POORNIMA
COLLEGE OF ENGINEERING

COURSE: B. Tech

SEMESTER: V th

SUBJECT: Power Electronics

SUB. CODE: 5EE1

CONTENT: RTU Course/Subject Syllabus, Blown-up, Deployment, Zero Lectures, Detailed lecture notes with cover page, Tutorial/Home-Assignment Sheets etc

SESSION: 2018-19

NAME OF FACULTY: Ravi Shankar Singh

DEPARTMENT: Electrical

CAMPUS: PCE

ISI-6, RIICO Institutional Area, Sitapura, Jaipur-302022 (Rajasthan)

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COLLEGE OF ENGINEERING

Course FileContent:-

S. No.	ITEM
1	(a) College Vision, Mission and Quality Policy
	(b) Department Vision, Mission, PEO's, PO's, PSO's
2	Syllabus
3	ABC Analysis
4	Blown-Up
5	Deployment
6	Zero Lecture (Department Vision, Mission, PEO's, PO's, PSO's, CO's vs PO's, Mapping, CO's vs PSO's Mapping, Target & Attainment)
7	Detailed lecture note with cover page
8	5 Year RTU Question Papers
9	Tutorial Sheets / Home Assignment
10	Open Book Test Question Paper
11	Important Question Bank
12	Expert Video Lecture(In CD)
13	Recording of Self Video Lecture
14	Audio Recordings of 2-lectures and 1-tutorial (if applicable)
15	Others, if any

NAME OF THE SUBJECT / ~~LAB~~ Power electronics

CODE 5EE1 YEAR III

NAME OF FACULTY Ravi Shankar Singh

DESIGNATION Asst. Prof. DEPARTMENT Electrical.

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POORNIMA
COLLEGE OF ENGINEERING

Calendar for Odd Semester (2018-2019)

July

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
[illegible]	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

August

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

September

Sun	Mon	Tue	Wed	Thu	Fri	Sat
		Mid-term-I.				1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						

October

un	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
4	15	16	17	18	19	20
	22	23	24	25	26	27
[illegible]	29	30	31			

November

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	Mid-term-II			1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

December

Sun	Mon	Tue	Wed	Thu	Fri	Sat
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30	31					

Note: - Please do the needful.

1) Indicate/Underline the Mid-Term Exams dates as per Academic Calendar (AC).
2) Encircle the holidays as per AC.
3) Calculate the number of days available for actual conduction of classes as per time table provided by HOD.
4) If you are pursuing higher studies please plan for replacement of classes.

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Achieving Excellence Together

POORNIMA FOUNDATION

ACADEMIC CALENDAR

(Subject to revision as per RTU notifications)

ODD SEMESTER (2018-19)

For all Engineering Faculty and Students of PCE / PIET / PGI only

June, 2018

Friday, 15	Eid-ul-fitar (Holiday)
Monday, 25	First Day for all Faculty & Staff Members
Monday, 25-Saturday, 30	Training of all Faculty & Staff Members

July, 2018

Monday, 02	First Day B.Tech. III Sem & V Sem
Monday, 09	First Day, B. Tech. VII Sem.

August, 2018

Wednesday, 01	First Day, B. Tech. I Sem.
Wednesday, 01-Wednesday, 15	Orientation Programme for B.Tech. First Year
Wednesday,15	Celebration of Independence Day & Faculty Felicitation Program
Wednesday, 22	Eid-ul-zuha (Holiday)
Sunday, 26	Raksha Bandhan (Holiday)

September, 2018

Monday, 03-Saturday 08	First Mid Term Exam B.Tech. V & VII Sem
Wednesday, 05	Celebration of Teachers Day at Dept. level,
Saturday, 15	Blood Donation Camp and Activities under WISE
Monday, 17-Saturday, 22	Celebration of Engineers' Day and Inter College Debate Competition "Manthan"
Monday, 24-Thursday, 27	First Mid Term Exam B.Tech. I & III Sem.
Friday, 28-Saturday, 29	Department Day (PCE)
	Department Day (PIET)

October, 2018

Monday, 01	Department Day (PGI)
Monday, 02	Annual Day Kalanidhi-2018 & Prize Distribution Ceremony
Friday, 19	Vijay Dashami (Holiday)
Friday, 26	Last Teaching Day of VIII Sem.
Saturday, 27	Last Teaching Day of V Sem.
Monday, 29 - Saturday, 3 Nov.	Second Mid Term Exam B.Tech. V & VII Sem.

November, 2018

Monday, 05-Saturday, 10	Diwali (Holiday)
Monday, 12 - Wednesday, 14	End-Term Practical Exam B.Tech. V & VII Sem.
Saturday, 24	Last Teaching Day of I & III Sem.
Monday, 26 - Saturday, 01 Dec.	Second Mid Term Exam B.Tech. I & III Sem.

December, 2018

Monday, 03 - Wednesday 05	End-Term Practical Exam B.Tech. I & III Sem.
Monday, 25	Christmas (Holiday)

JUNE 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

JULY 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

AUGUST 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

SEPTEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

OCTOBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

NOVEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
				1	2	3
4	5	6	7	8	9	10
11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	28	29	30	

DECEMBER 2018

Sun	Mon	Tue	Wed	Thu	Fri	Sat
30	31					1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29

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POORNIMA COLLEGE OF ENGINEERING

TIME TABLE FOR ODD SEM. SESSION -2018-19

DEPARTMENT OF ELECTRICAL ENGINEERING

DAY/TIME	8:00-9:00	9:00-10:00	10:00-11:00	11:00-11:40	11:40-12:40	12:40-01:40	01:40-02:30
MONDAY	7EE6/C CT-04		7EE6/C3 AT-10	LUNCH			7EE6/D1 CT-23
TUESDAY		5EE1/A3 AT-11	5EE1/A1 AT-10		5EE1A AT-05	7EE6.2/D CT-23	7EE6/C1 5EE1/A AT-05 C1
WEDNESDAY	5EE7/B2/	AT-12				7EE6.2/D CT-23	
THURSDAY	5EE1/A AT-05		7EE6/C CT-04		5EE1/A2 AT-10	~~7EE6/D2~~ CT-23	5EE1/B2 C2 AT-11
FRIDAY	5EE1/B2 AT-11		7EE6.2/D CT-23		7EE6/C CT-04	5EE7/B1	/AT-12
SATURDAY						5EE1/A AT-05	

Dinesh Kr. Sharma/ Anil Pratap Singh
TIME TABLE COORDINATOR

Dr. Virendra Sangtani
HOD, EE

Dr. Om Prakash Sharma
DIRECTOR, PCE

Ravi Shankar Sharma
(RSS)

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Course: B. Tech.
Name of Faculty: Ravi Shankar Singh

ABC Analysis
Class/Section: V Sem.
Name of Subject: Power Electronics

Date: 29th June, 2018
Subject Code: 5EE1A

Unit No.	CO	Category A	Category B	Category C	Preparedness for "A" topics
1	CO1	Thyristor Commutation methods	Construction, Principle of operation, Characteristics and applications of Power Transistor & Thyristor, Characteristics of GTO, Power MOSFET and IGBT	*DIAC, MCT, TRIAC Two-Transistor Model of Thyristor*	Extra Revision class
2	CO2	Rating extension by series and parallel connections	Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on, triggering circuits for SCR: R, RC, UJT relaxation oscillator	string efficiency, Protection of SCR-Protection against over voltage, over current, dv/dt, di/dt, Gate protection	QUIZ
3	CO3 & CO4	Three phase full converters with RL load, Three phase dual converters	Single phase half & full wave converters with RL & RLE load, Single phase dual converters	Three phase half wave converters.	OBT
4	CO5	Single and three-phase semi converters with RL & RLE load.	Power factor improvement-Extinction angle control, symmetrical angle control, pulse width modulation control and sinusoidal pulse width modulation control	Inversion operation, Effect of load and source impedances	Video lecture
5	CO6	Analysis of type A Chopper Voltage, current and load commutated chopper	Multiphase Chopper	Step Up/Down Copper, Control strategies, Chopper Configurations	PPT

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POORNIMA
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BLOWN UP SYLLABUS

Date: 29-06-2018

Campus: PCE Course: B.TECH Class/Section: III Year Code: 5EE1A

Name of Faculty: RAVI SHANKAR SINGH Name of Subject: POWER ELECTRONICS

S.No.	Topic as per Syllabus	BLOWN UP TOPICS (Upto 10 TIMES SYLLABUS)
1	UNIT-I POWER SEMICONDUCTOR DEVICES :- **1.1** Introduction	1.1.1 The p-n junction. 1.1.2 Depletion layer. 1.1.3 Power diode. 1.1.4 Structure of power diode. 1.1.5 Characteristics. 1.1.5.1 V-I Characteristics 1.1.5.2 Reverse recovery characteristics 1.1.6 Types of power diode & applications.
2	**1.2** Power Transistor	1.2.1 Bipolar Junction Transistors. 1.2.1.1 Steady State Characteristics. 1.2.1.2 Output/Input Characteristics. 1.2.1.3 Relation between alpha and beta 1.2.1.4 BJT Switching Performance. 1.2.1.5 Safe operating area 1.2.2 Applications
3	1.3Thyristor	1.3.1 Introduction. 1.3.2 Construction and Terminal Characteristics. 1.3.2.1 Working Principal. 1.3.2.2 Static I-V Characteristics. 1.3.3 Thyristor Turn on Methods. 1.3.4 Switching Characteristics 1.3.4.1 Switching Characteristics during turn-on. 1.3.4.2 Switching Characteristics during turn-off. 1.3.5 Applications.
		1.4.1 Basic Structure

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	1.4 GTO	1.4.1.1 Turn-on Process. 1.4.1.2 Turn-off Process. 1.4.2 Statics I-V Characteristics. 1.4.3 Switching Performance 1.4.3.1 Gate Turn-on. 1.4.3.2 Gate Turn-off. 1.4.4 Comparison Between GTO and Thyristor. 1.4.5 Applications & rating. 1.4.6 Advantage and disadvantage.
5	**1.5** Power MOSFET	1.5.1 Introduction 1.5.2 Basic structure 1.5.3 Characteristics 1.5.3.1 Output Characteristics. 1.5.3.2 Transfer Characteristics. 1.5.3.3 Switching Characteristics. 1.5.4 Comparison Between PMOSFET and BJT. 1.5.5 Applications
6	**1.6** Power IGBT	1.6.1 Introduction. 1.6.2 Basic Structure. 1.6.3 Equivalent Circuit. 1.6.4 Working 1.6.4.1 IGBT Characteristics. 1.6.4.2 Switching Characteristics. 1.6.5 Application of IGBT. 1.6.6 Comparison of IGBT with MOSFET.
7	**1.7** DIAC	1.7.1 Introduction 1.7.2 Working 1.7.3 V-I Characteristic 1.7.4 Applications
8	**1.8** TRIAC	1.8.1 Introduction 1.8.2 Working 1.8.3 V-I Characteristic 1.8.4 Applications
9	**1.9** Two-Transistor Model of Thyristor	1.9.1 Introduction 1.9.2 Working 1.9.3 Applications
10	1.10 Thyristor Commutation Method	1.10.1 Methods of commutation 1.10.1.1 Load commutation 1.10.1.2 Resonant pulse commutation 1.10.1.3 Complementary commutation 1.10.1.4 Impulse commutation

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		1.10.1.5 External commutation 1.10.1.6 Line commutation 1.10.2 Working
1	UNIT-II **SCR: -** 2.1 Introduction	2.1.1 Construction of SCR 2.1.2 Charneteristics of SCR 2.1.3 Working of SCR 2.1.4 Anode Voltage Rating 2.1.5 Latch current 2.1.6 Holding current 2.1.7 break over voltage
2	2.2 Specification and ratings	2.2.1 Current Rating 2.2.2 Voltage Rating 2.2.3 Power Rating
3	2.3 Pulse transformer	2.3.1 Introduction 2.3.2 Construction 2.3.3 Working Principle
4	2.4 Optical isolators	2.4.1 Introduction 2.4.2 Construction. 2.4.3 Working Principal.
5	2.5 Firing Circuits	2.5.1 Resistance method 2.5.1.1 Introduction 2.5.1.2 Working. 2.5.1.3 Advantage and disadvantage 2.5.2 RC. 2.5.2.1 Introduction 2.5.2.2 Working. 2.5.2.3 Advantage and disadvantage 2.5.3 UJT relaxation oscillator. 2.5.3.1 Introduction 2.5.3.2 Working. 2.5.3.3 Advantage and disadvantage
6	2.6 Rating extension by series connections	2.6.1 Series connections. 2.6.1.1 Unequal voltage distribution 2.6.2 Parallel connections.
7	2.7 String efficiency.	
8	2.8 Protection of SCR-Protection against.	2.8.1 Introduction. 2.8.2 Over voltage. 2.8.2.1 Suppression of Overvoltage

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		2.8.3 Over current. 2.8.3.1 Electronics Crowbar Circuit. 2.8.4 dv/dt& di/dt 2.8.4.1 Sunbber Circuit 2.8.5 Gate protection.
	UNIT-III **CONVERTERS-I :-**	
1.	3.1 Introduction.	3.1.1 Principal of phase control
2.	3.2 Single phase half wave converters with R load.	3.2.1 Introduction 3.2.2 Circuit Diagram, Waveforms 3.2.3 Working.
3.	3.3 Single phase half wave converters with RL load.	3.3.1 Introduction 3.3.3 Circuit Diagram, Waveforms 3.3.3 Working.
4.	3.4 Single phase half wave converters with RLE load	3.4.1 Introduction 3.4.2 Circuit Diagram, Waveforms 3.4.3 Working.
5.	3.5 Single Phase full wave converters with RL load	3.5.1 Introduction 3.5.2 Circuit Diagram, Waveforms 3.5.3 Working.
6.	3.6 Single Phase full wave converters with RLE load	3.6.1 Introduction 3.6.2 Circuit Diagram, Waveforms 3.6.3 Working.
7.	3.7 Single phase dual converters	3.7.1 Introduction 3.7.2 Circuit Diagram, Waveforms 3.7.3 Working.
8.	3.8 Three phase half wave converters with R load	3.8.1 Introduction 3.8.2 Circuit diagram, Waveforms. 3.8.3 Working.
9.	3.9 Three phase half wave converters with RL load	3.9.1 Introduction 3.9.2 Circuit diagram, Waveforms. 3.9.3 Working.
10.	3.10 Three phase full converters with RL load	3.10.1 Introduction 3.10.2 Circuit diagram, Waveforms. 3.10.3 Working.

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11.	3.11 Three phase dual converters	3.11.1 Introduction 3.11.2 Circuit diagram, Waveforms. 3.11.3 Working.
	UNIT-IV **CONVERTERS-II: -**	
1.	4.1 Introduction.	
2.	4.2 Single-phase semi converters with RL load	4.2.1 Introduction 4.2.2 Circuit Diagram, Waveforms 4.2.3 Working.
3.	4.3 Single-phase semi converters with RLE load	4.3.1 Introduction 4.3.2 Circuit Diagram, Waveforms 4.3.3 Working.
4.	4.4 Three-phase semi converters with RL load	4.4.1 Introduction 4.4.2 Circuit Diagram, Waveforms 4.4.3 Working.
5.	4.5 Three-phase semi converters with RLE load.	4.5.1 Introduction 4.5.2 Circuit Diagram, Waveforms 4.5.3 Working.
6.	4.6 Power Factor Improvement-	4.6.1 Introduction 4.6.2 Extinction angle control 4.6.2.1 Introduction 4.6.2.2 Working. 4.6.3 Symmetrical angle control 4.6.3.1 Introduction 4.6.3.2 Working. 4.6.4 Pulse width modulation control 4.6.4.1 Introduction 4.6.4.2 Working. 4.6.5 Sinusoidal pulse width modulation control. 4.6.5.1 Introduction 4.6.5.2 Working.
7	4.7 Inversion operation	
8	4.8 Effect of load and source impedances	
	UNIT-V **DC-DC CONVERTERS: CHOPPERS:**	
1.	5.1 Introduction	
2.	5.2 Principle of Chopper	

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3.	5.3 Step Up/Down Copper	5.3.1 Step Down Chopper. 5.3.2 Step Up Chopper.
4.	5.4 Chopper Configurations	5.4.1TYPE-A 5.4.2TYPE-B 5.4.3TYPE-C 5.4.4 Four Quadrant Chopper 5.4.5 Multiphase Chopper
5	5.5 Analysis of class A Chopper	
6	5.6Chopper commutation Techniques	5.6.1Voltage Commutated Chopper 5.6.2 Current Commutated Chopper 5.6.3Load Commutated Chopper

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SYLLABUS DEPLOYMENT

Name of Faculty : RAVI SHANKAR SINGH | College : PCE | DATE: 29/06/2018 | Department : EE

Name of Subject With Code: POWER ELECTRONICS (5EE1A) | Branch: EE | Class: VTH

S.No	TOPICS AS PER UNIVERSITY SYLLABUS	LECT.NO.	PLANNED DATE	ACTUAL DEL. DATE	REASON OF DEVIATION	COURSE OUTCOME	REF. BOOK
1	*Zero lecture* 0.1 Introduction to subject 0.2 Definition 0.3 History 0.4 Application	L0	3/7	3/7			
2	**UNIT-I** **POWER SEMICONDUCTOR DEVICES** **Unit Introduction** **Lecture Introduction** **1.1** Introduction **The p-n junction.** **1.1.2 Depletion layer.** 1.1.3 Power diode. 1.1.4 Structure of power diode. 1.1.5 Characteristics. **1.1.5.1 V-I Characteristics** **1.1.5.2 Reverse recovery characteristics** 1.1.6 Types of power diode & applications.	L1	5/7	4/7	Adjustment	CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
3	**Lecture Introduction** 1.2 Power Transistor **1.2.1** Characteristics of Power Transistor. **1.2.2** Bipolar Junction Transistors **1.2.2.1** Steady State Characteristics. **1.2.2.2** Output/Input Characteristics **1.2.2.3** BJT Switching Performance. **1.2.3**Applications **Lecture Conclusion**	L2	7/7	5/7	Adjustment Previous lecture.	CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid

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Lecture Introduction **1.3** Power MOSFET. **1.3.1** Introduction **1.3.2 Output** Characteristics. **1.3.3**Tansfer Characteristics. **1.3.4** Switching Characteristics. **1.3.5** Applications **Lecture Conclusion**	L3	10/7	7/7	Previous lecture adjusted.	CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.4** Power IGBT. **1.4.1** Introduction. **1.4.2** Basic Structure. **1.4.3** Equivalent Circuit. **1.4.4** Working **1.4.4.1** IGBT Characteristics. **1.4.4.2** Switching Characteristics. **1.4.5** Application of IGBT. **1.4.6** Comparison of IGBT with MOSFET **Lecture Conclusion**	L4	12/7	9/7 9/7 (Revision of Previous devices)	adjustment	CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.5**Thyristor. **1.5.1** Introduction. **1.5.2** Construction and Terminal Char. **1.5.2.1** Working Principle. **1.5.2.2** Static I-V Characteristics **1.5.3**Thyristor Turn on Methods. **Lecture Conclusion**	L5	14/7	10/7 & 12/7	Previous lecture adjusted.	CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.5.4** Switching Characteristic of thyristor **1.5.4.1**Switching Characteristics during turn-on. **1.5.4.2**Switching characteristics during turn-off. **1.5.5** Applications. **Lecture Conclusion**	L6	17/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.6** GTO. **1.6.1** Basic Structure **1.6.1.1** Turn-on Process. **1.6.1.2** Turn-off Process. **1.6.2** Statics I-V Characteristics. **1.6.3** Switching Performance **1.6.3.1** Gate Turn-on. **1.6.3.2** Gate Turn-off. **1.6.4** Comparison Between GTO and Thyristor. **1.6.5** Applications	L7	19/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid

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Lecture Conclusion						
Lecture Introduction **1.7** Two-Transistor Model of Thyristor **1.7.1** Introduction **1.7.2** Working **1.7.3** Applications **Lecture Conclusion**	L8	21/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.8** DIAC **1.8.1** Introduction **1.8.2** V-I Characteristics **1.9** TRIAC **1.9.1** Introduction **1.9.2** V-I Characteristics **1.9.3** Operating Modes **Lecture Conclusion**	L9	24/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.10** MCT **1.10.1** Introduction **1.10.2** V-I Characteristic **Lecture Conclusion**	L10	26/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **1.11** Thyristor Commutation Methods **1.11.1** Types **Lecture Conclusion**	L11	28/7			CO1	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Revision of Unit-1	L12	31/7				
UNIT-II **SCR: -** **Unit Introduction** **Lecture Introduction** **2.1** Introduction **2.2** Specification and ratings **2.2.1** Anode Voltage Rating **2.2.2** Current Rating. **Lecture Conclusion**	L13	2/8			CO2	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **2.3** Pulse transformer. **2.3.1** Introduction **2.3.2** Construction. **2.3.3** Working Principle. **Lecture Conclusion**	L14	2/8			CO2	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **2.4** Optical isolators	L15	4/8			CO2	Text Book-Power

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2.4.2 Construction. 2.4.3 Working Principle. **Lecture Conclusion**						Electronics by P.S. Bimbhra Ref. Book- Power
Lecture Introduction **2.5** Firing Circuits: **2.5.1** Resistance Method. **2.5.1.1** Introduction **2.5.1.2** Working. **2.5.2** RC. **2.5.2.1** Introduction **2.5.2.2** Working **2.5.3** UJT relaxation oscillator. **2.5.3.1** Introduction **2.5.3.2** Working. **Lecture Conclusion**	L16	7/8			CO2	Electronics by M. H. Rashid
Lecture Introduction **2.6** Rating extension by series connections. **2.6.1** Series connections. **2.6.2** Parallel connections. **2.7** String efficiency. **Lecture Conclusion**	L17	9/8			CO2	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **2.8** Protection of SCR- Protection against. **2.8.1** Introduction. **2.8.2** Over voltage. **2.8.2.1** Suppression of Overvoltage **2.8.3** Over current. **2.8.3.1** Electronics Crowbar Circuit. **2.8.4** dv/dt& di/dt **2.8.4.1** Snubber Circuit **2.8.5** Gate protection. **Lecture Conclusion**	L18	11/8			CO2 CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
QUIZ	L19	11/8				
UNIT-III **CONVERTERS-II :-** **Unit Introduction** **Lecture Introduction** **3.1** Introduction **3.2** 1- Ø half wave converters with R load **3.2.1** Introduction **3.2.2**CircuitDiagram,Waveforms **3.2.3** Working **Lecture Conclusion**	L20	14/8			CO3 CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid Text Book- Power Electronics by P.S. Bimbhra Ref. Book-
Lecture Introduction **3.3** 1- Ø half wave converters	L21	16/8				

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with RL load. **3.3.1** Introduction **3.3.2**CircuitDiagram, Waveforms. **3.3.3** Working. **3.3.4** RL load with Freewheeling Diode **Lecture Conclusion**						Power Electronics by M. H. Rashid
Lecture Introduction **3.4** 1- Ø half wave converters with RLE load. **3.4.1** Introduction **3.4.3**CircuitDiagram, Waveforms. **3.4.3** Working. **Lecture Conclusion**	L22	18/8			CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **3.5** 1- Ø full wave converters with RL load. **3.5.1** Introduction **3.5.2**CircuitDiagram, Waveforms. **3.5.3** Working. **Lecture Conclusion**	L23	18/8			CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **3.6** 1- Ø full wave converters with RLE load. **3.6.1** Introduction **3.6.2**CircuitDiagram, Waveforms. **3.6.3** Working **Lecture Conclusion**	L24	21/8			CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **3.7** 3-Ø half wave converters with R load. **3.7.1** Introduction **3.7.2**CircuitDiagram, Waveforms. **3.7.3** Working. **Lecture Conclusion**	L25	23/8			CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **3.8** 3-Ø half wave converters with RL load. **3.8.1** Introduction **3.8.2**CircuitDiagram, Waveforms. **3.8.3** Working. **Lecture Conclusion**	L26	25/8			CO3	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **3.9** 3-O full converters with RL load. **3.9.1** Introduction	L27	25/8				Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Pow...

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Waveforms. **3.9.3** Working. **Lecture Conclusion**					CO3	Electronics by M. H. Rashid
Lecture Introduction **3.10** 1- Ø and 3- Ø dual converters. **3.10.1** Introduction **3.10.2**CircuitDiagram, Waveforms. **3.10.3** Working. **Lecture Conclusion**	L28	28/8				
OBT I **First Assessment**	L29 L30	30/8 1/9				
UNIT-IV **CONVERTERS-II: -** **Unit Introduction** **Lecture Introduction** **4.1** Introduction. **4.2** 1- Ø semi converters with RL load. **4.2.1** Introduction **4.2.2**CircuitDiagram, Waveforms. **4.2.3** Working. **Lecture Conclusion**	L31	11/9			CO4	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **4.3** 1- Ø semi converters with RLE load. **4.3.1** Introduction **4.3.2**CircuitDiagram, Waveforms. **4.3.3** Working. **Lecture Conclusion**	L32	13/9			CO4	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **4.4** 3-Ø semi converters with RL load. **4.4.1** Introduction **4.4.2**CircuitDiagram, Waveforms. **4.4.3** Working. **Lecture Conclusion**	L33	15/9			CO4	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid
Lecture Introduction **4.5** 3-Ø semi converters with RLE load. **4.5.1** Introduction **4.5.2**CircuitDiagram, Waveforms. **4.5.3** Working. **4.6** Inversion operation. **Lecture Conclusion**	L34	18/9			CO4	Text Book- Power Electronics by P.S. Bimbhra Ref. Book- Power Electronics by M. H. Rashid

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Lecture Introduction **4.7** Power Factor Improvement **4.7.1**extinction angle control **4.7.2**symmetrical angle control **4.7.3**Pulse width Modulation and Sinusoidal pulse width modulation	L35	20/9			CO4	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **4.8** Effect of load and source impedances.	L36	22/9			CO5	
Video lecture	L37	25/9				
UNIT-V **DC-DC CONVERTERS: CHOPPERS:** **Unit Introduction** **Lecture Introduction** **5.1** Introduction **5.2**Principle of Chopper **5.2.1** Step Down Chopper. **5.2.2** Step Up Chopper. **Lecture Conclusion**	L38	27/9			CO5	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **5.3** Chopper Configurations. **5.3.1** TYPE-A **5.3.2** TYPE-B **5.3.3** TYPE-C **5.3.4** Four Quadrant Chopper **5.4** Multi Phase Chopper **Lecture Conclusion**	L39	29/9			CO5 CO5 CO5	Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **5.5** Analysis of Type A Chopper **Lecture Conclusion**	L40	2/10				Text Book-Power Electronics by P.S. Bimbhra Ref. Book-Power Electronics by M. H. Rashid
Lecture Introduction **5.6** Voltage Commutated Chopper **Lecture Conclusion**	L41	4/10			CO5	
Lecture Introduction **5.7** Current Commutated Chopper **5.8** Load Commutated Chopper **Lecture Conclusion**	L42	6/10			CO5	
PPT	L43	9/10				

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POORNIMA
COLLEGE OF ENGINEERING

Session: 2018-19(Odd Sem.)

COURSE: B.TECH | **CLASS/SECTION: III**

NAME OF FACULTY: Ravi Shankar Singh | **Branch: Electrical Engineering**

Zero Lecture

1). Name of Subject with Code : **POWER ELECTRONICS (5EE1A)**
Course Nature (Compulsory/Elective) : **Compulsory**

2). Self-Introduction:

a). Name: Ravi Shankar Singh
b). Qualification: *M.E.*, B.E.
c). Designation: Assistant Professor
d). Research Area: Renewable Energy Sources, Power Electronics
e). E-mail Id: ravi.shankar@poornima.org
f). other details:

1. Areas of proficiency/expertise:
   - 1.1 Subjects taken:
     - 1.1.1 Power Electronics
     - 1.1.2 Electrical machine
     - 1.1.3 Switchgear & Protection
     - 1.1.4 Power System Analysis
     - 1.1.5 Basic Electrical Engineering
     - 1.1.6 High voltage engineering
   - 1.2 Laboratories Taken
     - 1.1.1 Electrical machine Lab
     - 1.1.2 Basic Electrical Lab
     - 1.1.3 Power electronics Lab
     - 1.1.4 PTS Training
   - 1.3 Member of Professional Body
     - None
   - 1.4 Academic Proficiency
     - 1.4.1 English
     - 1.4.2 Hindi
   - 1.5 Book Authored
     - None
   - 1.6 Papers published in National/ International Conferences/ Journals
     - **1.6.1**"Mathematical modeling and simulation study PV module used in SUN tracking system " Published in ICETCCT(IEEE XPLORE) INSPEC Accession number : 17561279 DOI: 10.1109/ICETCCT.2017.8280319

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...international journal for science and advanced research in technology volume 4, Issue 3 in March 2018. Paper ID:IJSARTV41321720

1.6.3"A comparative study of Multilevel inverter topologies" published in International research journal of engineering & technology volume 5,Issue 3 march 2018(e-ISSN: 23950056 p-ISSN: 2395-0072)

1.6.4 Three phase four switches solar inverter using ilst control algorithm for transformerless photovoltaic system. **JOURNAL:**IJAER (Scopus journal) ISSN 0973-4562, Volume 10, Number 4 (2015) pp. 10795-10808.

1.6.5 Attended TEQIP-III Sponsored one week FDP on **Advancement in power system & power electronics** organised by Rajasthan technical University, Kota.

1.6.6 Attended One week FDP on **Intelligent algorithms Application to deregulated power system organised by MNIT Jaipur** and sponsored by Ministry of Electronics & Information technology, Govt. of India.

3) Department Vision and Mission

Vision and Mission of Department

Vision

To be a model of excellence in Professional Education and Research by creating electrical engineers that are prepared for lifelong engagement in the rapidly changing fields and technologies with the ability to work in team.

Mission

Provide a dynamic environment of Technical Education wherein students learn in collaboration with others to develop a disciplined and conceptual knowledge in the field of electrical engineering and become a good professional, researcher and lifelong learner.

4) Department Programme Educational Objectives (PEOs)

The programme Educational Objectives of the Department of Electrical Engineering have been defined as follows:-

1: Graduates will have the ability to formulate, analyze and apply design process to solve electrical engineering problems.

2: Graduates will have successful transition into a broad range of career options including industry, government, research and professional education as lifelong learner to compete with global environment.

3: Graduates will exhibit dynamic communication and presentation skills with the quality of leadership, team management and time management.

4: Graduates will exhibit social and professional responsibility with a commitment towards ethic, equity, public and environmental safety.

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5) Department Programme Outcomes & Programme Specific Outcomes (POs and PSOs)

Programme Outcomes of Electrical Engineering Department are as follows:-

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

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12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific outcomes (PSOs)

PSO1: - Graduates possesses the ability to apply the recent trends and technologies in electrical engineering for the benefit of society.

PSO2: - Graduates will be competent to apply fundamental skills of electrical, electronics and computer on practical grounds to meet the requirement of industries.

PSO3: - To provide sound fundamental knowledge and niche skills to make students increasingly employable in the emerging areas of new power and energy systems, including solar power, renewable energy, electric and hydrogen powered vehicles, communication and networking solutions for the smart cities in India.

6).Introduction of Students:

a).*Students will be asked to introduce them covering the following points:*

- Name
- Place to which he/she belongs
- Academic merit
- Percentage of marks in XII
- Merit in AIEEE
- Co-curricular activity
- Day scholar/Hosteller
- Medium in class XII: English/Hindi
- Why he/she wants to become an Engineer.

b).*Records of students in 12th*

Sr. No.	Average result of 12th	Name of student scored highest marks	Marks 60% above (No. of students)	Marks between 40%-60% (No. of students)	English Medium Students (No.)	Hindi Medium Students (No.)	No. of Hostellers	No. of Day Scholar
1.								

d). Methods of Evaluation

(i) I & II Mid-Term Examination.
(ii) Assignment / Tutorials / Lab Records.
(iii) Quiz (Objective) / Viva-Voce
(iv) OBT
(v) OET
(vi) Google Classroom

7). Instructional Language: - 100 %English

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8). Introduction to subject: -

a). Relevance to Branch:

Power Electronics is very important subject for the students of Electrical Branch because it deals with application of electronics fundamentals with electrical circuit in real world. Power electronics explain about the controlling, working principle and operation of the instruments and devices used in the field of electrical engineering for very high range.

b). Relevance to Society:

Students learning power electronics today have to work in real world industries tomorrow therefore it is necessary that they learn the fundamental of industrial electronics from the beginning. Students of engineering are therefore called upon to learn the rudiment of power electronics strategies very early in their graduation courses. Power electronic converters can be found wherever there is a need to modify the electrical energy form (i.e. modify its voltage, current or frequency).Therefore their power range from some mill watts (as in a mobile phone) to hundreds of megawatts (e.g. in a HVDC transmission system) An AC/DC converter (rectifier) is the most typical power electronics device found in many consumer electronic devices, e.g., television sets, personal computers, battery chargers, etc. The power range is typically from tens of watts to several hundred watts. In industry the most common application is the variable speed drive (VSD) that is used to control an induction motor. The power range of VSDs starts from a few hundred watts and end at tens of megawatts.

c). Relevance to Self:

Being from Electronics & Communication Department Power Electronics subject is very much relative to me. Basic device like Power Diode, Power MOSFET etc are belong to Electronics part . These devices works on high power and have more PIV so used in power application. The basic construction of the devices is based on semiconductor so this power Electronics subject is very much related to me.

d). Relation with lab:

In the previous year we had studied Power electronics-I&II for basic concept of electrical, electronic circuit. In Last sem. we also studying Power Electronics-III now we will study further the concept of advanced power electronics in that semester. This subject relevance in B.Tech higher Sem. subjects like that Electrical Drives & Control System and HVDC System.

e).Pre- Requisites (Connection with previous year): -

1. Electrical & Electronics Engineering
2. Electronics Devices & Control
3. Advanced Power Electronics

As in previous semester, the concepts learnt in Power Electronics were related to build the basics of the students. They understood the characteristics of basic semiconductor devices and design the converters from those devices. The various solutions for the calculation of output parameters had been learnt by them in Engineering Mathematics- I and Engineering Mathematics- II. This subject is the basic building block of electrical engineering enabling students in easy grasping of various electrical concepts.

f) Course Outcome:

- CO1: Students will be able to understand working of various power semiconductor devices and their characteristics.
- CO2: Students will be able to understand working, characteristics and Protections of SCR.
- CO3: Students will be able to design and draw waveform of the different types of single phase converters at various load condition.
- CO4: Students will be able to design and draw waveform of the different types of three phase

converters and three phase dual converters.

- CO5: Students will be able to understand various power factor improvement techniques in converters.
- CO6: Students will be able to understand the different types of chopper and their use in power electronic circuits.

9). Syllabus of Rajasthan Technical University, Kota

a) RTU Syllabus with Name of Subject & Code:

UNIT-I POWER SEMICONDUCTOR DEVICES

Construction, Principle of operation, Characteristics and applications of Power Transistor & Thyristor, Characteristics of GTO, DIAC, MCT, TRIAC, Power MOSFET and IGBT, Two- Transistor Model of Thyristor, Thyristor Commutation methods.

UNIT-II SCR

Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on, triggering circuits for SCR: R, RC, UJT relaxation oscillator. Rating extension by series and parallel connections, string efficiency, Protection of SCR-Protection against over voltage, over current, dv/dt, di/dt, Gate protection

UNIT-III CONVERTERS-I

Single phase half & full wave converters with RL & RLE load, Single phase dual converters, three phase half wave converters, three phase full converters with RL load, Three phase dual converters.

UNIT-IV CONVERTERS-II

Single and three-phase semi converters with RL & RLE load. Power factor improvement-Extinction angle control, symmetrical angle control, pulse width modulation control and sinusoidal pulse width modulation control. Inversion operation, Effect of load and source impedances

UNIT-V DC-DC CONVERTERS

Step Up/Down Chopper, Control strategies, Chopper Configurations, Analysis of type A Chopper Voltage, current and load commutated chopper. Multiphase Chopper

b). ABC analysis (RGB method) of unit & topics:

UNIT-I POWER SEMICONDUCTOR DEVICES

Construction, Principle of operation, Characteristics and applications of Power Transistor & Thyristor, Characteristics of GTO, DIAC, MCT, TRIAC, Power MOSFET and IGBT, Two- Transistor Model of Thyristor, Thyristor Commutation methods

UNIT-II SCR

Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on, triggering circuits for SCR: R, RC, UJT relaxation oscillator. Rating extension by series and parallel connections, string efficiency, Protection of SCR-Protection against over voltage, over current, dv/dt, di/dt, Gate protection

UNIT-III CONVERTERS-I

Single phase half & full wave converters with RL & RLE load, Single phase dual converters, Three phase half wave converters, Three phase full converters with RL load, Three phase dual converters.

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UNIT-IV CONVERTERS-II

Single and three-phase semi converters with RL & RLE load. Power factor improvement-Extinction angle control, symmetrical angle control, pulse width modulation control and sinusoidal pulse width modulation control. Inversion operation, Effect of load and source impedances

UNIT-V DC-DC CONVERTERS

Step Up/Down Chopper, Control strategies, Chopper Configurations, Analysis of type A Chopper Voltage, current and load commutated chopper. Multiphase Chopper

RED : Hard BLUE : Moderate GREEN : Easy

c) Impact of PMEPI:

i) Use of Keywords

Unit No.	Syllabus	Keywords
I	Construction, Principle of operation, Characteristics and applications of Power Transistor & Thyristor, Characteristics of GTO, DIAC, MCT, TRIAC, Power MOSFET and IGBT, Two- Transistor Model of Thyristor, Thyristor Commutation methods	Thyristor, GTO, DIAC, MCT, TRIAC, IGBT, Commutation
II	Construction and characteristics, specification and ratings, pulse transformer, optical isolators, methods of turn on, triggering circuits for SCR: R, RC, UJT relaxation oscillator. Rating extension by series and parallel connections, string efficiency, Protection of SCR-Protection against over voltage, over current, dv/dt, di/dt, Gate protection	SCR, UJT, Triggering method, String efficiency, Thyristor protection, Gate protection, Series and parallel Thyristor, Pulse transformer, Isolator.
III	Single phase half & full wave converters with RL & RLE load, Single phase dual converters, three phase half wave converters, three phase full converters with RL load, Three phase dual converters.	Rectifier, Freewheeling diode, R and RL Load, Dual converter, Circulating current, Conduction angle
IV	Single and three-phase semi converters with RL & RLE load. Power factor improvement-Extinction angle control, symmetrical angle control, pulse width modulation control and sinusoidal pulse width modulation control. Inversion operation, Effect of load and source impedances.	Semi-converter, Power factor, Extinction angle, Pulse width modulation,
V	Step Up/Down Chopper, Control strategies, Chopper Configurations, Analysis of type A Chopper Voltage, current and load commutated chopper. Multiphase Chopper	Chopper, Voltage, Current and load commutation, Current control, TRC Method.

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ii) Recent Technologies & Publication:

Topic	Trends	Publication
Power semiconductor devices	Improvements in power losses, MOS-gate thyristor(MCT, EST, DG-BRT)	Trends in power conductor devices
SCR	Triggering method of SCR	Neuro fuzzy based triggering method
Rectifier	Low harmonic content, Power factor improvement technique and control strategies	A new control technique for harmonics elimination in six-switch active filters.
Semi- converter	Applications of semi-converter in DC machine drives.	Thyristor based speed control techniques of DC Motor.
DC-DC chopper	Control strategies of chopper	Design and simulation of soft switched DC boost converter for switched reluctance motor.

iii) Vocabulary Improvement

- Learning 10 New Words each day with their meanings. Sentence formation using these words.

iv) Current Affairs

- Discussion over 5 daily Current affair

v) Role Plays By Students on important topics.

vi) Group Discussion on a topic having different techniques.

vii) Feedback of every lecture by student

viii) Think-Pair-Share

10). Books/ Website/Journals & Handbooks/ Association & Institution:

a). Recommended Text & Reference Books and Websites:

S. No.	Title of Book	Authors	Publisher	Cost (Rs.)	No. of books in Library
Text Books					
T1	Power electronics	P.S. Bimbhra	Khanna Publishers.	350/-	90
T2	Power electronics	M D Singh and K B Khanchandani	TMH,	360/-	32
T3	Power electronics	M.H. Rashid	Pearson.	560/-	30
Reference Books					
R1	Power Electronics	P.C. Sen	TMH	330/-	26

b). Journals & Handbooks: - To give information about different Journals & Handbooks available in library related to the subject and branch.

1. Journal of Scientific and Industrial Research
2. Indian Journal of Engineering and Material Science
3. Green Energy
4. Down of Earth
5. Science Competition Vision
6. Electrical India

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c). ***Associations and Institutions:*** -To give information about different Associations and Institutions related to the subject and branch.

1. Department Of Science and Technology(DST)
2. IEEE
3. IETE
4. BARC
5. DRDO
6. MNIT & IIT

d) ***Websites related to subject:-***

1. www.nptel.ac.in
2. www.4shared.com
3. www.mit.com
4. www.google.co.in

11). Syllabus Deployment: -

a). Total weeks available for academics (excluding exams/ holidays) as per PGC calendar-

SEMESTER	V
No. of Working Days Available (Approx.)	93
No. of Weeks(Approx.)	17

- Total weeks available for covering RTU syllabus- 10-11 weeks (Approx.)
- Total weeks available for special activities (as mentioned below)- 01 weeks (Approx.)

ii) Recent Technologies & Publication:

Topic	Trends	Publication
Power semiconductor devices	Improvements in power losses, MOS-gate thyristor(MCT, EST, DG-BRT)	Trends in power conductor devices
SCR	Triggering method of SCR	Neuro fuzzy based triggering method
Rectifier	Low harmonic content, Power factor improvement technique and control strategies	A new control technique for harmonics elimination in six-switch active filters.
Semi- converter	Applications of semi-converter in DC machine drives.	Thyristor based speed control techniques of DC Motor.
DC-DC chopper	Control strategies of chopper	Design and simulation of soft switched DC boost converter for switched reluctance motor.

b). Course Assesment Methods (Special Activities):

(To be approved by HOD. Dean & Campus Director& must be mentioned in deployment):

- Open Book Test- Once in a semester
- Quiz (50% Technical & 50% Aptitude)- Once in a semester
- Special Lectures (SPL)- 10% of total no. of lectures including following
  - i. One PPT by the faculty, who is teaching the subject

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ii. SPL by expert faculty at PGC level
iii. SPL by expert from industry/academia (other institution)

- Revision classes:- 1 to 3 turn at the end of semester (Before II Mid Term Exam)
- Solving Important Question Bank- 1 Turn before I & II Mid Term Exam (each) - Total Two turn.
- I and II Midterms
- RTU University Examinations

c). Lecture schedule per week/ Contact Hours:

i). University scheme (L+T+P) = 3+1+0
ii). PGC scheme (L+T+P) = 3+1+0

Sr. No.	Name of Unit	No. of lectures	Broad Area	Degree of difficulty (High/Medium/Low)	Text/ Reference books
1.	Power semiconductor devices	12	BJT, MOSFET	Medium	P.S. Bimbhra, M D Singh and K B Khanchandani
2.	SCR	8	Characteristics	High	P.S. Bimbhra, M D Singh and K B Khanchandani
3.	Converter-I	8	Half wave & full wave	High	P.S. Bimbhra, M D Singh and K B Khanchandani
4.	Converter-II	7	Semi-converters	Medium	P.S. Bimbhra, M D Singh and K B Khanchandani
5.	DC-DC chopper	6	Choppers	Low	P.S. Bimbhra, M D Singh and K B Khanchandani

d). Introduction & Conclusion: Each subject, unit and topic shall start with introduction & close with conclusion. In case of the subject, it is Zero lecture.

e). Time Distribution in lecture class: -Time allotted: 60 min.

i. First 5 min. should be utilized for paying attention towards students who were absent for last lecture or continuously absent for many days + taking attendance by calling the names of the students and also sharing any new/relevant information.
ii. Actual lecture delivery should be of 50 min.
iii. Last 5 min. should be utilized by recapping/ conclusion of the topic. Providing brief introduction of the coming up lecture and suggesting portion to read.
iv. After completion of any Unit/Chapter a short quiz should be organized.
v. During lecture student should be encouraged to ask the question.

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12) Mapping of POs and PSOs with Course Outcome

Subject Code	COs and LOs	COs and LOs (Descriptive)	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
5EE1A	C301.1	1. Students will be able to understand working of various power semiconductor devices and their characteristics.	2	2	1	1	—	1	—	—	1	1	—	1
	C301.2	2. Students will be able to understand working, characteristics and Protections of SCR.	2	1	—	1	—	—	—	—	1	2	1	1
	C301.3	3. Students will be able to design and draw waveform of the different types of single phase converters at various load condition.	2	2	1	1	1	1	2	—	1	1	—	1
	C301.4	4.Students will be able to design and draw waveform of the different types of three phase converters and three phase dual converters.	1	2	2	—	1	1	—	—	—	—	1	2
	C301.5	5. Students will be able to understand various power factor improvement techniques in converters.	2	1	1	—	—	—	—	—	—	1	1	1
	C301.6	6. Students will be able to understand the different types of chopper and their use in power electronic circuits.	2	1	—	1	—	—	—	—	1	2	1	1
			1.83	1.50	1.25	1.00	1.00	1.00	2.00	—	1.00	1.40	1.00	1.17

Subject Code	COs	COs (Descriptive)	PSO 1	PSO 2	PSO 3
5EE1A	C301.1	1. Students will be able to understand working of various power semiconductor devices and their characteristics.	1	3	1
	C301.2	2. Students will be able to understand working, characteristics and Protections of SCR.	—	2	1
	C301.3	3. Students will be able to design and draw waveform of the different types of single phase converters at various load condition.	1	2	—
	C301.4	4. Students will be able to design and draw waveform of the different types of three phase converters and three phase dual converters.	—	2	1
	C301.5	5. Students will be able to understand various power factor improvement techniques in converters.	—	3	—
	C301.6	6. Students will be able to understand the different types of chopper and their use in power electronic circuits.	1	3	1
			1	2.5	1

*3-Strong 2- Medium 1-Weak

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13). Examination Systems:

Sr. No.	Name of the Exam	Max. Marks	% of passing marks	Nature of paper Theory + Numerical	Syllabus coverage (in %)	Conducted by
1.	Ist Mid Term Exam	40	40%	T+N	60%	PCE
2.	IInd Mid Term Exam	40	40%	T+N	40%	PCE
3.	University (End) Term Exam	80	30%	T+N	100%	RTU

Place: **Jaipur**
Date: **29/06/2018**

RAVI SHANKAR SINGH
(Assistant Professor)

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RTU QUESTION PAPERS ANALYSIS

Subject: Power Electronics

Sub. Code: 5EE1A

UNIT 1-

1.Explain and draw the switching characteristics of the Gate turn - off thyristor.

2.Explain and draw the switching characteristics of the power IGBT.

3.Explain and draw the, switching characteristics of Power MOSFET.

UNIT 2-

1.Explain the significance of di / dt and dv / dt in SCRs.

2.Explain and draw the switching characteristics of the SCR.

3. Explain the series operation of thyristor.

UNIT 3-

1.Describe working of a single - phase full converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input power factor.

2.Explain principle of operation of three phase dual converter without circulating current in detail.

UNIT 4-

Describe the working of a single phase two-pulse semi converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input, power factor.

2. Explain Sinusoidal Pulse width modulation control technique of power factor improvement along with circuit diagram and waveforms.

3.Explain Extinction angle control technique of power factor improvement along with circuit diagram and waveforms.

UNIT 5-

1. Describe the principle of step Up/ Down chopper. Derive an expression for the average output voltage in terms of input dc voltage and duty cycle.

2.Explain Voltage commutated chopper along with circuit diagram and waveforms.

3.Derive the expressions for steady-state maximum and minimum current for type-A chopper.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: Ravi Shankar Name of Subject: PE Code: S.E.E.1
Date (Prep.): ..... Date (Del.): ..... Unit No.: ..... Lect. No: 1

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Diode - types.
- V-I char of diodes.
- Switching char of diodes.

IMPORTANT & RELEVANT QUESTIONS:

- Briefly explain about the switching char of diodes & also derive an expressions for I_{rr} & T_{rr}.
- write short notes on V-I char of Power diode.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- why the char of Power diode is different from signal level diode.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Diode & its type.
- Switching char of diode.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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Three types of switch

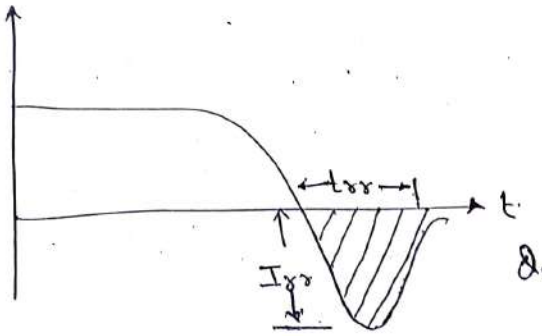
i) uncontrolled switch — Diode

ii) Semi-~~conduct~~ controlled switch — SCR

iii) controlled switch — BJT

Diode:

→ Minority carrier require certain time to recombine.



$Q_{rr} = \frac{1}{2} I_{rr} \times t_{rr}$

Specification

→ Avg. Forward current

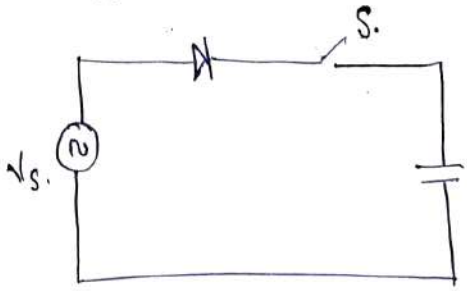
→ Reverse blocking Vg

→ on-state Vg drop — determine ~~closse~~ conduction losses. (cooling requirement, Heat sink).

→ trr

→ Surge current rating

→ I^2R rating.



when switch 'S' is closed at $\omega t = \pi/2$,
o/p Vg is higher (maxm), capacitor Vg not change immediately, so large surge current flow through the diode.

Types of diode

i) Rectifier diode — slow diode — conventional diode.

Max^m rating — 6KV — block
— 4500A — carry current

ii) Fast recovery diode — used in High f^r application

Max^m — 6KV
— 1.1KA — carry current

t_{rr} — .1 μs (could be the order of 1μs

iii) Schotty diode — very low on state V_g drop.
— current due to majority carrier.

Max^m rating — 100 KV
300 KA

(iv) Silicon carbide Diode — ultra low Power loss.
— Ultra fast switching behaviour.
— Highly reliable.
(no temp^r influence on the sw performance)

→ Process of manufacturing is very expensive.

