ENHANCING THE PRACTICAL SKILLS USING SELF STUDY COMPONENT IN THE COURSE LINEAR INTEGRATED CIRCUITS (LIC)

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Abstract— **This paper describes the method of enhancing the practical skills of handling linear ICs such as OPAmps using self study component. In today's technology miniaturization plays an important role in every aspects like power, size, cost and speed, so learning linear integrated circuits is very essential for VLSI design. OpAmp has become the heart of every analog integrated circuit design. The main reason for this is its versatility, noise immunity, wide bandwidth and high gain characteristics which made it popular in every analog ICs. To get comfortable with the working of OpAmp without knowing its internal circuitry is difficult, to make these things easier the LIC syllabus is modified and design of current mirrors, differential pair is added. This time instead of studying OpAmp as device, syllabus is began with circuit level implementation of Opamp then proceeded towards the construction of linear applications and then the non linear applications. Since lab was not there in the curriculum, self study component with 1 credit is introduced in the course, which gives the platform to make students to explore different Opamp based circuits given in the syllabus and practically implement them for their functionality.**

Keywords— ***OpAmp, Microcap, SS component, Proteus, EAGLE 6.5.***

I. INTRODUCTION

Linear integrated circuit is a conceptual based analog design subject. To understand this subject the student should have a very good visualization capacity. In order to develop that ability in students, the faculty should have some innovative, creative ideas and also content should be framed in suitable way. This time the topics of syllabus began with circuit level implementation of Op-Amp in first unit, which includes current mirrors then differential amplifier and the Op-Amp construction from these sub circuits [3]. The amplifier circuits and importance of feedback were included in second unit .Following to which the linear and non linear applications are introduced in third unit [1][2]. To support theory the new initiation SS component is introduced. The detailed structure of SS component is explained in section 2, in section 3 extracurricular activities which were conducted during the semester are discussed. In future scope we are planning to implement think pair share activity to enhance the thinning capability and group discussion skills.

II. SELF STUDY COMPONENTE

Self study component is the new initiation to enhance practical skills of students by assigning new innovative mini projects. These mini projects reflects the applications of Op-Amp in which student can apply theoretical knowledge and can see the working of analog integrated circuits. Each student was made to select five circuits based on OPAMP within which at least two sensor based circuits, which were thoroughly scrutinized in 4 different reviews with individual attention to single student and awarding suitable marks to encourage the student. The details of which are given in following subsections.

Details of Self Study Implementation Stages.

1. Literature Survey .(5 marks)
2. Circuit Simulation.(5 marks)
3. Circuit Implementation on Bread Board. (5 marks)
4. PCB Implementation. (10 marks)

A. *Literature Survey*

In literature survey each student should search for 5 circuits with OPAMP(two sensor based circuits) and should submit the synopsis following with the presentation focusing on working of each circuit. Special care is taken to see that there is no repetition of circuits, as the strength of students in each class is 75, total number of circuits obtained are 375, for one division, thus for both division the total number of students is 150 and obtained circuits are 750. Getting 750 different circuits using opamp and sensors was really a challenge, thus we have decided to have some repeating topics with different implementation approach. The first review was done with above mentioned perspective.

B. Circuit Simulation

In the second phase of the execution of self study component which was simulation of freezed 5 circuits, the students were asked to implement circuits in any EDA tool of their choice since learning EDA tool was not the prime goal of self study. Since students were comfortable with Microcap and Proteus EDA tool, the presentation on working of the selected 5 circuits was done in Microcap and Proteus.

The expectation in the second review is to build OPAMP based circuit analysis capability and enhance the confidence in presentation skills. Each student is made to explain the working of selected circuits and contribution of circuit component in that application. Along with this he have to study the data sheets of each ICs which were used in the applications and he has to include silent features of those ICs in the report.

C. Circuit Implementation On Bred Board

The Circuit Implementation on Bred Board is third phase of execution of self study component, where the finalized circuits simulated in the second review were practically implemented on bred board, to confirm the functionality of circuits. The motto behind third review is to check practical skills of the students and their error debugging capability. So that they gain enough confidence move forward with printing the circuits on PCB.

