Department of Electrical & Electronics Engineering

Course File

POWER ELECTRONIC CONVERTERS

(Course Code: GR20D5026)

I M.Tech I Semester

2021-22

Dr. Suresh Kumar Tummala
Professor

Gokaraju Rangaraju Institute of Engineering & Technology
(Autonomous)
Bachupally, Kukatpally, Hyderabad – 500 090, A.P., India.

POWER ELECTRONIC CONVERTERS

Check List

POWER ELECTRONIC CONVERTERS

Course Code: GR20D5026 **L/T/P/C: 3/0/0/3**
I Year I Semester

Course Objectives:

1. To understand the characteristics and principle of operation of different power electronic devices.
2. To articulate the working of different converters
3. To apply the different PWM and SVM control techniques
4. To elaborate the working of matrix converters with the switching control strategy
5. To demonstrate the feedback control strategy for different converters

Course Outcomes:

Upon the completion of the course the student will be able to

1. Discuss the advances in power electronic devices.
2. Design & analyze the different converter topologies with their applications.
3. Articulate & apply the different modulation techniques.
4. Design & analyze the different matrix converters.
5. Apply the dynamic modeling, control and analysis of different converters.

UNIT I

MODERN POWER SEMICONDUCTOR DEVICES: Modern power semiconductor devices-MOS turn Off Thyristor (MTO)-Emitter Turn off Thyristor (ETO)-Integrated Gate-Commutated thyristor (IGCTs)-MOS-controlled Thyristors (MCTs)-Insulated Gate Bipolar Transistor (IGBT)-MOSFET-comparison of their features.

UNIT-II

D.C. TO D.C. CONVERTERS: Analysis of step-down and step-up dc to dc converters with resistive and Resistive, inductive loads-Switched mode regulators -Analysis of Buck Regulators-Boost regulators- buck and boost regulators-Cuk regulators-Condition for Continuous inductor current and capacitor voltage-comparison of regulators-Multi-output boost converters-Advantages-Applications.

UNIT III

PWM TECHNIQUES: single PWM-Multiple PWM-sinusoidal PWM-modified PWM-phase displacement Control-Advanced modulation techniques for improved performance-Trapezoidal, staircase, stepped, harmonic injection and delta modulations-Advantage-application. Third Harmonic PWM-60-degree PWM-space vector modulation-Comparison of PWM techniques-harmonic reductions.

UNIT IV

MATRIX CONVERTER: principle-matrix converter switches - 3phase matrix converter-switching control strategy-Venturini control method-principle-switching duty cycles-modulation matrix-realization of input filter-commutation and protection issues in matrix converter

UNIT V

CONVERTER DYNAMICS / SIMULATIONS: Feedback control for converters: regulation and control problem, control principles, model for feedback, P and PI control. Nonlinear dynamic modeling, Control and analysis of choppers, voltage mode and current mode control. Simulation: process, mechanics, techniques, PSPICE simulator. EMI and Power Quality Problems. Power conditioning. PLL/Micro computer based converters and choppers.

TEXT BOOKS:

1 Power Electronics – Mohammed H. Rashid – Pearson Education Third Edition – First Indian reprint 2004.
2 Power Electronics – Ned Mohan, Tore M. Undeland and William P. Robbins – John Wiley and Sons – Second Edition.
3 Modern Power Electronics and AC Drives PHI- Bimal K Bose,
4 Elements of Power Electronics- P. T. Krein
5 Power Electronics, Advanced Conversion Technologies, CRC Press-Fang Lin Luo & Hong Ye.
6 Power Electronics, Converters and Regulators, Springer-Branko L Dokic & Branko Blanusa,

REFERENCE BOOKS:

1 Power Electronics – Daniel W. Hart, McGraw Hill Publications.
2 Power Electronics Devices, Circuits and Industrial applications, V. R. Moorthi, Oxford University Press
3 Power Electronics, Dr. P. S. Bimbhra, Khanna Pubishers.
4 Elements of Power Electronics, Philip T. Krein, Oxford University Press.
5 Power Electronics, M. S. Jamil Asghar, PHI Private Limited.
6 Principles of Power Electronics, John G. Kassakian, Martin F. Schlect, Geroge C. Verghese, Pearson Education.
7 Fundamentals of Power Electronics, Robert W. Erickson, Dragan and Maksimobic, Springer.
8 Principles and Elements of Power Electronics-Barry Williams, University of Strathclyde.
9 Power Converter Circuits, Marcel Dekker Inc- William Shepherd & Li Zhang.
10 Introduction to Modern Power Electronics-A.M. Trzynadlowski, Wiley, 2010.

Timetable

I M.Tech. PEC – I Semester

Day/Hour	9-10	10-11	11-12	12-1	1-2	2-3	3-4
Monday	PEC			**BREAK**			
Tuesday							
Wednesday		PEC					
Thursday							
Friday							
Saturday							

Vision of the Institute

To be among the best of the institutions for engineers and technologists with attitudes, skills and knowledge and to become an epicenter of creative solutions.

Mission of the Institute

To achieve and impart quality education with an emphasis on practical skills and social relevance.

Vision of the Department

To impart technical knowledge and skills required to succeed in life, career and help society to achieve self sufficiency.

Mission of the Department

- To become an internationally leading department for higher learning.
- To build upon the culture and values of universal science and contemporary education.
- To be a center of research and education generating knowledge and technologies which lay groundwork in shaping the future in the fields of electrical and electronics engineering.
- To develop partnership with industrial, R&D and government agencies and actively participate in conferences, technical and community activities.

Program Educational Objectives (M.Tech. – EEE / Power Electronics)

Postgraduates will be able to

PEO 1: Have a successful technical or professional career, including supportive and leadership roles on multidisciplinary teams.

PEO 2: Acquire, use and develop skills as required for effective professional practices.

PEO 3: Able to attain holistic education that is an essential prerequisite for being a responsible member of society.

PEO 4: Engage in life-long learning, to remain abreast in their profession and be leaders in our technologically vibrant society.

Program Outcomes (M.Tech. – EEE / Power Electronics)

At the end of the Program, a post-graduate will have the ability to

PO 1: Apply knowledge of mathematics, science, and engineering.

PO 2: Design and conduct experiments, as well as to analyze and interpret data.

PO 3: Design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

PO 4: Function on multi-disciplinary teams.

PO 5: Identify, formulates, and solves engineering problems.

PO 6: Understanding of professional and ethical responsibility.

PO 7: Communicate effectively.

PO 8: Broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.

PO 9: Recognition of the need for, and an ability to engage in life-long learning.

PO 10: Knowledge of contemporary issues.

PO 11: Utilize experimental, statistical and computational methods and tools necessary for engineering practice.

PO 12: Demonstrate an ability to design electrical and electronic circuits, power electronics, power systems; electrical machines analyze and interpret data and also an ability to design digital and analog systems and programming them.

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

COURSE OBJECTIVES

On completion of this Subject/Course the student shall be able to:

S.No	Objectives
1	To understand the characteristics and principle of operation of different power electronic devices
2	To articulate the working of different converters
3	To apply the different PWM and SVM control techniques
4	To elaborate the working of matrix converters with the switching control strategy
5	To demonstrate the feedback control strategy for different converters

COURSE OUTCOMES

The expected outcomes of the Course/Subject are:

S.No	Outcomes
1.	Discuss the advances in power electronic devices
2.	Design & analyze the different converter topologies with their applications.
3.	Articulate & apply the different modulation techniques
4.	Design & analyze the different matrix converters
5.	Apply the dynamic modeling, control and analysis of different converters

Signature of faculty

Note: Please refer to Bloom's Taxonomy, to know the illustrative verbs that can be used to state the outcomes.

