ELECTRICAL CIRCUITS AND MACHINES

ENEE 154

Lecture : 4 **Year : I**
Tutorial : 1 **Part : II**
Practical : 3/2

Course Objectives:
To develop a comprehensive understanding of electric circuit theory and analysis techniques, alongside the principles and operation of electric machines including transformers, DC and AC machines.

1 Transients in Electric Circuit (7 hours)

1.1 Characteristics of various network elements
1.2 Nodal analysis with dependent and independent sources
1.3 Mesh analysis with dependent and independent sources
1.4 Application of matrix method in network analysis
1.5 Procedure of evaluating initial conditions
1.6 Initial values of derivatives
1.7 Initial condition in the case of R-L-C network

2 Transient Analysis R-L-C Circuit by Classical Method (10 hours)

2.1 Introduction
2.2 First order differential equation with constant coefficient
2.3 Higher order homogenous and non-homogenous differential equation with constant coefficient
2.4 Particular integral by method of undetermined coefficient
2.5 Response of R-L and R-C circuits with DC excitation
  2.5.1 DC excitation
  2.5.2 Exponential excitation
  2.5.3 Sinusoidal excitation
2.6 Response of Series R-L-C circuits with
  2.6.1 DC excitation
  2.6.2 Exponential excitation
  2.6.3 Sinusoidal excitation
2.7 Response of Parallel R-L-C circuits with
  2.7.1 DC excitation
  2.7.2 Exponential excitation

3 Transient Analysis Using Laplace Transform (7 hours)

- 3.1 Introduction
- 3.2 Response of R-L and R-C circuits with
  - 3.2.1 DC excitation
  - 3.2.2 Exponential excitation
  - 3.2.3 Sinusoidal excitation
- 3.3 Response of series R-L-C circuits with
  - 3.3.1 DC excitation
  - 3.3.2 Exponential excitation
  - 3.3.3 Sinusoidal excitation
- 3.4 Response of parallel R-L-C circuits with
  - 3.4.1 DC excitation
  - 3.4.2 Exponential excitation

4 Network Transfer Function and Frequency Response (8 hours)

- 4.1 Concept of complex frequency
- 4.2 Transfer functions of two port networks
- 4.3 Poles and zeros of networks
- 4.4 Magnitude and phase response
- 4.5 Bode diagrams
- 4.6 Band width, high-q and low-q circuits
- 4.7 Basic concept of filters: High-pass, low-pass, band-stop and band-pass filters

5 Two-Port Parameters of Network (8 hours)

- 5.1 Definitions of two-port networks
- 5.2 Parameters of two-port networks
  - 5.2.1 Open circuit impedance parameters
  - 5.2.2 Short circuit admittance parameters
  - 5.2.3 Transmission line parameters
  - 5.2.4 Inverse transmission line parameters
  - 5.2.5 Hybrid parameters
  - 5.2.6 Inverse hybrid parameters
- 5.3 Relationship and transformation between sets of parameters
- 5.4 Interconnection of two port networks
- 5.5 Condition for reciprocity and symmetry

6 Magnetic Circuit and Induction (3 hours)

- 6.1 Magnetic circuit and its types
- 6.2 B-H relationship and hysteresis with DC excitation
- 6.3 Hysteresis with AC excitation
- 6.4 Hysteresis loss and Eddy current loss

6.5 Faraday's law of electromagnetic induction, statically and dynamically induced EMF
6.6 Force on current carrying conductor

7 Transformers (6 hours)

7.1 Construction, operating principle and EMF equation of single-phase transformer
7.2 No load and load operation of transformer
7.3 Equivalent circuit diagram of transformer
7.4 Transformer testing (Open circuit and short circuit)
7.5 Voltage regulation, losses, efficiency and condition for maximum efficiency
7.6 Auto transformer, Isolation transformer

8 DC Machine (5 hours)

8.1 Constructional details of DC machine
8.2 Operating principle and EMF equation of DC generator
8.3 Operating principle and torque equation of DC motor
8.4 Types of DC machine
8.5 Back EMF and its role in DC motor
8.6 Performance characteristics of DC motor
8.7 Starting of DC motor using 3-point starter
8.8 Speed control of DC motor (Armature control, field control)
8.9 Losses and efficiency

9 AC Motor (6 hours)

9.1 Construction, production of rotating magnetic field and operating principle of three-phase induction motor
9.2 Torque equation of three-phase induction motor at standstill and running condition
9.3 Torque slip characteristics, condition for maximum torque and effect of rotor resistance on torque slip characteristics
9.4 Single-phase induction motor
9.5 Double field revolving theory
9.6 Starting of single-phase induction motor (Capacitor start and run, shaded pole)
9.7 Introduction to permanent magnet brushless DC motor, hysteresis motor, stepper motor, servo motor, universal motor

Tutorial (15 hours)

The tutorial sessions will focus on chapter-specific exercises aimed at enhancing understanding and application in electrical circuits and machines.

Practical (22.5 hours)

1. Transient response in first order system passive circuit

- Measure step and impulse response RL and RC circuit using oscilloscope
- Relate time response to analytical transfer function calculation

2. Transient response in second order system passive circuit
   - Measure step and impulse response RLC series and parallel circuit using oscilloscope
   - Relate time response to analytical transfer function and pole-zero configuration
3. Two port network
   - To calculate and verify 'ABCD' parameters of two-port network
   - To determine equivalent parameters of parallel connection of two-port network
4. Two winding transformers
   - Measure amplitude and phase response and plot Bode diagram for RLC circuits
   - To perform open circuit (OC) and short circuit (SC) test to determine
5. DC motor
   - speed control of DC Shunt motor by (a) armature control method (b) field control method
   - To observe the effect of increasing load on DC shunt motor's speed, armature current and field current
6. Single phase AC motors
   - To study the effect of a capacitor on the starting and running of a single-phase induction motor
   - Reversing the direction of rotation of a single-phase capacitor start induction motor

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapter	Hours	Mark distribution*
1	7	7
2	10	10
3	7	7
4	8	8
5	8	8
6	3	3
7	6	6
8	5	5
9	6	6
Total	**60**	**60**

* There may be minor deviation in marks distribution.

References

1. Van Valkenburg, M. E. (2019). Network analysis. Pearson Education.
2. Hayt, W.H., Kemmerly, J.E., Phillips, J.D., Durbin, S.M. (2019). Engineering circuit analysis. McGraw-Hill Education.
3. Ciletti, M.D. (1995). Introduction to circuit analysis and design (Latest Edition). Oxford University Press.
4. Soni, K.M. (2013). Circuits and systems. S. K. Kataria & Sons.
5. Nagrath, F.I.J., Kothari, D.P. (2017). Electric machines. McGraw Hill Education.
6. Fitzgerald, A.E., Kingsley, C. (2017). Electric machinery. McGraw Hill Education.
7. Sahdev, S.K. (2018). Electrical machines. Cambridge University Press.
8. Hussain, A. (2016). Electrical machines. Dhanpat Rai & Co.