D. PCB Implementation

The PCB implementation is the final phase of the self study component. Once the functionality of the circuit is ensured with simulation and bred board implementation, then finally to get the working prototype the circuit is transferred on PCB. The students were given the liberty to select PCB CAD tool of their choice and the PCB was designed with Proteus and EAGLE 6.5.

The weight for marks is highest for PCB implementation compared to other reviews since there are many challenges in PCB design such as layout, component mounting, Soldering, Routing etc. And the student is reviewed by considering all the above mentioned challenges.
In final demo student must show the circuit along with power point presentation.

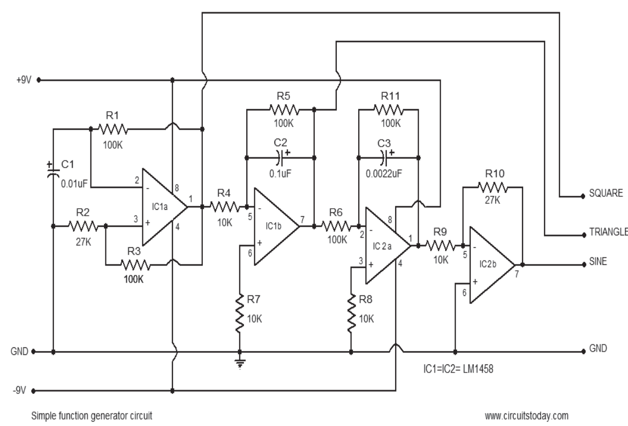
III. EXTRA CURRICULAR ACTIVITIES

- Data sheet study of op amp 741C.
  - Teaching during ideal and practical characteristics, the study of data sheet is necessary, during implementation of circuits on bread board. With this students can learn electrical parameters of op amp.
- Quizzes, Chalk and talk assignments.
- To see the students understanding capability mini quizzes were conducted.
- During class hours problem statements were given to the students then told them to explain on black board.
- Result comparison and discussion, relating problem solutions to the theory.
- Explanation of real time applications.

IV. CASE STUDY:SAMPLE REPORT

To exhibit the flow of execution of the self study component, the sample report submitted by the student at the end of the completion of self study is given. The report shows the detailed description of all the 5 circuits selected by individual student including Bill Of Materials (BOM) for each selected circuit, Pin diagrams of ICs used in circuits and PCB layout of 2 circuits selected out of 5.

1. *Function Generator:*



1.1 *Description:*

A simple function generator circuit using LM1458 is known here. LM1458 is a dual general purpose operational amplifier. The two opamps inside LM1458 has a common bias network, power supply line and are independent of each other in operation. The LM1458 does not require an external frequency compensation circuit and has built in short circuit protection. Lm 1458 has a wide supply voltage range and it is available in 8 pin mini DIP package. Four opamps (2 from each IC) is used in the function generator circuit. First opamp IC 1a is wired as an a stable multivibrator.R1 is the feedback resistor and C1 is the timing capacitor output of IC 1a is feed back to its non inverting input (pin 3) from the junction of R3 & R2.The output of IC 1a will be a square wave and its frequency can be varied by varying R1 or C1.

The next opamp IC 1b is wired as an integrator.R5 is the feedback resistor and C2 is the integrating capacitor. Non inverting input of IC 1b (pin6) is tied to ground using resistor R7. The output of IC 1a which is a square wave is applied to the inverting input of IC 1b (pin 5) through R4 which is the input resistance of IC 1b. The output of IC 1b will be a triangular wave form, because integrating a square wave will result in a triangular waveform.

IC 2a forms another integrator, where R11 is its feedback resistor and C3 is the integrating capacitor.R6 is the input resistance of IC 2a. Non inverting input of IC 2a (pin 3) is tied to ground using the 10K resistor R8. IC 2b forms an inverting amplifier where R9 is its input resistor and R10 the feedback resistor. With the used values of R10 & R9, the gain of the inverting amplifier stage will be 27, (AV = -Rf/Rin). The triangular output waveform from the IC 1b is further integrated using IC 2a inverter using IC 2b circuit diagram.

