Ref No:

Sri Krishna Institute of Technology
Bengaluru-560090

COURSE PLAN

Academic Year - 2018-2019

Program:	B E – Electrical & Electronics Engineering
Semester :	4
Course Code:	17EEL48
Course Title:	OP AMP & LIC Lab
Credit / L-T-P:	2 / 0-0-2
Total Contact Hours:	36
Course Plan Author:	Bharati.S.K

Academic Evaluation and Monitoring Cell

#29, Hesaragatta Main Road, Chimney Hills
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INSTRUCTIONS TO TEACHERS

- Classroom / Lab activity shall be started after taking attendance.
- Attendance shall only be signed in the classroom by students.
- Three hours attendance should be given to each Lab.
- Use only Blue or Black Pen to fill the attendance.
- Attendance shall be updated on-line & status discussed in DUGC.
- No attendance should be added to late comers.
- Modification of any attendance, over writings, etc is strictly prohibited.
- Updated register is to be brought to every academic review meeting as per the COE.

Table of Contents

Note : Remove "Table of Content" before including in CP Book
Each Laboratory Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. LABORATORY INFORMATION

1. Laboratory Overview

Degree:	B.E	*Program:*	EE
Year / Semester :	2/ 4	*Academic Year:*	2018-19
Course Title:	OP AMP & LIC Lab	*Course Code:*	17EEL48
Credit / L-T-P:	2 / 0-0-2	*SEE Duration:*	180 Minutes
Total Contact Hours:	36Hrs	*SEE Marks:*	60 Marks
CIA Marks:	40 Marks	*Assignment*	-
Lab. Plan Author:	Bharati S K	*Sign*	Dt :
Checked By:		*Sign*	Dt :

2. Laboratory Content

Expt.	Title of the Experiments	Lab	Concept	Blooms

		Hours		Level
1	Design and verify a precision full wave rectifier. Determine the performance parameters.	3	Rectification	L4
2	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain.	3	Frequency Response	L4
3	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.	3	Sinosoidal signal Generation	L4
4	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).	3	Square/ Rectangular Wave Generation	L4
5	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.	3	Voltage Comparision	L3
6	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.	3	Airthmatic Operation	L4
7	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency response characteristic.	3	Active filtration	L4
8	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	3	Different Signal Generation	L4
9	Design and realization of R – 2R ladder DAC	3	Digital to Analog Conversion	L4
10	Realization of Two bit Flash ADC.	3	Analog to Digital Conversion	L3
11	Design and verify an IC 555 timer based pulse generator for the specified pulse.	3	Pulse Generation	L4
12	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series.	3	Voltage Regulation	L4

3. Laboratory Material

Books & other material as recommended by university (A, B) and additional resources used by Laboratory teacher (C).

Expt.	Details	Expt. in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
2,6,7, 9,10	Op-Amps and Linear Integrated Circuits,Ramakant A Gayakwad, Pearson 4 th Edition 2015	5	In Lib / In Dept
1,3,4,5 ,8,11,12	Operational Amplifiers and Linear ICs,David A. Bell,Oxford,3 rd Edition 2011	7	In Lib/ In dept
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
12	Linear Integrated Circuits; Analysis,Design and Applications,B. Somanthan Nair, Wiley India,2013	8	In Lib
8,	Linear Integrated Circuits S. Salivahanan, et al McGraw Hill 2 nd Edition,2014.	7	In Lib
3	Operational Amplifiers and Linear Integrated Circuits K. Lal Kishore Pearson 1 st Edition, 2012	4	In lib
C	**Concept Videos or Simulation for Understanding**	-	-
CO1	Rectification https://nptel.ac.in/courses/108101091/46		

CO2	Frequency Response of Op Amp https://www.youtube.com/watch?v=wHN0-wQKtZI		
CO3	RC Phase Shift Oscillator: https://www.youtube.com/watch?v=8iPRR6iCD8A&t=778s https://www.youtube.com/watch?v=8eLolUGSXns		
CO4	Schmitt Trigger: https://www.youtube.com/watch?v=V-bAduYIuil&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=50		
CO5	Comparator and ZCD: https://www.youtube.com/watch?v=V-bAduYIuil&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=50		
CO6	Mathematical Operations: https://www.youtube.com/watch?v=RSWsJjUqD2w&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=49		
CO7	Filter(LPF,HPF and BPF): https://www.youtube.com/watch?v=W70GFpfILKk&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=24 https://www.youtube.com/watch?v=2e0--YSb2lo&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=25 https://www.youtube.com/watch?v=uj4b2O4XVVE&list=PLuv3GM6-gsE3npYPJJDnEF3pdiHZT6Kj3&index=26		
CO8	Signal Generator(square,Triangular and Sin wave): https://www.youtube.com/watch?v=PlsNKq9kDTQ		
CO9	R-2R Ladder DAC: https://www.youtube.com/watch?v=wa7plviT-do&t=1991s		
CO10	Flash ADC: https://www.youtube.com/watch?v=wa7plviT-do&t=1991s		
CO11	Multivibrators using 555 Timer: https://www.youtube.com/watch?v=Rd3QSzye72w		
CO12	Voltage Regulation https://www.youtube.com/watch?v=5rRKmZs2lil		
D	**Software Tools for Design**	**-**	**-**
CO1-CO12	Multisim		
E	**Recent Developments for Research**	**-**	**-**
CO1	Improved accuracy-https://ieeexplore.ieee.org/abstract/document/4303403		
CO2	High performance-https://ieeexplore.ieee.org/abstract/document/896237		
CO3	Improved linearity-https://ieeexplore.ieee.org/abstract/document/4671125		
CO4	Improved timing accuracy -https://patents.google.com/patent/US6055287A/en		
CO5	Improved timing accuracy -https://patents.google.com/patent/US6055287A/en		
CO6	High		

	performance-https://ieeexplore.ieee.org/abstract/document/896237		
co7	High frequency operation - https://www.tandfonline.com/doi/abs/10.1080/00207219308925897		
co8	Improved linearity-https://ieeexplore.ieee.org/abstract/document/4671125		
co9	High performance-https://ieeexplore.ieee.org/abstract/document/896237		
co10	High performance-https://ieeexplore.ieee.org/abstract/document/896237		
co11	Reduced recovery time - https://digital-library.theiet.org/content/journals/10.1049/iet-cds_20060359		
co12	Low drop out voltage with improved stability - https://patents.google.com/patent/US6373233B2/en		
F	**Others (Web, Video, Simulation, Notes etc.)**		
	Nptel online video lecture	Www.onlinecourses.nptel.ac.in	Nptel online video lecture

4. Laboratory Prerequisites:

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

Expt.	Lab. Code	Lab. Name	Topic / Description	Sem	Remarks	Blooms Level
1	17ELN24	Basic Electronics	Semiconductor devices and BJT/ Fundamentals and characteristics of diode , transistor characteristics	2		L2 Understand
2	17EE34	Analog Electronics Circuits	Working and design of Clipping and Clamping circuits	3		L4 Analyze
3	17EE34	Analog Electronics Circuits	Feedback amplifier (Feedback concept)	3		L2 Understand
4	17EE34	Analog Electronics Circuits	Working and design of oscillators.	3		L4 Analyze

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Expt.	Topic / Description	Area	Remarks	Blooms Level
1	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and	Analyze L4

	Computation of BPM		assignment questions.	
2	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
3	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
4	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
5	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
6	NPTEL Videos /Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
7	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
8	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
9	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
10	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
11	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4
12	NPTEL Videos /Introdutction to Gas Sensors and Experiment on Signalconditioning Circuit for Operating Heater Voltage of MQ-7 Gas Sensor	Placement/ GATE	Video lecturing by IISc professor on "Electronics Modules for Industrial Applications" and assignment questions.	Analyze L4

B. Laboratory Instructions

1. General Instructions

SNo	Instructions	Remarks
1	Observation book and Lab record are compulsory.	
2	Students should report to the concerned lab as per the time table.	
3	After completion of the program, certification of the concerned staff in-charge in the observation book is necessary.	
4	Student should bring a notebook of 100 pages and should enter the readings /observations into the notebook while performing the experiment.	
5	The record of observations along with the detailed experimental procedure of the experiment in the Immediate last session should be submitted and certified staff member in-charge.	

6	Should attempt all problems / assignments given in the list session wise.	
7	It is responsibility to create a separate directory to store all the programs, so that nobody else can read or copy.	
8	When the experiment is completed, should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.	
9	Any damage of the equipment or burn-out components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year	
10	Completed lab assignments should be submitted in the form of a Lab Record in which you have to write the algorithm, program code along with comments and output for various inputs given	

2. Laboratory Specific Instructions

SNo	Specific Instructions	Remarks
1	Students are expected to study the circuit, theory and procedures, expected output before doing the experiment.	
2	Adjustment of signal generator: - Before connecting the signal generator to the circuit check the followings. a. Set the shape of the waveform (sinusoidal), b. Set the frequency using coarse and fine adjustments. c. Set the offset adjustments. Set the CRO in DC mode and ensure the waveform is symmetry in both positive and negative cycle. If not , adjust it using the DC offsetting potentiometer d. Set the voltage magnitude using Vcourse settings and Vfine adjustments.	
3	Adjustment of CRO: a. Select the right voltage and time scale to get the proper waveform b. For clipper and clamper circuits, observe the waveform in DC mode only c. Set the input waveform mainly for offset setting in DC mode only. d. Before measurement, ensure X & Y are in calibrated mode (if provided externally) e. Ensure that Channel selection and trigger mode are properly set. f. In case of two channels do not mix the signal and ground terminals	
4	Multi-meter adjustments:- a. Set the right mode before taking the readings. b. For current reading, connect the multimeter in mA (or A) mode to the circuit before switching on the supply. Do not remove the current meter when the supply is on. Check for ac and dc modes as required. c. For voltage reading ensure that proper ac or dc setting. d. Use the proper leads for the measurement. Wrong cables damage the instrument.	
5	After adjusting the input voltage, check the circuit connections before turning the power on.	
6	After adjusting the input voltage, check the circuit connections before turning the power on.	
7	Don't pull out the connections with the power supply on.	
8	Wear your College ID card Do not operate the IC trainer kits without permission	
9	Avoid loose connection and short circuits	
10	Do not interchange the ICs while doing the experiment	
11	Handle the trainer kit properly	
12	Do not panic if you do not get the output	
13	After completion of the experiment switch off the power and return the components	

C. OBE PARAMETERS

1. Laboratory Outcomes

Expt.	Lab Code #	COs / Experiment Outcome	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
-	-	**At the end of the experiment, the student should be able to . . .**	-	-	-	-	-
1	17EEL48.1	Design and verify OP-Amp as a precision full wave rectifier using lic hardware kit.	03	Rectification	Conduction	Test & Viva Voce	L4
2	17EEL48.2	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain using lic hardware kit.	03	Frequency Response	Conduction	Test & Viva Voce	L4
3	17EEL48.3	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency using lic hardware kit.	03	Sinosoidal signal Generation	Conduction	Test & Viva Voce	L4
4	17EEL48.4	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP) using lic hardware kit.	03	Square/ Rectangular Wave Generation	Conduction	Test & Viva Voce	L4
5	17EEL48.5	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector using lic hardware kit.	03	Voltage Comparision	Conduction	Test & Viva Voce	L3
6	17EEL48.6	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator using lic hardware kit.	03	Airthmatic Operation	Conduction	Test & Viva Voce	L4
7	17EEL48.7	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency response characteristic using lic hardware kit.	03	Active filteration	Conduction	Test & Viva Voce	L4
8	17EEL48.8	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency using lic hardware kit.	03	Different Signal Generation	Conduction	Test & Viva Voce	L4
9	17EEL48.9	Design and realize of R – 2R ladder DAC using lic hardware kit.	03	Digital to Analog Conversion	Conduction	Test & Viva Voce	L4
10	17EEL48.10	Realize of Two bit Flash ADC using lic hardware kit.	03	Analog to Digital Conversion	Conduction	Test & Viva Voce	L3
11	17EEL38.11	Design and verify an IC 555 timer based pulse generator for the specified pulse using lic hardware kit.	03	Pulse Generation	Conduction	Test & Viva Voce	L4
12	17EEL38.12	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series using lic hardware kit.	03	Voltage Regulation	Conduction	Test & Viva Voce	L4
-		**Total**	**36**	**-**	**-**	**-**	**-**

Note: Identify a max of 2 Concepts per unit. Write 1 CO per concept.