Gokaraju Rangaraju Institute of Engineering and Technology
(Autonomous)

Department of Electrical & Electronics Engineering

GUIDELINES TO STUDY THE COURSE / SUBJECT

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Guidelines to study the Course/ Subject: Power Electronic Converters

Course Design and Delivery System (CDD):

- The Course syllabus is written into number of learning objectives and outcomes.
- Every student will be given an assessment plan, criteria for assessment, scheme of evaluation and grading method.
- The Learning Process will be carried out through assessments of Knowledge, Skills and Attitude by various methods and the students will be given guidance to refer to the text books, reference books, journals, etc.

The faculty be able to –

- Understand the principles of Learning
- Understand the psychology of students
- Develop instructional objectives for a given topic
- Prepare course, unit and lesson plans
- Understand different methods of teaching and learning
- Use appropriate teaching and learning aids
- Plan and deliver lectures effectively
- Provide feedback to students using various methods of Assessments and tools of Evaluation
- Act as a guide, advisor, counselor, facilitator, motivator and not just as a teacher alone

Signature of HOD

Date:

Signature of faculty

Date:

Gokaraju Rangaraju Institute of Engineering and Technology
(Autonomous)

Department of Electrical & Electronics Engineering

COURSE SCHEDULE

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

The Schedule for the whole Course / Subject is:

S. No.	Description	Duration (Date)		Total No. Of Periods
		From	To	
1.	**UNIT-I:** Modern power semiconductor devices MTO Characteristics, ETO Characteristics, IGCTs Characteristics, MCTs Characteristics, IGBT Characteristics MOSFET Construction & Characteristics, comparison of switch features Design aspects of switches Problems & Revision	16.11.2021	07.12.2021	14
2.	**UNIT-II:** Analysis of step-down dc to dc converters with resistive and Resistive, inductive loads, Analysis of step-up dc to dc converters with resistive and Resistive, inductive loads-Switched mode regulators Analysis of Buck Regulators, Boost regulators, buck and boost regulators, Cuk Regulators-Condition for Continuous inductor current and capacitor voltage Comparison of regulators-Advantages-Applications, Multi-output boost converters Problems	08.12.2021	05.01.2022	13
3.	**UNIT-III:** Analysis of single, Multiple PWM-sinusoidal PWM, Modified PWM-phase displacement Control Advanced modulation techniques for improved performance for Trapezoidal, staircase, stepped, harmonic injection and delta modulations Advantage-application. Comparison of PWM techniques, Third Harmonic PWM-60-degree PWM-space vector modulation, Problems	11.01.2022	08.02.2022	11
4.	**UNIT-IV:** Class E resonant inverter, ZCS resonant converter L-type ZCS resonant converter M-type ZCS resonant converter ZVS resonant converter Resonant DC link inverters Problems	09.02.2022	16.02.2022	11
5.	**UNIT-V:** Modelling & design of DC-DC converter small signal modelling Power electronics for controlling electric drives analysis & comparison of different PWM techniques for IM drives Problems Old question paper discussion	22.02.2022	02.03.2022	11

Total No. of Instructional periods available for the course: 60 Hours

ILLUSTRATIVE VERBS FOR STATING INSTRUCTIONAL OBJECTIVES

These verbs can also be used while framing questions for Continuous Assessment Examinations as well as for End – Semester (final)Examinations

ILLUSTRATIVE VERBS FOR STATING GENERAL OBJECTIVES/OUTCOMES

Know	Understand	Design

ILLUSTRATIVE VERBS FOR STATING SPECIFIC OBJECTIVES/OUTCOMES:

A. COGNITIVE DOMAIN (KNOWLEDGE)

1	2	3	4	5	6
Knowledge	Comprehension Understanding	Application of knowledge & comprehension	Analysis Of whole w .r.t. its constituents	Synthesis	Evaluation Judgment
Define Identify	Convert Describe (a Procedure) Distinguish Explain why/how	Demonstrate Prepare Relate Show Solve	Differentiate Discriminate Distinguish Separate	Categorize Combine Design Generate Plan	Compare

