CODE	COURSE NAME	CATEGORY	L	T	P	CREDITS
EET456	DESIGN OF POWER ELECTRONIC SYSTEMS	PEC	3	0	0	3

Preamble : To impart knowledge about the design and protection of power electronic systems.

Prerequisite : EET306 Power Electronics

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

CO 1	Design gate drive circuits for various power semiconductor switches.
CO 2	Design protection circuits for various semiconductor devices.
CO 3	Select appropriate passive components for power electronic circuits.
CO 4	Design the magnetic components for power electronic circuits.
CO 5	Design signal conditioning circuits and passive filters for converters.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	3	2	-	-	-	-	-	-	-	2
CO 2	3	2	3	2	-	-	-	-	-	-	-	2
CO 3	3	3	-	-	-	-	-	-	-	-	-	2
CO 4	3	3	3	2	-	-	-	-	-	-	-	2
CO 5	3	2	3	2	-	-	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember (K1)	10	10	20
Understand (K2)	10	10	20
Apply (K3)	20	20	50
Analyse (K4)	10	10	10
Evaluate (K5)	-	-	-
Create (K6)	-	-	-

End Semester Examination Pattern : There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Design a gate/base drive using totem pole arrangement (K1, K3, PO1, PO2, PO4)
2. Design a gate drive using a non-isolated circuit (K1, K3, PO1, PO2, PO4)
3. Design high side and low side switch drives using isolated gate drivers (K1, K3, PO1, PO2, PO4)
4. Explain the boot-strap technique for gate drives using gate drive IC IR 2110 (K1, K2, PO1)

Course Outcome 2 (CO2):

1. Design a turn-off and turn-on snubber circuit for SCR (K1,K3,PO1, PO2, PO4)
2. Design a Snubber circuit for a buck converter (K1, K3, PO1, PO2, PO4)
3. Describe the thermal protection, short-circuit and over-current protection in IGBTs (K1,K2, PO1)
4. Explain the steps for the design of heat sinks (K1,K2, PO1)

Course Outcome 3 (CO3):

1. Explain the different types of inductor and transformer assembly (K1, PO1)
2. Explain the types of capacitors used in power electronic circuits and their selection (K1,K2, PO1)
3. Explain the effect of equivalent series resistance and equivalent series Inductance of capacitors in converter operation (K4, PO1)
4. Explain the filter design for single phase and three phase inverters (K3, PO1, PO2)
5. Describe the various types of power resistors used in power electronic circuits (K1, PO1)

Course Outcome 4 (CO4):

1. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits(K1,K2)
2. Explain the Inductor design in power electronics circuits (K3)
3. Explain the transformer design in power electronics circuits (K3)
4. Explain the wire selection and skin effect in power electronics circuits (K1,K2)

Course Outcome 5 (CO5):

1. Explain the design of current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics circuits (K2, K3, PO1)
2. Design input and output filters for single phase and three phase inverters (K3, PO1, PO2, PO4)

3. Explain the corner frequency selection and harmonic filtering performance in inverter circuits (K2,K4, PO1)
4. Explain the various components in an Intelligent Power Module (K1,K2, PO1)

Model Question Paper

QP CODE:

PAGES:2

Reg.No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET456

Course Name: DESIGN OF POWER ELECTRONIC SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)

Answer all Questions. Each question carries 3 Marks

1. A MOSFET has an input capacitance Ciss = 800 pF. A gate resistance of 250 Ω is used along with a gate drive voltage peak of 12 V. If the threshold gate voltage is Vgs(th) = 4 V, how long will it take this gate signal to turn on the MOSFET?
2. Design a gate drive using non-isolated and isolated circuits.
3. Design a turn-off and turn-on snubber circuit for SCR.
4. Design a Snubber circuit for a buck converter.
5. Explain the different types of inductor and transformer assembly.
6. Explain the types of capacitors used in power electronic circuits and their selection.
7. Describe the selection of amorphous, ferrite and iron cores used in power electronic circuits.
8. Explain the Inductor design in power electronics circuits.
9. Design current transformers, resistive shunts, hall-effect based voltage and current sensors for power electronics applications.
10. Design input and output filters for single phase and three phase inverters.