2. Laboratory Applications

Expt.	Application Area	CO	Level
1	Rectifiers are used in DC regulated power supply.	CO1	L4
2	Anlysis of freqency response of op amp	CO2	L4
3	Signal generator is used in industry, agriculture, boimedicine and other fields such as high frequency induction heating, melting , quenching, ultrasonic diagnosis, nuclear magnetic resonance imaging etc..	CO3	L4
4	Used in square wave generation.	CO4	L4
5	Comparators are used in oscillators, DAC, ADC , multi-vibrators and etc	CO5	L3
6	Summing amplifier is Used in audio mixer to add different signals with n equal gains. Instrumentaion amplifiers are used in data acquisition systems.	CO6	L4
7	Active filters are used in communication systems for suppressing noise, in audio systems , biomedical instruments to interface psychological sensors with diagnostic equipments and data logging.	CO7	L4
8	Use in signal/function generator.	CO8	L4
9	DAC are used in data acquition system.	CO9	L4
10	ADC are used in data acquition system.	CO10	L3
11	Use in frequency divider, pulse width modulation ,linear ramp generator and voltage controlled oscillator.	CO11	L4
12	Regulators are used in developing regulated DC power supply.	CO12	L4

Note: Write 1 or 2 applications per CO.

3. Mapping And Justification

CO – PO Mapping with mapping Level along with justification for each CO-PO pair.
To attain competency required (as defined in POs) in a specified area and the knowledge & ability required to accomplish it.

Expt.	Mapping		Mapping Level	Justification for each CO-PO pair	Level
-	**CO**	**PO**	-	**'Area': 'Competency' and 'Knowledge' for specified 'Accomplishment'**	-
1	1	1	3	Knowledge of rectification using op amp is required in a designing of DC regulated power supply.	L2
	1	2	3	Analysis of DC regulated power supply need knowledge of rectification using op amp.	L3
	1	3	3	Design of rectifier using op amp is a part of DC regulated power supply design.	L4
	1	11	3	The Design of rectifier using op amp will be used in projects.	L4
2	2	1	3	Knowledge of frequency response of op amp is required in a designing of electronics circuits	L2
	2	2	3	Analysis of problem of electronics circuits need knowledge of frequency response of op amp.	L3
	2	3	3	Design of amplifier using op amp for given gain is a part of electronics circuits design.	L4
	2	11	3	The Design of amplifier for desired gain using op amp will be used in projects.	L4
3	3	1	3	Knowledge of signal generator using op amp is required in a designing of complex electronics circuits.	L2
	3	2	3	Analysis of complex electronics circuits may need knowledge of signal generator using op amp.	L3
	3	3	3	Design of signal generator using op amp is a part of complex electronic circuits design.	L4
	3	11	3	The Design of signal generator using op amp may be used in projects.	L4
4	4	1	3	Knowledge of comparator and converter using op amp is required in a designing of complex electronics circuits.	L2
	4	2	3	Analysis of complex electronics circuits may need knowledge of using comparator and converter using op amp.	L3
	4	3	3	Design of comparator and converter using op amp is a part of complex electronic circuits design.	L4

	4	11	3	The Design of comparator and converter using op amp will be used in projects.	L4
5	5	1	3	Knowledge of comparator and converter using op amp is required in a designing of complex electronics circuits.	L2
	5	2	3	Analysis of complex electronics circuits may need knowledge of using comparator and converter using op amp.	L3
	5	11	3	The Design of comparator and converter using op amp will be used in projects.	L4
6	6	1	3	Knowledge of linear applications such as adder,summer,AC and DC amplifier using op amp is required in understanding the working of complex electronic circuits.	L2
	6	2	3	Analysis of complex electronic circuits needs knowledge of Op amp linear applications.	L3
	6	3	3	Design of linear applications such as adder,summer,AC and DC amplifier using op amp are used in many instrumentation amplifier	L4
	6	11	3	The Design knowledge of linear applications of Op Amp can be used in electronic-projects.	L4
7	7	1	3	Knowledge of filters using op amp is required in understanding the working of complex electronic circuits.	L2
	7	2	3	Analysis of complex electronic circuits needs knowledge of filters using op amp.	L3
	7	3	3	Design of filters using op amp are used usually part of communication systems.	L4
	7	11	3	The Design knowledge of filters using Op Amp can be used in electronic-projects.	L4
8	8	1	3	Knowledge of signal generator using op amp is required in a designing of complex electronics circuits.	L2
	8	2	3	Analysis of complex electronics circuits may need knowledge of signal generator using op amp.	L3
	8	3	3	Design of signal generator using op amp is a part of complex electronic circuits design.	L4
	8	11	3	The Design of signal generator using op amp may be used in projects.	L4
9	9	1	3	Knowledge of D/A conversion using op amp is required in a designing of Data acquisition systems.	L2
	9	2	3	Analysis of Data acquisition system need knowledge of D/A conversion using op amp.	L3
	9	3	3	Knowledgeof D/Aconversion using op amp will be applied in projects.	L4
	9	11	3	Knowledgeof D/A conversion using op amp will be applied in projects.	L4
10	10	1	3	Knowledge of A/D conversion using op amp is required in a designing of Data acquisition systems.	L2
	10	2	3	Analysis of Data acquisition system need knowledge of A/D conversion using op amp.	L3
	10	11	3	Knowledgeof A/D conversion using op amp will be applied in projects.	L4
11	11	1	3	Knowledge of pulse generation using 555 timer is required in delay and timing circuits such as clock pulse generation.	L2
	11	2	3	Analysis of delay and timing circuits need knowledge of pulse generation using 555 timer.	L3
	11	3	3	Design of multi-vibrator using 555 timer can be a part of compex application design.	L4
	11	11	3	Knowledge of pulse generation using 555 timer will be applied in projects.	L4
12	12	1	3	Knowledge of regulators using op amp is required in a designing of DC power supply.	L2
	12	2	3	Analysis of DC power supply needs knowledgeof regulator using op amp.	L3
	12	3	3	Design of regulator using op amp is a part of DC power supply design.	L4
	12	11	3	The Design of DC power supply is used in developing a power supply system for projects.	L4

4. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Experiment Outcomes	Program Outcomes															-
Expt.	CO.#	**At the end of the experiment student should be able to . . .**	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3	Lev el
1	17EEL48.1	Design and verify OP-Amp as a precision full wave rectifier using lic hardware kit.	3	3	3								3					L4
2	17EEL48.2	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain using lic hardware kit.	3	3	3								3					L4
3	17EEL48.3	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency using lic hardware kit.	3	3	3								3					L4
4	17EEL48.4	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP) using lic hardware kit.	3	3	3								3					L3
5	17EEL48.5	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector using lic hardware kit.	3	3									3					L4
6	17EEL48.6	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator using lic hardware kit.	3	3	3								3					L4
7	17EEL48.7	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency response characteristic using lic hardware kit.	3	3	3								3					L4
8	17EEL48.8	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency using lic hardware kit.	3	3	3								3					L4
9	17EEL48.9	Design and realize of R – 2R ladder DAC using lic hardware kit.	3	3	3								3					L3
10	17EEL48.10	Realize of Two bit Flash ADC using lic hardware kit.	3	3									3					L4
11	17EEL38.11	Design and verify an IC 555 timer based pulse generator for the specified pulse using lic hardware kit.	3	3	3								3					L4
12	17EEL38.12	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series using lic hardware kit.	3	3	3								3					
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions;*																

		4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design

5. Curricular Gap and Experiments

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Expt	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					
4					
5					

Note: Write Gap topics from A.4 and add others also.

6. Experiments Beyond Syllabus

Topics & contents required (from A.5) not addressed, but help students for Placement, GATE, Higher Education, Entrepreneurship, etc.

Expt	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Experiment: Op-amp based ECG Signal Acquisition, Conditioning and Processing for Computation of BPM	Video Session	14th Feb 2019	Dr Hardik Pandey, IISc Professor	3

D. COURSE ASSESSMENT

1. Laboratory Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Unit	Title	Teaching Hours	No. of question in Exam							CO	Levels
			CIA-1	CIA-2	CIA-3	Asg-1	Asg-2	Asg-3	SEE		
1	Design and verify a precision full wave rectifier. Determine the performance parameters.	03		1	-	-	-	-	1	CO1	L4
2	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non- inverting configuration for a given gain.	03	1	-	-	-	-	-	1	CO2	L4
3	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.	03	-	1	-	-	-	-	1	CO3	L4
4	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).	03	-	1	-	-	-	-	1	CO4	L4
5	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.	03	1	-	-	-	-	-	1	CO5	L3
6	Design and verify the operssation	03	1	-	-	-	-	-	1	CO6	L4

	of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.										
7	Design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c)band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic.	03	1	-	-	-	-	-	1	CO7	L4
8	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	03		1	-	-	-	-	1	CO8	L4
9	Design and realization of R – 2R ladder DAC	03	-	-	1	-	-	-	1	CO9	L4
10	Realization of Two bit Flash ADC.	03	-	-	1	-	-	-	1	CO10	L3
11	Design and verify an IC 555 timer based pulse generator for the specified pulse.	03	-	-	1	-	-	-	1	CO11	L4
12	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series.	03	-	-	1	-	-	-	1	CO12	L4
-	**Total**	**40**	**4**	**4**	**4**				**12**	**-**	**-**

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	30	CO2, CO5, CO6, CO7	L4, L3, L4,L4
CIA Exam – 2	30	CO1, CO3, CO4,CO8	L4, L4, L3,L4
CIA Exam – 3	30	CO9, CO10, CO11,CO12	L4, L3, L4 ,L4
Assignment - 1	10	CO2, CO5, CO6, CO7	L4, L3, L4,L4
Assignment - 2	10	CO1, CO3, CO4,CO8	L4, L4, L3,L4
Assignment - 3	10	CO9, CO10, CO11,CO12	L4, L3, L4 ,L4
Seminar - 1			
Seminar - 2			
Seminar - 3			
Other Activities – define – Slip test			
Final CIA Marks	**40**	**-**	**-**

