Course Type	Course Code	Name of Course	L	T	P	Credit
DC	NECC511	Analog IC Design	3	1	0	4

Course Objective

The objective of the course is to present exclusively the Analog Integrated Circuits based on CMOS. It emphasizes the understanding of the necessary knowledge in the subject and steps wise design aspect of VLSI design in Silicon.

Learning Outcomes

Upon successful completion of this course, students will:

- have a broad understanding of MOSFET models and its various important parameters.
- have an in-depth understanding of actively loaded CMOS amplifiers.
- have a broad understanding to tackle noise, effect of frequency effect of non-ideality, and power aspects.
- be able to design various operational amplifiers with reliable performance using voltage referencing circuit.
- be able to design various types of Filters effectively.

Module No.	Topics to be Covered	Lecture Hours	Learning Outcome
1	**Introduction:** Analog circuits in VLSI, overview of circuit performance comparison in BJT, BiCMOS, and CMOS; CMOS device fundamentals: Basic MOS Models, device capacitances, parasitic resistances, substrate models, transconductance, output resistance, CLM, body effect, f_T, device parameters in subthreshold.	**5L+2T**	This will help students to understand the principle of MOSFET, various effects, including speed, area, and noise.
2	**Analog building blocks:** MOS current mirror, cascode current mirrors, analysis of current mirrors, use of CM as active load, bandgap references (BGR) circuit, constant current and constant gm bias generators, low dropout regulators (LDO).	**6L+2T**	This unit will help students in understanding various types of CMs, their o/p impedance and Bandwidth, including applications in IC. Importance and uses of BGR and LDO will also be evident.
3	**Single stage amplifiers:** Single stage amplifier configurations, cascode stage, frequency response.	**5L+2T**	This unit will help students to calculate various SSA parameters like gain, transconductance, and BW.
4	**Differential amplifiers:** Differential amplifiers with MOS Loads, device mismatch effects, frequency response of differential amplifiers, telescopic and folded cascode amplifier.	**6L+2T**	This will help students to design less noisy and high CMRR differential amplifier.
5	**Op-amp Design:** Performance parameters, one &two-stage op-amps, pole-zero compensation, gain boosting, active compensation, input range, slew rate, fully differential telescopic and feedforward compensated op-amp, Current mode circuits: introduction, internal structure, applications, Operational Transconductance amplifier (OTA).	**9L+3T**	In this unit, students will know about the design of complete operation amplifier by using knowledge gained in previous units.
6	**Noise:** Noise in resistors and MOS transistors; Noise models; Noise calculations for Single stage, Differential and Operational amplifiers; Noise scaling.	**4L+1T**	In this unit, students will develop the skills to perform noise analysis of MOS circuits.
7	**Non-linear analog blocks:** Comparators, charge pump circuits and multiplier; non-linearity cancellation in MOS circuits, introduction to switched capacitor circuits, Continuous time and Switched capacitor filters.	**7L+2T**	In this unit, student will get basic knowledge on nonlinear blocks, non-linearity cancellation, switched capacitor circuits and design of continuous time and switched capacitor filters.
Total		**42L+14T**	

Text Books:

1. Design of Analog CMOS Integrated Circuits, Behzad Razavi, McGraw Hill Indian, 2nd Edition (2017).

Reference Books:

1. CMOS Analog Circuit Design, E. Allen & Douglas R. Optoelectronics and Photonic Devices Holberg, Oxford Press Int. Edition, 3rd Edition (2012).
2. CMOS Circuit Design: Layout and Simulation, R. Jacob Baker, Wiley IEEE Press, 3rd Edition (2010).