PART B (14 x 5 = 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. a) Design high side switch drive using isolated gate drivers. **(6)**

b) Design low side switch drive using isolated gate drivers. **(8)**

12. a) Explain the boot-strap technique for gate drive design using gate drive IC IR 2110 **(8)**

    b) Design a gate drive circuit for IGBT **(6)**

Module 2

13. a) Describe the thermal protection in IGBTs. **(10)**
    b) Explain the steps for the design of heat sinks. **(4)**

14. a) Describe the short-circuit protection in IGBTs **(7)**
    b) Describe the over-current protection in IGBTs **(7)**

Module 3

15. a) Two capacitor values are made by a manufacturer. The two have similar size, and each has an ESL of 20 nH, and tan δ=0.2. One is 1000 μF and the other is 100 μF. Evaluate their ESRs and resonant frequencies. If 10 numbers of 100 μF capacitors are paralleled to make 1000 μF, evaluate the ESR, ESL and the resonant frequency of the paralleled combination. Which (a single 1000 μF or a parallel combination of 10 numbers of 100 μF), is better in terms of operating frequency? (**10**)
    b) Explain the filter design for single phase and three phase inverters
(4)

16. a) Describe the various types of power resistors used in power electronic circuits. **(6)**

    b) Explain the effect of equivalent series resistance of capacitor **(8)**

Module 4

17. a) Design high frequency transformer in power electronics circuits. **(8)**

    b) Explain the wire selection in power electronics circuits. **(6)**

18. a) A 2 mH inductor design for dc applications is as follows, for a maximum current of 0.5A: Core: 26x19; Aw = 40mm2, AC = 90mm2; N=37; aw = 0.29mm2 (23 SWG). For the above core and windings and N, evaluate the peak flux density, peak current density, window space factor (kw), and the inductance value, for air gap values of 0.08mm and 1mm. **(10)**

    b) Explain the thermal considerations in power electronic circuits **(4)**

Module 5

19. a) Explain the corner frequency selection in inverter circuits **(8)**
    b) Explain the various components in an Intelligent Power Module **(6)**

20. a) Explain the harmonic filtering performance in inverter circuits **(8)**
    b) Explain the methods for reducing stray inductance in power electronic circuits **(6)**

Syllabus

Module 1 (8 hrs)

Gate and base drive design: Gate drive requirements and gate/base drive design for SCRs, BJTs, MOSFETs, IGBTs-Gate drive design using discrete components - open collector, totem pole, non-isolated and isolated- optocoupler, pulse transformer based, use of ICs such as DS0026, TLP250- High side and low side switch driving using isolated gate drivers. Boot-strap technique for gate drives using gate drive IC IR 2110.

Major references: Ref.1, Ref.2, Ref.3

Module 2 (7 hrs)

Design of protection elements: Snubber circuits: Function and types of Snubber circuits, design of turn -off and turn-on snubber. Snubber design for step-down converter. Short-circuit and over-current protection in IGBTs, desaturation protection. Thermal protection, cooling, design and selection of heat sinks (natural cooling only).

Major references: Ref.1, Ref.2,

Module 3 (7 hrs)

Passive elements in Power electronics: Inductors: types of inductors and transformer assembly-. Capacitors: types of capacitors used in power electronic circuits, selection of capacitors, dc link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation. Design of filters - input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints. Resistors: power resistors, use in snubbers. Resistors for special purpose: high voltage resistors and current shunts.

Major references: Ref.1, Ref.4,

Module 4 (7 hrs)

Magnetics design: Magnetic materials and cores: amorphous, ferrite and iron cores-Inductor and transformer design based on area-product approach. Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss. Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect.

