

# GUJARAT TECHNOLOGICAL UNIVERSITY

## ELECTRONICS & COMMUNICATION (SIGNAL PROCESSING AND VLSI TECHNOLOGY) (26)

MULTIRATE SIGNAL PROCESSING

SUBJECT CODE: 2742603

SEMESTER: IV

**Type of course:** Major Elective

**Prerequisite:** Higher Engineering Mathematics, Control Systems, Digital Signal Processing

**Rationale:** PG Students of EC Engineering need to possess good understanding of the fundamentals and applications of signal processing. They should be able to process the signals with different sampling rate in the digital domain. They should apply the methods of multirate signal processing to various applications. They will be able to design digital signal processing systems.

### Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
4	0	2#	5	70	30	20	10	10	10	150

### Content:

Sr. No	Course Content	Hours	% Weightage
1	Fundamentals of multirate systems Introduction, basic multirate operations, Interconnection of building blocks, Polyphase representation, Multistage implementations, Special filters and filter banks;	5	20
2	Maximally decimated filterbanks Introduction, Errors created in QMF bank, Alias free QMF system, Power symmetric QMF banks, M-channel filter banks, Polyphase representation, Perfect reconstruction systems;	5	10
3	<i>Paraunitary Perfect Reconstruction (PR) Filter Banks</i> Introduction, Lossless transfer matrices, Filter bank properties induced by paraunitariness, Two channel FIR paraunitary QMF banks, Two channel paraunitary QMF lattice, M-channel FIR paraunitary filter banks;	5	10
4	<i>Linear Phase Perfect Reconstruction QMF Banks</i> Introduction, Lattice structures for linear phase FIR PR QMF banks, Formal synthesis of linear phase FIR PR QMF lattice;	4	15
5	<i>Cosine modulated Filter Banks</i> Introduction, Pseudo QMF bank, Design of pseudo QMF bank, Efficient polyphase structures, Cosine modulated perfect reconstruction systems;	4	10
6	Multirate filter bank theory Block filters, LPTV systems and Multirate filter banks, Unconventional Sampling theorems	4	10

7	Wavelet transform and its relation to Multirate filter banks The short time fourier transform, wavelet transform, Discrete time Orthonormal wavelets, Continuous – time Orthonormal wavelet basis	5	10
8	Multidimensional Multirate systems  Multidimensional signals , sampling, Minimum sampling density, alias-free decimation, cascade connections, Multirate filter design, special filters and filter banks, Maximally decimated filter banks	6	10
9	Applications of Multirate Signal Processing Analysis of audio, Speech, Image and video signals	2	5

### References Books:

1. P. P. Vaidyanathan, *Multirate Systems and Filter Banks*, Pearson-Education, Delhi, 2004.
2. Li Tan, Jean Jiang, *Digital Signal Processing fundamentals and applications* Academic Press, 2013
3. Sanjit K Mitra, *Digital Signal Processing*, Tata McGraw Hill, 2006
4. A. Spanias, T. Painter and V. Atti, *Audio Signal Processing & Coding*, Wiley-Interscience, NJ, USA, 2007.

### Course Outcome:

After learning the course the students should be able to

1. To analyze multirate systems
2. To design decimated filter bank
3. To design Paraunitary Perfect Reconstruction (PR) Filter Banks
4. To Design Linear Phase Perfect Reconstruction QMF Banks
5. To Design and analyze Cosinemodulated Filter Banks
6. To design and analyze Multirate filter bank.
7. To design wavelet transform filter with the help of multirate filter
8. To analyze multidimensional multirate systems

### List of Experiments:

Sr No.	Experiment Name
1	Write a program to reduce the sampling rate by an integer factor
2	Write a program to increase the sampling rate by an integer factor
3	Write a program to change the sampling rate by a non integer factor
4	Write a program to change the sampling rate by a non integer factor for a CD Audio player.
5	Write a program for demonstrating decimation using polyphase implementation.
6	Write a program for demonstrating interpolation using polyphase implementation.
7	Write a program for demonstrating oversampling of A/D converter.

8	Write a program for first-order Sigma-Delta Modulation Oversampling implementation.
9	Write a MATLAB SIMULINK model for Interpolation of a Sinusoidal Signal. Use digital interpolation using an FIR filter. Increase the sampling rate of its input signal by a factor of 9.
10	Write a MATLAB SIMULINK model for demonstrating the equivalence between the "FIR Rate Conversion" block and the straightforward but far less efficient system consisting of separate upsampling, FIR filtering, and downsampling blocks.
11	Design and realize a four channel uniform DFT analysis filter bank using a prototype linear-phase FIR filter of length 19. Design the prototype filter using the function <code>remez</code> of MATLAB. Assume a transition band of width $0.2\pi$ . Plot the magnitude responses of each filter on the same figure.

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

1. Write a MATLAB program or SIMULINK model to demonstrate any practical application of Multi rate signal processing.

**Major Equipment:** MATLAB, SCILAB, Computers.

**List of Open Source Software/learning website:** [www.nptel.ac.in](http://www.nptel.ac.in)

**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.