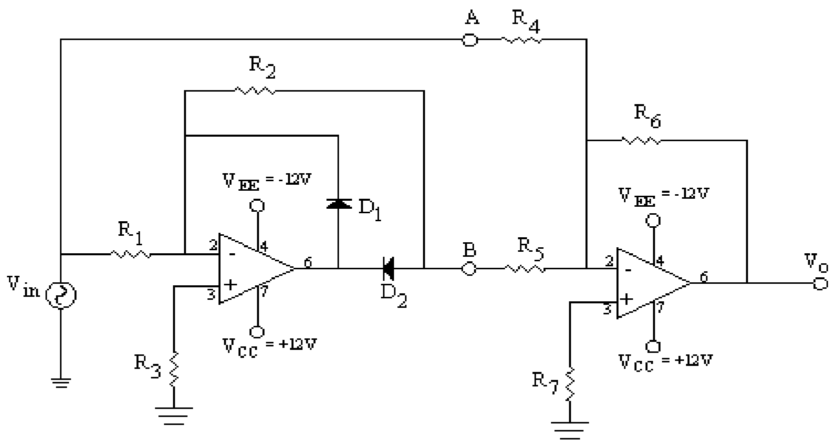
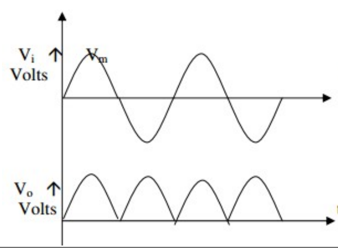
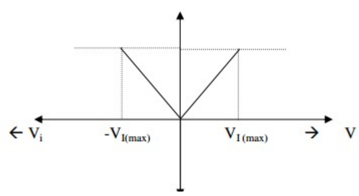
-

SNo	Description	Marks
1	Observation and Weekly Laboratory Activities	05 Marks
2	Record Writing	10 Marks for each Expt
3	Internal Exam Assessment	25 Marks
4	Internal Assessment	40 Marks
5	SEE	60 Marks
-	**Total**	**100 Marks**

E. EXPERIMENTS

Experiment 01 : Precision Full Wave Rectifier

<table>
<tr><th>-</th><th>Experiment No.:</th><th>1</th><th>Marks</th><th></th><th>Date Planned</th><th></th><th>Date Conducted</th><th></th></tr>
<tr><td>1</td><td>Title</td><td colspan="7">Design and verify a precision full wave rectifier. Determine the performance parameters.</td></tr>
<tr><td>2</td><td>Course Outcomes</td><td colspan="7">Design and verify OP-Amp as a precision full wave rectifier using licr hardware kit.</td></tr>
<tr><td>3</td><td>Aim</td><td colspan="7">To Design and verify OP-Amp as a precision full wave rectifier.</td></tr>
<tr><td>4</td><td>Material / Equipment Required</td><td colspan="7">Lab Manual/ CRO, Signal generator, capacitor, diodes, power chord, ameter, multi-meter, .
<table>
<tr><th>SI NO</th><th>Name</th><th>Range</th><th>Quantity</th></tr>
<tr><td>1</td><td>Regulated Dual Power Supply</td><td>0-20V</td><td>1</td></tr>
<tr><td>2</td><td>Resistors</td><td>1.5KΩ(1),22KΩ(2),10KΩ(1)</td><td>4</td></tr>
<tr><td>3</td><td>Capacitors</td><td>0.1μF, 0.01μF</td><td>2</td></tr>
<tr><td>4</td><td>CRO</td><td>-</td><td>1</td></tr>
<tr><td>5</td><td>Multimeter</td><td>-</td><td>1</td></tr>
<tr><td>6</td><td>ICμA741</td><td>-</td><td>1</td></tr>
<tr><td>7</td><td>Patch Chords</td><td>-</td><td></td></tr>
<tr><td>8</td><td>LIC Trainer Kit</td><td>-</td><td>1</td></tr>
<tr><td>9</td><td>Stepdown Transformer</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>5</td><td>Theory, Formula, Principle, Concept</td><td colspan="7">Full wave precision rectifier consisting of a summing circuit and a precision half wave rectifier.The advantage of the op-amp precision rectifier circuit over a simple diode rectifier are 1) no diode voltage drop between input and output 2) the ability to rectify very small voltages(less than the typical 0.7V diode forward voltage drop) 3) amplification . if required and 4) low output impedence .</td></tr>
</table>

		During positive half cycle , the output Vo =(R6/R5)Vin During negative half cycle, the output Vo =(R6/R5)Vin It is seen that the output Vo is a full wave rectified version of the input voltage.If resistors R6 equals R4 and R5, the circuit has an overall gain of 1.When R6 is greater than R4 and R5, amplification and rectification both occur.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	step 1: Do the connections as per the circuit diagram. • Step2: sine wave of 0.5Vp, 1MHZ as input to the op – amp. Bias the op – amp with supply voltage of +12V and -12V. Step3:observe input and rectified output waveform in CRO. Step4:calculate ripple fsctor and efficiency of full wave pricision rectifier. Step5: Draw the output waveform
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	 **WAVEFORM** **TRANSFERCURVE** 
8	Observation Table, Look-up Table, Output	
9	Sample Calculation	**Design a precision full wave rectifier circuit to produce a 2V peak output from a sine wave input with a peak value of 0.5V and a frequency of 1 MHZ..** Let I1 = 500µA (for adequate diode current) R1 = Vi/I1 = 0.5V/ 500µA = 1KΩ R2 = 2R1 = 2 KΩ (use two 1KΩ resistors in series) R3 = R1 || R2 = 1KΩ || 2KΩ = 670Ω (use 680Ω standard value) R4 = R5 = R1 = 1KΩ (std value) For the output to be 2V when the input is 0.5V R6 = (V0/Vin) x R5 = (2v/0.5v) x 1KΩ

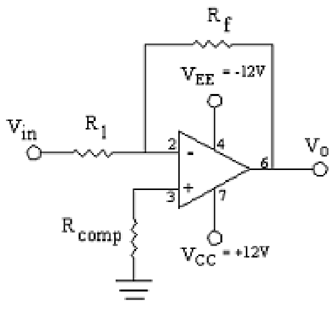
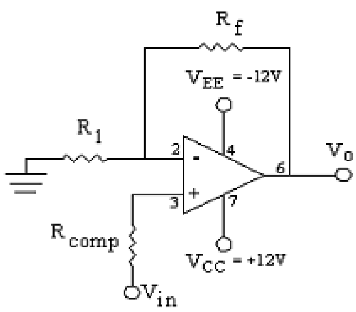
11		= 4 KΩ (use 3.9 KΩ std value) R7 = R4|| R5||R6 = 1KΩ || 1KΩ || 3.9KΩ = 443 KΩ (use 470Ω std value) **Calculations:** Ripple Factor = V_{oac} / V_{odc}
10	Graphs, Outputs	
11	Results & Analysis	Designed and Verifed the output of a precision full wave rectifier and determined the performance parameters such as efficiency and regulation.
12	Application Areas	Rectifiers are used in DC regulated power supply.
13	Remarks	
14	Faculty Signature with Date	

Experiment 02 : Frequency Response of an Op – Amp

-	Experiment No.:	2	Marks		Date Planned		Date Conducted	
1	Title	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non- inverting configuration for a given gain.						
2	Course Outcomes	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non- inverting configuration for a given gain using lic hardware kit.						
3	Aim	To design and realize to analyse the frequency response of an op – amp amplifier under inverting and non- inverting configuration for a given gain.						
4	Material / Equipment Required	Lab Manual/ CRO, Signal generator, capacitor, diodes, power chord, ammeter, multi-meter.						

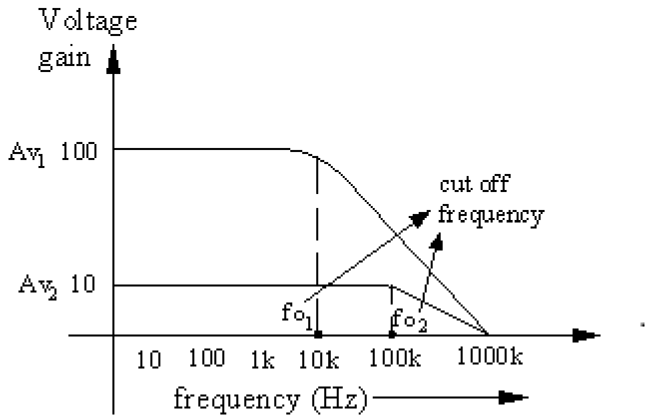
SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	

8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5	Theory, Formula, Principle, Concept	**THEORY:** **INVERTING AMPLIFIER**: The fundamental component of any analog computer is the operational amplifier or op-amp and the frequency configuration in which it is used as an inverting amplifier. An input voltage Vin is applied to the input voltage. It receives and inverts its polarity producing an output voltage. this same output voltage is also applied to a feedback resistor Rf, which is connected to the amplifier input analog with R1. The amplifier itself has a very high voltage gain. If Rf = R1 then Vo=Vi **NON- INVERTING AMPLIFIER:** Although the standard op-amp configuration is as an inverting amplifier, there are some applications where such inversion is not wanted. However, we cannot just switch the inverting and non inverting inputs to the amplifier itself. We will still need negative feedback to control the working gain of the circuit .Therefore, we will need to leave the resistor structure around the op-amp intact and swap the input and ground connections to the overall circuit. VO/VI = (Rf / Ri) +1 From the calculations, we can see that the effective voltage gain of the non-inverting amplifier is set by the resistance ratio. Thus, if the two resistors are equal value, then the gain will be 2 rather than 1.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	1)Do the connection as per the circuit diagram 2)Bias the op – amp with supply voltage of +12V and -12V. Apply a input sinusoidal signal of constant voltage to the inverting / non inverting terminal of the op-amp. 3)Tabulate the o/p voltage Vo w.r.t. different values of input frequency. 4)Calculate the gain A_f and plot the graph of frequency V/S A_f and check the graph to get approximately the same characteristic as shown in the expected graph.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	**CIRCUIT DIAGRAM:**   **Fig 2.1 Inverting Amplifier** **Fig2.2 Non -**

Inverting Amplifier

SPECIMEN GRAPH



8 Observation Table, Look-up Table, Output

TABULAR COLUMN

Inverting Amplifier for a gain of _ ,the v_{in} ------V

Frequency(HZ)	V_0(volts)	$A_f = V_0/V$	Gain in dB $A_{fdB}=20\log V_0/V_{in}$

Non -Inverting Amplifier for a gain of --------- the V_{in} is ----V

Frequency(HZ)	V_0(volts)	$A_f = V_0/V$	Gain in dB $A_{fdB}=20\log V_0/V_{in}$

<table>
<tr><td></td><td></td><td></td></tr>
<tr><td>9</td><td>Sample Calculations</td><td>

DESIGN

Inverting Amplifier:-

a) Let gain A_f =10
As WKT A_f= $-R_f / R_1$ and UGB =1MHz
let R_1 = 1KΩ
Therefore R_f= A_f R_1 = 10kΩ, R_{comp}=R_f ||R_1=10KΩ ||1KΩ = 1KΩ
β = R_1 / (R_1 + R_f) = 1KΩ/ (1KΩ + 10KΩ) = 1/11
f_F = f_o (1 + Aβ) = 5 (1 + 2 00,000 x (1/11)) = 90KHZ

b) Let gain A_f =100
As WKT A_f= $-R_f / R_1$ and UGB =1MHz
let R_1 = 1KΩ
Therefore R_f= A_f R_1 = 100kΩ, R_{comp}=R_f ||R_1=100KΩ ||1KΩ = 1KΩ
β = R_1 / (R_1 + R_f) = 1KΩ/ (1KΩ + 100KΩ) = 1/101
f_F = f_o (1 + Aβ) = 5 (1 + 2 00,000 x (1/101)) = 10KHZ

