22EEHO306	INTELLIGENT CONTROL OF ELECTRIC VEHICLES		SEMESTER			
PREREQUISITES		CATEGORY	PEC	Credit		C
			L	T	P	TH
Power Electronics and Electric Vehicle		Hours/Week	3	0	0	3

Course Objectives:

1.	To design and drive the mathematical model of a BLDC motor and its characteristics
2.	To learn the different control schemes for BLDC motor
3.	To study the basics of fuzzy logic
4.	To study the FPGA & VHDL basics
5.	To implement fuzzy logic control of BLDC motor in real time

UNIT I	**MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR**	**9**	**0**	**0**	**9**

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristics Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

UNIT II	**SPEED CONTROL FOR ELECTRIC DRIVES**	**9**	**0**	**0**	**9**

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor

UNIT III	**FUZZY LOGIC**	**9**	**0**	**0**	**9**

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems, overview of fuzzy expert system-fuzzy decision making

UNIT IV	**FPGA AND VHDL BASICS**	**9**	**0**	**0**	**9**

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection

UNIT V	**REAL TIME IMPLEMENTATION**	**9**	**0**	**0**	**9**

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of 48 V BLDC motor using FPGA.

Total (45L+0T) = 45 Periods

Reference Books:

1.	Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, Wiley 1st Edition 2018.
2.	VHDL Primer, A (3rd Edition), Jayaram Bhasker, Prentice Hall, 1st Edition 2015.
3.	Iqbal Hussain, "Electric and Hybrid Vehicles: Design Fundamentals, Third Edition" CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4.	Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012, 1st Edition.
5.	M.N. Cirstea, A. Dinu, J.G. Khor,M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6.	Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley 2017, 2nd Edition
7.	Electric and Plug-in Hybrid Vehicle Networks Optimization and Control, Emanuele Crisostomi • Robert Shorten, Sonja Stüdli • Fabian Wirth, CRC Press, 1st Edition. 2018.

Course Outcomes: Upon completion of this course, the students will be able to:			**Bloom's Taxonomy Mapped**
CO1	:	To design the mathematical model of a BLDC motor and to discuss about its characteristics	L2: Understanding
CO2	:	To demonstrate the PID control, anti-windup controller, Intelligent Controller and Vector Control. Control applied to BLDC motor.	L5: Evaluating
CO3	:	To illustrate the basics of fuzzy logic system	L1: Remembering
CO4	:	To describe the basics of VHDL & FPGA applied to control of EVs.	L2: Understanding
CO5	:	To design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time	L6: Creating

COURSE ARTICULATION MATRIX

COs/ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3								1	2		2	3		3
CO2	3								1	2		2	3		3
CO3	3						3		1	2		2	3		3
CO4	3						3		1	2		2	3		3
CO5	3						3		1	2		2	3	2	3
Avg	3	0	0	0	0	0	3	0	1	2	0	2	3	2	3
3/2/1-indicates strength of correlation (3- High, 2-Medium, 1- Low)															