1.2 Applications:

- The circuit can be used in labs to carryout experiments where different functional inputs are required.
- Used in circuits where sine or triangular or square wave in required.
- Used where 2dB of gain is required.
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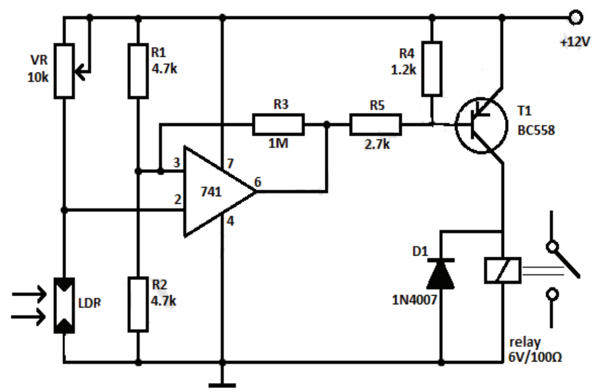
TABLE I. BILL OF MATERIALS FOR FUNCTION GENERATOR

S No.	COMPONENTS	SPECIFICATIONS	Amount in rupees		
			No.	Cost	Total
1	IC	LM1458 dual op-amp	2	30	60
2	Resistors	R1 - 100KΩ R2 - 27KΩ R3 - 100KΩ R4 - 10KΩ R5 - 100KΩ R6 - 100KΩ R7- 10KΩ R8 - 10KΩ R9 - 10KΩ R10 - 27KΩ	1 1 1 1 1 1 1 1 1 1	0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5	0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5 0.5
3	Capacitor	C1 - 0.01μF C2 - 0.1μF C3 - 0.022μF	1 1 1	1 1 1	1 1 1
4	BNC	-	3	15	45
Total			113		

2. *Dark activated switch:*



2.1 Description:

This dark activated switch can trigger a relay to operate an AC lamp at Sunset. The lamp remains on till morning and then turns off. This eliminates the need of switching the Porch lamp or Backyard lamp daily and also helps to light the premises of the house when the occupants are out of station.

The circuit utilizes the light sensing property of LDR to activate the circuit. The LDR (Light Dependent Resistor) has very high resistance as high as 10 Meg ohms in dark which reduces to a few Ohms in bright light.

Variable resistor VR and the LDR forms a potential divider that gives a variable voltage to the inverting input (pin2) of IC1. The non inverting input (pin3) of IC1 gets a fixed voltage (half supply voltage) from the junction of the potential divider R1 and R2. Feedback Resistor R3 gives some hysteresis so that the relay turns on when the light level falls to a particular value and does not turns off again until the light level rises above this value. This prevents spurious switching by sensing mild changes in the light level. This also prevents relay clicking when the light level gradually falls at sunset.

During day time LDR gets sunlight and it conducts. This reduces the voltage at pin2 of IC1. Since this voltage level is lesser than the voltage at pin3, output of IC1 goes high to make the PNP transistor T1 off. Thus relay remains off during day time.

When the light level decreases at sunset, LDR cease to conduct and the voltage level at pin 2 increases above the voltage level at pin3.Output of IC1 then turns low and T1 conducts. This activates the relay and the AC load connected to the NO (Normally Open) contacts of the relay turns on. This condition remains until LDR illuminates in the morning and then the lamp turns off. Diode D1 protects T1 from back e.m.f when T1 switches off.

VR can be used to adjust the sensitivity of LDR at the particular light level, say at 6 pm to turns on the lamp.

