7. SUBJECT DETAILS

7.4 POWER ELECTRONICS

7.4.1 Objectives and Relevance

7.4.2 Scope

7.4.3 Prerequisites

7.4.4 Syllabus

i. JNTU

ii. GATE

iii. IES

7.4.5 Suggested Books

7.4.6 Websites

7.4.7 Experts' Details

7.4.8 Journals

7.4.9 Finding and Development

7.4.10 i Session Plan

ii Tutorial Plan

7.4.11 Student Seminars

7.4.12 Question Bank

i. JNTU

ii. GATE

iii. IES

7.4.1 OBJECTIVE AND RELEVANCE

With the advent of semiconductor devices, revolution is taking place in the power transmission distribution and utilization. This course introduces the basic concepts of power semiconductor devices, converters and choppers and their analysis. Today, power electronics is an indispensable tool in any advanced country's industrial economy, saving energy is an important aspect of power electronic Applications.

7.4.2 SCOPE

Power electronics is that field of electronics which deals with conversion, control and switching of electrical energy for power applications and playing a major role in revolutionizing the Inudstrial controls. The market demands an Industry for productivity and quality are increasing. This results in the increasing demand for automation in production porcesses and hence for the use of vairable speed drives. To day power electronics is an indispensable tool in any advanced counrties Industrial economy. Saving energy is an impartant aspect of power elctronics applications.

7.4.3 PREREQUISITES

The students must have basic knowledge of the following subjects Network theory and various theorems,Basic electronics, semiconductors and their characteristics ,Basic electrical Machines

7.4.4.1 JNTU SYLLABUS

UNIT-I
OBJECTIVE
This unit deals with power semiconductor devices and circuits in terms of their terminal characteristics and functionality. It briefly describes the switching characteristics of SCR.

This unit deals with triggering circuits, protection circuit for SCR, ratings and series - parallel connection of SCRs. It also describes the various commutation methods.

SYLLABUS
POWER SEMI CONDUCTOR DEVICES AND COMMUTATION CIRCUITS: Thyristors, silicon controlled rectifiers (scr's), BJT, power MOSFET, power IGBT and their characteristics and other thyristors, basic theory of operation of SCR, static characteristics, turn on and turn off methods, dynamic characteristics of SCR, turn on and turn off times, salient points.

Two transistor analogy, SCR, UJT firing circuit, series and parallel connections of SCR's, snubber circuit details, specifications and ratings of SCR's, BJT, IGBT, numerical problems, line commutation and forced commutation circuits.

UNIT-II
OBJECTIVE
This unit discusses all possible configurations of half controlled converters with various loads along with their mathematical analysis as well as performance factors.

This unit discusses all possible configurations of full controlled converters with various loads along with their mathematical analysis as well as performance factors.

This unit discusses the three pulse, six pulse and dual converters with wave forms and the effect of source inductance on the performance of these converters.

SYLLABUS
AC-DC CONVERTERS(1-Phase & 3-Phase Controlled Rectifiers): Phase control technique, line commutated converters-midpoint and bridge connections, half controlled converters with resistive, RL and RLE loads, derivation of average load voltage and current, active and reactive power inputs to the converters with and without freewheeling diode, numerical problem

Fully controlled converters, Midpoint and bridge connections with resistive, RL and RLE Loads, Derivation of Average load voltage and current, Line commutated inverters, Active and reactive power inputs to the converters with and without freewheeling diode, Effect of source inductance, derivation load voltage and current, numerical problems three phase converters-three plus and six plus converters-midpoint and bridge connections average load voltage with R and RL loads –effect of source inductance-dual converters(both single phase and three phase)- waveforms-Numerical Problems..

UNIT-III
OBJECTIVE
This unit discusses the principle of operation of chopper in DC to DC conversion along with their control techniques and its configurations.

SYLLABUS

DC_DC CONVERTERS(CHOPPERS): Choppers, time ratio control and current limit control strategies, step down choppers, derivation of load voltage and current with R, RL and RLE loads, step up chopper load, voltage expression, morgan's chopper, jones chopper and oscillation chopper (principle of operation only) wave forms, AC chopper, problems.

THREE PHASE LINE COMMUTATED CONVERTERS: Three phase converters, three pulse and six pulse converters, midpoint and bridge connections, average load voltage with R & RL loads, effects of source inductance, dual converters (both single phase and three phase), waveforms, numerical problems.

UNIT-IV

OBJECTIVE

This unit discusses the characteristics of AC regulators with different types of loads and also introduces cyclo converters, their characteristics and applications.

SYLLABUS

AC-AC CONVERTERS (AC VOLTAGE CONTROLLERS) & FREEQUENCY CHANGERS(CYCLO CONVERTERS): AC voltage controllers, single phase two SCR'S in anti parallel with R and RL loads, modes of operation of TRIAC, TRIAC with resistive and RL loads, derivation of RMS load voltage, current and power factor wave forms, firing circuits, problems, cyclo converters, single phase mid point cyclo converters, with resistive and inductive load (principle of operation only), bridge configuration of single phase cyclo converter (principle of operation only) wave forms and numerical problems.

UNIT-V

UNIT-V

OBJECTIVE

This unit is a comprehensive treatment of DC - AC inverters in which the various voltages fed and current fed inverters are discussed.

SYLLABUS

DC-AC CONVERTERS(INVERTERS): Inverters, single phase inverter, basic series inverters, basic parallel capacitor inverter, operation, wave forms, three phase inverters(180,120 degrees conduction modes of operation)- voltage control techniques for inverters, pulse width modulation techniques, numerical problems.

7.4.4.2 GATE SYLLABUS

UNIT-I

Semiconductor power devices, diodes, transistors, thristors, triacs, GTO's, MOSFET, IGBT's, static characteristics and principle operation.

UNIT-II

Triggering circuits.

UNIT-III

Phase centrolled rectifiers, Bridge converters - Half controlled.

UNIT-IV

Bridge converters - Fully controlled.

UNIT-V

Bridge converters - Fully controlled and Half controlled.

UNIT-VI

AC voltage Regulators.

UNIT-VII

Principles of Choppers.

UNIT-VIII

Principles of Inverters.

7.4.4.3 IES SYLLABUS

UNIT-I
Power semiconductor devices, Power transitors, thyristors, GTO's, MOSFET's characteristics and operation.

UNIT-II
Not covered.

UNIT-III
AC to DC converters, single phase half controlled converters.

UNIT-IV
Single phase fully controlled converters.

UNIT-V
Three phase converters.

UNIT-VI
AC regulators, Thyristor controlled reactors.

UNIT-VII
DC to DC converters, switched mode power supplies.

UNIT-VII
Inverters - Single phase and three phase, PWM, sinusoidal modulations with uniform sampling.

7.4.4 Session Plan

7.4.5 SUGGESTED BOOKS

TEXT BOOKS

T1 Power Electronics, M.D. Singh and K.B. Khanchandani, Tata McGraw Hill Publishing Company, 1998.
T2 Power Electronics Circuits Devices and Applications, M.H. Rashid, 2nd Edn., Prentice Hall of India, 1998.

REFERENCE BOOKS

R1 Power Electronics, devices, converters and applications, G. Tulsi Ram Das, B S publications.
R2 Power Electronics, V.R. Murthy, 1st Edn., Oxford university press, 2005.
R3 Power Electronics, Vedam Subramanyam, New Age International (P) Ltd., Publishers.
R4 Power Electronics, C.W. Lander, 2nd Edn., McGraw Hill Companies, 1993.
R5 Power Electronics Principles and Applications, J. Vithayathil, McGraw Hill Companies, 1995.
R6 Power Electronics, PC Sen, Tata McGraw Hill Publishing Company.
R7 Thryistorised Power Controllers, J.K. Dubey, S.R. Dorada, A. Joshi and R.M.K. Sinha, New Age International Pvt Ltd. Publishers, 1996
R8 "Modern power electronics : Evolution, Technology and Applications", B.K. Bose, Jaico Publishing House, 1999.
R9 A text book on power electronics, Harish C Rai, 3rd Edn., Galgotia Publications.

7.4.6 WEBSITES

1. www.powerelectronics.com
2. www.powerdesigns.com
3. www.cdpowerelectronics.com
4. www.magnetekpower.com
5. www.micro-power.com

6. www.iitm.ac.in
7. www.iitd.ac.in
8. www.iitk.ac.in
9. www.iitb.ac.in
10. www.iitg.ernet.in
11. www.iisc.ernet-in

7.4.7 EXPERTS' DETAILS

INTERNATIONAL

1. Dr. P.K. Jain,
   Professor,
   Department of Electrical and Computer Engineering,
   Queen's University, Kingston,
   CANADA,
   email : praveen.jain@ece.queensu.ca.

2. Dr. J. Dixon,
   Professor,
   Department of Electrical Engineering,
   Pontificia University,
   Santigo - 6904411,
   Chile,
   email: jdixon@ing.puc.cl.

NATIONAL

1. Dr. V. T. Ranganathan,
   Professor,
   Department of Electrical Enginering,
   IISC, Bangalore,
   Bangalore - 560012,
   email: ee.iisc.ernet.in.

2. Mr. Gouatam Poddar,
   Assitant Professor,
   IIT, Kharagpur,
   Kharagpur,
   email: gpoddar @ee.iitkgp.ernet.in.

REGIONAL

1. Dr. T. Tulsi Ram Das,
   Principal,
   JNTU University, Kukatpally,
   Tel: 9866234645.

2. Mr. C.S. Murthy,
   Dy. Director,
   ATI, Ramanthapur,
   Hyderabad -13,
   Tel: 9849685355,
   email: murthychs@hotmail.com.

7.4.8 JOURNALS

1. IEEE Transactions on power electronics
2. IEEE Transactions on Industrial Electronics
3. IEEE Transactions on Electron Devices
4. IEEE Transactions on energy conversion
5. International Journal on power electronics

7.4.9 FINDINGS AND DEVELOPMENTS

1. A new hybrid random PWM scheme, K.S. Kim, Y. G. Jung and Y.C. Lim, IEEE Transactions on Power Electronics, Vol. 24, Jan. 2009.

2. DC link current minimization for high power current source motor drives, Y.W. Li, M. Pande, IEEE Transactions on Power Electronics, Vol. 24, Feb. 2009.

3. A systematic approach to synthesizing multi-input DC-DC converters, Y.C. Lieu and Y.M. Chen, IEEE Transactions on Power Electronics, Vol. 24, Jan. 2009.

4. Control of cascade statcom star configuration unbalanced conditions, Q. Song and W. Liu, IEEE Transactions on Power Electronics, Vol. 24, Jan. 2009.

5. Three port bidirectional converter for hybrid fuel cells system, J.L. D Clartee, M Hendrix, IEEE Transactions on power electronics vol. 22, March 07.

7.4.10 i. SESSION PLAN

S. No	Topics in JNTU Syllabus	Modules and Sub-Modules	Lecture No.	Books Suggested	Remarks
		UNIT-I			
1	Thyristors, Silicon Controlled Rectifiers (SCR's)	Power Electronics- Introduction, objective, relevance and birds eye view of syllabus	L1	T1-Ch1 T2-Ch1,Ch7 R2-Ch1,R3-Ch1	GATE IES
		Thyristor- Constructional details			
2	Thyristors, basic theory of operation of SCR, Static characteristics	Operation Principle	L2	T1-Ch1,T2-Ch7 R2-Ch1,R3-Ch1	
		Static V-I characteristics			
3	Turn on and Turn off methods, Dynamic characteristics of SCR, Turn on and Turn off times, Sa	Turn on and Turn off methods	L3	T1-Ch1,R2-Ch, R3-Ch1	
		Switching characteristics of during Turn-on			
		Switching characteristics of during Turn-off	L4	T1-Ch1,R2-Ch1 R3-Ch1	
4	BJT, Power MOSFET, Power IGBT and their characteristics	BJT-Basic Structure &Circuitry Symbol	L5	T1-Ch10,T2-Ch4 R2-Ch1,R3-Ch1	
		Input & output characteristics			
		Transistor switching performance			
		Power MOSFET-Basic Structure &Circuitry Symbol	L6	T1-Ch10,T2-Ch4 R2-Ch1,R3-Ch1	
		Transfer, output & Switching characteristics			
		IGBT-Basic Structure &Circuitry Symbol	L7	T1-Ch10,T2-Ch4 R2-Ch1	
		Static V-I, Transfer & Switching characteristics			
5	other Thyristors	Circuit Symbol & V-I Characteristics of following devices Gate Turn off Thyristor, Triac, Diac	L8	T1-Ch10,T2-Ch7 R2-Ch1,R3-Ch1	GATE IES

		Programmable Un-injunction Transistor	L9	T1-Ch1,R2-Ch1 R3-Ch1	
		Silicon Unilateral Switch			
		Silicon Controlled switch			
		Static Induction Thyristors			
UNIT-II					
6	Two transistor analogy	Two transistor analogy	L10	T1-Ch1,T2-Ch7 R2-Ch1,R3-Ch1	GATE IES
7	UJT Firing circuit	Features of firing circuit	L11	T1-Ch2,T2-Ch4 R2-Ch1,R6-Ch1	
		UJT-Basic structure , Circuit Symbol & V-I Characteristics			
		Synchronized UJT Triggering	L12	T1-Ch2, R2-Ch1 R6-Ch7	
		Ramp and Pedestal Triggering			
8	Series and Parallel connections of SCR's	String Efficiency and Derating Factor	L13	T1-Ch3,T2-Ch4 R3-Ch1, R6-Ch1	
		Series operation of SCR, problems			
		Parallel operation of SCR problems	L14	T1-Ch3,T2-Ch4 R3-Ch1,R6-Ch1	
9	Snubber circuit details	Thyristor protection circuits	L15	T1-Ch11,T2-Ch4 R2-Ch1,R6-Ch2	
		Design of Snubber circuit Problems			
10	Specifications and ratings of SCR's, BJT,IGBT	Specifications and ratings of SCR's ,BJT,IGBT	L16	T1-Ch1,Ch10 R2-Ch1	
11	Line commutation and Forced commutation circuits	Thyristor commutation principle Line commutation	L18	T1-Ch1,R6-Ch1	
		Load commutation			
		Resonant pulse commutation	L19	T1-Ch1,R2-Ch1 R6-Ch1	
		complementary commutation			
		Impulse commutation			
UNIT-III					
12	Phase control technique	Phase controlled rectifiers – introduction Principle of phase control	L20	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	GATE IES
13	Line commutated converters, Midpoint and bridge connections, Half controlled converters with resistive, RL and RLE Loads	Single phase half controlled mid point circuit with R, RL and RLE load with and without freewheeling diode	L21	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	GATE IES
		Single phase half controlled Bridge circuit with R, RL and RLE load with and without freewheeling diode	L22	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
14	Derivation of Average load voltage and current, Active and reactive power inputs to the converters with and without free wheeling diode, Numerical Problems	Derivation of average load voltage and current	L23	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Calculations of Active and Reactive power inputs to converters	L24	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Numerical Problems			
UNIT-IV					
15	Fully controlled converters, Midpoint and bridge	Single phase Fully controlled mid point circuit with R, RL & RLE load with & without	L25	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	GATE IES

	connections with resistive, RL and RLE Loads	freewheeling diode			
		Single phase Fully controlled Bridge circuit with R, RL & RLE load with & without freewheeling diode	L26	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
16	Line commutated inverters, Derivation of Average load voltage and current, Active and reactive power inputs to the converters with and without free wheeling diode, Effect of source inductance, derivation load voltage and current, numerical problems.	Operation of full converter as inverter	L27	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Derivation of average load voltage & current	L28	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Calculations of Active and Reactive power inputs to converters	L29	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Effect of source inductance on performance of full converter	L30	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Numerical Problems			
UNIT-V					
17	Three phase converters, Three pulse and six pulse converters, Midpoint and Bridge connections, average load voltage with R & RL Loads	Three phase full converter with R & RL Load (Mid pt and Bridge connections)	L31	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	GATE IES
		Three phase Half converter with R & RL Load(Mid pt and Bridge connections)	L32	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Calculation of average load voltage	L33	T1-Ch4,T2-Ch10 R2-Ch2,R3-Ch3	
		Numerical Problems			
18	Effects of source inductance, Dual converters (both single phase and three phase) Waveforms, Numerical Problems	Effect of source inductance on the performance of three phase full converter	L34	T1-Ch4,8,T2-Ch10 R2-Ch2,R3-Ch3	GATE IES
		Single phase dual converter			
		Three phase dual converter	L35	T1-Ch8,T2-Ch10 R2-Ch2,R3-Ch3	
		Numerical Problems			
UNIT-VI					
19	AC voltage controllers Single phase two SCR's in anti parallel with R and RL loads	AC Voltage Controller-principal of operation	L36	T1-Ch9,T2-Ch11 R2-Ch4,R3-Ch5	IES
		Types of control – Integral cycle control & phase control			
		One phase voltage controller with R load & RL load	L37	T1-Ch9,T2-Ch11 R2-Ch4,R3-Ch5	
20	Modes of operation of TRIAC, TRIAC with resistive and RL loads	TRIAC – circuit symbol & V-I characteristics	L38	T1-Ch9,10 R2-Ch1,Ch4 R6-Ch1	IES
		Operation of TRIAC with R & RL load			
21	Derivation of RMS load voltage, Current and power factor wave forms- Firing circuits- problems	Derivation of RMS Load voltage, current & power factor with R & RL load	L39	T1-Ch9,T2-Ch11 R2-Ch4,R3-Ch5	
		Gating signal requirements			
		problems			
22	Cyclo converters, single phase mid pointcyclo converters, with resistive and inductive load	cyclo converters – step up & step down	L40	T1-Ch7,T2-Ch11 R2-Ch6,R3-Ch5	
		Single phase midpoint cyclo converter with R and RL load-continuous & Discontinuous conduction			

	(principle of operation only)				
23	Bridge configuration of single phase cyclo converter (principle of operation only) wave forms and numerical problems.	Single phase bridge cycloconverter with R & RL Load	L41	T1-Ch7,T2-Ch11 R2-Ch6,R3-Ch5	
		Problems			
UNIT-VII					
24	Choppers, Time ratio control and current limit control strategies	Principal of chopper operation (step down)	L42	T1-Ch6,T2-Ch5 R2-Ch3,R3-Ch6	GATE IES
		Control strategies-Time ratio control & current limit control			
25	Step down choppers, Derivation of load voltage and current with R, RL and RLE loads, Step up chopper, load voltage Expression	Derivation of load voltage and current with R, RL and RLE loads for step down chopper	L43	T1-Ch6,T2-Ch5 R2-Ch3,R3-Ch6	
		Operation of step up chopper	L44	T1-Ch6,T2-Ch5 R2-Ch3,R3-Ch6	
		Derivation of load voltage expression for step up chopper			
UNIT-VIII					
26	Inverters, Single Phase inverter, Basic Series inverters, Basic Parallel capacitor inverter	Inverters –principle of operation & Classification	L48	T1-Ch5,T2-Ch6 R2-Ch5,R3-Ch7	GATE IES
		Analysis of inverter with R, RL & RLC Load			
		Series Inverter	L49	T1-Ch5,T2-Ch8 R2-Ch5,R3-Ch7	
		Parallel capacitor Inverter			
27	Bridge inverter, Wave forms, Simple forced commutation circuits for bridge inverters, McMurray and McMurray Bedford inverters	Single phase Bridge Inverter with R & RL load	L50	T1-Ch5,T2-Ch6 R2-Ch5,R3-Ch7	GATE IES
		Mc Murray Inverter	L51	T1-Ch5,R3-Ch7 R2-Ch5,R6-Ch9	
		Modified Mc Murray Inverter			
28	Voltage techniques for inverters, Pulse width modulation Techniques, Numerical problems	External control of DC output voltage	L52	T1-Ch5,T2-Ch6 R2-Ch5,R3-Ch7	GATE IES
		External control of ac output voltage			
		Internal control of inverter			
		Single pulse modulation	L53	T1-Ch5,T2-Ch6 R2-Ch5,R3-Ch7	
		Multiple Pulse modulation			
		Sinusoidal pulse modulation			
		Problems			
IES					
29	Switched mode power supplies Thyristor control reactors & Switched capacitor networks	Switched mode power supplies	L54	T1-Ch14,T2-Ch14 R2-Ch11	IES
		Thyristor control reactors Switched capacitor networks	L55	T2-Ch13, R2-Ch11	

7.4.11 STUDENT SEMINAR TOPICS

1. Increasing efficiency of frequency inverter, Musamettin Zurnaci, Electrical India, Vol. 49, Jan. 09.

2. IGBTs for three level inverter include efficiency in DC/AC conversion, Marco Dilella and Riccardo Ramin, Electrical India, Vol. 49, Feb. 09.

