<p>software.</p> <p>2f. Find the transient analysis of diode, transistor or MOSFET etc. based circuit using circuit simulation software.</p> <p>2g. Find the frequency response (AC simulation) of RC, diode, transistor etc. based electronic circuit using simulation software.</p> <p>2h. Find the frequency response (AC simulation) of analog/ digital IC based circuit using simulation software.</p> <p>2i. Find Circuit Design simulation Android/IOS application.</p>	<p>2.7 Frequency response (AC simulation) of RC, diode, and transistor etc. based electronic circuit.</p> <p>2.8 Frequency response (AC simulation) analog/ digital IC based electronic circuit.</p> <p>2.9 Install Circuit Simulation Android/IOS Application on your mobile and demonstrate it.</p>
Unit – III PCB Layout Design	<p>3a. Learn basics of PCB terms net list, back annotation, bill of material, footprint, PTH, track width, mil, etc. used in PCB layout design software.</p> <p>3b. Transfer an electronic circuit to PCB layout design software.</p> <p>3c. Search, add and create footprint of different electronic components used in PCB layout design software.</p> <p>3d. Place, route and generate the layout of given circuit using manual or auto routing using PCB layout design software.</p> <p>3e. Preview PCB using Layout Design Files.</p>	<p>3.1 Learn the basics terms of software & PCB layout - grid, top & bottom copper, pads, vias, netlists, silkscreen etc.</p> <p>3.2 Download, install and configure PCB designing software. Get components library for chosen software.</p> <p>3.3 Create a schematic of the chosen circuit & generate netlists from the created schematic.</p> <p>3.4 Arrange components in a neat manner. Trace each net on appropriate layers and finish routing the board.</p> <p>3.5 Check for any pending nets using tool. & Perform Design Rule Check (DRC) and Electrical Rule Check (ERC) of your board. Add copper pours, silkscreen, holes for mounting, etc.</p> <p>3.6 Generate design files (Gerber files) & Bill of Materials (BOM). Preview your completed PCB design</p>

		using the preview tool.
		3.7 Make custom library components for various SMD & PTH Parts.
Unit – IV PCB Fabrication, Assembly & Testing	4a. Study Different PCB Manufacturing techniques. 4b. Drawing and printing layout on board, photo etching process, masking process, etc. 4c. Solder components on PCB. 4d. Study Different PCB testing techniques. 4e. Follow the PCB testing steps. 4f. Describe the components of Electronic waste. 4g. Explain the steps of recycling process of electrical and Electronic waste.	4.1 PCB fabrication techniques. PCB fabrication steps of chosen technique. 4.2 PCB Assembly Techniques. 4.3 PCB Testing techniques. 4.4 Steps involved in manual PCB testing. 4.5 Components of Electronic Waste. 4.6 Steps for Recycling process of electronic and electrical waste: a) Collection and Transportation b) Shredding and sorting c) Dust Extraction d) Magnetic separation e) Water separation f) Purification of Waste (Plastic, Metal, Glass)

9. SUGGESTED SPECIFICATION TABLE FOR PROGRESSIVE ASSESSMENT

Unit No.	Unit Title	Teaching Hours	Approx. Distribution of Teaching Hours		
			R Level	U Level	A Level
I	Simulation of Electronic Circuits Using Simulation Software	4	01	01	02
II	Design Schematic of Electronic Circuits Using Software	10	02	02	06
III	PCB Layout Design	8	01	02	05
IV	PCB Fabrication, Assembly & Testing	6	01	01	04
Total		28	5	6	17

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary from table

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports of about 5 pages for each activity. They should also collect/record physical evidence for their (student's) portfolio which may be useful for their placement interviews:

- Prepare PCB layout of a given circuit on butter paper (Mini Project).
- Transfer the layout from Butter paper to copper cladded board (Paper Phenolic or glass epoxy material etc.)
- Industrial Visit to any PCB manufacturing Industry.
- Expert Lecture from PCB manufacturing industry personal
- Videos of PCB making steps and different PCB making Techniques

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/subtopics.
- b) Guide student(s) in undertaking micro-projects.
- c) '**L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature can be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.

