# GUJARAT TECHNOLOGICAL UNIVERSITY

## WIRELESS COMMUNICATION TECHNOLOGY (44)

SOFTWARE RADIO DESIGN

**SUBJECT CODE:** 2734401

M.E. 3RD SEMESTER

**Type of Course**: Elective

**Prerequisite:** Basic knowledge digital signal processing, communication systems, and wireless communication systems is desirable.

**Rationale:** With the rapid emergence of new standards and protocols in wireless communication, many functions of traditional radio receivers are being implemented in software. These new radio transceivers are called software-defined radios since their implementation relies heavily on digital signal processing techniques and require fewer radio-frequency components than classic hardware-based analog radios. Consequently, by utilizing software radio algorithms, it is possible exploit the multiple benefits a digital system offers. This course provides an overview of software-defined radio systems and the technologies necessary for their successful implementation. The student will also appreciate the current and future trends in the SDR space, including cognitive radio systems, and implemented SDR.

**Teaching and Examination Scheme:**

| Teaching Scheme | | | Credits | Examination Marks | | | | | | Total Marks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Theory Marks | | Practical Marks | | | | |
| L | T | P | C | ESE (E) | PA (M) | ESE (V) | | PA (I) | | |
| | | | | | | ESE | OEP | PA | RP | |
| 3 | 2# | 2 | 5 | 70 | 30 | 20 | 10 | 10 | 10 | 150 |

**Contents:**

| Sr. No. | **Topics** | **Teaching Hrs.** | **Module Weightage** |
|---|---|---|---|
| 1 | **Introduction to Software Radio Concepts**<br>The Need for Software Radios, What Is a Software Radio, Characteristics and Benefits of a Software Radio, Design Principles of a Software Radio | **2** | **5** |
| 2 | **Radio Frequency Implementation Issues**<br>The Purpose of the RF Front-End, Dynamic Range: The Principal Challenge of Receiver Design, RF Receiver Front-End Topologies, Enhanced Flexibility of the RF Chain with Software Radios, Importance of the Components to Overall Performance, Transmitter Architectures and Their Issues, Noise and Distortion in the RF Chain, ADC and DAC Distortion | **5** | **15** |
| 3 | **Multirate Signal Processing**<br>Introduction Sample Rate Conversion Principles, Poly-phase Filters, Digital Filter Banks. Timing Recovery in classical Analog Receiver, Timing Recovery in Digital Domain, Early-Late gate Synchronizer | **5** | **15** |
| 4 | **Digital Generation of Signals** | **6** | **16** |

| | | | |
|---|---|---|---|
| | Introduction, Comparison of Direct Digital Synthesis with Analog Signal Synthesis, Approaches to Direct Digital Synthesis, Analysis of Spurious Signals, Spurious Components due to Periodic Jitter, Bandpass Signal Generation, Performance of Direct Digital Synthesis Systems, Hybrid DDS-PLL Systems, Applications of direct Digital Synthesis, ROM compression Techniques, Sine-Phase Difference algorithm approach | | |
| 5 | **Smart Antennas**<br>Introduction, Vector Channel Modeling, Benefits of Smart Antennas, Structure for Beam Forming Systems, Smart Antenna Algorithms, Diversity and Space time Adaptive signal Processing, Algorithms for Transmit STAP, Hardware Implementation of Smart Antenna | **6** | **16** |
| 6 | **Digital Hardware Choices**<br>Introduction, Key Hardware Elements, DSP Processors, FPGA, Trade-offs in using DSPs FPGAs and ASICs, Power Management Issues , Combinations of DSPs , FPGAs and ASICs | **4** | **11** |
| 7 | **Case Studies in Software Radio Design**<br>Introduction, and Historical Perspective, SPEAKeasy, Wireless Information Transfer System, Current Trends | **5** | **15** |
| 8 | **Introduction and Concept of Cognitive Radio** | **3** | **7** |

**Reference Books:**


1. Software Radio: A Modern Approach to Radio Engineering By Jeffrey H. Reed Pearson Education Low Price Edition
2. Telecommunication Breakdown by C. Richard Johnson Jr., William A. Sethares, 2003, Prentice Hall.
3. Cognitive Radio Networks by Wyglinski, Alexander M. Nekovee, Maziar, Hou, Y. Thomas, 2010 Elsevier.
4. Multi-carrier and Spread Spectrum Systems, K. Fazel, S. Kaiser, John Wiley and Sons, Ltd. Publication, 2010


**Course Outcomes:**

After learning the course the students should be able to:

1. Understand the systems required by a software-defined radio to function.
2. Make system level decisions and trade-offs for software-defined radio technology and products.
3. Understand the basics of designing antenna systems to accommodate the needs of a software defined radio (i.e. smart antenna algorithms).
4. Understand how analog and digital technologies are used for software-defined radio.
5. Understand digital hardware architectures and its development methods
6. be aware of current industry trends

**List of Experiments:**

Practicals may be based on the syllabus using related simulation softwares and/or hardware platforms.

**Design based Problems (DP)/Open Ended Problem:**

1. Application of SDR in advanced communication systems
2. Challenges and issues regarding the implementation of SDR
3. Adaptive wireless communication systems
4. Parameter estimation for adaptation of wireless communication systems (learning environment and other factors)
5. SDR and cognitive radio architectures
6. Cognitive features in the upcoming standards (like 802.16m, LTE advanced, 802.11n, adaptive frequency hopping in Bluetooth) and in the 3G (2.5G) standards
7. Detailed study of WiMAX, LTE, and LTE-advanced

**Major Equipments:**

USRP/DSP/FPGA development board

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

MATLAB
GNU Radio
sdrforum.org
ecewp.ece.wpi.edu

**Review Presentation (RP):** The concerned faculty member shall provide the list of peer reviewed Journals and Tier-I and Tier-II Conferences relating to the subject (or relating to the area of thesis for seminar) to the students in the beginning of the semester. The same list will be uploaded on GTU website during the first two weeks of the start of the semester. Every student or a group of students shall critically study 2 papers, integrate the details and make presentation in the last two weeks of the semester. The GTU marks entry portal will allow entry of marks only after uploading of the best 3 presentations. A unique id number will be generated only after uploading the presentations. Thereafter the entry of marks will be allowed. The best 3 presentations of each college will be uploaded on GTU website.