3. A simple single – sensor MPPT solution by Ashish Pandey, Niveditha Das Gupta, IEEE Transactions on power electronics vol. 22, January 07.

4. Power quality problems compensation with universal power quality conditioning system by D Graovac, A Katic, IEEE Transactions on power electronics vol. 22, April 07.

5. New DC – DC converters for energy storage system interfacing in fuel cell hybrid electric vehicles, M Marchesoni, C Vacca, IEEE Transactions on power electronics vol. 22, January 07.

6. A novel method of selective harmonic eliminations in power electronic equipment, IEEE Transactions on power electronics vol. 22, January 07.

7.4.12 QUESTION BANK

UNIT-I

1. a)Sketch the static and dynamic characteristics of SCR during turn-on process.
   b) Explain briefly about turn on and turn off methods of SCR. (May/June-13)
2. (a) Explain the difference between holding current and latching current of a thyristor.
   (b) Define and explain turn-on and turn-off times of an SCR. (May/June 2012)
3. (a) Describe the different modes of operation of a thyristor with the help of schematic diagram of static VI characteristics and represent the holding and latching current.
   (b) Compare power MOSFET and IGBT. (Nov/dec 2012)

4. Explain briefly about BJT, MOSFET and SCR along with their symbol and characteristics. Mention their applications also. **(Dec 2011)**

5. Discuss in detail about the various mechanisms by which thyristors can be triggered into conduction. **(Dec 2011)**

6. i.Explain the transfer and output characteristics of MOSFET'S. **(Dec 2011)**
   ii.Compare and contrast MOSFET with SCR.

7. i.Sketch the dynamic characteristics of SCR during turn-ON process. Write down the necessary conditions required to turn-ON SCR.
   ii.A thyristor is connected in series with an inductance of 0.1 H and a resistance of 20 ohms and a sinusoidal voltage source of 230 V, 50 Hz. The latching current of SCR is 25 mA. Calculate the minimum width of gate pulse required to ensure reliable triggering if it is gated at an angle of 30^0 in every positive half cycle of supply voltage. **(May 11)**

8. i. Sketch static V-I characteristics of SCR. Explain how SCR could be operated as a switch with the help of the characteristics.
   ii.For an SCR the gate-cathode characteristics are given by a straight line passing through origin with gradient of 16 V/A. The turn-on time is 4 ìsec and gate current required is 500 mA. Given the gate source voltage of 15 V, calculate
   a. Gate power dissipation
   b. The resistance to be connected in series with gate. **(May 11)**

9. i.A BJT is acting as a switch, the forward current gain α is in the range 8 to 40. The load resistance is R_C = 11Ω. The dc supply voltage is V_{CC}=200v and the input voltage to the base circuit is V_B=10v. Find

a. The value of RB that results in saturation with an over drive factor of 5.
b. The β forced
c. The power loss PT in the transistor.

ii. What are the various applications of an IGBT? **(May 11)**

10 Discuss what would happen if gate is made positive with respect to cathode during the reverse blocking of a thyristor? **(May 11)**

11 i.Describe the different modes of operation of a thyristor with the help of schematic diagram, static V-I characteristics.

ii. Explain why holding current is less than latching current. **(Nov, June 10)**

12 Describe the various modes of operation of Power MOSFET with the help of its Circuit diagram and static V-I characteristics and transfer characteristics. Explain how Power MOSFET can be turned-on and turned-off. **(Nov, May 10)**

13 What are the different methods for turning-off an SCR. Explain all methods in detail with the help of waveforms and circuit diagrams. **(Nov 10)**

14 i. Define the **(Nov 10)**
a. Forward break over voltage b. Latching current
c. Finger voltage d. SCR turn-off time.

ii.Compare the SCR with power BJT and mention the salient points. **(June 10)**

15 Explain the dynamic characteristics of SCR for both turn-on and turn-off with the help of waveforms. Bring out salient features. **(June 10)**

16 i.Explain the operation of a Bipolar Junction Transistor (BJT) with the help of its circuit diagram and static V-I characteristics.

ii. Describe turn-on and turn-off operation of BJT. **(June 10)**

17. Explain in detail the following current ratings of SCR **(June 10)**
i. average on-state current
ii. surge current rating
iii. rms on-state current and
iv. I2t rating.

18. i. What are the three regions of operation for power BJTs. Explain in detail.
ii. What are turn-on and turn-off" times of BJTs
iii. What are base drive techniques for increasing switching speeds of BJTs.
iv. What is secondary breakdown of BJT. **(Nov 09, 07)**

19. Explain why holding current is less than latching current. **(Nov 09)**

20. Describe the different modes of operation of a thyristor with the help of its V-I characteristics? **(Nov 09, May 04)**

21. i. Explain the operating features of BJT, power MOSFET and SCR.
ii. Draw the dynamic characteristics of SCR during "turn-off" and explain its salient points. **(Nov 09)**

22. Explain the operation of power MOSFET and power IGBT with the help of their characteristics . **(Nov 09)**

23. i. Explain the operation of SCR using the schematic diagram and explain the importance of junctions.
ii. Sketch the static V-I Characteristics of SCR and discuss the importance of
a. Holding current
b. Latching current
c. Reverse breakdown voltage. **(Nov 09, 03)**

24. i. Describe the dynamic characteristics of SCR
ii. Discuss how SCRs suffer from unequal voltage distribution across them during their turn-on and turn-off process. **(Nov 09, Jun 03)**

25. Explain the turn-on and turn-off methods of SCR, BJT and Power MOSFET with neat waveforms. **(Nov 09, May 02)**

26. Explain the V-I Characteristics of Thyristors with elaborating the following :
    i. Latching current
    ii. holding current
    iii. on-state and off-state condition
    iv. turn-on and turn-off times
    v. finger voltage **(May 09, Feb 08, Nov 07, 06, 05)**

27. The latching current of a thyristor with d.c. voltage source of 100V is 50mA. Calculate the value of minimum width of the gate pulse current when connected to a pure inductive load of 1H. Compute the effect, if a resistance of 10 ohms is connected in series with the load. **(Nov, Feb 08)**

28. i. Explain the transfer and output characteristics of MOSFETs.
    ii. Why does the concept of saturation in BJTs and Power MOSFETs.
    iii. What are the differences between enhancement type MOSFETs and depletion type MOSFETs. **(Feb 08, Nov 06)**

29. The specifications of a Thyristor operating from a peak supply of 400V is as follows:
    Repetitive Peak current Ipk = 200A
    $(di/dt)_{max}$ = 15A/μs , $(dv/dt)_{max}$ = 108V/μs.
    Choosing a factor of safety of 2 for Ipk, $(di/dt)_{max}$ and $(dv/dt)_{max}$, design a suitable snubber circuit, if the minimum loads (RL_{min}) be 10 ohms resistive. **(Feb 08)**

30. A string of Thyristor connected in series to withstand a d.c. voltage of V_S= 15KV. The max. leakage current and recovery charge difference of thyristor are 10mA and 150 μC respectively. A derating factor of 20% is applied for the steady state and transient voltage sharing is 1000V. Determine
    i. Steady state voltage sharing resistance R for each thyristor
    ii. The transient voltage capacitance. **(Feb 08)**

31. Derive the Static equalizing and dynamic equalizing parameters in case of series and parallel connected SCRs. **(Nov 07)**

32. i. What is the importance of Surge current rating of a thyristor, explain in detail.
    ii. A thyristor has half-cycle surge current rating of 1000mA for a 50Hz supply. Calculate its one-cycle surge current rating and I^2t rating. **(Nov 07)**

33. A rectangular pulse of 30V with 10 us duration is applied at the gate. The average gate power dissipation of the thyristor is 0.5W and a peak gate drive power is 5W. Calculate the values of the series resistance to be connected in the gate circuit, the frequency and duty cycle of the triggering pulse. **(Nov 07)**

34. i. Define holding and latching currents.
    ii. Describe various modes of operation of thyristor with the help of V-I characteristics. **(Jun 03)**

35. i. What are the necessary conditions for turning on of an SCR. **(Jun 03)**
    ii. Define turn on and turn off times of SCR.

36. Draw thyristor gate V-I characteristics indicating clearly the gate drive limits. Explain, with the help of these characteristics, the selection of an operating point and the choice of gate circuit parameters. **(Jun 03)**

37. What is IGBT? Give the cross-section and the equivalent circuit for IGBT.Make comparative assessment between BJT, MOSFET and IGBT. **(IES 2000)**

38. Discuss the turn-off process in a GTO with relevant voltage and current waveforms. Enumerate the advantages and disadvantages of a GTO as compared to a conventional thyristor. **(IES 2000)**

39. During the trun-off process of a thyristor, the current flow does not stop at the instant when the current reaches zero but continues to flow to a peak value in the reverse direction. This is due to
    i. Commutation
    ii. hole storage effect
    iii. presenece of reverse voltage across the thyristor
    iv. protective inductance in series with the thyristor **(IES 2000)**

40. Consider the following statements
    i. BJT has lower power losses than MOSFET's
    ii. MOSFET's have lower power losses than IGBT's
    iii. SCRs have lower power losses than MOSFET's
    which of the these statments are correct?
    a. 1,2 and 3 b. 1 and 2 c. 2 and 3 d. 1 and 3 **(IES 2000)**

41. A thyristor . converter of 415V, 100 A is operating at rated load. Details of the thyristor used are as follows
    'ON state power loss = 150W
    Thermal resistance:
    Junction to case = 0.01^0 C/W
    Case to sinke = 0.08^0 C/W
    Sink to atmosphere = 0.09^0 C/W **(IES 2000)**

42. When ambient temperature as 35^0C. The junction temperature for 100% load is
    a. 48.5^0C b. 54.5^0C c. 60^0C d. 62^0C **(IES 2000)**

43. When compared to those of a smmetrical thyristor, the turn-off time and reverse blocking voltage of an asymmetrical thyristor are repectively.
    a. large and large b. large and small c. small and large d. small and small
    (IES2000)

44. Match list I (devices) with the list II (Propeties) and select the correct answer usig the codes given below the list:
    (IES2000)

45. When a thyristor is negatively biased **(IES 97)**
    i. all the three junctions are negatively biased
    ii. outer junctions are positely biased and inner junction is negatively biased
    iii. outer junctions are negatively biased and inner junction is positively biased
    iv. the junction near the anode is negatively biased and the one near the cathode is positively biased

46. Consider the following semiconductor devices. **(IES 97)**
    i. Triac
    ii. Thyristor
    iii . Amplifying gate thyristor
    The correct secquence of these devices in increasing order of their di/dt capabilities is
    a. i, iii, ii b. i, ii, iii c. iii, i, ii d. iii, ii, i

47. What is IGBT? Sketch the cross section and equivalent circuit of an IGBT. Discuss its advantages and disadvantages. **(IES 97)**

UNIT-II

1 a) What are the different firing circuits used for triggering SCR?
b) Compare and contrast SCR, BJT and IGBT. (May/June-13)

2 (a) Explain about class-C and class-D type of commutation methods.
(b) For the class-D commutation circuit, compute the value of the commutation capacitor `C' and commutating inductor `L' for the following data: E_{dc} = 50V, $I_{L(max)}$ = 50A, turn-o of SCR1 = 30 sec, chopping frequency f = 500Hz and the load voltage variation required is 10 to 100%.
(May/June 2012)

3 (a) Explain the two transistor analogy of thyristor.
(b) What are dv/dt and di/dt ratings of SCRs? What happens if there ratings are exceeded? Explain. (Nov/dec 2012)

4 i.Explain the need of commutation in the thyristor circuits. Discuss any one commutation circuit briefly.
ii. Draw RC full wave trigger circuit for SCR when the load is **(Dec 2011)**
a. ac type
b. dc type

5 i. Explain about class-C and class-D type of commutation methods.
ii.For the class-C commutation circuit, dc source voltage E_{dc} is 120V. Current through R_1 and R_2 is 20A. The turn-off time of both the SCRs is 60μsec. Calculate the value of commutating capacitance C for successful commutation. **(Dec 2011)**

6 i. Explain the two transistor analogy of a thyristor.
ii. Explain the working of an oscillator employing an UJT. **(Dec 2011)**

7 i. Discuss how thyristor may be subjected to internal and external over voltages. Describe the methods adopted for suppressing such over voltages in thyristor systems.
ii. Describe the UJT firing circuit used for triggering SCRs. **(Dec 2011)**

8 i. How a thyristor is protected from high values of dv/dt and di/dt. Derive an expression for parameters of the circuit required to protect thyristor from high values of dv/dt .
ii. Design a UJT relaxation oscillator circuit for triggering a thyristor. The UJT has the following parameters:
η=0.72, I_p= 60μA , V_v=2.5 V, I_v=4mA, V=15 V, R_{BB}= 5 k ohms
The leakage current with emitter open is 3mA.The triggering frequency is 1kHz and Vg(min) of thyristor is 0.3 V. Also calculate the minimum and maximum values of triggering frequency.
(May 11)

9 i. Draw the two transistor analogy of SCR and explain why gate loses control once thyristor is fired when anode current is greater than latching value.
ii. Derive an expression for dynamic resistance to be connected across each thyristor in string of n number of series connected SCRs. **(May 11)**

10 i. Compare a BJT, MOSFET, IGBT with respect to the following:
a. Basel Gate control variable
b. Control characteristic
c. Switching frequency
d. On-stage voltage drop
e. Max voltage rating
f. Max current rating.
ii. Write down the advantages and limitations of BJT and MOSFET. **(May 11)**

11 What are dv/dt and di/dt ratings of SCRs? What happens if there ratings are exceeded? Explain.
(Nov 10)

12 Explain the operation of series connected SCRs with the help of neat circuit diagram and derive the static and dynamic equalizing parameters. **(Nov 10, 09, June 10)**

13 An SCR is to be gated by using a relaxation oscillator which has a UJT with the characteristics, η = 0.7, Ip = 0.7 mA, Vp = 16.5 V, normal leakage current with emitter open = 37 mA, Vv = 1.0v, Iv = 6mA and Rb1b2 = 5.5Ω. The firing frequency as 1000 Hz. If C=0.1 μf. Calculate the values of R, R1

and R2.

(Nov 10)

14 The SCRs are used in a string to withstand a d.c. voltage of 12KV. The maximum leakage current and recovery charge difference of SCRs is 10 mA and 50 μC respectively. The values of R for steady state equalizing circuit is 40 KΩ and value of C of dynamic equalizing circuit is o.2 μf. Find the steady state and transient voltage derating factor. **(Nov 09, 10)**

15 i. Explain the following thermal ratings of SCRs **(June 10)**
a. junction temperature
b. transient thermal resistance
ii. What are dv/dt and di/dt ratings of SCRs. What happens if these ratings are exceeded, explain.

16 Discuss the working of Uni-junction Transistor (UJT) relaxation oscillator with he help of static characteristics and circuit diagram and derive the expressions involved. **(June 10)**

17 Explain the two-transistor analogy with neat circuit diagram and derive the expression for the anode current. **(Nov 09)**

18 Explain the two transistor analogy of SCR. Derive an expression for a node current. **(Nov 09)**

19 Explain in detail about the parallel operation of SCRs? Define and derive its string efficiency. **(Nov09)**

20 Explain in detail various voltage ratings and current ratings of a thyristor. **(Nov 09, 08, May 09)**

21 Explain the SCR firing circuits in detail with the help of circuits and waveforms
i. Resistance firing circuits
ii. RC firing circuit. **(Nov 09, 07, Feb 08)**

22 Explain the operation of class -C commutation circuit and also give its application with neat circuit.

(Nov 09, Feb 07)

23 The voltage and current ratings of a particular circuit are 3.3KV and 750 amps. SCRs with rating of 800V and 175 amps are available. The recommended minimum derating factor is 15%. Calculate min. series and parallel units required. Also calculate the values of resistance and capacitance to be used in the static and dynamic equalizing circuits if the max. forward blocking current for the SCRs is 25mA and DQ_{max} is 50μC. Where DQ_{max} is max. charge stored in thyristor.