Non -Inverting Amplifier:-

a)Let gain A_f =10
As WKT A_f = 1 +(R_f /R_1) and UGB = 1MHZ
Let R_1 = 1KΩ
10 = 1 +(R_f /1KΩ)
R_f =9KΩ = 10KΩ
β = R_1 / (R_1 + R_f) = 1KΩ/ (1KΩ + 10KΩ) = 1/11
f_F = f_o (1 + Aβ) = 5 (1 + 2 00,000 x (1/11)) = 90KHZ

b)Let gain A_f =100
As WKT A_f = 1 + (R_f /R_1) and UGB = 1MHZ
Let R_1=1kΩ
100 = 1 + (R_f /1kΩ)

</td></tr>
</table>

		R_f =99KΩ = 100KΩ, R_{comp}=R_f ||R_1=100KΩ ||1KΩ = 1KΩ β = R_1 / (R_1 + R_f) = 1KΩ/ (1KΩ + 100KΩ) = 1/101 f_F = f_O (1 + Aβ) = 5 (1 + 2 00,000 x (1/101)) = 10KHZ
10	Graphs, Outputs	
11	Results & Analysis	Designed and realized to analyse the frequency response of an op – amp amplifier under inverting and non- inverting configuration for a gain of 10.
12	Application Areas	Anlysis of freqency response of op amp
13	Remarks	
14	Faculty Signature with Date	**RC Phase Shift Oscillator**

Experiment 03: RC Phase Shift Oscillator

-	Experiment No.:	3	Marks		Date Planned		Date Conducted	
1	Title	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.						
2	Course Outcomes	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency using lic hardware kit.						
3	Aim	To design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.						
4	Material / Equipment Required	Lab Manual/ CRO, Signal generator, capacitor, resistors, power chord, ammeter, multi-meter, BJT.						

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5	Theory, Formula, Principle, Concept	**THEORY:** RC phase shift oscillator produces 360° of phase shift in two parts. Firstly, each and every RC pair in the feedback network produces

		60˚ phase shift and totally there were three pairs, thus producing 180˚ Phase shift and secondly, the feedback input is given to the inverting terminal of op-amp to produce another 180˚ phase shift and a total phase shift of 360˚. The frequency of oscillation is given by f0 = 1/ 2π√6 RC ; If an inverting amplifier is used, the gain must be atleast equal to 29 to ensure the oscillations with constant amplitude that is,$\|A_V\beta\| < 1$. Otherwise the oscillation will die out.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE:** **1)** Do the connection as per the circuit diagram**.** 2)Bias the op – amp with supply voltage of +12V and -12V. 3)Observe the amplitude and frequency of output waveform in CRO. 4) Draw the waveform
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	**CIRCUIT DI**

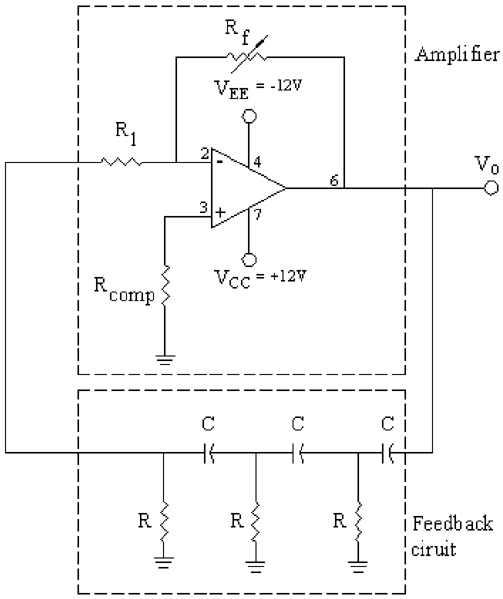
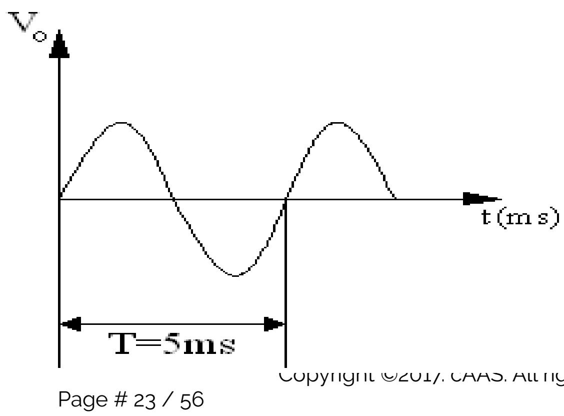


Fig. 3.1 RC Phase Shift Oscillator

WAVEFORM:



8	Observation Table, Look-up Table, Output	
9	Sample Calculations	**DESIGN:** **Design Propblem:** Design of RC Phase shift oscillator to oscillate at f_0 = 500 HZ. 1) Let **C = 0.1 µF** W.K.T f_0 = = 1/ 2π√6 RC f_0 = 0.065/RC therefore R = 0.065/f_0 C = 0.065/ (500 x 0.1x10^{-6}) = 1.31 KΩ **R = 1.5 KΩ (std)** 2)To prevent the loading of amplifier because of RC network, it is necessary that $R_1 \geq 10R$ so take R_1 = 10 x 1.5 KΩ **R_1 = 15 KΩ** 3)At the given frequency, the gain must be atleast 29 i.e (for inverting)R_f/R_1 = 29 Therefore R_f = 29 R_1 = 29 x 15 KΩ R_f= 435 KΩ **R_f = 1MΩ (std value)** 4)Let R_{comp} = R_f || R_1 = 15KΩ ||1MΩ **R_{comp}= 15KΩ** •
10	Graphs, Outputs	
11	Results & Analysis	Designed and verified the output waveform of an op – amp RC phase shift oscillator for a frequency of 500HZ
12	Application Areas	Signal generator is used in industry, agriculture, boimedicine and other fields

		such as high frequency induction heating, melting , quenching, ultrasonic diagnosis, nuclear magnetic resonance imaging etc..
13	Remarks	
14	Faculty Signature with Date	

Experiment 04 : Schmitt Trigger Circuit using an Op – Amp

-	**Experiment No.:**	4	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).						
2	Course Outcomes	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP) using lic hardware kit.						
3	Aim	To design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).						
4	Material / Equipment Required							

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5 Theory, Formula, Principle, Concept

THEORY:

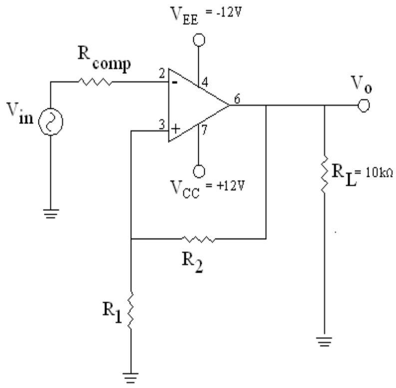
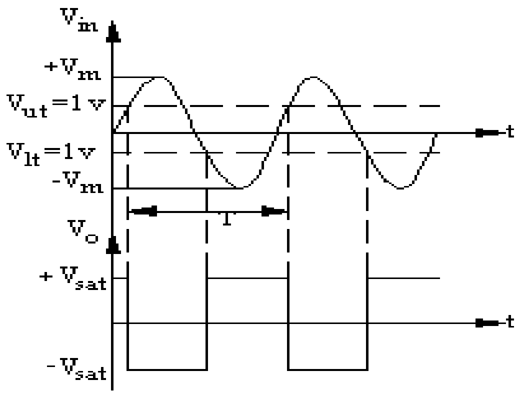
A circuit which converts a irregular shaped waveform to a square wave or pulse is called a Schmitt trigger or squaring circuit. The input voltage Vin triggers the output Vo every time it exceeds certain voltage levels called upper threshold voltage VUT and lower threshold voltage VLT. The threshold voltages are obtained by using the voltage divider. A comparator with positive feedback is said to exhibit hysteresis, a dead band condition. The hysteresis voltage is the difference between VUT & VLT.

There are two types of Schmitt trigger based on where the irregular wave is given. They are, Inverting & non-inverting Schmitt trigger. Schmitt trigger finds application in wave shaping circuits. The other name given to Schmitt trigger is regenerative comparator

6 Procedure, Program, Activity,

PROCEDURE:

1) Do the connection as per the circuit diagram.

	Algorithm, Pseudo Code	2) Bias the op – amp with supply voltage of +12V and -12V. 3) Apply the input signal to the inverting terminal of op – amp and set Vutp = 1V and Vltp = -1V. 4) Observe the Input and output waveform in CRO.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	**CIRCUIT DIAGRAM:**  **WAVEFORMS:** 
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	**DESIGN:** Select the desired value of Vutp and Vltp with same magnitude and opposite polarity. Let V_{utp} = +2V and V_{ltp} = -2V **Inverting Schmitt Trigger** 1)For op – amp µA741 IC $+V_{supply}$ = +12V and $+V_{sat}$= +11V. 2) $I_2 \geq I_{B(max)}$, Let $I_2 = 100 \times I_{B(max)}$ = 100 x 500 nA = 50 µA **3)** R_2 = |Trigger Voltage | / I_2 = 2V / 50 µA = 40KΩ = 39KΩ (standard value) I_{2new} = 2V / 39KΩ = 51.3 µA **4)**R_1 **= (** Vo - |Trigger Voltage|) / I_{2new} = (Vsat – 2V) / 51.3 µA= (11 - 2) / 51.3 µA = 175KΩ = 180KΩ (standard value)

		Non - Inverting Schmitt Trigger 1)For op – amp μA741 IC $-V_{supply}$ = -12V and $-V_{sat}$= -11V. 2)$I_2 \geq I_{B(max)}$, Let $I_2 = 100 \times I_{B(max)}$ = 100 x 500 nA = 50 μA **3)**R_1 = |Trigger Voltage | / I_2 = 2V / 50 μA = 40KΩ = 39KΩ (standard value) I_{2new} = 2V / 39KΩ = 51.3 μA **4)** R_2 **= |** Vo | / I_{2new} = 11 / 51.3 μA= (11 - 2) / 51.3 μA = 214KΩ = 180KΩ (standard value)
10	Graphs, Outputs	
11	Results & Analysis	Designed and realized Schmitt trigger circuit using an op – amp for upper trip point (UTP) of +2v and lower trip point (LTP) of -2V.
12	Application Areas	Used in square wave generation.
13	Remarks	
14	Faculty Signature with Date	

Experiment 05: Voltage Comparator and zero Crossing Detector using Op Amp

-	Experiment No.:	5	Marks		Date Planned		Date Conducted	
1	Title	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.						
2	Course Outcomes	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector using lic hardware kit.						
3	Aim	To verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.						
4	Material / Equipment Required							

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5 Theory, Formula, Principle, Concept

THEORY:

Comparator:

A comparator circuit is one which compares a voltage signal at one input with a known reference signal at the other input. It works in open loop mode. There are basically two types of comparator namely inverting and non-inverting comparators. The output will be either +Vsat or –Vsat depending upon the amplitude of the signal at the input terminal. If the amplitude of the noninverting terminal signal is greater than the inverting terminal signal then the output will be +Vsat and vice-versa.

