RF Circuit Design(404190)

Teaching Scheme:
Lectures: 3 Hrs/ Week

Examination Scheme:
In Semester Assessment:
Phase I : 30
End Semester Examination:
Phase II: 70

Course Objectives:

- To study RF issues related to active and passive components.
- To study circuit design aspects at RF.
- To learn design and modeling of circuits at RF.

Course Outcomes:

After successfully completion of the course students will be able to -

- Understand behavior of passive components at high frequency and modeling of HF circuit.
- Design HF amplifiers with gain bandwidth parameters.
- Understand Mixer types and characteristics.
- Gain the knowledge about PLLs and Oscillators with respect to their circuit topologies.

Unit I : RF Behavior of Passive Components 5L

HF Resistors, HF Capacitors, HF Inductors, Chip Components. Circuit Board Considerations: Chip Resistors, Chip Capacitors, Surface Mounted Inductors.

Unit II : Bandwidth Estimation 6L

Open Circuit Time Constant Method: Observations & Interpretations, Accuracy of OCτs, Considerations, Design examples. Short Circuit Time Constant Method: Background, Observations & Interpretations, Accuracy of SCτs, Considerations. Delay of a system in cascade, Rise time of systems in cascade, Relation Between Rise Time and Bandwidth.

Unit III : High Frequency Amplifier Design 6L

Shunt Peaked Amplifier, Shunt Series peak Amplifier, Two port bandwidth enhancement, Design example. Bandwidth enhancement techniques. Tuned Amplifier: Common Source Amplifier with Single Tuned Load, Analysis of Tuned Amplifier. Neutralization and unilateralization. Characteristics of RF amplifier. Amplifier power relations. Stability considerations. Stabilization methods.

Unit IV: Low Noise Amplifier Design 6L

MOSFET two port noise parameters, LNA topologies, Power-constrained noise optimization. Design examples: Single ended LNA, Differential LNA. Linearity and large signal performance. Spurious free dynamic range.

Unit V : Oscillators 6L

Problem with Purely Linear Oscillators, Describing Functions, Describing Function for MOS. Colpitts Oscillator: Describing Function Model and Start-up Model of Colpitts Oscillator. Resonators: Quarter-Wave Resonators, Quartz Crystals. Tuned Oscillators: Basic LC Feedback Oscillators, Crystal Oscillator. Negative Resistance Oscillator.

Unit VI : Mixers 6L

Mixer Fundamentals. Significant Characteristics of Mixer: Conversion Gain, Noise Figure, Linearity and Isolation, Spurs. Non Linear Systems as Linear Mixers. Multiplier Based Mixers: Single Balanced Mixer, Linearization techniques of Mixer, Active Double Balanced Mixer. Passive Double Balanced Mixer, Diode Ring Mixers.

Text Books

1. Reinhold Ludwig, Pavel Bretchko, "RF Circuit Design Theory and Applications", Pearson Education.
2. Thomas H. Lee, "The Design of CMOS Radio-Frequency Integrated Circuits", Second Edition, Cambridge Publications.

Reference Books

1. T. Yettrdal, Yunhg Cheng, "Devices modeling for analog and RF COMS circuits design", John Wiley publication.
2. Calvin Plett, "Radio frequency Integrated Circuits Design", Artech house.

Experiments:

1. To plot frequency response of the impedance magnitude of series and parallel LC circuits.
2. To plot the resonant frequency behavior of parallel LC circuit, as a function of resistance R.
3. To determine stability regions of the device and sketch them in the Smith Chart. Assume suitable parameters.
4. To design, prepare layout and simulate CMOS amplifier for given voltage gain and bandwidth.
5. To design, prepare layout and simulate CMOS Collpitt oscillator.
6. To design, prepare layout and simulate CMOS mixer.
7. To design, prepare layout and simulate CMOS LNA.