Course Name: Digital Signal Processing
Course Code: EE 605A
Credit: 3

Prerequisites:

Sl. No.	Subject	Description	Level of Study
01	Mathematics	Fourier Transform, Laplace Transform	1st Sem, 2nd Sem
02	Electric Circuit Theory	Laplace transforms, Continuous & Discrete, Fixed & Time varying	3rd Sem

Course Objective:

- To make students familiar with the most important methods in DSP, including digital filter design, transform-domain processing and importance of Signal Processors.
- To make students aware about the meaning and implications of the properties of systems and signals.

Course Outcomes:

At the end of the course, a student will be able to:

1. **Use** concepts of trigonometry, complex algebra, Fourier transform, z-transform to analyze the operations on signals and acquire knowledge about Systems
2. **Select** proper tools for analog-to-digital and digital-to-analog conversion. Also select proper tools for time domain and frequency domain implementation.
3. **Design**, implementation, analysis and comparison of digital filters for processing of discrete time signals
4. **Integrate** computer-based tools for engineering applications
5. **Employ** signal processing strategies at multidisciplinary team activities.
6. **Assess** the techniques, skills, and modern engineering tools necessary for analysis of different electrical signals and filtering out noise signals in engineering practice. Also **develop** creative and innovative designs that achieve desired performance criteria within specified objectives and constraints, understand the need for lifelong learning and continuing professional education

CO- PO mapping:

CO		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EE-605(A).	**1**	1	2	1	2	2	-	-	2	2	2	-	-
EE-605(A).	**2**	2	1	1	2	2	1	1	2	2	2	-	-
EE-605(A).	**3**	2	1	1	1	-	-	1	2	2	1	-	-
EE-605(A).	**4**	1	1	1	1	1	1	-	1	1	1	-	1
EE-605(A).	**5**	1	2	3	2	2	2	1	2	1	1	1	1
EE-605(A).	**6**	2	2	2	1	-	-	-	1	1	1	1	3
		*** Enter correlation levels 1, 2 or 3 as defined below: 1: Slight (Low) 2: Moderate (Medium)3: Substantial (High) and It there is no correlation, put "-"**											

Syllabus Indicating CO:

Module No.	Content	Relevant CO's
1	**Discrete-time signals:** Concept of discrete-time signal, basic idea of sampling and reconstruction of signal, sampling theorem, sequences, periodic, energy, power, unit-sample, unit step, unit ramp & complex exponentials, arithmetic operations on sequences. **LTI systems:** Definition, representation, impulse response, derivation for the output sequence, concept of convolution, graphical, analytical and overlap-add methods to compute convolution supported with examples and exercise, properties of convolution, interconnection of LTI systems with physical interpretations, stability and causality conditions, recursive and non recursive systems.	**CO1**
2	**Discrete Time Fourier Transform(DTFT):** Concept of frequency in discrete and continuous domain and their relationship (radian and radian/sec), freq. response in the discrete domain. Discrete system's response to sinusoidal/complex inputs (DTFT), Representation of LTI systems in complex frequency domain**.** **Z- Transforms:** Definition, mapping between s-plane & z-plane, unit circle, convergence and ROC, properties of Z-transform, Z-transform on sequences with examples & exercises, characteristic families of signals along with ROC, convolution, correlation and multiplication using Z- transform, initial value theorem, Perseval's relation, inverse Z-transform by contour integration, power series & partial-fraction expansions with examples and exercises. **Discrete Fourier Transform:** Concept and relations for DFT/IDFT, Relation between DTFT & DFT. Twiddle factors and their properties, computational burden on direct DFT, DFT/DFT as linear transformation, DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circulation convolution, computation of circular convolution by graphical, DFT/IDFT and matrix methods, linear filtering using DFT, aliasing error, filtering of long data sequences-Overlap-Save and Overlap-Add methods with examples and exercises. **Fast Fourier Transforms:** Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithm, signal flow graph, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations and exercises.	**CO1, CO4, CO5**
3	**Filter design:** Basic concepts of IIR and FIR filters, difference equations, design of Butterworth IIR analog filter using impulse invariant and bilinear transform, design of linear phase FIR filters no. of taps, rectangular, Hamming and Blackman windows. Effect of quantization.	**CO3, CO6**
4	**Digital Signal Processor:** Elementary idea about the architecture and important instruction sets of TMS320C 5416/6713 processor, writing of small programs in assembly Language. **FPGA:** Architecture, different sub-systems, design flow for DSP system design, mapping of DSP alrorithms onto FPGA.	**CO4, CO6**

Gaps in Syllabus:

Sl. No.	Gap	Action taken	Relevance to POs
1	**Wavelet Transform:** *This can provide the frequency of the signals and the time associated to those frequencies, making it very convenient for its application in numerous fields..* **Topics covered:** Basic principle, Bi-orthogonal wavelet, Daubechies, Haar, LeGall ,Orthogonal Wavelet, scaling Funtion.	The various topics are addressed by **lecture classes and by solving numerical problems.**	**PO 1, PO 2**
2	**Various Window Function :** *This topic is very much important for Filter design, but missing in the syllabus.* **Topics covered:** Bartlett, Blackman, Dolph-Chebyshev, Hann, Kaiser Window.	Additional **lecture classes** are organized to cover the topics. **Research literatures are provided for Filter design techniques**.	**PO 1, PO 2,** **PO 5**
3	**Short Time fourier Transform :** .*This topic use for signal analysis for the particular system.* **Topics covered:** Basic principle, Sampling in time and frequency dimention, Computation using MATLAB.	**Lectures** classes and p**ractical** are taken to that topic. Also some research papers are provided to the students.	**PO 1, PO 2,** **PO 3, PO 5**
4	**Chebyshev Filter:** *This is another type of filter very important but not covered in the syllabus.* **Topics covered:** Basic principle, design of chebyshev filter,	The various numerical are solved in classes.	**PO 1**

Lecture Plan:

Sl. No.	Date	Topics	Remarks
1		**Discrete-time signals:** Concept of discrete-time signal, basic idea of sampling and reconstruction of signal, sampling theorem	
2& 3		Sequences, periodic, energy, power, unit-sample, unit step, unit ramp	
4		Complex exponentials, arithmetic operations on sequences.	
5		**LTI systems:** Definition, representation, impulse response, derivation for the output sequence	
6 & 7		Concept of convolution, graphical, analytical and overlap-add methods to compute convolution supported with examples and exercise	
8		Properties of convolution	
9		Interconnection of LTI systems with physical interpretations,	
10		Stability and causality conditions, recursive and non recursive systems.	
11		Concept of frequency in discrete and continuous domain and their relationship (radian and radian/sec),	
12		Freq. response in the discrete domain.	
13		Discrete system's response to sinusoidal/complex inputs (DTFT), Representation of LTI systems in complex frequency domain**.**	
14		**Z- Transforms:** Definition, mapping between s-plane & z-plane, unit circle, convergence and ROC	
15		Properties of Z-transform, Z-transform on sequences with examples & exercises	
16		Characteristic families of signals along with ROC, convolution, correlation and multiplication using Z- transform	
17 & 18		Initial value theorem, Perseval's relation, inverse Z-transform by contour integration, power series & partial-fraction expansions with examples and exercises.	
19		**Discrete Fourier Transform:** Concept and relations for DFT/IDFT, Relation between DTFT & DFT.	
20		Twiddle factors and their properties, computational burden on direct DFT, DFT/DFT as linear transformation,	
21		DFT/IDFT matrices, computation of DFT/IDFT by matrix method, multiplication of DFTs, circulation convolution,	
22		Computation of circular convolution by graphical, DFT/IDFT and matrix methods	
23		Linear filtering using DFT, aliasing error, filtering of long data sequences-Overlap-Save and Overlap-Add methods with examples and exercises.	
24		**Fast Fourier Transforms:** Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithm,	
25		Signal flow graph, Butterflies, computations in one place, bit reversal,	
26		Examples for DIT & DIF FFT Butterfly computations	

27 & 28		**Filter design:** Basic concepts of IIR and FIR filters, difference equations,	
29 & 30		Design of Butterworth IIR analog filter using impulse invariant and bilinear transform	
31 & 32		Design of linear phase FIR filters no. of taps, rectangular, Hamming and Blackman windows.	
33		Effect of quantization.	
34		**Digital Signal Processor:** Elementary idea about the architecture	
35 & 36		Important instruction sets of TMS320C 5416/6713 processor,	
37		Writing of small programs in assembly Language.	
38 & 39		**FPGA:** Architecture, different sub-systems,	
40 & 41		design flow for DSP system design, mapping of DSP alrorithms onto FPGA.	

Recommended Books:

1. Digital Signal Processing-A computer based approach, S. Mitra, TMH
2. Digital Signal Processing: Principles, Algorithms & Application, J.C. Proakis & M.G. Manslakis, PHI
3. Fundamental of Digital Signal Processing using MATLAB , Robert J. Schilling, S.L. Harris, Cengage Learning.
4. Digital Signal Processing-implementation using DSP microprocessors with examples from TMS320C54XX, Avtar Singh & S. Srinivasan, Cengage Leasrning