COURSE HANDOUT

SRM University
Faculty of Engineering and Technology
Department of Electronics and Communication Engineering

EC0206 Linear Integrated Circuits

Fourth Semester, 2013-14 (even semester)

Course (catalog) description

This is a course on the design and applications of operational amplifiers and analog integrated circuits. This course introduces basic op-amp principles and show how the op-amp can be used to solve a variety of application problems. Much attention is given to basic op-amp configurations, linear and non-linear applications of op-amp and active filter synthesis, including switched capacitor configurations. It also deals with oscillators, waveform generators and data converters.

Compulsory/Elective course: Compulsory

Credit hours: 3

Co**urse coordinator: Mr. A. Joshua Jafferson** Assistant Professor (O.G), Department of ECE

Instructor(s)

Name of the instructor	Class handling	Office location	Phone	Email @ktr.srmuniv.ac.in	Schedule	Consultations
Mrs. V. K. Daliya	A	TP903A	9962543592	daliya.vk@ktr.srmuniv.ac.in	Day 2-2,Day 4-1&4, Day 5-7	Day 4 - 5 & 6
Mr. A. Joshua Jafferson	B	TP1206 A	9894356447	joshua.j@ktr.srmuniv.ac.in	Day 1-7,Day 4-2&3, Day 5-2	Day 3 - 3 & 4
Mrs R. Manohari	C	TP9S4	9445891928	manohari.r@ktr.srmuniv.ac.in	Day 1-2, Day 2-4, Day 3-2, Day 5-3	Day 3 - 5 & 6
Mrs. N. Saraswathi	D	TP10S1	9677169140	saraswathy.n@ktr.srmuniv.ac.in	Day 1-2&4, Day 3-4, Day 5-3	Day 4 - 5 & 6
Mrs. K. Suganthi	E	T P10S3	9443543338	suganthi.k@ktr.srmuniv.ac.in	Day 1-2, Day 2-3,	Day 1 - 3 & 4

					Day 3-7, Day 5-2		
Mrs. M.K. Srilekha	F	TP1006 A	9840291613	srilekha.m@ktr.srmuniv.ac.in	Day 1-3&7, Day 3-3,Day 4-3	Day 5 - 1 & 2	
Mr. M. Maria Dominic Savio	G	TP10S4	9994076650	mariadominicsavio.m@ktr.srmuniv.ac.in	Day 2-1, Day 4-4&7, Day5-2	Day 2 - 3 & 4	
Mr. A. Sriram	H	TP103A	8903892457	sriram.a@ktr.srmuniv.ac.in	Day 2-7, Day 4-3, Day5-1&3	Day 2 - 1 & 2	
Mrs. S. Krithiga	I	TP1203 A	9677117684	krithiga.s@ktr.srmuniv.ac.in	Day 1-7,Day 3-2, Day 4-5&6	Day 5 - 5 & 6	

Relationship to other courses

Pre-requisites	:	EC0203 Electron Devices
Assumed knowledge	:	Basic knowledge in circuit analysis and in phasor algebra or elementary calculus
Following courses	:	EC0301 Electronic Measurements and Instrumentation

Text Books

1. Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995
2. Ramakant A.Gayakwad, "*Op-Amps and Linear Integrated Circuits*", 4th edition, Pearson education.

References

1. Coughlin & Driscoll, "*Operational-Amplifiers and Linear Integrated Circuits*", 6th edition, Pearson education.
2. Sergio Franco, "Design with operational amplifier and analog integrated circuits", McGraw Hill, 1997.

Computer usage: OrCAD Pspice and Capture is used to facilitate analysis and design of circuits.

