MAT5009	Advanced Computer Arithmetic	L	T	P	J	C
		2	1	0	0	3

Prerequisite: None

Syllabus Version 1.1

Course Objectives:

1. An ability to understand various arithmetic operations that are implemented in digital systems.
2. An ability to perform error analysis of various VLSI architectures implemented using algorithms.
3. An ability to implement high-throughput, low-power and fault tolerant arithmetic circuits

Expected Course Outcomes:

At the end of the course the student should be able to

1. Introduce number systems and integer arithmetic
2. Apply modular arithmetic and FFT in engineering problems
3. Explore floating point arithmetic
4. Discuss function evaluation, CORDIC Algorithms
5. Implement high throughput arithmetic, low power arithmetic, fault tolerant arithmetic and perform error analysis

Student Learning Outcomes (SLO): 2, 9, 18

[2] Having a clear understanding of the subject related concepts and of contemporary issues
[9] Having an ability to use techniques, skills and modern engineering tools necessary for engineering practice
[18] Having critical thinking and innovative skills

Module:1	Introduction	5 Hours	

Review of Numbers and arithmetic. Redundant number systems. Residue number system.

Module:2	Integer Arithmetic	7 Hours	

Addition and Subtraction. Multiplication. Division. Roots. Greatest Common Division. Base Conversion: Quadratic Algorithms, Sub-quadratic Algorithms.

Module:3	FFT and Modular Arithmetic	7 Hours	

Representation: Classical Representation, Montgomery's Form, Residue Number Systems, MSB vs LSB Algorithms, Link with Polynomials. Addition and Subtraction. Multiplication: Barrett's Algorithm, Montgomery's Multiplication, McLaughlin's Algorithm, Special Moduli, Fast Multiplication Over GF(2)[x]. Division and Inversion, Exponentiation, Chinese Remainder Theorem

Module:4	Floating Point Arithmetic	5 Hours	

Floating point representation. Floating point operation. Errors and Error control. Precise and certifiable arithmetic

Module:5	Function Evaluation	7 Hours	

Square-Rooting Methods, The CORDIC Algorithms, Variations in Function Evaluation. Arithmetic by Table Lookup			
Module:6	**Implementations**	**7 Hours**	
High throughput arithmetic, Low power arithmetic, fault tolerant arithmetic			
Module:7	**Error Analysis**	**5 Hours**	
Absolute Versus Relative Error, Significant Digits. Uncertainty in Data. Chopping off and Rounding off. Truncation Error. Loss of Significance.			
Module:8	**Contemporary Topics**	**2 Hours**	
Applications of computer arithmetic in recent SoC design			
	Total Lecture:	**45 Hours**	
Mode of evaluation: Flipped Class Room, [Any one of Lecture to be videotaped], Use of physical and computer models to lecture, Min of 2 lectures by industry experts			

Text Books:	
1.	Computer Arithmetic: Algorithms and Hardware Design, Behrooz Parhami, (2/e) Oxford University Press, 2015.
2.	Modern Computer Arithmetic, Richard P Brent and Paul Zimmerman, Cambridge University Press, 2010
Reference Books:	
1.	Computer Arithmetic: Algorithms and Hardware Implementation, Mircea Vladutiu, Springer 2012.
2.	Elementary Functions: Algorithms and Implementation, J.M. Muller, 2nd Ed. Birkhauser,2006
3.	Advanced Computer Arithmetic Design, Michael J Flynn and Stuart F Oberman, John Wiley, March 2001.

Recommended by Board of Studies				
Approved by Academic Council	No. 46	Date	24-08-2017	