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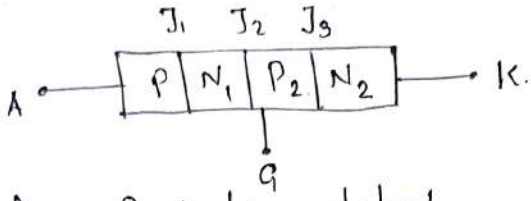
Semi-controlled device

→ Three terminal device — Anode, cathode & Gate.

→ 4 layers.



N_2 is very thin & highly doped.

P_2 is thicker than N_2 & is less highly doped

N_1 is thickest of all & is less doped.

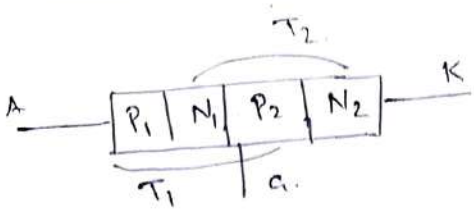
P_1 is similar to P_2.

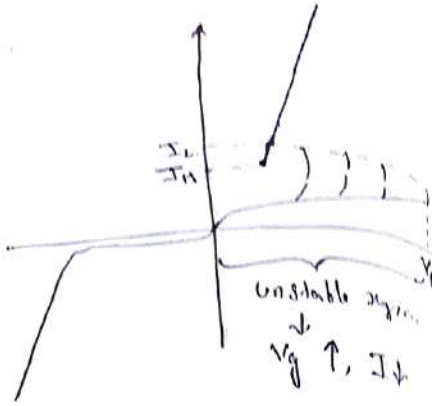
J_3 has low breakdown V_g in either dir^n.
cannot support very high reverse V_g.

→ V_{AK} is +ve (F.B.) & current flow is very small, device is called Forward blocking mode.
J_1 & J_3 are F.B. & J_2 is R.B.
entire V_g appear across J_2.

→ when V_{AK} is R.B.
J_1 & J_3 are R.B & J_2 is F.B.
J_3 cannot support high reverse V_g.
Entire V_g support by J_1.

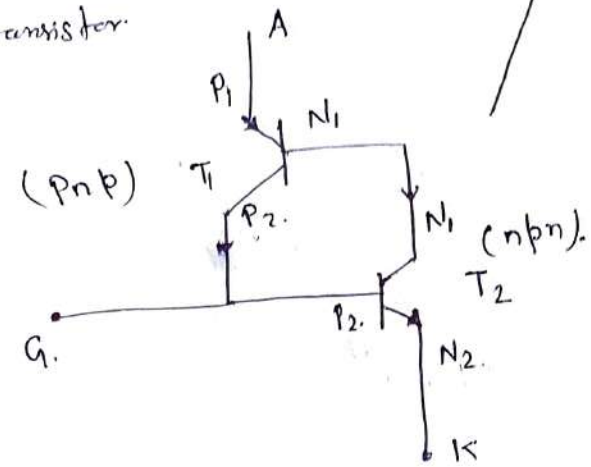
Two transistor analogy.

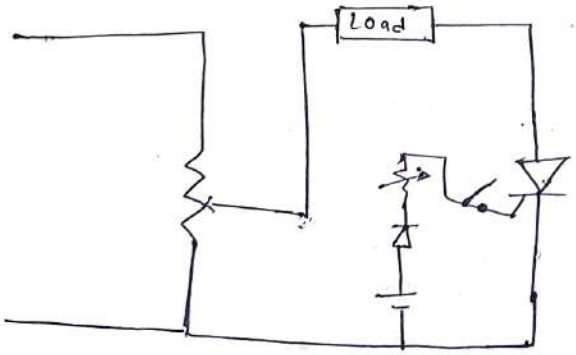


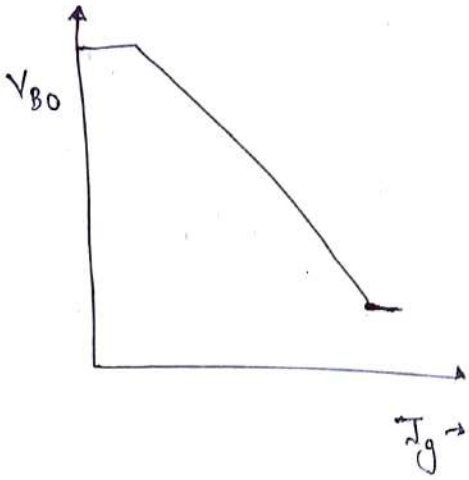


$P_1N_1P_2$ transistor

$N_1P_2N_2$ transistor







For any transistor

$$I_C = \alpha I_E + I_{CBO} \qquad \alpha = \frac{I_C}{I_E}$$

↳ leakage current of ~~collector~~ C-B jn

$$I_E = I_A \quad (\text{for } T_1)$$

$$I_{C_1} = \alpha_1 I_A + I_{CBO_1} \quad (pnp)$$

$$I_{C_2} = \alpha_2 I_K + I_{CBO_2} \quad (npn)$$

$$I_E = I_C + I_B$$

$$I_{E_1} = I_A \ \& \ I_{B1} = I_{C_2}.$$

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$\therefore I_{C_1} + I_{C_2} = I_A$

$\alpha_1 I_A + I_{CBO1} + \alpha_2 I_K + I_{CBO2} = I_A$.

$I_K = I_{B2} + I_{C2}$. $\quad (I_{B2} = I_{C_1})$

for finite I_g.

$I_K = I_{C1} + I_g + I_{C2}$.

$I_K = I_A + I_g$. $\quad (I_{C1} + I_{C2} = I_A)$. $\quad \alpha \uparrow$ if $I_E \uparrow$

$$\boxed{I_A = \frac{\alpha_2 I_g + I_{CBO1} + I_{CBO2}}{1-(\alpha_1+\alpha_2)}}$$

→ If $\frac{dV}{dt} \uparrow$, $I_{J2} \uparrow$, due to C_{J2} (J^n capacitor).
$\left(i_c = C\frac{dV}{dt}\right)$ $I_{CBO1} \uparrow$, I_A is amplified by transistor action

$\alpha_2 = \frac{I_{C_2}}{I_K}$.

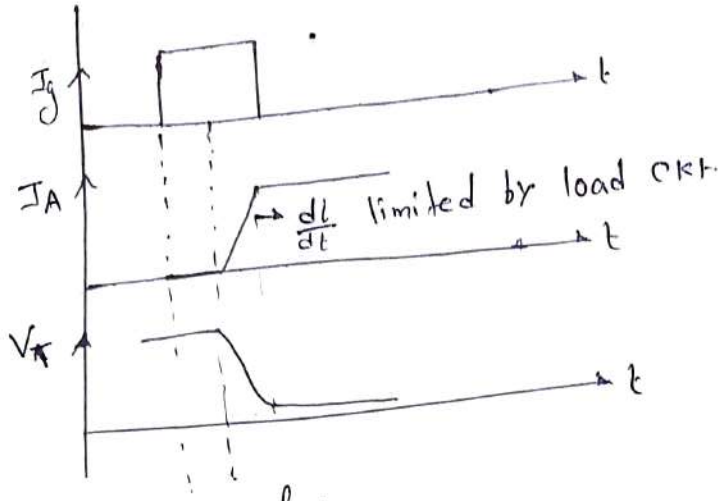
$I_K = \alpha_1 I_A + \alpha_2 I_K + I_{CBO1} + I_{CBO2} + I_g$.

$I_A - \alpha_1 I_A - \alpha_2 I_A$

$I_A - \alpha_1 I_A - \alpha_2 I_A = I_{CBO1} + I_{CBO2} + I_g$.

$I_A(1 - \alpha_1 - \alpha_2)$

Switching char.



→ If $\frac{di}{dt}$ is very high!

initially the device is off. conduction is confined at ga cathode Periphery (Small gate area), then it spreads across entire J^n with finite velocity.

I_A is very high & hotspot created.

→ During turn on, di/dt must be controlled.

→ If gate current continuously flow, Power loss in J^n J_3.

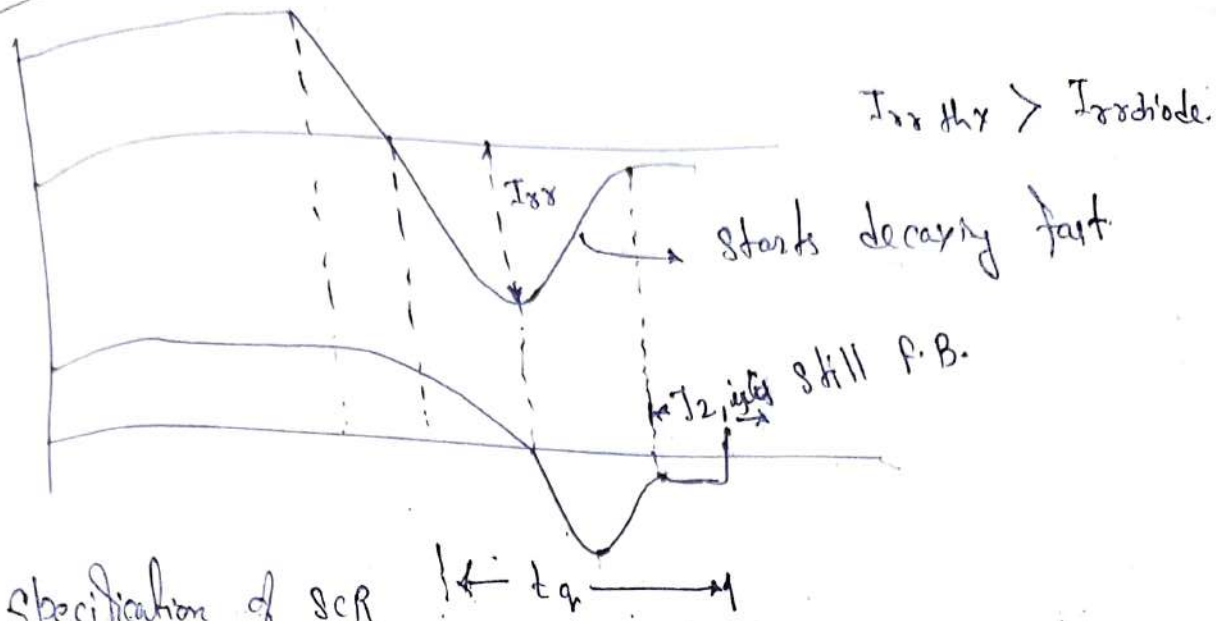
→ when reverse current attains -ve Peak, both J^n J_1 & J_3 block.

J_1 block first then J_3.

when this happen reverse current starts decaying.

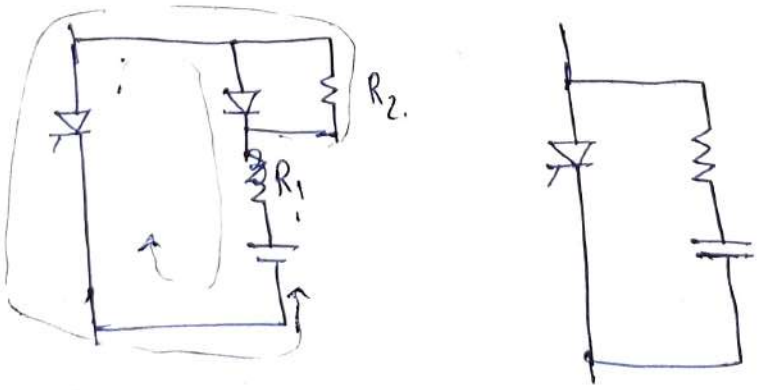
→ J_2 is still F.B. due to large minority carrier, so it need some time to recombine.

DETAILED LECTURE NOTES



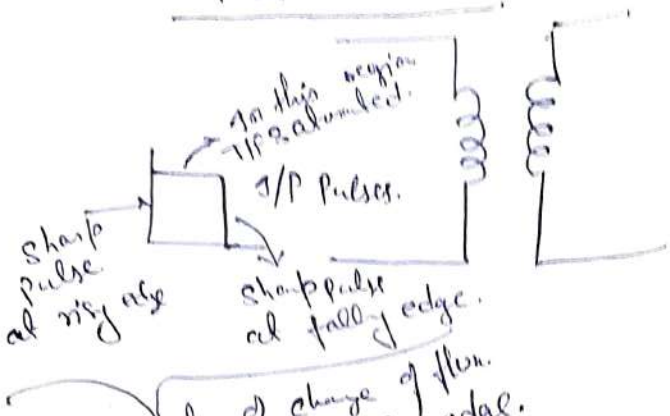
Specification of SCR

- Avg. forward current
- Reverse blocking v_g
- on-state v_g drop
- di/dt during turn on & turn-off
- Reapplied dv/dt.
- I^2R rating.
- device turn-off time (t_q)



Snubber ckt.

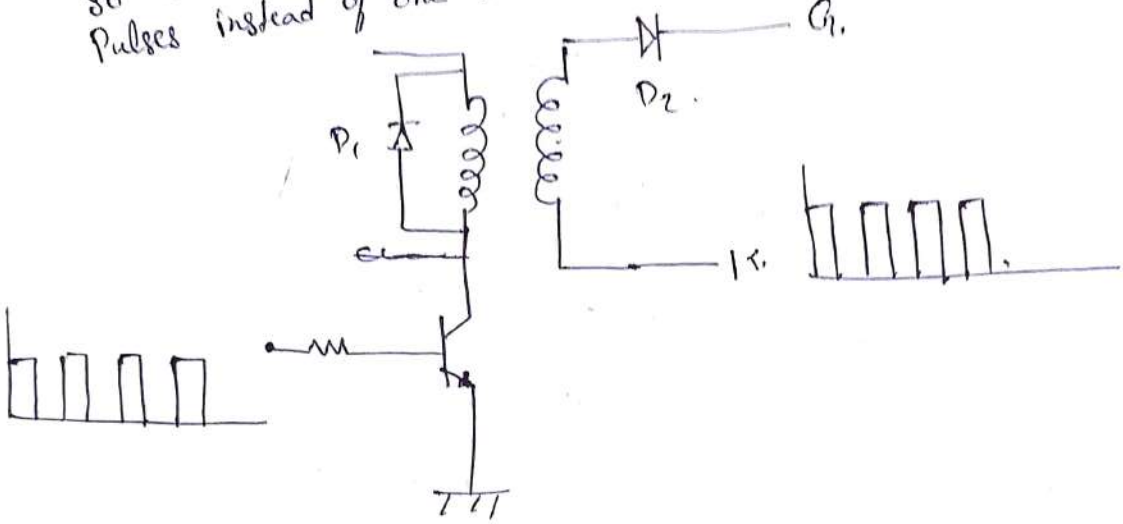
Pulse T/F :



Pulses only during Rising & falling edge bcoz rate of change flux.

bcoz rate of change of flux at only rising & falling edge.

So we can used no. of small Pulses instead of one broad Pulses.



→ one Pulse may not be sufficient to turn on the SCR.

→ Due to small Pulse T/F may not get saturated.

→ Small narrow pulses applied on the base of Transistor & current flow through the winding.
Diode provide path for magnetizing current during absence of Pulses.

→ -ve spike of Pulses during falling edge may be blocked by D2.

→ High f^n gating Pulse are required to turn on the circ.

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LECTURE NOTES

Campus: PCE Course: B.Tech. Class/Section: III A/B Date: .....
Name of Faculty: Ravi Shankar. Name of Subject: PE Code: SEEI
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 2

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- BJT – types
- V-I char
- Switchg char

IMPORTANT & RELEVANT QUESTIONS:

- write short notes on the construction of BJT.
- Briefly explain about V-I char & switching char of Transistor

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what is hard saturation region?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- BJT & its types.
- Switchg char of BJT.
- Significance of hard saturation region.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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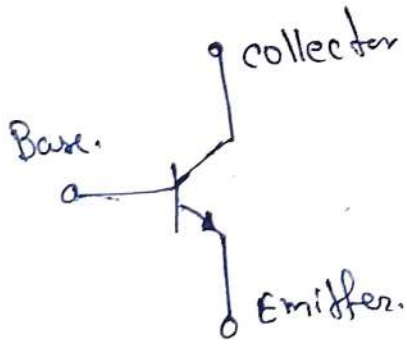
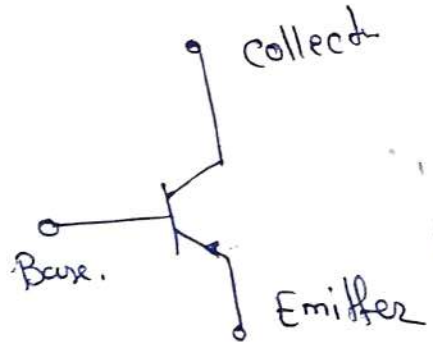
Bipolar Junction Transistors

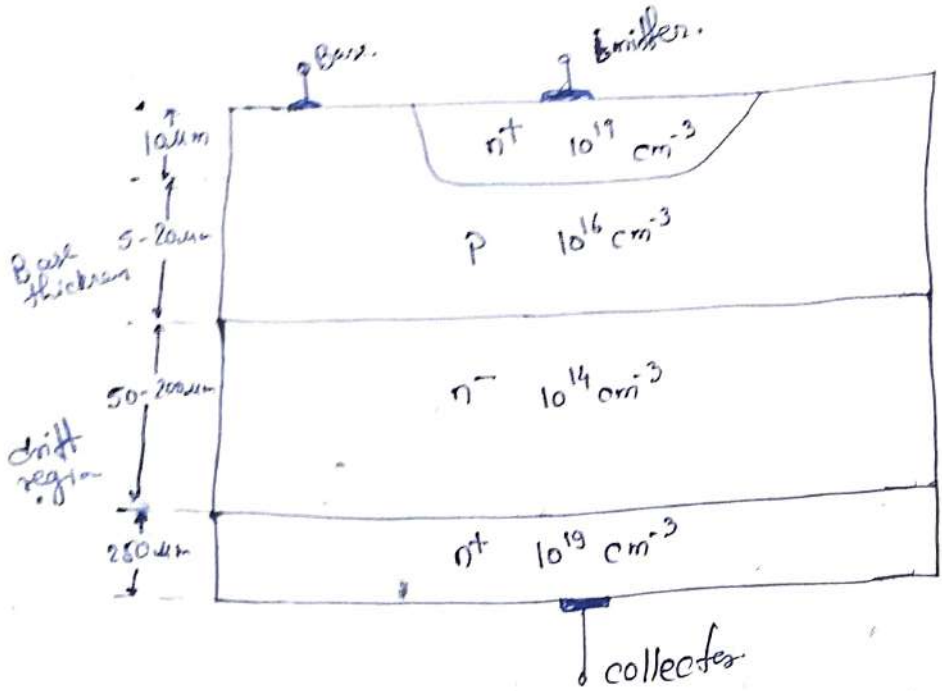
- A Power transistor has a vertically oriented four-layer structure of alternating p-type & n-type doping.
- The vertical structure is preferred for power transistors bcoz it maximizes the cross-sectional area through which the current in the device is flowing.
- This minimizes on-state resistance & thus power dissipation in the transistor.
- The thickness of drift region determines the breakdown voltage of transistor & thus can range from tens to hundreds of μm in extent.
- The base thickness is made as small as possible in order to have good amplification capabilities.



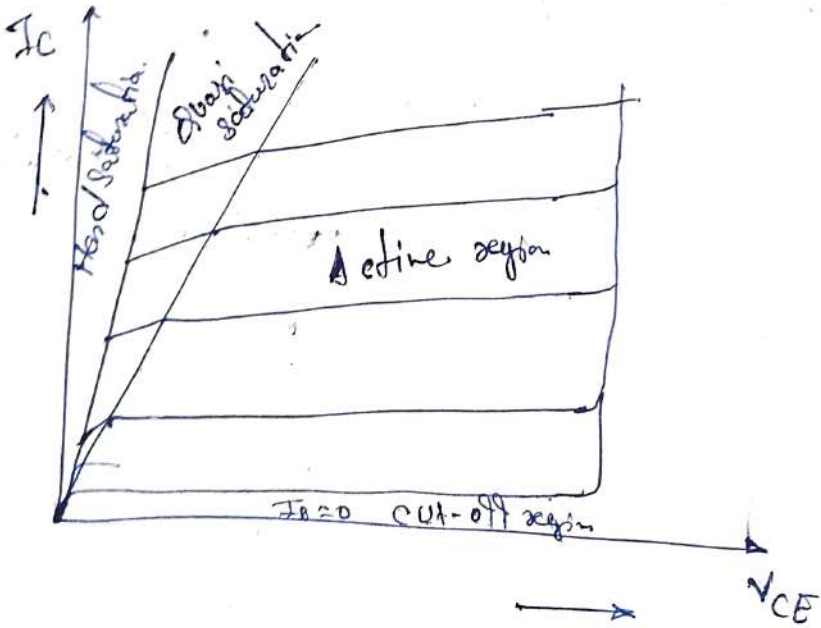
npn BJT



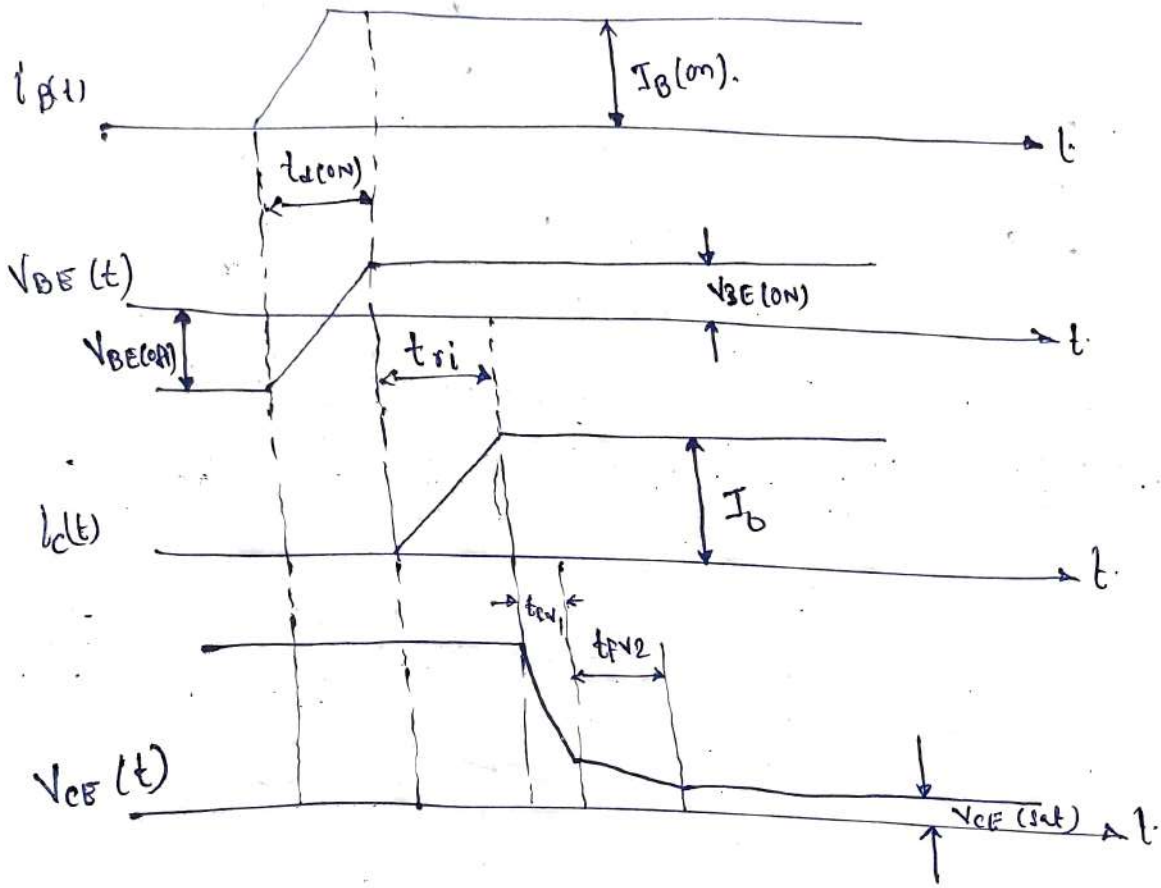
pnp BJT



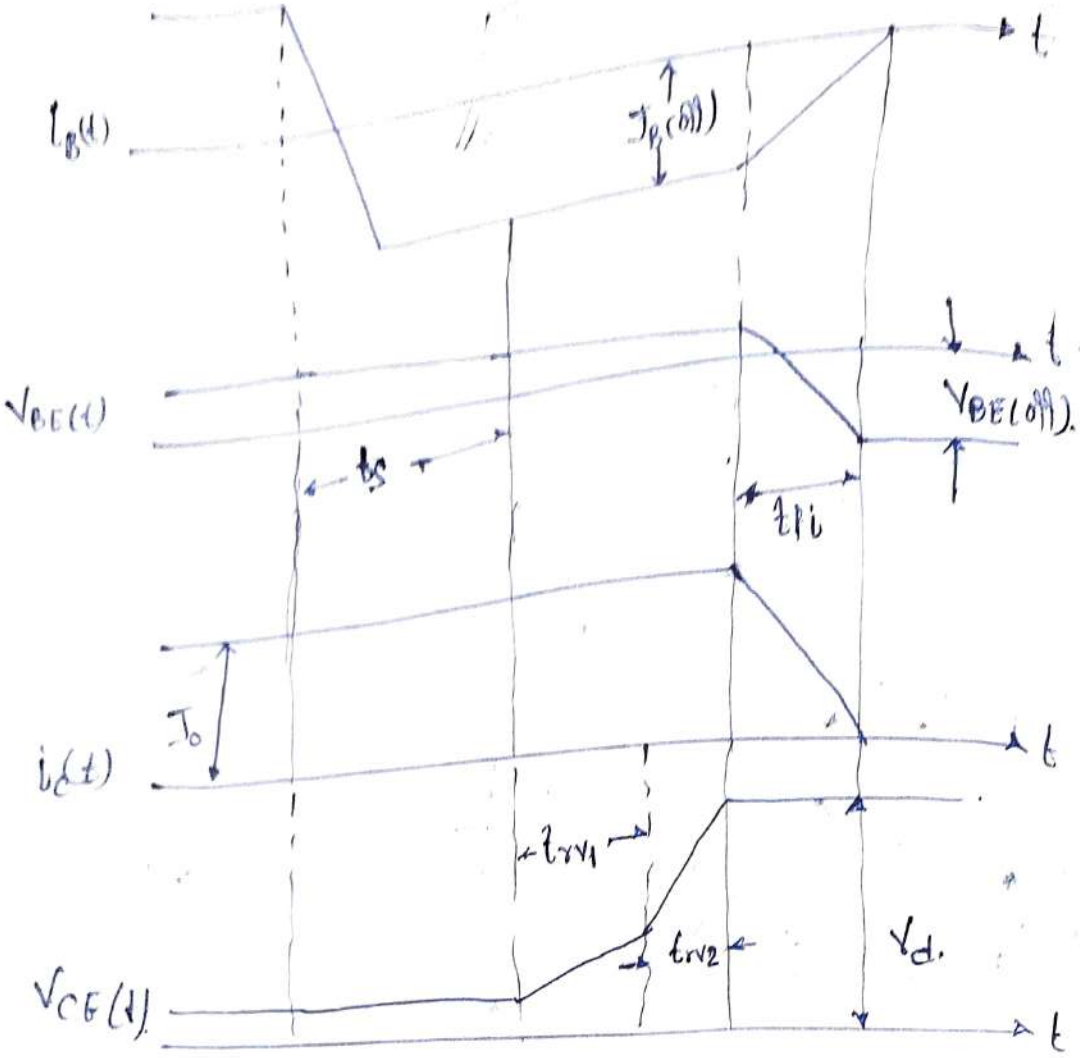
I – V characteristics



Switching char. of Transistors



Turn-on char.



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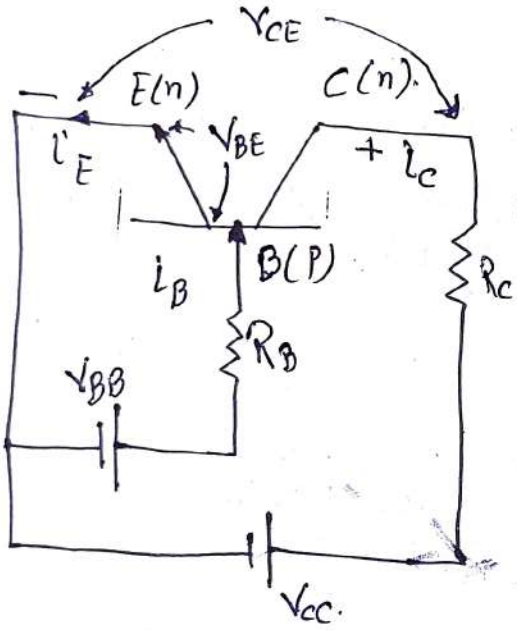
DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

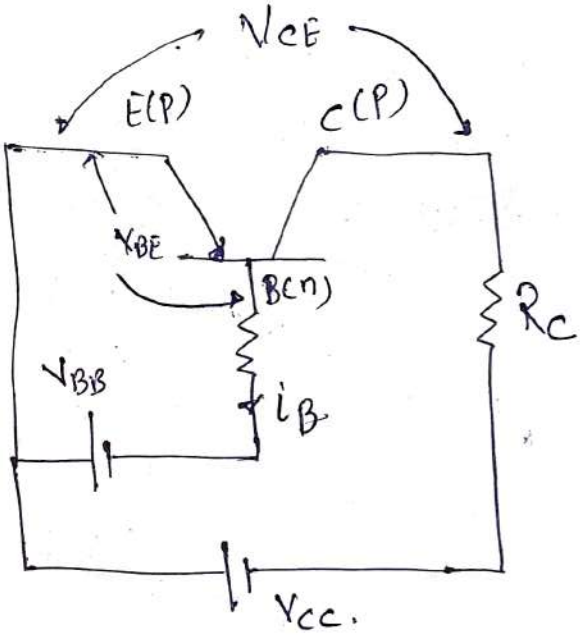
Bipolar Junction Transistor

→ BJT was the first semi-conductor device which have fully controlled switch. (Turn-on & Turn-off time)

→ BJT is a bipolar current controlled device.



n-p-n



P-n-P

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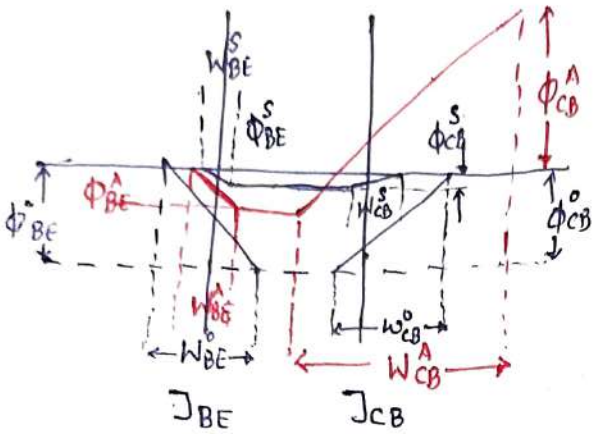
Emitter	Base	collector
n	p	n
(E)	(B)	(C)



→ If no external biasing V_g are applied (V_{BB} & V_{CC} are all transistors currents must be zero.
The transistor will be in thermal equilibrium and potential barriers ϕ^o_{BE} & ϕ^o_{CB} at the base emitter collector J^n respectively.
Depletion layer will be W^o_{BE} & W^o_{CB}.

→ In n-p-n transistor p-type base region is in a potential well & cannot escape.

→ when biasing V_g are applied the base-emitter J^n becomes forward biased whereas J_{CB} is R.B.
Potential barrier (ϕ^A_{BE}) & depletion layer (W^A_{CB}) both reduces at J^n J_{BE}.
or ϕ^A_{CB} & W^A_{CB} both are increases at J^n J_{CB}.

As the Potential barrier is reduced a large no. minority carriers are introduced into Base region & Emi region.

A portion of minority carriers reaching the base recombines with majority carriers. The rest, diffuse to the edge of the depletion region at J_{CB} where they are swept away to the collector region by the large electric fld.
Under this condition the transistor is said to be in the Active region.

→ As V_{BE} is increased injected minority charge into the base region increases & base & collector current also increases.

→ For fixed collector bias voltage V_{CC}, the V_g V_{CB} reduces with increase in collector current due to increasing drop in the external resistance R_C.
Therefore potential barrier at J_{CB} start reducing.

→ At one point J_{CB} becomes forward biased.

→ Due to F.B. of J_{CB} there will be minority carrier injection into the base from this J^n also.

→ Total V_g drop b/w collector & emitter will be the difference b/w forward bias V_g drop at J_{BE} & J_{CB}.
Under this condition transistor is said to be in saturation region.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A&B Date: .....
Name of Faculty: Ravi Shanka Name of Subject: PE Code: SEE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 3

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Power MOSFET
- construction
- I-V char
- Switching char

IMPORTANT & RELEVANT QUESTIONS:

- write Short notes on the construction of PMOSFET.
- Briefly explain about I-V char (output & transfer char of PMOSFET.
- Explain about the Switching char of PMOSFET.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what emitter are in small Polygon shape?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- PMOSFET – construction
- I-V char
- Switching char

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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P.S. Bimbhra.

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Power MOSFET

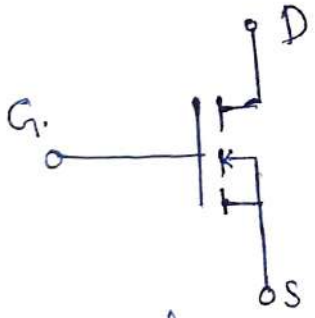
→ Metal-oxide semi-conductor field effect transistors.

→ A Power MOSFET has the vertically oriented four-layer structure of alternating p-type & n-type doping for a single cell of the many paralled cells of complete device.

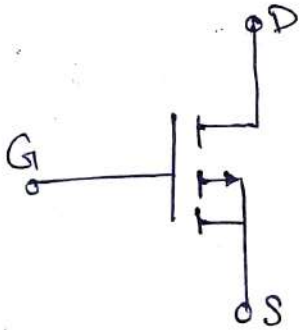
→ There can be no injection of minority carriers into the body region via the gate terminal bcoz gate is isolated from the body by a layer of silicon dioxide.

→ First, the source is constructed of many small polygon shaped areas that are connected in parallel & surrounded by the gate region.

→ The basic reason for the many small ~~polygon~~ source regions is to maximize the width of the gate region compared to its length.

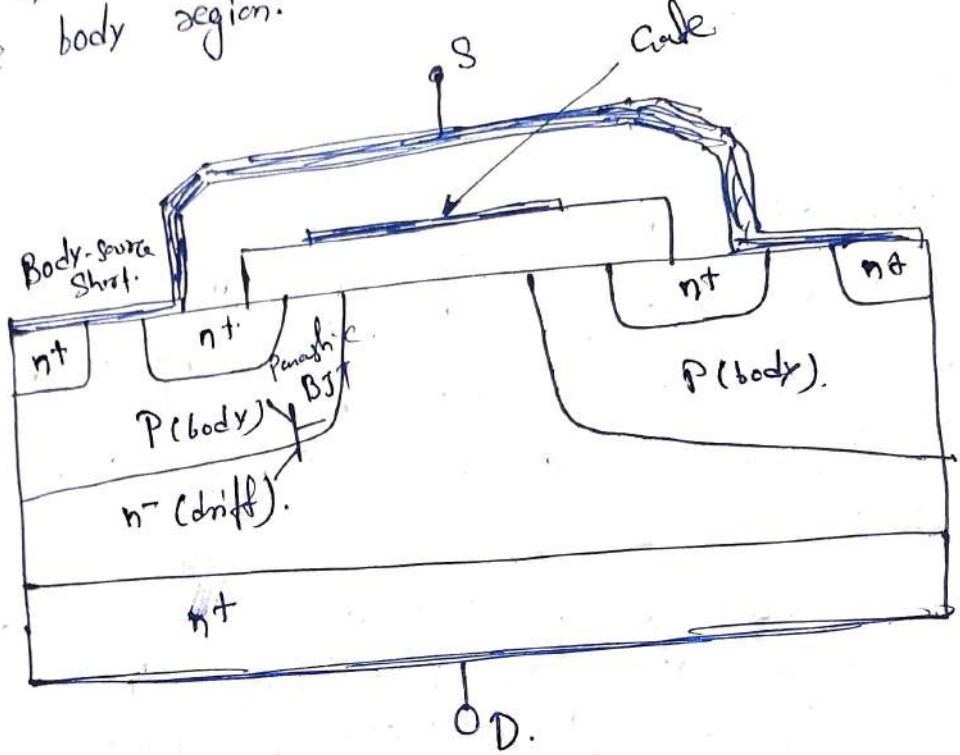


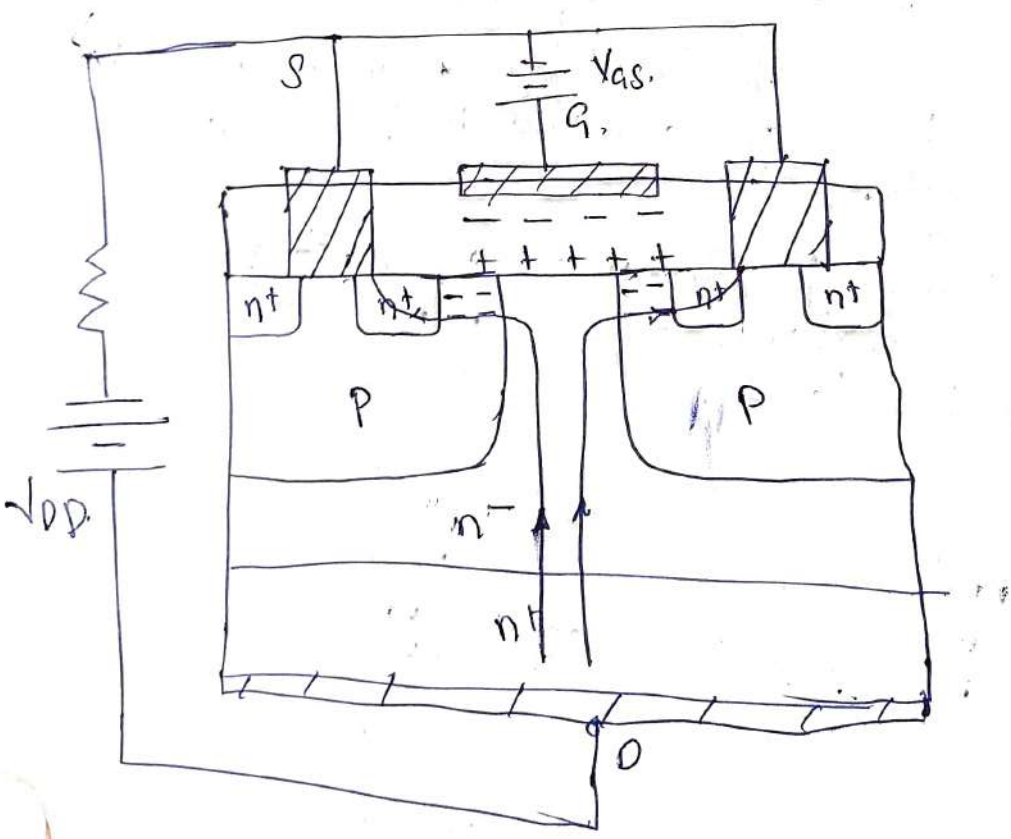
n- Channel.



P- Channel.

→ To minimize the possibility that this transistor will be turned on, p-type body region is shorted to the source metallization onto region by overlapping the p-type body region.





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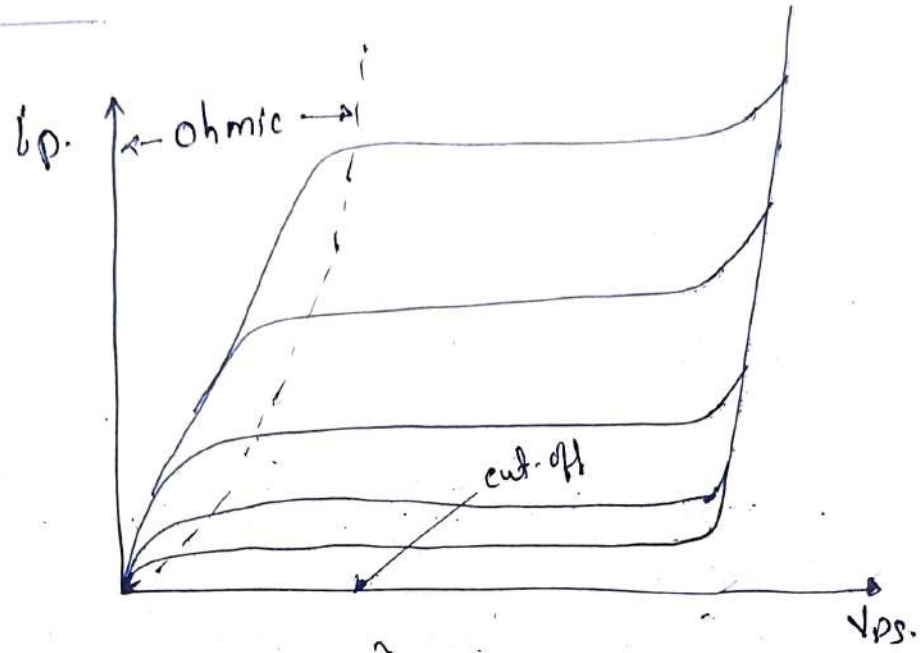
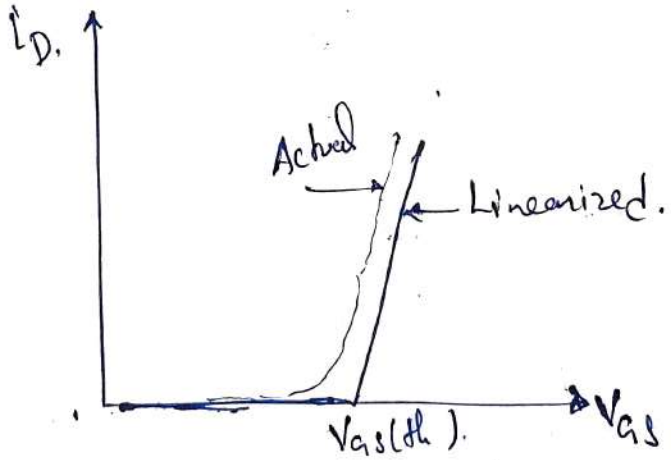
I-V char:



$i_D - V_{DS}$ char (O/P).



Transfer char

Transfer char.

→ Threshold V_g V_{GST} is an important parameter of MOSFET.

→ V_{GST} is the min.m V_g b/w G & S to indu n-channel.
≃ 2 to 3V.

O/P char.

→ For low values of V_{DS}, the graph b/w $I_D - V_{DS}$ almost linear, this indicate const value of on-state resistance.

→ For given V_{GS}, if V_{DS} is increased o/p char. relatively flat. & drain current is nearly const.

→ when P MOSFET is driven with large gate source V_g MOSFET is turned on, V_{DS} on small.

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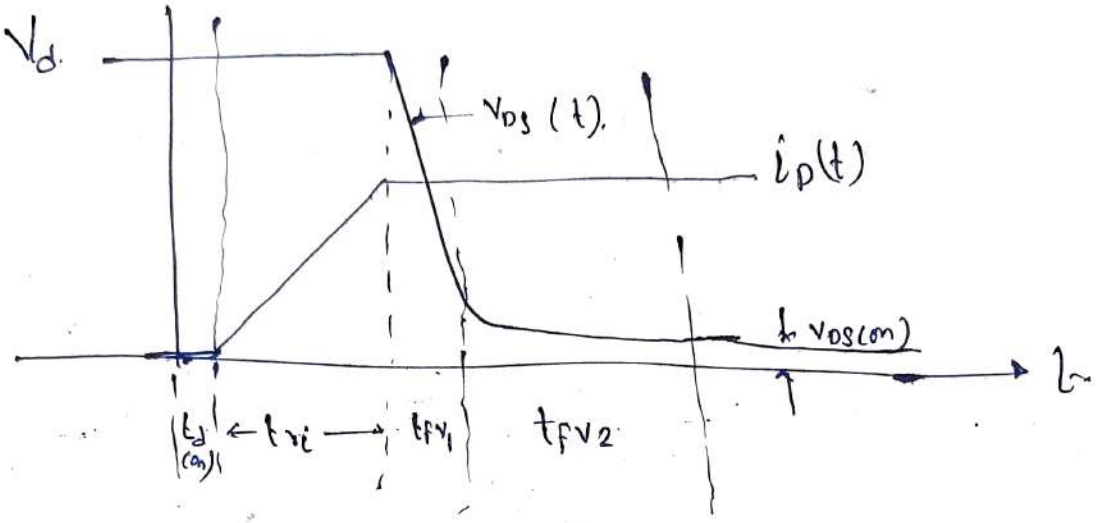
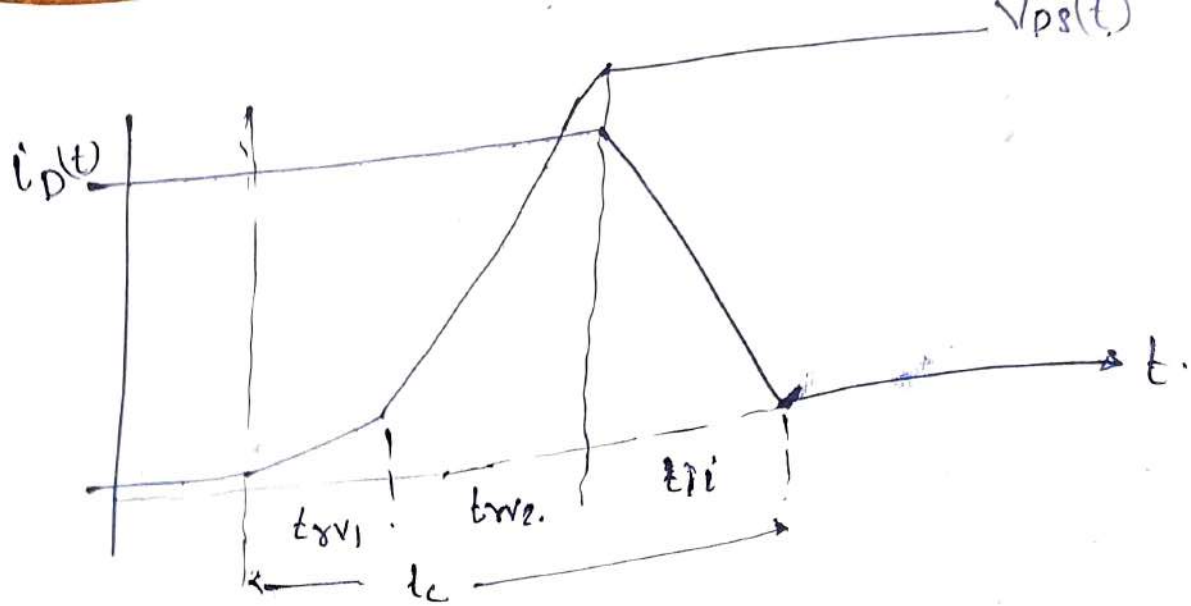
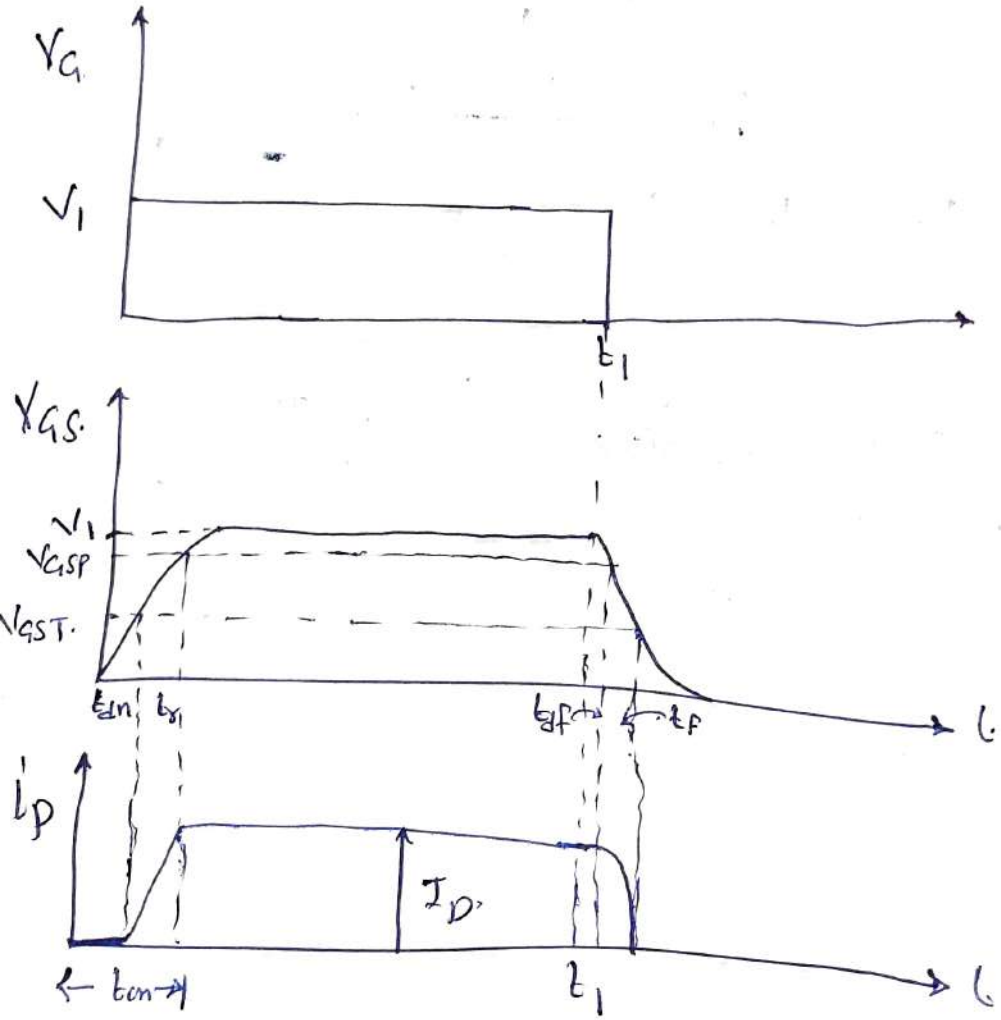
Switching char.



Turn-on time char. of MOSFET



Turn off char. of MOSFET



- when gate ckt. is open, J^n b/w n^+ region ~~below~~ drain & P- substrate is R.B. by g/p V_g V_{DD}.
- Therefore no current flows from Drain to Source.
- when gate is made +ve w.r.t. source, electric fld. is established & -ve charge is induced in the P- substrate. below SiO_2 layer & causing P layer below gate to become an induced 'n' layer.
- These -ve charge e^- form n- channel b/w two n^+ regions & current flows from drain to source.
- If V_{GS} is made more +ve, induced n- channel becomes more deep. & more current flows from D to S.
- This shows that drain current I_D is enhanced by the gradual increase of gate V_g.
- The main disadvantage of n- channel Planar MOSFET is that conducting n- channel in b/w D & S gives large on- state resistance

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R.S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 5

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ construction of IGBT
→ O/P & V/I char of an IGBT
→ Switching char of IGBT.