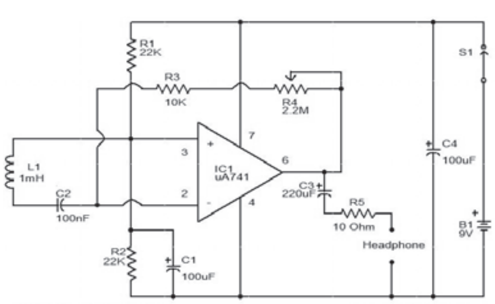
2.2 Applications:

- The circuit can be used in automatic street lights, automatic home lights etc
- Can be used in Heart beat sensor to calculate pulse rate

TABLE II. BILL OF MATERIALS FOR DARK ACTIVATED SWITCH

S No.	*COMPONENTS*	*SPECIFICATIONS*	*Amount in rupees*		
			No.	*Cost*	*Total*
1	IC	LM741 op-amp	1	15	15
2	Resistors	R1 - 4.7KΩ R2 - 4.7KΩ R3 - 1MΩ R4 - 1.2KΩ R5 - 2.7KΩ	1 1 1 1 1	0.5 0.5 0.5 0.5 0.5	0.5 0.5 0.5 0.5 0.5
2	Relay	6V	1	40	40
3	Pot	10KΩ	1	5	5
4	LDR	-	1	10	10
5	Transistor	BC558	1	5	5
6	Diode	1n4007	1	2	2
Total			79.5		

3. *Electromagnetic field sensor:*



3.1 Description:

This is a very simple circuit that can be used to sense electromagnetic radiations. The circuit can even detect hidden wrings. A 1mH inductor is used for sensing the electric field. The electric field will induce a small voltage in the sensor inductor and this induced voltage is amplified by the opamp. The headphone connect at the output of the opamp will give an audio indication of the electric field. For example, the electric field around mains transformer can be heard as a 50 Hz hum. The POT R4 can be used to adjust the gain of the amplifier. By keeping the sensor inductor near to a telephone line, you can even hear the telephone conversations.

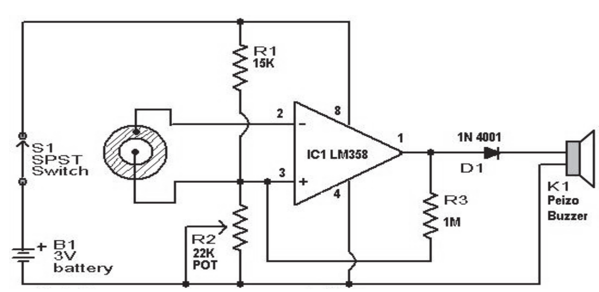
3.2 Applications:

- Used in radios, mobiles and other communication devices as a receiver of electromagnetic waves.
- Used in signal gamers.

TABLE III. BILL OF MATERIALS FOR *ELECTROMAGNETIC FIELD SENSOR*

S No.	*COMPONENTS*	*SPECIFICATIONS*	*Amount in rupees*		
			No.	*Cost*	*Total*
1	IC	LM741 op-amp	1	15	15
2	Resistors	R1 - 22KΩ R2 - 22KΩ R3 - 10KΩ R5 - 10Ω	1 1 1 1 1	0.5 0.5 0.5 0.5 0.5	0.5 0.5 0.5 0.5 0.5
3	Pot	R4 - 10KΩ	1	5	5
4	Inductor	1mH	1	8	8
5	Capacitor	C1 - 100µF C2 - 100nF C3 - 220µF C4 - 100µF	1 1 1 1	5 1 10 5	5 1 10 5
Total			79.5		

4. *Accelerometer / Shook sensor : (PCB implemented)*



4.1 Description:

Here is a simple shock sensitive alarm circuit that has many applications for home to automobiles. The main application of this circuit is to use it as an anti-theft alarm in automobiles. A piezo electric sensor is used as the shock sensor which has to mounted on the door which you have to protect.

Here the IC1 LM358 is wired as an inverting Schmitt Trigger. The POT R1 sets the threshold voltage of the circuit.R1 is used as a feedback resistor. When not activated the output from the piezo sensor will be low and so do the output of the IC. When the piezo sensor is activated its output voltage goes high and triggers the Schmitt trigger. This results the beeping of the buzzer. The buzzer remains beeping for some time even if the vibration is removed. This is because the increase in the inverting input has little effect when the IC is triggered and the state can't be easily reversed.