(Nov 09, 06, Mar 06)

24 Discuss the operation of class - A and class-B commutation circuits. Also mention their application with the help of neat circuit diagram. **(Nov 09, Mar 06)**

25 Describe class B self commutation by an LC circuit employed for a thyristor circuits. **(Nov 09, 04, 03)**

26 Ten thyristors are used in a string to withstand a d.c. voltage of 12KV. The maximum leakage current and recovery charge difference of SCRs is 10mA and 50μC respectively. The values of R for steady state equalizing circuit is 40k ohms and value of capacitance C of dynamic equalizing circuit is 0.2μF. Find the steady state and transient derating factor. **(May 09, Feb 08, 07, Nov 05)**

27 i. Draw the equivalent circuit of a UJT and explain its working.
ii. Describe the VI characteristics of a UJT. Clearly explain its negative resistance nature. **(May 09, Mar 06)**

28 i. What is the importance of Surge current rating of a thyristor, explain in detail.
ii. A thyristor has half-cycle surge current rating of 1000mA for a 50Hz supply. Calculate its one-cycle surge current rating and I^2t rating. **(Nov 08, 05)**

29 A 200A thyristor operates in parallel with a 300A thyristor. Their ON state voltage drops are respectively 1.5V and 1.0V. Calculate the value of the resistance to be inserted in series with each thyristor so that they share a load of 500A in proportion to their respective current ratings. **(Nov 08)**

30 Explain the auxiliary impulse commutation techniques used in the bridge type single phase inverter with neat circuit diagram. **(Feb 08)**

31 Explain the forced commutation techniques used for single phase bridge inverter with neat circuits and waveforms. **(Nov 07)**

32 A rectangular pulse of 30V with 10 us duration is applied at the gate. The average gate power dissipation of the thyristor is 0.5W and a peak gate drive power is 5W. Calculate the values of the series resistance to be connected in the gate circuit, the frequency and duty cycle of the triggering pulse. **(Feb 07, Mar 06)**

33 i. Explain the necessity of series and parallel connection of SCRs.
ii. What is String eciency in series and parallel connections.
iii. What are the problems arising in series and parallel connections. **(Nov 06, 05)**

34 i. The SCR is rated to give an average power dissipation of 0.5W. Its gate voltage varies from 2.5V to 10V. Keeping average gate power dissipation constant, plot allowable gate characteristics of SCR. For a triggering gate pulses of duty cycle 0.6. Calculate the value of average gate dissipation.
ii. Explain the gate characteristics of a Thyristor. **(Mar 06)**

35 The latching current of a thyristor with d.c. voltage source of 100V is 50mA. Calculate the value of minimum width of the gate pulse current when connected to a pure inductive load of 1H. Compute the effect, if a resistance of 10 ohms is connected in series with the load. **(Nov 05)**

36 Explain Thyristor gate characteristics with neat diagrams. **(Nov 04, May 04)**

37 i. What is derating factor with reference to SCR's.
ii.Twenty thyristors each of 500 V, 500 A are used in five columns and four rows in a circuit of 200 V and 1800 A. Calculate voltage and current derating factors. **(Nov, May 04)**

38 i. Describe the various anode voltage rating as applicable to an SCR. Indicate these voltage ratings on a relevant voltage waveform.
ii. Discuss how SCRs suffer from unequal voltage distribution across them during their turn on- and then-off process. **(Nov 04)**

39 i. Discuss the DC and UJT triggering circuits for SCR turn on.
ii. Discuss the significance of and in SCR's. **(Nov 04)**

40 Explain the Ramp firing circuit and Ramp and Pedestal firing circuits for SCR, with the help of circuit and waveforms. **(Nov 04)**

41 ii. A two thyristor class C turn off circuit is required to be designed for use as a blinker to turn on and off a lamp of constant resistance of 10 W from a DC supply of 100V. If the SCR used are converter grade with turnoff time 50µsec, find the value of commutation capacitor so that the commutation failure may not occur. **(Nov 04, 03, Jun 03)**

42 i. Discuss with relevant waveforms of class A self commutation by resonating the load, employed for thyristor circuits.
ii. For the class C commutation circuit, the DC source voltage E_{dc}=120V and current through R_1 and R_2 is 20A.The turnoff time of both the SCR is 60 µSec. Calculate the value of commutating capacitance for successful commutation. **(Nov 04, 03)**

43 i. Distinguish clearly between voltage commutation and current commutation in thyristor circuits.
ii. Discuss how the voltage across the commutating capacitance is preserved in a commutating circuit.
iii. A circuit employing resonance pulse commutation has C=20µF and L=3µ H the initial capacitor voltage = source voltage, Vs=230V DC. Determine conduction time for auxiliary thyristor and circuit turnoff time for main thyristor in case constant load current is 300A **(Nov 04, 03)**

44 i. With neat circuit Diagram and waveforms explain the operation of a class D auxiliary commutation employed for thyristor circuits.
ii. Circuit employing class B commutation has C=20µF and L=5µH.Initial voltage across capacitor is 230V. For a constant load current of 250A . Calculate:
a. Conduction time for auxiliary SCR
b. Voltage across the main SCR when it gets commutated. **(May 04)**

45 Explain the need of commutation in thyristor Circuits. What are the different methods of commutation scheme? Explain Class A commutation with neat diagram. **(May 04)**

46 A two thyristor class C turn off circuit is required to be designed for use as a blinker to turn on and off a lamp of constant resistance of 10 & 20 from a DC supply of 100V. If the SCR used are converter grade with turnoff time 50µsec, find the value of commutation capacitor so that the commutation failure may not occur. **(May 04)**

47 For the class C commutation circuit, the DC source voltage E_{dc}=120V and current through R_1 and R_2 is 20A.The turnoff time of both the SCR is 60 µSec. Calculate the value of commutating capacitance for successful commutation **(May 04)**

48 Draw the power circuit diagram of a current commutated chopper. Explain the working of a chopper by dividing its commutation process interval into well-defined modes. **(May 04)**

49 A thyristor string is made up of a number of SCR's connected in series and parallel. The string has voltage and current ratings of 11 KV and 4 KA respectively. The voltage and current ratings of available SCR's are 1800V and 1000A. For a string efficiency of 90%, calculate the number of series and parallel connected SCR's. **(May 04)**

50 A thyristor string with 5 SCR's in series is supplied with 4KV. The maximum permissible blocking voltage of each SCR is 1000V. Calculate the value of static equalizing resistance of each SCR, if maximum leakage current is 10mA. **(May 04)**

51 Calculate the number of SCR's each with rating of 500V, 75A required in each branch of a series and parallel combination for a circuit with the total voltage and current rating of 7.5KV and 1000A. Assume derating factor of 14%. **(May 04)**

52 SCR's with a rating of 1000V and 200A are available to be used in a string to handle 6KV and 1KA. Find number of series and parallel SCR's required. If derating factor (i.) 0.1 (ii). 0.2. **(May 04)**

53 What is complementary impulse commutation? Describe this type of commutation with a circuit diagram and appropriate waveforms. Derive expressions for current through and voltage across commutating capacitor. Find also the circuit turnoff times for the complementary Thyristors **(Nov, Jun 03)**

54 i. Describe the operation of class E commutation circuit with appropriate waveforms.
ii.For a class D commutation circuit Vs=230V, L=20µH and C=40µF .For a constant load current of 120 A calculate the circuit turnoff times for main and auxiliary thyristors. **(Jun 03)**

55 Explain the series operation of SCR's and derive resistance used for static voltage equalization for a series connected string. **(Jun 03)**

56 Describe the operation of voltage-commuted chopper with relevant circuit and voltage waveforms. **(May 03)**

57 i.Explain the need of commutation in thyristor circuits. What are the different commutation schemes? Explain class-A commutation with neat diagrams.
ii.A circuit employing parallel resonance turn off (Class B commutation) circuit has C=50mF L=20mH V=200V and initial voltage across the capacitor is 200V. Determine the circuit turnoff time for main thyristor for load R=1.5W. **(May 02)**

58 A circuit employing resonance pulse commutation has C=20mF and L=3m H the initial capacitor voltage is equal to source voltage, V_s=230V DC. Determine conduction time for auxiliary thyristor and circuit turnoff time for main thyristor in case constant load current is 300A. **(May 02)**

59 Explain the necessity of snubber circuit for SCR and give its operation. Derive the expression for snubber circuit parameters connected for SCR **(May 02)**

60 What is an Unijunction transistor? Draw a basic UJT pulse trigger circuit with typical waveforms and explain its operation. **(IES 03)**

61 Consider the thyristor circuit of figure below. The thyristor is given a triggering pulse after every 10 ms. Calculate the duration for which the thyrisor remains ON after each triggering pulse. Assume ideal devices and explain briefly the basis. **(GATE 95)**

UNIT-III

1 a)Explain the operation of a single-phase, half-wave converter for R-load with neat circuit diagram and necessary waveforms.
b) A resistive load of 10 ohms is connected through a half-wave SCR circuit to 220V, 50Hz, 1-phase source. Calculate the power delivered to load for a firing angle of 60^0. (May/June-13)

2 (a) Explain the operation of a single phase half wave converter for R-load with neat circuit diagram and necessary waveforms.
(b) An RL-load energized from 230V, 50Hz, 1- source through a single thyristor, has R = 10 and L=0.08 H. If thyristor is triggered in every positive half cycle at = 75^0, and the current expression as the function of time. (May/June 2012)

3 (a) Explain the operation of a single phase, half wave converter for α=60 with RL load with free wheeling diode. Derive the average output voltage and current expressions.
(b) Explain the purpose of free wheeling diode. (Nov/dec 2012)

4 i. Explain the half bridge configuration of single phase inverters.
ii. Draw output voltage, current waveforms for half bridge inverter with R and RL loads. **(Dec 2011)**

5 A DC battery is charged through a resistor R by single-phase, one-pulse thyrisotr controlled rectifier.
i. Derive the expression for the average value of charging current in terms of Vm, E, R and α. Here α > θ1, where θ1 can be obtained from Vm sin θ_1 = E.
ii. For an ac source voltage of 230V, 50Hz, find the value of charging current for R = 10Ω, E = 110V and for firing angle delay = 30^0. **(Dec 2011)**

6 Explain the operation of a single phase half wave converter for R-load with neat circuit diagram and necessary waveforms. Also derive the output average voltage and current for α = 30^0.**(Dec 2011)**

7 A voltage v = $V_m$sinwt feeds resistance through a thyristor. The thyristor conducts during positive half cycle. The firing angle, α may vary from 0 to π.
i. Derive an expression for an average output voltage
ii. If V_m = 200V and α =30^0, find V_{dc}
iii. Draw output voltage and current waveforms. **(Dec 2011)**

8 i. Explain the operation of single phase, half wave converter for R-load with circuit diagram and waveforms.
ii. A single phase ac supply 150 sin!t is used to charge a 75V battery through a thyristor and a 10 ohm resistance. The thyristor is continuously fired by a dc gate signal. Find the average current in the circuit. **(Dec 2011)**

9. i. What is meant by the term 'phase control'? Draw the circuit of a single phase half controlled bridge rectifier with common anode configuration. Explain the sequence of firing of thyristor to obtain output voltage across R-L load without free wheeling diode. Derive an expression for its output voltage.
ii. A single phase half controlled bridge rectifier is connected to a source of 115 V, 50 Hz and a load of 20 ohms. Determine the average load current at firing angle of a) 30 deg b) 60 deg. **(May 11)**

10. i. Derive an expression for average and rms values of output voltage in a single phase half wave controlled rectifier with R-L load.
ii. An SCR is connected between a source of 330 Sinùt and a load of 10 ohms and a battery with emf of 165 V. When it fired with a continuous dc signal, calculate
a. Average current
b. power supplied to battery
c. power dissipated in resistor. **(May 11)**

11 A 230v, 50Hz one pulse SCR controlled converter is triggered at a firing angle of 400 and the load current extinguishes at an angle of 2100. Find the circuit turn off time, average output voltage and the average load current for
i. R = 5Ω, L = 2mH
ii. R = 5Ω, L = 2mH, E = 110v. **(May 11)**

12 Power flow from 1 phase source to load R can be controlled through the use of a thyristor. Discuss why this method of power flow control is called phase controlled converter? **(May 11)**

13. Explain only the operation of a single phase fully controlled bridge converter for firing angle α for a R load (do not derive any expressions).
Derive the following expressions:
The converter is connected to a 120v, 50Hz supply. The load current Ia is continuous and its ripple content is negligible. The turns ratio of the transformer is unity. Express the input current in a Fourier series and determine the HF of the input current. **(May 11)**

14. A single phase half controlled bridge converter is operated from a 230 V, 50Hz supply and load is resistance of R = 10Ω. If the average output voltage is 35% of the maximum possible average output voltage. Calculate **(Nov 10, 09)**
a. delay angle
b. rms and average output currents and
c. average and rms thyristor currents.

15. Explain the operation of single phase half wave converter using single thyristor for RL load and free wheeling diode, with the help of neat circuit diagram and waveform. Explain the main features of free wheeling diode and its advantages. **(Nov 10)**

16. A single phase half wave converter with free wheeling diode is used to supply a heavily inductive load upto 5 A from 240 V a.c. supply. Determine the mean load voltage for firing angles of 0^0,30^0,60^0,120^0,150^0, and 180^0, neglecting the Thyristor voltage drops. Specify the required rating of the thyristor and diode and sketch the curve between output voltage and firing angle.
(June 10, Nov 09)

17. Discuss the working of single phase half wave converter using single thyristor for RL loads with the help of neat circuit diagram and necessary waveforms. Derive the expression for average load voltage, average load current and rms load voltage. **(June 10)**

18. A single phase half wave converter is operated from a 230 v, 50 Hz supply. If the load is resistance of value 10Ω and delay angle is $\alpha = \pi/3$. Determine **(June 10)**
i. efficiency
ii. form factor
iii. ripple factor and
iv. peak inverse voltage of SCR.

19. Explain the operation of single phase half-controlled bridge converter with RL loads with and without free wheeling diode. Also sketch circuit and waveforms for $\alpha = 60^0$. **(Nov 09, Feb 08)**

20. Explain the operation of a singe phase half wave converter for R-load with neat circuit diagram and necessary waveforms. Also derive the output average voltage and current for $\alpha = 30^0$.
(Nov 09, 08, 07, 05, June 09, Feb 08, 07)

21. i. Discuss about phase control techniques in converters. Explain the operation of a single phase, mid point, half wave converter with R-Load.
ii. A single phase, half controlled bridge converter feeds a load of R = 10 Ω and L = 10mH. The supply voltage is 230V at 50Hz. Compute the average output voltage and average load current for a firing angle of 45^0.
(Nov 09)

22. Explain the operation of single phase, half wave, and midpoint converter with RL load. **(Nov 09)**

23. A single phase, half wave, bridge converter is used to supply a RL load, where R=10 ohms and L=15mH. The supply voltage is 230V at 50HZ. Derive an expression for average output voltage. And also calculate the average load voltage, average load current and input power factor for a firing angle of 30^0. **(Nov 09)**

24. A two half controlled bridge converter feeds a load consisting of a resistance = 5 Ω and a large inductance which makes the current ripple free. There is a back emf of 80 V. The converter is supplied form a 220 V, 50Hz supply. For a = 60^0, 150^0, Determine
i. The average value of load voltage
ii. The average value of load current
iii. The power delivered to load
iv. The reactive power. **(May 09)**

25. i. Compare mid-point converters and bring out important features.
    ii. Compare discontinuous and continuous current modes of operation of converters and bring out salient features. **(Nov 08)**

26. Explain the working of single phase half-controlled bridge converter with RL loads for discontinuous and continuous current mode of operations with circuit and waveforms for $\alpha = 45^0$. **(Feb 08)**

27. Explain the operation of single phase half controlled bridge converter with R-load and derive the load voltage and load current with circuit diagram and necessary waveforms for $\alpha = 30^0$. **(Mar 06)**

28. i. What are the features of Half -controlled converters over full controlled converters.
    ii. Bring out the features of Free-wheeling diode used in converters. **(Mar 06, Nov 05)**

29. i. Draw the circuit diagram of a single phase half controlled converter and derive the equation for average current in case of RL load and discontinuous conduction.
    ii. Explain the effects of source inductance and freewheeling diode on the performance of converters. **(Nov 04)**

30. i. Draw the circuit diagram of a three phase Half controlled converter and obtain an expression for the average load voltage across a resistive load.
    ii. A three phase full converter is operated from a three phase 400V, 50Hz supply. The load resistance is 10 ohms. Calculate the firing angle for an average output voltage of 60% of the maximum possible mean output voltage. Calculate also the RMS value of load current. **(Nov 04)**

31. i. Derive the expressions for output voltage of single phase Half controlled converter in its various modes of operation when feeding to R-L load.
    ii. In a single phase mid point converter, turns ratio is 1.25. The source voltage is 130V,50Hz. For a resistive load of R=2 ohms, determine
    a. Maximum possible values of positive and negative voltages across SCRs
    b. Maximum output voltage and current and the corresponding firing and conduction angles.
    c. The value of firing angle for load voltage of 100V. **(Nov 03)**

32. The single phase half controlled AC to DC bridge converter of Figure below supplies a 10 Ohm resistor in series with a 100 V back emf load. The firing angle of the thyristors is set to 60°.
    i. Find the average current through the resistor.
    ii. What will be the new average current through the resistor, if a very large inductor is connected in series with the load? **(GATE 95)**

33. Why input power factor of a single phase half controlled bridge rectifier is higher than that for a fully controlled bride rectifier supplying an RL load for the same firing angle? **(IES 02)**

34. A single-phase semi converter feeds RLE load such that load current is constant for a firing angle of 230 degree. Sketch waveforms for source voltage, load voltage, load current, source current, one SCR current and freewheeling diode current for firing angle of 30 degree. Prove that the input PF for the above semi converter for firing angle 90 degree is 0.63 **(IES 01)**

