INSTITUTE	**FACULTY OF TECHNOLOGY**
PROGRAM	**MASTER OF TECHNOLOGY in ELECTRICAL ENGINEERING**
SEMESTER	**2**
COURSE TITLE	**ADVANCED ELECTRICAL DRIVES**
COURSE CODE	**01PE1202**
COURSE CREDITS	**4**

Objective:

1 To introduce basic concepts of modelling of machine in reference frame, vector control of induction motor, DTC of induction motor and advance motor drives for electric vehicle application.

Course Outcomes: After completion of this course, student will be able to:

1 Model the induction motor in different reference frames
2 Develop the vector control of induction motor drive for high performance application
3 Select the method for estimating the speed for sensor less vector control
4 Compare the Performance of Vector Control and Direct Torque Controlled Drives
5 Identify the role of open end winding and multiphase machine in heavy electric vehicle.

Pre-requisite of course: Basic Electrical Engineering, Electrical Machine, Power Electronics, Circuit and Network, Control System

Teaching and Examination Scheme

Theory Hours	Tutorial Hours	Practical Hours	ESE	IA	CSE	Viva	Term Work
3	0	2	50	30	20	25	25

Contents : Unit	Topics	Contact Hours
1	**Dynamic Modelling of Induction Machine** Transformation of variables, three phase to two phase transformation,, Static and rotating reference frames,, transformation relationships, voltage equation in arbitrary reference frame,, flux-linkage equation in arbitrary reverence frame, torque equation in arbitrary reference frame,, dynamic dq equivalent circuit of induction machine,	8

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Contents : Unit	Topics	Contact Hours
2	**Vector Control of Induction Motor:** Introduction to Field Oriented Control (FOC), Advantages of Vector control over scalar control,, DC Drive analogy, Principle of Vector control, Dynamic model of Induction machine in various reference frame,, principle of flux orientation control: Rotor flux orientation control & stator flux orientation control,, Direct or Feedback Vector Control,, Flux vector estimation: Voltage model & Current Model, Indirect or Feedforward Vector Control,, Parameter Sensitivity of the Indirect Vector Control.	10
3	**Sensor-less Vector Control** Introduction to sensor less vector control, Speed Estimation Methods: Slip calculation,, Direct synthesis from state equation, Model Referencing Adaptive System (MARS),, Speed Adaptive Flux Observer (Lemberger Observer),, Extended Kalman Filter (EKF), Slot Harmonics,, Injection of Auxiliary Signal on Salient Rotor	8
4	**Direct Torque and Flux Control (DTC)** Introduction of DTC, Comparison between FOC and DTC,, to SVPWM, Synthesis of Stator Voltage Space Vector,, Torque Expression with Stator and Rotor Flux,, Inverter voltage vectors and calculation of stator voltage space vector, Principle of Encoder less DTC Operation.	8
5	**Open End Winding and Multiphase Machines for EV application** Role of Multi-phase motor in heavy electric vehicles, Open end winding Induction Motor,, Multi-phase Induction Motor,, Multiphase PMSM, Multiphase BLDC Motor,, Converter for Multiphase machines,, Advantages of Multi-phase machine for Fault- tolerant operation of EV.	8
Total Hours		**42**

Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
1	**Experiment No - 01** To implement a change of variables (3 – f to 2 – f) in MATLAB simulation and to implement a change of variables (2 – f to 3 – f) in MATLAB simulation to implement a change of variables between two reference frames in MATLAB	2
2	**Experiment No - 02** To implement the model of IM in arbitrary reference frame and evaluate the dynamic performance of IM during the sudden change in the load torque.	2
3	**Experiment No - 03** To Simulate the Scalar Control of the Induction Machine and observe the dynamic performance of the system under the sudden change of load and command speed.	2

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Suggested List of Experiments:

Contents : Unit	Topics	Contact Hours
4	**Experiment No - 04** To implement the voltage model for the estimation of flux vector for FOC of IM.	2
5	**Experiment No - 05** To implement the current model for the estimation of flux vector for FOC of IM.	2
6	**Experiment No - 06** To estimate the rotor speed of IM using the slip calculation method	2
7	**Experiment No - 07** To estimate the rotor speed of IM using the direct synthesis from state equation method.	2
8	**Experiment No - 08** To Simulate Field-Oriented Variable-Frequency Induction Motor Drive	2
9	**Experiment No - 09** To simulate the Direct Torque Control technique for Induction Motor Drive	2
10	**Experiment No - 10** To simulate the speed control of BLDC motor drive	2
Total Hours		**20**

Textbook :

1 Advanced electric drives: analysis, control, and modeling using MATLAB/Simulink., Mohan, Ned., John wiley & sons,, 2014

2 Electric Motor Drives: Modeling, Analysis and Control, R. Krishnan, Prentice Hall, -

3 Modern power electronics and AC drives, Bose, Bimal K., Prentice hall, 2002

4 Vector control of AC machines. Vol. 22, Vas, Peter, Oxford University Press, USA, 1990

5 Electrical Machines : Modelling and Analysis, Mrittunjay Bhattacharyya, Prentice Hall, -

6 Electric motor control: DC, AC, and BLDC motors, Kim, Sang-Hoon, Elsevier, 2017

References:

1 Dynamic Simulation of Electric Machinery using MATLAB, Dynamic Simulation of Electric Machinery using MATLAB, ONG, Chee-Mun, Prentice Hall PTR, -

Suggested Theory Distribution:

The suggested theory distribution as per Bloom's taxonomy is as follows. This distribution serves as guidelines for teachers and students to achieve effective teaching-learning process

Distribution of Theory for course delivery and evaluation

Remember / Knowledge	Understand	Apply	Analyze	Evaluate	Higher order Thinking / Creative
5.00	10.00	15.00	30.00	20.00	20.00

Instructional Method:

1. The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc
2. The internal evaluation will be done on the basis of continuous evaluation of students in the laboratory and classroom.
3. Practical examination will be conducted at the end of semester for evaluation of performance of students in laboratory.
4. Students will use supplementary resources such as online videos, NPTEL videos, e-courses, Virtual Laboratory

Supplementary Resources:

1. https://nptel.ac.in/courses/108104011
2. https://archive.nptel.ac.in/courses/108/104/108104011/
3. https://archive.nptel.ac.in/courses/108/104/108104140/

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