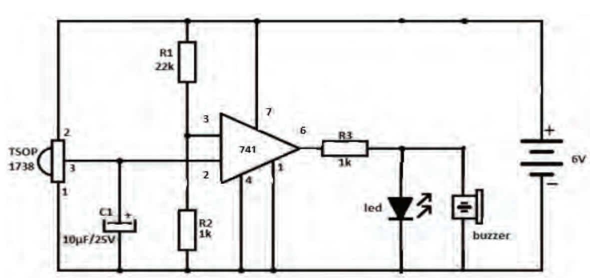
4.2 Applications:

- Used in accelerometer to sense the orientation of the devices.
- Used as a vibration sensor.

TABLE IV. BILL OF MATERIALS FOR ACCELEROMETER / SHOOK SENSOR : (PCB IMPLEMENTED)

S No.	COMPONENTS	SPECIFICATIONS	Amount in rupees		
			No.	Cost	Total
1	IC	LM358 op-amp	1	35	35
2	Resistors	R1 - 15KΩ R3 - 1MΩ	1 1	0.5 0.5	0.5 0.5
3	Pot	R2 - 22KΩ	1	5	5
4	Diode	1N4007	1	2	2
5	Piezo crystal	-	1	50	50
6	Buzzer	4Ω	1	30	30
7	PCB	4X3 inch	1/2	40	20
8	PCB Etching	Ferrous chloride	1/3	60	20
Total			163		

5. *IR remote control tester:(PCB implemented)*



5.1 Description:

This circuit can be used for testing your TV, DVD, VCD, etc. remote control. According to the datasheet of TSOP4838, the input voltage to IR sensor should be 3V-5V. When the sensor gets infrared signal, the voltage at its VO pin drops and that triggers the inverting pin. At each trigger signal the difference voltage will be amplified by the opamp741 . Thus, you can see the response of your remote control signal by flashing LED or as buzzer output.

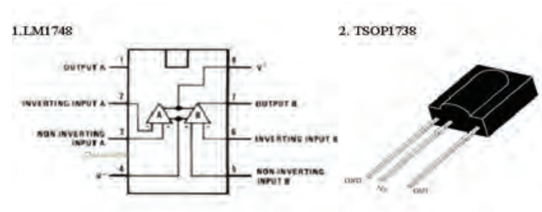
Applications:

- Used to test the IR remote whether it is working or not.

TABLE V. BILL OF MATERIALS FOR *IR REMOTE CONTROL TESTER:(PCB IMPLEMENTED)*

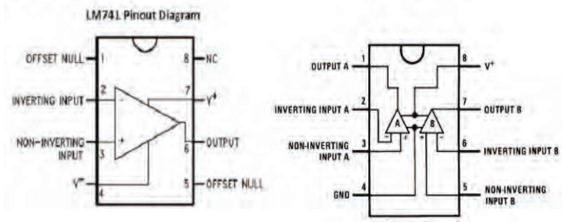
S No.	COMPONENTS	SPECIFICATIONS	Amount in rupees		
			No.	Cost	Total
1	IC	LM741 op-amp	1	15	15
2	Resistors	R1 - 22KΩ R2 -1KΩ R3 -1KΩ	1 1 1	0.5 0.5 0.5	0.5 0.5 0.5
3	IR sensor	TSOP1738	1	30	30
4	LED	Red	1	2	2
5	Capacitor	C1 - 10µF	1	5	5
6	Buzzer	4Ω	1	30	30
7	PCB	2X3 inch	1/4	40	10
8	PCB Etching	Ferrous chloride	1/6	60	10
Total			103.5		