B. AFFECTIVE DOMAIN (ATTITUDE)

Assist	Select
Change	Develop

C. PSYCHOMOTOR DOMAIN (SKILLS)

Bend	Dissect	Insert	Perform	Straighten
Calibrate	Draw	Keep	Prepare	Strengthen
Compress	Extend	Elongate	Remove	Time
Conduct	Feed	Limit	Replace	Transfer
Connect	File	Manipulate	Report	Type
Convert	Grow	Move Precisely	Reset	Weigh
Decrease	Increase	Paint	Set	

SCHEDULE OF INSTRUCTIONS
COURSE PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Unit No.	Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1.	1	16.11.2021	2	Introduction of the Course & Unit-I	1 1	Power Electronics MH Rashid
	2	17.11.2021	2	Modern power semiconductor devices MTO, ETO Characteristics	1 1	Power Electronics MH Rashid
	3	23.11.2021	2	IGCTs, MCTs Characteristics	1 1	Power Electronics MH Rashid
	4	24.11.2021	2	Insulated Gate Bipolar Transistor (IGBT) Characteristics	1 1	Power Electronics MH Rashid
	5	30.11.2021	2	MOSFET Construction & Characteristics,	1 1	Power Electronics MH Rashid
	6	01.12.2021	2	Design aspects of switches	1 1	Power Electronics MH Rashid
	7	07.12.2021	2	Problems & Revision	1 1	Power Electronics MH Rashid
2.	1	08.12.2021	2	Unit-II Introduction	2 2	Power Electronics MH Rashid
	2	14.12.2021	2	Analysis of step-down dc to dc converters with resistive and Resistive,	2 2	Power Electronics MH Rashid
	3	15.12.2021	2	Switched mode regulators	2 2	Power Electronics MH Rashid
	4	21.12.2021	2	Analysis of Buck Regulators- Condition for Continuous inductor current voltage	2 2	Power Electronics MH Rashid
	5	22.12.2021	2	Analysis of Boost regulators- Condition for Continuous inductor current and	2 2	Power Electronics MH Rashid
	6	28.12.2021	2	capacitor voltage"	2 2	Power Electronics MH Rashid
	7	29.12.2021	2	Analysis of buck and boost regulators- Condition for Continuous inductor current and capacitor voltage	2 2	Power Electronics MH Rashid
	8	04.01.2022	2	Analysis of Cuk Regulators- Condition for Continuous inductor current and	2 2	Power Electronics MH Rashid
	9	05.01.2022	2	capacitor voltage	2 2	Power Electronics MH Rashid
3.	1	11.01.2022	2	Comparison of regulators- Advantages-Applications, Multi-	3 3	Power Electronics MH Rashid

				output boost converters		
	2	25.01.2022	2	Problems	3 3	Power Electronics MH Rashid
	3	01.02.2022	2	Introduction, Analysis of single PWM	3 3	Power Electronics MH Rashid
	4	08.02.2022	2	Analysis of Multiple PWM-sinusoidal PWM, Analysis of Modified PWM	3 3	Power Electronics MH Rashid
4	1	09.02.2022	2	Advanced modulation techniques for improved performance for Trapezoidal, staircase	4 4	Power Electronics MH Rashid
	2	15.02.2022	2	Advantage-application. Comparison of PWM techniques, Third Harmonic PWM-60-degree PWM-space vector modulation, Problems	4 4	Power Electronics MH Rashid
	3	16.02.2022	2	principle-matrix converter switches, 3phase matrix converter, switching control strategy	4 4	Power Electronics MH Rashid
5	1	22.02.2022	2	Venturini control method, principle-switching duty cycles, modulation matrix realization of input filter	5 5	Power Electronics MH Rashid
	2	23.02.2022	2	commutation and protection issues in matrix converter, Problems	5 5	Power Electronics MH Rashid
	3	01.03.2022	2	Feedback control for converters: regulation and control problem, control principles, model for feedback, P and PI control.	5 5	Power Electronics MH Rashid
	4	02.03.2022	2	Nonlinear dynamic modeling, Control and analysis of choppers, voltage mode and current mode control.	5 5	Power Electronics MH Rashid