35. A single-phase, half-wave rectifier with an ac voltage of 150 V has a pure resistive load of 9 ohms. The firing angle a of the thyristor is $\pi/2$. Determine the i. rectification efficiency, ii. form factor, iii. transformer derating factor, iv. peak inverse voltage of the SCR, and v. ripple factor of the output voltage. Assume that the transformer ratio is 2:1. **(R2-Ch2)**

36. The half-controlled rectifier has on input supply voltage of 115 V (RMS) at 50 Hz. Also R = 6 ohms and L = 0.3 H. If the firing angle of the thyristors is kept at 65^0
    i. draw the load voltage and load current waveforms,
    ii. complete the RMS and dc magnitude of the load voltage, and
    iii. determine the magnitude of the dc load current**.** **(R2-Ch2)**

37. The half controlled rectifier has a input supply voltage of 115 volts (RMS) at 50hz. Also R= 6ohms and L=0.3 H. if the firing angle of the thyristors is kept at 65 degrees. a) Draw the load voltage and load current wave forms, b) compute the RMS and dc magnitude of the load voltage and c) determine the magnitude of the dc load current**.(R2-Ch2)**

38. A single phase, half wave rectifier is operated with extinction angle control with =60 degrees. the ac supply voltage is 200 volts (RMS) and a load resistance is 25 ohms. Determine the
    i. distortion factor
    ii. input power factor
    iii. average load voltage, and
    iv. average load current **(R2-Ch2)**

39. Explain the operation of single phase half controlled rectifier with inductive load with the associated waveforms **(R2-Ch2)**

40. Construct the single phase, half wave rectifier and sketch the load voltage wave forms for an R L LOAD at a firing angle $=30^0$. **(R2-Ch2)**

41. A single phase, half wave rectifier with an ac voltage of 150 v has a pure resistive load of 9ohms. The firing angle of the thyristor is pi/2. Determine the
    i. rectification efficiency
    ii. form factor
    iii. transformer derating factor
    iv. peak inverse voltage of the scr and
    v. ripple factor of the output voltage. Assume that the transformer is 2:1. **(R2-Ch2)**

42. A single phase half wave rectifier is used to supply a power to a load of impedance 10 ohms from 230 volts 50 Hz ac supply at the firing angle of 30 degrees. Calculate i. Average load voltage ii. effective value iii. Load current. **(R2-Ch2)**

43. A single phase bridge converter with a free wheeling diode feeds an R-L load. The load resistance is 7.5 ohms and inductance is very large providing ripple free load current. The converter is supplied by 120 V, single phase supply at a frequency of 50 Hz. Determine the average value of load current, device currents, power factor at a firing angle of 60^0. **(R3-Ch3)**

44. A three pulse converter is fed from a 220 V, 3-phase, 50 Hz supply. If feeds an RL load with a diode across it. The load resistance is 10 ohms and inductance provides perfect smoothing. It is required to obtain 50% of the maximum possible dc voltage at the load terminals. Determine i. the firing angle ii. rms and average values of load current iii. values of device currents iv. power factors. **(R3-Ch3)**

45. A single phase half controlled bridge converter has a ripple free load current. Draw the waveforms of voltages and currents. Using the Fourier analysis of the input current waveform, determine the expressions for displacement factor, distortion factor, harmonic factor. **(R3-Ch3)**

46. The two pulse half controlled bridge converter is connected to a 200V, 50 Hz supply. The converter supplies R-L load with perfect smoothing. The source is ideal. Draw the waveforms of device currents, oad current, line current. **(R3-Ch3)**

47. A two pulse midpoint converter feeding an R-L load has a freewheeling diode connected across the load. The load has a sufficiently large inductance to cause perfect smoothing. The value of resistance is R_d=7.5 ohms. The converter transformer has secondary voltage of 120V. The firing angle is a = 60^0. Determine the following.
    i. Average value of load voltage
    ii. Average value of load current
    iii. Displacement factor
    iv. Distortion factor
    v. The thyristor currents and voltages
    vi. The diode current. **(R3-Ch3)**

48. A two pulse half controlled converter feeds an R-L-E load with R = 10 ohms, L = 10 H and E = 50 V. The supply is 250 V, 50 Hz.
    i. Determine the voltage and current waveforms.
    ii. What is the Fourier series of output voltage?
    iii. What is the lowest order harmonic in the current and its rms value ? **(R3-Ch3)**

49. Draw the diagrams of two types of half controlled converters possible with two pulse bridge converters. **(R3-Ch3)**

50. What are the advantages of half controlled converters over the converters with free wheeling diode.

(R3-Ch3)

51. Discuss how the power factor improvement is possible in half controlled converters. **(R3-Ch3)**

52. Explain why inversion is not possible in half controlled converters. **(R3-Ch3)**

UNIT-IV

1 a) Explain the operation of single phase full wave controlled rectifier feeding an inductive load. Consider the effect of source inductance and derive an expression for output voltage in terms of source inductance and firing angle.
b) What are the advantages and disadvantages of a single-phase bridge converter over single-phase midpoint converter? (May/June-13)

2 A 20 V, 50 Hz, single phase ac supply feeds a highly inductive load through a fully controlled rectifier. A free wheeling diode is connected across load. The forward voltage drops across SCR and diode are 1.5 V and 0.7V respectively. Firing angle is 60^0. Find:
(a) Average load voltage neglecting voltage drops across SCR and diode.
(b) Average load voltage taking voltage drops across SCR and diode into account.
Sketch the output voltage waveform for both the cases. (May/June 2012)

3 (a) From the fundamentals derive the performance parameters of single phase full converters.
(b) A single phase full converter bridge is connected to RLE load. The source voltage is 230V, 50Hz. The average load current of 10A is connected over the working range. For R=0.4 Ω and L=2mH, calculate
(i) Firing angle delay for E=120V (ii) Firing angle delay for E= -120V. (Nov/dec 2012)

4. i. Describe the working of a single phase full converter in the inverter mode with RLE load. Illustrate your answer with necessary waveforms.
ii. A single-phase full converter feeds power to RLE load with R = 6Ω and L = 6mH and E = 60V. The ac source voltage is 230V, 50Hz. For continuous conduction, finnd the average value of load current for a firing angle delay of 500. **(Dec 2011)**

5. i. Give the comparison between transistors and thyristors.
ii. Explain about the static characteristics of an SCR. **(Dec 2011)**

6. i. What are the advantages and disadvantages of a single-phase bridge converter over single-phase midpoint converter?
ii. Describe the operation of single-phase, two-pulse, midpoint converter with relevant voltage and current waveforms. Discuss how each SCR is subjected to a reverse voltage equal to double the supply voltage in case turns ratio is unity. **(Dec 2011)**

7. i. Explain the operation of single-phase full wave, midpoint converter to RL load, with help of circuit diagram and waveforms.
ii. Discuss the effect of source inductance on the performance of a single-phase full converter indicating clearly the conduction of various thyristors during one cycle. **(Dec 2011)**

8. A single phase, full converter supplies an inductive load. Supply voltage is 230V, 50Hz and the firing angle is 600. Assume that the output current is continuous, ripple free and equal to 10 Amp. Determine
i. Average output voltage
ii. Supply rms current
iii. Input power factor
iv. Average thyristor current. **(Dec 2011)**

9. i. Explain the operation of single phase full wave controlled rectifier feeding an inductive load. Consider the effect of source inductance and derive an expression for output voltage in terms of source inductance and firing angle.
ii. A single phase fully controlled rectifier is operated from 120 V, 50 Hz supply. It has a load of having R= 0.5 ohm and inductance of 6.5 mH and E=10 V. The firing angle is 60^0. Calculate the average load current, average and rms values of thyristor current. **(May 11)**

10. i. Explain the operation of full wave controlled rectifier with input supply derived from a single phase transformer with centre tapped secondary.
    ii. Carry out harmonic analysis of input current in a fully controlled rectifier feeding an R-L load without free wheeling diode. **(May 11)**

11. Determine the expression for the following performance factors of single-phase fully controlled bridge converter **(May 11, Nov 10, 09, 06, Mar 06)**
    i. Input displacement factor
    ii. Input power factor
    iii. DC voltage ratio
    iv. Input current distortion factor
    v. Input harmonic factor
    vi. Voltage ripple factor
    vii. Active power input
    viii. Reactive power input.

12. A single phase fully controlled bridge converter is supplied with 230 V, 50 Hz source. The load consists of = 20Ω and a large inductance so as to reach the load current constant. For a delay angle of 60^0, determine **(Nov 10)**
    i. average output voltage
    ii. average output current
    iii. average values of SCR current and
    iv. input power factor.

13. Derive expressions for following for a single phase full wave mid-point converter for RL load
    i. average load voltage
    ii. average load current and
    iii. rms load voltage. **(Nov 10, 09, June 10)**

14. Describe the operation of a single phase two-pulse mid-point converter for RL loads with relevant voltage and current waveforms. Discuss how each SCR is subjected to a reverse voltage equal to double the supply voltage, in case of turns ratio from primary to each secondary is unity. **(Nov, June 10)**

15. Explain the operation of a single phase half wave converter using single Thyristor for resistive load with the help of neat circuit diagram and waveforms. Derive expression for average load voltage, load current and rms load voltage. **(June 10)**

16. A single phase fully controlled bridge converter is connected to RLE load. The source voltage is 230V, 50 Hz. The average load current of 10 A continues over the working range. For R=0.4Ω and L=2 mH, compute
    i. firing angle for E=120 V and
    ii. firing angle for E=-120 V. **(June 10, Nov 09)**

17. A single phase full wave converter supplies RL load. The input rms voltage is Vs=120 v, 60 Hz. The load is such that L=6.5 mH and R=2.5Ω. The delay angle of SCRs are equal $\alpha 1 = \alpha 2 = \pi/2$. Determine
    i. conduction angle of Thy1,
    ii. rms output voltage,
    iii. rms thyristor current,
    iv. rms output current and
    v. input power factor. **(June 10)**

18. Describe the working of a single phase fully controlled bridge converter in the following two modes
    i. Rectifying mode
    ii. Inversion mode. Also sketch the following waveforms for $\alpha = 45°$ and $\alpha = 120°$.
        a. Load voltage waveform
        b. load current waveform
        c. Thyristor current and voltage waveforms
        d. Supply voltage and current waveforms. **(Nov 09)**

19. A single phase fully controlled converter is feeding power to RL load when connected to 230V, 50Hz supply. Calculate average load voltage, load current and power dissipation, if R=10ohms and L=30mH with a firing angle of 60^0. **(Nov 09)**

20. Discuss the effect of source-inductance on the performance of a single phase fully controlled converter, indicating clearly the conduction of various thyristors during one cycle. Derive an expression for its output voltage in terms of Vm, α and μ **(Nov 09, Feb 08)**

21. A single phase fully controlled bridge is used for obtaining a regulated converter dc output voltage. The rms value of ac input voltage is 230V and firing angle is maintained at 60^0, so that the load current is 4A.
    i. Calculate the d.c. output voltage and active and reactive power input.
    ii. Assuming load resistance remains same and if free-wheeling diode is used at the output, calculate dc output voltage. The firing angle is maintained at 60^0. **(Nov 09, 07)**

22. Explain the operation of single phase fully-controlled bridge converter with RL loads for discontinuous and continuous current modes. Draw circuit and necessary waveforms for $\alpha = 60^0$. **(Nov 09, 05)**

23. A single phase full wave controller supplies an R load of R = 5 ohms. The input rms value of voltage is 220V at 50Hz. The delay angle of thyristors are equal as $\alpha_1 = \alpha_2 = 90^0$. Calculate
    i. the conduction angle of thyristor 1
    ii. the rms value of output voltage and current
    iii. the rms and average value of thyristor currents
    iv. input power factor **(May 09, Feb 08)**

24. A single phase fully controlled converter is connected to a load comprised of 2 ohms resistance and 0.3H inductance. The supply voltage is 230V at 50Hz. Estimate the average load voltage, average load current and input power factor for a firing angle of 20^0. Assume continuous and ripple free load current, draw load voltage waveform.**(Nov 08)**

25. Explain the operation of a single phase full wave mid-point converter with R-load with the help of circuit and output waveforms with respect to supply voltages.Derive the output voltage for $\alpha = 45^0$.
    (Feb 08, 07, Nov 07)

26. A single phase fully controlled bridge converter is operated from a single phase 220V, 50Hz supply. The load current is continuous and has negligible ripple. The average load current is I_{dc}= 50A and commutating inductance per phase is L_C = 0.5mH. Determine the overlap angle if (i) $\alpha = 30^0$ (ii) $\alpha = 60^0$ **(Nov 05)**

27. i. Derive the expression for the input power factor of single phase fully controlled bridge rectifier.
    ii. Explain the effect of freewheeling diode in detail. Also, justify the statement "Freewheeling diode improves the power factor the system". **(Nov, May 04)**

28. i. Describe the operation of a single phase two pulse mid point converter with relevant waveforms. Derive an expression for average output voltage.
    ii. A single phase fully controlled bridge converter is supplied at 230V, 50Hz, with source inductance of 2mH. Neglecting resistance voltage drop, when the converter is operating at a firing angle of 45^0 and the load current is constant at 10A. Determine also the load voltage. **(Nov 04)**

29. i. Show that the effect of source inductance on the performance of single phase fully controlled converter is to present an equivalent resistance of Ls ohms in series with the internal rectifier voltage
    ii. A single phase fully controlled converter is supplied at 220V,50Hz. Determine the average load voltage for the following cases when the firing angle is 45^0 for purely resistive load. **(Nov 04)**

30. ii. A single phase fully controlled double bridge converter is operated from a 120V, 60 Hz supply and the load resistance is 10 ohms. The circulating inductance is 40mH. Firing delay angle for converter I and II are 60^0 and 120^0 respectively. Calculate the peak circulating current and the current through converters.**(Nov 04)**

31. A 1-ϕ fully controlled bridge converter is supplied at 230 V, 50 Hz with source inductance of 2 mH. Neglecting resistance drop, when the converter is operating at a firing angle of 45^0 and the load current is constant at 10A. Determine the load voltage. **(May 04)**

32. i. Describe the working of single phase fully controlled bridge converter in the following two modes:
    a. rectifying mode
    b. inversion mode
    ii. Sketch the following waveforms of single phase fully controlled converter for firing angles 45^0 and 120^0.
    a. Load voltage and current waveforms
    b. Thyristor voltage and current waveforms

c. Supply voltage and current waveforms **(Nov 03)**

33. In a 1-ϕ midpoint converter, turns ratio is 1.25. The source voltage is 130 V, 50 Hz for a resistive load of R=2 ohms, Determine.
    i. Maximum possible values of positive and negative voltage across SCRs.
    ii. Maximum output voltage and current and the corresponding firing and conduction angles.
    iii. The value of firing angle at load voltage of 100V. **(May 03)**

34. The phase controlled mid point converter is operating at firing angle of 45 degree and the load current at steady state is constant at I_d. Neglecting source impedance.
    i. Draw the output voltage
    ii. Device currents
    iii. Voltage across the thyristor. **(GATE 94)**

35. Name the methods of improving the input PF of a single phase AC to DC bridge converter. Explain how cascade connection of converters improves the PF **(IES 02)**

36. In asingle phase semi-converter with resistive load and for a firing angle a, each SCR conduction and free wheeling action takes place respectively, for **(IES 98)**
    i. , 0^0 ii. pi - , iii. pi + , iv. pi - , 0^0

37. Consider the following statements:
    The overlap angle of a phase controlled converter would increase on increasing
    i. supply voltage ii. supply frequency
    iii. load current iv. source inductance
    Of these statements
    i. i, ii,& iii are correct. ii. ii, iii & iv are correct.
    iii. i, ii, & iv are correct. iv. i, iii,& iv are correct. **(IES 98)**

38. The ac-to-dc voltage ratio of a converter in the state of discontinuous conduction is
    i. depend upon the firing angle but independent of load time constant
    ii. depend upon the load time constant but independent of firing angle
    iii. depend upon both firing angle and load time constant
    iv. independent of both load time constant and firing angle **(IES 97)**

39. A pulse phase controlled midpoint converter feeds an R-L load. The load inductance is infinitely large to cause perfect smoothing. The load resistance is 10 ohms. The secondary voltage of the converter transformer is 230-V. Assuming the transformer and thyristors to be ideal, determine the average values of load voltage and load current for firing angles of $\alpha = 30^0, 60^0$,. Determine the ratings of thyristor. **(R3-Ch3)**

40. A single phase bridge converter feeds an R-L load having a resistance of 5.5 ohms and an inductance of a very large value causing perfect smoothing. The converter is fed from a 400 V, 50 Hz single phase supply. For a firing angle of $\alpha = 75^0$ determine.
    i. the average value of output current ii. the rms value of output current
    iii. the average and rms thyristor currents iv. the power factor of the ac source **(R3-Ch3)**

41. A single phase bridge converter feeding an R-L load with perfect smoothing is supplied from a 230 volts 50 Hz single phase supply via a 2:1 tranformer. The source including transformer offers an inductive reactance of 0.5 ohms. If the load resistance is 2.45 ohms, determine for a firing angle of $\alpha = 60^0$.
    i. the average value of load voltage ii. the average value of load current
    iii. the overlap angle iv. thyristor ratings. **(R3-Ch3)**

42. A two pulse bridge converter supplies power to load comprising a large inductance in series with a resistance of 1.5 ohm. The large inductance is responsible for perfect smoothing. If an additional dc source of 120-V is available in series with RL load, determine the value of firing angle to cause a current of 40 A in the load. The supply to the converter is at 120-V and 50 Hz. The source inductance amount to 0.75mH. Determine the overlap angle. **(R3-Ch3)**

43. A two pulse bridge rectifier feeds an RL load. The load current is ripple free. The load resistance is 2.5 ohms and L is very large. The source inductance is 2.5 mH. The rectifier is supplied at 50 Hz, the supply voltage being 110V. For a firing angle of 45^0, determine the displacement factor, average value of load current. The rectifier elements are ideal. **(R3-Ch3)**

44. A two pulse single phase mid point converter feeds and R-L load having sufficiently large inductance to smooth the dc load current perfectly. Determine the fundamental of the input current. Determine the reactive volt amperes of converter. **(R3-Ch3)**