Professional component

General	-	0%
Basic Sciences	-	0%
Engineering sciences & Technical arts	-	0%
Professional subject	-	100%

Broad area: Communication | Signal Processing | **Electronics** | VLSI | Embedded

Course objectives

The objectives of this course is to	Correlates to Program Objective
1. To study the basic principles, configurations and practical limitations of op-amp.	(2)
2. To understand the various linear and non-linear applications of op-amp	(2), (3)
3. To analyze and deign op-amp oscillators, single chip oscillators and frequency generators	(3)
4. To analyze, design and explain the characteristics and applications of active filters, including the switched capacitor filter	(3), (4)
5. To understand the operation of the most commonly used D/A and A/D converter types and its applications.	(3), (4)

Course Learning Outcome

This course provides the foundation education in operational amplifier and other linear integrated circuits.. Through lecture, laboratory, and out-of-class assignments, students are provided learning experiences that enable them to:	**Correlates to program outcome**		
	H	**M**	**L**
1. To discuss the op-amp's basic construction, characteristics, parameter limitations, various configurations and countless applications of op-amp.	c	a	b
2. Analyze and deign basic op-amp circuits, particularly various linear and non-linear circuits, active filters, signal generators, and data converters	c	d	e
3. Become proficient with computer skills (eg., Multisim, OrCAD Pspice and Capture) for the analysis and design of circuits	f		j

H: high correlation, M: medium correlation, L: low correlation

Detailed Session Plan

UNIT I – INTRODUCTORY CONCEPTS AND FUNDAMENTALS

Introduction to operational amplifier: Op-amp symbol, terminals, packages and specifications-Block diagram Representation of op-amp-Op-amp input modes-Op-amp Data sheets and interpretation-Ideal op-amp and practical op-amp-Open loop and closed loop configurations of op-amp **Practical Limitations of op-amp circuits**:-Bias and offset currents / offset voltage-Frequency compensation and stability-Gain bandwidth product-Slew Rate-Drift-CMRR and PSRR **Basic op-amp circuits**: Inverting and Non-inverting voltage amplifiers-Voltage follower-Summing , scaling and averaging amplifiers-Differential amplifiers-AC amplifiers. **Internal Schematic of 741 op-amps.**

Session No.	Topics to be covered	Text book
1	**Introduction to operational amplifier:** op-amp fundamentals	Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995 Chapter (s) - 2, 3,4
2	block diagram representation of op-amp Representation of op-amp-Op-amp input modes-Op-amp Data sheets and interpretation	
3	ideal op-amp and its characteristics .practical op-amp and its characteristics	
4	Open loop and closed loop configurations of op-amp	
5	Bias and offset currents / offset voltage(Problems as in Ex 3.1 to 3.3)	
6	Frequency compensation and stability-Gain bandwidth product	
7	Slew Rate-Drift-CMRR and PSRR	
8	**Basic op-amp circuits:** inverting amplifier, non-inverting amplifier(Problems as in Ex .2.1 to 2.4)	
9	voltage follower Summing Amplifier (Problems as in Ex. 4.1,4.2)	
10	Scaling, averaging and differential amplifiers. (Problems as in Ex. 2.5)	
11	AC amplifiers. **Internal Schematic of 741 op-amps.**	

UNIT II OP - AMP APPLICATIONS

Linear Applications: Instrumentation Amplifiers-V-to-I and I-to-V converters-Differentiators and Integrators.
Non-linear Applications: Precision Rectifiers-Wave Shaping Circuits (Clipper and Clampers)-Log and Antilog Amplifiers-Analog voltage multiplier circuit and its applications-Operational Trans conductance amplifier (OTA)-Comparators and its applications-Sample and Hold circuit.

Session No.	Topics to be covered	Text book
12	Instrumentation Amplifiers-V-to-I and I-to-V converters	Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995 Chapter (s) 4 ,5
13	Differentiators and Integrators.	
14	Precision Rectifiers	
15	Wave Shaping Circuits (Clipper and Clampers)	
16	Log and Antilog Amplifiers	
17	Analog voltage multiplier circuit and its applications	
18	Operational Trans conductance amplifier (OTA)	
19	Comparators and its applications-Sample and Hold circuit	

UNIT III - OSCILLATORS AND FREQUENCY GENERATORS

Op-amp oscillators: Positive feedback and the Barkhausan criterion-Wien Bridge and phase shift oscillators- Square / Triangle / Ramp function generators.
Single Chip oscillators and Frequency generators: Voltage controlled oscillator-555 Timer-555 Monostable operation and its applications-555 Astable operation and its applications-Phase Locked Loop-Operation of 565 PLL-Closed loop analysis of PLL-PLL applications.