		Zero Crossing Detector: The zero crossing detector is a special case basic comparator circuit. If we set reference voltage zero then a comparator behaves like a zero crossing detector.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE:** 1)Do the connection as per the circuit diagrams. 2) Bias the op – amp with supply voltage of +12V and -12V. 3)A fixed reference voltage Vref is applied to the inverting terminal and to the non inverting terminal a varying voltage Vin is applied as shown in circuit diagram. 4)Vary the input voltage above and below the Vref and note down the output at pin 6 of 741 IC. 5)Observe that, when Vin is less than Vref, the output voltage is -Vsat (@ - VEE) when Vin is greater than Vref, the output voltage is +Vsat (@+VCC) 6)Observe input and output waveforms in CRO. 7)Draw the waveforms. •
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	CI **CIRCUIT DIAGRAM:**

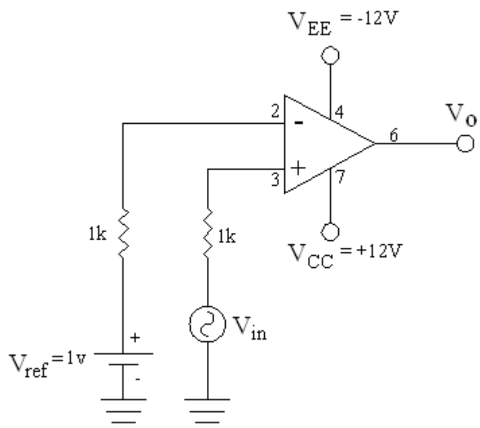


Fig 5.1 Voltage Comparator

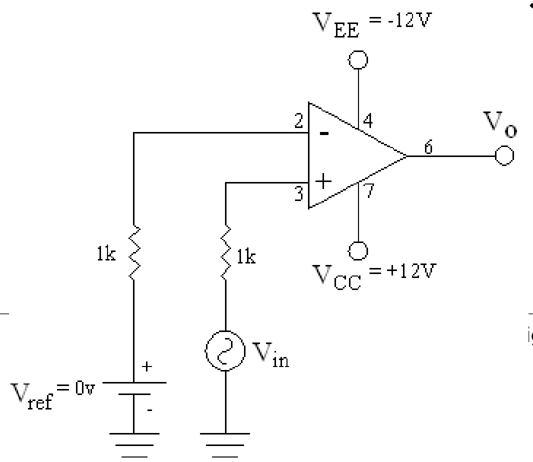
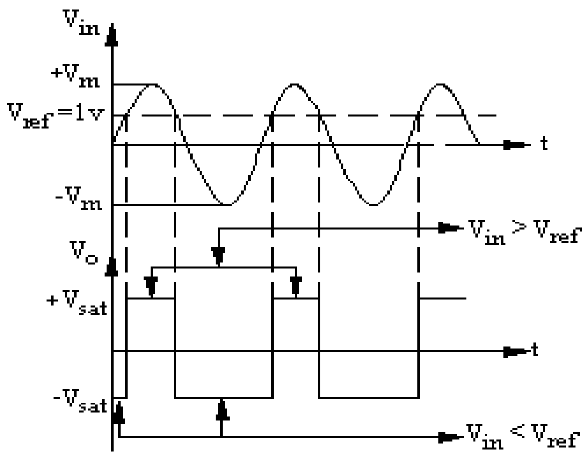
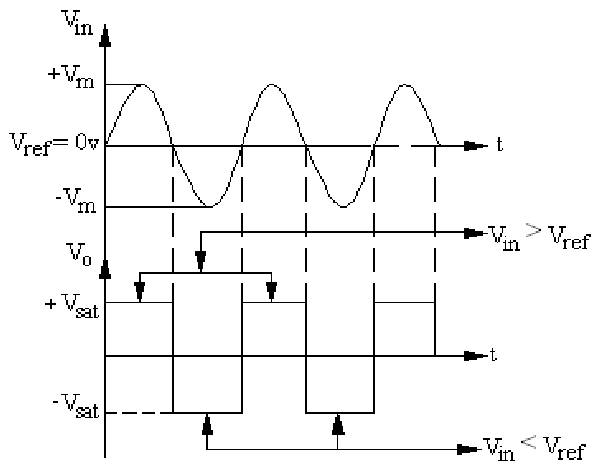


Fig 5.2 Zero Crossing Detector

W W AEFORM:



Volt Voltage Comparator



Z Zero Crossing Detector

8	Observation Table, Look-up Table, Output	
9	Sample Calculations	
10	Graphs, Outputs	

11	Results & Analysis	Verified the operation of an op – amp as (a) voltage comparator circuit for Vref ±1V and (b) zero crossing detector.
12	Application Areas	Comparators are used in oscillators, DAC, ADC , multi-vibrators and etc
13	Remarks	
14	Faculty Signature with Date	

Experiment 06: Op – Amp as an (a) Adder (b) Subtractor (c) Integrator and (d) Differentiator.

-	Experiment No.:	6	Marks		Date Planned		Date Conducted	
1	Title	Design and verify the operssation of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.						
2	Course Outcomes	Design and verify the operssation of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator using lic hardware kit.						
3	Aim	To design and verify the operssation of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.						
4	Material / Equipment Required	(see table below)						

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1

5 Theory, Formula, Principle, Concept

THEORY:

Adder*:* A two input summing amplifier may be constructed using the inverting mode. The adder can be obtained by using either non-inverting mode or differential amplifier. Here the inverting mode is used. So the inputs are applied through resistors to the inverting terminal and non-inverting terminal is grounded. This is called "virtual ground", i.e. the voltage at that terminal is zero. The gain of this summing amplifier is 1, any scale factor can be used for the inputs by selecting proper external resistors.

Subtractor: A basic differential amplifier can be used as a subtractor as shown in the circuit diagram. In this circuit, input signals can be scaled to the desired values by selecting appropriate values for the resistors. When this is done, the circuit is referred to as scaling amplifier. However in this circuit all external resistors are equal in value. So the gain of amplifier is equal to one. The output voltage Vo is equal to the voltage applied to the noninverting terminal minus the voltage applied to the inverting

		terminal; hence the circuit is called a subtractor. **Integrator:** In an integrator circuit, the output voltage is integral of the input signal. The output voltage of an integrator is given by Vo = -1/R1Cf ∫ *Vi dt* At low frequencies the gain becomes infinite, so the capacitor is fully charged and behaves like an open circuit. The gain of an integrator at low frequency can be limited by connecting a resistor in shunt with capacitor. **Differentiator:** In the differentiator circuit the output voltage is the differentiation of the input voltage. The output voltage of a differentiator is given by Vo = -RfC1 *dVi /dt.*.The input impedance of this circuit decreases with increase in frequency, thereby making the circuit sensitive to high frequency noise. At high frequencies circuit may become unstable.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE** **Adder/Susbstractor** 1. Connect the circuit as shown in the diagram. 2. Apply the bias voltages of ±12v to pin 7 and pin 4 of IC741 respectively. 3. Apply two different signals (DC/AC) to the inputs. 4. Vary the input voltages and note down the corresponding output at pin 6 of IC741 5. Notice that the output is equal to the sum/difference of the two inputs. **Integrator** 1. Connect the circuit as per the diagram shown in Fig6.3 2. Apply a square wave/sine input of 4V(p-p) at 1KHz 3. Observe the output at pin 6. 4. Draw input and output waveforms . **Differentiator** 1. Connect the circuit as per the diagram shown in Fig 6.4 2. Apply a square wave/sine input of 4V(p-p) at 1KHz

		3. Observe the output at pin 6 4. Draw the input and output waveforms .
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	**CIRCUIT DIAGRAM** **Fig 6.4 Differentiator**
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	
10	Graphs, Outputs	
11	Results & Analysis	Designed and verifed the operation of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.
12	Application Areas	Summing amplifier is Used in audio mixer to add different signals with n equal gains. Instrumentaion amplifiers are used in data acquisition systems.
13	Remarks	
14	Faculty Signature with Date	

Experiment 07: Op – Amp Based First Order Butterworth (a) Low Pass (b) High Pass and (c)Band pass Filters

-	**Experiment No.:**	7	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c)band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic.						
2	Course Outcomes	Design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c)band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic using lic hardware kit.						
3	Aim	To design and realize an op – amp based first order Butterworth (a) low pass (b) high pass and (c)band pass filters for a given cut off frequency/frequencies to verify the frequency response characteristic.						
4	Material / Equipment Required							

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

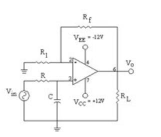
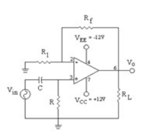
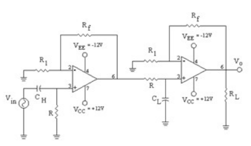
5 Theory, Formula, Principle, Concept

THEORY:

Active Lpf :

A filter circuit which allows only low frequency range up to a higher cut-off frequency fH is called as Low Pass Filter. An active filter uses transistor and components such as resistor & capacitor for its design. An active filter offers the following advantages over a passive filter.

1. Gain & frequency adjustment flexibility.
2. No loading problem because of high input impedance & low output impedance.

		3. More economical because of variety of op-amps and absence of inductors. From the frequency response, when f<fH; the gain is maximum lAl. When f=fH; the gain is 70.7% of the maximum gain and when f fH; the gain drops or rolls off. The frequency range from 0 to fH is called as Passband & fH to is called as Stopband. Out of Butterworth, chebyshev & cauer filters, Butterworth filter is preferred because it has flat pass band as well as flat stop band (flat-flat) filter. Active Hpf: An active high pass filter is simply formed by interchanging the frequency determining resistor and capacitor in lowpass filter. A filter circuit which allows only high frequency range greater then a lower cut-off frequency fL is called as HIGH PASS FILTER. From the frequency response, when f<fL; the gain gradually increases from the lowest value. When f = fL; the gain reaches 70.7% of the maximum gain lAl and when f > fL, the gain is maximum lAl. The frequency range from 0 to fL is called as Stopband & fL to is called as Passband. (This is exactly opposite to active LPF)The order of the filter tells the roll-off rate at stop band. Order n = 1 indicates -20dB / dec (-6db / octave); Order n = 2 indicates -40dB / dec & so on. Higher the order of the filter, better the quality will be & complex the circuit will be. Active Bandpass Filter: A filter which has a pass band between two cut-off frequencies fH & Fl is called as Bandpass filter. Where fH > fL BPF is basically of two types (i) Wide band pass filter. (ii) Narrow band pass filter.Based on figure of merit or quality factor Q, the types are classified as follows. If Q<10, selectivity is poor & allows higher bandwidth & such BPF is called as wide BPF.If Q > 10, selective is more and allows only narrow bandwidth & such BPF is called as Narrow BPF. Relationship between Q & center frequency fC is given as When frequency fL < f < fH then gain is maximum. At f < fL the gain is gradually increasing (positive roll-off) from lower value & at f > fH the gain is gradually decreasing (Negative roll-off) & exactly when f = fL & f = fH the gain is 70.7% of maximum gain lAl .
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE (LPF /HPF /BPF):** • 1)Do the connection as per the circuit diagram. • 2)Bias the op – amp with supply voltage of +12V and -12V. • 3)Apply a input sinusoidal signal of constant voltage to the non inverting terminal of the op-amp. • 4)Tabulate the o/p voltage Vo w.r.t. different values of input frequency. • 5)Calculate pass band gain and plot the graph of frequency V/S Av and check the graph to get approximately the same characteristic as shown in the expected graph.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	CIRCUIT DIAGRAM  Fig 7.1 Low Pass Filter  Fig 7.2 High Pass Filter  Fig 7.3 Band Pass Filter

8	Observation Table, Look-up Table, Output	**OBSERVATION TABLE:**

For LPF V_{in} = -------V

I/P frequency, f(HZ)	Output Voltage |Vo|	Gain A_f= |Vo/V_{in}|	Gain (dB) = 20log |Vo/ V_{in}|

For HPF V_{in} = -------V

I/P frequency, f(HZ)	Output Voltage |Vo|	Gain A_f= |Vo/V_{in}|	Gain (dB) = 20log |Vo/ V_{in}|

For BPF V_{in} = -------V

I/P frequency, f(HZ)	Output Voltage |Vo|	Gain A_f= |Vo/V_{in}|	Gain (dB) = 20log |Vo/

			V_{in}l

9	Sample Calculations	**DESIGN:**

DESIGN:

Design Problem : Design of LP/HP filters for cut – off frequency of fH = fL = 1khz and pass band gain = 2

1) Select the value of C < 1 μF.