6. *Pin configurations of different components used:*



3.LM741

4. LM358

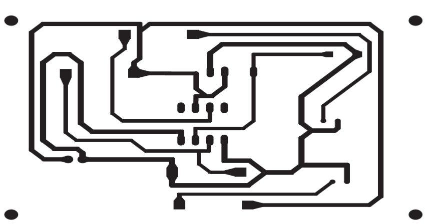


5. BC558

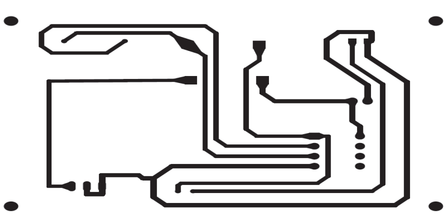
6. RELAY

7. *Layout of PCB implemented circuits:*

1. IR remote tester



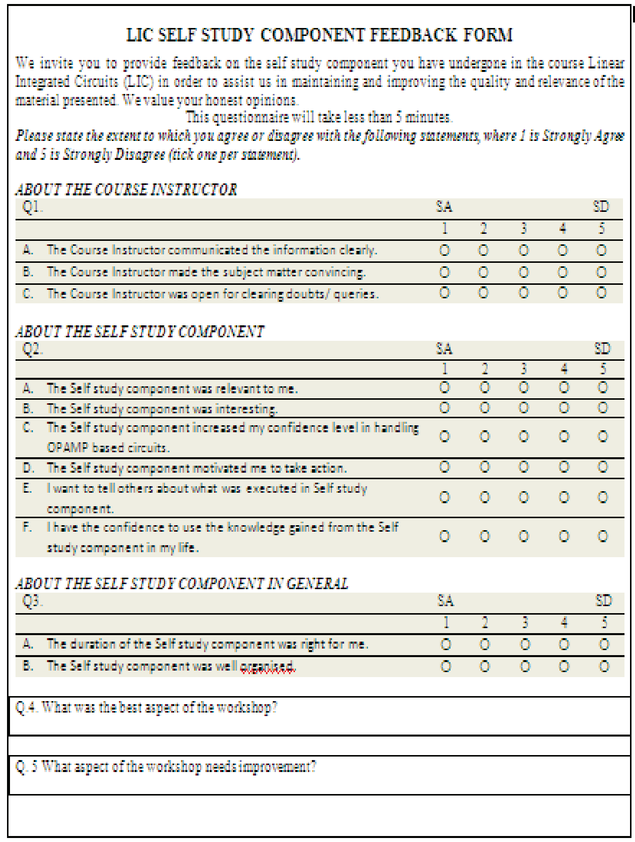
2. Shock sensor



V. SELF STUDY COMPONENT FEEDBACK

Since we are undergoing the continuous teaching and learning process and there is always a scope for improvement just to check where we stand and to what level we have motivated the students, the feedback was taken. The feedback was taken from 20 students at the end of the course and the their response is recorded and analysed as shown on figures 1,2 and 3.By seeing the graphs we can say that the students really enjoyed the self study component execution.

The feedback form template is given,



LIC SELF STUDY COMPONENT FEEDBACK FORM

We invite you to provide feedback on the self study component you have undergone in the course Linear Integrated Circuits (LIC) in order to assist us in maintaining and improving the quality and relevance of the material presented. We value your honest opinions.

This questionnaire will take less than 5 minutes.

Please state the extent to which you agree or disagree with the following statements, where 1 is Strongly Agree and 5 is Strongly Disagree (tick one per statement).

ABOUT THE COURSE INSTRUCTOR

Q1.	SA				SD
	1	2	3	4	5
A. The Course Instructor communicated the information clearly.	O	O	O	O	O
B. The Course Instructor made the subject matter convincing.	O	O	O	O	O
C. The Course Instructor was open for clearing doubts/ queries.	O	O	O	O	O

ABOUT THE SELF STUDY COMPONENT

Q2.	SA				SD
	1	2	3	4	5
A. The Self study component was relevant to me.	O	O	O	O	O
B. The Self study component was interesting.	O	O	O	O	O
C. The Self study component increased my confidence level in handling OPAMP based circuits.	O	O	O	O	O
D. The Self study component motivated me to take action.	O	O	O	O	O
E. I want to tell others about what was executed in Self study component.	O	O	O	O	O
F. I have the confidence to use the knowledge gained from the Self study component in my life.	O	O	O	O	O

ABOUT THE SELF STUDY COMPONENT IN GENERAL

Q3.	SA				SD
	1	2	3	4	5
A. The duration of the Self study component was right for me.	O	O	O	O	O
B. The Self study component was well organized.	O	O	O	O	O

Q 4. What was the best aspect of the workshop?

