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| **ECX536** | **Analog VLSI Design** | **L-T-P: 3-0-0; Total 42 Lectures** |

***Pre-requisite:*** Analog Electronics

***Objectives:*** To acquaint the students with basic CMOS analog building blocks and analog sub-system design.

***Topics Covered:***

1. Necessity and advantages of CMOS Analog Circuits; review of MOSFETs; their characteristics and models; components available in MOS technology: MOS capacitor. (5L)
2. Overview of MOS amplifiers and their analysis; analysis of typical MOS circuits using square law; frequency response, bandwidth enhancement; MOS bias circuits; various types of current mirrors (Simple , Wilson, modified Wilson and cascode); differential amp: linear range; diff amp with active load biased with current source: Gm, Rout; Diff. To single ended converter; output stage and level shifting stage. (10L)
3. Op-amp architectures: CMOS op-amps; two stage CMOS op-amp architectures; calculation of overall gain and rout; determination of dominants poles; compensation and relocation of poles and zeros; other CMOS op-amp architectures. Gilbert cell. (10L)
4. CMOS OTAs and transconductors: CMOS OTA-linear range and transconductance; linearized CMOS OTSs-single ended and differential. (2L)
5. MOSFET-C integrated filters; MOS fully differential integrator, derivation of MOSFET-C biquads based on conventional op-amp RC biquads. (4L)
6. Nonlinearity cancellation in MOS Analog Circuits: basic topologies for non-linearity cancellation using one, two and four matched MOSFETs; exemplary circuits for realising linear grounded / floating CMOS voltage- controlled oscillators. (5L)
7. Phase locked loop 8 Frequency multiplier-Phase locked loop; Lock range limitations; type II loop; Jitter & Phase noise; Continuous time approximation; PLL transfer functions; Reference feed through spurs; LC oscillators (5L)

***Reading:***

1. Behzad Razavi, Design of Analog CMOS integrated circuits, McGraw Hill Co. Inc.,2013.
2. R. Jacob Baker, CMOS: circuit Design, Layout and Simulation, Wiley,2009
3. Douglas R. Holberg, Phillip E. Allen, CMOS Analog Design, 3rd Edition, Oxford University Press,2013

***Outcomes:*** Upon successful completion of this course, students should be able to:

1. Understand the basic operation and properties of MOSFET.
2. Analyze the operation of MOS amplifiers.
3. Understand the design of Operational Amplifier using MOS and their characteristics, compensation techniques and stability analysis.
4. Understand the design of Operational transconductance amplifier and their applications.
5. Design of MOSFET-C biquads, voltage controlled oscillators.