2) Assume C = 0.1 μF. Calculate R from

fH = fL = 1 /2π RC

R = 1 / 2π (fH or fL)C

= 1/ 2π x 1x103 x 0.1 x 10-6

R = 1.5KΩ

3) Determine the value of R1 and Rf from pass band gain of the filter

Af = 1 + (Rf/R1)

2 = 1 + (Rf/R1)

therefore Rf = R1 to select Af = 2

let Rf = R1 = 22KΩ and RL = 10KΩ

4) Calculate the practical gain in dB using Gain(dB) = 20log(Vo/Vin).

Theorotical gain given as lVo/Vinl = Af / √1+(f/ fH or fL)2

Af = Pass Band Gain

f = i/p frequency

fH = upper cut off frequency of LPF

fL = Lower cut off frequency of HPF

Design problem: Design a BPF to pass a band of 1KHZ to 10KHZ with a passband gain of 4.

1) Select the highest cut – off frequency of LPF as fH = 10KHZ and lowest cut-off frequency of HPF as fL = 1KHZ.

2) Design the HPF first by taking fL = 1 KHZ. Assume the value of C < 1 μF. Let CH = 0.1 μF

3) Calculate RH from the expression fL = 1/ 2 π RH CH

Therefore RH = 1/ 2 π fL CH

= 1/ 2 x π x 1x103x 0.1x10-6

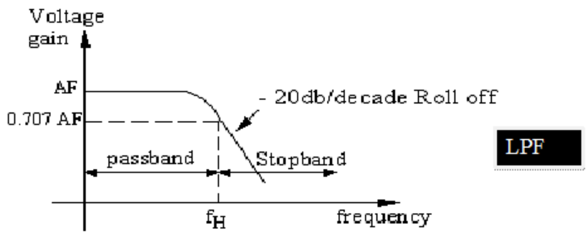
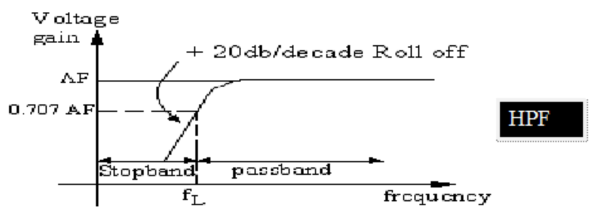
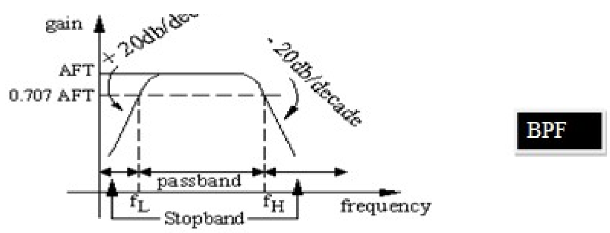
= 1.59

RH = 1.5KΩ (std)

4) Then design the LPF by taking fH = 10 KHZ. Assume the value of C < 1 μF. Let CL = 0.01 μF

5) Calculate RL from the expression fH = 1/ 2 πRLCL

Therefore RL = 1/2πfLCL

		$= 1/ 2 \times \pi \times 10\times10^3 \times 0.01\times10^{-6}$ $= 1.59$ RL= 1.5KΩ (std) 6) Calculate the values of Rf and R1 with the use of pass band gain. Overall pass band gain of BPF = 4 = 2(HPF) X 2(LPF) Therefore for both HPF and LPF , the value of Rf = R1 to obtain an individual pass band gain of 2. Af = 1 + (Rf/R1) = 2 (for HPF) Af = 1 + (Rf/R1) = 2 (for LPF) Let Rf = R1 = 22 KΩ 7) Q of the filters is calculated as fC / BW = fC / (fH - fL) where fC = √fHfL is centre frequency $= \sqrt{10 \times 10^3 \times 1 \times 10^3}$ = 3162.2HZ fC = 3.16 KHZ 8) Cascade HPF and then LPF to form BPF. Calculate the practical gain in dB using 20log(VO/Vin) and theoretical gain as lVo/Vinl = Af t(f/f L) / √[1+(f/fL)2] x [1 + (f/fH)2] Where Aft = total passband gain
10	Graphs, Outputs	**EXPECTED GRAPH:**   
11	Results & Analysis	Design [illegible] worth (a) low pass (b) high pass filters for 1Khz cut off frequency to verify the frequencyresponse characteristic and (c)band pass filters for a1Khz-10Khz cut off frequencies to verify the frequency response characteristic.
12	Application Areas	Active filters are used in communication systems for suppressing noise, in audio systems , biomedical instruments to interface psychollogical sensors with diagnostic equipments and data logging.
13	Remarks	

14	Faculty Signature with Date	

Experiment 08: Op – Amp Based Function Generator to Generate Sine, Square and Triangular Waves

-	**Experiment No.:**	3	**Marks**		**Date Planned**		**Date Conducted**	

1	Title	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.
2	Course Outcomes	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency using lic hardware kit.
3	Aim	To design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.
4	Material / Equipment Required	

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5 Theory, Formula, Principle, Concept

THEORY:

Function generator generates waveforms such as sine, triangular, square waves and so on of different frequencies and amplitudes. The circuit shown in Fig 8.1 is a simple circuit which generates square waves and triangular waves simultaneously. Here the first section is a square wave generator and second section is an integrator. When square wave is given as input to integrator it produces triangular wave.

6 Procedure, Program, Activity, Algorithm, Pseudo Code

PROCEDURE:

- 1.Connect the circuit as per the circuit diagram shown above.
- 2.Bias the op – amp with supply voltage of +12V and -12V
- 2.Obtain square wave at Vo1 and Triangular wave at Vo2 as shown in Fig 8.1.
- 3. Observe the output waveforms in CRO.

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph

CIRCUIT DIAGRAM:

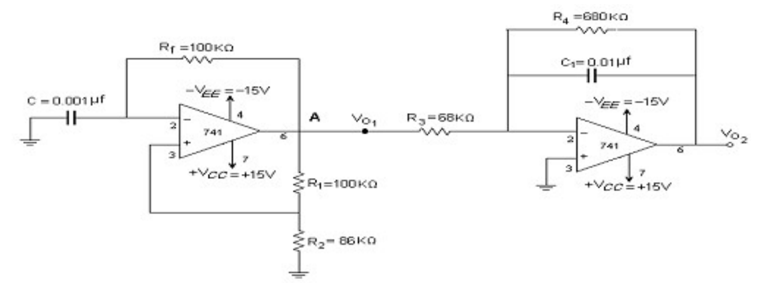
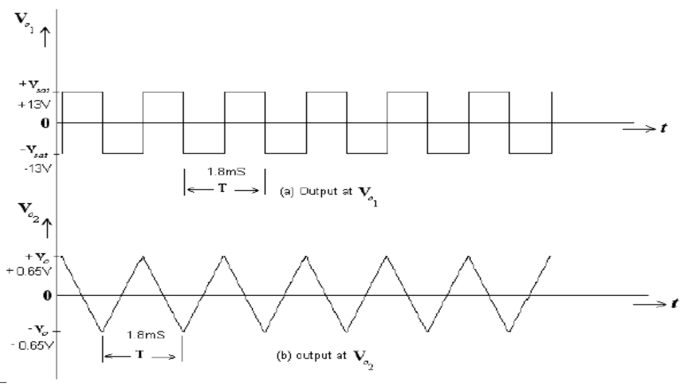


		Fig 8.1 Function Generator
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	**DESIGN** : Let Vopp = 7v and frequency of oscillation f0 = 2KHZ. Vsat = 12 – 1 = 11V Vopp = 2 x (R2/R3) x Vsat 7 = 2 x (R2/R3) x 11 R2/ R3 = 7/ (2 x 11) = 0.318 R3 = 3.14 * R2 Let R2 = 10KΩ R3 = 3.14 * 10KΩ R3 = 31.4KΩ = 33KΩ (Standard value) Frequency of oscillation f0 = R3 / 4 x R1 x C1 x R2 Let C1 = 0.01µF 2 x 103 = 33KΩ / 4 x R1 x 0.01 x 10-6 x 10 x 103 R1 = 41.25KΩ = 39KΩ (Standard value)
10	Graphs, Outputs	**WAVEFORM:** 
11	Results & Analysis	Designed and realized an op – amp based function generator to generate sine, square and triangular waves of 2KHZ frequency
12	Application Areas	Use in signal/function generator.
13	Remarks	
14	Faculty Signature with Date	

Experiment 09:R – 2R ladder DAC

-	**Experiment No.:**	9	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Design and realization of R – 2R ladder DAC						
2	Course Outcomes	Design and realize of R – 2R ladder DAC using lic hardware kit.						

3 Aim

To design and realization of R – 2R ladder DAC

4 Material / Equipment Required

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1μF, 0.01μF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICμA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5 Theory, Formula, Principle, Concept

THEORY:

Real world signals are analog. Digital systems that interface with the real world do so using analog-to-digital converters (ADC). Conversion back to analog is accomplished using digital-to- analogue converters (DAC). The R-2R ladder network is commonly used for Digital to Analog conversions.

In basic N bit R-2R resistor ladder network the digital inputs or bits range from the most significant bit (MSB) to the least significant bit (LSB). The bits are switched between either 0V or VR and depending on the state and location of the bits Vo will vary between 0V and VR . The MSB causes the greatest change in output voltage and the LSB causes the smallest.

The R-2R ladder is inexpensive and relatively easy to manufacture since only two resistor values are required. It is fast and has fixed output impedance R. In R-2R ladder type D to A converter, only two values of resistor is used (i.e.R and 2R). Hence it is suitable for integrated circuit fabrication. The typical values of R are from 2.5KΩ to 10KΩ. In this output voltage is a weighted sum of digital inputs. Since the resistive ladder is a linear network, the principle of super position can be used to find the total analog output voltage for a particular digital input by adding the output voltages caused by the individual digital inputs.The output voltage is linearly proportional to the digital input and the range can be adjusted by changing the reference voltage VR

6 Procedure, Program, Activity, Algorithm, Pseudo Code

PRCODURE:

1)Wire the R/2R ladder 4 bit DAC circuit .
2)Bias the op – amp with supply voltage of +12V and -12V
3) Reference voltage VR is set as 5V .

4) Find the output voltage Vo for different combinations of digital binary inputs from 0000 to 1111.
5)Compare the calculated values with observed values and plot DAC characteristics.