IMPORTANT & RELEVANT QUESTIONS:

→ How Power IGBT is differ from Power MOSFET.
→ write Short notes on the switching char of an IGBT.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ What is the importance of p^+ layer?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ V-I char of IGBT
→ Switching char of IGBT
→ Difference & Similarity b/w IGBT & MOSFET.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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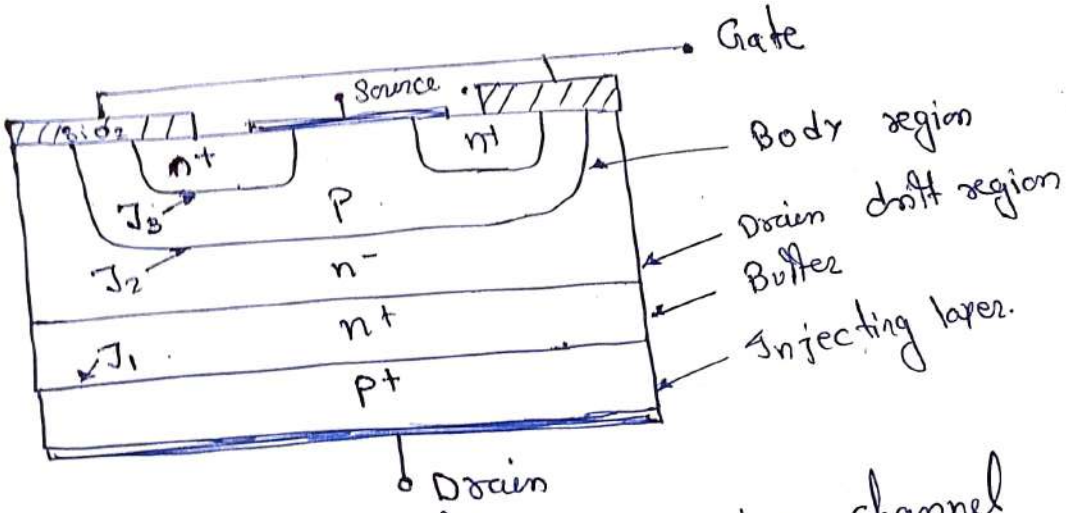
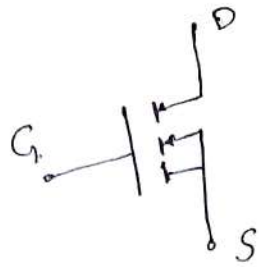
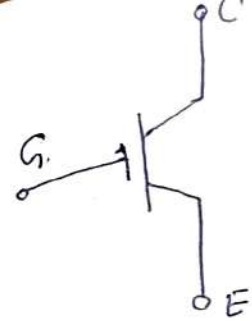
Insulated Gate Bipolar Transistors (IGBT)

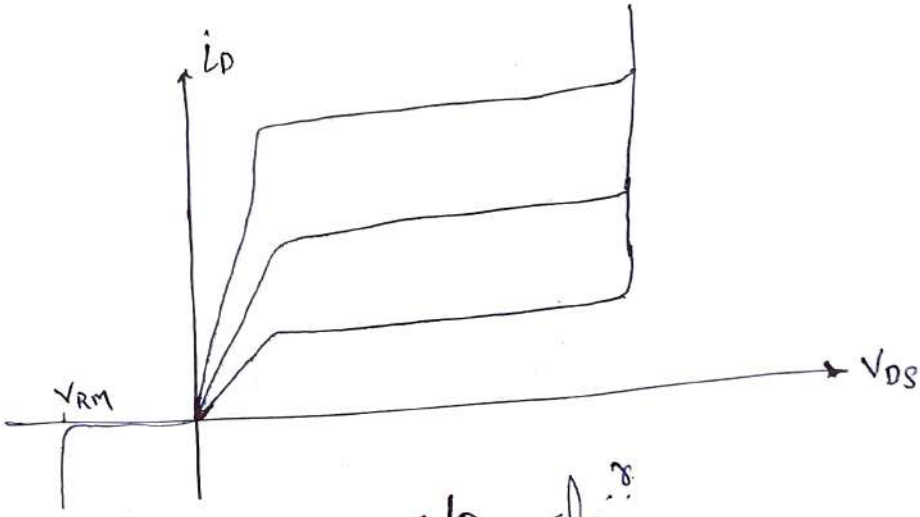
- BJT & MOSFET have characteristics that complement each other in some respects.
- BJT have lower conduction losses in the ON state, but have longer switching times.
- MOSFET can be turned on & off much faster, but their on-state conduction losses are larger.



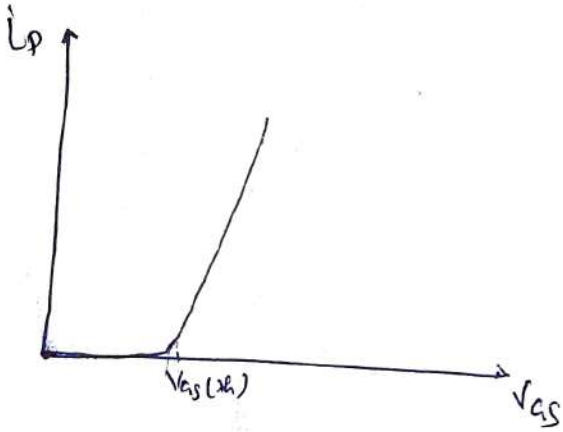
- The vertical cross-section of a generic n-channel IGBT is shown above.
- The Principal difference b/w MOSFET & IGBT is the presence p^+ layer that forms the drain of the IGBT.
- This layer forms a PN J^n, which injects minority carri into what would appear to be the drain region of MOSFET.







o/p char.



Transfer char.

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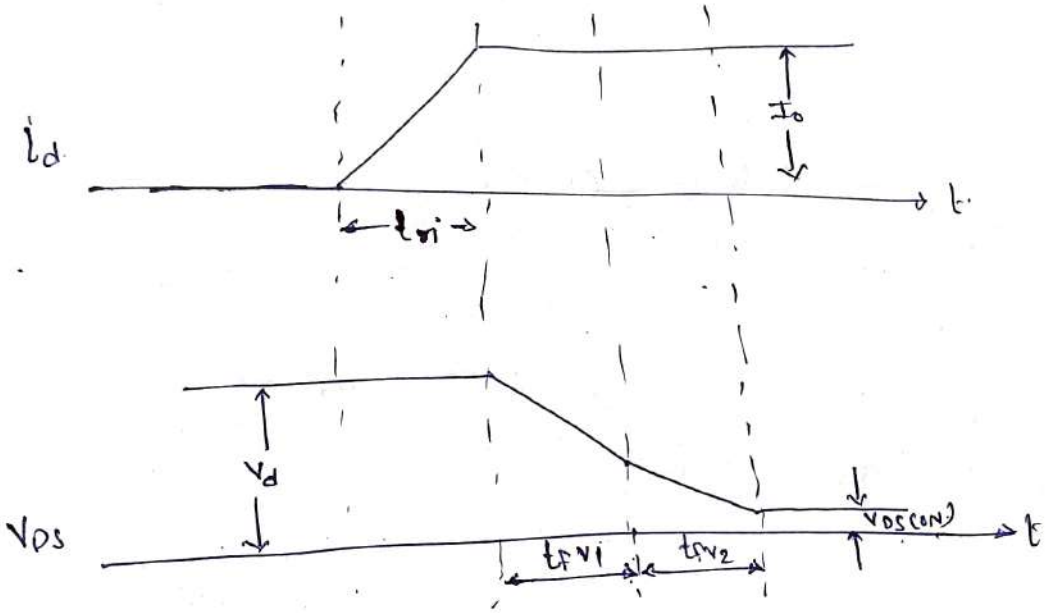
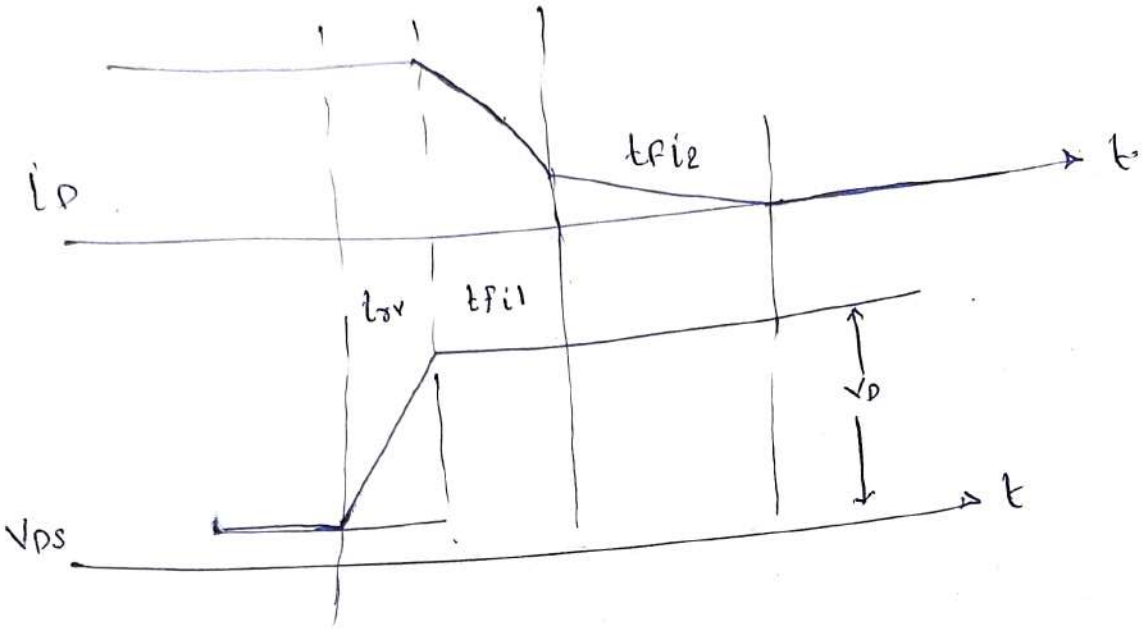
DETAILED LECTURE NOTES

- Since IGBT is basically a MOSFET, the gate-source V_g controls the state of the device.
- When V_{GS} is less than $V_{GS(th)}$, there is no inversion layer created to connect the drain to source & hence device is in off state.
- The applied drain-source V_g is dropped across the J_1 & J_2 & only a very small leakage current flows.
- The depletion region of the J_2 J^n extends principally in the n^- drift region, since P-type body region is purposely doped much more heavily than the drift region.
- The thickness of drift region is large enough to accomodate the depletion layer so that depletion layer boundary does not touch the p^+ layer.
- When gate source V_g exceeds the threshold, an inversion layer forms beneath the gate of the IGBT.
- This inversion layer shorts the n^- drift region to n^+ source region exactly as in the MOSFET.
- An electron current flows through this inversion layer, which in turn causes substantial hole injection from the p^+ drain contact layer into the n^- drift region.

Turn – ON transient



Turn-off transient



→ The rapid drop that occurs during t_{fi1} interv corresponds to the turn-off of the MOSFET section ; IGBT.

→ The tailing of the drain current during the second in t_{fv2} is due to the stored charge in the n^- drift region

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R.S. Singh Name of Subject: PE Code: SEE1
Date (Prep.): ..... Date (Del.): .....Unit No.: I .....Lect. No: 5

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Basic & application of thyristor.
- I-V char. of thyristor.
- construction of thyristor

IMPORTANT & RELEVANT QUESTIONS:

- what happen if you applied the -ve gate current during forward bias condition.
- why thyristor is not turned-off when we apply a -ve gate current.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- construction of thyristor.
- Application of gate current

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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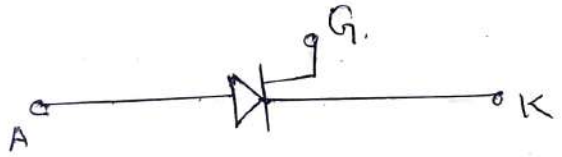
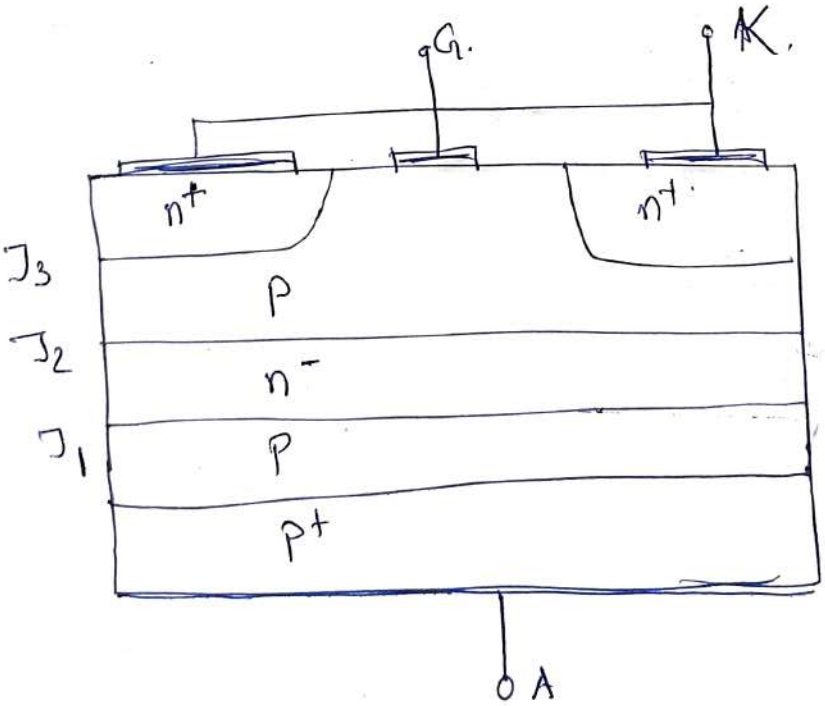
Thyristors

→ The n^- region of the thyristors absorbs the depletion layer of the J^n that blocks the applied voltage when thyristor is in the off state.

→ The P layer that forms the anode of the thyristor is a feature of the thyristor structure not found in BJT.





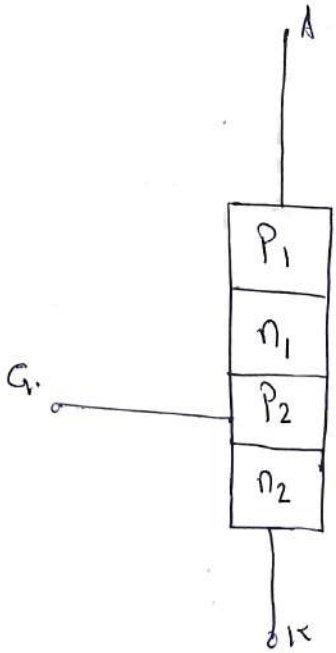
→ In the forward direction ... connected together ... an states or that are unstable mode that appears as a negative ... on the i-v char.

→ The Holding current I_H represents the min.m current that can flow through the thyristor & still maintain device in the on state.

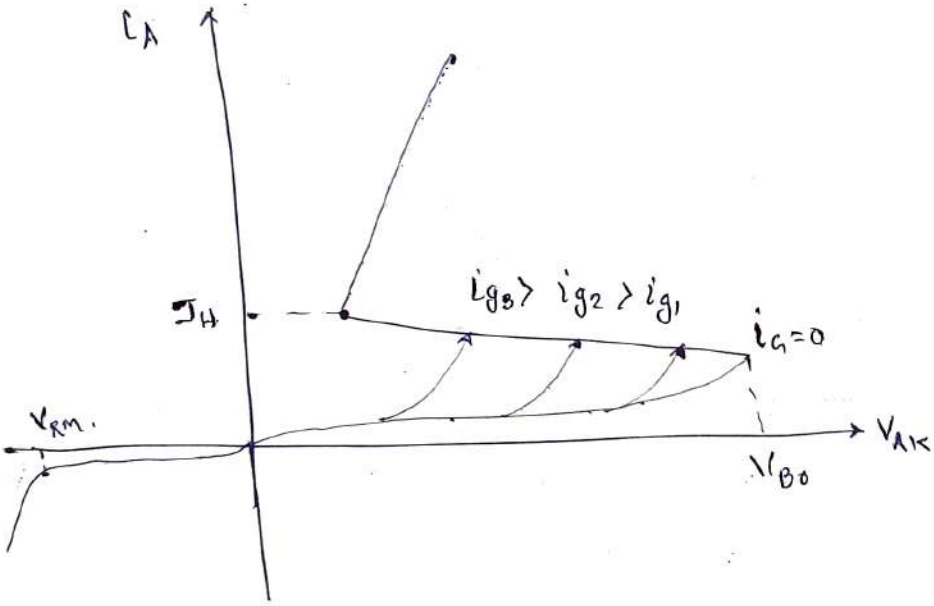
→ The breakover V_g & current are defined for zero gate current.

→ If the gate current is applied to the thyr... then breakover to the on state will occur at smaller value of anode-to-cathode V_g.

→ However once the thyristor is in the on state the gate cannot be used to turn the device off



DETAILED LECTURE NOTES



COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.Tech. Class/Section: III, ~~IV~~ Date: .....
Name of Faculty: R.S. Sirl Name of Subject: P.E Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: II Lect. No: 16

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ Switching Characteristics of an SCR.

IMPORTANT & RELEVANT QUESTIONS:

→ what happen if you reduced the turn-on rise time of an SCR?

→ why anode current goes to -ve max^m side & then reduces to zero.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what is the difference b/w thyristor turn-off time & circuit turn-off time?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Switching char^s of an SCR.

→ Impact of di/dt on rise time.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

→ Ned Mohan

→ P.S. Bimbhra

→ M.H. Rashid

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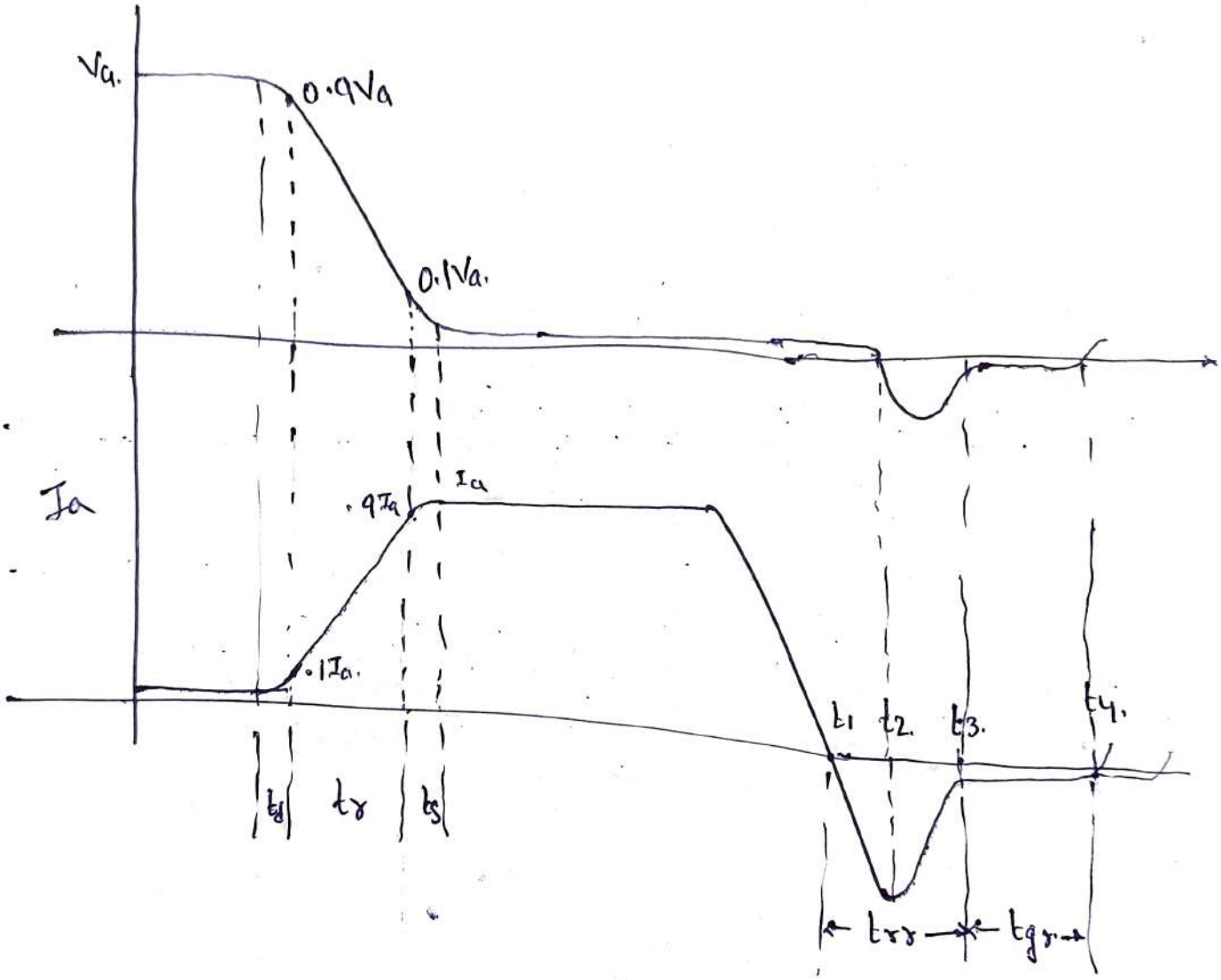
DETAILED LECTURE NOTES

Switching Characteristics



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Turn-ON Transi

→ The anode current ↑ at which is set by external ckt. times of other devices or stray inductance in ckt.

→ Three distinct time-interval can be defined:
turn-on delay time ($t_{d(on)}$)
rise time (t_r)
spread time (t_s)

→ During turn-on delay time, thyristor appears to in the blocking state.

→ Gate current during this time injecting excess carr P_2 layer (base of npn) in the vicinity of gate contac

→ This increase in excess carrier causes the sum of base $\alpha_1 + \alpha_2$ to increase until they equal to unity

→ At this point, the thyristor is at breakover

→ At this point, the thyristor is at breakover heavy electron injection into P_2 layer from n_2 la & hole injection from P_1 layer into n_1 layer commences in the vicinity of gate regions. The anode current begins to increase, & this mark end of the turn-on delay time.

→ During rise time interval, a large excess carri built up in the vicinity of gate region, which spread laterally across the face of the cathode the entire cross-sectional area of the thyristor filled with high excess-carrier density.

During rise time, the V_g drop is fairly rapid b the localized regions of high densities in the vicinity of gate

→ After rise time, the plasma still continues to spread over the lateral area of the thyristor. until the thyristor is completely shorted out by the large excess - carrier densities.

→ The time - required for the plasma to spread from the initial regions around the gate terminals to the entire device cross-section is called spread time T_s.

→ The rate of v_g drop during spread time is slower ~~than rise time~~ bcoz 't_s' is larger than t_r & due to that most of the drop occurs during 'T_r' interval.

→ It is important that rate of rise of anode current is kept less than max^m value given on the specification sheet.

→ If di_T/dt exceeds this max^m limits, the device may be damage or even fail.

→ Such damage may occur bcoz large rate of of current growth mean that rise time will be short, & consequently Turned - ON area around the Gate region of the thyristor will be quite small at the end of the rise time interval compared with cross - sectional area of the device.

→ A small turn-on area further means that the thyristor will not have fallen very far from the blocking state value during rise time.

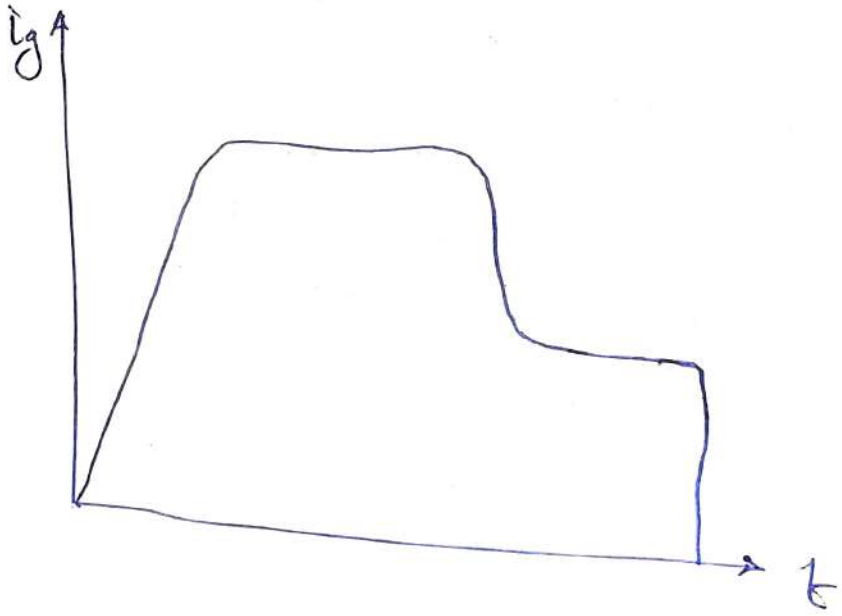
→ Hence the instantaneous power dissipation during t_r will be large & confined to a relatively small volume.

→ Due to that heat generated & damage the device.

→ Larger value of gate current during $t_{d(ON)}$ & turned-ON area intervals will increase the size of excess carriers. by providing larger amount of will reduce the Peak

→ A large turned-ON area instantaneous power dissipation.

→ For this region, gate current applied is often large at the start of the turn-on interval & gradually reduced as time proceeds.



Turn-off transients

→ As time proceeds, the current continues to decrease & soon passes through zero at time t_1 & then grows towards -ve value.

→ The V_g across the thyristor remains small & +ve until either J^n J_1 or J_3 starts to become reverse bias, an even that does not occur until the excess-carrier density at the J^n decayed to zero.

→ usually J_3 will become R.B. first occuring at t_2 & then very quickly goes into avalanche breakdown as anode-cathode V_g goes -ve bcoz of heavy doping in the 'n_2' & 'p_2' layers means that the reverse blocking capability of this J^n is not very large.

→ After 't_2' the excess-carrier distribution in the thyristor is no longer large enough to sustain the ever-growing -ve anode current & so the current attains its peak -ve value I_{rr} & begins to decay back toward zero.

→ At about the same time excess carrier density at goes to zero & it becomes R.B.

→ At t_1 anode current becomes zero.
After t_1, anode current builds up in the reverse dir. with the same di/dt slope as before t_1.

→ The reason for the reversal of anode current after t_1 is due to the presence of carriers stored in the four layers.

→ The reverse - recovery current removes excess carriers from J_1 & J_3 b/w instant t_1 & t_3.

→ At t_2, 60% of stored charges are removed from outer two layers.

→ The reverse current decay fast in the beginning but gradual thereafter.
The fast decay occurs due to reverse V_g across the device due to ckt. inductance.

→ At 't_3' when I_{rr} has fallen nearly to zero value and J^n J_1 & J_3 recover & SCR is able to block the reverse V_g.

→ At the end of recovery interval, the middle J^n still has trapped some charges, therefore the thyristor is not able to block the forward V_g at t_3.

→ The trapped charges in the inner two layers, cannot flow to the external ckt., therefore these trapped charges must decay only by recombination.

→ This recombination is possible, if reverse V_g is maintained across SCR, though magnitude of this V_g is not important.

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LECTURE NOTES

Campus: PCE Course: B. Tech Class/Section: III Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 6

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ Switching char. of thyristor
→ Importance of gate current.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on the switching char. of thyristor.
→ what happend if di/dt has higher value compared to its permissible limit.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what is the importance of ts period.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Switching char. of thyristor.
→ Importance of di/dt value.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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M. H. Rashid.

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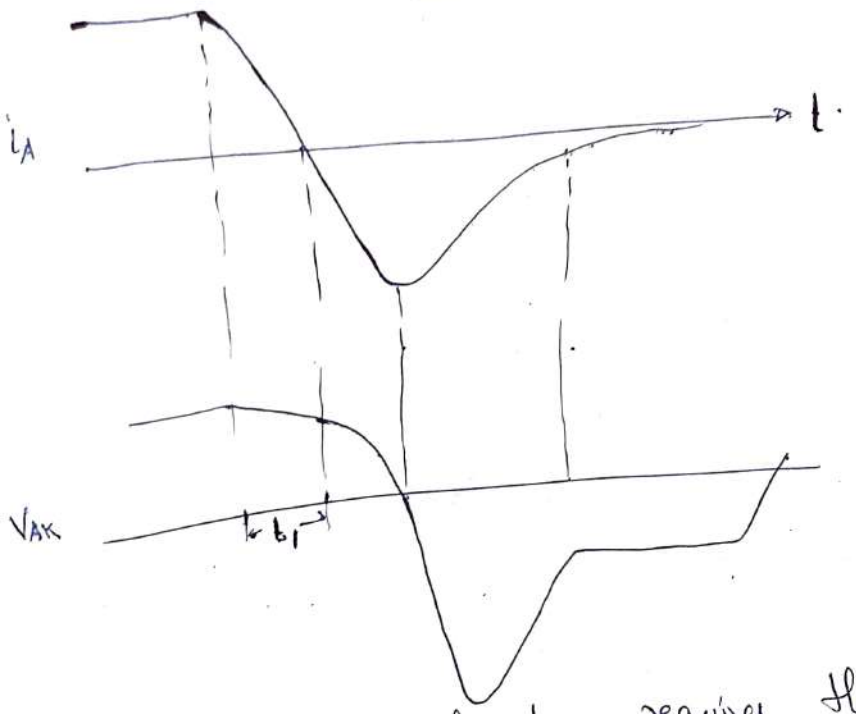
Turn-off Process

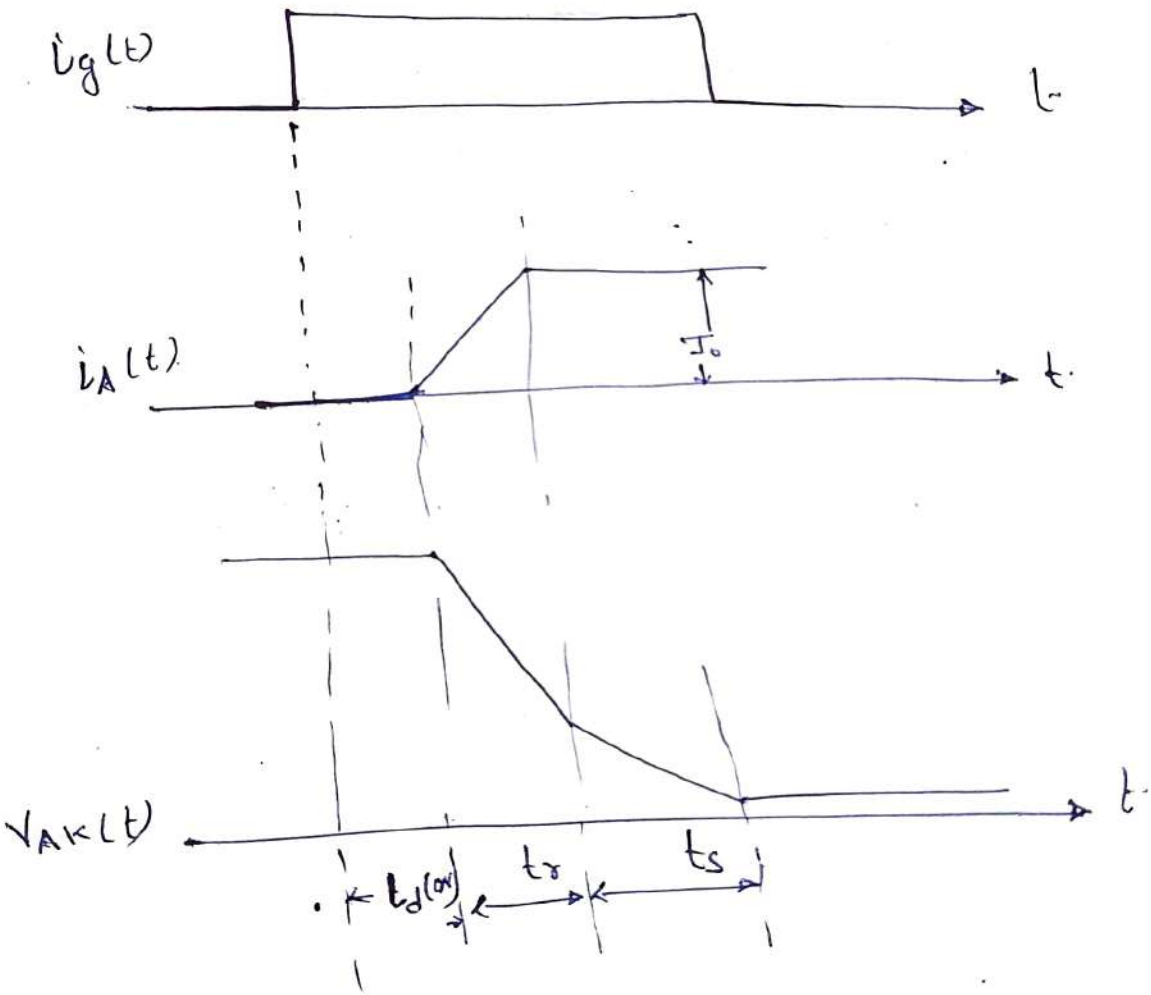


→ Turn-off the thyristor requires that it be reverse biased by the external ckt. for a min^m time-period.

→ As time proceeds, the current continues to decrease & soon passes through zero at t_1 & then grows towards negative value.

→ The V_g across thyristor remain small & the until either J_1 or J_3 starts to become reverse bias

Switching characteristics of thyristors



Turn - on process

→ During turn-on delay time, the thyristor appears remain in the blocking state.

→ However, the gate current during this time is in the vicinity excess carriers into the P_2 layer gate contact.

→ The increase in excess carriers causes the sum of base $\alpha_1 + \alpha_2$ to increase until they equal unit

→ During rise time, a large excess carrier density is up in the vicinity of the gate regions, which then sp laterally across the face of the cathode until the entir cross-sectional area of the thyristor is filled with a excess carrier density.

The time required for the plasma to spread from initial regions around the gate terminals to the entire c cross-section is the plasma-spreading time t_{ps}.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: SEE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 1

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- difference b/w GTO & conventional thyristor.
- Switching char^n of GTO

IMPORTANT & RELEVANT QUESTIONS:

- Switchi: write short notes on switching char^n. of GTO.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- why there is a overshoot in Anode current.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Difference b/w GTO & conventional thyristor.
- Switching char^n of GTO

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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M.H. Rashid.

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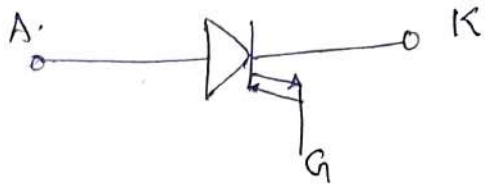
Gate turn-off thyristors (GTO).

- The GTO retains the basic four-layer structure of the thyristor & its doping profile.
- The thickness of the p_2 base layer is generally somewhat smaller in a GTO than in conventional thyristor.
- Three significant difference b/w GTO & conventional thyristor.
- First, the gate & cathode structure are highly interdigitated with various types of geometric forms being used to lay out the gates & cathodes.
  The basic goal is to maximize the periphery of the cathode & minimize the distance from the gate to the center of a cathode region.
- Second, the cathode areas are usually formed by etching away the silicon surrounding the cathodes so that they appear as islands.
  When the GTO is packaged, the cathode islands are directly contacted to a metal heat sink, which also forms the cathode connection to the outside world.

→ A third major diffe
region of the GTO.

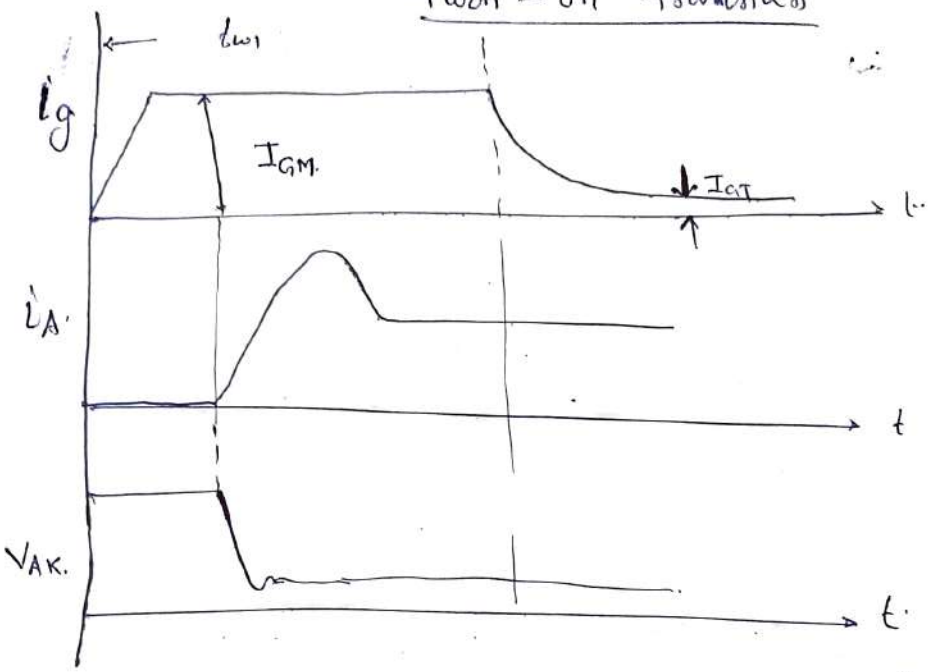
→ At regular intervals, n^+ regions penetrate the anode (P_1 layer) to make contact with n^- region forms the n_1 base layer.



→ The i-v char^n of a GTO in the forward is identical to that of a conventional thyristor. However in the reverse dir^n, GTO has virtu no blocking capability because of the anode-sho structure.

→ The only J^n that blocks in the reverse direction i & it has rather low voltage bcoz of large dopi densities on both sides of the J^n.

Turn-on transients



→ During turn-on, both the rate of gate current increase di/dt, & the Peak gate current I_{GM} should be large to ensure that all cathode islands begin to conduct.

→ A large I_{GM} value is supplied for a long enough time period e.g. 10μs, to ensure that turn-on process is complete.

→ After completion of turn-on, there must be a min^m continous gate current I_{GT} flowing during the entire on-period to prevent unwanted turn-off.

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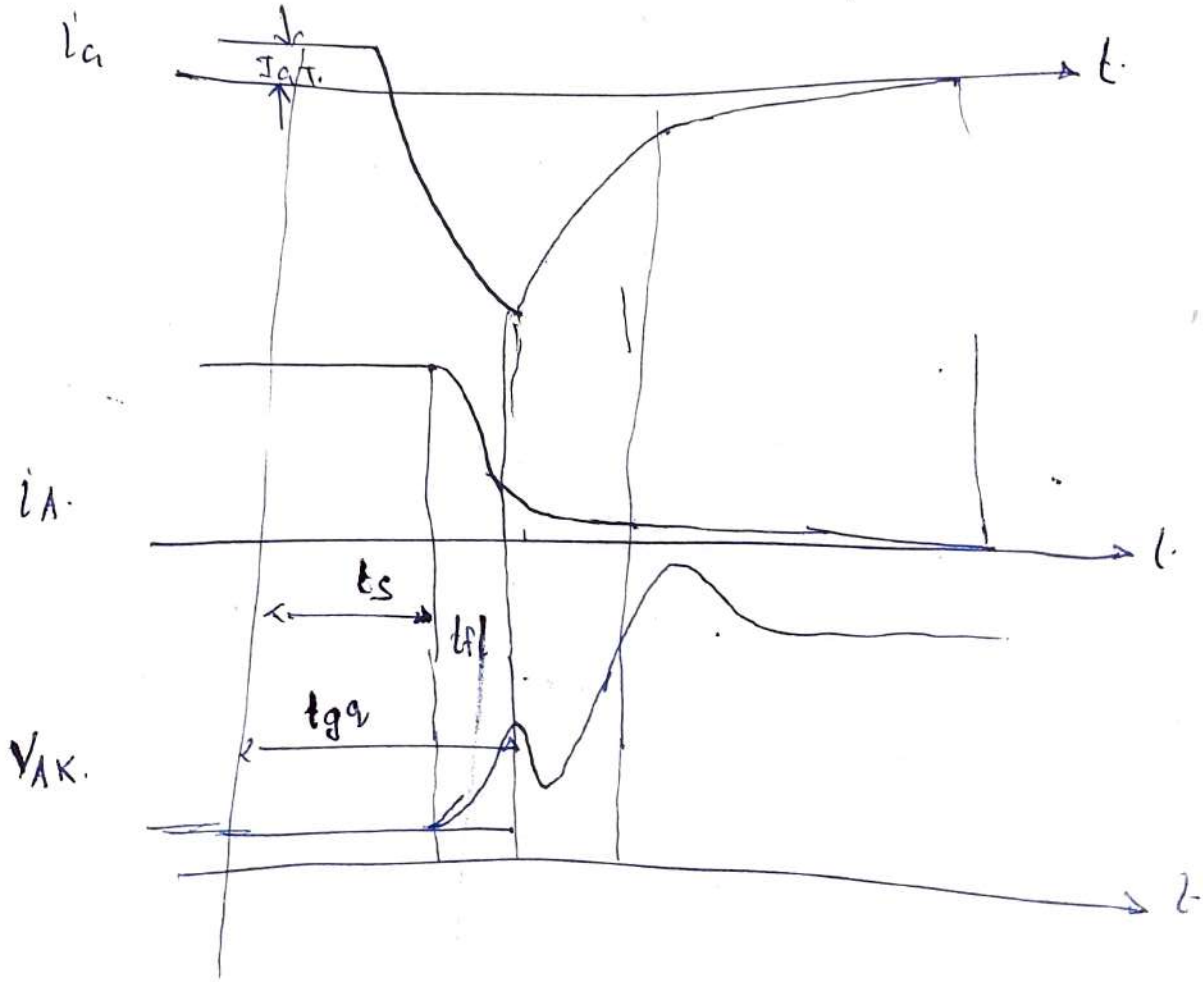
→ During the growth of the snubber is limited shared b/w the turn-on
→ If the di/dt of the anode current is high large value, then the V_g inductance bcoz of its quickly to a fairly low value. GTO will drop
The overshoot in the anode current comes from reverse recovery of the free-wheeling diode D_f.

Turn-Off Time



→ GTO is turned off by applying a large negative current.

→ The gate - current must be very large, on the order of 1/5 - 1/3 of the anode current being turned off, but fortunately this large negative current is required for only a relatively short time.

→ During the first time interval, the storage time t_s, the growing negative gate current is removing charge stored in the p_2 & n_2 layers at the periphery of cathode islands.

→ As the stored charge continues to be removed p the periphery, the size of the plasma - free region grows as it expands in the lateral dir^n towards center of the cathode.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A/B Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 02

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Two transistor model of thyristor.
- How thyristor will be turned ON?

IMPORTANT & RELEVANT QUESTIONS:

- Briefly explain the two transistor model of a SCR. and also ~~deduce~~ obtain the formula for anode current.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what is the effect of Junction capacitance?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Students got an idea about various method of to turn-on the SCR.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

- Ned Mohan
- P. S. Bimbhra.
- M. H. Rashid

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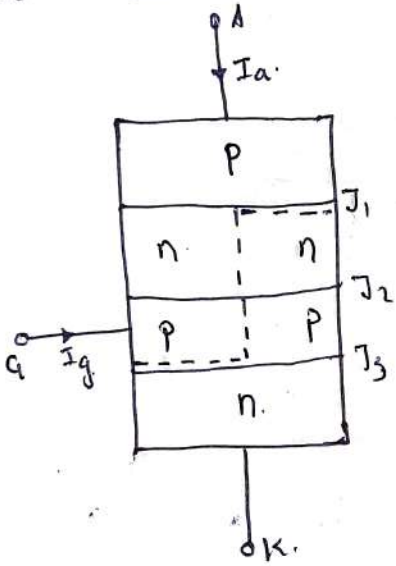
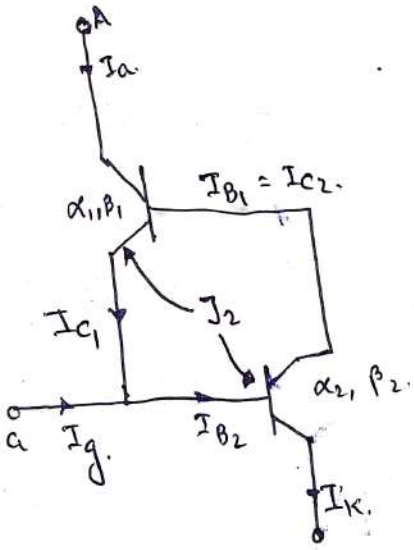
us: ..... Course: ..... Class/Section: ..... Date: .....
e of Faculty: ..... Name of Subject: ..... Code: .....

WO TRANSISTOR MODEL

Principle of thyristor operation can be explained with the use of its TWO TRANSISTOR MODEL.

Two transistor model is obtained by bisecting the two middle layer.





→ In the off-state of transistor, collector current I_C is related to the emitter current I_E as:

$$I_C = \alpha I_E + I_{CBO}$$

where α is the common-base current gain & I_{CBO} is the common-base leakage current of collector base J^n of trans

transistor Q_1, I_E = anode current I_a & I_c current I_{c_1}.

$$\therefore I_{c_1} = \alpha_1 I_a + I_{CBO}$$

$$\& \quad I_{c_2} = \alpha_2 I_K + I_{CBO2}.$$

→ The sum of two collector current is equal to the circuit current I_a entering at anode terminal A.

$$I_a = I_{c_1} + I_{c_2}$$

$$= \alpha_1 I_a + I_{CBO1} + \alpha_2 I_K + I_{CBO_2}.$$

when gate current is applied $I_K = I_a + I_g$

$$I_a = \alpha_1 I_a + I_{CBO1} + \alpha_2 (I_a + I_g) + I_{CBO2}$$

$$I_a = \frac{\alpha_2 I_g + I_{CBO1} + I_{CBO2}}{1-(\alpha_1+\alpha_2)}$$

→ If emitter current increases then $\alpha \uparrow$.

Triggering of SCR

(i) Gate triggering:

→ with anode +ve w.r.t. to cathode & $I_g = 0$, the current, equal to forward leakage current is somewhat more than $I_{CBO1} + I_{CBO2}$.

Under these conditions, the device is in forward blocking

Now .

AF 01A : (1:30)

i) Forward V_g triggering.

Forward $V_g \uparrow$, $V_{CE} \uparrow$,
as result leakage current of J_2 $J^n \uparrow$.
so collector current $\uparrow$.

iii) $\frac{dv}{dt}$ triggering:

J_2 behaves like capacitor

$i = C\frac{dv}{dt}$.

$\downarrow$

collector current of Q_1 & Q_2.

iv) Temp^n triggering:

At high temp^n forward leakage current $\uparrow$.

v) Light trigger

electron-hole pairs $\uparrow$., leakage current $\uparrow$

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LECTURE NOTES

Campus: PCE Course: B.Tech. Class/Section: III Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 9

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ construction of DIAC.
→ construction of TRIAC
→ Modes of operation of TRIAC.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on DIAC & its construction.
→ write short notes on TRIAC, its construction & modes of operation.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ why Triac is turned on for +ve & -ve gate current?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ DIAC & its operation
→ Triac & its operation

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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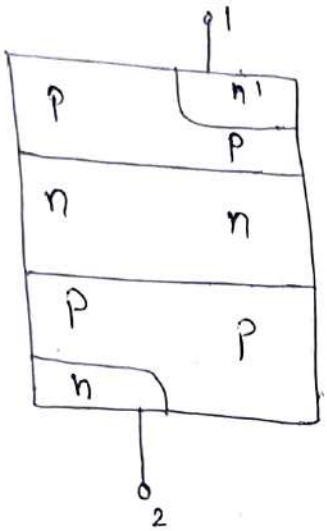
DIAC



→ If voltage V_{12}, with terminal 1 positive w.r.t. terminal 2, exceeds breakover voltage V_{BO1}, then structure pnpn conducts.

→ In case terminal 2 is the w.r.t. terminal 1 & when V_{21} exceeds breakover voltage V_{BO2}. Structure pnpn' conducts.

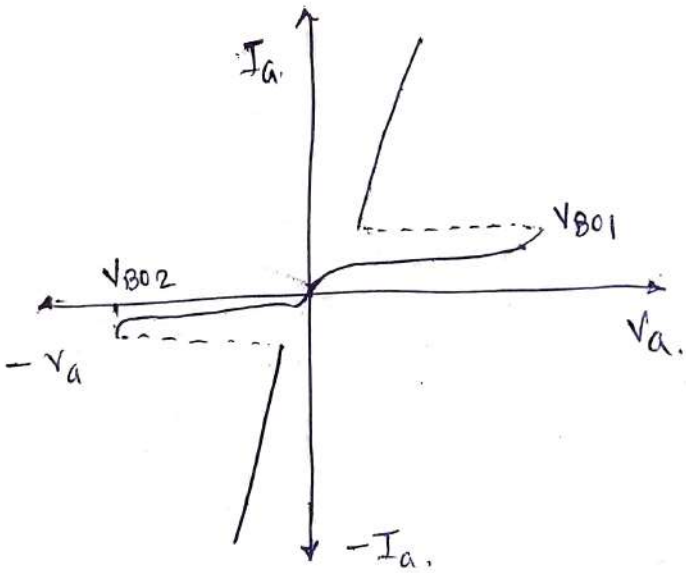
→ The term 'diac' is obtained from capital letters, DIode that can work on AC.

→ DIAC has symmetrical break-down char.
Its leads are interchangeable.

→ Its turn-on voltage is about 30V.

→ when conducting, it acts like a battery with about 3V drop across it.

→ when not conducting, it acts like an open



I - V char.