45. A single-phase fully controlled bridge rectifier supplies an RL E_b load. The data are V_{s1} = 230 V (RMS), E_b = 130 V, L_{1d} = 12 mH, $\alpha = 30^0$, and frequency of ac supply = 50 Hz. (a) what value will the load resistance be if the conduction is required to be just continuos ? (b) Determine the average values of the load voltage and load current. (c) Sketch the waveforms of the load voltage and load current. **(R3-Ch3)**

46. Find the rectifier efficiency for a single-phase bridge rectifier for which the data are V_s = 120 V (RMS) at 50 Hz, $\alpha = 40^0$, R_{1d} = 12 ohms, L_{1d} = 50 mH. Sketch the voltage across a thyristor and the current through it. Also calculate the ripple factor of the output voltage. **(R3-Ch3)**

47. Find the mean values of load voltage and current for a centre-tapped type of rectifier with the following data: $V_{s1} = V_{s2}$ = 135 V (RMS) at 50 Hz, Eb = 98 V, R_{1d}=3.5 ohms, L_{1d} = 14.5 mH, $\alpha = 50^0$. Also calculate the ripple factor of the output voltage. **(R3-Ch3)**

48. Find the mean values of the load voltage and current for a centre tapped type of rectifier with the following data $V_{s1}=V_{s2}$=125V (RMS) at 50 Hz, Eb=88 V, R_{1d}=3ohms, L_{1d}=11.5mh, $\alpha=50^0$. Also sketch the wave forms. **(R3-Ch3)**

UNIT-V

1 a) Explain the effect of free wheeling diode in the case of three phase converters with neat waveforms.
b) Explain clearly the operation of a three phase dual converter. (May/June-13)

2 A three phase, half wave rectifier is supplied by a transformer with a secondary voltage of 180V (rms) at 50Hz. Other data are R = 10Ω and L = 10mH, and back emf E_b is 153V. Determine the average output voltage and average load current for a ring angle of 60^0. Also sketch the waveforms. (May/June 2012)

3 (a) With neat circuit diagram and wave forms explain the principle of operation of 3 phase dual converter, with circulating mode, firing angel $\alpha=60^0$
(b) A 3 phase full converter charges a battery from a 3 phase supply of 230V 50Hz. The battery emf is 200 V and its internal resistance is 0.5 ohms. On account of inductance connected in series with battery, charging current is constant at 20A. Compute firing angle delay and the supply power factor. (Nov/dec 2012)

4. Explain the operation of a 3-phase dual converter with relevant voltage and current waveforms. Derive an expression for the circulating current. **(Dec 2011)**

5. i. Explain the simple SCR inverter circuit employing class A-type commutation. Sketch the limitations of this inverter.
ii. State different methods of voltage control in inverter. Describe about PWM control in inverter. **(Dec 2011)**

6. A three-phase, half controlled converter supplies an RL-load with a ripple free current following in the load. The resistance in the load circuit is 2.5ohms. The supply voltage to the converter is 120V, 3-phase, 50Hz. Determine the average value of load current for a firing angle of 120^0. Determine also the power delivered to load, the average and rms values of device currents. Also sketch the relevant waveforms. **(Dec 2011)**

7. Draw the typical voltage and current waveforms of a three-phase, fully controlled bridge converter feeding a pure resistive load. From the Fourier expansion of the input current, determine the displacement factor, power factor, rms value of line current. **(Dec 2011)**

8. A three phase full wave controlled rectifier is operated from a three-phase, star connected, 230V, 50Hz supply and the load resistance is 10ohms. If it is required to obtain an average output voltage of 50% of maximum possible output voltage, calculate the delay angle. If the leakage inductance of each

phase of the input transformer is 2mH, calculate the overlap angle and the drop in the DC output voltage. **(Dec 2011)**

9. i. Draw the circuit of 3-phase fully controlled rectifier. Explain how the output voltage can be obtained with the help of the waveform. Derive an expression for the average output voltage.
   ii. Sketch the output voltage waveform of a single phase dual converter. Derive an expression to determine the amplitude of circulating current when both the bridges are on. **(May 11)**
10. i. Explain the operation of a 3-pulse converter fed from 3-phase 4-wire system and derive an expression for its output voltage.
   ii. A three phase fully controlled bridge is connected to a highly inductive load with a resistance of 60 ohms. Determine average voltage, average load current and input power factor for firing angle of 30^0. The input supply voltage is 400 V, 50 Hz. Assume load current to be ripple free. **(May 11)**

11. Clearly explain the effect of source inductance on a three-phase full converter bridge by deriving expressions for output voltage with overlap and also the voltage regulation due to source inductance. **(May 11)**
12. A 3 phase M-3 converter is operated from 3-phase, 230v, 50Hz supply with load resistance R = 10Ω. An average output voltage of 50% of the maximum possible output voltage is required. Determine
   i. Firing angle
   ii. Average and rms values of load current
   iii. Rectification efficiency. **(May 11)**

13. i. Explain the operation of a three phase fully controlled bridge converter with inductive load. Draw the voltage and current waveforms for α = 700. List the firing sequence of SCRs.
   ii. Derive the expression for average load voltage. **(Nov 10)**
14. A three phase half wave converter is supplying a load with a continuous constant current of 50 A over a firing angle from 0^0 to 60^0. What will be the power dissipated by the load at these limiting values of firing angle. The supply voltage is 415 V(line). **(Nov 10)**

15. Explain the operation of three phase half wave converter with resistance load and inductive load with circuit diagram. Sketch the associated waveforms also. **(Nov, June 10)**

16. A three phase fully controlled bridge converter is connected to three phase 415 V (line), 50 Hz supply and is operating in inverting mode at a firing angle of 30^0. If a.c. supply has resistance and inductance per phase of 0.09Ω and 1 mH respectively. Find **(Nov 10)**
   i. d.c. source voltage and
   ii. overlap angle.

17. Derive an expression for output voltage of a three phase fully controlled bridge converter by considering the following factors **(June 10, Nov 09, Feb 08)**
   i. overlap angle
   ii. source inductance
   Explain the effect of source inductance.

18. Explain in detail the operation of a three phase dual converter with Circulating current with the help of circuit diagram and waveforms for RL load. List the advantages and disadvantages of the same scheme. **(June 10)**

19. Explain the operation of six pulse mid-point converter with inter phase reactor with the help of neat circuit diagram and necessary waveforms. Sketch the waveforms for $\alpha = 30°$ and $\alpha = 120°$. **(Nov 09)**

20. Explain the operation of three phase half controlled converter for a firing angle of 60^0 with neat circuit diagram and waveforms. **(Nov 09)**

21. A three phase, half wave converter is operated from a three phase, star connected 220V, 60Hz supply and load resistance is R=15 ohms. If the average output voltage is 25% of maximum possible average output voltage, calculate
   i. Firing angle
   ii. RMS and average output currents. **(Nov 09)**

22. A three-phase-fully controlled bridge converter is supplying a dc load of 400V, 60A from a three phase 50Hz, 660V (line) supply. If the thyristor have a voltage drops of 1.2V when conducting, calculate firing angle of thyristor and rms value of thyristor currents, neglecting overlap.

22. Explain the operation of three phase half-wave controlled converter with resistive load, and inductive load. Sketch the associated waveforms. **(Nov 09, 07)**

23. For a 3-ϕ full converter, explain how output voltage wave, for a firing angle of 30^0, is obtained by using
    i. phase voltages and
    ii. line voltages. **(Nov 09, 04)**

24. i. Derive the expression for peak value of the circulating current in a dual converter. **(Nov 09, 04)**

25. A resistive load of 10 ohm is connected to a 3-phase full converter. The load takes 5 kW for a firing angle delay of $70^{0.}$ Find the magnitude of per phase input supply voltage. **(Nov 09, May 04)**

26. A three phase fully controlled bridge converter supplies a dc voltage source of 400V having an internal resistance of 1.8 ohm. Assume highly inductive load with a constant load current of 20A. The supply RMS load voltage per phase is 230V and source inductance in each phase is 0.005H. Compute the following by ignoring the source resistance
    i. firing angle for an output voltage of 436V
    ii. Overlap angle **(Nov 09, May 03)**

27. Explain the principle of operation of a 3-phase fully controlled rectifier with neat circuit diagram and waveforms with
    i. Continuous
    ii. Discontinuous modes **(Nov 09)**

28. Explain the operation of three phase half-wave controlled converter with resistive load, and inductive load. Sketch the associated waveforms. **(May 09, Nov 06, 05, Mar 06)**

29. A three phase, half wave controlled converter is connected to a 380V (line) supply. The load current is constant at 32A and is independent of firing angle. Find the average load voltage at firing angle of 0^0 and 45^0, given that the thyristors have a forward voltage drop of 1.2V. What value of current and peak reverse voltage rating will the thyristor require and what will be the average power dissipation in each thyristor.
    (Nov 08, 07)

30. A three phase, fully controlled converter is connected to a resistive load. Show that the average output voltage is given by
    (Nov 08, Feb 07)

31. A six pulse thyristor converter connected on the secondary of the 6.6KV/415V, 50Hz transformer is supplying to 460V, 200A a.c, load. Calculate
    i. Converter firing angle
    ii. DC power delivered by the converter
    iii. ac terminal power
    iv. ac line current **(Feb 08)**

32. A 3-phase, full wave converter is connected to a 3-phase ac supply of 400V, 50Hz and operates with a firing angle of $\pi/4$ rad. The load current is maintained constant at 10 amps and load voltage is 360 V. Calculate source inductance and overlap angle. **(Feb 08, Nov 07)**

33. Explain the operation of single phase dual converter for RL loads with non-circulating current modes with circuit and necessary voltage and current waveforms. **(Feb 08)**

34. The three phase half wave converter is operated from a three phase star connected 220V, 60Hz supply and load resistance is R = 10 ohms. If the average output voltage is 25% of max. possible average output voltage, calculate the
    i. firing angle
    ii. rms and average output currents
    iii. average and rms thyristor currents
    iv. input power factor **(Feb 08)**

35. A three phase semi converter is operated from a three phase star connected 220V, 60Hz supply. The load current is continuous and has negligible ripple. The average load current is I_{dc} = 150A and commutating inductance per phase is Lc = 0.5mH. Determine the overlap angle if (a) $\alpha=\pi/6$ (b) $\alpha=\pi/3$ **(Feb 08)**

36. A three phase, six pulse fully controlled converter is connected to three phase ac supply of 440V and 50Hz and operates with a firing angle of $\pi/5$ radians. The load current is maintained constant at 5 Amps and load voltage is 440V. Calculate load resistance, source inductance and overlap angle. **(Feb 08, 07, Nov 05)**

37. A three phase full converter is supplied from a three phase 230V, 60Hz supply. The load current is continuous and has negligible ripple. If the average load current Idc = 150A and commutating inductance Lc = 0.1mH, determine the overlap angle when (a) $\alpha = 10^0$ (b) $\alpha = 30^0$ and (c) $\alpha = 60^0$ **(Nov 07)**

38. Explain the operation of three phase fully controlled bridge converter with RL loads. Describe in detail with discontinuous conduction mode with associated waveforms. **(Nov 07)**

39. Explain the operation of 3-phase dual converter fed to RL loads for non-circulating current mode. With neat circuit diagram and waveforms. **(Feb 07, Mar 06)**

40. A three phase, half wave converter is supplying a load with a continuous constant current of 40A over a firing angle from 0^0 to 750. What will be the power dissipated by the load at these limiting values of firing angle? The supply voltage is 415V (line). **(Nov 06)**

41. A three phase, fully controlled bridge converter is supplying dc load of 400V, 60A from a three phase 50Hz, 660V (line) supply. If the thyristors have a voltage drop of 1.2V when conducting, then neglecting overlap, compute
    i. firing angle of thyristor
    ii. RMS value of thyristor currents
    iii. mean power loss in thyristors **(Nov 06)**

42. Single phase dual converter is operated from 230V, 50Hz supply and the load resistance 10 ohms. The circulating inductance is $L_C = 40$mH, firing angles are $\alpha_1 = 60^0$ and $\alpha_2 = 120^0$. Calculate the peak circulating current, peak currents of converter 1 and converter 2. Also compute the load current. **(Nov 06, Mar 06)**

43. A six pulse thyristor converter is connected to the mains through a transformer of 6% reactance. If the rms value of the voltage at the secondary of the transformer is 415V, calculate the voltage regulation. Neglect resistance in converter. The full load dc current is 200A. What is the value of commutation angle.
(Nov 07, 05)

44. A three phase, fully controlled converter is connected to a resistive load. Show that the average output voltage is given by
and
(Mar 06)

45. A three phase, half wave converter is supplying a load with a continuous constant current of 40A over a firing angle from 0^0 to 75^0. What will be the power dissipated by the load at these limiting values of firing angle? The supply voltage is 415V (line). **(Mar 06)**

46. i. Describe the effect of source inductance on the performance of a 3-phase full converter with the help of phase voltage waveforms. Indicate the sequence of conduction of various thyristors and sketch load current waveforms for both positive and negative group of thyristors.
    ii. For the purpose of delivering energy from dc source to 3-phase system, the firing angle of the 3-phase converter has been increased to 150^0. For the same value of DC source current of 10A, compute the output ac line voltage.**(Nov, May 04)**

47. i. Describe in detail the operation of dual converter in non- circulating current mode.
    ii. Two three phase full converters are connected in anti parallel to form a three phase dual converter of the circulating current type. The input to the dual converter is 3 phase, 400V, 50Hz. If the peak value of the circulating current is to be limited to 20A, find the value of inductance needed for the reactor for firing angle of 60°. **(Nov 04)**

48. A resistive load of 10 ohm is connected to a 3-phase full converter. The load takes 5 kW for a firing angle delay of 70^0. Find the magnitude of per phase input supply voltage. **(Nov 04)**

49. i. Explain the line commutated inverter operation of a 3-phase full converter.
    ii. A naturally commutated three phase bridge inverter is used for power transfer from a 300V battery to a 3-phase 230V,50Hz ac supply. Devices used in the bridge inverter circuit may be considered as ideal. A large filter inductor having 10 ohms resistance is included on the dc side. Calculate the power transferred and the power factor if i. $\alpha = 90°$ and ii. $\alpha = 120°$. **(Nov 04)**

50. i. Explain the operation of dual converter in circulating current mode. List the advantages and disadvantages of the scheme.
    ii. Calculate the peak value of the circulating current for the 3 phase circulatory current type dual converter consisting of two three phase fully controlled bridges for a the given data:
    per phase supply RMS voltage = 230V, Frequency, f = 15 Hz,
    L=0.015 H, $_1$ =60°, $_2$= 120° **(Nov 04)**

51. For a 3-ϕ full converter, explain how output voltage wave for a firing angle of 30^0 is obtained by using
    i. phase voltage
    ii. line voltage of 60^0. **(May 04)**

52. Two three phase full converters are connected in anti parallel to form a three phase dual converter of the circulating current type. The input to the dual converter is 3 phase, 400V, 50Hz. If the peak value of the circulating current is to be limited to 20A, find the value of inductance needed for the reactor for firing angle of 60°. **(May 04)**

53. A three phase full converter is operated from a three phase 400V, 50Hz supply. The load resistance is 10 ohms. Calculate the firing angle for an average output voltage of 60% of the maximum possible mean output voltage. Calculate also the RMS value of load current. **(Nov, May 03)**

54. Explain the operation of dual converter in circulating mode. List the advantages and disadvantages of the scheme **(May 03)**

55. A three-phase Bridge is used to provide rectified output from a 400 V 50 Hz 3 phase supply to a RL load with 10Ohm resistance and 300 mH inductance. Determine the
    i. DC level of the output voltage
    ii. RMS value of the diode current
    iii. RMS value of source current
    iv. Apparent power drawn from the mains **(GATE 99)**

56. A 3 phase fully controlled thyristor converter is operated from an ac supply of 400 V rms line to line. When the converter is operated in the rectifier mode at a control angle of 30^0, the overlap angle due to the line reactance is 15^0. Calculate the reduction in dc output voltage due to overlap, if the converter operates in the inverter mode with firing angle of 120^0 and without any change in the dc load current, what will be the overlap angle. **(GATE 93)**

57. A line commutated ac to dc converter is operated from a 3-phase, 50 Hz, 580 V (line to line) supply .it supplies a load current of 346A. Assume load current to be ripple free and neglect source inductance.
    i. calculate the delay angle of the converter if its average output voltage is 648V.
    ii. calculate the power delivered to the load R in KW.
    iii. Sketch the waveform of the supply current.
    iv. Calculate fundamental reactive power drawn by converter from the supply in KVAR. **(GATE 92)**

58. In a 3 phasse semi-converter, if firing angle is less than or equal to 60^0, then the duration of conduction of each thyristor and diode would be respectively.
    i. 60^0 and 60^0
    ii. 90^0 and 30^0
    iii. 120^0 and 120^0
    iv. 180^0 and 180^0 **(IES 2000)**

59. A 3-pulse semi-converter feeds an RLE load. The source has a definite inductance causing overlap. The thyristors are ideal. It has an overlap angle '' of 20 degrees at the minimum firing anlge ''. The current remains constant in the complete range of firing angles. The range of firing angles of the converter would be.
    i. $0^0 < a < 180^0$
    ii. $20^0 < a < 180^0$
    iii. $20^0 < a < 160^0$
    iv. $0^0 < a < 160^0$ **(IES 2000)**

60. Analysis of voltage wave form of a single phase bridge converter shows that it contains x% of sixth harmonic. The sixth harmonic content of voltage waveform of a 3-phase bridge converter would be
    i.. Less than x% due to increase in number of pulses **(IES 98)**
    ii. equal to x%, the same as that of 1-phase converter.
    iii. greater than x% due to changes in input and output voltages of converter.
    iv. difficult to predict as the analysis of converters is not governed by any generaliseed theory.

61. In a three phase bridge rectifier fed from the star connected secondary winding of a transformer, let the voltage to the neutral of the A-phase(phase sequence A, B, C) be $V_m$sinwt. At the instant when the voltage of A-phase is maximum, the out put voltage at the rectifier terminals will be **(IES 97)**
i. V_m/ ii. V_m iii. $1.5V_m$ iv.