Major References: Ref.1,2,3,5,6

Module 5 (7 hrs)

Measurements and signal conditioning: Design of current transformers for power electronic applications, resistive shunts, hall-effect based voltage and current sensors, typical design based on hall-effect sensors, signal conditioning circuits- level shifters, anti-aliasing

filters. Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar.Introduction to Intelligent Power Module.

Major References: Ref.6

Assignments/ course projects may be given based on the topic: Demonstrative design of a converter such as Buck converter/ Flyback converter.

Text/Reference Books:

1. Mohan N., T. M. Undeland and W. P. Robbins., Power Electronics, Converters, Applications & Design, Wiley-India, 2002.
2. L. Umanand, Power Electronics – Essentials & Applications, Wiley-India, 2009.
3. V. Ramanarayanan, Course material on 'Switched mode power conversion' 2007.
4. Daniel W. Hart, Power Electronics, Tata McGraw-Hill Education, 2011.
5. Erickson, Robert W., and Maksimovic, Dragan, Fundamentals of Power Electronics, 1997.
6. Krein P. T., Elements of Power Electronics, Oxford University Press, 1998.
7. Joseph Vithayathil, Power Electronics: Principles and Applications, McGraw-Hill College; International edition,1995.
8. Singh M. D. and K. B. Khanchandani, Power Electronics, Tata McGraw Hill, New Delhi, 2008.
9. Muhammad H. Rashid, Power Electronics Circuits, Devices and Applications, Pearson Education, 2014.
10. P.S. Bimbhra, Power Electronics, Khanna Publishers, New Delhi, 1990.

Course Contents and Lecture Schedule:

No.	Topic	No. of Lectures
1	**Design of gate and base drive circuits (8 hours)**	
1.1	Gate drive requirements and gate drive design for SCRs, BJTs, MOSFETs, IGBTs.	3
1.2	Gate drive design using discrete components	3
1.3	High side and low side switch driving using isolated gate drivers	1
1.4	Boot-strap technique for gate drives using gate drive IC IR 2110	1
2	**Design of protection elements (7 hours)**	
2.1	Snubber circuits: Function and types of Snubber circuits, design of turn off and turn-on snubber.	2
2.2	Snubber design for step-down converter.	2
2.3	Short-circuit and over-current protection in IGBTs, desaturation	1

	protection.	
2.4	Thermal protection, cooling, design and selection of heat sink (natural cooling only).	2
3	**Passive elements in Power electronics (7 Hours)**	
3.1	Inductors: types of inductors and transformer assembly	1
3.2	Capacitors: types of capacitors used in power electronic circuits, selection of capacitors	1
3.3	DC link capacitors in inverters, filter capacitors in dc-dc and inverter circuits, equivalent series resistance and equivalent series Inductance of capacitors and their effects in converter operation.	2
3.4	Design of filters: input and output filters - typical filter design for single phase and three phase inverters - LC filter - corner frequency selection - harmonic filtering performance – design constraints.	2
3.5	Resistors: power resistors, their use in snubbers. Resistors for special purpose: high voltage resistors and current shunts.	1
4	**Magnetics design (7 Hours)**	
4.1	Magnetic materials and cores: amorphous, ferrite and iron cores	1
4.2	Inductor and transformer design based on area-product approach	3
4.3	Magnetic characteristics and selection based on loss performance and size, eddy current and hysteresis loss	1
4.4	Thermal considerations, leakage inductance, comparison of sizes of transformer and inductor, wire selection and skin effect	2
5	**Measurements and signal conditioning (7 Hours)**	
5.1	Design of current transformers for power electronic applications, resistive shunts	2
5.2	Hall-effect based voltage and current sensors, typical design based on hall-effect sensors	1
5.3	Signal conditioning circuits- level shifters, anti-aliasing filters	2
5.4	Minimizing stray inductance in drive circuit, shielding and portioning of drive circuit, reduction of stray inductance in bus bar	1
5.5	Introduction to Intelligent Power Module	1