TRIAC

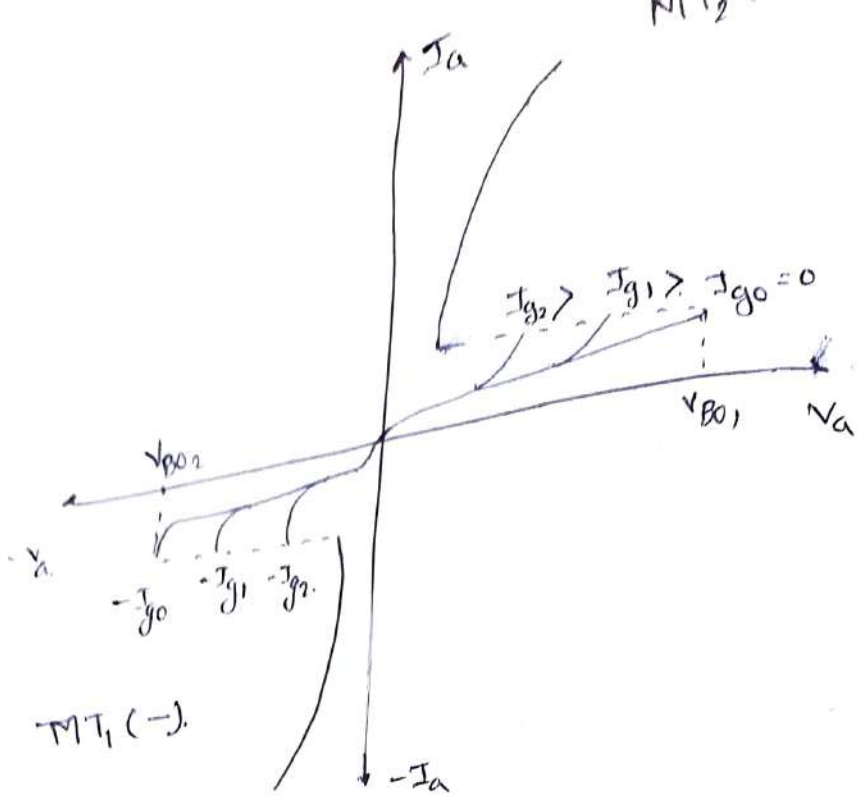
→ An SCR is a unidirectional device as it can conduct from anode to cathode only. A triac can conduct in both directions.

→ A triac is thus a bidirectional thyristor with three terminals.

→ It is used extensively for the control of Power in AC Ckt.

→ Triac is the word desired by combining the capital letters from the words TRIode & AC.

→ When in operation, a triac is equivalent to two SCRs connected in antiparallel.



Mode of operation

(i) MT_2 is +ve & gate current is also +ve.

→ $P_1 N_1 P_2 N_2$ are F.B.

→ Gate current flows through $P_2 N_2$.

) MT_2 is +ve but gate current is −ve.

→ when gate current is −ve w.r.t. MT_1, gate flows through $P_2 N_3$ J^n

→ $P_1 N_1 P_2 N_3$ conducts.

(III) MT_2 is negative but gate current is +ve:

→ gate current I_g forward bias P_2N_2 J^n.

→ $P_2 N_1 P_1 N_4$ conducts.

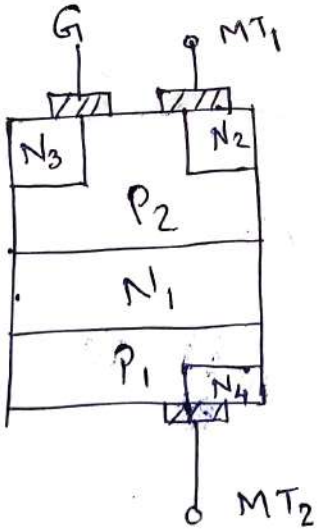
→ N_2 injects electrons into P_2 layer.

(IV) MT_2 is -ve & gate current are -ve.

→ I_g flows from P_2 to N_3.

→ $P_2 N_1 P_1 N_4$ conducts.

→ N_3 injects electrons into P_2 layer.



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LECTURE NOTES

pus: PCE Course: B.Tech Class/Section: III Date: .....
e of Faculty: R. S. Singh Name of Subject: P.E Code: 3EE1
(Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 10

BJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which ill be taught in this lecture)

construction of MCT
cha^r of MCT.

MPORTANT & RELEVANT QUESTIONS:

write short notes on construction & working operation of an MCT.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

Disadvantage of MCT.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Application of gate voltage on MCT.
→ construction & cha^r of an MCT.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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Ned Mohan

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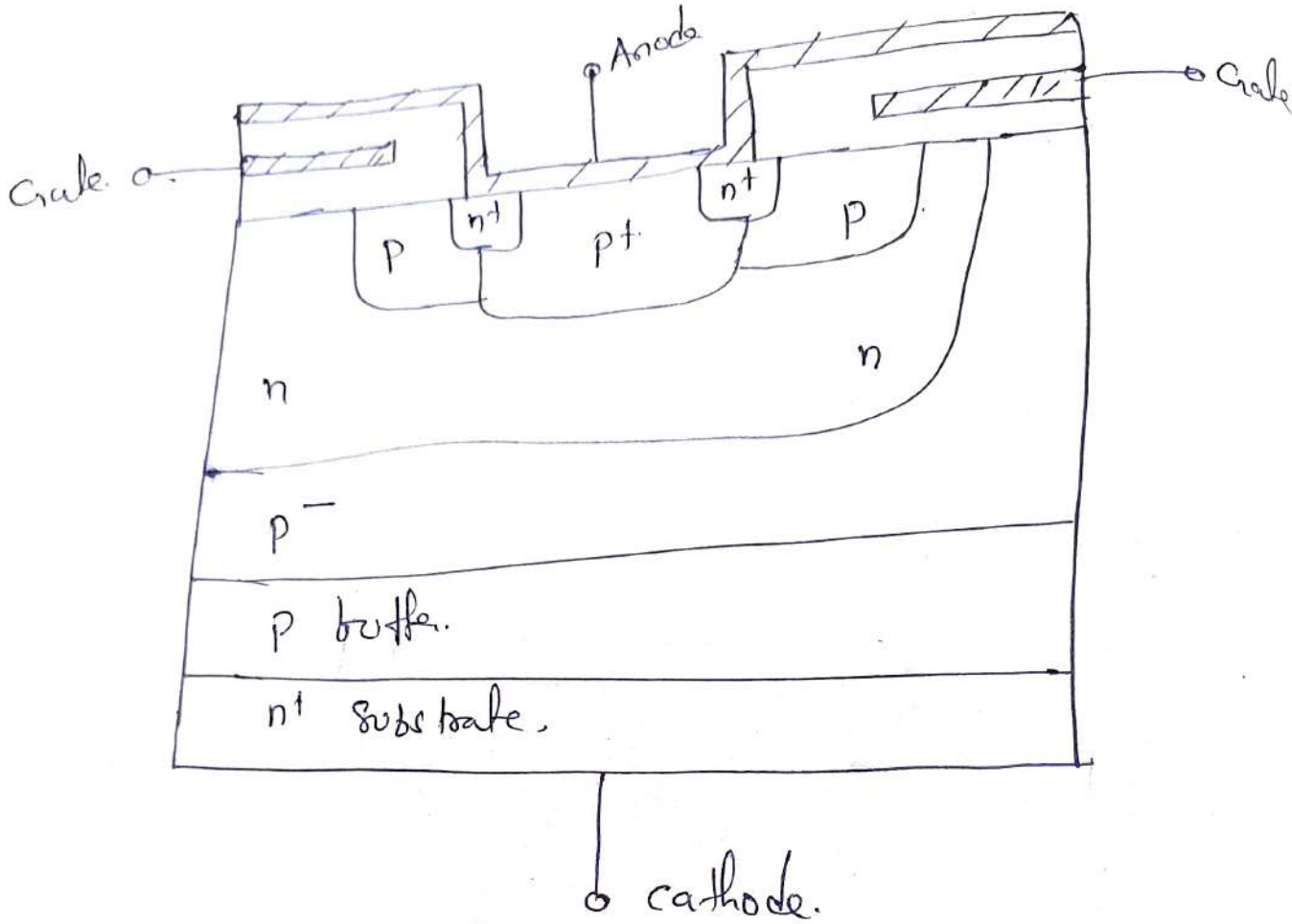
MOS - controlled Thyristor (MCT)

- An MCT is a new device in the field of semiconductor - controlled device.
- It is basically a thyristor with two MOSFET built into the gate structure.
- one MOSFET is used for turning on the MCT & other for turning off the device.
- An MCT is a high f^{x}, high Power, low conduction drop switching device.
- An MCT combines into it the features of both conventional thyristor having regenerative action & MOS - gate structure.
- In MCT, anode is the reference with respect to which all gate signals are applied.
  In conventional SCR, cathode is the reference term for gate signals.



The basic structure of an MCT cell shown above.

MCT consists of thousands of these basic cells connected in parallel Just like PMOS

This is done in order to achieve a current carrying capacity of the device.

Turn-on process :

→ MCT is turned-on by applying a -ve V_g pulse at the gate w.r.t. anode.

→ Gate is made -ve w.r.t. anode by V_g pulse b/w gate & anode.

→ MCT initially F.B. & then only a negative V_g be applied.

→ with the application of this -ve V_g pulse, on-FET gets turned on whereas off-FET is turned off.

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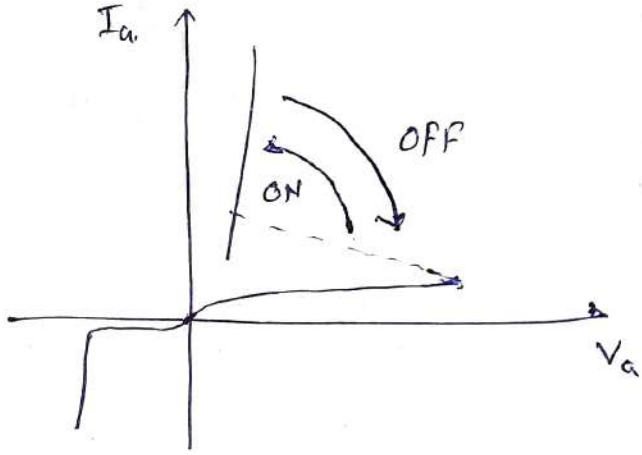
Turn-off process.

→ For turning off the MCT, off FET is energized
+ve V_g pulse at the gate.

→ with application of +ve V_g pulse, off-P
is turned on & on-FET is turned off.

→ After off FET is turned on, emitter base
terminals of pnp transistor are short circuited
by off-FET.

I-V characteristics



Similar to I-V char. of GTO.

Forward on-state voltage drop increases slightly with anode current as in a thyristor.

It is a V_g controlled device.

Low reverse voltage blocking capability.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R.S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: I Lect. No: 11

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Thyristor commutation
- Types of commutation

IMPORTANT & RELEVANT QUESTIONS:

- write short notes on the types of thyristor commutation technique.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what is the need of commutation.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Types of commutation
- Need of commutation.

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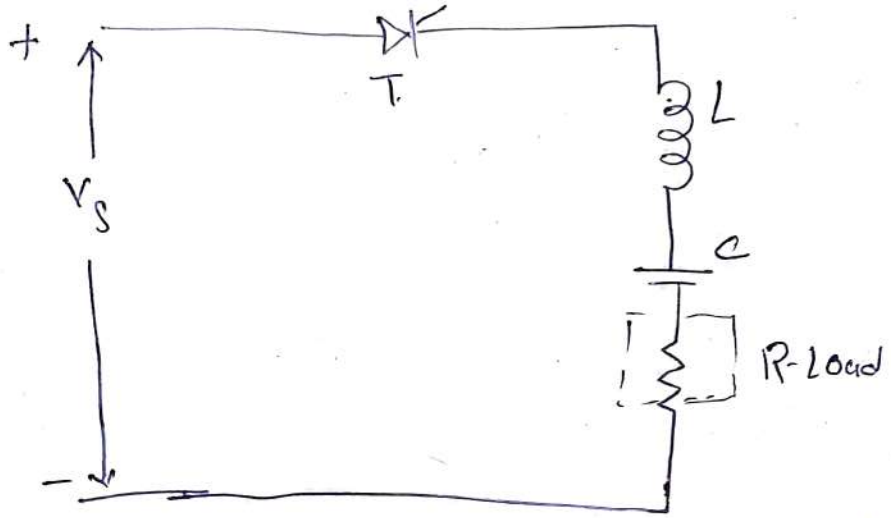
Sitapura, JAIPUR

Thyristor commutation Method

1) Class A commutation or Load commutation



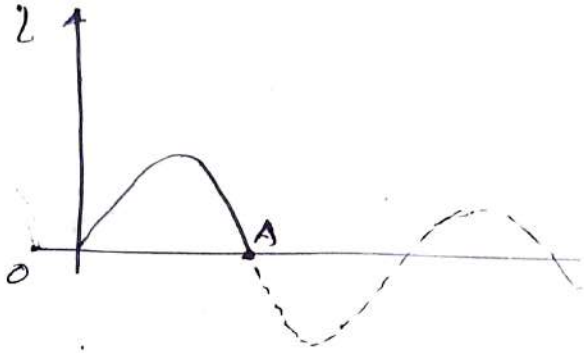
→ For achieving load commutation of a thyristor the commutating components L & C are connected as shown above.

→ For low value of R, L & C are connected in series.

→ For high value of R, load R is connected across C.

→ The overall ckt. must be uninterrupted.

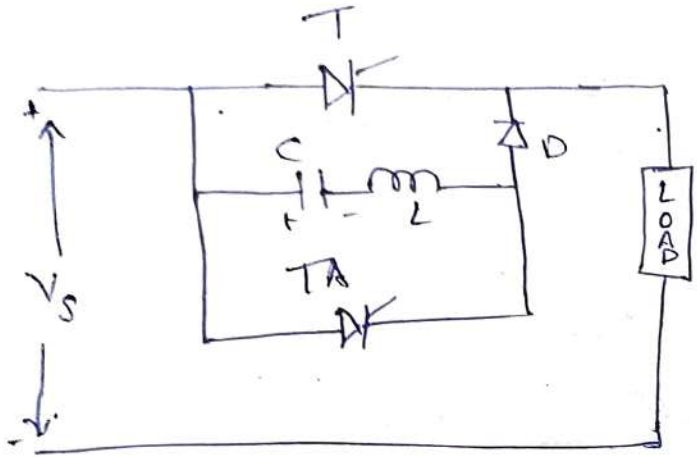
→ The current 'i' first rises to max^m value then begins to fall. when current decays to zero tends to reverse, 'T' is turned - off on its at instant A.



→ Load commutation is possible in DC ckts. & not AC ckts.

→ Class A, or load commutation is also called resonant commutation or self-commutation.

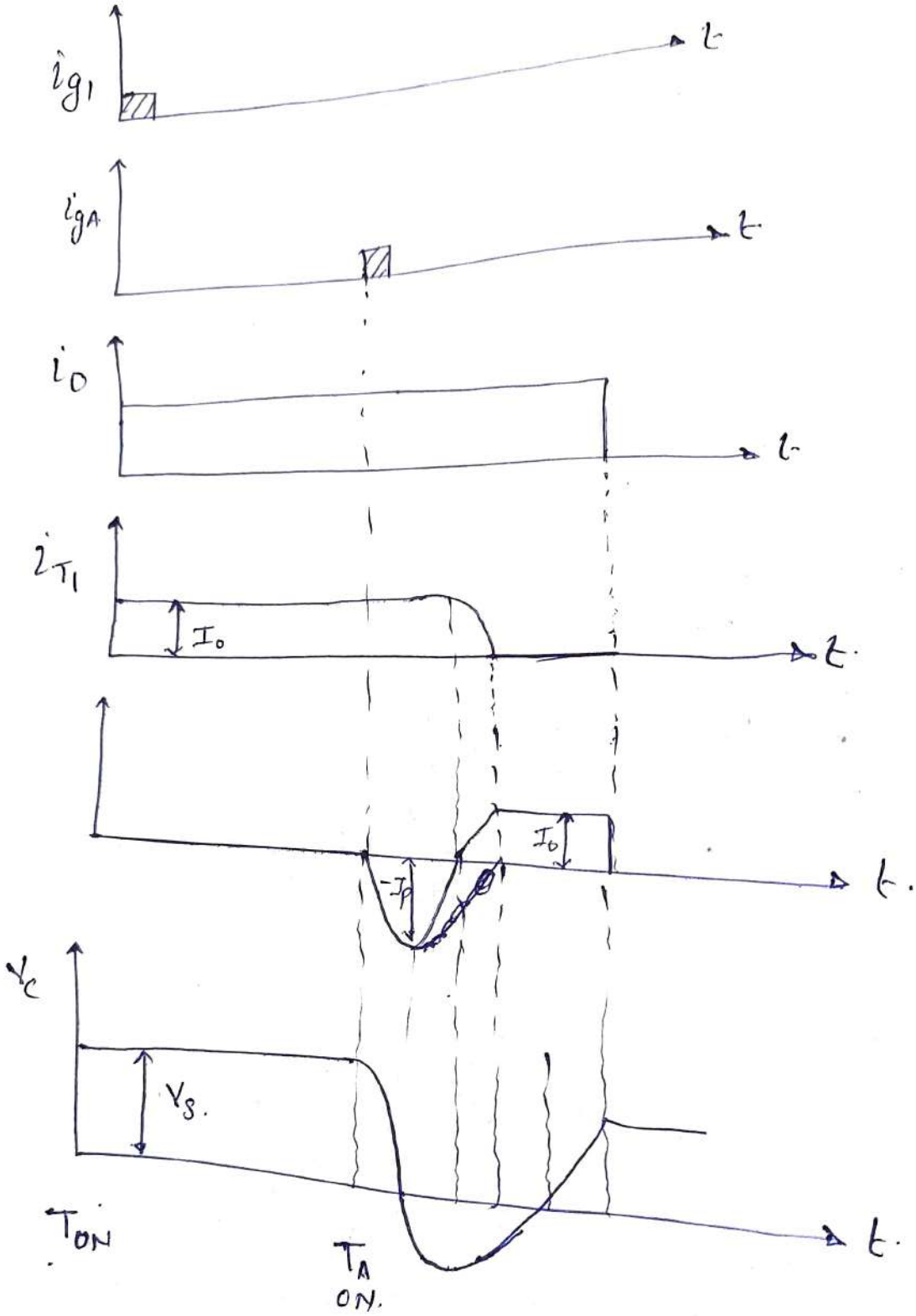
Class B commutation
or
Resonant Pulse commutation



→ Source V_g 'Vs' charges capacitor C to V_g V_S with left hand plate +ve.

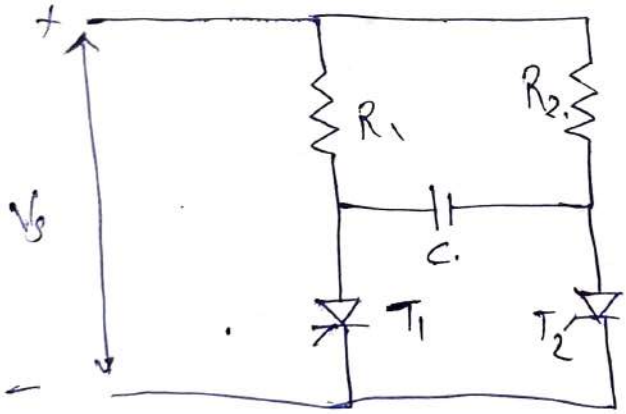
→ T_1 & TA are in off position.

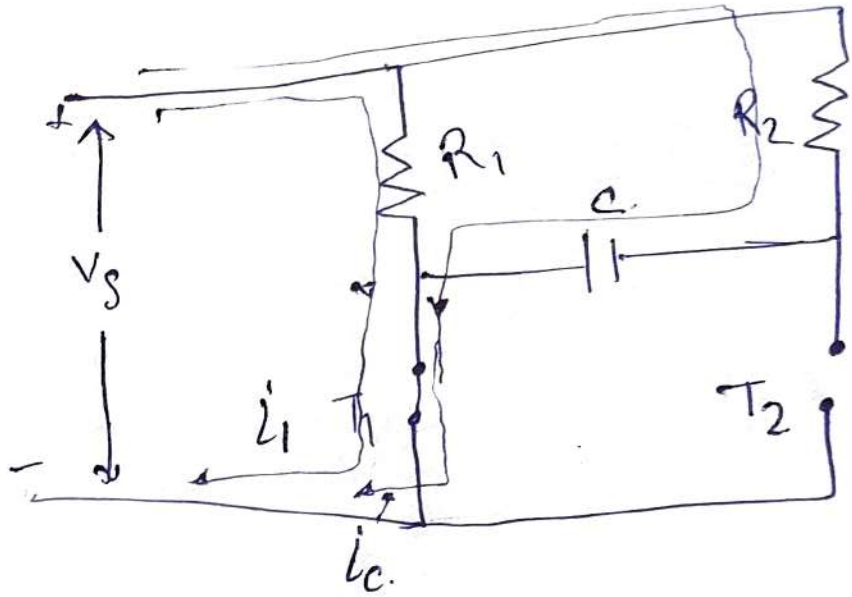
→ when T_1 is turned on at $t = 0$, a cons current I_0 is established in the load crt.



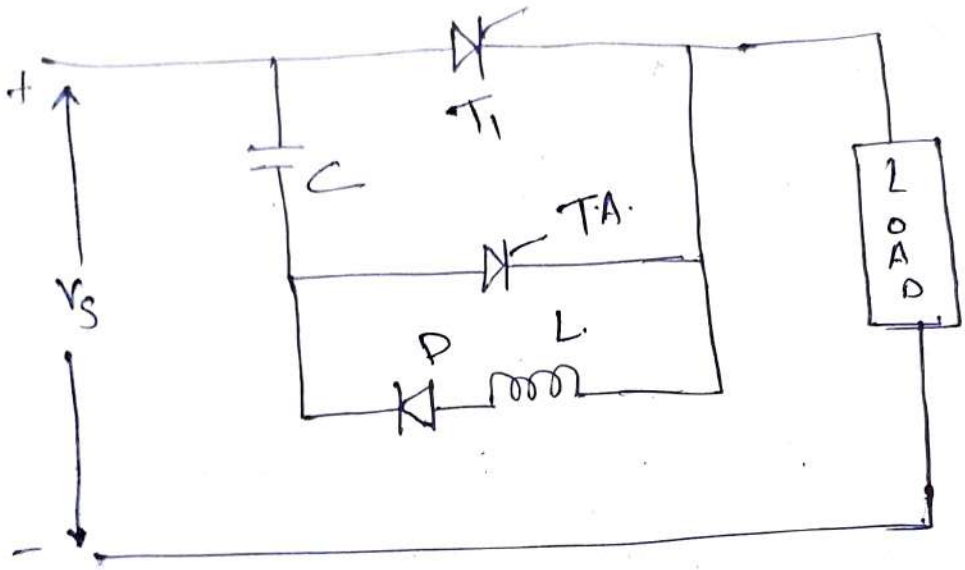
Class C commutation or complementary commutation

- In this type of commutation, thyristor carrying load current is commutated by transferring its load current to another incoming thyristor.





Class D commutation or Impulse commutation



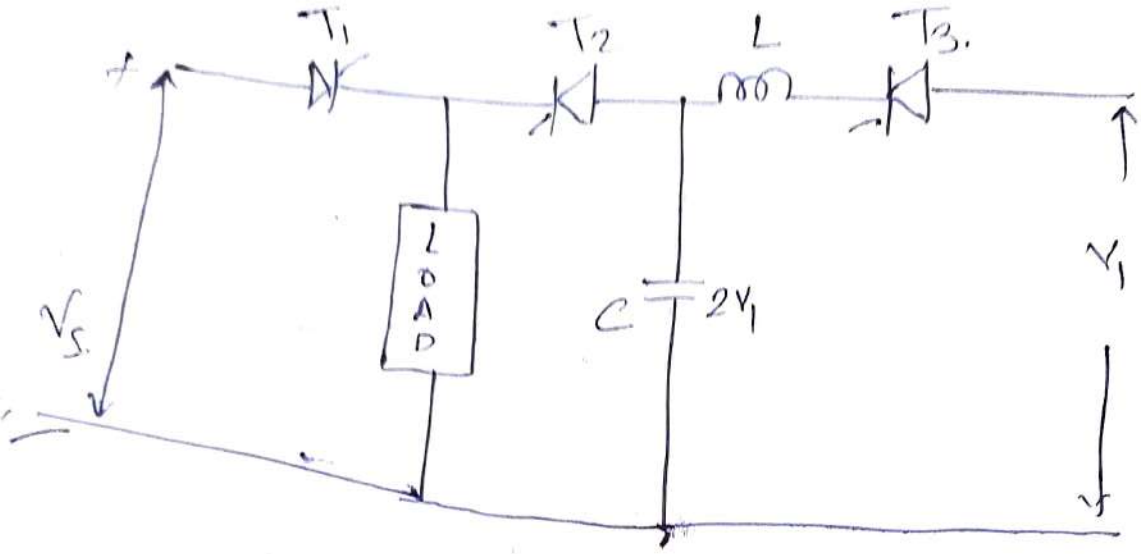
→ Initially T_1 & TA are off & capacitor is assumed charged to V_S with upper plate +ve.

→ When T_1 is turned on at $t = 0$, V_S is applied across load & load current I_0 begins to flow which is assumed to remain const.

→ With T_1 on at $t = 0$, another oscillatory current consisting of C, T_1, L & D is formed where capacitor current is given by

$$i_c = V_S \sqrt{C/L}.$$

Class E commutation
or
External Pulse commutation



→ In this type of commutation, a pulse of V is obtained from separate Vg source to off the conducting SCR.

→ The peak value of this Vg pulse must be more than the magnitude of main source

→ Vs is the voltage of the main source

V1 is the Vg of aux. supply.

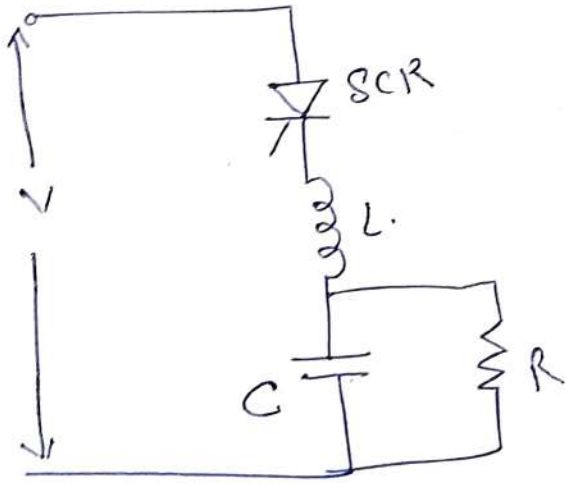
DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

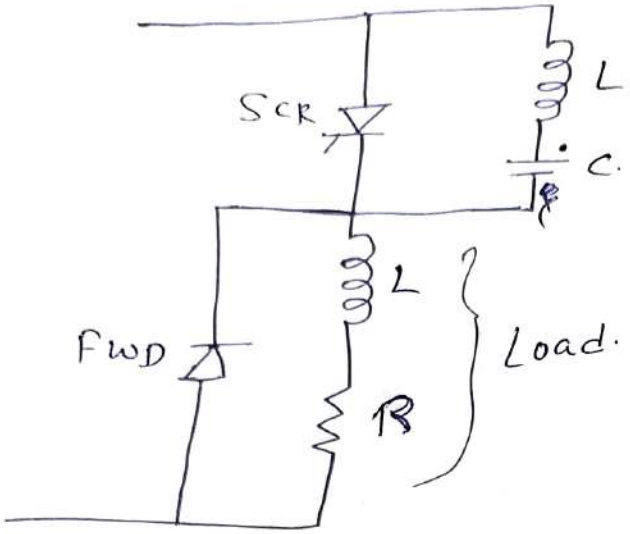
Thyristor commutation method:

- Class A: Self commutated by resonating load.
- Class B: " " by LC ckt.
- Class C: L-C switched by another load carrying SCR
- Class D: C or LC switched by an auxiliary SCR.
- Class E: An external pulse source for commutation.
- Class F: AC line commutation

Class A commutation:

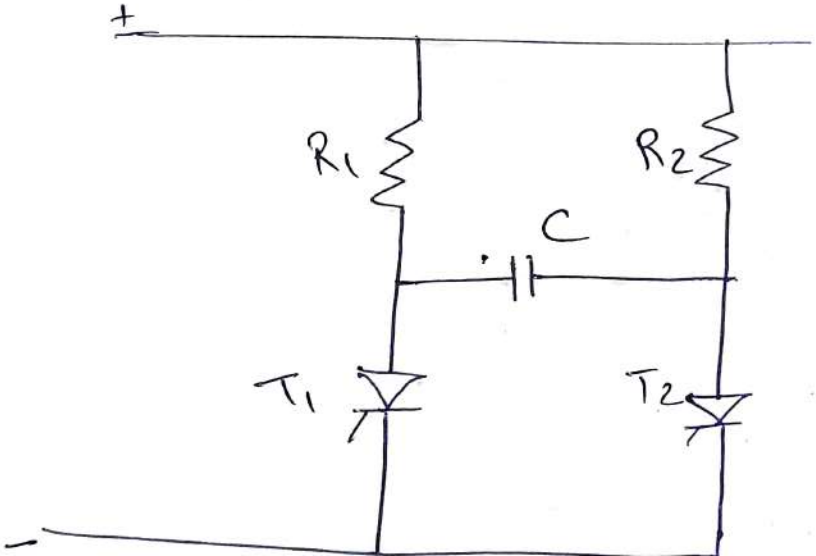


Class B commutation



→ LC is connected in series with thyristor in class
whereas in parallel ~~with~~ in class B.

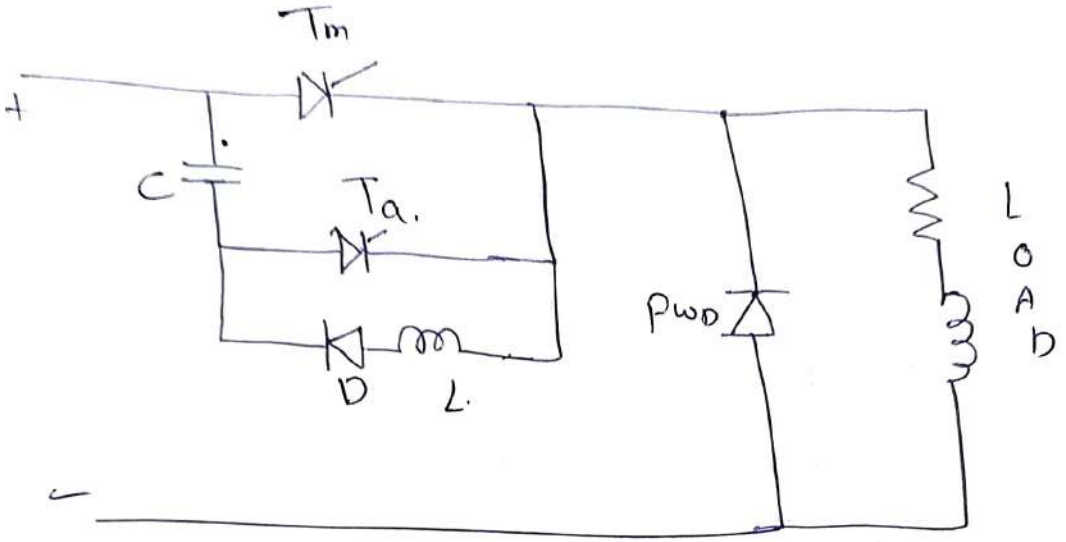
Class C commutation



DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

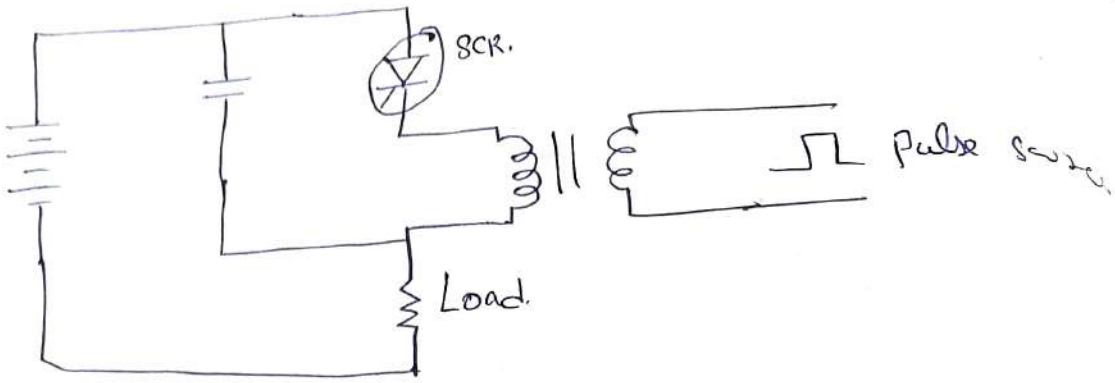
class D commutation



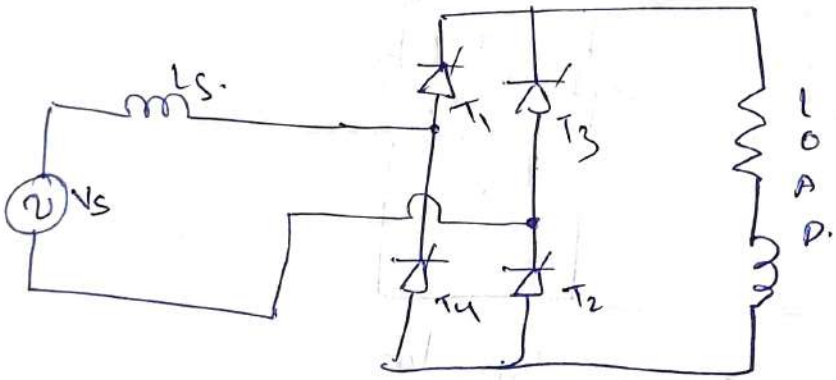
→ In class both SCR carry the load current but in class only main thy. (Tm) carry load current

→ when Tm is triggered, two components of current commutating component passes through C − Tm − L − D
Load current flow through load.

class E commutation



class F :



POORNIMA
COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A Date:
Name of Faculty: R. S. Singh Name of Subject: PE Code: SEE1
Date (Prep.): Date (Del.): Unit No.: II Lect. No: 18

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Introduction of SCR.
- Turn-on Process
- Turn-off Process
- V-I char. of an SCR.

IMPORTANT & RELEVANT QUESTIONS:

- why SCR is turn-ON when +ve gate Pulse are applied?
- why SCR is not turn-off when -ve gate Pulse are applied?

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- which Junction blocks the voltage during F.B. & R.B.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Students got an idea about V-I char. of an SCR.
- Impact of gate Pulse on SCR.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

- Ned Mohan
- M.H. Rashid
- P.S. Bimbhra.
- NPTEL

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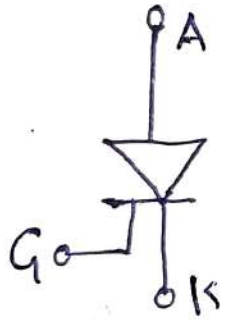
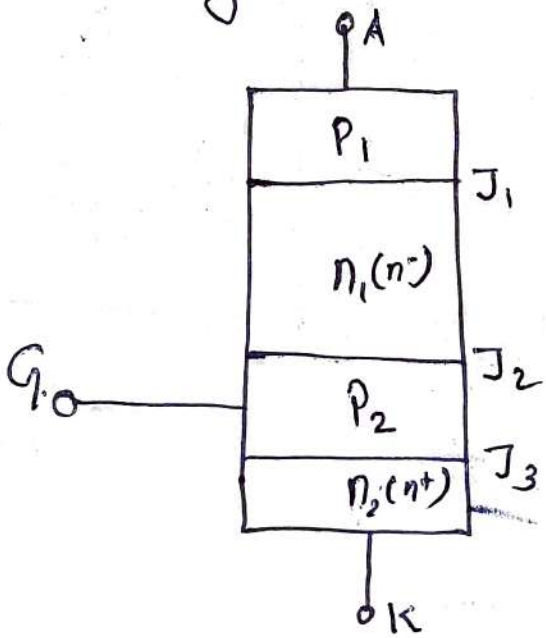
SCR: Silicon controlled Rectifier

- Invented by J.L. Moll & others at BELL LAB in 1956 for use in Bell's Signal application.
- Engineers at General Electric quickly recognized its significance to power conversion & control & within Nine months announced the first commercial SCR in 1957.
- continous current carrying capacity of 25A & blocking vg. of 300v.
- Now it is available upto blocking vg capability upto 6KV & continous current rating upto 4KA.





Clas → In Reverse blocking state, anode is -ve biased w.r.t. cathode.

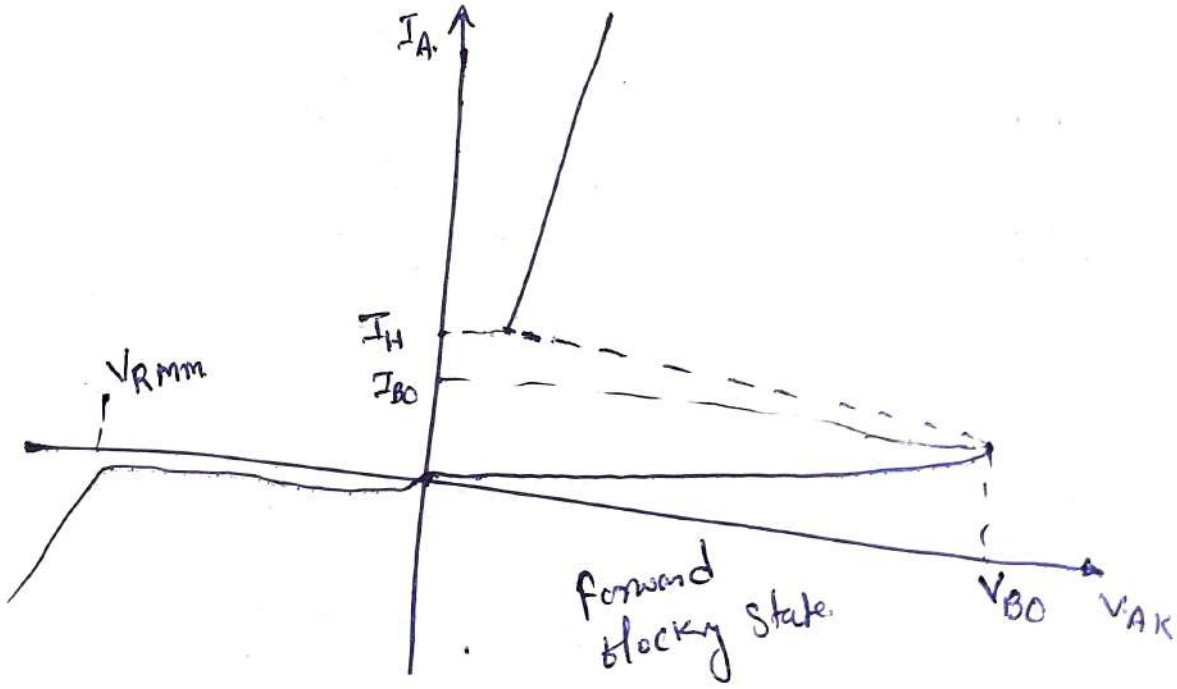
→ J_1 & J_3 are R.B. & J_2 is F.B.

→ J_1 must support the Reverse V_g bcoz J_3 has low doping on both sides as a consequence of heavy doping on both J^n.

→ The reverse-blocking capability of J_1 is usually limited the length of (n^-) n_1 layer.

→ In the forward-blocking state, J_1 & J_3 are F.B. is R.B.

→ The doping densities in each of the layers are such that layer is where the depletion region of R.B. J^n J_2 & thus this region again determines the blocking V_g & this time for the forward blocking state.



Turn - ON PROCESS

$$I_A = \frac{\alpha_2 I_G + I_{CBO1} + I_{CBO2}}{1-(\alpha_1+\alpha_2)}.$$

→ if $\alpha_1+\alpha_2$ approaches unity, the anode current will be large.

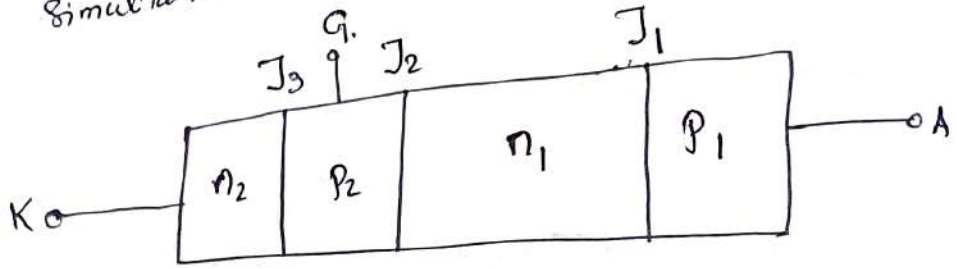
→ If this occurs, thyristor will be at break-over point where it is about to go into -ve- resistance state, once in this region, the device will quickly carry itse to the stable on state.

→ The mechanism that causes 'α' to increase is the growth of the depletion region of J^n J_2 into n_1 laye as anode-cathode V_g is increased.

→ This causes the effective base thickness of $P_1 n_1 P_2$ BJT BJT to get smaller & hence α_{pnp} ↑.

→ The extension of J_2 depletion layer into P_2 will likewise cause an increase in α_{npn}.

Cla → If a +ve gate current a significa
applied to the thyristor, the F.B. J^n J3 into P2 base
injection across the npn transistor will occur.
→ The electrons will diffuse across the base & be swept a
J2 into n1 base layer of the pnp transistor.
→ These extra electrons in the n1 layer will ha
two simultaneous effects.



C → First, the depletion layer of J^n J2 will grow in th
bcoz additional +ve space charge from ionized d
is needed to partially compensate for the −ve spa
charge of the electrons.
→ This growth of depletion layer into n1 layer w
reduce the effective base thickness of the pnp transi
& thus α_{pnp} to get larger.
→ Second, the injection of ~~holes into~~ electrons into the ba
pnp transistor will cause the injection holes into ba
(bcoz of space charge neutrality requirements)
→ This injected holes will diffuse across the base & be s
across the depletion region of J2 J^n & into the base
of npn BJT.
→ These holes will cause a further increase in electro
injection (bcoz holes attracts the electrons
the base region of npn BJT.

→ These additional injected electrons will go through the same cycle just describe for the intial injection of electrons.
This +ve reinforcement is thus a regenerative process.

→ This regenerative action carries the thyristor into the ON state.
The large current flow b/w the anode & cathode injects enough carriers into base region to keep the BJT saturated without any continous gate current flow.

Turn-off Process.

→ once the thyristor is latched into the ON-state the gate terminal no longer has any control over the state of device.

→ Turn-off can be done only through the external ckt., reducing the anode current below the holding current for a min^m specified period of time.

→ During this time, the simultaneous action of internal recombination & carriers sweep-out will remove enough stored charge, so that the the BJT are pulled out of saturation into the active region.

Imp

→ In thyristor, a -ve pulse cannot turn-off the device. bcoz the cathode region is much greater in area than the gate area.

→ when -ve gate current flows, it can only locally reverse bias the gate - cathode (base-emitter of npn transistor) J^n.

→ Lateral V_g drop in the P_2 region caused by I_G will result in current crowding toward the centre of cathode region.

→ The anode current that now flows more in center of each cathode region keeps the gate-cathode J^n forward biased in this center portion & thyristor stays on inspite of -ve gate current.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R. S. Syal Name of Subject: PE Code: 5EE1 15
Date (Prep.): ..... Date (Del.): ..... Unit No.: II Lect. No: .....

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- working of Pulse Transformer.
- Application

IMPORTANT & RELEVANT QUESTIONS:

- write short notes on working principle & Application of Pulse Transformer

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- why we don't fed broad pulses at the input of Primary winding?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Need of pulse Transformer.
- working of pulse Transformer

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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PULSE TRANSFORMER

→ The pulse transformer is a basically a T/F which couples a source of pulses of electrical energy to load. ~~with its shape &~~

→ The traditional T/F deals with sinusoidal waveforms, but pulse T/F deals with square pulse ~~transfor~~ waveforms.

→ The general construction of Pulse T/F are quite similar to that of Power transformers.

→ But some special improvement or modification is provided.

→ As they are used in sophisticated electronics applications, therefore the design of that transformers should carried out in such a way, that they can minimize the effects of signal distortion.

→ The Pulse T/F are designed on shell ty
core construction.

→ The main reason for shell type constructio
to provide reduce susceptibility for eddy
as well it can withstand with high Vg leve

→ For shell type core construction, capacitance effe
in b/w the Primary & secondary winding is red

Small sized pulse T/F, that is Signal T/F
used in low Vg electronics applications like
camera flasher.

High Vg T/F, that is power pulse T/F
used in radars, particle acceleration purposes.

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): .....Unit No.: II .....Lect. No: 16

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ working of opto-isolator
→ Application of opto-isolator.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on working & application of opto-isolatess.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ How Signal transmit from light emitting diode to Photosensor?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ working of opto-isolator.
→ Need & application

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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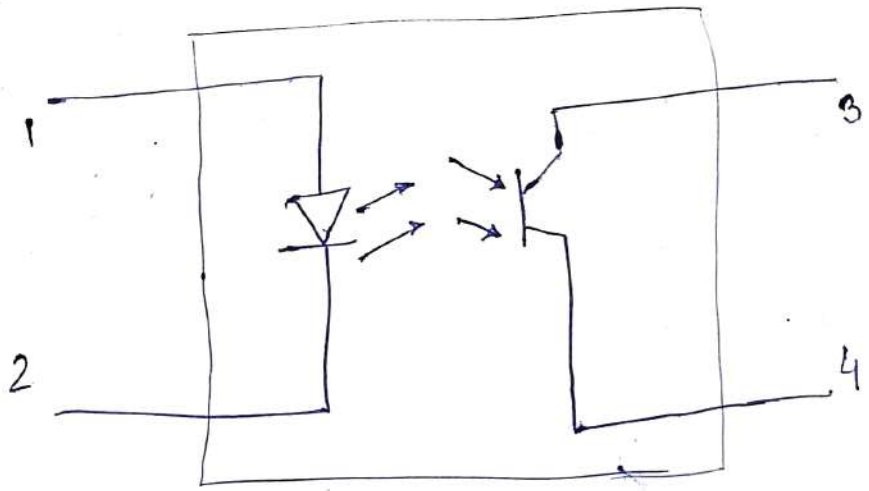
OPTO - ISOLATOR

→ In electronics, an opto-isolator, also called an opto coupler, Photocoupler, is a component that transfers electrical signal b/w two isolated ckt. by using light.

→ opto-isolators prevent high voltages from affecting the system receiving the signal.

→ commercially available opto-isolators withstand input-to-output voltages upto 10 KV & vg transie with speeds upto 10 KV/μs.



→ A common type of opto-isolator consists of LED & phototransistors in the same opaque p

→ Other types of source sensor combinations include Photodiode, LED - LASCR, pairs

→ An opto-isolator contains a source (emitter) of light, almost always a near infrared light emitting diode that converts electrical signal light, a closed optical channel & a photosensor which detects incoming light & either generates an energy directly

→ The f^n of an opto-isolator is to block high V_g & voltage transients, so that surge one part of the SXS. will not destroy the parts.

An opto-isolator connects input & output sides with a beam of light modulated by current,

It transforms useful I/P signal into light sends it across the dielectric channel, captures light on the output sides & transform it back into electric signal.

Photo diode opto - isolators

- Diode opto - isolators employ LED as sources of light & silicon photo diodes as sensors.
- when photo-diode is reverse-biased with an external V_g source, incoming light increases the reverse current flowing through the diode.
- The diode itself does not generate energy, it modulates the flow of energy from an external source.

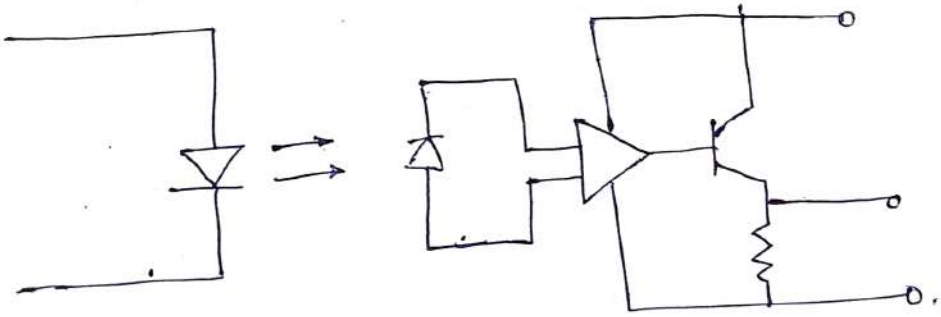


Photo-diode opto isolator

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LECTURE NOTES

Campus: PCE Course: B.Tech. Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: Power Electron. Code: EE-LA
Date (Prep.): ..... Date (Del.): ..... Unit No.: 02 Lect. No: 16

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

* Firing ckts of SCR ① Resistance firing ckt
② R-C firing ckt ③ RC-full wave firing ckt
* Working of UJT and UJT relaxation oscillator

IMPORTANT & RELEVANT QUESTIONS:

* Explain the working of the UJT and mention its important applications
* Discribe the resistance firing & R-C halfwave triggering ckt for SCR with wave diagram

FEED BACK QUESTIONS (AFTER 20 MINUTES):

* How UJT works?
* Draw RC firing ckt diagram used for triggering.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

* Students know about UJT.
* Students are able to explain the different firing ckt used in SCR triggering

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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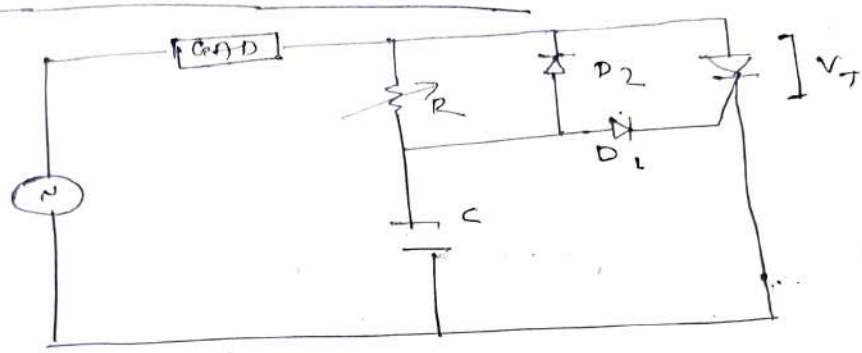
DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

RC - half wave trigger ckt:-



→ By varying R firing angle can also be controlled from 0 to 180°

→ In ⊕ve half cycle capacitor charges through D2 with lower plate ⊕ve to the peak supply voltage Vm at -90°

→ After ωt = -90° source voltage decreases from -Vm to zero at ωt = 0°

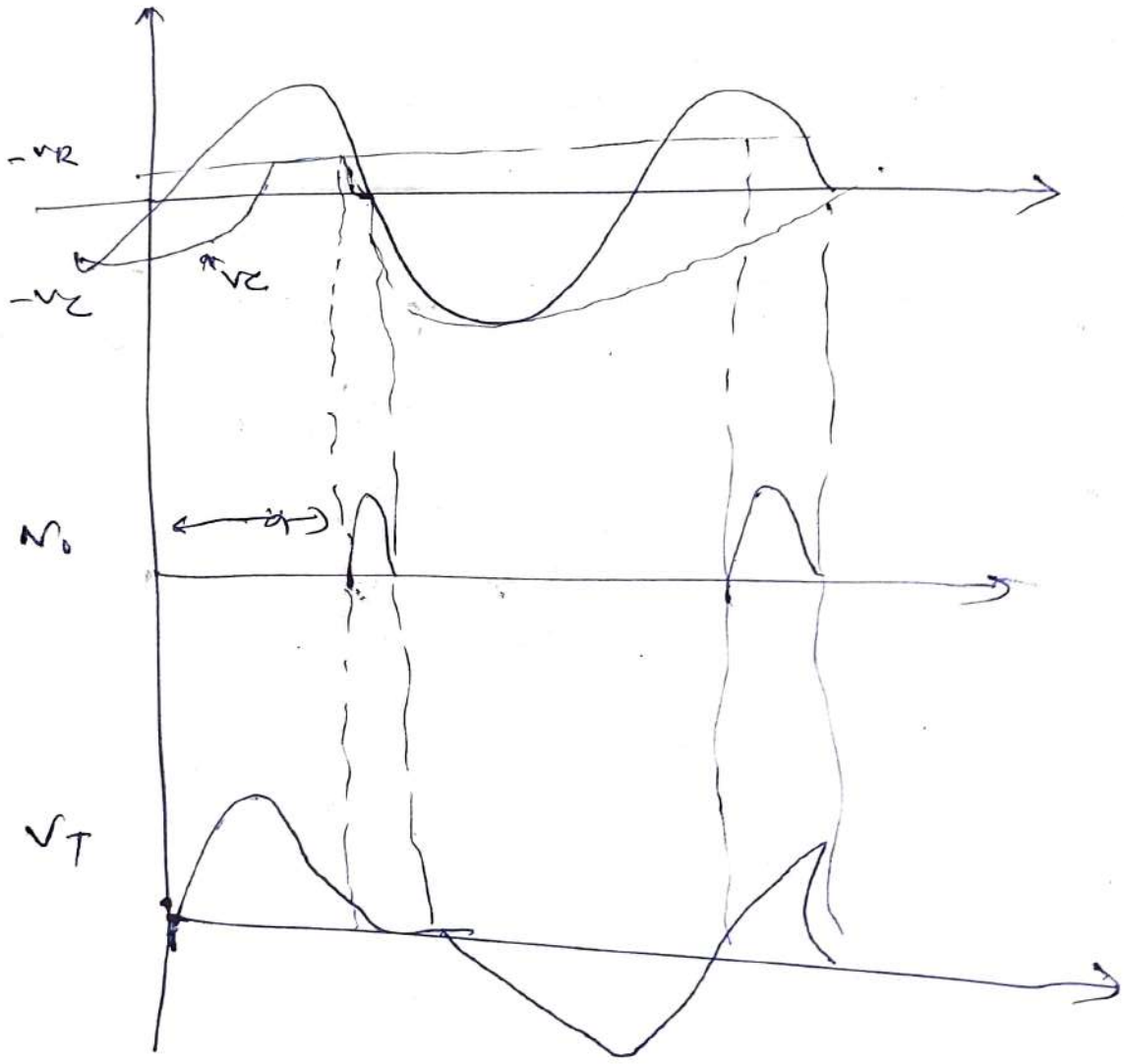
→ During this time capacitor voltage 'VC' may falls from Vm.