62. A 3-pulse converter feeds the pure resistive load at firing angle 60°. The average value of current flowing in the load is 10A. If a very large inductance is connected in the ;load circuit, than
i. average value of current will remain 10A. **(IES 97)**
ii. average value of current will become greater than10A.
iii. average value of current will become less than 10A.
iv. trend of variation of current cannot be predicted unless the exact value of inductane connected is known.

63. In a 3-phase rectifier circuit, thyristor number 1, 2 and 3 are connected to R, Y, B phases of star connnected transformer respectively. When the current is being commutated from thyristor 1 to 2, the eeffect of transformer leakage and the A.C system inductance will be such that it will
i. prolong the conduction in No.1 and delay the turn on of No.2 correspondingly
ii. stop the conduction in No.1 at the scheduled time but the delay turn on of No.2.
iii. produce conduction in both No.1 and No.2 in parallel for an overlapping period through transient.
iv. double the voltage output through commutation transient. **(IES 97)**

UNIT-VI

1 What are steps involved in determining the output voltage waveform for single phase ac voltage controller with two SCRs connected back to back? (May/June-13)

2 A single-phase, full wave, ac voltage regulator has an input voltage of 150V (rms) and a load of 8ohm resistance. The ring angle of thyristors is 30^0. Find:
(a) Average output voltage
(b) rms output voltage
(c) Power output.
Also draw the output voltage and current waveforms. (May/June 2012)

3 (a) with neat diagram and waveforms explain the principle of operation of single phase mid point type step down cyclo-converter.
(b) A single phase voltage controller feeds power to a resistive load of 3Ω from 230V, 50Hz source. Calculate
i) The maximum value of average and rms thyristor current for any firing angle
ii) The maximum circuit turn of time for any firing angle. (Nov/dec 2012)

4. i. What is an AC voltage controller? Describe the two types of ac voltage controllers and list out some of their industrial applications.
ii. Explain the working of single-phase, bridge type cycloconverter with R-load. Draw the relevant waveforms for f_o = fs/2. **(Dec 2011)**

5. For a single-phase ac voltage controller feeding a resistive load, draw the waveforms of source voltage, gating signals, output voltage, source and output currents and voltage across SCRs. Describe its working with reference to the waveforms drawn. **(Dec 2011)**

6. Compare the operational features of single-phase, midpoint and bridge type cycloconverters for RL loads with circuit diagrams and waveforms. Mention their limitations and applications. **(Dec 2011)**

7. A single-phase, voltage controller is employed for controlling the power flow from 230V, 50Hz source into a load circuit consisting of R = 3Ω and *w*L = 4Ω. Calculate
i. The control range of firing angle
ii. The maximum value of rms load current
iii. The maximum power and power factor
iv. The maximum possible value of di/dt that may occur in the thyristor. **(Dec 2011)**

8. i. What are steps involved in determining the output voltage waveform for single phase ac voltage controller with two SCRs connected back to back. Assume that the load is highly inductive.
   ii. A single phase ac voltage controller given in (i) has a resistive load of 10 ohms and the source voltage is 120 V(rms). The delay angles of thyristor are 90 deg each. Determine
   a. Rms output voltage
   b. Input power factor
   c. Average current of thyristor. **(May 11)**

9. i. Draw the circuit diagram of ac voltage controller with two thyristors connected back to back. Obtain its output voltage waveform.
   ii. A 1-ϕ controller operating from 230 V, 50 Hz supply uses integral cycle control to control the flow of power to 10 ohms load. The thyristors conduct for 18 cycles and remain off for 32cycles. Find
   a. rms value of output voltage
   b. power output to the load
   c. input power factor
   d. average thyristor current. **(May 11)**

10. Explain clearly the difference triggering modes of bidirectional triode thyristor.**(May 11)**

11. i.What is the output voltage range for the control range of the delay angle for a single phase bidirectional ac voltage controller?
   ii. What are the advantages and disadvantages of a cyclo converter? **(May 11)**

9. A single phase load of resistance 12Ω in series with an Inductance of 24 mH is fed from a 230V(rms), 50Hz supply by a pair of inverse parallel thyristors. Find mean power in the load at firing angles of i) 0^0 ii) 60^0 and iii) 135^0. Ignore source inductance and device voltage drops. **(Nov 10)**

10. Describe the principle of working of a single phase bridge type cyclo-converter for both continuous and discontinuous conduction with the help of neat circuit diagram and waveforms. **(Nov 10)**

11. For a single phase AC voltage controller feeding resistance load, draw waveforms of supply voltage, gating signals, output voltage, source and output current and voltage across SCRs. Describe its working with reference to the waveforms drawn, with neat circuit diagram. **(Nov 10, 09)**

12. Discuss the operation of a single phase AC voltage controller with resistance and inductive load, when α is less than or equal to load phase angle ϕ. Hence show that for α less than ϕ, output voltage of the a.c. regulator can not be regulated. **(Nov 10, 09, June 10)**

13. Explain the principle of operation of single phase to single phase mid-point cycloconverter for output frequency of 1/3 fs and 1/5 fs with the help of circuit diagram and waveforms. **(June 10)**

14. A single phase bidirectional AC Voltage Controller has a resistance load of 1.5Ω with input voltage of 120 V at 60 Hz. If the desired output power is 7.5 kW. Determine:
   i. Delay angle of Thyristor
   ii. rms output voltage
   iii. Input power factor
   iv. average current of Thyristor and
   v. rms voltage of current of Thyristor. **(Nov 09)**

15. Explain the operation of single phase, mid-point cyclo converter when fed from a 230V, 50Hz source and controlling power to R-load. Draw the relevant waveforms for fo = 3fs. **(Nov 09)**

16. i. Explain the working of single phase, ac voltage controller when fed from 230V, 50Hz ac source and controlling power to RL load. Derive the expression for average output voltage.
   ii. A single phase, ac full wave controller supplies an R-load. The input voltage is 120V at 60Hz and the load resistance is 5 ohms. The delay angles of both the thyristors are equal to 60^0. Determine the conduction angles of the thyristor and rms output voltage. **(Nov 09)**

17. A single phase, ac voltage controller controls the power input to a load circuit consisting of R=3 ohms and ωL=4 ohms. If the supply voltage is 230V, 50HZ, Calculate
   i. Control range of firing angle
   ii. Maximum power input to the load

iii. Explain the operation of a single phase, step up bridge type cyclo converter feeding a R-load. Draw the relevant waveforms for fo = 4fs. **(Nov 09)**

18. A single phase ac voltage controller feeds power to a resistive load of 4 ohms from 230V, 50Hz source. Determine
    i. The max. values of average and rms thyristor currents for any firing angle α.
    ii. The minimum circuit turn-off time for any firing angle α.
    iii. The max. value of di/dt occurring in the thyristors. **(Nov 09, 08)**

19. Explain the operation of a single phase ac voltage controller with neat circuit diagram and output waveforms with respect to source voltage waveforms at $\alpha = 60^0$ for Resistive load. **(Nov 09 ,08, 05, May 09, Feb 08, 07)**

20. Explain the working of single phase bridge type cycloconverter with RL load for
    i. Continuous conduction and for
    ii. discontinuous conduction with the help of neat circuit diagram and relavent output waveforms.
    (Nov 09, 04, May 04)

21. i. What is a cyclo converter?
    ii. What are the varieties of single phase cyclo converters.
    iii. What are the salient features of cyclo converters.
    iv. What are the major limitations of cyclo converters. **(May 09, Nov 05)**

22. Explain the operation of single phase bridge type cyclo converter when fed form 230V, 50Hz source and controlling power to resistive load with the help of neat circuit diagram and output voltage and current waveforms for $\alpha = 45^0$ and $\alpha = 1600$ for $f_0 = 1/5$ fs. **(May 09, Nov 07)**

23. A 1-ϕ 230V, 50 Hz source connected to an anti parallel connected thyristor circuit controlling power to the following loads, when $\alpha = 30^0/90^0$. Calculate output voltages, output current and load power factor
    i. R=10 ohms, L=0H
    ii. R=10 Ohms, L=20 MH. **(May 09, 03, Nov 04)**

24. For a single phase mid-point cyclo-converter, explain the operation of the circuit when fed to R-load with the help of neat circuit diagram and relevant output waveforms for $\alpha = 30^0$ and $\alpha = 120^0$ for $f_0 = 1/4$ fs.
    (May 09, 05, Nov 08, 07, 06, Feb 08)

25. Explain the operation of single phase midpoint cyclo converter with R-L load s for continuous conduction with relevant circuit diagram nd necessary output waveforms for $f_0 = 1/3$ fs.
    (Nov 08, 07, Feb 08, 07, Mar 06)

26. The ac voltage controller uses on-off control for heating a resistive load of R = 4 ohms and the input voltage is Vs = 208V, 60Hz. If the desired output power is $P_0 = 3KW$, determine the
    i. duty cycle δ
    ii. input power factor
    iii. sketch waveforms for the duty cycle obtained in (i.) **(Nov 08, 07, Feb 08, 07, Mar 06)**

27. Two SCRs are connected back-to-back have a load resistance of 400 ohms and a supply of 110V ac. If firing angle is 600, find
    i. the rms output voltage
    ii. average power. **(Nov 08, 06)**

28. Discuss the working of a single phase bridge type cyclo converter with RL loads and for discontinuous operations with relevant output waveforms and circuit diagram for $f_0 = 1/2$ fs.
    (Nov 08, 07, Feb 08, 07, Mar 06)

29. A single phase ac voltage controller is connected to a resistive load of 10 ohms. The supply voltage is 230V, 50Hz. Determine the rms load voltage, rms load current and input power factor for a trigger angle of 60^0. Sketch the output waveforms. **(Feb 08)**

30. A load commutated chopper, fed from a 230V dc source has a constant load current of 50A. For a duty cycle of 0.4 and a chopping frequency of 2 KHz, Calculate
    i. the value of commutating capacitance
    ii. average output voltage
    iii. circuit turn-off time for one SCR pair
    iv. total commutation interval **(Feb 08)**

31. A single phase, 220V, 1 KW electric room heat is connected across 220V supply through a Triac. For a delay angle of 90^0 calculate
    i. the power dissipated by the heater element
    ii. find the value of a for output voltage of 0.25V **(Feb 08)**

32. i. Explain the principle of ON-OFF control used in a.c. voltage controller.
    ii. Derive the expression for the input power factor in an a.c. voltage controller using ON-OFF control.
    iii. Explain its application with the help of a circuit and waveforms. **(Feb 08, Nov 07, Mar 06)**

33. Derive the output rms voltage, output rms current and source power factor for a single phase ac voltage controller fed to R-L load. **(Nov, Feb 07)**

34. A single phase full wave ac voltage controller has a resistance load of
    a. 10 ohms and b. 5 ohms.
    The input ac voltage is 230V, 50Hz. For a delay angle of 90^0, determine the rms load voltage, rms load current, rms thyristor current and input power factor for above two loads. **(Nov 06, 05, May 05)**

35. Discuss the operation of a single phase ac voltage controller with RL load when a is less than, or equal to load phase angle. Hence show that for a less than load angle, the output voltage of the ac voltage controller can not be regulated. **(Mar 06)**

36. An a.c. voltage controller supplies power to a resistive load of 20 ohms. The rms of input voltage is 220V at 50Hz. The thyristors are switched ON for 30 cycles and OFF for 70 cycles. Calculate the values of
    i. the rms output voltage
    ii. input power factor
    iii. the average and rms values of thyristor currents **(Nov 05)**

37. Discuss the working of a single phase mid point cyclo converter with R-L loads and for discontinuous operation with neat circuit diagram and output rms voltage and current waveforms for f_0=1/3 fs. **(Nov 05)**

38. Explain 1-ϕ phase step down cycloconverter with output frequency of ¼ of input frequency with the help of bridge type for RL load continuous conduction with neat waveform. **(May 05, 04)**

39. i. What is cycloconverter? What are its limitations?
    ii. Compare the operational features of single phase midpoint and bridge type cycloconverter for R-L loads, with neat circuit diagrams and waveforms. **(May 05, 02, Nov 04)**

40. Derive the expressions for the power dissipated in the load, rms load voltage and current for a single phase AC voltage controller feeding Resistive-inductive load for discontinuous operation of current. Explain the operation of the above circuit for continuous current condition. **(May 05, 02)**

41. Explain the operation of single phase A.C. voltage controller with Resistive and Resistive- sketch the transfer characteristics. **(Nov 04)**

42. Explain the operation of single phase A.C. Triac based circuit when controlling Power to RL loads. Give the output voltage, current waveforms with neat circuit diagram. Suggest the firing circuit for Triac. **(Nov 04)**

43. i. Derive the expressions for the output r.m.s voltage, output r.m.s current and output power for a single phase A.C voltage controller when feeding power to R-load.
    ii. For a single phase AC voltage controller with R-load, obtain V_o r.m.s, I_o r.m.s when supplied from 230V, 50Hz single phase source and fired at 65^o. **(Nov 04)**

44. Discuss the working of single phase midpoint cycloconverter when feeding R and RL loads with neat circuit diagram and relavent output waveforms. **(Nov 04)**

45. For a given 1-ϕ AC Voltage controller obtain the transfer characteristics for
    i. Resistive load of 100 ohms **(May 04)**
    ii. Resistive-inductive load of R=100, L=90 MH where fed from 230V, 50Hz, 1-Phase AC source.

46. Derive the expression for the output rms voltage, output rms current and output power for a 1-phase AC voltage controller when feeding power to R load. **(May 03)**

47. A single-phase ac regulator has a resistive load of R=20 ohms and input voltage (rms) 230 V, 50 Hz. The firing angles of both the thyristors are same and equal to 90 degree. Determine
   i. rms output voltage
   ii. Power dissipated in resistor
   iii. Supply PF
   iv. Average current of the thyristor
   v. rms current of thyristor (**GATE 96)**

48. Enumerate the basic differences between a triac and a thyristor. Draw and explain V-I Characteristics of a Triac. Draw and explain a full wave triac phase control circuit. (**GATE 95)**

49. An Inter-group reactor is used in a single-phase cyclononverter circuit to
   a. Reduce current-ripples b. Reduce voltage-ripples
   c. Limit circulating current d. Limit di/dt in the smiconductor switch
   Directions:
   The following Eleven (11) items consist of two statements - one labelled as the Assertion i. and the other as Reason (R). You are to examine these two statements carefuly and select the answers to these items using the codes given below:
   Codes:
   i. Both A and R are individually true and R is the correct explanation of A.
   ii. Both A and R are individually true and R is not correct explanation of A.
   iii. A is true but R is false
   iv. A is false but R is true. **(IES 03)**

50. How many switched are used to construct a three-phase to three -phase cycloconverter?
   i. 3 ii. 6 iii. 12 iv. 18 **(IES 02)**

51. A 3 phase cycloconverter is used to obtai a variable -frequency single -phase ac. output. The single phase ac load is 220V, 60A at a power factor of 0.6 lagging. The rms value of input voltage per phase required is
   i. 376.2V ii. 311.12V iii. 266V iv. 220V **(IES 02)**

52. A single phase ac voltage regularot is fed from a 50Hz supply system. If it supplies a load comprising a resistance of 2 ohm connected in series with an inductuance of 6.36 mH, then the range of firing angle ‘’ providing controlled voltage would be
   i. $0^0<<180^0$ ii. $45^0<<180^0$ iii. $90^0<<180^0$ iv. $0^0<<45^0$ **(IES 01)**

53. The most accurate and versatile method of achieving reactive power compensation is by using
   i. Switched capacitors
   ii. Fixed capacitors with controled reactor
   iii. Saturable reactor with capacitor bank
   iv. Switched capacitor with controlled reactor **(IES 01)**

54. A single phase ac voltage controller feeding a pure reesistance load has a load voltage of 20V (rms) when fed from a source of 250 V (rms). The input power factor of the controllers is
   i. 0.64 ii. 0.8 iii. 0.894 iv. difficult to estmate because of insufficiency of data **(IES 01)**

55. In a thyristor controlled reactor the firing angle of thyristor is to be controlled in the range of
   i. 0^0 to 90^0 ii. 0^0 to 180^0 iii. 90^0 to 180^0 iv.90^0 to 270^0 **(IES 01)**

56. Which one of the following is NOT the advantage of solid state switching of ac capacitors into ac supply over relaya -based switiching?
   i. low transients ii. low losses iii. fast reponse iv. long life **(IES 01)**

57. The quality of output ac voltage of a cyclonconverter is imporved with
   i. increase in output voltage at reduced frequency.
   ii. increase in output voltage at increased frequency.
   iii. decrease in output voltage at reduced frequency
   iv. decrease in output voltage at icreased frequency. **(IES 01)**

58. The torque produced by a single phase induction motor fed through an A.C voltage controller for speed control is due to **(IES 98)**
   i. fundamental component of current as well as harmonics, both odd and even.
   ii. fundamental component and even harmonic of current
   iii. fundamental component and odd harmonic of current.

iv. fundamental component of current alone.

59. Effect of transformer leakage and the A.C system inductance will be such that it will **(IES 97)**
   i. prolong the conduction in No.1 and delay the turn on of No.2 correspondingly
   ii. stop the conduction in No.1 at the scheduled time but the delay turn on of No.2.
   iii. produce conduction in both No.1 and No.2 in parallel for an overlapping period through transient.
   iv. double the voltage output through commutation transient.

