NIRMA UNIVERSITY
School of Technology, Institute of Technology
B.Tech. Electronics & Communication Engineering
Semester - VII
Department Elective IV

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Course Code	2ECDE07
Course Title	RF Communication Circuits

Course Outcomes (COs):

At the end of the course, students will be able to -

1. understand the RF fundamentals and RF transceiver architectures.
2. design RF integrated circuits used in receiver RF front end like LNA, Mixers, and VCO/PLL.
3. analyse other RF integrated circuits like amplifiers, switches, attenuators, couplers, etc.
4. apply RF layout fundamentals in implementing RF integrated circuits.

Syllabus **Teaching Hours: 45**

UNIT I: RF Fundamentals **04**

Importance of RF integrated circuit design, Behavior of passive component like resistors, inductors, capacitors at RF frequencies, Noise, and distortion, RF fundamentals – transmission line, reflection, impedance matching, s-parameters, etc, RF Design tradeoffs

UNIT II: RF Transceiver Architectures **08**

Receiver Front End - Intermodulation, Third-order Intercept Point (IP3), Noise figure (NF), sensitivity, selectivity, dynamic range, Various RF receiver and transmitter architectures e.g. Superheterodyne receiver, Direct Conversion Receiver, Low-IF Receiver, RF Sampling Receiver, RFIC Technologies comparison

UNIT III: MOS Device Physics

FETs, MOSFET Physics – long channel approximation, Operation in Weak Inversion (Subthreshold), MOS in Short Channel region, other effects **03**

UNIT IV: CMOS Low Noise Amplifier (LNA) Design

LNA Input and Output Matching techniques, LNA Design parameters Gain, Noise Figure, Stability, LNA Design examples **06**

UNIT V: CMOS Mixer Design

Introduction to Mixers, two and three-port mixers, Gilbert Cell Mixers, Linearity, and Noise in Mixers. Mixer Design examples **06**

UNIT VI: CMOS Voltage Controlled Oscillator (VCO) and Phase-Locked Loop (PLL) Design

Fundamentals of oscillation, CMOS Voltage Controlled Oscillator Design architectures, Design examples, PLL Theory, Integer N and fractional N PLL frequency synthesizers **06**

UNIT VII: CMOS Wideband Amplifies and Power Amplifier Design

Circuit theory of RF wideband amplifiers and power amplifiers, Case studies of few exemplary designs of CMOS wideband amplifier and RF Power Amplifier **06**

UNIT VIII: Supplementary RF Circuits

Functions of other RF circuits like RF switches, attenuators, phase shifters, combiners and splitters, direction couplers, RF transformers, etc. **02**

UNIT IX: CMOS RF Layout Fundamentals

Fundamentals of RF circuit layout in CMOS VLSI process **04**

Self-Study:

The self-study contents will be declared at the commencement of the semester. Around 10% of the questions will be asked from self-study contents.

Assignments:

The students will be given simulation/design assignments as per the following:

(i) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the low noise amplifier (LNA)

(ii) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the double-balanced Gilbert Cell RF Mixer

(iii) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the RF Voltage Controlled Oscillator (VCO).

(iv) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the RF PLL frequency synthesizer

(v) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the RF power amplifier

(vi) Using the Electronic Design Automation (EDA) tools, design in CMOS VLSI technology the RF wideband amplifier

(vii) Using the Electronic Design Automation (EDA) tools, simulate the RF Front End (RFE) of a wireless transceiver system

(viii) Using the Electronic Design Automation (EDA) tools, simulate the functioning of the RF Direct Sampling Receiver

Suggested Readings:

1. Thomas H Lee, The Design of CMOS Radio-Frequency Integrated Circuits, Cambridge University Press
2. Behzad Razavi, RF Microelectronics, Pearson
3. Bosco Leung, VLSI for Wireless Communication, Prentice Hall - Electronics and VLSI Series
4. Robert Caverly, CMOS RF IC Design Principles, Artech House
5. David M Pozar, Microwave Engineering, John Wiley

L = Lecture, T = Tutorial, P = Practical, C = Credit