7 Block, Circuit, Model Diagram, Reaction Equation, Expected Graph

CIRCUIT DIAGRAM:

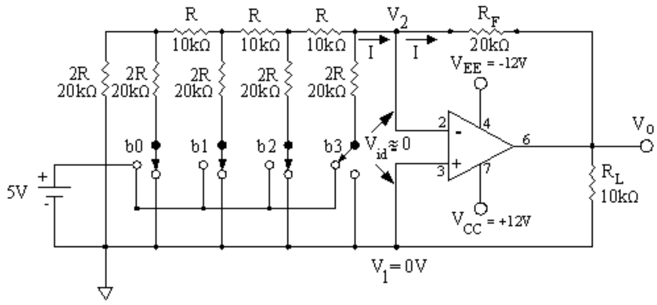


Fig 9.1 4 – Bit R- 2R Ladder Digital To Analog Converter

8 Observation Table, Look-up Table, Output

Decimal Value	Binary Input	Theoretical Value	Practical Value
0	0000	0	
1	0001	-0.625	
2	0010	-1.25	
3	0011	-1.875	
4	0100	-2.50	
5	0101	-3.125	
6	0110	-3.750	
7	0111	-4.375	
8	1000	-5	
9	1001	-5.625	
10	1010	-6.25	
11	1011	-6.875	
12	1100	-7.50	
13	1101	-8.125	
14	1110	-8.875	
15	1111	-9.375	

9 Sample Calculations

DESIGN:

- For gain = Rf / R = 2 Rf = 2R Let R = 10KΩ then Rf = 2R = 20KΩ

CALCULATIONS:

- Output Voltage is given by
- Vo = - (VR / 16) *(Rf/ R)* (b0 + 2b1 + 4b2 + 8b3)
- where, VR = 5V , b3 (MSB bit) and b0 (LSB bit) then Resolution = FS / (2n- 1) , where n= no of digital inputs VFS = Value of analog output when digital input is 1111.

		• Resolution = 0.625 = Value of LSB bit.
10	Graphs, Outputs	
11	Results & Analysis	Designed and realized 4-bit R – 2R ladder DAC
12	Application Areas	DAC are used in data acquition system.
13	Remarks	
14	Faculty Signature with Date	

Experiment 10:Two Bit Flash ADC.

-	Experiment No.:	10	Marks		Date Planned		Date Conducted	
1	Title	Realization of Two bit Flash ADC.						
2	Course Outcomes	Realize of Two bit Flash ADC using lic hardware kit.						
3	Aim	To realization of Two bit Flash ADC.						
4	Material / Equipment Required	(see table below)						

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5 Theory, Formula, Principle, Concept

THEORY:

Flash ADC is also called as parallel ADC.Its response is very fast.It converts analog signal into digital signal using parallel set of comparators. As its conversion time is very fast it is called as flash. ADC.Reference ladder(voltage divider) consists of 2N equal size resistors. N – bit flash ADC consist of parallel combination of 2N-1 comparators. Outputs of all comparators are connected to an encoder.

Analog voltage is applied to non inverting terminals of all comparators using a single line.Reference voltage is applied to inverting terminals of comparators using divider circuit.Each comparator produces digital output in the form of 1 or 0. If unknown analog voltage is greater than reference voltage comparator produces high logic.If analog voltage is less than reference voltage then comparator produces low logic i.e 0.Thus all parallel comparator produces digital representation of analog voltage in the form of zero and one. These outputs
of comparator are then applied to the fast encoder. Encoder converts those zeros and ones into binary number and producesdigital binary output.

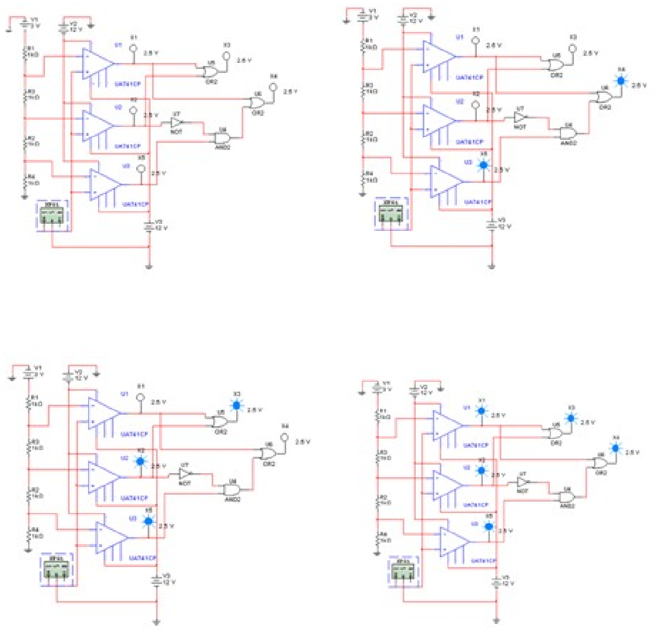
6 Procedure, RCODURE:

Program, Activity, Algorithm, Pseudo Code

- 1)Do the connection as per the 2- bit flash ADC circuit .
- 2) Bias the op – amp with supply voltage of +12V and -12V
- 3) Reference voltage VR is set as 3V .
- 4)Apply the analog input signal of Vp = 3V from function generator to
- ADC. Check the digital output voltage Vo for different values of analog voltage values.

7 **Block, Circuit, Model Diagram, Reaction Equation, Expected Graph**

CIRCUIT DIAGRAM WITH SIMULATED OUTPUT:



8 **Observation Table, Look-up Table, Output**

ADC TABLE:

Analog Voltage in volts	Comparator Output			Digital(Encoder) Output	
	A	B	C	D1	D0
0	0	0	0	0	0
1	0	0	1	0	1
2	0	1	1	1	0
3	1	1	1	1	1

9 **Sample Calculations**

10	Graphs, Outputs	-
11	Results & Analysis	Realized Two bit Flash ADC.
12	Application Areas	ADC are used in data acquition system.
13	Remarks	
14	Faculty Signature with Date	

Experiment 11: IC 555 timer Based Pulse Generator

-	**Experiment No.:**	3	**Marks**		**Date Planned**		**Date Conducted**	
1	Title	Design and verify an IC 555 timer based pulse generator for the specified pulse.						
2	Course Outcomes	Design and verify an IC 555 timer based pulse generator for the specified pulse using lic hardware kit.						
3	Aim	To design and verify an IC 555 timer based pulse generator for the specified pulse.						
4	Material / Equipment Required							

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2),10KΩ(1)	4
3	Capacitors	0.1μF, 0.01μF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICμA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5	Theory, Formula, Principle, Concept	**THEORY:** An Astable Multivibrator or a Free Running Multivibrator is the multivibrator which has no stable states. Its output oscillates continuously between its two unstable states without the aid of external triggering. The time period of each states are determined by Resistor Capacitor (RC) time constant. Monostable Multivibrators or "One-Shot Multivibrators" as they are also called, are used to generate a single output pulse of a specified width, either "HIGH" or "LOW" when a suitable external trigger signal or pulse T is applied.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE FOR ASTABLE MULTIVIBRATOR:** Asymmetrical: Frequency 1 KHz with 0.75 duty cycle. 1.Verify the components and patch chords whether they are in good condition. 2.Connect the Astable multivibrator circuit using IC 555 timer as shown in the ckt as per the design. 3.Switch on the DC power supply unit Vcc=12V. 4.Observer the output waveform at pin no 6 on CRO.(capacitor output) 5.Also observe the output waveform at pin no 3 on CRO.(Multivibrator output) 6.For the capacitor output at pin no 6 , measure the maximum and minimum voltage levels. Verify that VUT =2/3Vcc and VLT= 1/3 Vcc. 7.Compare the capacitor voltage Vc with output waveform Vo and note that capacitor charges and Vc rises exponentially when output is high. The capacitor C discharges through RB and the diode and Vc falls exponentially when output is low. 8.Verify the designed value of frequency matches with practical value. Symmetrical: Frequency 1 KHz with 0.50 duty cycle 1.Verify the components and patch chords whether they are in good condition. 2.Connect the Astable multivibrator circuit using IC 555 timer as shown in the ckt as per the design. 3.Switch on the DC power supply unit Vcc=12V. 4.Observer the output waveform at pin no 6 on CRO.(capacitor output) 5.Also observe the output waveform at pin no 3 on CRO.(Multivibrator output) 6.For the capacitor output at pin no 6 , measure the maximum and minimum voltage levels. Verify that VUT =2/3Vcc and VLT= 1/3 Vcc. 7.Compare the capacitor voltage Vc with output waveform Vo and note that capacitor charges and Vc rises exponentially when output is high. The capacitor C discharges through RB and the diode and Vc falls exponentially when output is low. 8.Verify the designed value of frequency matches with practical valu **PROCEDURE FOR MONOSTABLE MULTIVIBRATOR:** 1.Verify all the components and patch chords. 2.Connect the Monostable Multivibrator circuit using IC 555-timer as like shown in ckt. 3.Switch on the D… …eriodic input trigger pulse at pin no 2 u… 4.Adjust the input … …and adjust the input pulse amplitude t… …ss the capacitor 'C'.. 5.Observe the tim… …asure its higher and lower voltage leve… 6.Measure the ou… …hat it is equal to the designed frequen… 7.Verify whether t… …practical values and observe the outpu…
7	Block, Circuit, Model Diagram,	

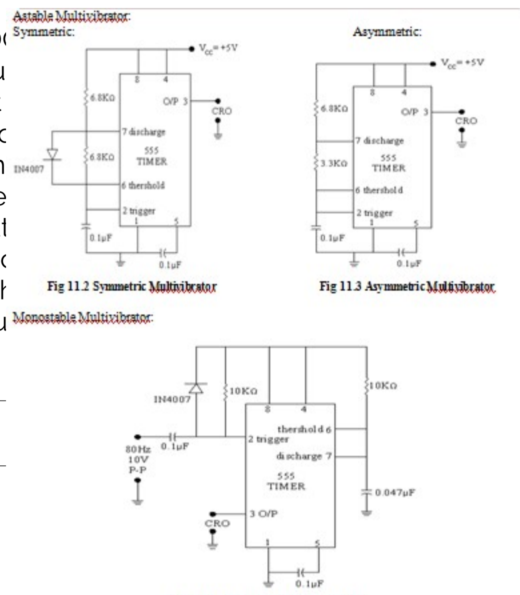
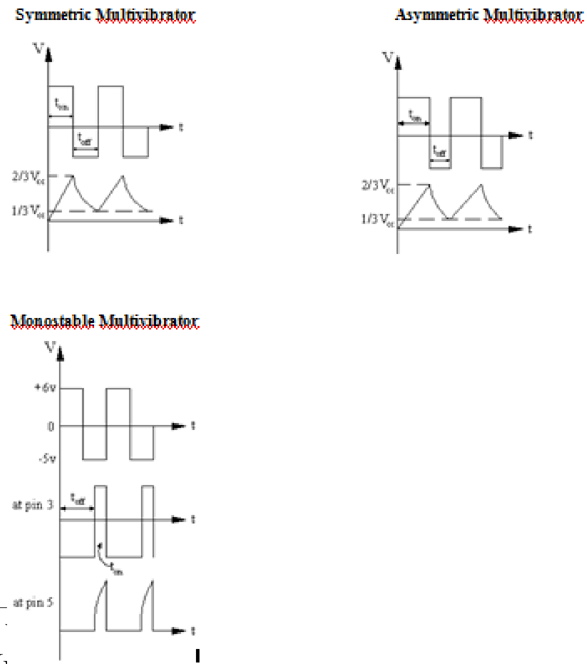


Fig 11.2 Symmetric Multivibrator
Fig 11.3 Asymmetric Multivibrator
Fig 11.1 Monostable Multivibrator