→ Now SCR anode voltage through zero & become ⊕ve 'C' begin to charge through variable R

When 'C' charges to +ve voltage equal to gate trigger voltage 'Vgt' SCR is fired.

→ D_1 is used to prevent the breakdown of cathode to gate &

→ voltage drop across it falls to 1 to 1.5 V.



COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.Tech. Class/Section: III A/B Date:
Name of Faculty: Name of Subject: P.E Code: EE1
Date (Prep.): Date (Del.): Unit No.: II Lect. No: 18

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Series operation
- Parallel operation
- Static & dynamic equalization ckt.

IMPORTANT & RELEVANT QUESTIONS:

- What is the need of a series & Parallel connection of an SCR?
-

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what is string efficiency?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Series operation
- Parallel operation
- Impact on Parallel string if one SCR is not turned-on.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

- Ned Mohan
- P.S. Bimbhra.
- M.H. Rashid.

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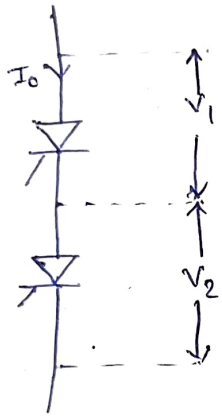
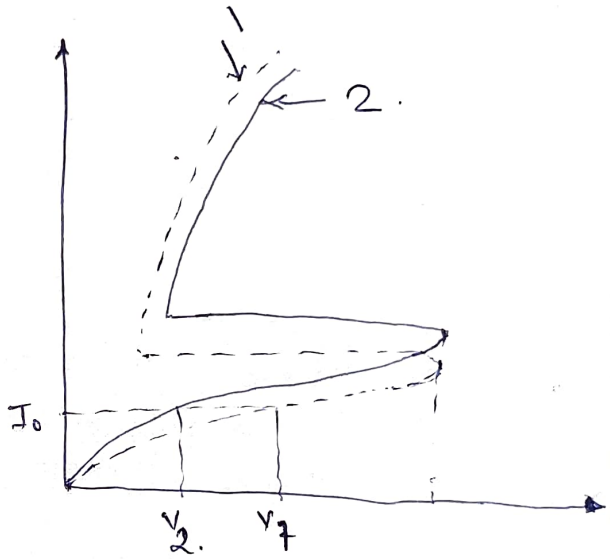
Series operation:

→ when a sys. V_g is more than the V_g rating of a single thyristor, SCRs are connected in series in a string.





→ For SCR_1, leakage resistance (V_1/I_0) is high whereas for SCR_2, it is low (V_2/I_0).

→ For the same leakage current I_0 in the series connected SCRs, SCR_1 supports rated V_g V_1 whereas SCR_2 support $V_2 < V_1$.

→ Each SCR is rated for a forward blocking V_g V_1 volts which is less than its forward break-over V_g.

→ Two SCRs can support a max. V_g of not the rated V_g $2V_1$.

Rlw
eig

string $\eta = \frac{V_1 + V_2}{2V_1} = \frac{1}{2}(1 + V_2/V_1)$.

→ T
to
→ v

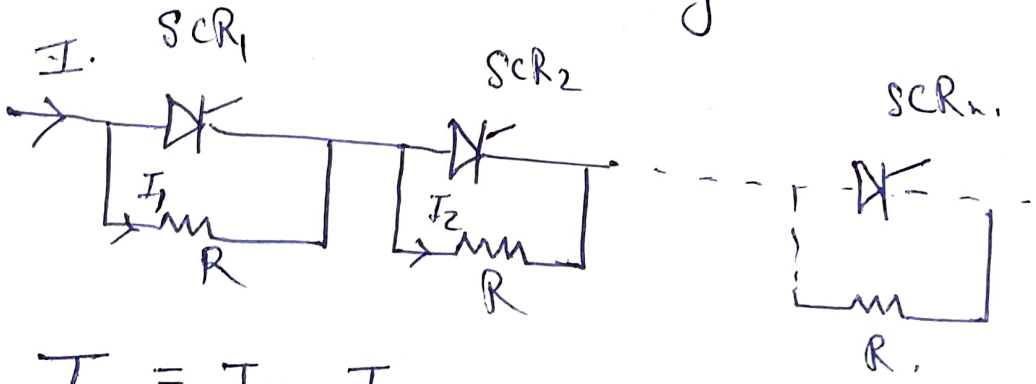
→ A uniform V_g distribution in steady-state can achieved by connecting a suitable resistance across SCR such that each parallel combination has the same resistance.
It is a difficult proposition.

→ A more practical way of obtaining a reasonably uniform V_g distribution during steady state working of series-connected SCR is to connect the same value of shunt 'R' across each SCR.

→ This shunt resistance R is called the static equalizing ckt.

→ consider 'n' thyristor connected in series. Let has min.m leakage current I_{bmn} & each remaining (n-1) SCR have the same leakage current $I_{bmx} > I_{bmn}$.

→ An examination reveals that an SCR with lower current blocks more V_g.



$I_1 = I - I_{bmn}$; $I_2 = I - I_{bmx}$.

V_g across SCR_1 $V_{bm} = I_1 R$.

V_g " $(n-1)$ SCR_s $= (n-1) I_2 R$.

DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

For string by 'V_s'

$$V_s = I_1 R + (n-1) I_2 R$$

$$= V_{bm} + (n-1) R (I - I_{bmx})$$

$$V_s = V_{bm} + (n-1) R (I_1 - (I_{bmx} - I_{bmn}))$$

$$= V_{bm} + (n-1) R I_1 - (n-1) R \cdot \Delta I_b$$

$$\Delta I_b = I_{bmx} - I_{bmn}$$

$$V_s = n V_{bm} - (n-1) R \Delta I_b$$

$$\boxed{R = \frac{n V_{bm} - V_s}{(n-1) \cdot \Delta I_b}}$$

→ It is likely that SCRs will have dynamic char.

→ In such a case, series connected SCRs will have V_g distribution during transient conditions.

→ It is assumed that turn-on time of SCR_2 is of SCR_1.

→ Before these two SCR are gated at the same time, $V_s/2$ by each SCR.

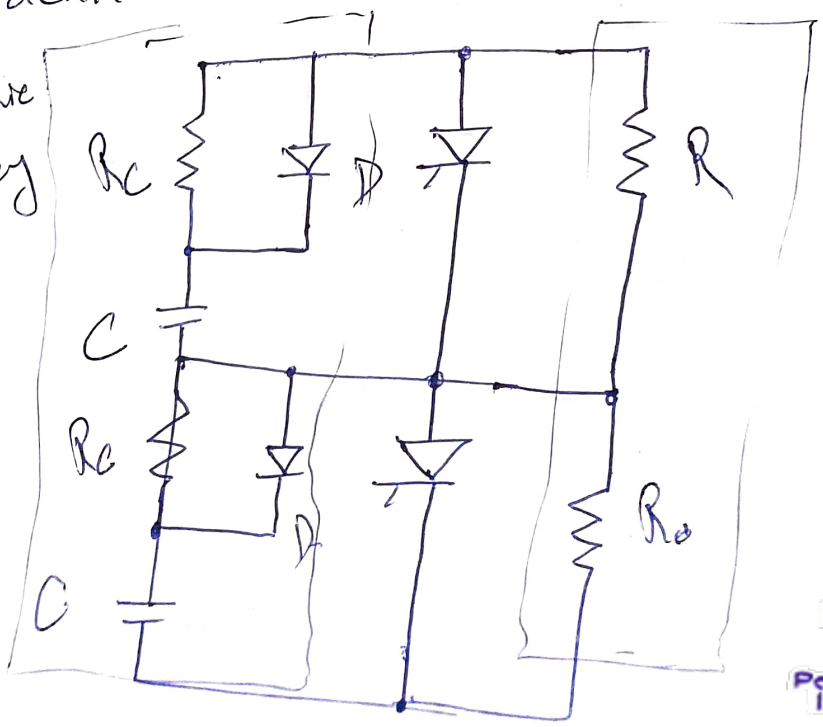
→ Now both SCRs are gated at same time. SCR_1 has left (turn-on) while SCR_2 is yet off.

→ V_g drop across SCR_1 drops from $V_s/2$ to almost V_g across SCR_2 will boost from $V_s/2$ to where as V_g shared by two SCRs are equal.

Thus V_g

→ During turn-on & turn-off, the capacitance of the R.B. J.n determines the V_g distribution across SCRs in a series connected string.

V_g equalization under these conditions can how be achieved by employing shunt capacitors.



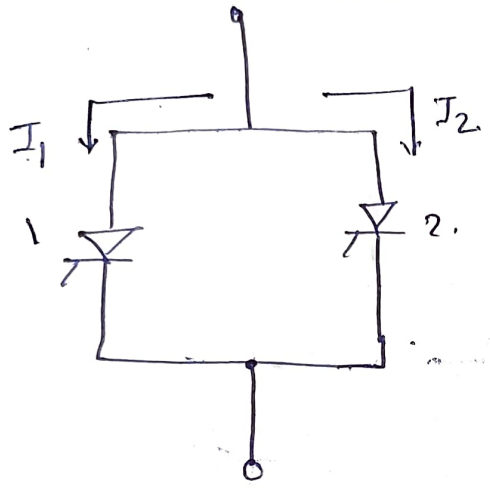
Static equalizing ckt.

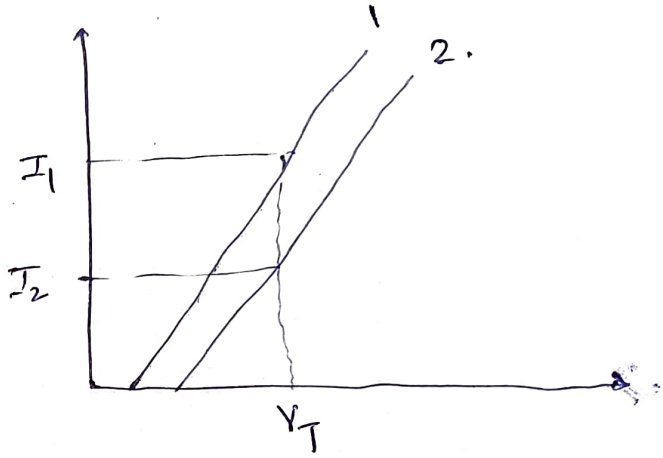
Dynamic equalizing ckt.

DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

Parallel operation





So by $\eta = \dfrac{I_1 + I_2}{2 I_1} = \dfrac{1}{2}\left(1 + I_2/I_1\right)$.

→ unequal current distribution:

(i) Simultaneous turn-on:

DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

Parallel operation of SCR

1) Simultaneous turn on:
→ consider 'n' parallel thyristors. (SCRs).
→ For satisfactory operation, they should get turn on at the same moment.
→ consider SCR1 has larger turn-on time whereas (n-1) SCR have low turn-on time.
→ So, (n-1) SCRs turn on first whereas SCR1 is remain in off state.
→ The Vg drop across (n-1) SCRs falls to low value & SCR1 is therefore subject to this low Vg.
→ For a given gate drive power, anode to cathode must have some min^m forward Vg - called finger Vg for thyristor for turn-on.
→ If SCR1 has Vg drop lesser than finger Vg then SCR1 is not turn-on & (n-1) SCRs share the entire load current.

(ii) Same temp^r rise

→ If one SCR1 in a parallel unit carries more current than other SCR, then this SCR1 will greater J^n temp^r. rise.

→ As a result, its dynamic resistance (dV_a/dI_a) decreases & this further increases the current shared by this SCR.

→ This process of anode current rise becomes cumulative & subsequently J^n temp^r. of SCR1 increases its rated value, as a result SCR1 will damage.

(iii) Uniform current sharing

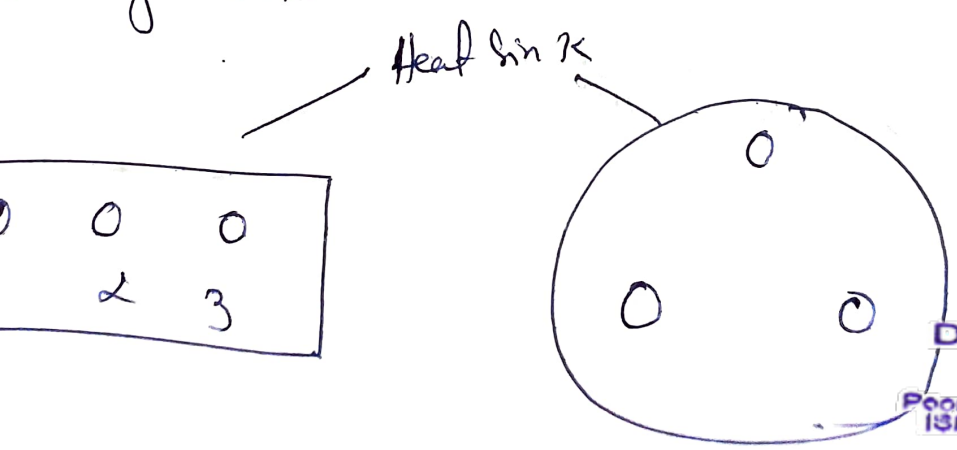
→ Current shary in a parallel connected SCRs can be made uniform by connecting external resistance in series with each SCR.

) Symmetrical arrangement

→ When SCRs are arranged unsymmetrically, the middle conductor will have more inductance bcoz of more flux linkage from two nearby conductors.

As a consequence, less current flows through the middle SCR as compared to order two SCR.

This unequal current distribution can be avoided by nearby SCRs symmetrically on the heat sink.



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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A/B Date:
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): Date (Del.): Unit No.: II Lect. No: 17

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ Triggering ckt.
→ Types of Triggering ckt.
→ Generation of gate Pulses through Triggering ckt.

IMPORTANT & RELEVANT QUESTIONS:

→ Briefly explain about Resistance and Resistance capacitance triggering ckt. why firing angle is restricted b/co 0 to 90° in case of Resistance firing ckt.
→ Briefly explain about UJT firing ckt.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what happened if the value of resistance changed?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Students got an idea about triggering ckt. & their types.
→ Advantage of UJT triggering ckt.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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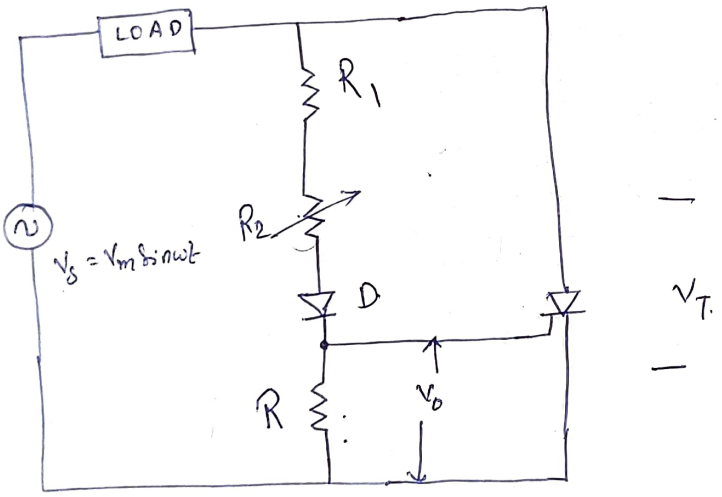
Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

Triggering circuit for SCR.

(I) Resistance firing circuit
(II) RC " "
(III) UJT oscillator triggering

(I) Resistance firing circuit



→ Simplest & most economical.
→ limited range of firing angle (0° to 90°)
→ R_2 is variable resistance & R is the stablizing resistance.

→ In case $R_2 = 0$, gate current may flow from S
(ii) Sa load, R_1 D & gate to cathode.

→ This current should not exceed max^m permis
current I_{gm}.

$$\frac{V_m}{R_1} \leq I_{gm}$$

$$R_1 \geq \frac{V_m}{I_{gm}}.$$

→ It is thus seen that f^n of R_1 is to limit th
gate current to a safe value as R_2 is varied.

(iii) → Resistance R should have such a value the max
V_g drop across it does not exceed max^m pos
gate V_g V_{gm}. This can only happen when $R_2 = 0$,

$$\frac{V_m}{R_1 + R} \cdot R \leq V_{gm}.$$

$$R \leq \frac{V_{gm} \cdot R_1}{V_m - V_{gm}}.$$

→ As resistance R_1, R_2 are large, gate trigger ckt. draws
small current.

→ Diode D allows the flow of current during the half-cy
only i.e gate V_g (V_g) is half-wave DC Pulse.
The amplitude of DC Pulse can be controlled by varying

→ The Potentiometer setting R_2 determines the gate V_g amplit
when R_2 is large, current 'i' is small & V_g across R
is also small.

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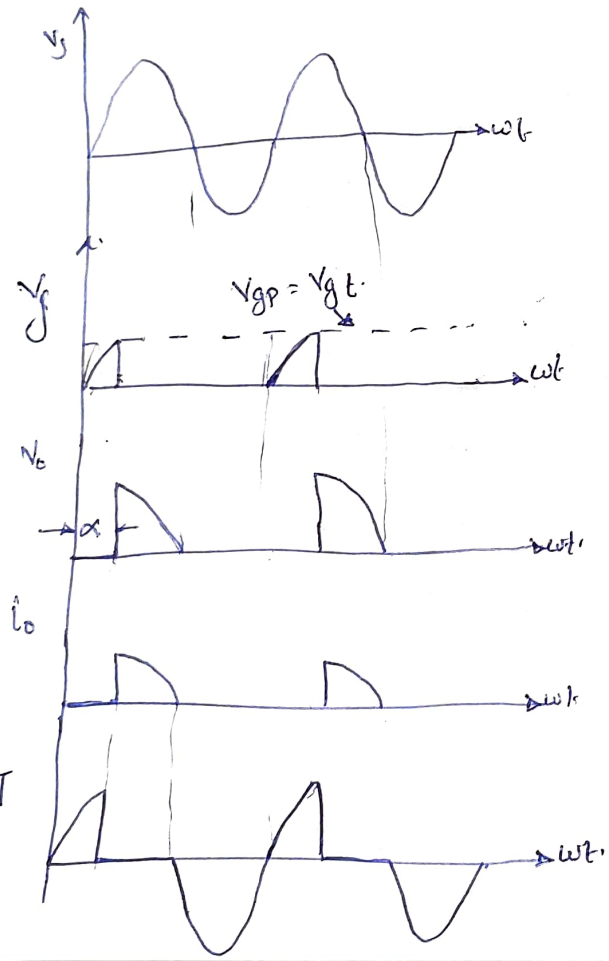
→ As V_{gp} (Peak V_g) is less than V_{gt} (gate trigger V_g) SCR will not turn ON.

→ R_2 is adjusted such that $V_{gp} = V_{gt}$. This gives the value of firing angle as 90°



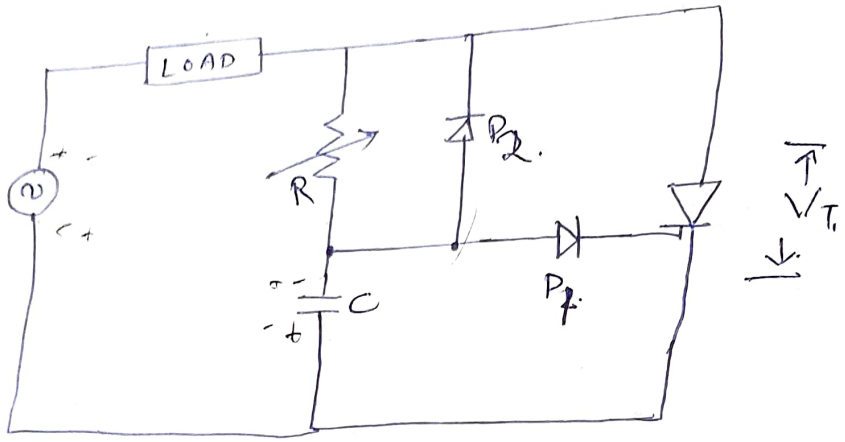
$\alpha = 90°$

RC firing circuit

(ii) Sa

RC half-wave trigger circuit

→



→ By varying the value of R. firing angle can be contr from 0° to 180°.

→ In the -ve half-cycle, capacitor 'c' charges through with lower plate +ve to the peak supply v_g V_m at

→ After $\omega t = -90°$, source v_g V_s decreases from $-V_m$ to zero $\omega t = 0°$.

→ During this period capacitor v_g 'V_c' may fall from

→ Now SCR anode v_g passes through zero & becomes 'c' begin to charge through variable resistance R

→ when capacitor 'c' charges to +ve V_g equal to gate trigger V_g, 'V_{gt}', SCR is ~~fired~~ fired.

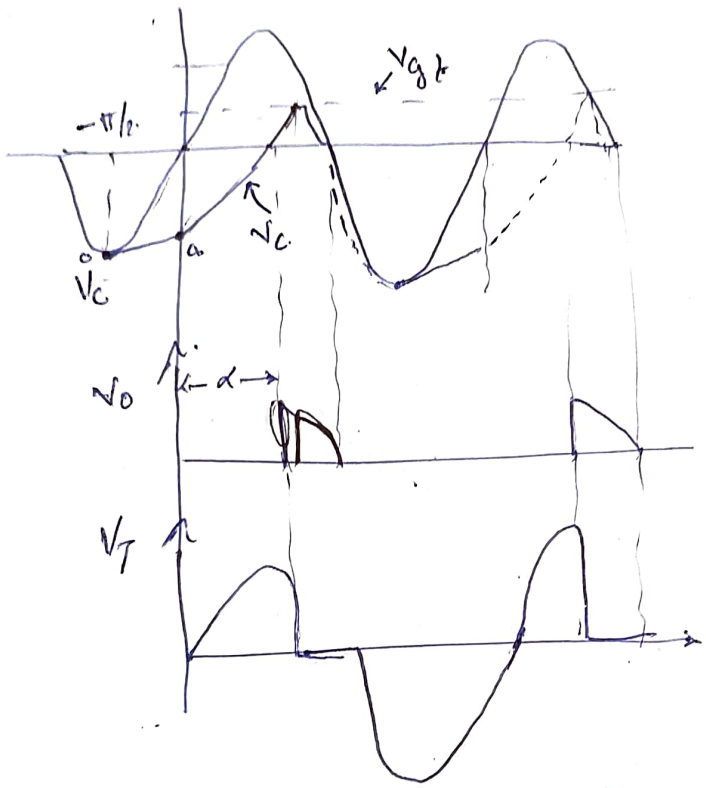
→ D_1 is used to prevent the break-down of cathode to gate J^n

When SCR triggers, v_g drop across it falls to 1 to This in turn, lowers the V_g across value of 1 to 1.5V.

DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

→ Low V_g across SCR during conduction period keeps C discharged in the half-cycle until -ve half-cycle across 'c' appears.

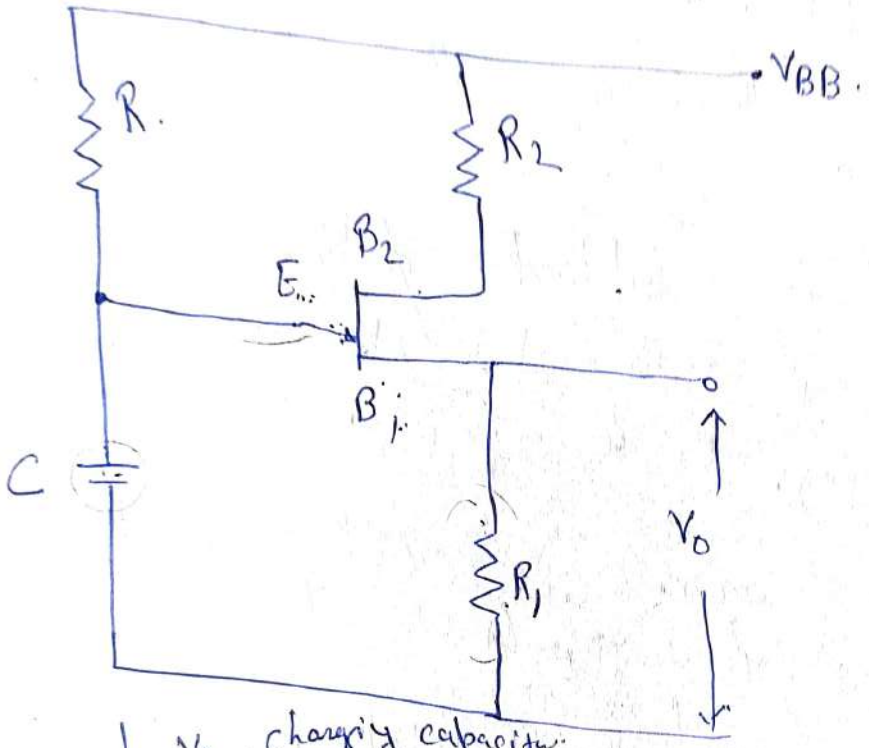


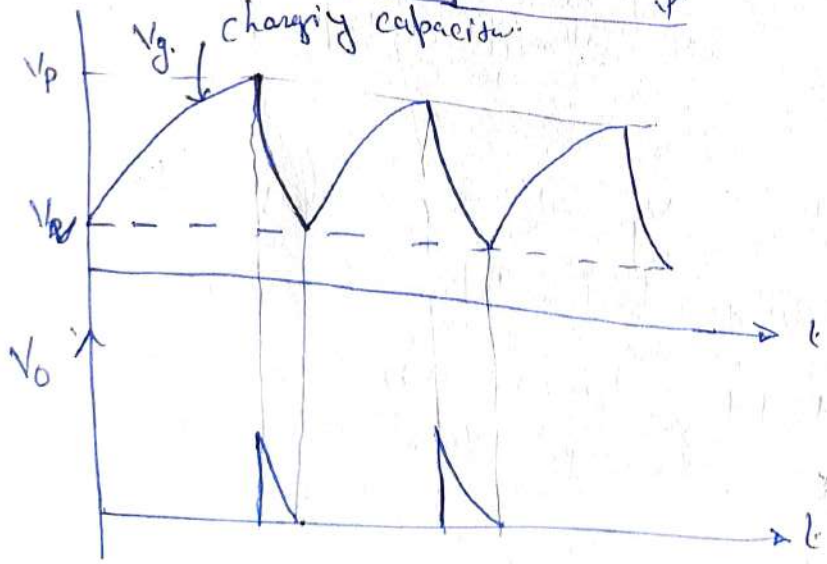
high value of 'R'

→ R is more, the time taken for C to charge from -oa to $(V_{gt} + V_d)$ is more, firing angle is more & avg. output V_g is low.

Campus: ..... Course: .....
Name of Faculty: .....
Class/Section: .....
Name of Subject: .....
Date: .....
Code: .....

UJT oscillator triggering





→ The UJT is a highly efficient switch, its switching time is in the range of nanoseconds.

→ Since UJT exhibits -ve resistance char^n, it can used as a relaxation oscillator.

→ The external resistances R_1, R_2 are small in comparison with internal resistances R_{B1}, R_{B2} of UJT bases.

→ The charging resistance R should be such that its line ~~char~~ intersects the device char^n only in the -ve resistance region.

→ when V_g, 'V_{BB}' is applied, capacitor C begins to charge through 'R' exponentially towards V_{BB}

→ During this charging, emitter CKT. of UJT is an open CKT.
capacitor V_g V_c, equal to emitter V_g 'V_e' is

$$V_c = V_e = V_{BB}\left(1 - e^{-t/RC}\right).$$

Time const. of the charge ckt $\tau_1 = RC$.

→ when this emitter V_g 'V_e' reaches the Peak-point V_g 'V_P' the unijunction b/w E – B_1 breaks down. As a result UJT turns on & capacitor C rapidly discharges through low resistor R_1 with time constant $\tau_2 = R_1 C$.

→ Here τ_2 is much smaller than τ_1.

→ V_g drop across R_1 equal to V_o, is applied b/w gate-cathode ckt. of SCR.

LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A&B Date: .....
Name of Faculty: ..... Name of Subject: P.E Code: SEE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: II Lect. No: 18

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ Tyristor Protection.
→ Impact of high di/dt and dV/dt on thyristor.
→ Design of Snubber ckt.

IMPORTANT & RELEVANT QUESTIONS:

→ what happened on the thyristor if di/dt and dV/dt rating is higher than maximum permissible limit?
→ How you can protect thyristor from over-current & over-voltage?

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what is the use of resistor in Snubber ckt.
→ which material is used as voltage clamping device?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Students got an idea about thyristor Protection?
→ Impact of high di/dt and dV/dt ~~rating~~ on thyristor.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

1. Ned mohan
2. P. S. Bimbhra.
3. M. H. Rashid

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Campus: ..... Course: .....
Name of Faculty: .....
Class/Section: .....
Name of Subject: .....
Date: .....
Code: .....

Thyristor Protection :

di/dt Protection :

→ when thyristor is forward biased & is turned on by gate pulse, conduction of anode current begins in the immediate neighbourhood of the gate-cathode J^n.

→ Thereafter, the current spreads across the whole area of J^n.

→ The thyristor design permits the spread of conduction to the whole of J^n area as rapidly as possible.

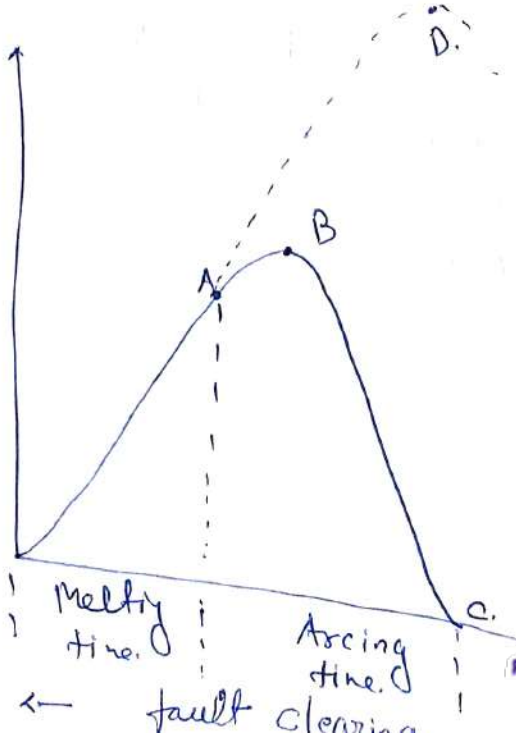
→ However, if rate of rise of anode current, (di/dt) is large as compared to spread velocity of carriers, local hot-spots will be formed near the gate connection on account of high current density.

→ The localised heating may destroy the thyristor. Therefore di/dt of anode current at time of turn-on must be kept below the specified limit.

→ The value of di/dt can be maintained below acceptable limit by using a small inductor in series with anode circuit.

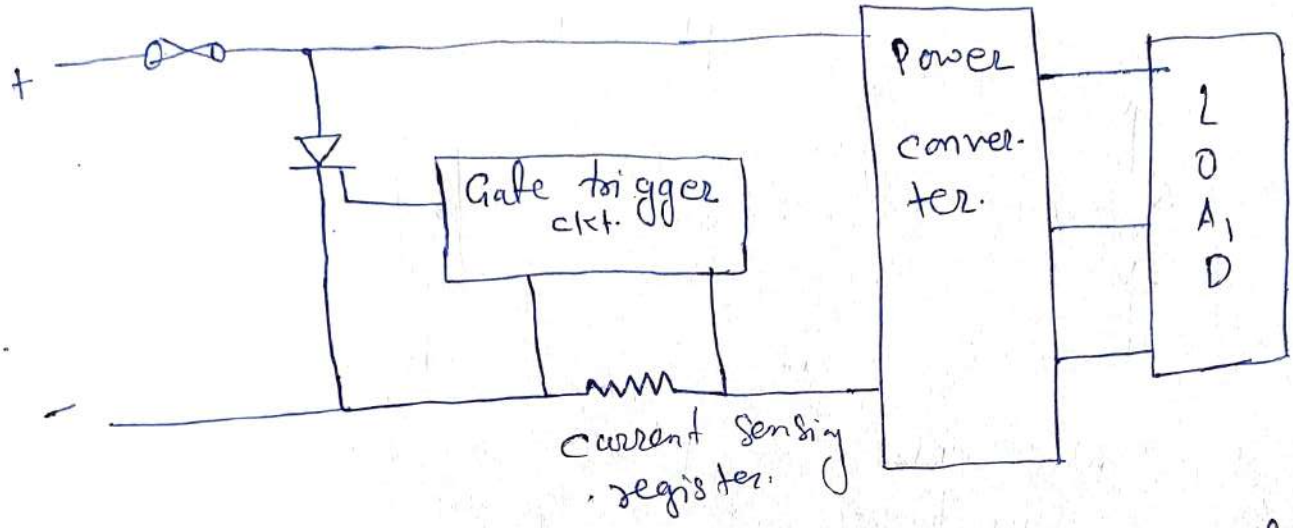
→ Thyristors have small thermal time consta
thyristor is subjected to over-current due to fault,
→ Surge current, its jn temp. may exceed the rated va
→ over-current protection thyristors ckt. is achieved th
the use of circuit breakers & fast-acting fuses.

→ The type of Protection used against overcurrent def
upon whether the supply system is weak or stiff.
→ In a weak-supply sys. fault current is limited by
source impedance.
→ In a stiff supply sys, magnitude & rate of rise of c
is limited by fast-acting current-limiting fuses.
→ These fuses & thyristors are found to have similar
thermal properties, so their co-ordination is simpler.
→ These fuses consists of one or more fine silver
having very-short fusing time.
→ Fault occur at zero crossing of ac sine wave
without fuse, the fault current rises upto A &
follow the dotted curve, reach peak value D.
→ A properly selected fuse melts at A & an
is then struck.



Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

Electronic crowbar Protection :



→ A crowbar thyristor is connected across the input DC terminals.

→ A current sensing resistor detects the value of converter current.

→ If it exceeds preset value, gate ckt. provides the signal to crowbar SCR & turn it on in a few micro seconds.

→ The I/P terminals are then S.C. by crowbar SCR & shunts it away the converter over-current.

→ After some time, main fuse interrupts the fault current.

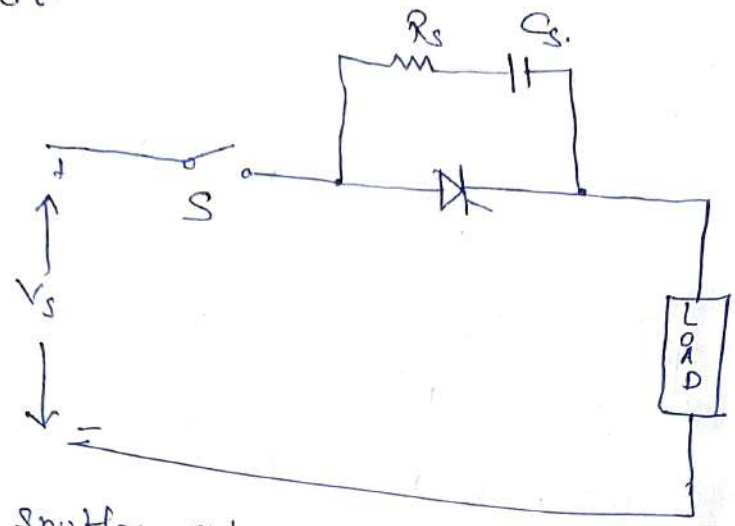
Over-voltage protection

→ dv/dt protection:

→ If ~~rad~~ dv/dt is high, the device may get on.

→ It leads the maloperation of thyristor.

→ Snubber ckt. is design to protect the SCR dv/dt.



→ A snubber ckt. consist of a series combination Rs & capacitance Cs in parallel with thyristor.

→ when switch 'S' is closed, a sudden Vg appears across the ckt.
Cs behaves like s.c., so the Vg across SCR is zero

→ with passage of time, Vg across Cs builds up at slow rate such that dv/dt across Cs & hence across SCR is less.

→ Before SCR is fired by gate Pulse, Cs charges full Vg 'Vs'.

→ when SCR is turned on, capacitor discharges the SCR & sends current equal to Vs/(resistance of path formed by Cs & SCR).

→ As resistance is quite low, turn ON di/dt will to be excessive & as a result SCR may be destroyed

→ In order to limit the magnitude of discharge current resistance Rs is inserted in series

DETAILED LECTURE NOTES

Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

→ Transiont overv$_g$ cause either maloperation of ckt. by unwanted turn-on of a thyristor. or permanent damage of the device due to reverse-break-down.

→ A thyristor is subjected to internal or external over-v$_g$.
Internal-over-v$_g$ caused by thyristor operation & External over-v$_g$ is caused by supply lines or the load ckt.

Internal over-voltage (I.O.V.)

→ Large v$_g$ may be generated internally during the commutation of a thyristor.

→ After anode current reduces to zero, anode current reverse due to stored charge.

→ This reverse current rises to a peak value at which time the SCR begins to block.

→ After this peak, reverse current decays abruptly with large di/dt.

→ Bcoz of series inductance 'L' of the ckt. large transient v$_g$ is produced (L di/dt).

→ As this internal over-v$_g$ may be several times the break-over v$_g$ of the device, the thyristor may be destroyed permanently.

External over-v_g (E.O.V.)

→ It is due to the interruption of current flo
inductive ckt. & also due to lightning stroke
feeding the thyristors sys.

→ The effect of over-v_g is usually minimis
RC ckt. & non-linear resistor called 'v_g c

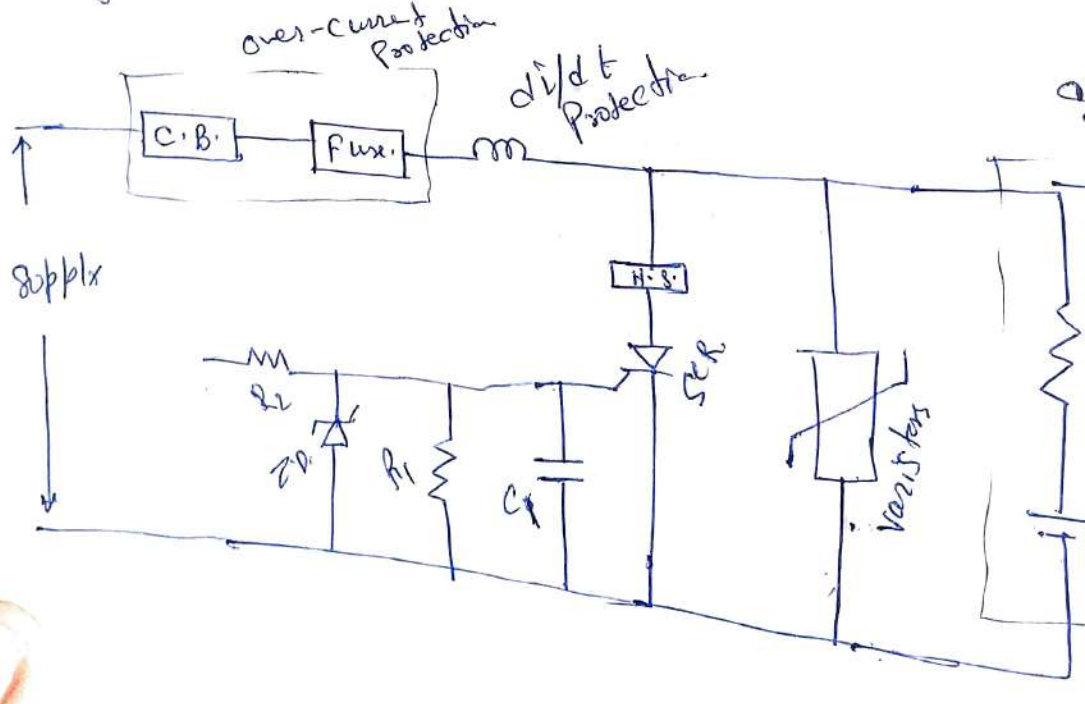
→ A v_g clamping device (V.C.) is non-li
connected across SCR.

→ The V.C. has falling resistance cha^r.
v_g.

→ under normal working conditions of v_g
clamping level, the device has high res
draws only small leakage current.

→ when v_g surges appears, the V.C. opera
low resistance region & produces vir
across the SCR.

→ e.g.: Selenium thyrector diodes, metal-oxi



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COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.TECH Class/Section: III A/B Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: III Lect. No: 20

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ uncontrolled Rectifier
→ controlled Rectifier
→ Principle of Rectifier.

IMPORTANT & RELEVANT QUESTIONS:

→ Briefly explain about the principle of operation of 1 ϕ Rectifier.
→ what is Rectifier? Briefly explain about 1-ϕ HWR for R Load. Also draw the necessary waveform.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what are the applications of Rectifier?
→ what is Natural commutation?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ students got a basic idea about Rectifier & its application.
→ 1-ϕ HWR with R Load.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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PHASE CONTROLLED RECTIFIER

Many industrial applications make use of controllable DC Power.

a) Steel - rolling mills, paper mills, Printing Presses

b) Traction System working on DC.

c) Electrochemical process

d) magnet Power Supplies.

e) HVDC.

→ ~~Thyristors is~~ A Rectifier is a device which convert AC waveform to D.C waveform.

→ In Phase controlled rectifier, a thyristor is turned off as ac supply V_g reverse biases it, provided anode current has fallen to a level below the holding current.

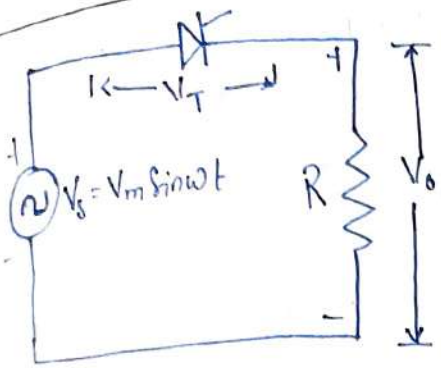
→ A Phase controlled rectifier need no commutation circuitry, these are simple, less expensive

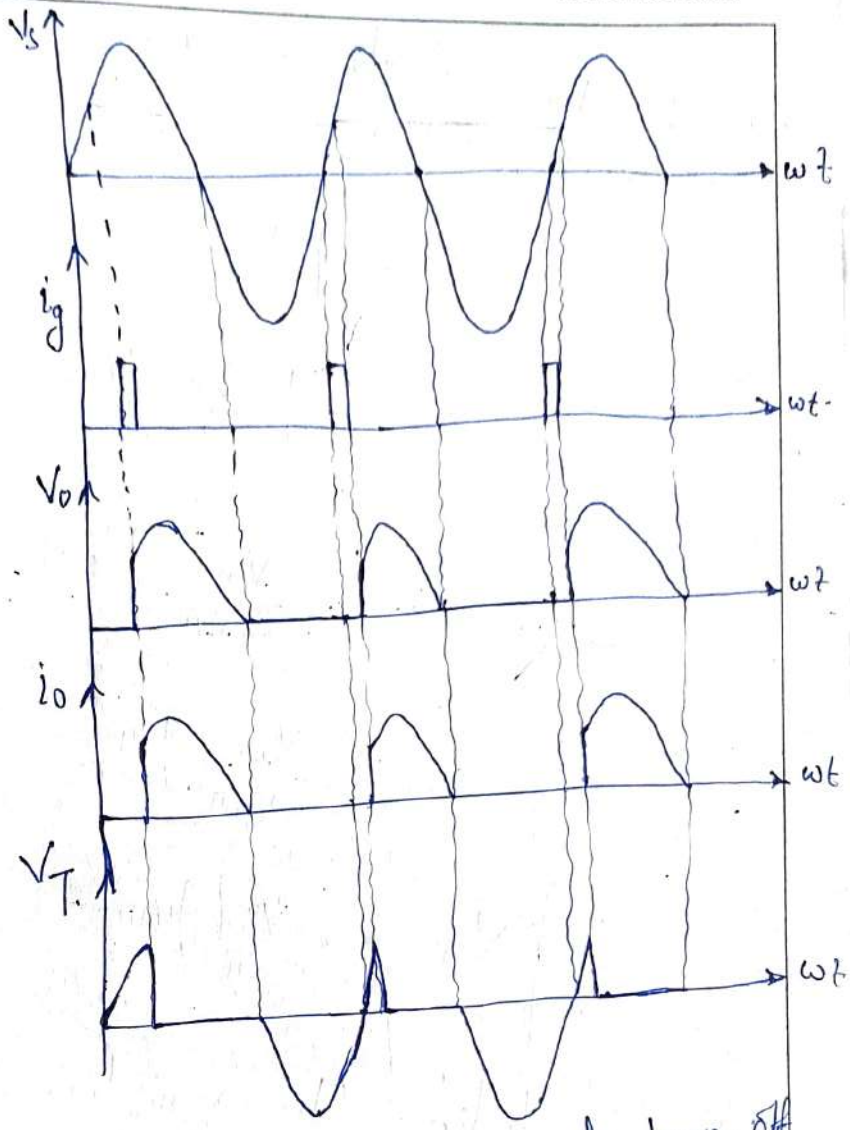
1-ϕ Half wave Rectifier with R- Load

* The Source V_g $V_s = V_m \sin\omega t$.
* An SCR can conduct only when anode V_g is +ve & Signal is applied.
* At the instant of delay angle 'α', V_o rises from to $V_m \sin\alpha$.

* Firing angle of a thyristor is measured from the it would start conducting if it were replaced by diode.

  A firing angle may thus be defined as the angle the instant thyristor would conduct if it were a diode instant it is triggered.
* The angle measured from the instants SCR gets F.B instant it is triggered.
* A Single - ϕ half wave ckt. is one which prod only one pulse of load current during one cycle of Sourc





* $V_s = V_o + V_T$.
* Thyristor is R.B. for π-radians., the circuit turn-off time is given by,

$$\boxed{t_c = \frac{\pi}{\omega} \text{ sec}}$$

$\omega = 2\pi f$

$t_c > t_q$ (thyristor turn-off time).

$$V_0 = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \sin\omega t \, d(\omega t).$$

$$= \frac{V_m}{2\pi}(1+\cos\alpha).$$

$$I_0 = \frac{V_0}{R} = \frac{V_m}{2\pi R}(1+\cos\alpha)$$

* Loads like electric heating & incandescent lamps have rms voltage (V_{or}).

$$V_{or} = \left[\frac{1}{2\pi}\int_{\alpha}^{\pi} V_m^2 \sin^2\omega t \, d(\omega t)\right]^{1/2}.$$

$$= \left[\frac{V_m^2}{2\pi}\int_{\alpha}^{\pi}\frac{(1-\cos 2\omega t)}{2} d(\omega t)\right]^{1/2}.$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[\omega t - \frac{\sin 2\omega t}{2}\right]_{\alpha}^{\pi}$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[\pi - \frac{\sin 2\pi}{2} - \alpha + \frac{\sin 2\alpha}{2}\right]$$

$$\boxed{V_{or} = \frac{V_m}{2\sqrt{\pi}}\left[(\pi-\alpha) + \frac{1}{2}\sin 2\alpha\right]^{1/2}}$$

* Power deliver to resistive load = (rms load V_g) (rms load current)

$$= V_{or} \cdot I_{or}.$$

* Input voltamperes = (rms Source V_g) × (Total line current)

$$= V_g \cdot I_{or}.$$

Input Power factor = $\frac{\text{Power delivered to load}}{\text{Input VA}} = \frac{V_{or}}{V_g}$

$$= \frac{V_{or}}{V_g}.$$

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LECTURE NOTES

Campus: PCE Course: B.TECH Class/Section: III A Date: .....
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: III Lect. No: 28 & 21

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ 1 ϕ HWR for RL Load
→ Function of Load Inductance.