Q. 5 What aspect of the workshop needs improvement?

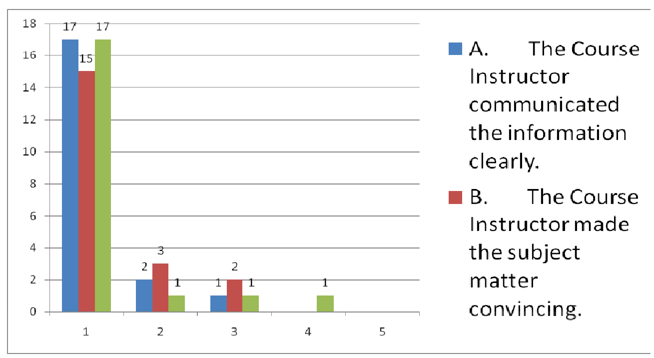


Figure 1: Attainment for the section ABOUT THE COURSE INSTRUCTOR

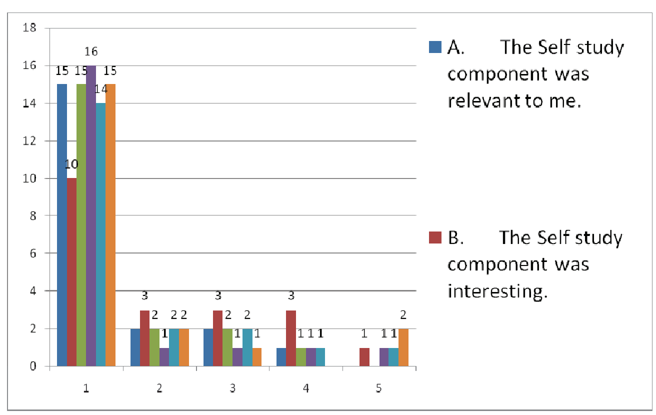


Figure 2: Attainment for the section ABOUT THE SELF STUDY COMPONENT

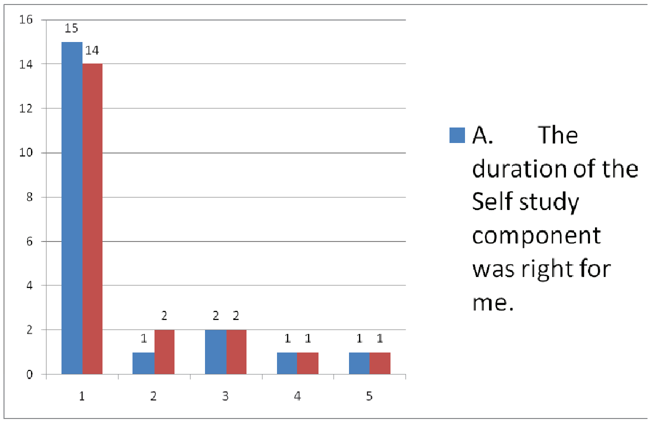


Figure 3: Attainment for the section ABOUT THE SELF STUDY COMPONENT IN GENERAL

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I express my warm thanks to our HOD Dr.Uma M for her constant support and valuable inputs and

All my colleagues people who provided me with the facilities being required and conductive conditions for my paper.

VI. CONCLUSION

As described in this paper the self study component is used as a tool to strengthen the practical skills of the students and making them to do something different which they were not able to do in the lab such as writing the BOM for the components used for their circuits, using the EDA tool to verify the functionality and finally using the PCB CAD tool to design the PCB. The main focus of the self study is to make the students to go through the different steps involved in getting the prototype from the circuit diagram of the application, and this was achieved which can be evident from the sample report given in case study chapter. The graph data shows that majority of students strongly agree about the points such as the self study component increased the confidence level for handling OPAMPs. This also helped them to explore different open source EDA tools. The student's response was very good and they really appreciated the way the self study component was organised and executed. The extracurricular activities also helped them in understanding, designing and analysing the OPAMP circuits.

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