60. For an n-pulse rectirier ,the rms value of the ac current to related to the dc load current as
   $I_{rms}=I_d/n$ ii.. $I_{rms}=I_d/\pi_n$ iii.. $I_{rms}=I_d$ iv. $I_{rms}=2I_d/\pi$ **(IES 95)**

61. A twelve phase converter consists of two sets of bridge rectifiers,one set fed from a delta-connected secondary and the other from a star-connected one.The two sets are connected to the dc motor aramature through an inter phase reactor.The purpose of this inter-phase reactor is to
   i. permit each 6-pulse converterset to operate independently in the normal manner
   ii. increase the current output
   iii. match the voltages to two sets of converters
   iv. counteract the effect of inductance of the armature **(IES 95)**

UNIT-VII

1 a) What are choppers and how are they classified?
b) Explain the operation of a dc – dc converter with a load commutation circuit. Sketch the waveforms of current, voltage across thyristor, load voltage. (May/June-13)

3 (a) Explain the operation of a chopper in any two-quadrants in detail with circuit diagram.
b)A chopper has an input voltage of 600V. It feeds an RL load having R = 10Ω Chopping frequency is 500Hz. Find load inductance so that the maximum ripple in load current is 20% of the average current of 50A. (May/June 2012)

4 (a) With neat circuit diagram and wave forms explain the operation of jones chopper.
(b) A step –up chopper has input voltage of 220V and out put voltage of 600V. If the non conducting time of thyrister chopper is 100 micro sec, compute the pulse width of output voltage. In case pulse width is halved for constant frequency operation find th e new out put voltage. (Nov/dec 2012)

4. What is a dc chopper? Describe the various types of chopper configurations with appropriate diagrams wherever necessary. **(Dec 2011)**

5. i. What is a chopper and how they are classified? **(Dec 2011)**
   ii. A dc chopper is supplying a resistive load. If the input and output voltages are 200V and 120V and the chopping frequency is 800Hz, find the periods of conduction and blocking in each cycle.

6. A chopper, fed from a 220V dc source, is working at a frequency of 50Hz and is connected to an RL-load, of R = 5Ω and L = 40mH. Determine the value of duty cycle at which the minimum load current will be 20A. Calculate the corresponding value of maximum current and ripple factor. **(Dec 2011)**

7. i. What is a chopper? How is chopper controlled? Why forced commutation is necessary for choppers?
   ii. A DC chopper has an input voltage of 230V and an output voltage of 150V. It is operating at a frequency of 1 kHz. Find the periods of conduction and blocking each cycle. **(Dec 2011)**

8. i. Discuss the control strategies of dc to dc converters (a) time ration control (b) Current limit Control. Sketch the waveform of load voltage and current for the above cases.
   ii. A step down chopper is feeding an R-L load of R=5 ohms, L= 7.5 mH, E=0 V from a source of 220 V (dc) .Calculate the minimum and maximum values of average value of load current. **(May 11)**

9. i. Explain the operation of a dc-dc converter with a load commutation circuit. Sketch the waveforms of current, voltage across thyristor, load voltage.
   ii. A step down chopper is connected to a resistive load of 10 ohms. The ON time and OFF time of the chopper are 200 μsec and 300 μsec repectively. Determine the average output voltage, power consumed by load. **(May 11)**

10. i. Explain the single pulse modulation technique of a pulse-width modulated inverter by deriving expression for rms value of output voltage.
    ii. What are the drawbacks of external control of dc input voltage method of voltage control in single phase inverter? **(May 11)**

11. Explain clearly the force commutated thyristor half-bridge type inverter with all necessary waveforms and expressions. **(May 11)**

12. A simple d.c. chopper is operating at a frequency of 2 kHz from a 110 V d.c. source to supply a load resistance of 10Ω. The load time constant is 6 ms. If the average load voltage is 57.6V, Find the period of the chopper, the average load current and the magnitude of the ripple current. **(Nov 10)**

13. Explain the operation of d.c. jones chopper with its commutation procedure by sketching circuit diagram and necessary waveforms. **(Nov, June 10)**

14. Discuss the working of a Morgan's chopper circuit and its commutation procedure with the help of neat circuit diagram. **(Nov, June 10)**

15. A simple d.c.chopper is operating at a frequency of 2 kHz from a 96 v d.c. source to supply a load resistance of 8 Ω. The load time constant is 6 ms. If the average load voltage is 57.6V, find T period of the chopper, the average load current and the magnitude of the ripple current. **(June 10)**

16. Describe the principle of operation of basic d.c. chopper with the help of neat circuit diagram and necessary waveforms. Derive an expression for output voltage. **(June 10)**

17. Explain various control strategies including current limit control for a d.c.chopper with the help of gating signals. **(June 10)**

18. Explain the working of a single phase series inverter with circuit diagram and output waveforms for an resistive load. **(June 10, Nov 09)**

19. A single dc chopper is operating at a frequency of 2 KHz from a 96V dc source to supply a load resistance of 8 ohms. The time constant is 6ms. If the average load voltage is 57.6V, find 't'_{on} period of the chopper and the average load current. **(Nov 09)**

20. Explain the time ratio control and current limit control strategies used for choppers, with necessary waveforms and circuit. **(Nov 09, 08, Feb 08, Mar 06)**

21. For the ideal type A-chopper circuit, following conditions are given, E_{dc} = 220V, chopping frequency, = 500 Hz, duty cycle δ=0.3 and R = 1 ohm, L = 3mH and E_b = 23V. Compute the following quantities.
    i. Check whether the load current is continuous or not.
    ii. Average output current
    iii. maximum and minimum values of steady state output current **(Nov 09, 08, Feb 08)**

22. Explain the operation of a basic dc chopper and obtain the following as a function of E_{dc}, R and duty cycleδ
    i. average output voltage and current
    ii. rms value of the output voltage
    iii. RMS and average load currents **(Nov 09, 07, Feb 08, 07, Mar 06, 05)**

23. Explain the operation of DC Jones chopper for RL loads with neat circuit diagram and output voltage and current waveforms. Also sketch firing signals. **(Nov 09, Feb 08)**

24. Explain the operation of DC Morgan's Chopper for resistive load with neat circuit diagram and output voltage and current waveforms. **(Nov 09, 06)**

25. i. Describe the operation of voltage commuted chopper with relevant circuit and voltage waveforms.
    ii. A load commutated chopper fed from a 230V, DC source, has a constant load current of 50A. For a duty cycle of 0.4 and a chopping frequency of 2KHz compute i. the average output voltage ii. the value of commutating capacitance. **(Nov 09, Jun 03)**

26. Describe the principle of DC Chopper operation. Derive an expression for its average DC output voltage. **(Nov 09, May 03)**

27. Explain the operation of step-up chopper with neat circuit diagram and necessary output waveforms and also derive expression for output voltage. **(May 09, Feb 08)**

28. A load commutated chopper, fed from a 230V dc source has a constant load current of 50A. For a duty cycle of 0.4 and a chopping frequency of 2 KHz, Calculate
    i. the value of commutating capacitance
    ii. average output voltage
    iii. circuit turn-off-time for one SCR pair
    iv. total commutation interval **(Nov 08, 07, 06)**

29. Derive the expression for minimum and maximum values of load current for a type - A chopper and also derive the current ripple. **(Nov 08)**

30. An ideal chopper operating at a chopping period of 2ms supplies a load of 4 ohms having an induction of 8 mH from a 80V battery. Assuming the load is shunted by a perfect commutating diode, and battery to be loss less, compute load current waveforms for Ton / Toff values of 1/1, 4/1. **(Feb 08, Nov 06)**

31. A current commutated chopper controls a battery powered electric car. The battery voltage is 100V, starting current is 100A, thyristor turn-off time is 20 µs, chopping frequency is 400Hz. Compute the values of commutating capacitor and commutating inductor. Assume Icm / Iom = 3. **(Feb 08, Mar 06,Nov 05)**

32. i. A step-up chopper with a pulse width of 150 µs operating on 220V, dc supply. Compute the load voltage if the blocking period of the device is 40 µs.
    ii. What is the necessity of step-up chopper where do you use. **(Nov 06, 05)**

33. A dc on-off chopper operating at 1 KHz and duty cycle of 10% is supplied from a 200V source. If the load inductance is 10mH and resistance 10 ohms. Compute the max. and min. circuit in the load. **(Mar 06)**

34. i. Explain the operation of Jones chopper with neat waveforms.
    ii. Mention the advantages of Jones chopper circuit over other chopper circuits. Give the applications of this chopper. **(May 04)**

35. i. Describe the operation of a Morgan chopper with neat circuit diagram and associated waveforms.
    ii. Enumerate the demerits of Morgan chopper over Jones chopper and also give few applications.**(May 04)**

36. i. Explain the principle of operation of an oscillation chopper with neat sketches.
    ii. Explain in brief how average voltage across the load is made more than DC supply voltage using chopper .Derive the expression for average voltage. **(May 04)**

37. i. Explain the operation of single phase AC chopper.
    ii. With the help of voltage and current waveforms, explain the working of type D chopper. **(May 04)**

38. i. Derive the expressions for the Power dissipated in the load, for a single phase AC voltage controller feeding Resistive-inductive load for discontinuous operation of current.
    ii. Explain the operation of the above circuit for continuous current conditions. **(Nov 03)**

39. i. What is current limit control of chopper? Explain the operation.
    ii. The speed of a separately excited dc motor is controlled by a chopper. The dc supply voltage is 120V, armature circuit resistance is Ra=0.5, armature circuit inductance is La=20mH, and motor back emf constant is Kb=0.05 v/rpm. The motor drives a constant torque load requiring an average armature current of 20A.Assume that motor current is continuous. Determine
    a. the range of speed control
    b. the range of the duty cycle. **(Jun 03)**

40. i. Draw the power circuit diagram of a current commuted chopper. Explain the working of a chopper by dividing its commutation process interval into well defined modes.
    ii. A step up chopper has input voltage of 220V and output voltage of 660V, if the non-conducting time of the thyristor chopper is 100 µsec, compute the pulse width of output voltage. In case pulse width is halved for constant frequency operation, find the new output voltage. **(Jun 03)**

41. A step up chopper has input voltage of 220 V and output voltage of 660V. The non-conducting time of the SCR chopper is 100 microsecs. Compute the pulse width of output voltage. In case pulse width is halved for constant frequency operation, find the new output voltage. **(May 03)**

42. A battery is charged from a constant dc source of 220 V through a chopper. The dc battery is to be charged from its internal emf of 90 V to 122 V.The battery has internal resistance of 1 ohm. For a constant charging current of 10 A. compute the range of duty cycle. **(May 02)**

43. A chopper circuit is operating on TRC principle at frequency 1KHZ on a 220 V dc supply .if the load voltage is 180, calculate the conducting and blocking period of thyristor in each cycle. **(May 02)**

44. Describe the principle of operation of a step down chopper. Derive an expression for the average output voltage in terms of input dc voltage and duty cycle. **(May 02)**

45. A load commutated chopper fed from a 230V, DC source has a constant load current of 50A. For a duty cycle of 0.4 and a chopping frequency of 2KHZ Compute.
    i. The average output voltage ii. The value of commutating capacitance **(GATE 03)**

46. A load commutated thyristor chopper circuit is operated at 500 Hz with 50% duty cycle. The load takes a constant current of 20A.
    i. Evaluate the circuit turnoff time for the main thyristor
    ii. Calculate the value of inductance L, if the peak current trough the main thyristor is limited to 180 % of the load current.
    iii. Calculate the maximum instantaneous output voltage of the chopper. **(GATE 01)**

47. A voltage commutated thyristor chopper circuit is shown in figure. The chopper is operated at 500 Hz with 50% duty ratio. The load takes a constant current of 20A
    i. Explain the circuit turn off times for the main thyristor Th_1.
    ii. Calculate the value of the peak current through the main thyristor Th_1.
    iii. Calculate the maximum instantaneous output voltage of the chopper. **(GATE 01)**

48. A separately excited DC motor is fed from a chopper operating at 500 Hz with a duty cycle of 50% and is drawing an average current of 10A from a 200 V DC source. A freewheeling diode is connected across it. The motor has negligible armature resistance, a field inductance of 50 mh and a torque constant of 0.5 N-m/A. Determine the minimum and maximum motor current, motor back e.m.f. and the mechanical torque developed. **(GATE 97)**

49. The chopper circuit, shown in figure below, is operating at duty ratio of 0.5 at 100 Hz. The load current is continuous at steady state but varies between 10A and 3A Draw the following wave shapes of currents through,
    i. Load (i_L) ii. Free wheeling diode (i_f) iii. Commutation capacitor (i_c) **(GATE 94)**

50. An ideal chopper operating at a frequency of 500Hz feeds a RL load R=30 and L=9mH from a 48 V battery. The load is shunted by a freewheeling diode. Battery is lossless. Assuming the duty cycle of chopper to be 50%, compute
    i. Peak load current ii. Minimum load current iii. Average load current
    iv. Average load voltage v. Current exertions in load current **(GATE 96)**

51. The circuit of a chopper driven separately excited dc motor. The single-pole double throw switch operates with a switching period (Ton/Ts) is 0.2.The motor may be assumed to be loss less, with an armature inductance of 10 mH. The motor draws an average current of 20 A at a constant back emf of 80 V steady state.
    i. Sketch and label the label the voltage waveform.
    ii. Sketch and label the motor current for one switching period
    iii. Evaluate the peak-to-peak current ripples of the motor. **(GATE 91)**

52. A boost regulator has an input voltage of 5 V and the average output voltage of 15V. The duty cycle is
    i. 3/2 ii. 2/3 iii. 5/2 iv. 15/2 **(IES 03)**

53. Explain in brief how average voltage across the load is made more than DC supply voltage using chopper. Derive the expression for average voltage. **(IES 03)**

54. What is DC chopper? Discuss with necessary circuit diagram the principle of operation of a
    i. Step down chopper ii. Step up chopper,
    Give comments on chopping frequency. **(IES 03)**

55. In a switched-mode power supply (SMPS) after conversion of ac supply to highly filtered dc voltage, a switching tansistor is switched ON and OFF at a very high speed by a pulse width modulator (PWM) which generates very-high frequency square pulses. The frequency of the pulses is typically in the range of i. 100 Hz - 200 Hz ii. 500 Hz - 1 kHz iii. 2 kHz - 5kHz iv. 20kHz - 50kHz **(IES 02)**

56. A 3-phase wound motor induction motor is controlled by a choppper -controlled reistance in it srotor circuit. A resisttnace of 2 ohm is connected in the rotor circuit and a reistance of 4 ohm is additionally connected during OFF periods of the chopper. The OFF period of the chopper is 4 ms. The averge reistnce in the rotor cirucit for the chopper frequency of 200 Hz is
i. 26/5 ohms ii. 24/5 ohms iii. 18/5 ohms iv. 16/5 ohms **(IES 02)**

57. The most suitable device for high frequency inversion in SMPS is
i. BJT ii. IGBT iii MOSFET iv. GTO **(IES 01)**

58. A four quadrant chopper cannot be opererated as
i. one quadrant chopper ii. cyclonconverter iii. inverter iv.bi-driectional rectifier **(IES 01)**

59. Enumerate the basic difference between a Triac and a thyistor. Draw and explain V-I characteristic of a Triac. Draw and explain a full wave Triac phase control circuit. **(IES 2000)**

60. In dc choppers feeding highly inductive loads, the waveforms for input and output currents are
i. discontinous andcontinous respectively ii. both continous
iii. both discontinous iv. continous and discontinous respectively **(IES 97)**

61. What is a resonant pulse converter? List different types of converters. Discuss the advantages and disadvantages of parallel resonant inverters. **(IES 97)**

62. In D.C choppers per unit ripple is maximum when the duty cycle is
i. 0.2 ii. 0.5 iii. 0.7 iv. 0.9 **(IES 97)**

63. Consider the following statements:
Switched mode power supplies are preferred over the continuous types, because they are
i. Suitable for a.c and d.c both
ii. more efficient
iii Sutable for low power circuits
iv. suitable for high power circuits
Of these statements
i. i and ii are correct ii. i and iii are correct iii. ii and iii are correct iv. ii and iv are correct **(IES 97)**

64. The D.C chopper is fed from the constant voltage mains the duty ratio of chopper is progressively increased while chopper feeds a R-L load. The per unit current ripple would be
i. increased progressively
ii. decreased progressively
iii. decreased to minimum values at α=0.5 and than increase
iv. increased to maximum values at α=0.5 and than decrease **(IES 97)**

UNIT-VIII

1 .a) Explain the simple SCR inverter circuit employing class A-type commutation. Discuss the limitations of this inverter.
b) Explain the operation of a series inverter. In a series inverter R = 4Ω, L = 50mH and C = 6μF. The DC input voltage is 200V DC and output frequency is 6 kHz. SCR turn-off time is 6μs. Find
i) Available circuit turn-off time. ii) Maximum possible frequency (May/June-13)

2 A single-phase half-bridge inverter has load R = 2ohms and DC source voltage Vs/2 = 115 V.
(a) Sketch the waveforms for V_0, i_0, currents through thyristor1 and diode1 and voltage across thyristor T_1. Harmonics other than fundamental component are neglected. Indicate the devices that conduct during the di erent intervals of one cycle.
(b) Find the power delivered to load due to fundamental current.
(c) Check whether forced commutation is required. (May/June 2012)

3 (a) describe the working of a MC Murray inverter. What is its main draw back ? Explain how this drawback is overcome.
(b)What is pulse width modulation ? List the various PWM techniques. (Nov/dec 2012)

4. Explain the operation of a series inverter. In a series inverter R = 4Ω, L = 50H and C = 6μF. The DC input voltage is 200V DC and output frequency is 6 kHz. SCR turn-off time is 6μs. Find
   i. Available circuit turn-off time.
   ii. Maximum possible frequency. **(Dec 2011)**

5. Explain the operation of single-phase, full-bridge inverter.
   A single-phase, full bridge inverter is fed from a dc source such that fundamental component of output voltage is 230V. Find the rms value of thyristor diode currents, where the load values are R = 2Ω, X_L = 8Ω and X_C = 6Ω.**(Dec 2011)**

6. i. Explain the operation of single phase bridge inverter with the help of waveform.
   ii. Why PWM control is implemented in inverter circuits? Explain any two PWM control techniques employed in single phase inverters. **(May 11)**

7. i. Why is it not possible to obtain pure sine wave output from a single phase bridge inverter? Derive an expression for its output voltage in terms of harmonic components.
   ii. Calculate the output frequency of series inverter with the following components:
   L= 6mH, C= 1.2 μF, load resistance = 100 ohms, Take T_{off}= 0.2 msec.
   Also find the range of output frequency if the load is changed from 40 ohms to 140 Ohms. **(May 11)**

8. Write short notes on:
   i. Advantages of pulse-width modulation control over frequency – modulation control in a chopper control strategy.
   ii. Drawbacks of a basic series inverter.
   iii. Applications of a cyclo converter **(May 11)**