IMPORTANT & RELEVANT QUESTIONS:

→ write Short notes on 1ϕ HWR with RL Load. Also draw the necessary waveform.
→ Deduce the formulae for average output V_g, RMS V_g, avg. current, RMS current, I/P P.f., Displacement factor,

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ why the output V_g goes beyond π.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Principle of HWR for RL Load.
→ Effect of load Parameters on circuit.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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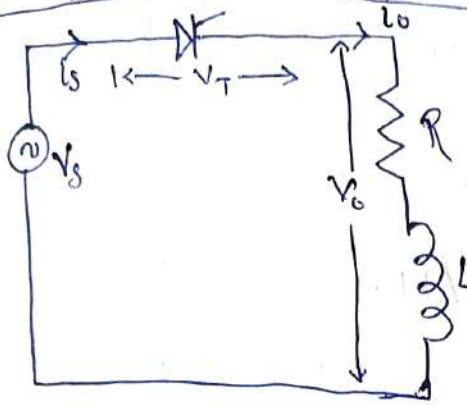
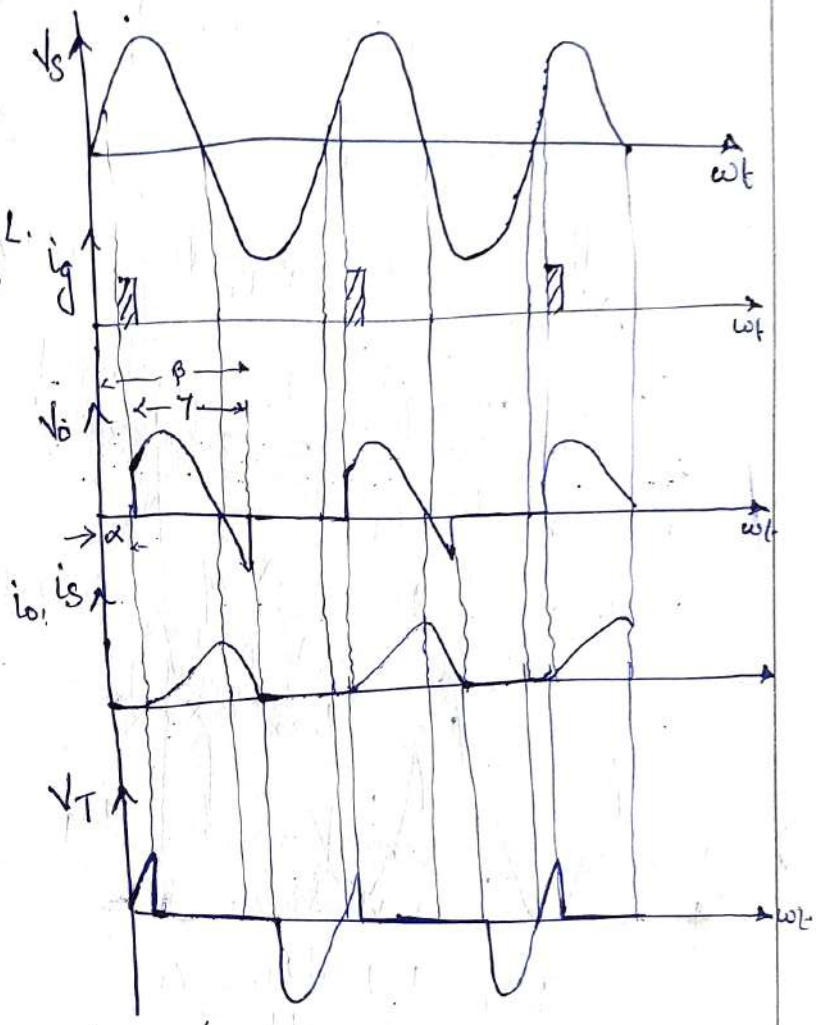
1-ϕ HWR with RL Load





Circuit turn-off time $(t_c) = \frac{2\pi - \beta}{\omega}$

$\beta = \alpha + \gamma$

β → Extinction angle.
α → firing angle
γ → conduction angle.

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$$V_0 = \frac{1}{2\pi}\int_{\alpha}^{\beta} V_m \sin\omega t \, d(\omega t).$$

$$\boxed{V_0 = \frac{V_m}{2\pi}(\cos\alpha - \cos\beta)}$$

$$I_0 = V_0/R.$$

$$V_{or} = \left[\frac{1}{2\pi}\int_{\alpha}^{\beta} V_m^2 \sin^2\omega t \, d(\omega t)\right]^{1/2}.$$

$$= \frac{V_m}{2\sqrt{\pi}}\left[(\beta-\alpha) - \frac{1}{2}(\sin 2\beta - \sin 2\alpha)\right]^{1/2}.$$

<u>RMS Load current,</u>

$$V_m \sin\omega t = R i_0 + L\, di/dt. \quad \text{——(1)}$$

* Load current i_0 consist of two component one steady state component i_S & other tran component i_T.

$$i_S = \frac{V_m}{\sqrt{R^2+X^2}} \sin(\omega t - \phi)$$

$$\phi = \tan^{-1} X/R \quad (\phi \text{ is angle b/w}$$

* Transient component i_T can be obtained force-free equation.

$$R i_t + L\frac{di_t}{dt} = 0$$

$$i_t = A e^{-(R/L)t}.$$

$$i_0 = i_S + i_t$$

$$= \frac{V_m}{Z}\sin(\omega t - \phi) + A e^{-(R/L)t}.$$

To find the value of A,

At $\omega t = \alpha$, $i_0 = 0$.

So, $t = \alpha/\omega$.

$$0 = \frac{V_m}{Z}\sin(\alpha-\phi) + A e^{-R\alpha/L\omega}$$

$$A = -\frac{V_m}{Z}\sin(\alpha-\phi)\, e^{R\alpha/L\omega}$$

So,

$$i_0 = \frac{V_m}{Z}\sin(\omega t-\phi) - \frac{V_m}{Z}\sin(\alpha-\phi)\, e^{-\frac{R}{\omega L}(\omega t-\alpha)}$$

To find the value of β,

at $\omega t = \beta$, $i_0 = 0$

$$\sin(\beta-\phi) = \sin(\alpha-\phi)\, e^{-\frac{R}{\omega L}(\beta-\alpha)}$$

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LECTURE NOTES

Campus: PCE Course: B.TECH Class/Section: III A&B Date: .....
Name of Faculty: R.S. Singh Name of Subject: P.E Code: 5EE1
Date (Prep.): ..... Date (Del.): ..... Unit No.: III Lect. No: 28

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ 1 ϕ HWR for RL Load with FD.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on 1ϕ HWR for RL Load with FD.

→ what is FD? what is effect of FD on avg. output Vg. & RMS Vg.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ what is FD? Why o/P Vg during freewheeling time.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Effect of FD on circuit operation?

→ Improvement in I/P P.f.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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1 ϕ HWR with RL Load & freewheeling diode.

* A freewheeling diode is also called by-pass or commutating diode.
* It is assumed that during freewheeling period, load current does not decay to zero until the SCR is triggered again at $(2\pi+\alpha)$.
* V_g drop across FD is taken zero, the load V_g, V_0 is therefore zero during the freewheeling period.
* Ckt. turn-off time, $t_c = \pi/\omega$ sec.

Mode 1 operation: when thyristor conducts, (α to π)

$$V_m \sin\omega t = R i_0 + L\frac{di_0}{dt}$$

It sol^n is

$$i_0 = \frac{V_m}{Z}\sin(\omega t-\phi) + A e^{-(R/L)t}$$

At $\omega t = \alpha$, $i_0 = I_0$,

$$A = \left[I_0 - \frac{V_m}{Z}\sin(\alpha-\phi)\right]e^{\frac{R\alpha}{\omega L}}$$

$$i_0 = \frac{V_m}{Z}\sin(\omega t-\phi) + \left[I_0 - \frac{V_m}{Z}\sin(\alpha-\phi)\right]e^{-\frac{R}{L}\left(t-\frac{\alpha}{\omega}\right)}$$

For Mode 2, FD conducts (π to $2\pi+\alpha$).

$$0 = Ri_0 + L\, di_0/dt$$

Its sol^n is $i_0 = Ae^{-(R/L)t}$

At $\omega t = \pi$; $i_0 = I_{01}$

$$A = I_{01}\, e^{R\pi/\omega L}.$$

$$i_0 = I_{01} \cdot e^{\left[-\frac{R}{L}(t-\pi/\omega)\right]}$$

$$V_0 = \frac{1}{2\pi}\int_{\alpha}^{\pi} V_m \sin\omega t\, d(\omega t)$$

$$= \frac{V_m}{2\pi}(1+\cos\alpha).$$

* In HWR with RL Load, load consumes power fr ~~from~~ Source for α to π, whereas energy stored in i L is ~~stored~~ returned to the source as power P_2 p As a result net power consumed by the load is th of these two power.

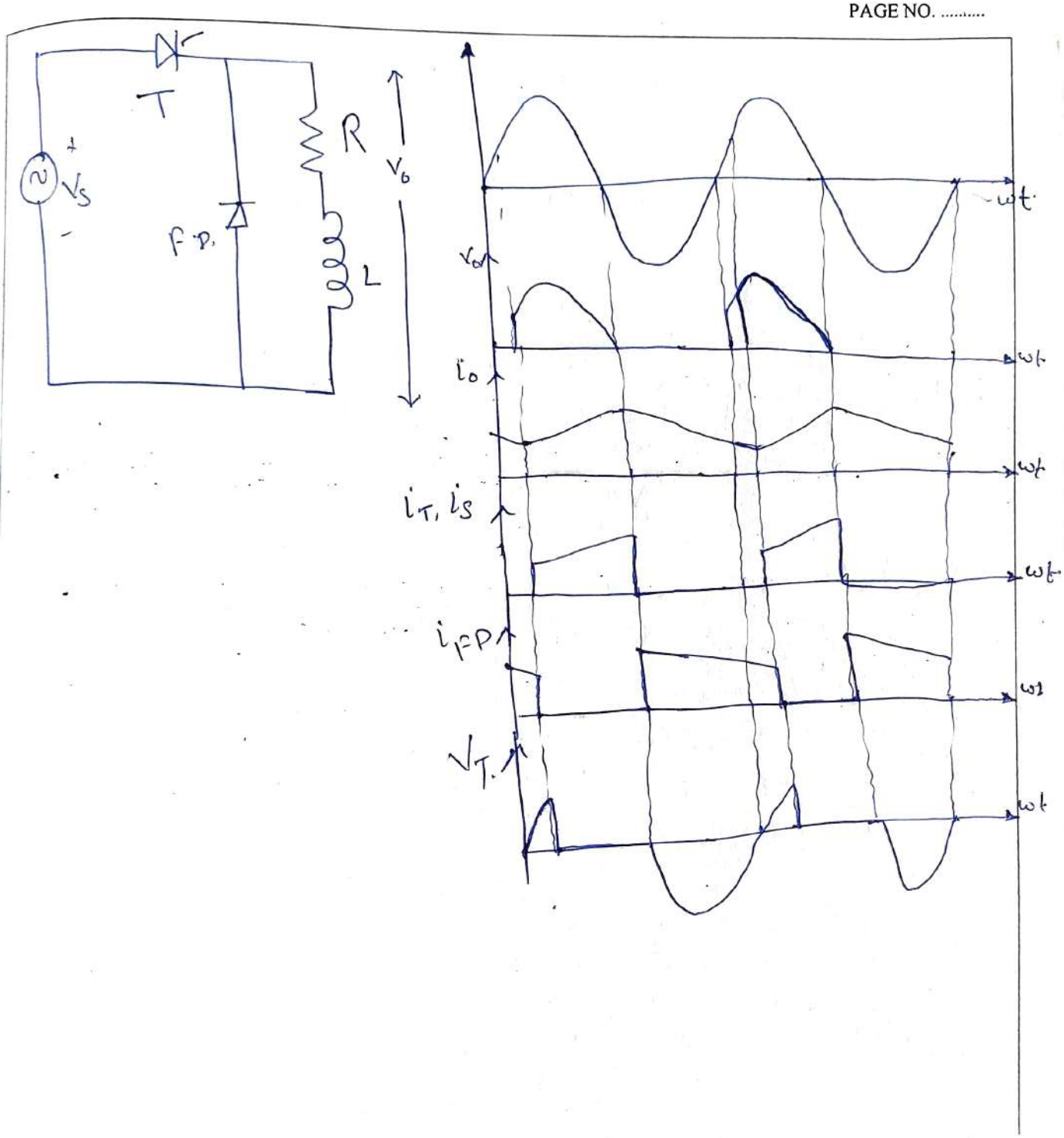
* But incase of FD, load absorbs power for α but for π to $2\pi+\alpha$, energy stored in L is de to load resistance R through FD, as a result consumed by load is more.

* It can be concluded that power delivered to load Same firing angle, is more when FD is used.

* As volt-ampere input is almost the same, th PF with the use of FD is improved.

* In case of HWR with RL & RL-FD, the supply cu taken from the Source is unidirectional & is in th of DC Pulses. 1 ϕ HWR thus introduces DC co into the supply line. This is undesirable as it leads Saturation of the supply T/F & other [illegible]

DETAILED LECTURE NOTES



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COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.TECH Class/Section: III A&B Date:
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): Date (Del.): Unit No.: III Lect. No: 28

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- 1 ϕ HWR for RLE Load.
- Impact of 'E' on waveform.

IMPORTANT & RELEVANT QUESTIONS:

- Write Short notes on 1ϕ HWR for RLE Load. Also deduce the value for V_{oav} & V_{orms}. Draw the necessary waveform.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- Why there is a limitations (min^m & max^m firing angle) in case of RLE Load?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Effect of E on circuit Performance.
- Principle working of 1 ϕ HWR for RLE load

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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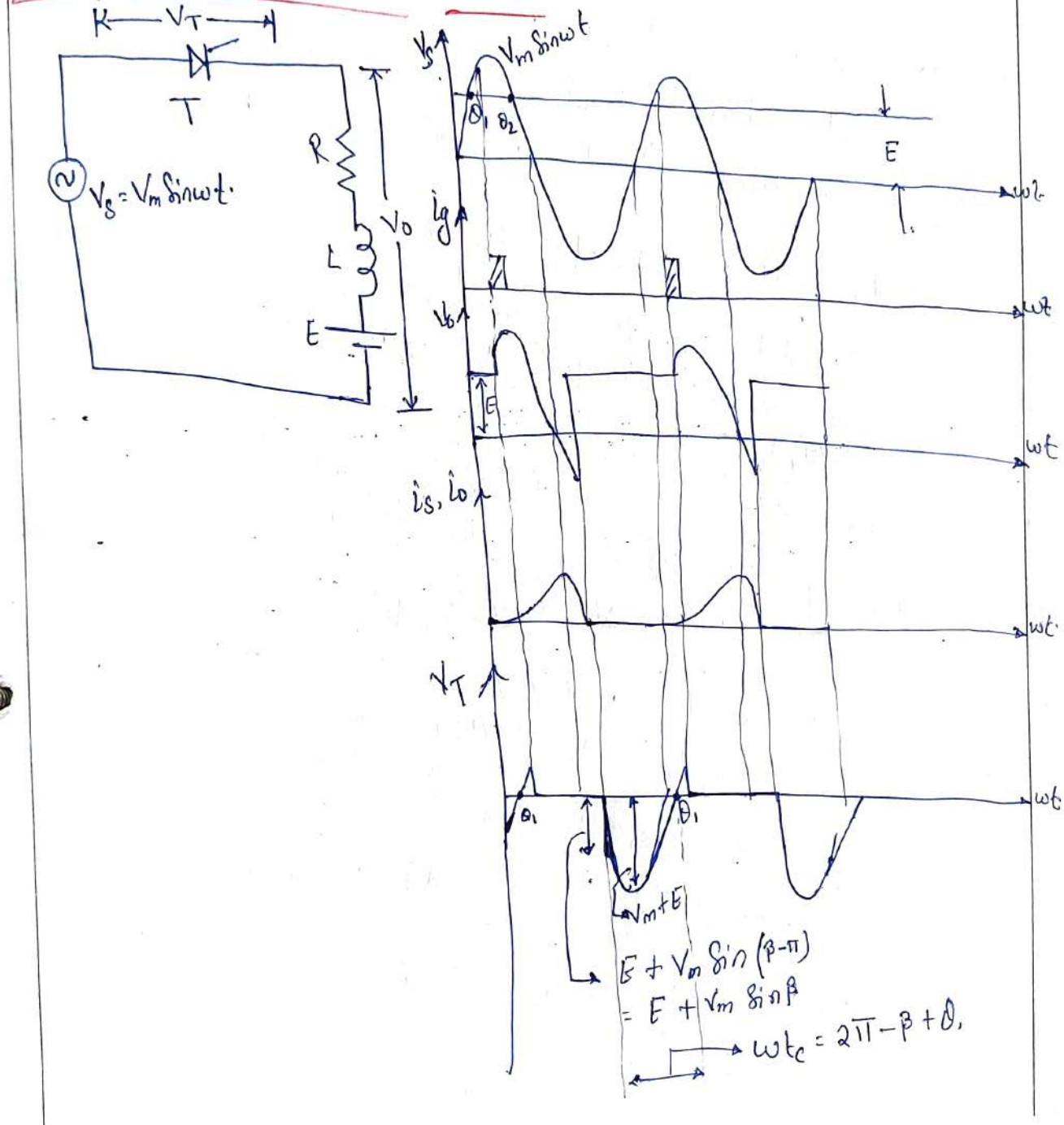
PAGE NO. .....

1 ϕ HWR with RLE Load



* The counter EMF 'E' in the load may be a battery or DC motor.
* The min^m value of firing angle is obtained from relation $V_m \sin\omega t = E$.

$$V_m \sin\delta_1 = E$$

$$\boxed{\delta_1 = \sin^{-1}(E/V_m)}$$

* Max^m value of firing angle $\delta_2 = \pi - \delta_1$.
* During the interval load current i_0 is zero, load $V_0 = E$ & during the i_0 is not zero, V_0 follows

$$V_m \sin\omega t = R i_0 + L\, di_0/dt + E$$

The sol^n of the above eq^n is a combination two components: steady-state current (i_s) & transient current (i_t).

i_s may be sum of i_{s_1} & i_{s_2} where i_{s_1} is due source V_g alone & i_{s_2} is due to 'E' acting alone

$$i_{s_1} = \frac{V_m}{Z} \sin(\omega t - \phi)$$

$$i_{s_2} = -(E/R).$$

$$i_t = A e^{-(R/L)t}.$$

$$i_0 = i_{s_1} + i_{s_2} + i_t.$$

$$i_0 = \frac{V_m}{Z} \sin(\omega t - \phi) - \frac{E}{R} + A e^{-(R/L)t}.$$

At $\omega t = \alpha$, $i_0 = 0$, $t = \alpha/\omega$,

$$A = \left[\frac{E}{R} - \frac{V_m}{Z} \sin(\alpha - \phi)\right] e^{R\alpha/L\omega}$$

* Avg load V_g across inductance is zero. Thus avg. value of load current can be obtained by integrating $(V_m \sin\omega t - E)/R$ b/w α & β.

$$I_0 = \frac{1}{2\pi R}\left[\int_\alpha^\beta \left(\frac{V_m \sin\omega t - E}{R}\right) d(\omega t)\right]$$

$$= \frac{1}{2\pi R}\left[V_m(\cos\alpha - \cos\beta) - E(\beta - \alpha)\right]$$

$$V_0 = I_0 R + E$$

$$I_{or}^2 = \frac{1}{2\pi}\int_\alpha^\beta \left(\frac{V_m \sin\omega t - E}{R}\right)^2 d(\omega t).$$

$$I_{or} = \left[\frac{1}{2\pi R^2}\left\{(V_s^2 + E^2)(\beta - \alpha) - \frac{V_s^2}{2}(\sin 2\beta - 2\sin 2\alpha) - 2V_m E(\cos\alpha - \cos\beta)\right\}\right]^{1/2}$$

$$P = I_{or}^2 R + I_0 E$$

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LECTURE NOTES

Campus: PCE Course: B.TECH Class/Section: III A&B Date:
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): Date (Del.): Unit No.: Lect. No: 2

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- 1 ϕ FWR for R Load.
- 1 ϕ FWR for RL Load
- Comparison b/w HWR & FWR Ckt.

IMPORTANT & RELEVANT QUESTIONS:

- Briefly explain about 1 ϕ FWR for RL Load. Deduce its necessary formulae & draw the waveform?

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- How it is operated in Two quadrant?

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- working of 1 ϕ FWR Ckt.
- Factor deciding continuous & Discontinuous mode of operation.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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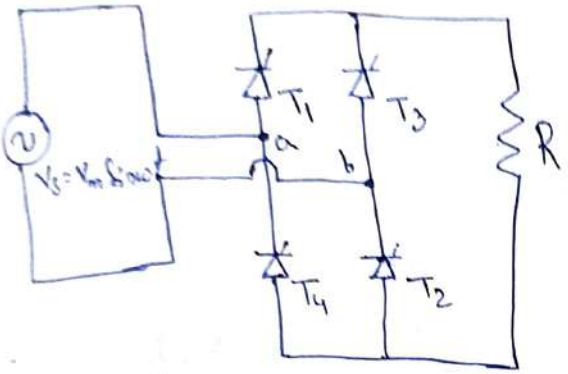
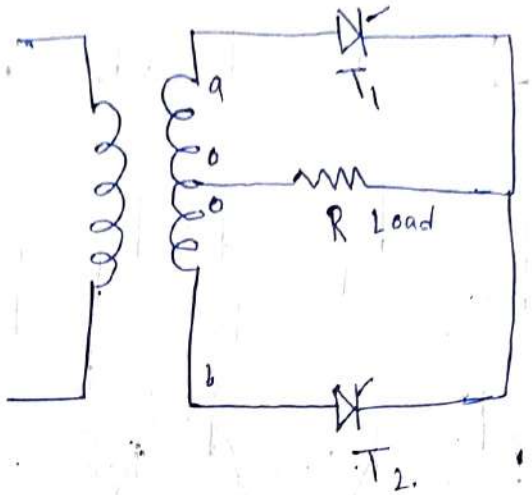
1-Φ FWR with R-Load



Bridge type.

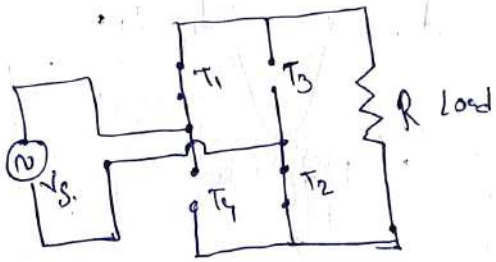


Centre tapped type

During +ve half-cycle..

$V_{ab} = V_m \sin\omega t$

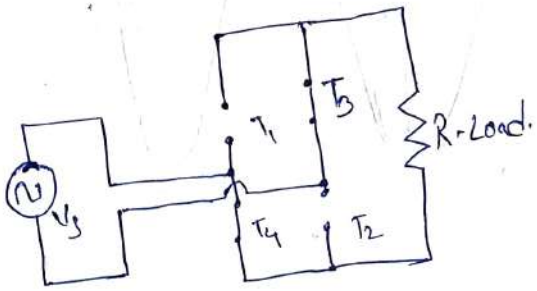
$V_{ba} = -V_m \sin\omega t$

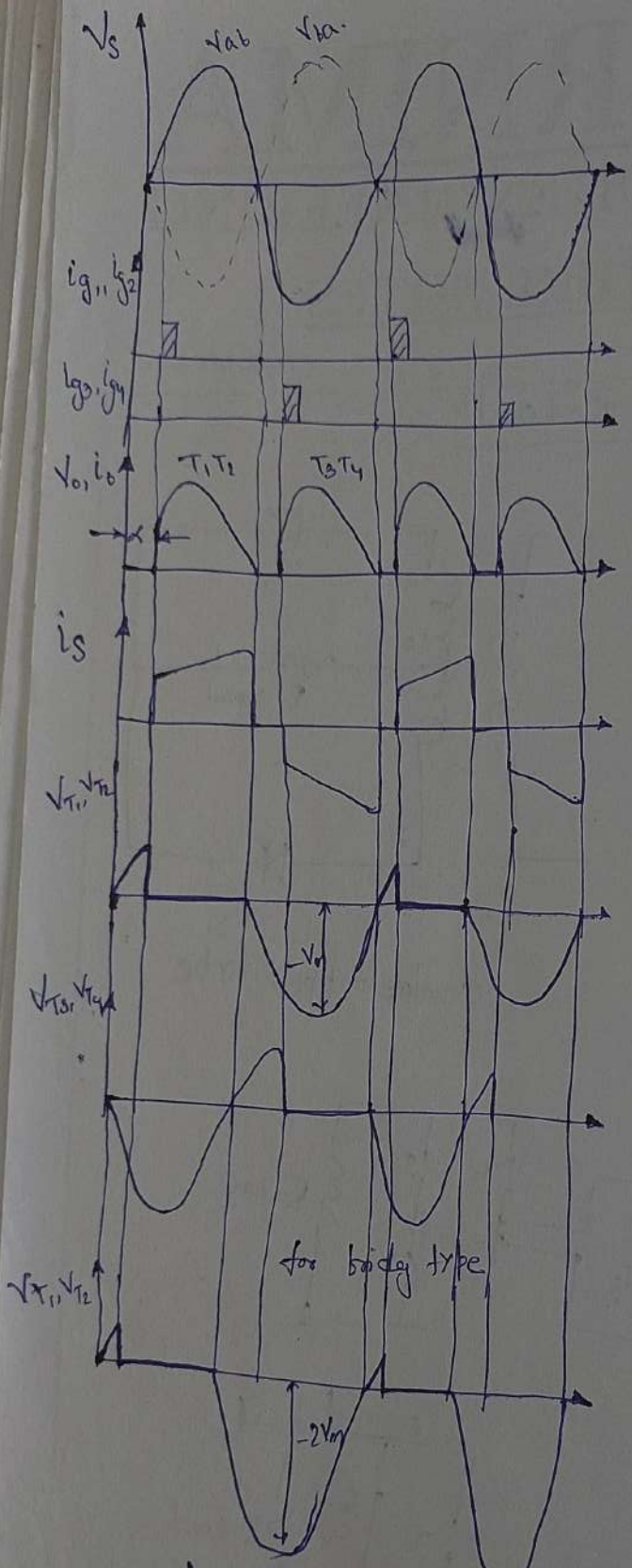


During -ve half cycle.

$V_{ba} = V_m \sin\omega t$

$V_{ab} = -V_m \sin\omega t$





for centre-tapped type.

$$V_0 = \frac{1}{\pi}\int_{\alpha} V_m \sin\omega t \, d(\omega$$

$$V_0 = \frac{V_m}{\pi}(1+\cos\alpha)$$

$$V_{orms} = \left[\frac{1}{\pi}\int_{\alpha}^{\pi} V_m^2 \sin^2\omega t \, d(\omega$$

$$= \frac{V_m}{\sqrt{\pi}}\left[\int_{\alpha}^{\pi} \frac{1-\cos 2\omega t}{2} d\omega\right]^{1/2}$$

$$= \frac{V_m}{\sqrt{2\pi}}\left[\omega t - \frac{\sin 2\omega t}{2}\right]$$

$$V_{orms} = \frac{V_m}{\sqrt{2\pi}}\left[(\pi-\alpha) + \frac{1}{2}\sin 2\alpha\right]$$

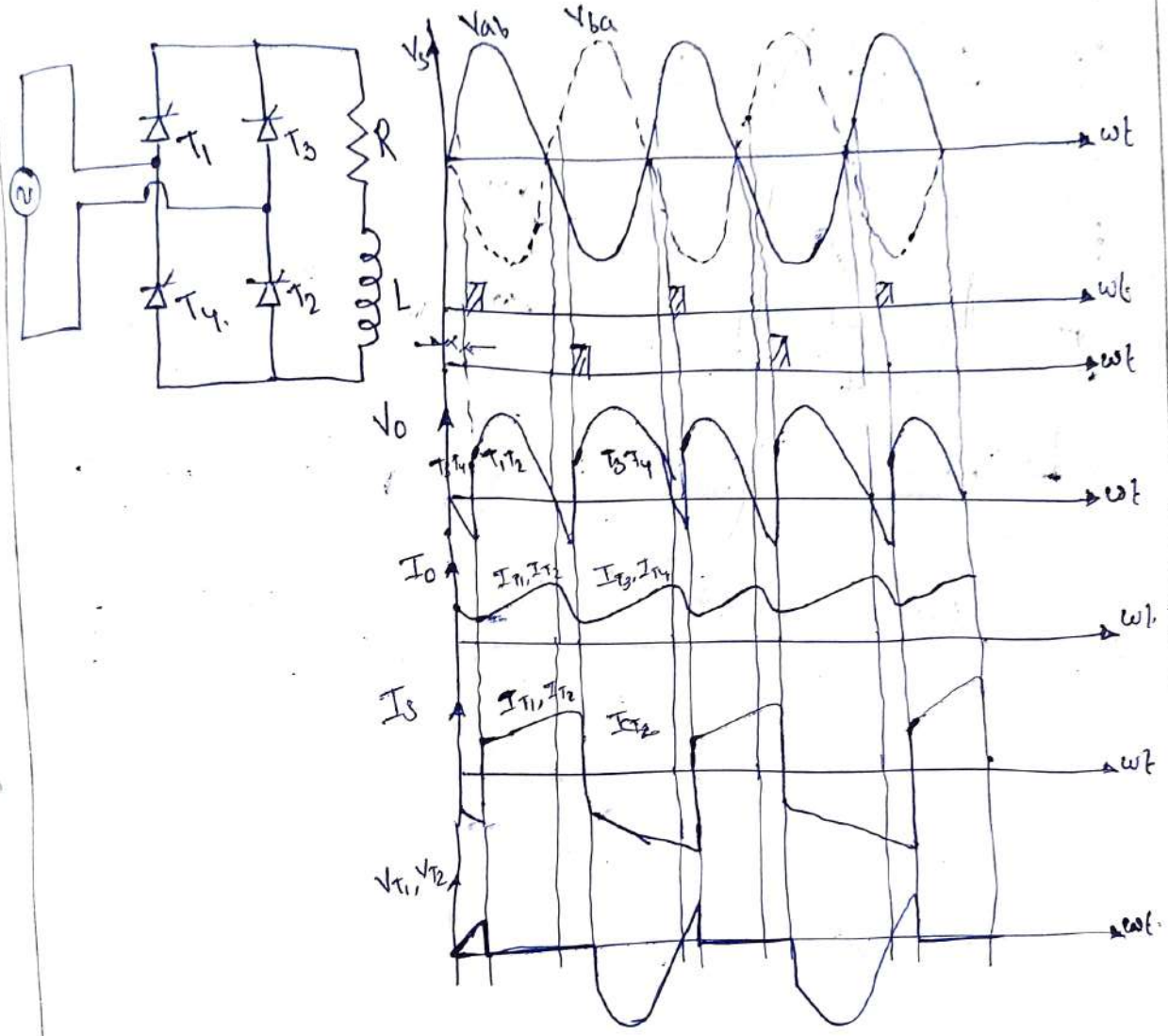
Turn-off time for SCR, T_1, T_2 (t_q

" " " " " T_3, T_4 (t_q

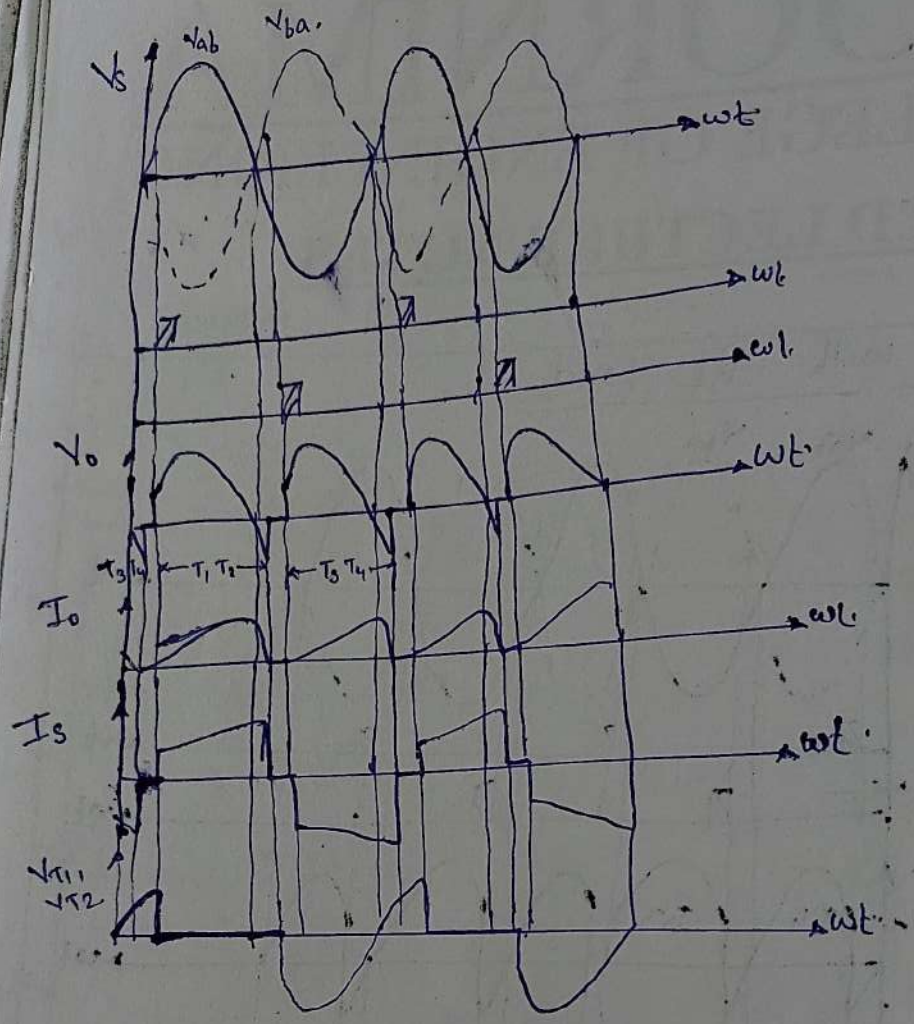
for centre tapped PIV $= -2V_m$.

for bridge type PIV $= -V_m$

1Φ FWR with RL Load



continous mode.



Discontinous mode.

continuous mode.

$$V_0 = \frac{1}{\pi}\int_{\alpha}^{\pi+\alpha} V_m \sin\omega t \, d(\omega t)$$

$$V_{avg} = \frac{2V_m}{\pi}\cos\alpha.$$

$$V_{rms} = \left[\frac{1}{\pi}\int_{\alpha}^{\pi+\alpha} V_m^2 \sin^2\omega t \, d(\omega t)\right]^{1/2}.$$

Discontinuous mode.

$$V_{avg} = \frac{1}{\pi}\int_{\alpha}^{\beta} V_m \sin\omega t \, d(\omega t)$$

$$= \frac{V_m}{\pi}(\cos\alpha - \cos\beta)$$

$$V_{rms} = \left[\frac{1}{\pi}\int_{\alpha}^{\beta} V_m^2 \sin^2\omega t \, d(\omega t)\right]^{1/2}.$$

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LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A & B Date: .....
Name of Faculty: R. S. Singh Name of Subject: P.E. Code: .....
Date (Prep.): ..... Date (Del.): ..... Unit No.: III Lect. No: 28 & 25

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ Basics of 3-ϕ Rectifier.
→ Principle & operation of 3-ϕ HWR.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on 3-ϕ HWR circuit. Also draw the related waveform at firing angle α = 0°, 30°, 60°, 90°, 120°

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ why conduction starts from ωt = 30°

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Basic principle & operation of 3-ϕ HWR circuit.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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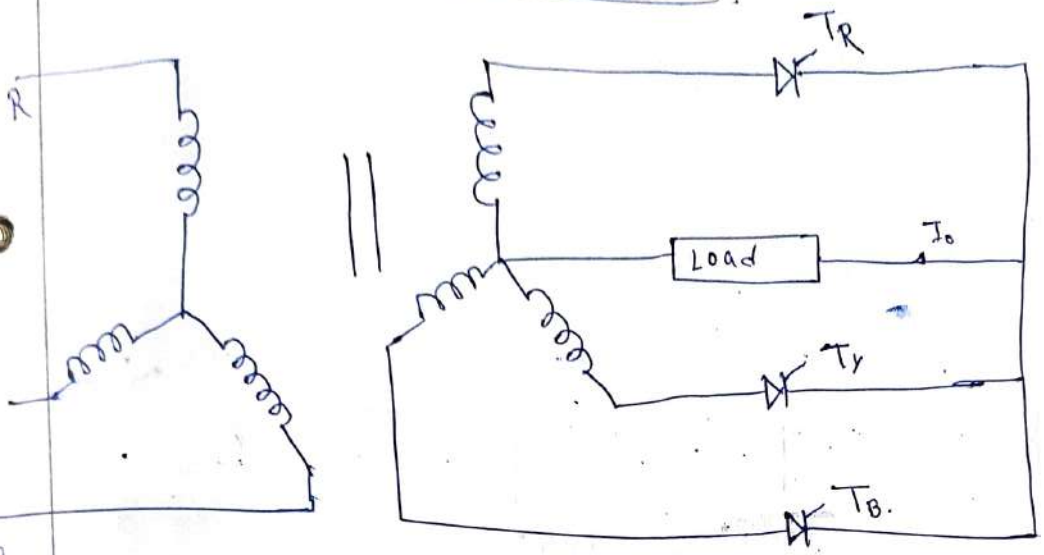
3 ϕ HWR with R-Load.



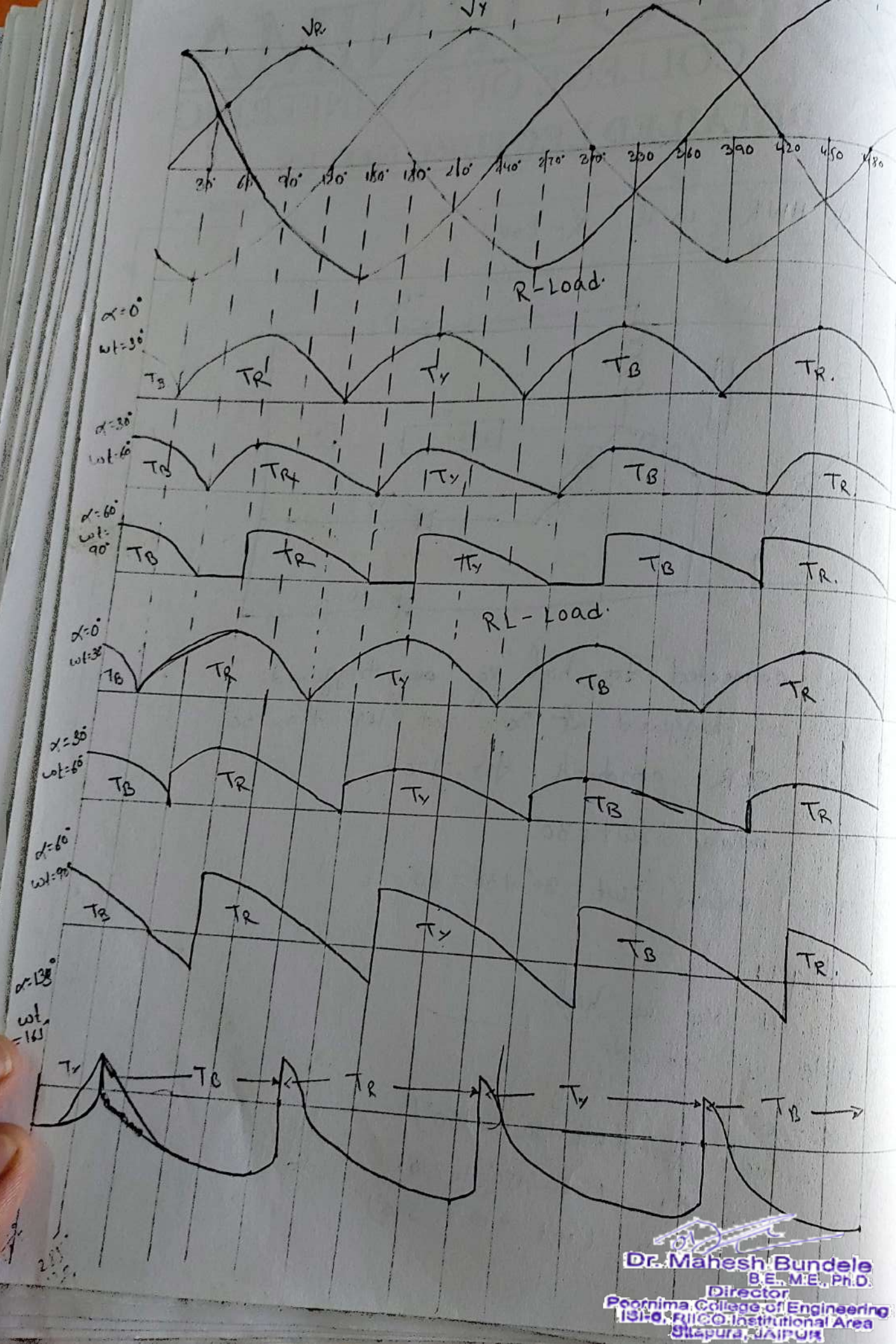
* SCR connected to high V_g is triggered.
* SCR is triggered at 30° not less than 30°
* Each SCR conducts for 120°

$\alpha = 0°$ means $\omega t = 30°$

$\alpha = 30°$ means $\omega t = 30° + 30° = 60°$

Advantages:
* avg. O/P V_g is high.
* Ripple is reduced.

For $\alpha = 0°$
* T_R conducts from ($\omega t = 30°$ to $150°$)
* T_Y " " ($\omega t = 150°$ to $270°$)
* T_B " " ($\omega t = 270°$ to $390°$)



Case I $\alpha < 30^\circ$

$$V_0 = \frac{3}{2\pi} \int_{\pi/6+\alpha}^{5\pi/6+\alpha} V_m \sin\omega t \, d(\omega t).$$

Case II $\alpha > 30^\circ$

$$V_0 = \frac{3}{2\pi} \int_{\pi/6+\alpha}^{\pi} V_m \sin\omega t \, d(\omega t).$$

For RL Load

for $\alpha < 30^\circ$ (Same like R Load)

for $30^\circ < \alpha < 90^\circ$

for $90^\circ < \alpha < 180^\circ$ (Line commutated Inverter).

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LECTURE NOTES

Campus: PCE Course: B. Tech. Class/Section: III A(B) Date: .....
Name of Faculty: R. S. Singh Name of Subject: P.E. Code: .....
Date (Prep.): ..... Date (Del.): .....Unit No.: III .....Lect. No: 26

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

→ 3-ϕ Full wave converter – Principle & operation.
→ output Voltage waveform.

IMPORTANT & RELEVANT QUESTIONS:

→ write short notes on the principle & operation of 3-ϕ Full wave converter. Also draw the waveform for firing angle $\alpha = 0°, 30°, 60°, 90°, 120°$

FEED BACK QUESTIONS (AFTER 20 MINUTES):

→ why we take V_{ms} instead of V_{mp} in the derivation of output V_g.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

→ Principle & operation of 3ϕ Full wave Rectifier.
→ How we draw the O/P V_g waveform?

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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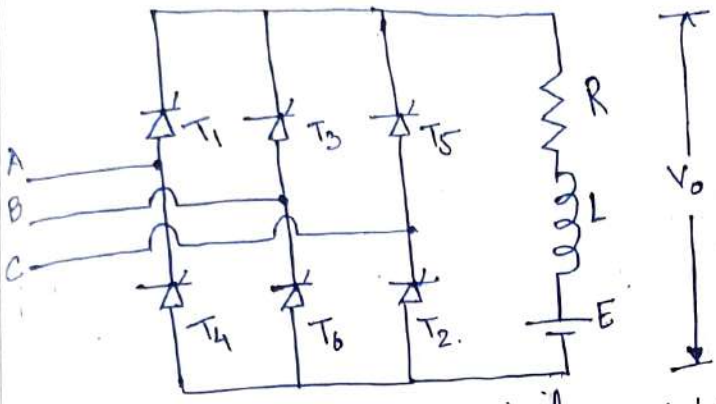
THREE-PHASE FULL WAVE CONVERTER FOR RLE LOAD



→ The three-phase input supply is connected to terminals A, B, C & the load RLE is connected across the O/P terminals of converter.

→ For $\alpha = 0°$, $T_1, T_2 \ldots T_6$ behave like diodes. For $\alpha = 0°$, T_1 is triggered at $\omega t = \pi/6$, T_2 at 90°, T_3 at 150° & so on.

→ For $\alpha = 60°$, T_1 is triggered at $\omega t = 30° + 60° = 90°$ T_2 at $90° + 60° = 150°$ & so on.

→ Each SCR conducts for 120°, when T_1 is triggered, reverse biased thyristor T_5 is turned off & T_1 is turned on. T_6 is already conducting.

→ As T_1 is connected to A & T_6 to B V_g 'V_{ab}' appears across the load.
It varies from 1.5 V_{mp} to zero.

→ Note that the group of SCRs are fired at an interval of 120°, my the group of SCRs are fired at an interval of 120° amongst them..

→ But SCR from the group alternate
This means that commutation occurs every 60°
upper & lower group of SCRs.

→ At any time, two SCRs one from the group & one from the group must conduct together.

$$V_0 = \frac{3}{\pi}\int_{\pi/3+\alpha}^{\frac{2\pi}{3}+\alpha} V_{ml}\sin\omega t \, d(\omega t)$$

$$V_0 = \frac{3V_{ml}}{\pi}\cos\alpha.$$

$$V_{or} = \frac{3}{\pi}\int_{\pi/3+\alpha}^{2\pi/3+\alpha} V_{ml}^2 \sin^2\omega t \, d(\omega t)$$

$$= V_{ml}\sqrt{\frac{3}{2\pi}\left[\pi/3 + \frac{\sqrt{3}}{2}\cos 2\alpha\right]}^{1/2}$$

→ Source current for Phase A i.e. i_A flows for 120° for 180°. Therefore in case output current is assumed constant rms value of source current is

$$I_s = \sqrt{I_0^2 \times \frac{2\pi}{3} \times \frac{1}{\pi}} = I_0 \cdot \sqrt{2/3}.$$

→ Each SCR conducts for 120° for every 360°. Therefore R value of thyristor current

$$I_{Th} = \sqrt{I_0^2 \times \frac{2\pi}{3} \times \frac{1}{\pi}} = I_0 \times \sqrt{1/3}$$

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LECTURE NOTES

Campus: PCE Course: B. TECH Class/Section: III A/B Date:
Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1
Date (Prep.): Date (Del.): Unit No.: IV Lect. No: 27

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- 1 ϕ Semi-converter.
- asymmetrical & symmetrical mode.
- conduction period of Thyristor & Diode.

IMPORTANT & RELEVANT QUESTIONS:

- Briefly explain about 1 ϕ Semi converter for RL Load. Also draw its waveform.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- What is the use of this ckt.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- working of 1ϕ semi-converter.
- Effect of free wheeling period.
- Its quadrant operation & which mode is better?

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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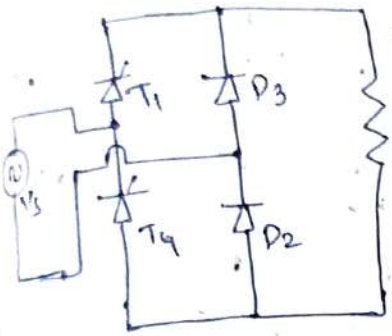
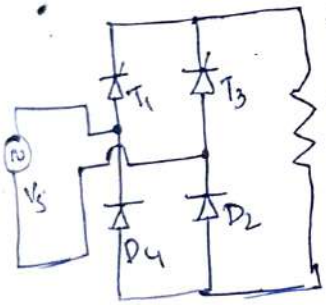
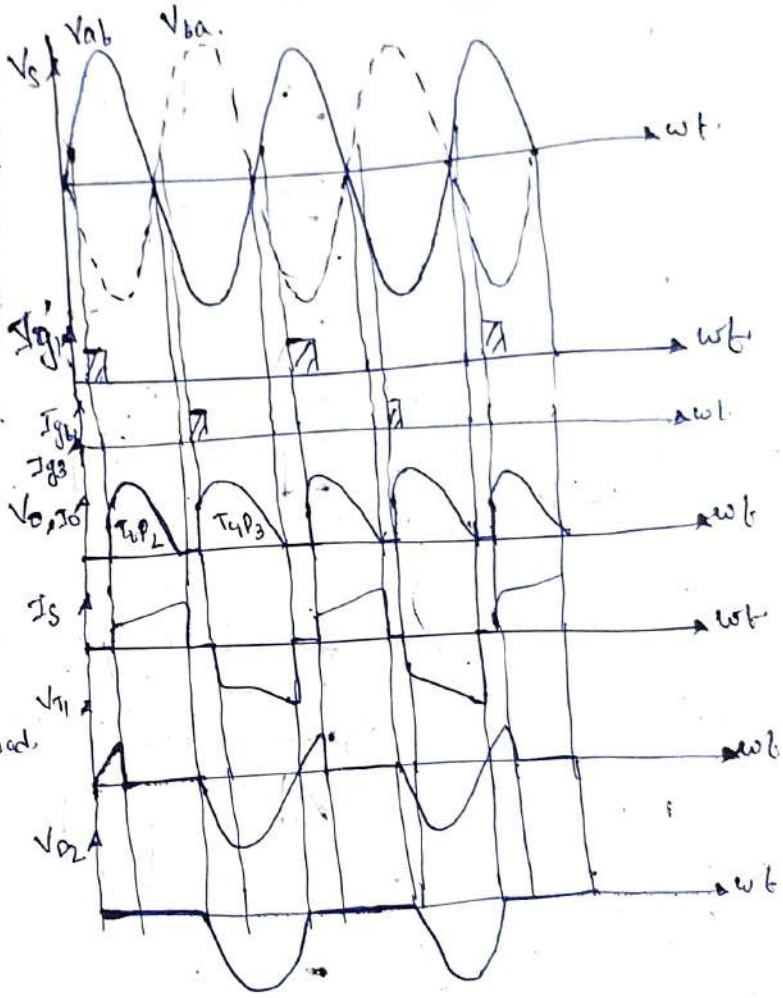
1 ϕ Semi-converter with R-Load



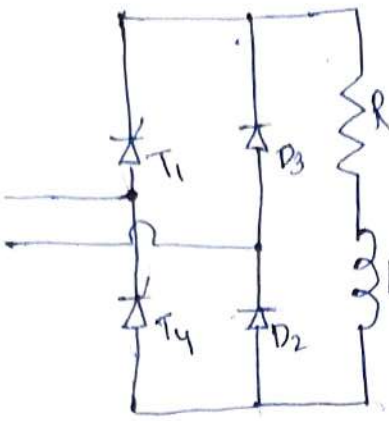
asymmetrical type.



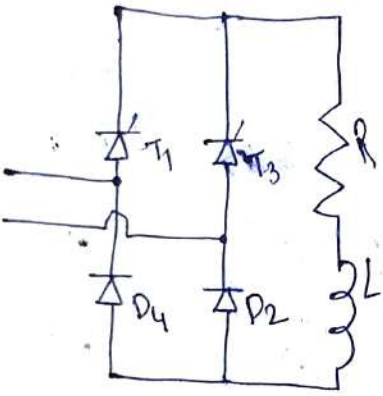
Symmetrical type.



