

# RF and Mixed-Signal Integrated Circuits (3 – 1 – 0)

## MODULE – I

(13 hours)

**Introduction:** Overview of wireless principles, Characteristics of passive IC components – resistors, Capacitors, Inductors, Transformers, Interconnect at RF and high frequencies, Skin effect.

**Bandwidth Estimation Techniques:** Method of open-circuit time constants, Method of short-circuit time constants, Rise time, Delay and Bandwidth.

**High-frequency Amplifier Design:** Zeros as bandwidth enhancers, Shunt-series amplifier, Bandwidth enhancement with  $f_T$  doublers, Tuned amplifiers, Neutralization and unilateralization, Cascaded amplifiers, AM-PM conversion.

## MODULE – II

(13 hours)

**Voltage Reference:** Review of diode behavior, Diodes and Bipolar Transistors in CMOS technology, Supply-independent bias circuits, Bandgap voltage reference, Constant- $g_m$  bias.

**Noise:** Thermal noise, Shot noise, Flicker noise, Popcorn noise, Classical two-port noise theory, Examples of noise calculations.

**Low-Noise Amplifier (LNA) Design:** Derivation of intrinsic MOSFET two-port noise parameters, LNA topologies – Power match Vs. Noise match, Power-constrained noise optimization, Design Example, Linearity and large signal performance, Spurious-free dynamic range.

## MODULE – III

(14 hours)

**Mixers:** Mixer fundamentals, Non-linear systems as linear mixers, Multiplier-based mixers, Sub-sampling mixers, Diode-ring mixers.

**RF Power Amplifiers:** Classes of power amplifiers, RF power amplifier design example, Power amplifier characteristics and Design consideration.

**Phase-Locked Loops (PLL):** Introduction to PLL, Linearized PLL models, Some noise properties of PLLs, Phase detectors, Sequential phase detectors, Loop filters and charge pumps, PLL design examples.

**Oscillators and Synthesizers:** Problems with purely linear oscillators, Describing functions, Resonators, Tuned oscillators, Negative resistance oscillators, Frequency synthesis.

### Textbooks:

1. Thomas H. Lee, *The Design of CMOS Radio-Frequency Integrated Circuits*, 2<sup>nd</sup> Edn., Cambridge University Press, 2004.

### Recommended Reading:

1. E.N. Farag and M.I. Elmasry, *Mixed Signal VLSI Wireless Design: Circuits & Systems*, Kluwer, 1999.

