



# GUJARAT TECHNOLOGICAL UNIVERSITY

## Master of Engineering Syllabus

**Subject Code : 3726304**

**Subject Name : RF IC Design**

WEF Academic Year :	2023 - 24
Semester :	2
Category of the Course :	Program Elective

<b>Prerequisite :</b>	Basic knowledge of Analog VLSI Circuit Design and Communication Engineering.
<b>Rationale :</b>	The modern era of wireless communication, on-chip Radio-Frequency (RF) circuits are required to integrate with low power dissipation and low noise interference capabilities. Therefore, it is utmost important for the students to develop their skills to design these modules. This course provides a platform oscillators, LNAs, phase-locked loop, and power amplifier circuits.

### Course Scheme :

Teaching Scheme			Total Credits C	Assessment Pattern and Marks				Total Marks
L	T	PR		Theory		Practical		
				ESE (E)	PA(M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

### Course Content :

Sr. No.	Course Content	No. of Hours	% of Weightage
1	<b>Introduction to RF Design and Wireless Technology :</b> Design and Applications, complexity and choice of Technology, Basic concepts in RF Design: Nonlinearity and Time variance, Inter-symbol Interference, random process and noise, sensitivity and dynamic range, conversion of gain and distortion.	4	10
2	<b>RF Modulation :</b> Analog and Digital Modulation of RF Circuits, comparison of various techniques for power efficiency, Coherent and non-coherent detection, Mobile RF Communication and basics of Multiple Access techniques, Receiver and Transmitter architectures. Direct conversion and two-step transmitters.	8	25
3	<b>RF Testing :</b> RF Testing for heterodyne, Image reject, Direct IF and subsampled receivers.	4	10
4	<b>BJT and MOSFET behavior at RF Frequencies :</b> BJT and MOSFET behavior at RF Frequencies, Modeling of the transistors and SPICE model, Noise performance and limitations of devices, integrated parasitic elements at high frequencies and their monolithic implementation.	12	20



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5	<b>RF Circuit Design :</b> Overview of RF Filter Design, Active RF Components and modeling, Matching and biasing Networks. Basic blocks in RF system and their VLSI implementation, Low noise Amplifier Design in various mixers working and implementation. Oscillators- Basic topologies VCO and definition of phase noise, Noise power and trade off. Resonator VCO designs, Quadrature and single sideband generators. Radio frequency Synthesizers- PLLS, Various RF synthesizers architectures and frequency dividers, power amplifier design, liberalization techniques, Design issues in integrated RF Filters.	18	35
<b>Total</b>		<b>46</b>	<b>100</b>

### Course Outcome :

After Completion of the Course, Student will be able to :

No.	Course Outcomes	RBT Level*
01	Understand the basic concept of RF in CMOS IC Design.	UN
02	Understand the concept of different constraints, and optimization techniques of CMOS IC Design for RF Applications.	UN
03	Analyze various RF Components and their modeling.	AN
04	Understand the concept of Testing in RF CMOS IC Design.	UN
05	Evaluate the behavior of Active devices like BJT and MOSFET at RF Frequencies.	EL

\*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

### Suggested Course Practical List :

**The listed experiments can be performed using any SPICE tool.**

1. Introduction to RF CMOS IC Design, CAD Tools and SPICE Models.
2. To study Active RF Components and their modelling.
3. To design & implement CMOS Inverter at RF Frequency.
4. To design & implement CMOS Amplifier at RF Frequency.
5. To design & implement CMOS Low Noise Amplifier at RF Frequency.
6. To design & implement Voltage Controlled Oscillator at RF Frequency.
7. To design & implement RF Filter.
8. To study about various design issues in integrated RF Filters.
9. Seminar/Mini Project.



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### Reference Books :

1. Thomas H. Lee "Design of CMOS RF Integrated Circuits" Cambridge University Press 1998.
2. B. Razavi "RF Microelectronics" PHI 1998.
3. Y. P. Tsividis "Mixed Analog and Digital Devices Technology" TMH 1996.
4. Design of Analog CMOS Integrated Circuits by Behzad Razavi, McGrawHill.
5. CMOS – Circuit Design, Layout and Simulation by R. Jacob Baker, Wiley.
6. CMOS Mixed-Signal Circuit Design by R. Jacob Baker, Wiley.
7. Phillip E. Allen, Douglas R. Holberg, "CMOS Analog Circuit Design", 2<sup>nd</sup> Edition, Oxford University Press, 2002.

### List of Open Source Software/learning website :

Ng-Spice -- <https://ngspice.sourceforge.io/>

LTSpice -- <https://www.analog.com/en/design-center/design-tools-and-calculators/ltspace-simulator.html>

[www.nptel.com](http://www.nptel.com)

[www.nptel.ac.in](http://www.nptel.ac.in)

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