Signature of HOD

Date:

Signature of faculty

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

Gokaraju Rangaraju Institute of Engineering and Technology
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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS
UNIT - I PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1	16.11.2021	2	Introduction of the Course & Unit-I	1 1	Power Electronics MH Rashid
2	17.11.2021	2	Modern power semiconductor devices MTO, ETO Characteristics	1 1	Power Electronics MH Rashid
3	23.11.2021	2	IGCTs, MCTs Characteristics	1 1	Power Electronics MH Rashid
4	24.11.2021	2	Insulated Gate Bipolar Transistor (IGBT) Characteristics	1 1	Power Electronics MH Rashid
5	30.11.2021	2	MOSFET Construction & Characteristics,	1 1	Power Electronics MH Rashid
6	01.12.2021	2	Design aspects of switches	1 1	Power Electronics MH Rashid
7	07.12.2021	2	Problems & Revision	1 1	Power Electronics MH Rashid

Signature of HOD

Signature of faculty

Date:

Date:

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3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

Gokaraju Rangaraju Institute of Engineering and Technology
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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS

UNIT - II PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1	08.12.2021	2	Unit-II Introduction	2 2	Power Electronics MH Rashid
2	14.12.2021	2	Analysis of step-down dc to dc converters with resistive and Resistive,	2 2	Power Electronics MH Rashid
3	15.12.2021	2	Switched mode regulators	2 2	Power Electronics MH Rashid
4	21.12.2021	2	Analysis of Buck Regulators-Condition for Continuous inductor current voltage	2 2	Power Electronics MH Rashid
5	22.12.2021	2	Analysis of Boost regulators-Condition for Continuous inductor current and	2 2	Power Electronics MH Rashid
6	28.12.2021	2	capacitor voltage"	2 2	Power Electronics MH Rashid
7	29.12.2021	2	Analysis of buck and boost regulators- Condition for Continuous inductor current and capacitor voltage	2 2	Power Electronics MH Rashid
8	04.01.2022	2	Analysis of Cuk Regulators-Condition for Continuous inductor current and	2 2	Power Electronics MH Rashid
9	05.01.2022	2	capacitor voltage	2 2	Power Electronics MH Rashid

Signature of HOD

Date:

Signature of faculty

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
2. ADDITIONAL TOPICS COVERED, IF ANY, MAY ALSO BE SPECIFIED IN BOLD
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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS

UNIT - III PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1	11.01.2022	2	Comparison of regulators-Advantages-Applications, Multi-output boost converters	3 3	Power Electronics MH Rashid
2	25.01.2022	2	Problems	3 3	Power Electronics MH Rashid
3	01.02.2022	2	Introduction, Analysis of single PWM	3 3	Power Electronics MH Rashid
4	08.02.2022	2	Analysis of Multiple PWM-sinusoidal PWM, Analysis of Modified PWM	3 3	Power Electronics MH Rashid

Signature of HOD

Signature of faculty

Date:

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
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Department of Electrical & Electronics Engineering

SCHEDULE OF INSTRUCTIONS

UNIT - IV PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1	09.02.2022	2	Advanced modulation techniques for improved performance for Trapezoidal, staircase	4 4	Power Electronics MH Rashid
2	15.02.2022	2	Advantage-application. Comparison of PWM techniques, Third Harmonic PWM-60-degree PWM-space vector modulation, Problems	4 4	Power Electronics MH Rashid
3	16.02.2022	2	principle-matrix converter switches, 3phase matrix converter, switching control strategy	4 4	Power Electronics MH Rashid

Signature of HOD

Date:

Signature of faculty

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
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3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

SCHEDULE OF INSTRUCTIONS

UNIT -V PLAN

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No.	Date	No. of Periods	Topics / Sub-Topics	Objectives & Outcomes Nos.	References (Textbook, Journal)
1	22.02.2022	2	Venturini control method, principle-switching duty cycles, modulation matrix realization of input filter	5 5	Power Electronics MH Rashid
2	23.02.2022	2	commutation and protection issues in matrix converter, Problems	5 5	Power Electronics MH Rashid
3	01.03.2022	2	Feedback control for converters: regulation and control problem, control principles, model for feedback, P and PI control.	5 5	Power Electronics MH Rashid
4	02.03.2022	2	Nonlinear dynamic modeling, Control and analysis of choppers, voltage mode and current mode control.	5 5	Power Electronics MH Rashid