9. Discuss the operation of Mc Murray inverter with the help of circuit diagram and necessary waveforms. **(Nov, June 10)**

10. Discuss various voltage control techniques for single phase bridge inverter with the help of signal waveforms for each of the technique. **(Nov 10)**

11. Explain the operation of Mc Murray-Bedford inverter with the help of neat circuit diagram and necessary waveforms including its commutation process. **(Nov 10)**

12. Discuss the working of a single phase parallel inverter and its commutation process with neat circuit diagram and necessary waveforms. **(June 10, Nov 09)**

13. Explain the operation of a single phase bridge inverter for RL loads with the help of neat circuit diagram and necessary waveforms. **(June 10, Nov 09)**

14. i. Explain the principle of operation of McMurray-Bedford inverter.
   ii. Explain multiple pulse width modulation technique employed in voltage control of inverter? Discuss its merits and demerits. **(Nov 09)**

15. Draw and explain the simple SCR series inverter circuit employing class A type commutation. With the help of important waveforms. State the limitations of this inverter. **(Nov 09, 08,07, 06, 05,Feb 08, 07, Mar 06)**

16. i. What are the different pulse width modulation techniques used for inverters.
   ii. Which of the schemes gives better quality of voltage and current. **(Nov 09, 06, Feb 08, 06)**

17. Compare Sinusoidal pulse width modulation over multiple pulse width modulation.**(Nov 09,04, May 04)**

18. Explain the operation of a parallel inverter and mention its merits. **(Nov 09, 03, June 03)**

19. Explain the forced commutation techniques used for single phase bridge inverter with neat circuits and waveforms. **(Nov 09, Feb 07, Mar 06)**

20. Explain the voltage control in case of single phase bridge inverter circuit, in order to get variable voltage and variable frequency output. **(May 09, Feb 08, Nov 07, 05, Mar 06)**

21. The single phase modified Me Murray full-bridge inverter is fed by dc source of 300V. The d.c. source voltage may fluctuate by ±15% . The current during commutation may vary form 20 to 100A. Obtain the value of commutating components, if the thyristor turn-on time is 20 μs. Also compute the value of R. **(May 09, Nov 07, 06)**

22. Single phase half bridge inverter has a resistive load of R = 3 ohms and dc input voltage E_{dc} = 50V. Calculate
    i. rms output voltage at fundamental frequency E_1
    ii. the output power
    iii. average and peak current of each thyristor. **(May 09, 08, 07, 06, Nov 07, 05)**

22. A single phase full bridge inverter uses a uniform PWM with two pulses per half cycle for voltage control. Plot the distortion factor, fundamental component, and lower order harmonics against modulation index. **(Nov 08, 05, Feb 08)**

23. What are the methods for voltage control within the inverters. Explain in detail with waveforms. **(Nov 08, Mar 06)**

24. Calculate the output frequency of a series inverter circuit with following parameters, L = 10mH, C = 0.1 μF, R = 400 ohms, t_{off} = 0.2 μsec. Also determine the attenuation factor. **(Nov, Feb 08, 07)**

25. The single phase full bridge auxiliary commutated inverter has a load of R = 5 ohms, L = 10mH and C = 25μF. The input dc voltage is V_S = 220V and inverter frequency is f_0 = 60Hz, t_q = 18μs. Determine the optimum values of commutation components C_m and L_m. **(Feb 08, Nov 07, 06)**

26. A single PWM inverter feeds an RL load with R = 10 ohms, and L = 20mH. If the Vs = 120 V, find out the total harmonic distortion in the load current. The width of each pulse is 120^0 and the output frequency is 50Hz. **(Feb 08, Nov 06)**

27. Explain the auxiliary impulse commutation techniques used in the bridge type single phase inverter with neat circuit diagram. **(Feb 08, Nov 05)**

28. A single phase bridge Inverter feeds an RLC series load with R-3 ohms, L=6mH and C= 15mF. The output frequency is 120 Hz, supply voltage in 180V. Express the output voltage in terms of Fourier series and determine.
    i. RMS values of thryistor current load current.
    ii. Current at the instant of commutation consider up to 7th harmonics only. **(Nov 05)**

29. i. A single-phase bridge Inverter feeds an R-L-C series load with R=3, L=6mH & C=15μF. The output frequency is 120Hz, supply voltage being 180V. Ex-press the output voltage in terms of Fourier series & determine,
        a. RMS values of thyristor current load current.
        b. Current at the instant of commutation considering up to 7th harmonics only.
    ii. What is meant by load commutation in an Inverter? Under what condition commutation can be achieved by load. **(May 05)**

30. A single PWM full bridge inverter feeds an RL load with R = 10 ohms and L = 10 mH. If the source voltage is 120V, find out the total harmonic distortion in the output voltage and in load current. The width of each pulse is 1200 and output frequency is 50Hz. **(May 05)**

31. Explain Single pulse width modulation technique in a single phase bridge Inverter and mention its salient points. **(Nov, May 04)**

32. A three phase fully controlled converter has R-L load of 1.5W and 4.5mH respectively and back Emf of 12V, the input voltage is 150V (rms)at 60Hz. Give the SPICE representation of the model circuit to calculate average and RMS thyristor current and instantaneous o/p current at $w_t = \alpha = 30^0$. **(Nov 04)**

33. i. Briefly discuss the different methods by which voltage control can be done externally in an inverter.
    ii. State why the output voltage in a parallel Inverter is not a pure sine wave. **(Nov, May 04, Jun 03)**

34. i. Explain the necessity of Inverters and list out the different applications of the same.
    ii. Briefly explain the different types of Inverters with working principle. **(Nov, May 04)**

35. i. How it is possible to achieve voltage control within the Inverter. Briefly explain them.

ii. Compare Single pulse width modulation over Multiple pulse width modulation technique. **(May 04)**

36. i. Explain briefly the commutation process in an auxiliary commutated inverter with waveforms.
    ii. State the factors, which are going to affect the commutation interval in a McMurray-Bedford Inverter.

37. State why the output voltage in a parallel Inverter is not a pure sine wave. **(May 04)**

38. Compare single pulse width modulation with multiple pulse width modulation technique. **(May 04)**

39. i. Give the difference between principle of operation of series and parallel Inverter circuits.
    ii. Distinguish between different methods commonly used for forced commutation in Inverters **(Nov, June 03)**

40. Mention the purpose of feedback diodes in Inverter and condition under which those are not required. **(Nov, June 03)**

41. i. Explain why output voltage control is required in Inverters.
    ii. Briefly list out the merits and demerits of any three types of voltage control technique used at the input of Inverter. **(Nov 03)**

42. i. Discuss the main classification of dc to ac thyristor converters. Which of these is most commonly employed why? **(May 03)**
    ii. Describe the principle DC chopper operation. Derive an expression for its average dc output voltage.

43. Give two differences between principle of operation of series and parallel inverter circuits. **(May 03)**

44. Distinguish between different methods commonly used for forced commutation in inverters. **(May 03)**

45. Mention the purpose of feedback diodes in inverter and condition under which those are not required. **(May 03)**

46. i. For a single-phase bridge inverter the source voltage is 60V, load is a resistance of 1.2ohm. Determine the RMS value of 1^{st} , 3^{rd} & 5^{th} harmonic o/p current, load power, average and peak current in each thyristor, PIV across thyristor and total harmonic distortion and distortion factor.
    ii. What are the factors to be considered while selecting commutating elements in Inverters? **(May 02)**

47. Briefly list out the merits and demerits of any three types of voltage control technique used at the input of inverter. **(May 02)**

48. Draw the possible output current and voltage waveforms possible in a 1Ø bridge inverter connected with R, R-L, R-C, R-L-C under C under/over damped circuits. Mention whether forced commutation is required or not in each case. Explain the significance of dead zone in series Inverters **(May 02)**

49. Explain briefly the commutation process in an auxiliary commutated inverter with waveforms. State the factors, which are going to affect the commutation interval in a McMurray-Bedford Inverter. **(May 02)**

50. For perfectly balanced operation of a certain 3-phase ac power electronic circuit generates odd harmonics currents of order of five and seven in the three phases of the ac mains. Identify which of these harmonics form a positive sequence system and which forms a negative sequence system. **(GATE 00)**

51. A single phase bridge inverter is fed from a 200 V DC supply and is operated at 50Hz. It is connected to a load having a resistance of 20 ohms and an inductance of 0.2 H. Draw the load current waveform in the steady indicating the peak values **(GATE 97)**

52. In a self-controlled synchronous motor fed from a variable frequency inverter
    i. The rotor poles invariably have damper windings
    ii. There are stability problems
    iii. The speed of the rotor decides stator frequency
    iv. The frequency of the stator decides the rotor speed. **(GATE 97)**

53. With the help of equivalent circuits obtain the nature of waveform of phase voltage of a star connected resistive load fed from a three phase DC to AC bridge inverter operating in 180° conduction mode**.(IES 02)**

54. Compared to a single phase half-bridge inveter, the output power of a single phase full-bridge inverter is hgiher by a factor of
    i. 12 ii. 8 iii. 4 iv.2 **(IES 02)**

55. What is PWM? Explain sinusoidal pulse width modulation as used in PWM inverters. Discuss the conditions leading to the number of pulses generated per half Cycle as fc/2f or (fc/2f-1). Here fc and f are the frequencies of carrier reference Signals respectively. Bring out the important features of SPM.**(IES 01)**

56. The most suitable solid state converter for controlling the sped fo the thre-phase cage motot at 25Hz is
   i. Cycloconverter
   ii. Current source inverter
   iii. Voltage source inverter
   iv. Load commutated inverter **(IES 01)**

57. In case of voltage source inverter, free wheeling can be avoided for the lad of
   i. inductive nature
   ii. capacitive nature
   iii. resistive nature
   iv. back emf nature **(IES 01)**

58. PWM switching is preferred in voltage source inverters for the purpose of
   i. controlling output voltage
   ii output harmonics
   iii. reducing filter size
   iv. controlling output voltage, output harmonics and reducing filter size. **(IES 01)**

59. Discuss with necessary circuit diagram and waveform the principle of operation of 1 phase full bridge inverter. Obtain an expression of instantaneous load current for RL load. Name the different methods used for controlling the output voltage of inverters. Explain briefly the sinusoidal pulse width modulation techniques. **(IES 2000)**

60. A voltage source inverter will have better performance if its.
   i. load inductance is small and source inductance is large
   ii. Both load and source inductances are large
   iii. both load and source inductances are small
   iv. load inductance is large and source inductance is small **(IES 2000)**

61. Consider the following features:
   i. Inherent short circuited protection.
   ii. Regeneration capability.
   iii. Need for inverter grade thyristors.
   iv. Voltage spikes across the load. **(IES 2000)**

62. A series capacitor comuted inverter can operate satisfactorily
   a. b. c. d. irrespective of the values of R, L and C**(IES 2000)**

63. A single phase full-bridge voltage source inverter operating in square wave mode supplies a purely indctive load. If the inverter time period is T, then the time duration for which the feedback diodes conduct in a cycle is
   i. T ii. T/2 iii. T/4 iv. T/8 **(IES 2000)**

64. Explain the principle of operation of a 1 phase inverter. Name the commonly used techniques for controlling the gain and hence the output of the inverter. Explain the Multiple pulse width modulation technique. **(IES 97)**

65. What is a resonant pulse converter? List different types of converters. Discuss the advantage and disadvantages of parallel resonant inverters. **(IES 97)**

66. A single phase voltage source square wave inverter feeds pure inductive load.The waveform of the load current will be

   i. sinosoidual ii. rectangular iii. trapezoidal iv. triangular **(IES 97)**

67. Consider the following satatements **(IES 97)**
   The diodes in avoltage source inverter(Mc Murray inverter) sahould be able to
   i. withstand a large voltage in the reverse direction
   ii. carry the commuataing current excess of load current
   iii. provide the required reverse bias to the outgoing thyristor
   iv. feedback the reactive currentto the source
   Of these sataements

a. 1,2 and 3 are correct
b. 1,3 and 4 are correct
c. 2,3 and 4 are correct
d. 1,2 and 4 are correct

68. Explain the principle of operation of single phase inverter. Name the commonly used techniques for controlling the gain and hence the output of inverter. Explain multiple PWM technique. **(IES 97)**

7.4.13 Assignments

Unit I

1 Sketch the dynamic characteristics of SCR during turn-on and turn-off process.

2 Explain briefly about turn on and turn off methods of SCR.

3 Define and explain turn-on and turn-off times of an SCR

4 Describe the different modes of operation of a thyristor with the help of schematic diagram of static VI characteristics and represent the holding and latching current.

5 Compare power MOSFET and IGBT.

Unit II

1 Explain the two transistor analogy of thyristor.

2 What are dv/dt and di/dt ratings of SCRs? What happens if there ratings are exceeded?

3 Explain about class-C and class-D type of commutation methods.

4 For the class-D commutation circuit, compute the value of the commutation capacitor `C' and commutating inductor `L' for the following data: E_{dc} = 50V, $I_{L(max)}$ = 50A, turn-o of SCR1 = 30 sec, chopping frequency f = 500Hz and the load voltage variation required is 10 to 100%.

5 What are the different firing circuits used for triggering SCR?

Unit III

1 Explain the operation of a single-phase, half-wave converter for R-load with neat circuit diagram and necessary waveforms.

2 A resistive load of 10 ohms is connected through a half-wave SCR circuit to 220V, 50Hz, 1- phase source. Calculate the power delivered to load for a firing angle of 60^0.

3 An RL-load energized from 230V, 50Hz, 1- source through a single thyristor, has R = 10 and L=0.08 H. If thyristor is triggered in every positive half cycle at = 75^0, nd the current expression as the function of time.

4 Explain the operation of a single phase, half wave converter for α=60 with RL load with free wheeling diode. Derive the average output voltage and current expressions.

5 Explain the purpose of free wheeling diode.

Unit IV

1 From the fundamentals derive the performance parameters of single phase full converters.

2 A single phase full converter bridge is connected to RLE load. The source voltage is 230V, 50Hz. The average load current of 10A is connected over the working range. For R=0.4 Ω and L=2mH, calculate
(i) Firing angle delay for E=120V (ii) Firing angle delay for E= -120V.

3 A 20 V, 50 Hz, single phase ac supply feeds a highly inductive load through a fully controlled rectifier. A free wheeling diode is connected across load. The forward voltage drops across SCR and diode are 1.5 V and 0.7V respectively. Firing angle is 60^0. Find:
(a) Average load voltage neglecting voltage drops across SCR and diode.

(b) Average load voltage taking voltage drops across SCR and diode into account. Sketch the output voltage waveform for both the cases.

4 Explain the operation of single phase full wave controlled rectifier feeding an inductive load. Consider the effect of source inductance and derive an expression for output voltage in terms of source inductance and firing angle.

5 What are the advantages and disadvantages of a single-phase bridge converter over single-phase midpoint converter?

Unit V

1 Explain the effect of free wheeling diode in the case of three phase converters with neat waveforms.

2 Explain clearly the operation of a three phase dual converter.

3 A three phase fully controlled bridge is connected to a highly inductive load with a resistance of 60 ohms. Determine average voltage, average load current and input power factor for firing angle of 30^0. The input supply voltage is 400 V, 50Hz. Assume load current to be ripple free.

4 A three phase, half wave rectifier is supplied by a transformer with a secondary voltage of 180V (rms) at 50Hz. Other data are R = 10Ω and L = 10mH, and back emf E_b is 153V. Determine the average output voltage and average load current for a ring angle of 60^0. Also sketch the waveforms.

5 A 3 phase full converter charges a battery from a 3 phase supply of 230V 50Hz. The battery emf is 200 V and its internal resistance is 0.5 ohms. On account of inductance connected in series with battery, charging current is constant at 20A. Compute firing angle delay and the supply power factor.

Unit VI

1 with neat diagram and waveforms explain the principle of operation of single phase mid point type step down cyclo-converter.

2 A single phase voltage controller feeds power to a resistive load of 3Ω from 230V, 50Hz source. Calculate

i) The maximum value of average and rms thyristor current for any firing angle

ii) The maximum circuit turn of time for any firing angle.

3 A single-phase, full wave, ac voltage regulator has an input voltage of 150V (rms) and a load of 8ohm resistance. The ring angle of thyristors is 30^0. Find:

(a) Average output voltage

(b) rms output voltage

(c) Power output.

Also draw the output voltage and current waveforms.

4 What are steps involved in determining the output voltage waveform for single phase ac voltage controller with two SCRs connected back to back?

5 with neat diagram and waveforms explain the principle of operation of single phase bridge type step up cyclo-converter.

Unit VII

1 Explain the operation of a dc – dc converter with a load commutation circuit. Sketch the waveforms of current, voltage across thyristor, load voltage.

2 Explain the operation of a chopper in any two-quadrants in detail with circuit diagram.

3 A chopper has an input voltage of 600V. It feeds an RL load having R = 10Ω Chopping frequency is 500Hz. Find load inductance so that the maximum ripple in load current is 20% of the average current of 50A.

4 With neat circuit diagram and wave forms explain the operation of jones chopper.

5 A step –up chopper has input voltage of 220V and out put voltage of 600V. If the non conducting time of thyrister chopper is 100 micro sec, compute the pulse width of output voltage. In case pulse width is halved for constant frequency operation find th e new out put voltage.

Unit VIII

1 Describe the working of a MC Murray inverter. What is its main draw back ? Explain how this drawback is overcome.

2 What is pulse width modulation ? List the various PWM techniques and Explain.

3 A single-phase half-bridge inverter has load R = 2ohms and DC source voltage Vs/2 = 115 V.

(a) Sketch the waveforms for V_0, i_0, currents through thyristor1 and diode1 and voltage across thyristor T_1. Harmonics other than fundamental component are neglected. Indicate the devices that conduct during the di erent intervals of one cycle.

(b) Find the power delivered to load due to fundamental current.

(c) Check whether forced commutation is required.

4 Explain the simple SCR inverter circuit employing class A-type commutation. Discuss the limitations of this inverter.

5 Explain the operation of a series inverter. In a series inverter R = 4Ω, L = 50mH and C = 6μF. The DC input voltage is 200V DC and output frequency is 6 kHz. SCR turn-off time is 6μs. Find

i) Available circuit turn-off time. ii) Maximum possible frequency.