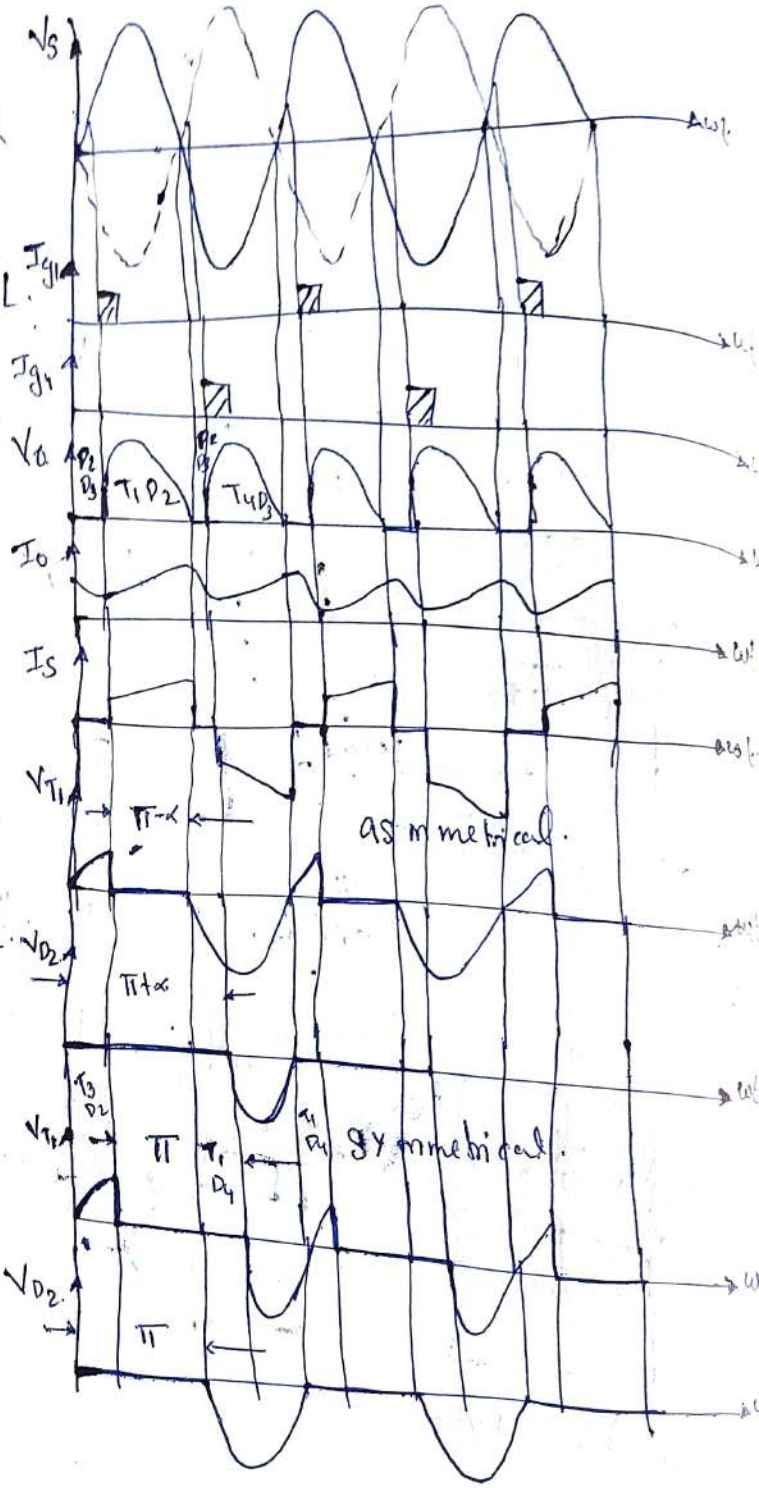
For RL type Load



asymmetrical type



Symmetrical type.



Campus: ..... Course: ..... Class/Section: ..... Date: .....
Name of Faculty: ..... Name of Subject: ..... Code: .....

For symmetrical mode.

from 0 to α	$T_3 D_2$ are ON	All thyristors & Diode are conduct for 'π' interval.
from α to π	$T_1 D_2$ are ON	
from π to π+α.	$T_1 D_4$ are ON	
from π+α to 2π	$T_3 D_4$ are ON	

For asymmetrical mode.

from 0 to α	$D_2 D_3$ are ON	For each cycle of 2π, thyristor conduct upto (π−α) interval. & Diode conducts upto (π+α) interval.
from α to π	$T_1 D_2$ are ON	
from π to π+α	$D_2 D_3$ are ON.	
from π+α to 2π	$T_4 D_3$ are ON.	

$$V_0 = \frac{1}{\pi} \int_{\alpha}^{\pi} V_m \sin\omega t \, d(\omega t)$$

$$V_0 = \frac{V_m}{\pi} (1 + \cos\alpha)$$

COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A & B Date: .....

Name of Faculty: R.S. Singh Name of Subject: P.E. Code: .....

Date (Prep.): ..... Date (Del.): ..... Unit No.: IV Lect. No: 28

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Principle & operation of 3-ϕ Semi-converter
- Applications.

IMPORTANT & RELEVANT QUESTIONS:

- Write short notes on 3-ϕ semi-converter. Also draw the related waveform.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

-

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Principle & operation of 3 ϕ semi-converter.
-

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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M.H. Rashid.

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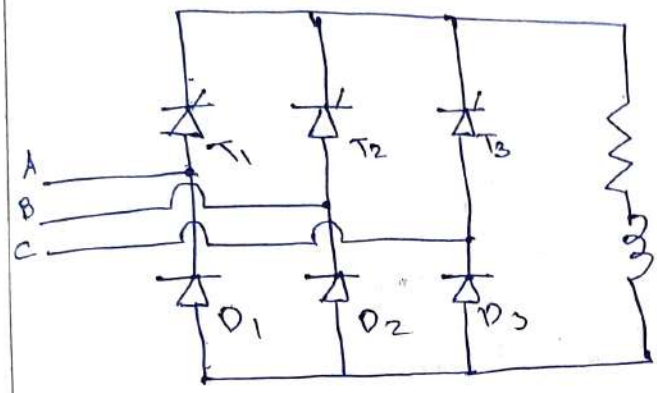
THREE – PHASE SEMI-CONVERTER.



$T_1, T_2, T_3 \longrightarrow$ +ve group $\rightarrow$ conduction varied, depend on α.

$D_1, D_2, D_3 \longrightarrow$ −ve group $\rightarrow$ conduction does not vary.

For $\alpha < 60°$,

$$V_0 = \frac{3}{2\pi}\left[\int_{\pi/3+\alpha}^{2\pi/3} V_{ml}\sin\omega t\, d(\omega t) + \int_{\pi/3}^{2\pi/3+\alpha} V_{ml}\sin\omega t\, d(\omega t)\right]$$

$$= \frac{3V_{ml}}{2\pi}(1+\cos\alpha)$$

$$V_{or} = \frac{V_{ml}}{2}\sqrt{\frac{3}{\pi}}\left[\frac{2\pi}{3} + \frac{\sqrt{3}}{2}(1+\cos 2\alpha)\right]^{1/2}.$$

For $\alpha > 60°$

$$V_0 = \frac{3}{2\pi}\int_{\alpha}^{\pi} V_{ml}\sin\omega t\, d(\omega t)$$

$$= \frac{3V_{ml}}{2\pi}(1+\cos\alpha).$$

$$V_{or} = \frac{V_{ml}}{2}\sqrt{\frac{3}{\pi}}\left[(\pi-\alpha) + \frac{1}{2}\sin 2\alpha\right]^{1/2}.$$

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COLLEGE OF ENGINEERING

LECTURE NOTES

Campus: PCE Course: B.Tech Class/Section: III A&B Date: .....
Name of Faculty: R. S. Singh Name of Subject: P.E. Code: .....
Date (Prep.): ..... Date (Del.): ..... Unit No.: IV Lect. No: 29

OBJECTIVE: To be written before taking the lecture (Pl. write in bullet points the main topics/concepts etc., which will be taught in this lecture)

- Effect of source impedance on output voltage of rectifier.
- Derivation for 1ϕ and 3ϕ Rectifier.

IMPORTANT & RELEVANT QUESTIONS:

- Briefly explain about the effect of source impedance on the output or characteristics of Rectifier. Also derive the expression for output V_d & current for 1ϕ and 3ϕ Rectifier.

FEED BACK QUESTIONS (AFTER 20 MINUTES):

- what happen if all the thyristors are kept ON in case of Rectifier ckt.

OUTCOME OF THE DELIVERED LECTURE: To be written after taking the lecture (Pl. write in bullet points about students' feedback on this lecture, level of understanding of this lecture by students etc.)

- Effect of source resistance.
- Effect of source inductance.
- How we can choose the specification of thyristor.

REFERENCES: Text/Ref. Book with Page No. and relevant Internet Websites:

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Ned Mohan.

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Effect of Source impedance

→ when incoming SCRs T_1 & T_2 are fired in a 1ϕ phase full converter, outgoing SCRs T_3 & T_4 get turned off due to the application of reverse v_g & current shifts to SCRs T_1 & T_2 instantaneously.

→ This is possible only if the v_g source has no internal impedance.

→ In actual, source possess internal impedance.
If source impedance is resistive, then there will be v_g drop across the resistance & avg. o/p v_g of a converter gets reduced by $I_0 \cdot r_s$ for 1ϕ & $2 I_0 \cdot r_s$ for 3ϕ.

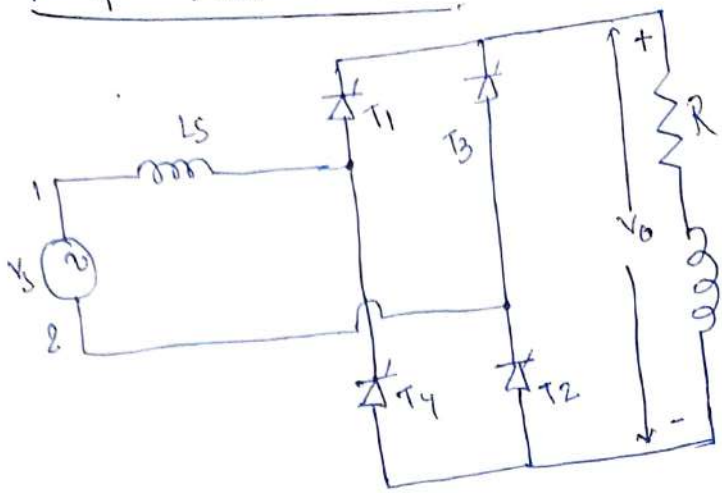
→ If source impedance is purely inductive.
The load inductance is assumed large so that o/p current is virtually constant.
The source ~~impedance~~ inductance causes the outgoing & incoming SCRs to conduct together.

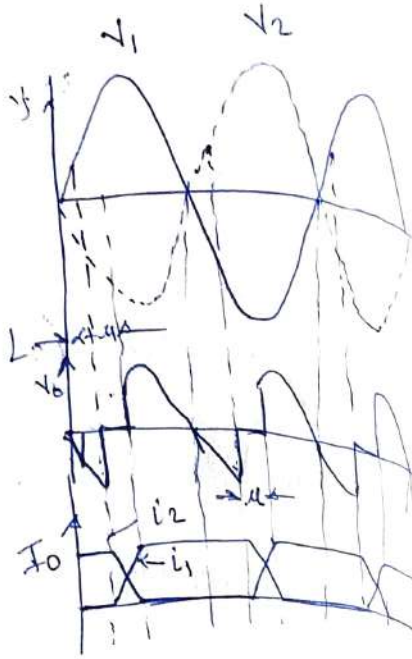
→ During commutation period, the o/p v_g is equal to the avg. value of the conducting-phase v_g.

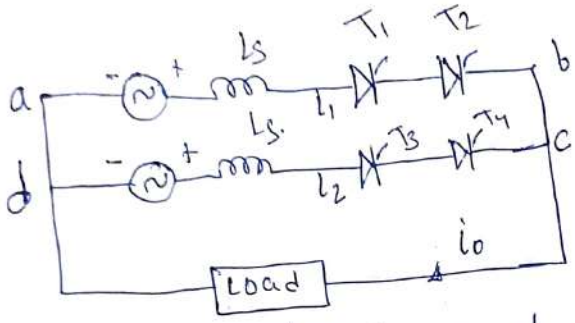
→ For the 1ϕ converter, the load v_g will be zero & for 3ϕ, the load v_g is $(v_a + v_b)/2$.

→ The effect of source inductance (i) lower the mean o/p v_g (ii) to distort the o/p v_g & current waveform (iii) modify the performance parameters of the converter.

1-ϕ Full converter







→ Load current is assumed constant

During overlap angle u, KVL for the loop abcda.

$$V_1 - L_s \, di_1/dt = V_2 - L_s \, di_2/dt \quad \text{——— (1)}$$

$$V_1 - V_2 = L_s\left(\frac{di_1}{dt} - \frac{di_2}{dt}\right).$$

$$V_1 = V_m \sin\omega t$$
$$V_2 = -V_m \sin\omega t.$$

$$L_s\left(\frac{di_1}{dt} - \frac{di_2}{dt}\right) = 2V_m \sin\omega t. \quad \text{——— (2)}$$

$$i_0 = i_1 + i_2 \quad \text{——— (3)}$$

↳ assumed constant.

Differentiate w.r.t. 't' (3),

$$\frac{di_1}{dt} + \frac{di_2}{dt} = 0 \quad \text{——— (4)}$$

from (3) —

$$\frac{di_1}{dt} - \frac{di_2}{dt} = \frac{2V_m}{L_s}\sin\omega t \quad \text{—(5)}$$

Adding (4) & (5) —

$$\frac{di_1}{dt} = \frac{V_m}{L_s}\sin\omega t \quad \text{—(6)}$$

At $\omega t = \alpha$, $i_1 = 0$

At $\omega t = \alpha + u$, $i_1 = I_0$.

$$\therefore \int_0^{I_0} di_1 = \frac{V_m}{L_s}\int_{\alpha/\omega}^{\alpha+u/\omega} \sin\omega t \, dt.$$

$$I_0 = \frac{V_m}{\omega L_s}\left[\cos\alpha - \cos(\alpha+u)\right] \quad \text{—(7)}$$

→ O/P Vg V_o is zero from α to $\alpha + u$.

Thus avg. O/P Vg V_{or} is given by —

$$V_{or} = \frac{V_m}{\pi}\int_{\alpha+u}^{\alpha+\pi} \sin\omega t \, d(\omega t).$$

$$= \frac{V_m}{\pi}\left[\cos(\alpha+u) - \cos(\pi+\alpha)\right].$$

$$= \frac{V_m}{\pi}\left[\cos\alpha + \cos(\alpha+u)\right]. \quad \text{—(8)}$$

→ Avg. O/P Vg at no load $= \frac{2V_m}{\pi}\cos\alpha$.

$$V_{omax} = \frac{2V_m}{\pi}$$

so, $V_{ox} = \frac{V_{om}}{2}\left[\cos\alpha + \cos(\alpha+u)\right]$. —(9)

from eq.n (7) —

$\cos(\alpha+u) = \cos\alpha - \frac{\omega L_s}{V_m} I_o$ —(10)

Substitute $\cos(\alpha+u)$ in eq.n (8)

$$V_{ox} = \frac{2V_m}{\pi}\cos\alpha - \frac{\omega L_s}{V_m} I_o.$$

POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET No.....

Campus: PCE Course: P.E. Class/Section: III Date: .....

Name of Faculty: R. S. Sisodiya Name of Subject: P.E Code: SEET

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) What is power electronics?

2) What is Power diode? Derive an expression for reverse recovery charge. Also draw its characteristics diagram.

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) What is Power MOSFET? Briefly explain about its characteristics.

2) Briefly explain about latch up condition for an IGBT.

3) What is thyristor commutation method? Explain its types.

OTHER IMPORTANT QUESTIONS

1) What is IGBT? Briefly explain about its V-I and switching characteristics .

2) What IS MCT? Briefly explain about its characteristics.

3) Write short notes on two transistor analogy of thyristor.

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TUTORIAL SHEET

SHEET No.....

Campus: PCP Course: PE Class/Section: III Date: .....

Name of Faculty: R.S.Singh Name of Subject: P.E. Code: SEE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) What is power electronics?

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2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) Write short notes on two transistor analogy of thyristor

2) What IS MCT? Briefly explain about its characteristics.

3) What is thyristor commutation method? Explain its types.

OTHER IMPORTANT QUESTIONS

1) What is Power MOSFET? Briefly explain about its characteristics.

2) What is IGBT? Briefly explain about its V-I and switching characteristics .

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TUTORIAL SHEET SHEET No.....

Campus: PCE Course: PE Class/Section: III Date: .....

Name of Faculty: R. S. Sisodiya Name of Subject: PE Code: SEE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

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TUTORIAL SHEET SHEET No.....

Campus: PCE Course: PE Class/Section: ..... Date: .....

Name of Faculty: R. S. Singh Name of Subject: PE Code: 5EE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1)Find the number of thyristors each with rating of 500V & 75A required for each branch of a series –parallel combination for a circuit for a total voltage & current rating of 7.5Kv & 1KA. Assume derating factor of 14%.

2) Derive an expressions for the resistance used for static voltage equalization for a series connected string of SCRs.

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) Describe different modes of operation of a thyristor with the help of its V-I characteristics.

2) Explain the turn ON methods of SCR.

3) How does a power transistor structure differ from that of a logic level transistor?

OTHER IMPORTANT QUESTIONS

1) Explain the switching characteristics of power SCR along with suitable waveforms.

2) Draw the switching characteristics of power MOSFET along with suitable waveforms.

3) Describe the different modes of operation of a TRIAC.

4) Explain the switching characteristics of power SCR along with suitable waveform.

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TUTORIAL SHEET

SHEET No.....

Campus: RCE Course: RE Class/Section: .....

Name of Faculty: R.S.Sil Name of Subject: RE Date: .....

Code: 5 EE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

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TUTORIAL SHEET SHEET No.....

Campus: RCE Course: PE Class/Section: III Date: .....

Name of Faculty: R.S.Sir Name of Subject: PE Code: SEE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

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POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET SHEET No.....

Campus: PCE Course: PE Class/Section: ..... Date: .....

Name of Faculty: R.S.S.K Name of Subject: PE Code: SEB1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) A 230 V, 50 KHz , one pulse SCR Controlled converter is triggered at a firing angle of 40 degree & the load current extinguishes at an angle of 210 degree. Find the circuit turn-off time, average load current for i) R=5ohm & L= 2mH ii) R= 5 ohm, L = 2 mH & E = 110V.

2) A Single phase one pulse SCR controlled converter feeds on RL load with a freewheeling diode across load. Discuss the role of freewheeling diode. Sketch the relevant waveform.

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) A single phase half wave rectifier using a thyristor is fed by a transformer whose secondary voltage is 400sinωt. Find the average load voltage. Rms load voltage, rms load current if firing angle is 30 degree. Take R=50ohm.

2) Describe the working of a single phase two quadrant converter with RL load through the relevant waveform. Also derive an expression for load voltage and input power factor.

OTHER IMPORTANT QUESTIONS

1) Draw the output voltage and input current waveform of a single phase full converter. Obtain the relevant waveform for i) R load ii) RL load

2) Describe the operation of a single phase two pulse mid-point converter with voltage and current waveform.

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POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET No.....

Campus: PCE Course: B.E. Class/Section: III Date: .....

Name of Faculty: R.S.Sh. Name of Subject: R.E. Code: SEE7

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) A 230 V, 50 KHz , one pulse SCR Controlled converter is triggered at a firing angle of 40 degree & the load current extinguishes at an angle of 210 degree. Find the circuit turn-off time, average load current for i) R=5ohm & L= 2mH ii) R= 5 ohm, L = 2 mH & E = 110V.

2) A Single phase one pulse SCR controlled converter feeds on RL load with a freewheeling diode across load. Discuss the role of freewheeling diode. Sketch the relevant waveform.

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) A single phase half wave rectifier using a thyristor is fed by a transformer whose secondary voltage is 400sinωt. Find the average load voltage. Rms load voltage, rms load current if firing angle is 30 degree. Take R=50ohm.

2) Draw the output voltage and input current waveform of a single phase full converter. Obtain the relevant waveform for i) R load ii) RL load

3) Write short notes on three phase dual converter.

OTHER IMPORTANT QUESTIONS

1) Describe the operation of a single phase two pulse mid-point converter with voltage and current waveform.

2) Describe the working of a single phase two quadrant converter with RL load through the relevant waveform. Also derive an expression for load voltage and input power factor.

3) Describe the working principle of single phase dual converter.

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TUTORIAL SHEET

Campus: RCE Course: PE SHEET No.....

Name of Faculty: R. S. Sh Class/Section: ..... Date: .....

Date of Tut. Sheet Preparation:..... Name of Subject: PE Code: SEE1

Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) A 230 V, 50 KHz , one pulse SCR Controlled converter is triggered at a firing angle of 40 degree & the load current extinguishes at an angle of 210 degree. Find the circuit turn-off time, average load current for i) R=5ohm & L= 2mH ii) R= 5 ohm, L = 2 mH & E = 110V.

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2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) A single phase half wave rectifier using a thyristor is fed by a transformer whose secondary voltage is 400sinωt. Find the average load voltage. Rms load voltage, rms load current if firing angle is 30 degree. Take R=50ohm.

2) Describe the operation of a single phase two pulse mid-point converter with voltage and current waveform.

OTHER IMPORTANT QUESTIONS

1) Draw the output voltage and input current waveform of a single phase full converter. Obtain the relevant waveform for i) R load ii) RL load

2) Describe the working of a single phase two quadrant converter with RL load through the relevant waveform. Also derive an expression for load voltage and input power factor.

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COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET No.....

Campus: RCE Course: BE Class/Section: III Date: .....

Name of Faculty: R.S. Sir Name of Subject: PE Code: SEE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS	1) Why we need power factor improvement technique in single phase & 3 phase converter? 2) With the help of relevant waveform explain various types of power factor improvement technique.
2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS	1) why it is necessary to use forced commutation techniques for power factor improvement in phase controlled converters. 2) Write short notes on single phase semi-converter for R, RL Load.
OTHER IMPORTANT QUESTIONS	1) Briefly explain about symmetrical angle control & sinusoidal pulse-width modulation technique.

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POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET No.....

Campus: RCE Course: PE Class/Section: ..... Date: .....

Name of Faculty: R. S. Sai Name of Subject: PE Code: S EE7

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS

1) Why we need power factor improvement technique in single phase & 3 phase converter?

2) With the help of relevant waveform explain various types of power factor improvement technique.

2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS

1) Why it is necessary to use forced commutation techniques for power factor improvement in phase controlled converters.

2) Write short notes on single phase semi-converter for R, RL Load.

OTHER IMPORTANT QUESTIONS

1) Briefly explain about symmetrical angle control & sinusoidal pulse-width modulation technique.

2) Explain the working principle of extinction angle control method.

3) Briefly explain about working principle of three phase semi converter.

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POORNIMA
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TUTORIAL SHEET

SHEET No.....

Campus: PCE Course: PE Class/Section: III

Name of Faculty: R.S. Singh Name of Subject: R.E. Date: .....

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :..... Code: 3EE1

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS	1) Why we need power factor improvement technique in single phase & 3 phase converter? 2) With the help of relevant waveform explain various types of power factor improvement technique.
2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS	1) why it is necessary to use forced commutation techniques for power factor improvement in phase controlled converters. 2) Write short notes on single phase semi-converter for R, RL Load.
OTHER IMPORTANT QUESTIONS	1) Briefly explain about symmetrical angle control & sinusoidal pulse-width modulation technique. 2) Write short notes on extinction angle control method.

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POORNIMA
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TUTORIAL SHEET SHEET No.....

Campus: PCE Course: PE Class/Section: ..... Date: .....

Name of Faculty: R. S. Sisodiya Name of Subject: PE Code: 5EE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS	1) What is chopper? Explain the working principle of DC-DC chopper with its circuit diagram and waveforms. 2) Explain the control technique used in DC-DC chopper.
2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS	1) Briefly explain about the different types of choppers. Also sketch its circuit diagram and waveform. 2) What is commutation? Briefly explain about the need of commutation in chopper. 3) What is voltage commutated chopper? Briefly explain about the working principle of voltage commutated chopper.
OTHER IMPORTANT QUESTIONS	1) What is multi- Phase chopper? Briefly explain about the working principle and application of multiphase chopper. 2) What is current commutated chopper? Briefly explain about the working principle of current commutated chopper.

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TUTORIAL SHEET

SHEET No.....

Campus: PCE Course: PE Class/Section: III Date: .....

Name of Faculty: R. S. Singh Name of Subject: PE Code: SEE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS	1) What is chopper? Explain the working principle of DC-DC chopper with its circuit diagram and waveforms. 2) Explain the control technique used in DC-DC chopper.
2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS	1) Briefly explain about the different types of choppers. Also sketch its circuit diagram and waveform. 2) What is commutation? Briefly explain about the need of commutation in chopper. 3) What is multi- Phase chopper? Briefly explain about the working principle and application of multiphase chopper.
OTHER IMPORTANT QUESTIONS	1) What is voltage commutated chopper? Briefly explain about the working principle of voltage commutated chopper. 2) Briefly explain about current commutated and load current commutated chopper.

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POORNIMA
COLLEGE OF ENGINEERING

TUTORIAL SHEET

SHEET No.....

Campus: RCE Course: PE Class/Section: III Date: .....

Name of Faculty: R.S. Sirl Name of Subject: PE Code: 5EE1

Date of Tut. Sheet Preparation:..... Scheduled Date of Tut.:.....Actual Date of Tut. :.....

Name of Student:.....Scheduled & Actual Date of H.A. Submission:.....&.....

FIRST 20 MT. CLASS QUESTIONS	1) What is chopper? Explain the working principle of DC-DC chopper with its circuit diagram and waveforms. 2) Explain the control technique used in DC-DC chopper.
2 HRS. SOLVABLE HOME ASSIGNMENT (H.A.) QUESTIONS	1) Briefly explain about the different types of choppers. Also sketch its circuit diagram and waveform. 2) What is commutation? Briefly explain about the need of commutation in chopper. 3) What is multi- Phase chopper? Briefly explain about the working principle and application of multiphase chopper.
OTHER IMPORTANT QUESTIONS	1) What is voltage commutated chopper? Briefly explain about the working principle of voltage commutated chopper.

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UNIT - V

5 (a) Explain Voltage commutated chopper along with circuit diagram and waveforms.

(b) Explain working principle of type-C Chopper along with circuit diagram and waveforms.

OR

5 (a) Describe the working of buck-boost regulator along with relevant circuit diagram and waveforms.

(b) Derive the expressions for steady-state maximum and minimum current for type-A chopper.

5E3123

Roll No. : _____ Total Printed Pages : 4

5E3123

B. Tech. (Sem. V) (Main/Back) Examination, December - 2013
Electrical Engineering
5EE1 Power Electronics - III (Common with Electrical & Electronics)

Time : 3 Hours] [Total Marks : 80
[Min. Passing Marks : 24

Attempt any five questions. Selecting one question from each unit. All questions carry equal marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used / calculated must be stated clearly.

Use of following supporting material is permitted during examination.
(Mentioned in form No. 205)

1. NIL 2. NIL

UNIT - I

1 (a) Explain and draw the switching characteristics of Power MOSFET.

(b) Explain principle of operation of Thyristor using Two-Transistor model.

OR

1 (a) Explain and draw the switching characteristics of the power IGBT.

(b) Write various factors which influences the turn-off time of thyristor. Explain how the turn-off time can be minimized ?

UNIT - II

2 (a) Explain the series operation of thyristor. How SCRs suffer from unequal voltage distribution across them during their turn-on and turn-off processes ?

(b) Explain how SCR is protected against high dv/dt.

OR

2 (a) Explain in detail RC Full Wave triggering circuit for thyristor along with circuit diagram and related waveforms.

(b) Find the number of thyristors each with a rating of 500 V and 75A required for each branch of a series-parallel combination for a circuit for a total voltage and current rating of 7.5 kV and 1 kA. Assume derating factor of 14%.

UNIT - III

3 (a) Describe working of a single-phase two quadrant converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input power factor.

(b) A 220 V, 50 Hz, one-pulse SCR controlled converter is triggered at a firing angle of 60° and the load current extinguishes at an angle of 220°. Find the circuit turn off time, average output voltage and the average load current for R = 7 ohms and L = 3mH.

OR

3 (a) A single-phase dual converter is operated from a 200 V, 50 Hz supply and the load resistance is R = 20 ohms. The circulating inductance is L_r = 50 mH; delay angles are α_1 = 50° and α_2 = 130°. Calculate the peak circulating current and the peak current of converter1.

(b) Explain principle of operation of single-phase dual converter without circulating current in detail.

UNIT - IV

4 (a) Describe the working of a single-phase two-pulse semi converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input power factor.

(b) Explain Pulse width modulation control technique of power factor improvement along with circuit diagram and waveforms.

OR

4 (a) A single phase full converter is supplied from 220 V, 50 Hz source. If load resistance R = 8 ohms and source has an inductance of 1.5 mH for a firing angle delay of 60° determine :

(i) Average output voltage

(ii) The angle of overlap.

(b) Explain Sinusoidal Pulse width modulation control technique of power factor improvement along with circuit diagram and waveforms.

UNIT-V

) Explain working principle of type-C chopper along with relevant circuit diagram & waveform. [8]

) Explain the load commutated chopper along with relevant circuit diagram & waveform. [8]

OR

Describe the working of Buck-Boost regulator along with circuit diagram & waveform. [8]

Derive the expressions for steady-state maximum & minimum current for type-A chopper. [8]

5E5041

Roll No. _____

Total No of Pages: 4

5E5041

B. Tech. V Sem. (Main / Back) Exam., Dec. 2014
Electrical & Electronics Engineering
5EX1A Power Electronics
(Common for EX, EE)

Time: 3 Hours

Maximum Marks: 80
Min. Passing Marks: 24

Instructions to Candidates:

*Attempt any **five questions**, selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

(Mentioned in form No. 205)

1. NIL 2. NIL

UNIT – I

Q. 1 (a) Explain the constructional details and working of power MOSFET. [8]

(b) Explain and draw the switching characteristics of the power IGBT. [8]

OR

(a) Discuss the two transistor model of a thyristor. [8]

(b) Describe the various commutation of thyristor. [8]

UNIT-II

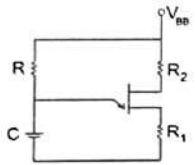
) Explain how SCR is protected against high dv/dt. [8]

) Explain various turning on methods of a thyristor. [8]

OR

Explain series operation of thyristor. [8]

In a UJT triggering oscillator as shown in figure, R=6.8 kW and C=0.1 ∝F. If η= 0.82, calculate the frequency of oscillation of relaxation oscillator. [8]



UNIT-III

Describe working of a single phase full converter with RL load through the wave form of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expression for load voltage & input power factor. [10]

A single phase half wave controlled converter is operated from a 120V, 50Hz supply. Load resistance R=10 ohms. If average out put voltage is 25% of the maximum possible average output voltage, determine:- [6]

(i) Firing angle

(ii) RMS & Average output current

OR

(a) Explain principle of operation of single-phase dual converter without circulating current in detail. [8]

(b) A single-phase dual converter is operated from a 200 V, 50 Hz supply and the load resistance is R=20 ohms. The circulating inductance is L_r = 50mH, delay angle are $\propto_1$ = 50° and $\propto_2$ =130°. Calculate the peak circulating current and the peak current of converter1. [8]

UNIT-IV

Q. 4 (a) Explain the extinction angle control technique of power factor improvement along with the circuit diagram and waveform. [8]

(b) Describe the working of a single phase semi-converter with RLE load, through the wave form of supply voltage, load voltage load current and voltage across thyristor and also, derive expression for load voltage and input power factor. [8]

OR

(a) Explain pulse with modulation control technique of power factor improvement along with circuit diagram & wave form. [8]

(b) A single-phase full converter is supplied from 200V, 50Hz Source. If load resistance R=8 ohms and source has an inductance of 1.5 mH, for a firing angle delay of 60°, determine:

(i) Average output voltage

(ii) The angle of overlap. [8]

OR

Draw the circuit diagram & current wave form of multiphase chopper for phase shifted operation for $\alpha = 0.50$ and $\alpha = 0.60$ [8]

Explain the working & circuit of Load Commutated Chopper. Give its merits & demerits. [8]

5E5041

Roll No. _____

Total No of Pages: 4

5E5041

B. Tech V Sem. (Main/Back) Exam. Nov-Dec. 2015
Electrical Engineering
5EE1A Power Electronics
Common with EX (Electrical & Electronics)

Time: 3 Hours

Maximum Marks: 80
Min. Passing Marks Main: 26
Min. Passing Marks Back: 24

Instructions to Candidates:

*Attempt any **five questions**, selecting **one question** from **each unit**. All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

1. NIL 2. NIL

UNIT-I

Q.1 (a) Explain the working & characteristic of power transistor. [8]

(b) Explain switching characteristics of an IGBT. [8]

OR

Q.1 (a) Describe the basic structure of MOS controlled thyristor (MCT). Give its equivalent circuit & explain the turn on & turn oft processes. [12]

(b) Compare power MOSFETs with BJTs. [4]

UNIT-II

Q.2 (a) The specification sheet for an SCR gives maximum rms on state current as 35 A. If this SCR is used in a resistive circuit, compute average on state current rating for half sine wave current for conduction angles of [12]

(i) 180°

(ii) 90°

(iii) 30°

(b) Discuss thyristor protection. [4]

OR

Q.2 (a) How can we improve thyristor characteristics? [8]

(b) Explain the construction & working of relaxation oscillator. Give necessary diagrams. [8]

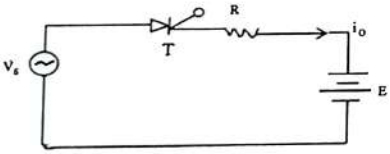
UNIT-III

Q.3 (a) A dc batty is charged though a resistor R as shown in fig. Derive an expression for the average value of charging current in terms of V_m, E, R etc on the assumption that SCR is fired continuously. [12]

(i) For an ac source voltage of 230V, 50HZ, find the value of average charging current for R = 8Ω & E = 150V.

(ii) Find the power supplied to battery & that dissipated in the resistor.

(iii) Calculate the supply pf



(b) List out the application of phase controlled rectifiers. [4]

OR

Q.3 (a) A single phase full converter delivers power to a resistive load R for ac source voltage Vs. Show that average output Vo is gives by-

$$\left[V_o = \frac{\sqrt{2}V_s}{\Pi}(1+\cos\alpha)\right]$$

Sketch the time variations of source voltage, output voltage, output current & voltage across one pair of SCRs. Find the circuit turn off time. [8]

(b) For the converter of pert (a), show that rms value of output current is given by

$$I_{or} = \frac{V_s}{R}\left[\frac{1}{\Pi}\left\{(\Pi - \alpha) + \frac{1}{2}\sin 2\alpha\right\}\right]^{1/2}$$ [8]

UNIT-IV

Q.4 (a) Discuss the effect of source impedance on the performance of converters. [8]

(b) Discuss the mechanism of pulse width modulation control. [8]

OR

Q.4 Write short note on- [8×2=16]

(a) Extinction angle control.

(b) Symmetrical angle control.

UNIT-V

Q.5 (a) Explain principle of chopper operation. Give its control strategies. [8]

(b) For type A chopper, dc source voltage = 230V, load resistance is 10Ω. Take a voltage drop of 2V across chopper when it is on. For a duty cycle of 0.4, calculate – [8]

(i) Average & rms values of output voltage.

(ii) Chopper efficiency.

5E5041

Roll No. _____ Total No of Pages: 3

5E5041

B. Tech. V Sem. (Main/Back) Exam., Nov.-Dec.-2016
Electrical & Electronics Engineering
5EX1A Power Electronics
EX, EE

Time: 3 Hours

Maximum Marks: 80
Min. Passing Marks Main: 26
Min. Passing Marks Back: 24

Instructions to Candidates:

*Attempt any **five questions**, selecting **one question from each unit.** All questions carry **equal** marks. Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly.*

Units of quantities used/calculated must be stated clearly.

Use of following supporting material is permitted during examination.

(Mentioned in form No. 205)

1. NIL 2. NIL

UNIT – I

Q.1 (a) What are the differences in the gating characteristics of thyristors & transistors? [8]

(b) What are the differences between enhancement type MOSFETs & depletion type MOSFETs? [8]

OR

Q.1 (a) Briefly explain the V – I characteristics of an IGBT. [8]

(b) Give the merits & demerits of a GTO as compared to a conventional SCR. [8]

UNIT – II

Q.2 (a) The gate circuit of an SCR has a source voltage of 15V & the load line has a slop of –120V per ampere. The minimum gate current to turn-on the SCR is 25mA. Calculate:

(i) Gate – source resistance R_S. [8]

(ii) The gate voltage & gate current for an average gate power dissipation of 0.4 watts.

(b) What is the purpose of having parallel operation of SCRs? What care must be taken when paralleling the SCRs? [8]

OR

Q.2 (a) Explain the various types of triggering methods of SCR briefly. Which is the universal method & why? [8]

(b) What are $\frac{dv}{dt}$ & $\frac{di}{dt}$ rating of SCRs? What happens if these rating are exceeded? Explain. [8]

UNIT – III

Q.3 (a) Explain with a neat circuit diagram the basic principle of a dual converter. [8]

(b) For 3 – ϕ full converter operating from 3- ϕ, 415/50Hz supply, determine & plot the following - [8]

(i) Fundamental component of the supply current.

(ii) 5th, 7th, 11th, & 13th harmonics for $\propto = 0°, 30°, 60°, 90°, 120°, 150°$.

Assume large inductive load with $R_L = 10\ \Omega$.

OR

Q.3 (a) Describe working of a single phase full converter with RLE load through the waveform of supply voltage, load voltage, load current & voltage across thyristor. Also derive expression for load voltage & input power factor. [8]

(b) A single- phase half- wave controlled converter is operated from a 120V, 50Hz supply. Load resistance R = 10 Ω. If the average output voltage is 25% of the minimum possible average output voltage, determine: – [8]

(i) Firing angle

(ii) rms & average output current

(iii) rms & average SCR current

UNIT – IV

Q.4 (a) Explain with associated waveform, how power factor can be improved with symmetrical angle control scheme. [8]

(b) A single-phase semi converter is operated from 200V, 50Hz source. If load resistance R = 8Ω & source has an inductance of 1.5mH, for an firing angle delay of 60°, determine: – [8]

(i) Average output voltage

(ii) The angle of overlap.

OR

Q.4 (a) Explain in detail the sinusoidal pulse width modulation control scheme for power factor improvement. [8]

(b) Describe the working of a single phase semi converter with RL load, through the waveform of supply voltage, load voltage, load current & voltage across thyristor & also derive expression for load voltage & input power factor. [8]

UNIT – V

Q.5 (a) What is the principle of operation of a step down chopper? [8]

(b) A DC chopper circuit connected to a 100V DC source supplies an inductive load having 40mH in series with a resistance of 5Ω. A free wheeling diode is placed across the load. The load current varies between the limits of 10A & 12A. Determine the time ratio of the chopper. [8]

OR

Q.5 (a) Explain multiphase chopper along with relevant circuit diagram & waveform. [8]

(b) Explain working principle of type–A chopper along with relevant circuit diagram & waveform. [8]

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RTU QUESTION PAPERS ANALYSIS

Subject: Power Electronics

Sub. Code: 5EE1A

UNIT 1-

1.Explain and draw the switching characteristics of the Gate turn - off thyristor.

2.Explain and draw the switching characteristics of the power IGBT.

3.Explain and draw the, switching characteristics of Power MOSFET.

UNIT 2-

1.Explain the significance of di / dt and dv / dt in SCRs.

2.Explain and draw the switching characteristics of the SCR.

3. Explain the series operation of thyristor.

UNIT 3-

1.Describe working of a single - phase full converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input power factor.

2.Explain principle of operation of three phase dual converter without circulating current in detail.

UNIT 4-

1. Describe the working of a single phase two-pulse semi converter with RL load through the waveforms of supply voltage, load voltage, load current and voltage across thyristor. Also, derive expressions for load voltage and input, power factor.

2. Explain Sinusoidal Pulse width modulation control technique of power factor improvement along with circuit diagram and waveforms.

3.Explain Extinction angle control technique of power factor improvement along with circuit diagram and waveforms.

UNIT 5-

1. Describe the principle of step Up/ Down chopper. Derive an expression for the average output voltage in terms of input dc voltage and duty cycle.

2.Explain Voltage commutated chopper along with circuit diagram and waveforms.

3.Derive the expressions for steady-state maximum and minimum current for type-A chopper.

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Name of subject: Power Electronics

Code- 5EE1A

[1] When a line commutated converter operates in the inverter mode
(a) It draws both real and reactive power from the AC supply
(b) It delivers both real and reactive power to the AC supply
(c) It delivers real power to the AC supply
(d) It draws reactive power from the AC supply

[2] A chopper operating at a fixed frequency is feeding an RL load. As the duty ratio of the chopper is increased from 25% to 75%, the ripple in the load current is
(a) Remains constant
(b) Decreases, reaches a minimum at 50% duty ratio and then increases
(c) Increases, reaches a maximum at 50% duty ratio and then decreases
(d) Keeps on increasing as the duty ratio is increased

[3] To turn off a SCR, the reverse bias should be applied for a period ..... the turn-off time of the SCR.
(a) Equal to
(b) Longer than
(c) Less than
(d) Irrespective of

[4] Comparing with the full wave rectifier using two diodes, the four diode bridge rectifier has the dominant advantage of
(a) Lower current carrying
(b) Lower peak inverse voltage requirement
(c) Lower ripple factor
(d) Higher efficiency

[5] A SCR is rated at 75A peak, 20A average. The greatest possible delay in the trigger angle if the rated value is
(a) 4
(b) 3 or 45°
(c) 7
(d) 1

JMP QUE

[6] In synchronized UJT triggering of an SCR, voltage VC across capacitor reaches UJT threshold voltage in each half cycle so that there are three firing pulses during each half cycle. The trigger angle of the SCR can be controlled
(a) Once in each half cycle
(b) Twice in each half cycle
(c) Thrice in each half cycle
(d) Four times in each half cycle
(e) None of the above

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[7] In GTO, anode current begins to fall when gate current
(a) Is negative peak at time t=0
(b) Is negative peak at t = storage period tS
(c) It begins to become negative at t = 0
(d) Is negative peak at t = (tS + fall time)

[8] The SCR can be turned on by
(a) Applying anode voltage at a sufficiently fast rate
(b) Applying sufficiently large anode voltage
(c) Raising the temperature of SCR to a sufficiently large value
(d) Applying sufficiently large gate current
OP
1) A
2) C
3)
4)
5) All above options

[9] IGBT has three terminals called:
a) C Collector, Emitter and Base
b) E Emitter, Source and Base
c) S Source and Gate
d) C Collector and Gate

[10 Function of snubber circuit connected across the SCR is to:
a) Suppress dv/dt
b)
c)
d)

[11 IGBT exhibits negative resistance region:
a) Between peak point
b) Between peak and valley point
c) Between valley point
d)

[12 Dual operation require:
a) Two converters in series
b) Two converters connected back to back
c) Two converters connected in parallel
d) Two semi converters connected back to back

[13 In circulating-current type of dual converter, the nature of the voltage across the re
a) Pulsating
b) Pulsating
c)
d) Regular

[14 Resistor connected across the gate and cathode of an SCR in a circuit increases its
a) Rating

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b) ! ing cu.
c) : Imm.
d) off ti.
[1 R is tl. l state equivalent of
(a) sistor
(b) ratron
(c) uum di
(d) tal di

[1 h gat. if the supply voltage exceeds the breakover voltage of SCR, then SCR
w duct
(a
(b
(c DC
(d AC

[1 SCR ed off when the anode current falls below
(a ard c ating
(b k ove ge
(c ling cu
(d hing c

[1 SCR t, the angle of conduction can be changed by changing
(a le vo
(b le cur
(c ard c ating
(d curre

[1 he norm y to close a SCR is by appropriate
(a ate curre
(b hode c
(c de cur
(d ard c

[2 SCR .....PN junctions
(a o
(b ur
(c ee
(d

[2 gate cu. s increased, the anode-cathode voltage at which SCR closes is.....
(a eased
(b creased
(c ximum
(d st

[2 conduc R can be opened by reducing ..... to zero
(a ly vo
(b voltag
(c d curre
(d ode cu

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[2 With gate a SCR can be turned-on by making supply voltage....
(a imum
(b erse
(c ual to ca voltage
(d ual to b er voltage

[2 f firing a in a SCR rectifier is increased, output is....
(a eased
(l imum
(c eased
(c ffected

[2 SCR is tch
(a o direct
(l irecti
(c direc
(c direct

[2 e anod 2 is always maintained at.....potential with respect to cathode
(a itive
(l
(c ive
(c

[2 the cl witching frequency is 200Hz and Ton time is 2ms, the duty cycle is
(a
(l
(c
(c of th

[2 single p full wave controlled rectifier, maximum output voltage is obtained at
c ion a minimum at connection angle...
(a 180°
(l °, 0°
(c °
(c 180

[2 of introducing inductance in the load circuit of SCR is
(a e cu rises slowly
(b le cu is re than without it
(c has t ed for anode current
(c retur g can be raised
V ements are true?
(1
(2
(3
(4

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POORNIMA
COLLEGE OF ENGINEERING

ASSESSMENT I

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-30 **TIME-I Hr**

1) What is IGBT? Describe its construction and working. Compare between Power MOSFET and IGBT.

OR

2) What is thyristor? Discuss the switching characteristics of thyristor.

3) Explain the working of an oscillator employing an UJT. Derive expression for the frequency of triggering and firing angle delay.

OR

4) Explain the principle of pulse transformer.

5) Explain the working of a triac with its different modes.

OR

6) Why thyristor is not turned off when negative gate pulse are applied? What happened when negative gate pulse are applying during forward bias condition in thyristor?

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COLLEGE OF ENGINEERING

ASSESSMENT I

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-30 **TIME-1 Hr**

1) What is IGBT? Describe its construction and working. Compare between Power MOSFET and IGBT.

OR

2) What is thyristor? Discuss the switching characteristics of thyristor.

3) Explain the working of an oscillator employing an UJT. Derive expression for the frequency of triggering and firing angle delay.

OR

4) Explain the principle of pulse transformer.

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ASSESSMENT II

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-20 **TIME-I Hr**

1) Describe the operation of 3 phase full converter, draw the output voltage and current waveform for a firing angle of 30 degree and calculate the average output voltage.

OR

2) Explain principle of operation of single phase dual converter with circulating current mode.
3) Explain the working principle of type C chopper along with circuit diagram and waveforms?

OR

4) What is chopper? Briefly explain about types of choppers.

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19/1SFE003	DEVANSH PRAJAPATI	6		3		4		2		7					5	45	6	6	7	6	7	6		
19/1SFE004	DEVENDRA SINGH		4	2				6			4	5			4.5	20	5	3	4	5	5	5		
19/1SFE005	DEVESH GOTAN	3		7			2	2			3				5	31	5	3	2	2	5	2		
19/1SFE006	DEVILAL OLA										7	8			5.5	32	3	6	2	8	3	8		
19/1SFE007	DHARMENDRA BOCHLYA	9		9			6	8								A	0	0	0	0	0	0		
19/1SFE008	DHEERAJ PARIHAR		9	9		4		9			10	10		10		57	9	9	7	10	10	10		
19/1SFE009	DILIP PRAJAPATI		7			7		8			4		4	7	9.5	54	9	9	5	4	7	4		
19/1SFE010	DIVYESH SHRINGI	2		4		1		5		6					7	12	7	2	7	3	2	3		
19/1SFE020	DURLABH CHAND GARG	9		8		9			8	4			1	2	3	26	3	4	2	3	3	3		
19/1SFE050	GAJENDRA SINGH RATHORE															41	9	8	9	0	0	0		
19/1SFE051	GAURAV MAHAWAR	3		10		5			9			4		10		A	0	0	0	0	0	0		
19/1SFE052	GAURAV MEENA			7			3	4			5		5	7	7.5	35	5	10	6	2	9	2		
19/1SFE053	GAUTAM KUMAR		6								8		2	7	6.5	35	1	6	3	5	7	5		
19/1SFE054	GIRDHARI SAHU	2		8		4			8			3		8	2	2	5	0	0	5	4	5		
19/1SFE055	GOVIND KRISHAN TIWARI		5	8		4			10		4		8	9	7	23	4	8	5	2	8	2		
19/1SFE056	GUPTA SURBHI RAJENDRAKUMAR	8		8		7		7			3		7	7	4	27	6	9	6	6	7	6		
19/1SFE057	HARMANJOT SINGH	9			7	7			5		4	4		6	8	46	8	8	7	5	8	5		
19/1SFE058	HARSHIT ARORA	5		5			6			8		3		5	5.5	36	8	7	7	4	6	4		
19/1SFE059	HARSHIT GUPTA		4	5					8		4		4	7	6	23	4	4	5	6	5	6		
19/1SFE060	HARSHITA GARG		9	8		5		6			10		10	6	4	47	5	6	2	4	6	4		
19/1SFE061	HEMANT KULDEEP														8.5	42	8	8	5	10	7	10		
19/1SFE062	HEMANT MAHAWAR		3	4		7		3			5	5				A	0	0	0	0	0	0		
19/1SFE063	HIMANSHU AGARWAL	8		6		3		3			4				10	40	3	4	6	5	7	5		
19/1SFE064	HIMANSHU AGRAWAL												2	7	7	37	7	5	3	3	7	3		
19/1SFE065	HIMANSHU BANSARE	8		10				7			7		3	9	4	A	0	0	0	0	0	0		
19/1SFE066	HIMANSHU SHARMA	10			9	7		3			7		9		8	37	8	9	2	5	8	5		
19/1SFE067	HITESH KUMAR JAIN		4	3			2								7	48	8	8	6	8	4	8		
19/1SFE068	HITESH MORYA		9				9		8	4			1	3	1	46	3	2	2	0	0	0		
19/1SFE069	HRITVIK TRIPATHI		8	8			8	8		6.5			7.5	9		22	9	2	9	3	2	3		
19/1SFE070	INDRARAJ SHARMA		6	6			3.5		5	7		4.5		6	9.5	48	8	8	8	7	9	7		
19/1SFE071	JAGDISH KUMAR SONAL		2	8.5		7.5		7					7	6	6.5	33	6	6	4	6	6	6		
19/1SFE072	JANAK CHOUDHARY	9		7.5		9.5		9			5.5	7.5		7	7	33	3	8	7	4	7	4		
19/1SFE073	JOBIN THOMAS		7	8			3	7			6		9.5	8.5	6.5	48	9	8	9	7	7	7		
19/1SFE182	KAPIL GUPTA		6	8			3	7		4.5		2			8	50	7	8	4	8	8	8		
19/1SFE074	KARAN CHOUDHARY		10	8			8	4			7		5.5	7	10 6.5	42	6	8	4	3	8	3		
19/1SFE075	KARAN SHARMA		8.5	7.5		6		7			2	3		7	8	44	9	7	7	6	8	6		
19/1SFE076	KARISHMA KUMARI		6	7			7	7			2		2.5	2	7.5	30	8	7	6	3	7	3		
19/1SFE077	KARTIKEYA BHATIA		7	8				5		1.5			3		2	41	6	7	7	2	2	2		
19/1SFE078	KESHAV KUMAR		7.5	7.5		7		7		7.5			8.5		6 1	A	7	7	1	2	4	2		
19/1SFE079	KHUSHI RAM MEENA	2		5.5			3	3.5		5.5			2		7.5 3.5	37	7	7	7	8	4	8		
19/1SFE189	KRISHAN KANT SOUNKRIA		2	1						0		0			6 0	19	2	5	3	4	5	4		
19/1SFE080	KRISHNA KUMAR		5.5	8			6		8	2			4.5		2	16	2	1	0	0	0	0		
19/1SFE081	KULWANT SINGH RAJPUROHIT		6.5	5			7		9		4		4.5	6	7.5	32	6	[illegible]	[illegible]	5	5	3		
19/1SFE082	KUMAR HRISHABH														2	41	7	6	8	4	4	4		
19/1SFE083	KUNAL DHAWAN		7.5	7			5	4			4		2	2.5		A	0	3	1	1	1	0		
19/1SFE084	KUNTAL VERMA		6	10			6	5		7			2		5	26	7	6	5	3	3	3		
19/1SFE085	KUSUM MEENA		7	7				6			7	8		2	10 7.5	32	6	9	8	9	9	5		
19/1SFE086	LAKSHYA SWAMI		7	7		5		5			1	5		3	4.5	27	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
19/1SFE087	MAHESH KUMAR	5.5		10		6					6.5	3.5			5	23	7	1	1	1	1	3		
															10 3	29	4	8	2	2	7	5		

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OBT I

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-40 **TIME-I Hr**

1) Compare power MOSFET and BJT.
2) Explain the need of commutation in thyristor circuits. Compare different methods commutation schemes?
3) Asingle phase full converter is connected to an AC supply of 330sin314t volts. If operates at firing angle $\alpha=\pi/4$. The load current is maintained constant at 5A and load voltage is 140V. Calculate:
   (a) Source inductance
   (b) Angle of overlap
   (c) The load resistance
4) A 3 phase 3 pulse converter is connected to RLE load. The source voltage is 3 phase, 230V, 50Hz and load current is 10A. For R=0.5Ω and L=2H, determine
   a)Firing angle for E=134V
   b) Firing angle advance for E = -134V

References:

1.P.S.bimbhra: Power Electronics, Khanna Publication

2.Ned Mohan: Power Electronics, John Wiley

3.Krein P.T: Elements of Power Electronics, Oxford

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OBT II

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-20 **TIME-I Hr**

1) Give a comparison of various power factor improvement techniques in converters.
2) An impulse commutated chopper feeds inductive load requiring a constant current of 260A. The voltage is 220V DC and the chopping frequency is 400Hz. Turn –off time for main thyristor is 18μs. Peak current through main thyristor is limited to 1.8 times the constant load current. Taking aload factor ofsafety 2 for main thyristor, calculate the value of
   a) Commutating components C & L
   b) The minimum and maximum output voltage?