	Reaction Equation, Expected Graph	
8	Observation Table, Look-up Table, Output	
9	Sample Calculations	**DESIGN:** **Astable Multivibrato**r: Symmetric: For frequency of 1KHZ and 50% duty cycle. F = 1KHZ so T = 1 / F = 1/ (1000) = 1msec T = TH + TL = 0.5msec + 0.5msec Where T = total period of the cycle TH = upper threshold time TL = lower threshold time TH = TL = 0.5msec RA = RB = R TH = TL = 0.693RC = 0.5msec Therefore R = 0.5msec / (0.693C) Let C = 0.1μF R = 0.5 x 10-3 / (0.693 x 0.1 x 10-6) = 7.22KΩ = 6.8KΩ (std) So RA =RB = 6.8KΩ Asymmetric : For frequency of 1KHZ and duty cycle of 75%. T = 1 / F = 1 / 1000 = 1msec Therefore T = TH + TL = 0.75msec + 0.25msec TH = 0.693(RA + RB) C = 0.75msec RA + RB = TH / (0.693 C) Let C = 0.1μF = 0.75 x 10-3 / (0.693 x 0.1 x 10-6) RA + RB = 10.82KΩ TL = 0.693 RB C = 0.25msec RB = TL / (0.693C) Let C = 0.1μF = 0.25 x 10-3 / (0.693 x 0.1 x 10-6) = 3.6KΩ RB = 3.3KΩ (std) W.K.T RA + RB = 10.82KΩ Therefore RA = 10.82KΩ - RB = 10.82KΩ - 3.3KΩ = 7.49KΩ RA = 6.8KΩ (std) **Monostable:**

		For time delay of 1msec or frequency of 1KHZ T = 1.1RC Let C = 0.1µF R = τ / (1.1C) = 1 x 10-3/ (1.1 x 0.1 x 10-6) = 9.09KΩ = 10KΩ (std)
10	Graphs, Outputs	
11	Results & Analysis	Designed an a) Astable Multivibrator using IC 555 timer to generate a clock signal of i) Frequency 1 KHz with 0.75 duty cycle. (Asymmetrical)ii)Frequency 1 KHz with 0.50 duty cycle. (Symmetrical) b) To design a Monostable Multivibrator using IC 555 (timer).
12	Application Areas	Use in frequency divider, pulse width modulation ,linear ramp generator and voltage controlled oscillator.
13	Remarks	
14	Faculty Signature with Date	

Experiment 12: Fixed Voltage Power Supply (voltage regulator) using IC Regulators 78 Series and 79 Series.

-	Experiment No.:	3	Marks		Date Planned		Date Conducted	
1	Title	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series.						
2	Course Outcomes	Design of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series using lic hardware kit.						
3	Aim	To designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series.						
4	Material / Equipment Required							

SI NO	Name	Range	Quantity
1	Regulated Dual Power Supply	0-20V	1
2	Resistors	1.5KΩ(1),22KΩ(2	4

		),10KΩ(1)	
3	Capacitors	0.1µF, 0.01µF	2
4	CRO	-	1
5	Multimeter	-	1
6	ICµA741	-	1
7	Patch Chords	-	
8	LIC Trainer Kit	-	1
9	Stepdown Transformer		

5	Theory, Formula, Principle, Concept	**THEORY:** A voltage regulator is a circuit that supplies a constant voltage regardless of changes in load current and input voltage. IC voltage regulators are versatile, relatively inexpensive and are available with features such as programmable output, current/voltage boosting, internal short circuit current limiting, thermal shunt down and floating operation for high voltage applications. The 78XX series consists of three-terminal positive voltage regulators with seven voltage options. These IC's are designed as fixed voltage regulators and with adequate heat sinking can deliver output currents in excess of 1A. The 79XX series of fixed output voltage regulators are complements to the 78XX series devices. These negative regulators are available in same seven voltage options. Typical performance parameters for voltage regulators are line regulation, load regulation, temperature stability and ripple rejection.
6	Procedure, Program, Activity, Algorithm, Pseudo Code	**PROCEDURE:** 1)Do the connection as per the circuit diagram. 2)Vary the load resistance. But start applying from 100Ω. 3)Note down the current and Vo for different values of RL 4)Check that Vo should be 5V for different values of RL.
7	Block, Circuit, Model Diagram, Reaction Equation, Expected Graph	**CIRCUIT DIAGRAM:**

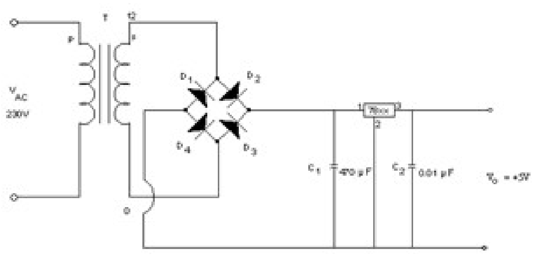


Fig 12.1 Positive Voltage Regulator Using 7805 IC

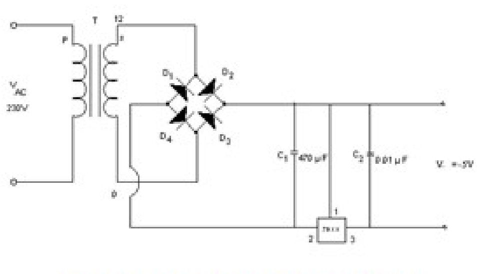


Fig12.2 Negative Voltage Regulator Using 7905 IC

8 Observation Table, Look-up Table, Output

For 7805 Regulator

Load Resistance(RL) in Ω	Load Current in mA	Output voltage in volts
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		

For 7905 Regulator

Load Resistance(RL) in Ω	Load Current in mA	Output voltage in volts
100		
200		
300		
400		
500		
600		
700		
800		
900		
1000		

9 Sample Calculations

DESIGN:
Vinrms = 12V
Vodc = 2Vm/π = 10.8v = 10v
Iodc = 100mA
RL (min) = Vodc/Iodc = 100Ω
Let Rf = 10Ω
Ripple = γ = Vorm s / Vodc = 0.48
Let γ=6%=0.06, F = 50HZ and RL = 100 Ω
WKT γ = 1/4√3 F C1 RL , C 1= 470⌙ F and let C2 = 0.01μF

10 Graphs, Outputs

11 Results & Analysis

Designed and verified fixed voltage power supply (voltage regulator) using IC regulators 7805 for +5V and 7905 for -5V.

12	Application Areas	Regulators are used in developing regulated DC power supply.
13	Remarks	
14	Faculty Signature with Date	

F. Content to Experiment Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Expt-#	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1	Design and verify a precision full wave rectifier. Determine the performance parameters.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
2	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
3	Design and verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
4	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).	3	L4	L4	Analyze	Experiment	Internal Assessment Test
5	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.	3	L3	L3	Analyze	Experiment	Internal Assessment Test
6	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
7	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off	3	L4	L4	Analyze	Experiment	Internal Assessment Test

	frequency frequencies to verify the frequency response characteristic.						
8	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
9	Design and realization of R – 2R ladder DAC	3	L4	L4	Analyze	Experiment	Internal Assessment Test
10	Realization of Two bit Flash ADC.	3	L3	L3	Analyze	Experiment	Internal Assessment Test
11	Design and verify an IC 555 timer based pulse generator for the specified pulse.	3	L4	L4	Analyze	Experiment	Internal Assessment Test
12	Designing of Fixed voltage power supply (voltage regulator) using IC regulators 78 series and 79 series.	3	L4	L4	Analyze	Experiment	Internal Assessment Test

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Expt - #	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	Design and verify a precision full wave rectifier. Determine the performance parameters.	Rectification	Rectification	Determination of efficiency of designed precision full wave rectifier for given input and output signal amplitude.	1.Design and verify 2.OP-Amp as a precision full wave rectifier 3.using lic hardware kit.	Design and verify OP-Amp as a precision full wave rectifier using lic hardware kit.
1	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain.	Frequency Response	Frequency Response	Designing of inverting and non - inverting amplifier using op amp for a given gain.Analysis frequency response of inverting and non inverting amplifer.	1.Design and realize 2.analysis of the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain 3.using lic hardware kit.	Design and realize to analyse the frequency response of an op – amp amplifier under inverting and non - inverting configuration for a given gain using lic hardware kit.
2	Design and	Sinosoidal	Sinosoidal	Designing and	1.Design and verify	Design and verify the output

	verify the output waveform of an op – amp RC phase shift oscillator for a desired frequency.	signal Generation	signal Generation	verifying the output of an op amp RC phase shift oscillator for a given frequency.	2.the output waveform of an op – amp RC phase shift oscillator for a desired frequency 3.using lic hardware kit.	waveform of an op – amp RC phase shift oscillator for a desired frequency using lic hardware kit.
2	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP).	Square/ Rectangular Wave Generation	Square/ Rectangula r Wave Generation	Generation of Square/Rectangula r wave for a given UTP and LTP of Schmitt trigger circuit using an op – amp .	1.Design and realize 2.Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP) 3.using lic hardware kit.	Design and realize Schmitt trigger circuit using an op – amp for desired upper trip point (UTP) and lower trip point (LTP) using lic hardware kit.
3	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector.	Voltage Comparisio n	Voltage Comparisio n	Generating square wave by comparing signal with given Vref using voltage comparator or ZCD.	1.Verify t 2. operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector 3.using lic hardware kit.	Verify the operation of an op – amp as (a) voltage comparator circuit and (b) zero crossing detector using lic hardware kit.
3	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator.	Airthmatic Operation	Airthmatic Operation	Performing arithmetic operations, using op amp, such as addition, substraction, integration and differentiation.	1.Design and verify 2. the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator 3.using lic hardware kit.	Design and verify the operation's of op – amp as an (a) adder (b) subtractor (c) integrator and (d) differentiator using lic hardware kit.
4	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency r esponse	Active filtration	Active filtration	Frequency response of designed LPF,HPF AND BPF for given cut[i] off frequency.	1.Design and realize 2.op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency response characteristic 3.using lic hardware kit.	Design and realize an op – amp based first order Butterworth (a) Low pass (b) High pass and (c) Band pass filters for a given cut off frequency frequencies to verify the frequency response characteristic using lic hardware kit.

	characteristic.					
4	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency.	Different Signal Generation	Different Signal Generation	Generation of square, triangular and sin wave for a given frequency using op amp.	1.Design and realize 2. op – amp based function generator to generate sine, square and triangular waves of desired frequency 3.using lic hardware kit.	Design and realize an op – amp based function generator to generate sine, square and triangular waves of desired frequency using lic hardware kit.
5	Design and realization of R – 2R ladder DAC	Digital to Analog Conversion	Digital to Analog Conversion	Design and verification of R-2R ladder DAC for given gain.	1.Design and realize 2.R – 2R ladder DAC 3.using lic hardware kit.	Design and realize of R – 2R ladder DAC using lic hardware kit.
5	Realization of Two bit Flash ADC.	Analog to Digital Conversion	Analog to Digital Conversion	Verification of 2 bit flash ADC	1.Realize 2.Two bit Flash ADC 3.using lic hardware kit.	Realize of Two bit Flash ADC using lic hardware kit.
	Design and verify an IC 555 timer based pulse generator for the specified pulse.	Pulse Generation	Pulse Generation	Square wave trigger pulse ageneration for given frequency using 555 timer.	1.Design and verify 2.IC 555 timer based pulse generator for the specified pulse 3. using lic hardware kit.	Design and verify an IC 555 timer based pulse generator for the specified pulse using lic hardware kit.