Session No.	Topics to be covered	Text book
20	**op-amp oscillators:** +ve feedback and Barkhausen criterion	Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995 Chapter (s) – 5,8 & 9
21	Phase shift and Wein bridge oscillator. (Problems as in Ex. 5.4)	
22	Square wave, traingular wave and saw-tooth wave generator.	
23	**Single Chip oscillators and Frequency generators:** VCO and its applications	
24	555 Timer	
25	Monostable ,Astable operation and its applications. (Problems as in Ex. 8.1, 8.2)	
26	Phase Locked Loop-Operation of 565 PLL	
27,28	Closed loop analysis of PLL-PLL applications.	

UNIT IV - ACTIVE FILTERS AND VOLTAGE REGULATOR

Filter Fundamentals: Filter types-Filter order and poles-Filter class or alignment (Butterworth, Bessel, Chebyshev and Elliptic or Cauer)
Realizing Practical Filters: Sallen-Key LPF and HPF Realizations-BPF Realization-Notch Filter (Band Reject) Realization-State Variable Filters-All Pass Filters **Switched Capacitor Filters, Voltage Regulators**-Need for Regulation-Linear Regulators-Monolithic IC Regulators (78xx,79xx,LM 317,LM 337,723)-Switching Regulators.

Session No.	Topics to be covered	Text book
29	**Active filters:** Basic filters and their characteristics	Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995 Chapter (s) – 6 &7
30	Differences among a Butterworth, a Chebyshev and a Cauer filter.	

31	I order active LPF and HPF. Sallenkey LPF and HPF Realizations.(Problems as in EX.7.1 to 7.4)	
32	Wide band pass and narrow band pass filter.(Problems as in EX.7.6)	
33	Wide band reject and narrow band reject filters .(Problems as in EX.7.7 and 7.8)	
34	State Variable Filters, All-pass filter	
35	Switched Capacitor Filters	
36	**Voltage Regulators:** Linear Regulators-Monolithic IC Regulators (78xx,79xx,LM 317,LM 337,723)	
37	Switching Regulators	

UNIT V - DATA CONVERSION DEVICES

Advantages and disadvantages of working in the digital domain, **Digital to Analog Conversion**: DAC Specifications-DAC circuits-Weighted Resistor DAC-R-2R Ladder DAC-Inverted R-2R Ladder DAC Monolithic DAC, **Analog to Digital conversion**: ADC specifications-ADC circuits-Ramp Type ADC Successive Approximation ADC-Dual Slope ADC-Flash Type ADC-Tracking ADC-Monolithic ADC

Session No.	Topics to be covered	Text book
38	**D/A converter:** Characteristics & specifications	Roy Choudhury and Shail Jain, " *Linear Integrated Circuits*", Wiley Eastern Ltd,1995 Chapter (s) – 10
39	**D/A types:** Weighted resistor DAC	
40	R-2R Ladder DAC	
41	Inverted R-2R Ladder DAC,Monolithic DAC	
42	**A/D converter:** Characteristics & specifications	
43	**A/D types:** Flash type ADC, Ramp type ADC	
44	Successive Approximation type ADC	
45	Dual Slope ADC, Tracking type ADC Monolithic ADC	

Test Schedule

S.No.	TEST	PORTIONS	DURATION
1	Cycle Test-1	Session 1 to 12	2 Periods
2	Cycle Test-2	Session 13 to 24	2 Periods
3	Model Exam	Session 1 to 45	3 Hrs

Evaluation methods

Attendance	-	5%
Cycle Test – I	-	10%
Cycle Test – II	-	10%
Model Test	-	20%
Surprise Test	-	5%
End Semester	-	50%

Prepared by: Mr. A. Joshua Jafferson

Dated: 31th December 2013 **Revision No.:** 00 **Date of revision:** NA

Program Educational Objectives

1. To prepare students to compete for a successful career in Electronics and Communication Engineering profession through global education standards.
2. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Electronics and Communication Engineering problems.
3. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints.
4. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts
5. To create an awareness among the students about the need for life long learning to succeed in their professional career as Electronics and Communication Engineers.