Signature of HOD

Signature of faculty

Date:

Date:

Note: 1. ENSURE THAT ALL TOPICS SPECIFIED IN THE COURSE ARE MENTIONED.
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3. MENTION THE CORRESPONDING COURSE OBJECTIVE AND OUT COME NUMBERS AGAINST EACH TOPIC.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 01 Duration of Lesson: 1hr30 MIN

Lesson Title: Introduction of the Course & Unit-I

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand three phase utilities usage in day life.
To familiarize students on Boost type PFC
To understand students the concept of Interphases & control and their need for its improvement.
To provide information on global scenario of PFC.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
70 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment – I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 02 Duration of Lesson: 1hr30 MIN

Lesson Title: Circuit Model Analysis, Boost type PFC

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand three phase utilities usage in day life.
To familiarize students on Boost type PFC
To understand students the concept of Interphases & control and their need for its improvement.
To provide information on global scenario of PFC.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions: .
Refer assignment – I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 03 Duration of Lesson: 1hr30 MIN

Lesson Title: Design - three phase utility

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand three phase utilities usage in day life.
To familiarize students on Boost type PFC
To understand students the concept of Interphases & control and their need for its improvement.
To provide information on global scenario of PFC.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions: .

Refer assignment – I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 04 Duration of Lesson: 1hr30 MIN

Lesson Title: Interphases & control

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand three phase utilities usage in day life.
To familiarize students on Boost type PFC
To understand students the concept of Interphases & control and their need for its improvement.
To provide information on global scenario of PFC.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:
Refer assignment – I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 05 Duration of Lesson: 1hr30 MIN

Lesson Title: Problems

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand three phase utilities usage in day life.
To familiarize students on Boost type PFC
To understand students the concept of Interphases & control and their need for its improvement.
To provide information on global scenario of PFC.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions: .
Refer assignment – I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 06 Duration of Lesson: 1hr30 MIN

Lesson Title: Buck Regulator

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
70 min for the class
15 min for doubts

Assignment / Questions: .
Refer assignment-I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-I)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 07 Duration of Lesson: 1hr30 MIN

Lesson Title: Boost Regulator

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions: .
Refer assignment-I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos..1,2,3,4 & 1,3.

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 01 Duration of Lesson: 1hr30 MIN

Lesson Title: Buck-Boost Regulator

INSTRUCTIONAL/LESSON OBJECTIVES:
To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-I & tutorial-I sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 02 Duration of Lesson: 1hr30 MIN

Lesson Title: Cuk Regulator

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 03 Duration of Lesson: 1hr30 MIN

Lesson Title: Comparison of Regulator

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-I & tutorial-I sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 04 Duration of Lesson: 1hr30 MIN

Lesson Title: Derivation of Buck & Boost regulators

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-I & tutorial-I sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 05 Duration of Lesson: 1hr30 MIN

Lesson Title: Problems

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of regulators & their need in day life.
To familiarize students on Buck and Boost type regulators
To understand students the concept of Cuk Regulator.
To provide information on global scenario of Buck-Boost regulators.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-I & tutorial-I sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 06 Duration of Lesson: 1hr30 MIN

Lesson Title: DC Power Supplies introduction

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
70 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 07 Duration of Lesson: 1hr30 MIN

Lesson Title: Switched mode DC power supplies classification & types

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 08 Duration of Lesson: 1hr30 MIN

Lesson Title: Fly back converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-II)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 09 Duration of Lesson: 1hr30 MIN

Lesson Title: Forward converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-III)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 01 Duration of Lesson: 1hr30 MIN