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OBT II

B. Tech III YEAR V SEMESTER

5EE1A POWER ELECTRONICS

MAX. MARKS-20 **TIME-1 Hr**

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Department of Electrical Engineering
Technical Quiz

Subject Name & Code: 5EE01 A	
Name of Faculty:	Rathi Shankar
Name of Student:	
Day & Date:	
Roll No:	

Q.1 The terminals of a power BJT are called

a. emitter, base, collector b. emitter, base, drain

c. source, base, drain d. source, base, collector

Q.2 For a BJT $\alpha = 0.98$, then $\beta =$

a. 0.02 b. 0.5 c. 4.9 d. 49

Q.3 The terminals of a power MOSFET are called

a. emitter, base, collector b. source, gate, drain c. source, base, drain d. emitter, gate, drain

Q.4 In a thyristor the gate current is increased, then

a. anode current will increase

b. anode current will decrease

c. anode current will remain constant

d. anode current may increase or decrease

Q.5 The number of leads in an SCR are

a. 2 b. 3 c. 4 d. 5

Q.6 "Assertion (A): A TRIAC is a bidirectional SCR.

Reason (R): A TRIAC is a four layers 3 terminal device and can conduct in both directions."

a. Both A and R are correct and R is correct explanation of A
b. Both A and R correct but R is not correct explanation of A
c. A is correct but R is wrong
d. A is wrong but R is correct

Q.7 Which of these triggering methods for series connected SCRs use LASCR in the gate circuit?

a. Resistance triggering

b. Simultaneous triggering

c. Sequential triggering

d. Optical triggering

Q.8 A thyristor is reverse biased. A positive gate pulse is applied. The thyristor

a. will be turned on

b. may or may not turn on

c. will not turn on

d. will turn on after sometime

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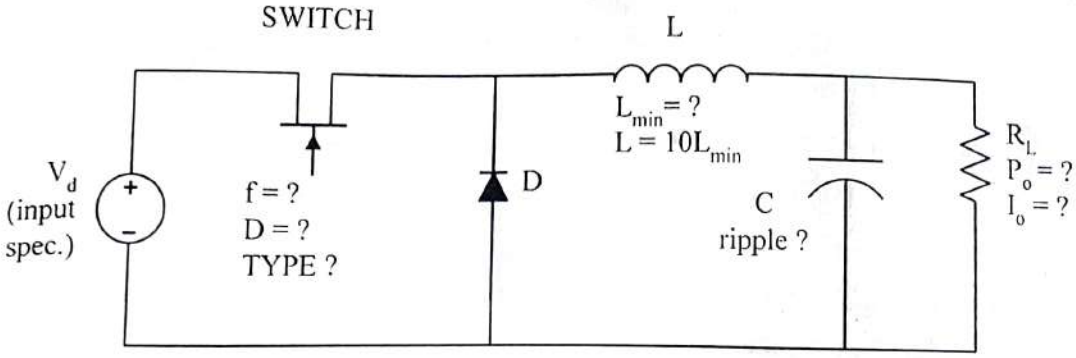
Basic design procedures



Calculate D to obtain required output voltage.

- Select a particular switching frequency (f) and device
  - preferably f>20KHz for negligible acoustic noise
  - higher fs results in smaller L and C. But results in higher losses. Reduced efficiency, larger heat sink.
  - Possible devices: MOSFET, IGBT and BJT. Low power MOSFET can reach MHz range.
- Calculate L_{min}. Choose L>>10 L_{min}
- Calculate C for ripple factor requirement.
  - Capacitor ratings:
    - must withstand peak output voltage
    - must carry required RMS current. Note RMS current for triangular w/f is $I_p/3$, where I_p is the peak capacitor current given by $\Delta i_L/2$.
    - ECAPs can be used

- Wire size consideration:
  - Normally rated in RMS. But i_L is known as peak. RMS value for i_L is given as:

$$I_{L,RMS} = \sqrt{I_L^{\,2} + \left(\frac{\Delta i_L/2}{\sqrt{3}}\right)^2}$$

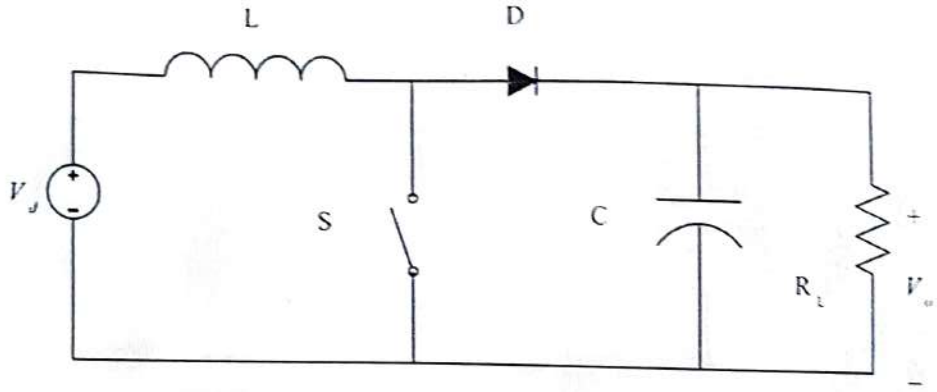
Examples

- A buck converter is supplied from a 50V battery source. Given L=400uH, C=100uF, R=20 Ohm, f=20KHz and D=0.4. Calculate: (a) output voltage (b) maximum and minimum inductor current, (c) output voltage ripple.

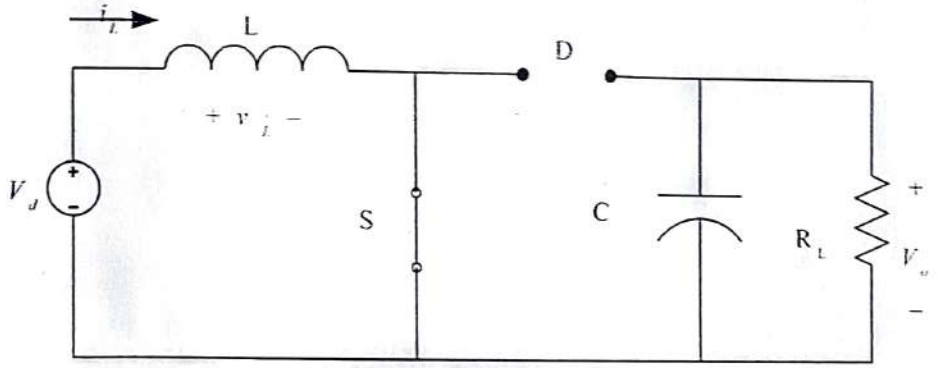
- A buck converter has an input voltage of 50V and output of 25V. The switching frequency is 10KHz. The power output is 125W. (a) Determine the duty cycle, (b) value of L to limit the peak inductor current to 6.25A, (c) value of capacitance to limit the output voltage ripple factor to 0.5%.

- Design a buck converter such that the output voltage is 28V when the input is 48V. The load is 8Ohm. Design the converter such that it will be in continuous current mode. The output voltage ripple must not be more than 0.5%. Specify the frequency and the values of each component. Suggest the power switch also.

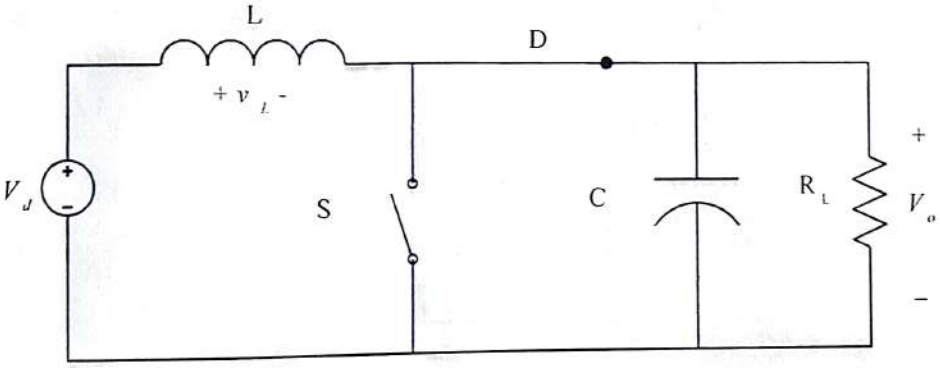
Boost (step-up) converter



CIRCUIT OF BOOST CONVERTER

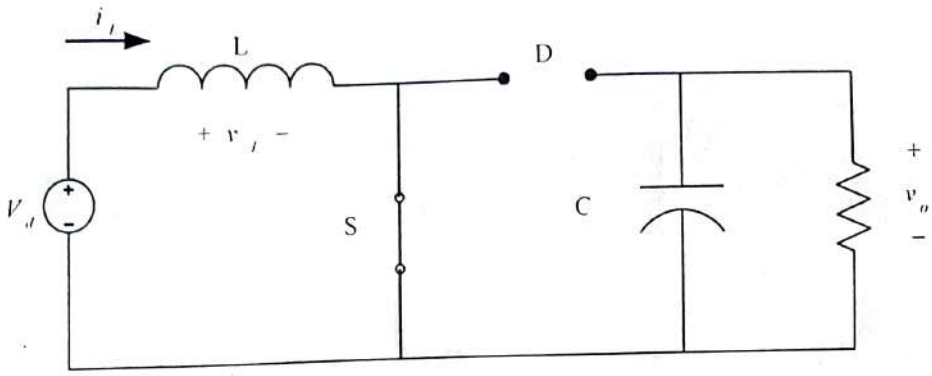


CIRCUIT WHEN SWITCH IS CLOSED



CIRCUIT WHEN SWITCH IS OPENED

Boost analysis:switch closed



$$v_L = V_d$$

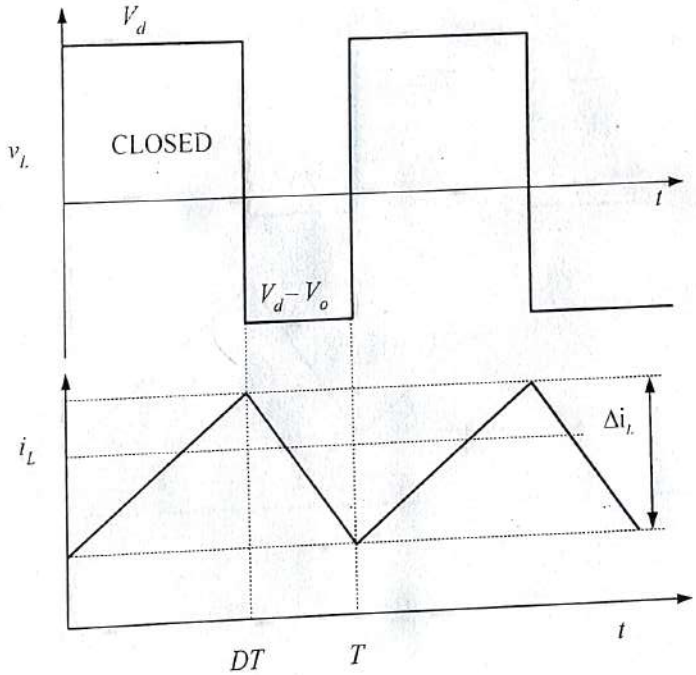
$$= L\frac{di_L}{dt}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_d}{L}$$

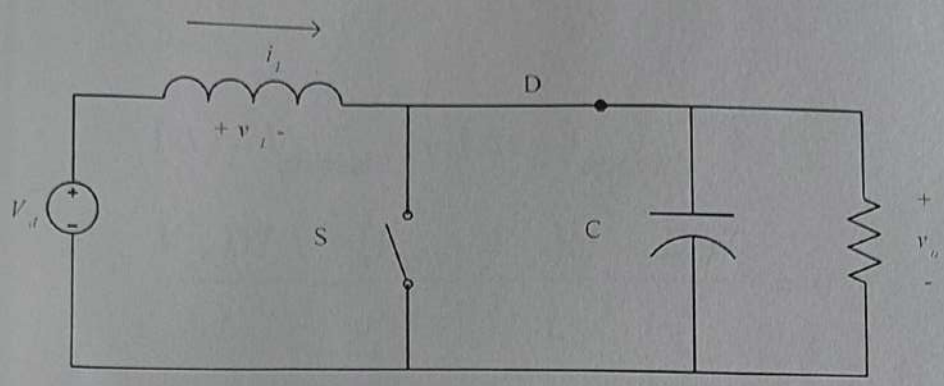
$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_d}{L}$$

$$(\Delta i_L)_{closed} = \frac{V_d DT}{L}$$



Switch opened



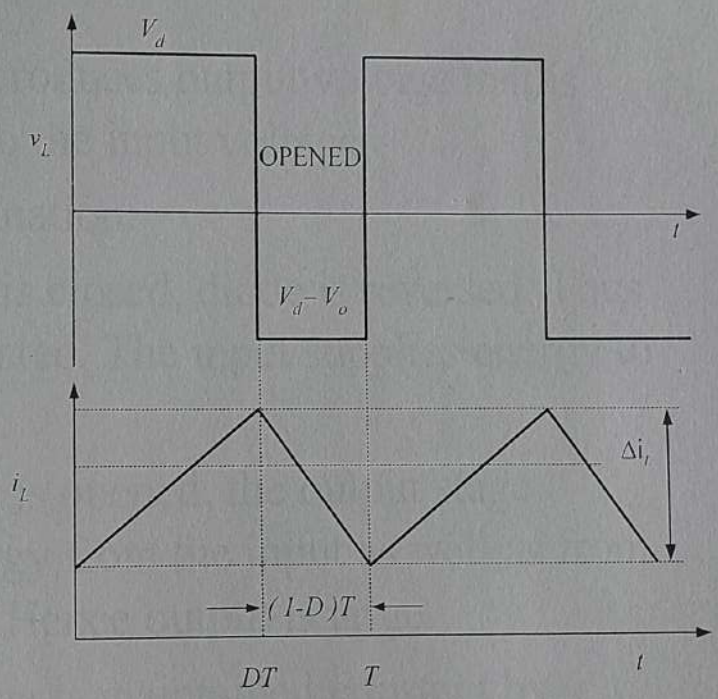
$$v_L = V_d - V_o$$

$$= L\frac{di_L}{dt}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_d - V_o}{L}$$

$$\frac{di_L}{dt} = \frac{\Delta i_L}{\Delta t}$$

$$= \frac{\Delta i_L}{(1-D)T}$$



$$\Rightarrow \frac{di_L}{dt} = \frac{V_d - V_o}{L}$$

$$\Rightarrow (\Delta i_L)_{opened} = \frac{(V_d - V_o)(1 - DT)}{L}$$

Steady-state operation

$$(\Delta i_L)_{closed} + (\Delta i_L)_{opened} = 0$$

$$\frac{V_d DT}{L} + \frac{(V_d - V_o)(1 - D)T}{L} = 0$$

$$\Rightarrow V_o = \frac{V_d}{1 - D}$$

- Boost converter produces output voltage that is greater or equal to the input voltage.
- Alternative explanation:
  - when switch is closed, diode is reversed. Thus output is isolated. The input supplies energy to inductor.
  - When switch is opened, the output stage receives energy from the input as well as from the inductor. Hence output is large.
  - Output voltage is maintained constant by virtue of large C.

Average, Maximum, Minimum Inductor Current

Input power = Output power

$$V_d I_d = \frac{V_o^2}{R}$$

$$V_d I_L = \frac{\left(\frac{V_d}{(1-D)}\right)^2}{R} = \frac{V_d^2}{(1-D)^2 R}$$

Average inductor current :

$$\Rightarrow I_L = \frac{V_d}{(1-D)^2 R}$$

Maximum inductor current :

$$\Rightarrow I_{max} = I_L + \frac{\Delta i_L}{2} = \frac{V_d}{(1-D)^2 R} + \frac{V_d DT}{2L}$$

Minimum inductor current :

$$\Rightarrow I_{min} = I_L - \frac{\Delta i_L}{2} = \frac{V_d}{(1-D)^2 R} - \frac{V_d DT}{2L}$$

L and C values

For CCM,

$$I_{min} \geq 0$$

$$\frac{V_d}{(1-D)^2 R} - \frac{V_d DT}{2L} \geq 0$$

$$L_{min} = \frac{D(1-D)^2 TR}{2}$$

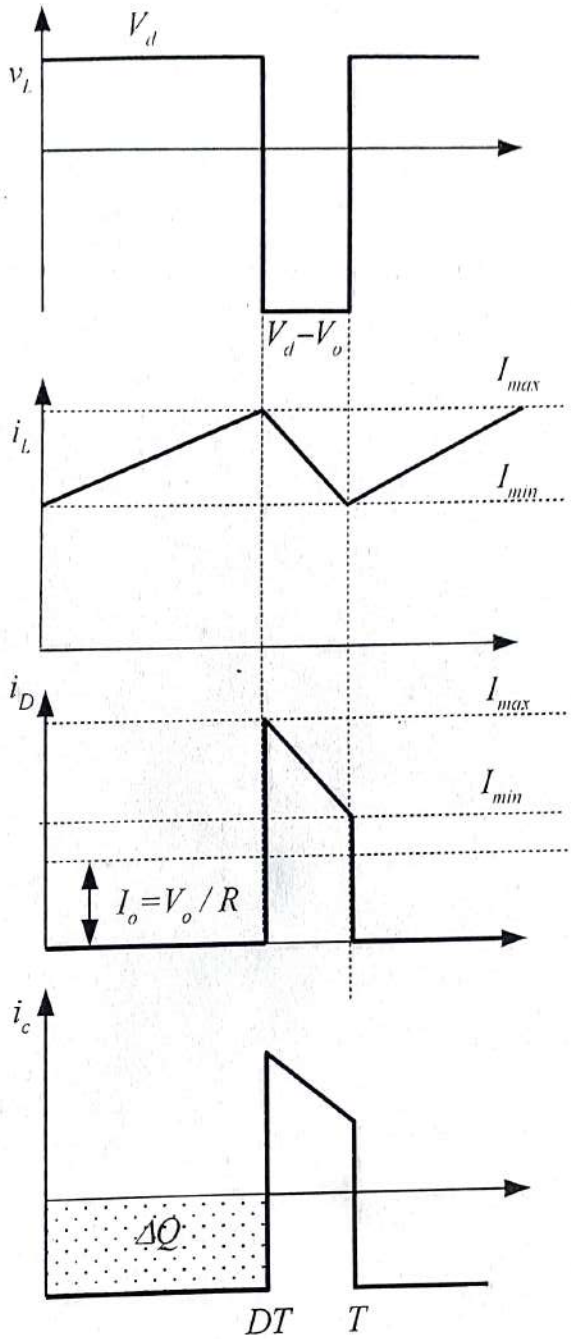
$$= \frac{D(1-D)^2 R}{2f}$$

Ripple factor

$$|\Delta Q| = \left(\frac{V_o}{R}\right) DT = C \Delta V_o$$

$$\Delta V_o = \frac{V_o DT}{RCf} = \frac{V_o D}{RCf}$$

$$r = \frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

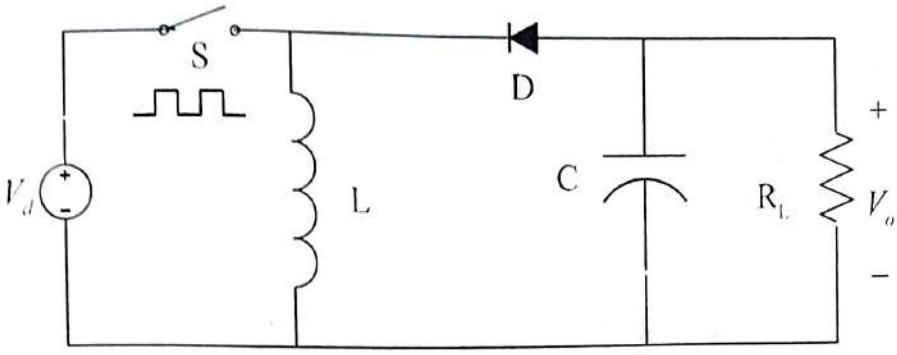


Examples

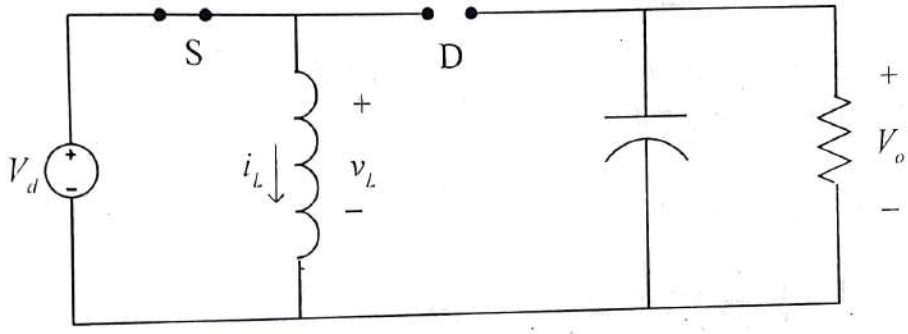
- The boost converter has the following parameters: V_d=20V, D=0.6, R=12.5ohm, L=65uH, C=200uF, f_s=40KHz. Determine (a) output voltage, (b) average, maximum and minimum inductor current, (c) output voltage ripple.

- Design a boost converter to provide an output voltage of 36V from a 24V source. The load is 50W. The voltage ripple factor must be less than 0.5%. Specify the duty cycle ratio, switching frequency, inductor and capacitor size, and power device.

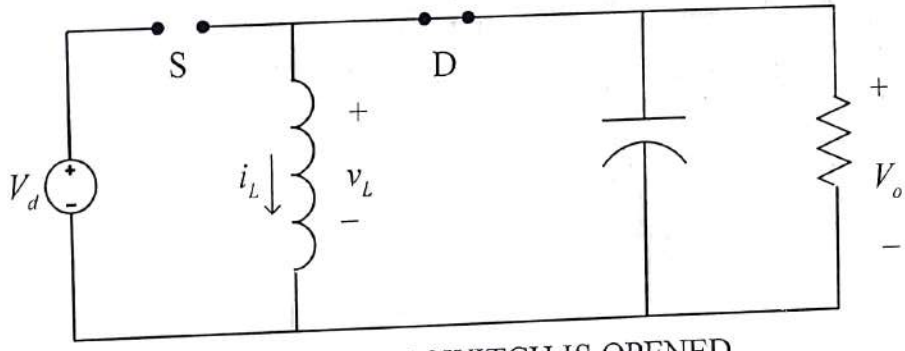
Buck-Boost converter



CIRCUIT OF BUCK-BOOST CONVERTER



CIRCUIT WHEN SWITCH IS CLOSED



CIRCUIT WHEN SWITCH IS OPENED

Buck-boost analysis

Switch closed

$$v_L = Vd = L\frac{di_L}{dt}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_d}{L}$$

$$\frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{DT} = \frac{V_d}{L}$$

$$\Rightarrow (\Delta i_L)_{closed} = \frac{V_d DT}{L}$$

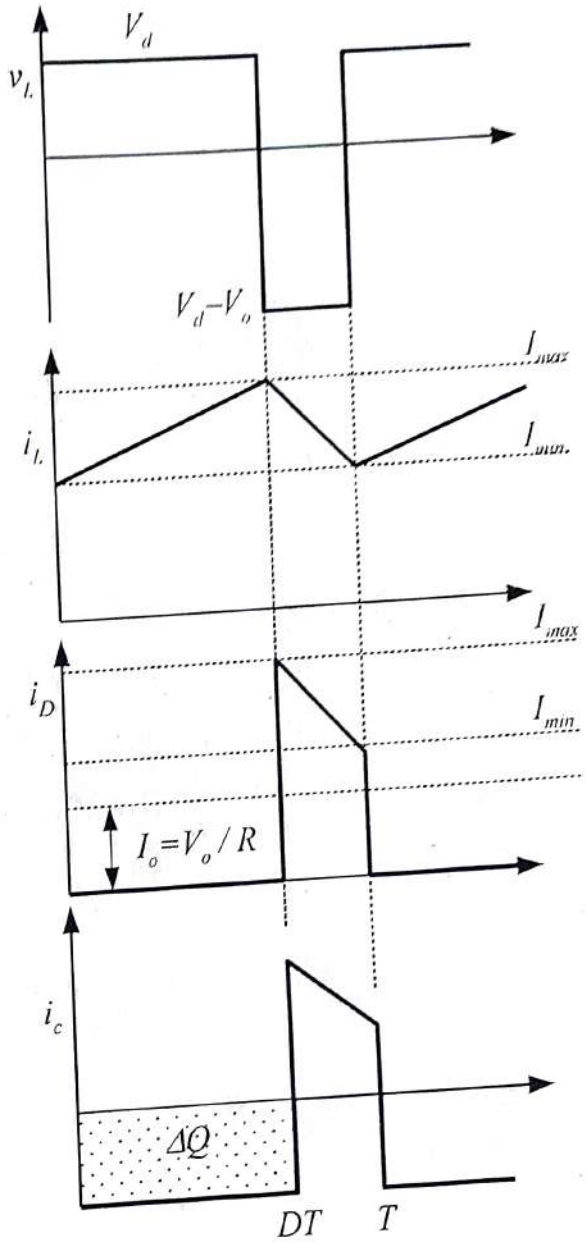
Switch opened

$$v_L = V_o = L\frac{di_L}{dt}$$

$$\Rightarrow \frac{di_L}{dt} = \frac{V_o}{L}$$

$$\frac{\Delta i_L}{\Delta t} = \frac{\Delta i_L}{(1-D)T} = \frac{V_o}{L}$$

$$\Rightarrow (\Delta i_L)_{opened} = \frac{V_o(1-D)T}{L}$$



Output voltage

Steady state operation :

$$\Delta_{iL(closed)} + \Delta_{iL(opened)} = 0$$

$$\Rightarrow \frac{V_d DT}{L} + \frac{V_o(1-D)T}{L} = 0$$

Output vol tage :

$$\Rightarrow V_o = -V_s\left(\frac{D}{1-D}\right)$$

- NOTE: Output of a buck-boost converter either be higher or lower than input.
  - If D>0.5, output is higher than input
  - If D<0.5, output is lower input

- Output voltage is always negative.

- Note that output is never directly connected to load.

- Energy is stored in inductor when switch is closed and transferred to load when switch is opened.

Average inductor current

Assuming no power loss in the converter, power absorbed by the load must equal power supplied the by source, i.e.

$$P_o = P_s$$

$$\frac{V_o^2}{R} = V_d I_s$$

But average source current is related to average inductor current as :

$$I_s = I_L D$$

$$\Rightarrow \frac{V_o^2}{R} = V_d I_L D$$

Substituti ng for V_o,

$$\Rightarrow I_L = \frac{V_o^2}{V_d RD} = \frac{P_o}{V_d D} = \frac{V_d D}{R(1-D)^2}$$

L and C values

Max and min inductor current,

$$\Rightarrow I_{max} = I_L + \frac{\Delta i_L}{2} = \frac{V_d D}{R(1-D)^2} + \frac{V_d DT}{2L}$$

$$\Rightarrow I_{min} = I_L - \frac{\Delta i_L}{2} = \frac{V_d D}{R(1-D)^2} - \frac{V_d DT}{2L}$$

For CCM

$$\frac{V_d D}{R(1-D)^2} + \frac{V_d DT}{2L} = 0$$

$$\Rightarrow L_{min} = \frac{(1-D)^2 R}{2f}$$

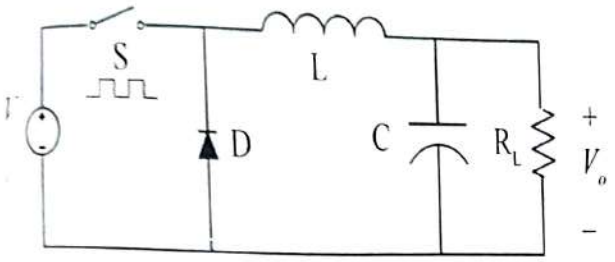
Output vol tage ripple,

$$|\Delta Q| = \left(\frac{V_o}{R}\right) DT = C \Delta V_o$$

$$\Delta V_o = \frac{V_o DT}{RC} = \frac{V_o D}{RCf}$$

$$r = \frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

Converters in CCM: Summary

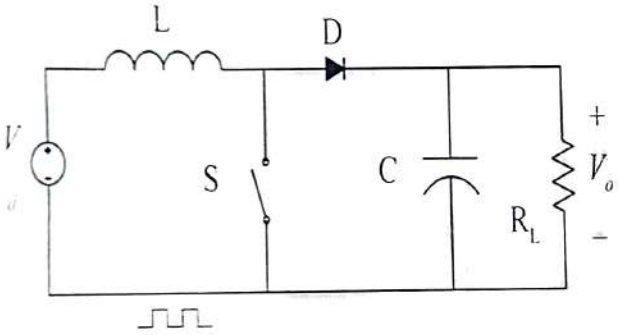


Buck

$$\frac{V_o}{V_d} = D$$

$$\frac{\Delta V_o}{V_o} = \frac{1-D}{8LCf^2}$$

$$L_{min} = \frac{(1-D)R}{2f}$$

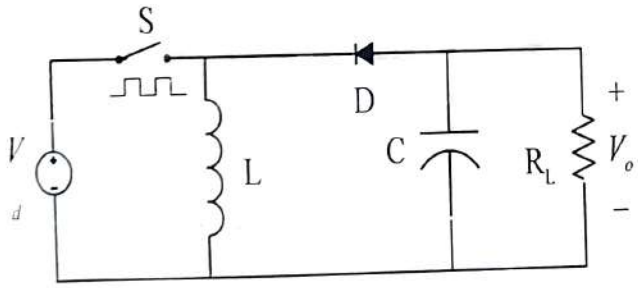


Boost

$$\frac{V_o}{V_d} = \frac{1}{1-D}$$

$$\frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

$$L_{min} = \frac{D(1-D)^2 R}{2f}$$



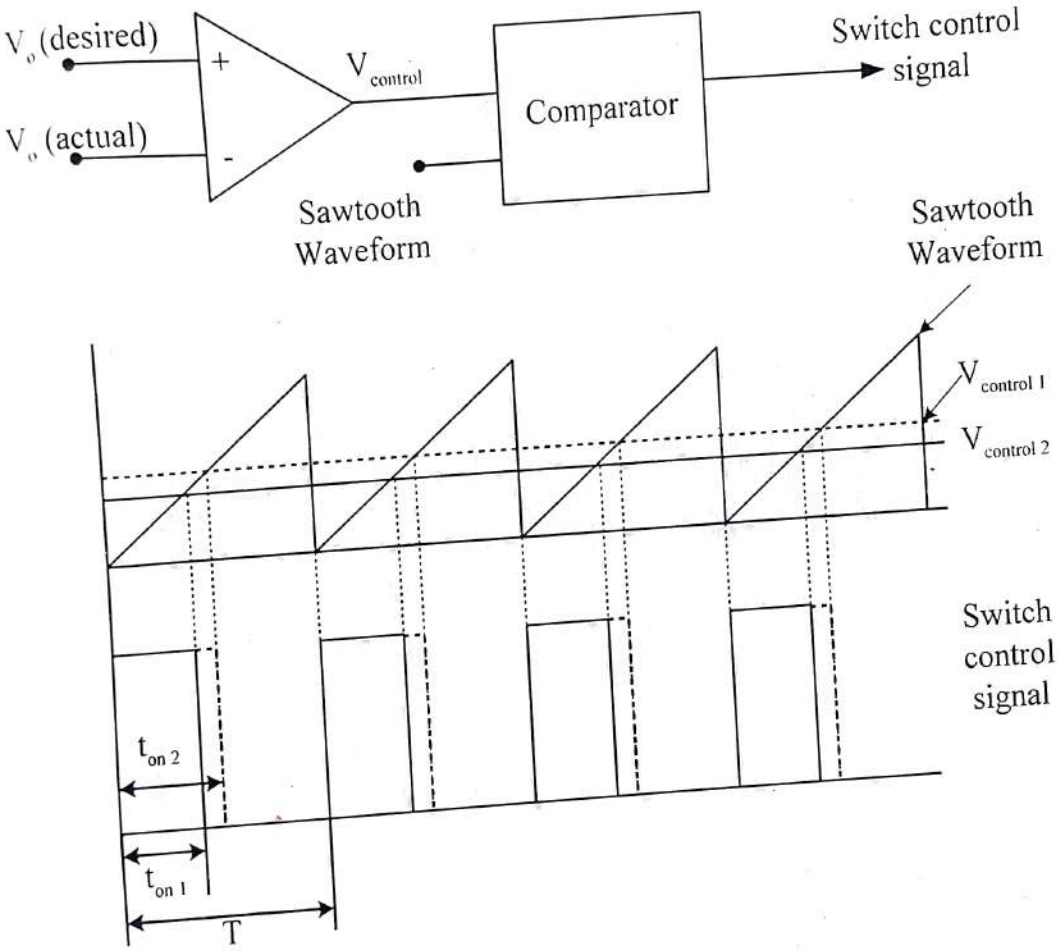
Buck – Boost

$$\frac{V_o}{V_d} = -\frac{D}{1-D}$$

$$\frac{\Delta V_o}{V_o} = \frac{D}{RCf}$$

$$L_{min} = \frac{(1-D)^2 R}{2f}$$

Control of DC-DC converter: pulse width modulation (PWM)



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AASHOJ SAINI .	7									
ABHISHEK CHAUDHARY .	6									
ABHISHEK CHAUDHARY .	9									
ABHISHEK JAIN .	0									
ABHISHEK KUMAR .	0									
ABHISHEK PANDEY .	0									
ABHISHEK PRAJAPAT .	? 10									
ABHISHEK SINGH .	0									
ABHISHEK SINGH RAO .	0									
ADITYA GAURAV .	6									
ADITYA SINGH .	0									
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(1)

Where i= any +ve number 1,2,3…n pixel of image

a_i= pixel value of secret image.

b_i= pixel value of securing image.

a'_i= pixel value of key image.

b'_i= pixel value of key image.

For reforming the secret image same operations perform on other end. Apply this for all pixel values.

II.A Deformation side:

At the sender end we take any image which we want to provide security (secret image) and other image that use as a securing image through which we provide the security in fallowing method. In this method we are simple exchange the pixel value of one secret image into another image. This is done very efficiently and takes less amount of time. From this method we generate a two share of image. This share known as a key image. Through which we can reconstructs the original image.

$$a_1 = a_1 + b_1 .$$

$$b'_1 = a_1 - b_1.$$

$$a'_1 = a_1 - b'_1.$$

Put the value of a'_1 and b'_1 in new image for forming the key image.These key image is transmitted over a network and received by the receiver.

II.B Formation side:

When the receiver receives these key image then same method are used for reconstructing the original secret image. At receiver end these method work efficiently and take less amount of time for reconstructing the original image.

By using any these key images we can retrieve secret image.

$$a'_1 = a'_1 + b'_1$$

$$b_1 = a'_1 - b'_1$$

$$a_1 = a'_1 - b_1$$

Find out the values of a_1 andb_1 which are the pixel values of secret image and the securing image.

III. Proposed Algorithms:

III.A Deformation Algorithm:

Step1: Choose secret and securing image for generating key Image.

Step2: Select i^{th}pixels from secret image and securing images and calculate the key images value using eq. (1).

Step3: All value stored in key image in pixel values.

Step4: Apply step 2nd and 3rd for each and every pixel value.

III.B Formation Algorithm:

Step1: Select all key images.

Step2: Retrieve the jth pixel values of key image and calculate the original pixel value using same formula as given by eq (1).

Step3: All value stored in key image in pixel values.

Step4: Apply step 2nd and 3rd for each and every pixel value.

Step5: Combine the entire pixel secret image formed.

IV. Experimental Results:

Successfully we have received some experimental results which are mentioned here:

*Fig. (1)*is the secret image, *Fig. (2)*are the securing images, *Fig. (3) and (4)* is the key image and *Fig (5)* is the retrieved image using and key image by above algorithms.

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ANKIT .										
ANKIT KUMAR JANGID .										
ANOOP DADHICH .										
ANSHUMAN .										
ANUJ KUMAR MEENA .										
ARUN SINGHAL .										
ASHUTOSH KUMAR GUPTA .										
AWANISH MISHRA .	8									
BABU LAL SHARMA .										
BANTI SAINI .	7									
BRAJDAS MEENA .										
CHETAN NAWARIA .										
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CHINMAY JAIN .	8									
DEEPESH GUPTA .										
DHRUTI PATEL .										
DINESH KUMAR MEENA .										
EKAGRAVEER MEHTA .										
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GAURAV SAINI .	8									

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A Secret Sharing Scheme for Image

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Abstract—

Secret sharing is a very secure and efficient way through which we transmit a color image from one user to another user over a network. In this paper we give a method to generate a secret through a image. Based on secure image schemes, an effective and generalized scheme of color image hiding is proposed by means of numerical computations, we generate the secret image by using deformation(d) and formation(f) algorithms. It has been shown through the experimental result that the proposed scheme transmits the image secretly and then efficiently recovers the same image at receiver site. In this paper we are going to present a new scheme for securing color images by hackers and intruders. It is a matrix computation scheme which uses a concept of secret sharing . This paper proves that proposed scheme is more efficient and secure in terms of secret sharing

Keywords: Security, Image, Secret Sharing, key Safeguarding.

I. Introduction:

In this computer era security require more attention there are several techniques used for data security like key safeguarding, encryption and other cryptography techniques. For security purposes text data converted into image so, there must be more concerned about security. Since text can be decoded and recognized by the system using brute force attack, but an image cannot be easily decoded and recognized by the any system. Image recognition is a very difficult task for any system.

Key safeguarding is a basic technique for data and image security but it can be broken easily by the brute force attack and another draw back of this technique that if key is lost then data cannot be recovered.

The secret sharing scheme is one of the solutions for the solid protection of secret information and its secure presentation. So we use secret image sharing technique for generating secret by forming the shares and secret image is reformed by these shares. We can send data converting it into an image. This means strong content level security.

This method introduces by the AdiShamir [1] and he was able to transmit a secure data over the network form one end to other. Harn and Lin [2] have given a technique for secret sharing scheme to solve the secret regeneration problem by extending the lifespan of the shadows. Blundo. Santis and Naor[4] have proposed a Scheme for gray level images. Thein and Lin[5] have described a numerical processing based approach to share a protected image secretly where an image is permuted into random image and then shared images are generated using secret sharing. In the paper of the blakley[3] cryptographic approach takes lots of time for generating the Share of the Image at the sender end and also take the lots of time for reconstructing the original image form the share at the receiver end. It means that we can say it consumes lots of time for encoding and decoding the image.

The fallowing paper and proposed scheme remove such type of problem. Paper consists following sections are arranged: The 2nd section proposed scheme, 3rd section describes the deformation and formation algorithms, 4th section describes the experimental results, 5th section describes the conclusion and 6th section references.

II. Proposed scheme:

Here in this paper we proposed a new security scheme for color images which is based on secret image sharing. Here we have taken an idea from matrix calculation for generating the key image(share of key image) using the secret colorimage and securing images and reforming the secret color image using the share of key image.

Suppose we have to secure an image which should retrieved by share of key images. This is done by one pixels value of secret image(suppose a_i value) and *one* pixels value of securing images(suppose b_j value) by equation given below we exchange the pixel value of secret image and securing image and new value put in key image.

$$a_i = a_i + b_i$$

$$b'_j = a_i - b_i$$

$$a'_j = a_i - b$$

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GOLU KUMAR RAI	10									
GOURANK NUWAL										
GOURAV AGRAWAL										
HANSU BAGORIYA	7									
HARDIK AGRAWAL	10									
HARSHAL CHOUDHARY	10									
HARSHIT KUMAR BAINI	10									
HARSHIT SHRIVASTAVA	0									
HARSHIT SRICHANDANI										
HEMANT PANWAR	0									
HEMANT VERMA										
HIMANI	10									
HIMANSHU BHARTI										
RAHUL YADAV	10									
RAJNISH PUSHKARNA	10									
RAMJEET BAIRWA	10									
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RISHAV KUMAR DUBEY	10									
ROHAN SHARMA	10									
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SACHIN KUMAR YADAV	10									

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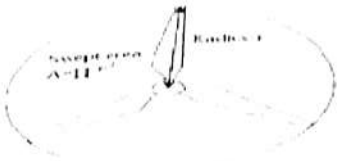


Fig:-6

R= radius of turbine and

T= time taken for one complete oscillation of wind turbine rotor blade

Air density correlation

It is a function of both air pressure and temperature. When air pressure increases ? increases and when air temperature decreases ? increases. This in accordance with equation of the state

R=Gas constant

Both temp and pressure decreases with increasing elevation. Hence site location is important in air density factor.

Following relation shows air density:

H_m= Site elevation in meter

Power coefficient analysis

The coefficient of power the most important parameter of power regulation from wind. As total power available in the wind are not converted as the electrical power, so it is defined as the ratio of total energy produced to the energy available in the wind. It is a non-linear function whose value is unique to each turbine type and wind speed in operation.The Cp is the fraction of upstream wind power captured by rotor. It has a maximum value of 0.59 when the V_o/V is 1/3. However the maximum achievable is 0.45 for high speed two blade turbine and 0.2-0.4 for slow speed turbine with more blades. It is the function of major as TSR and pitch angle of the blade is:

Where, c1=0.5, c2=116/λ, c3=0.4, c4=0, c5=5, c6=21/λ where the values of the coefficients C1 to C6 and x depend on turbine type, where β is defined as the angle between the plane of rotation and the blade cross section chord. For particular turbine types c1=0.5, c2=116/λ, c3=0.4, c4=0, c5=5, c6=21/λ

The following empirical relation has been suggested for coefficient of power by Anderson and Bose.

$$?\,?\,(?,?) = 1/2(? - 0.022\beta - 5.6)?^{?\,?\,?\,?}$$

Where β is the pitch angle and ? is the tip speed ratio of the turbine

the average of the velocities at the entry and rotor blades of turbine.

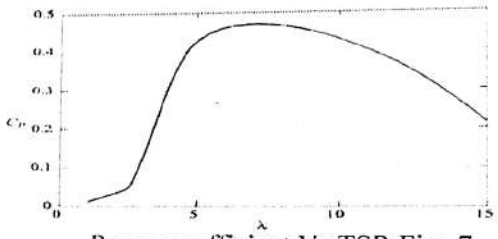
IV. PERFORMANCE CHARACTERISTIC OF WIND GENRATION

The output power or torque of the wind turbine is determined by several factor such as turbine speed, Solidity, Rotor blade tilt, Rotor blade pitch angle, Size and shape of turbine, Area of turbine, Rotor geometry and a Wind speed. With it also mainly depend on Power, Torque and thrust. Which vary with wind speed. Usually convenient to express through non-dimensional characteristic performance curve which determines the actual performance despite of how turbine operates. The characteristic of Power, torque and thrust W.R.T tip speed ratio has been shown.

- The Cp – ? performance curve
- The effect of solidity on performance
- The Cq – ? curve
- The Ct – ? curve

✓ **The Cp – ? performance curve**

Power coefficient changes with the change in the tip speed ratio and the pitch angle of the blade. The maximum limit according to Betz is 59% for maximum TSR.



Power coefficient Vs TSR Fig:-7

Performance curve for modern three blade turbine

✓ **The effect of solidity on performance**

Solidity defined as the total blade area by the area swept by the rotor. Solidity changes with blade chord as well as change in no of blade. The main effect with change of blade and solidity are as: (Fig:-8)

✓ **The Cq – ? curve**

The maximum value of Cq ? curve is increased the torque when the rotor is connected to a gearbox and a generator.

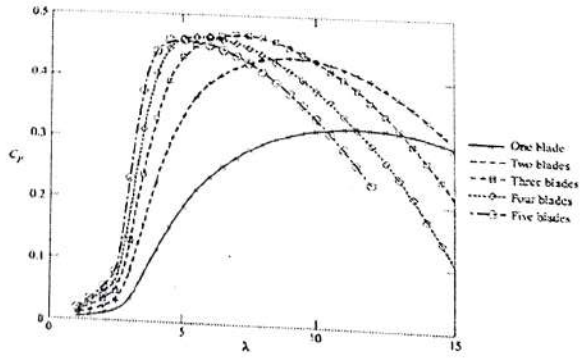


Fig: 8 Effect of change of solidity

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SAJID ANWAR	6	6	6	6	6					
SANJAY SAINI	8	8	9	9	8					
SAURABH KESHRI	10	10	10	9	10					
SAURABH SHARMA	9	9	10	8	8					
SAURAV KUMAR DAS	10	10	9	8	8					
SHAMANK VAGORIA	7	7	8	7	7					
SHEKHAR SHRINGI	8	8	7	7	7					
SHINU KUNDU	10	10	10	9	9					
SHIV PRASAD NAGAR	7	7	8	7	7					
SHIVANSHU RATNAKAR	7	7	8	7	8					
SHOBHRAJ KHICHI	10	10	10	9	9					
SHUBHAM KUDESHIYA	7	7	7	8	7					
SHUBHAM KUMAR	10	10	9	8	8					
SHUBHAM MALAV	8	8	7	7	7					
SHUBHAM SHARMA	9	8	10	9	8					
SHUBHAM SHRINGI	10	9	8	8	8					
SHUBHAM YADAV	9	9	7	7	8					
SHYAM MOHAN JANGID	10	10	9	9	9					
SIDDHANT MISHRA	6	6	5	5	7					
SIDDHARTH BASWAL	8	8	9	9	9					
SIMRAN MANDIA	9	8	8	9	9					
SONU KUSHWAH	7	7	7	6	6					
SRISHTI BANSAL	10	10	10	9	9					

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(b) Hospitality	
(c) Technical / Domain Knowledge of Students	
(d)Personality Traits of Students	
(e) Communication & Presentation of Students	
2. Suggestions (Kindly Comment)	
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(b) Area of Improvement	
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(d) Any Other Suggestions	

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SWETA KUMARI .	10	10	10	8	8					
TANUJ VYAS .	7	7	8	7	8					
TARUN SHARMA .	9	8	8	7	8					
UDDESHYA KUMAR .	9	8	8	8	8					
UTSAV MAHARISHI .	7	7	7	8	8					
UTTAM KUMAR .	10	10	10	9	9					
VAIBHAV TIWARI .	7	7	6	6	7					
VARSHA SHARMA .	10	10	10	9	9					
VIKASH KUMAR .	7	7	6	6	6					
VIKASH KUMAR PANDEY .	7	7	7	5	6					
VIKRAM KUMAR YADAV .	9	9	10	8	8					
VIKRAM SAINI .	10	10	10	9	9					
VIPIN GAUTAM .	8	8	7	8	7					
VISHNU VIJAY .	10	10	10	9	9					
VIVEK SHARMA .	10	9	10	8	9					
YATHARTH JOIYA .	6	6	5	5	5					
YOGITA SUTHAR .	7	7	7	6	6					
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SAJID ANWAR	Ab		SRISHTI BANSAL					
SANJAY SAINI			SURYA PRAKASH MEENA					
SAURABH KESHRI			SWETA KUMARI					
SAURABH SHARMA			TANUJ VYAS					
SAURAV KUMAR DAS			TARUN SHARMA					
SHAMANK VAGORIA			UDDESHYA KUMAR					
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SHUBHAM KUMAR			VIKRAM KUMAR YADAV					
SHUBHAM MADAV			VIKRAM SAINI					
SHUBHAM SHARMA			VIPIN GAUTAM					
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