12. SUGGESTED MICRO-PROJECTS

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and sixth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This must match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

Following is the list of proposed student activities such as:

1. Prepare PCB layout of a given circuit on butter paper (Mini Project).
2. Prepare PCB layout using circuit simulation software.
3. Install Circuit Design simulation Android/IOS application in mobile and demonstrate it.

13. SUGGESTED LEARNING RESOURCES

Sr.No.	Title of Book	Author	Publication
1.	QUCS User Manual	QUCS Team	https://qucs.sourceforge.net/docs.html
2.	eSim User Manual	eSim Team, FOSSEE at IIT, Bombay	https://esim.fossee.in/resource/book/esimusermanual.pdf
3.	Multisim Tutorial	NI	https://www..com/help/getting-started/
4.	Eagle User Manual	Autodesk	http://eagle.autodesk.com/eagle/documentation
5.	KiCAD Manuals	KiCAD Team	https://docs.kicad.org/
6.	Orcad Tutorials	Cadence	https://www.orcad.com/resources/orcad-tutorials
7.	Altium Designer Tutorials	Altium	https://www.altium.com/documentation/altium-designer/tutorial-complete-design-walkthrough

14. SOFTWARE/LEARNING WEBSITES

- a. eSim Download - <https://esim.fossee.in/downloads>
- b. QUCS Download - <https://qucs.sourceforge.net/download.html>
- c. Multisim - <https://www.multisim.com/>
- d. Eagle Tutorials - <https://learn.sparkfun.com/tutorials/tags/eagle>
- e. KiCAD Download - <https://www.kicad.org/download/>
- f. EasyEDA - <https://easyeda.com/>
- g. LTSpice - <https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html>
- h. Altium Designer - <https://www.altium.com/altium-designer/>
- i. OrCAD - <https://www.orcad.com/>
- j. Eagle Component Libraries by Sparkfun - <https://github.com/sparkfun/SparkFun-Eagle-Libraries>
- k. Eagle Component Libraries by Adafruit - <https://github.com/adafruit/Adafruit-Eagle-Library>
- l. NPTEL eSim Course -

https://onlinecourses.swayam2.ac.in/aic20_sp59/preview

- m. Eagle Tutorial YouTube Playlist -
<https://www.youtube.com/playlist?list=PLr0mEvO7yBe6QHexsgU2WFUGesFFobGZp>
- n. KiCAD Tutorial YouTube Playlist -
<https://www.youtube.com/playlist?list=PLEBQazB0HUyR24ckSZ5u05TZHV9khgA1O>
- o. eSim Tutorial YouTube Playlist -
https://www.youtube.com/playlist?list=PLVORbPb_s0PsMlqyqvQ1xm9rP0bq-l6_e
- p. OrCAD Tutorial YouTube Playlist -
<https://www.youtube.com/playlist?list=PLRoTfNt8BjdBLOUWGmaS1-H3ZvndnltFC>
- q. Altium Designer Tutorial YouTube Playlist -
https://www.youtube.com/playlist?list=PLDclr_SCaTAxEpaE0uf9RDQUNtW5YSoxW

PO-COMPETENCY-CO MAPPING

Semester III	Electronic Circuits & Networks (Course Code: 434---)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
Competency	<ul style="list-style-type: none"> Simulate/test the electronic circuit using Circuit Simulation Tools. Prepare PCB layout of electronic circuits by using PCB layout design tools 						
Course Outcomes CO1 a. Simulate simple electronic circuit using simulation software.	3	3	2	3	1	1	1

CO2 a. Make schematic of electronic circuits in the software	3	2	3	3	1	1	1
CO3 a. Design and develop layout of PCB using PCB layout design tool (free or licensed).	3	3	3	3	0	1	2
CO 4 a. Fabrication of PCB of miniature electronics circuit with hardware soldered on it. .	1	0	0	3	3	1	1

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Sr. No.	Name and Designation	Institute
1.	Mr. Sunil J Chauhan, HOD, EC Dept.	Government Polytechnic, Palanpur
2.	Mr. Kunal J Pithadiya, Lecturer EC Dept.	B & B Institute of Technology, V V Nagar
3.	Mr. Milav J Dabgar, Lecturer EC Dept.	Government Polytechnic, Palanpur