Lesson Title: Push-pull converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-III)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 02 Duration of Lesson: 1hr30 MIN

Lesson Title: Half bridge converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of DC Power Supplies.
To familiarize students on Fly back & Forward converter.
To understand the concept of Switched mode DC power supplies classification & types.
To provide information on push-pull and half bridge converter.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-II & tutorial-II sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-III)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 03 Duration of Lesson: 1hr30 MIN

Lesson Title: Class E resonant inverter, ZCS resonant converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
70 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-III)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 04 Duration of Lesson: 1hr30 MIN

Lesson Title: L type ZCS resonant converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-IV)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 01 Duration of Lesson: 1hr30 MIN

Lesson Title: M type ZCS resonant converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-IV)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 02 Duration of Lesson: 1hr30 MIN

Lesson Title: ZVS resonant converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-IV)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 03 Duration of Lesson: 1hr30 MIN

Lesson Title: Resonant DC link inverters

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-V)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 01 Duration of Lesson: 1hr30 MIN

Lesson Title: Problems

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Class E resonant inverter, ZCS resonant converter.
To familiarize students on L & M type ZCS resonant converters.
To understand the concept of ZVS resonant converter.
To provide information on Resonant DC link inverters.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-IV & tutorial-IV sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-V)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 02 Duration of Lesson: 1hr30 MIN

Lesson Title: Modelling & design of DC-DC converter

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Modelling & design of DC-DC converter.
To familiarize students on Power electronics for controlling electric drives.
To understand the concept of small signal modelling.
To provide information on analysis & comparison of different PWM techniques for IM drives.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
70 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-V & tutorial-V sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-V)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 03 Duration of Lesson: 1hr30 MIN

Lesson Title: small signal modelling

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Modelling & design of DC-DC converter.
To familiarize students on Power electronics for controlling electric drives.
To understand the concept of small signal modelling.
To provide information on analysis & comparison of different PWM techniques for IM drives.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-V & tutorial-V sheets

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

LESSON PLAN (U-V)

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Lesson No: 04 Duration of Lesson: 1hr30 MIN

Lesson Title: Power electronics for controlling electric drives

INSTRUCTIONAL/LESSON OBJECTIVES:

To make students understand the concept of Modelling & design of DC-DC converter.
To familiarize students on Power electronics for controlling electric drives.
To understand the concept of small signal modelling.
To provide information on analysis & comparison of different PWM techniques for IM drives.

TEACHING AIDS :PPTs
TEACHING POINTS :

5 mins for taking attendance
15 for revision of previous class
55 min for the class
15 min for doubts

Assignment / Questions:

Refer assignment-V & tutorial-V sheets.

Signature of faculty

Note: Mention for each question the relevant Objectives and Outcomes Nos.1,2,3,4 & 1,3..

ASSIGNMENT SHEET – 1

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This Assignment corresponds to Unit No. 1

1. Describe the method to turn-off MTO
2. Discuss Turn-on & Turn-off methods in Emitter Turn-Off Thyristor with pn-structure & Equivalent circuit
3. Discuss Turn-on & Turn-off methods in MCTs with schematic & Equivalent circuit for p-channel MCTs

Please write the Questions / Problems / Exercises which you would like to give to the students and mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 1

Outcome Nos.: 1

Signature of HOD

Date:

Signature of faculty

Date:

ASSIGNMENT SHEET – 2

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This Assignment corresponds to Unit No. 2

1. What are the elements of Switching mode regulators
2. Draw the circuit diagram of Buck Boost Regulator
3. Derive the expression of continuous inductor current & capacitor voltage in Buck regulator with circuit diagram & necessary waveforms
4. Derive the expression of continuous inductor current & capacitor voltage in Buck-Boost regulator with circuit diagram & necessary waveforms

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 2

Outcome Nos.: 2

Signature of HOD

Date:

Signature of faculty

Date:

ASSIGNMENT SHEET – 3

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This Assignment corresponds to Unit No. 3

1. What are the commonly used PWM techniques for Voltage Control
2. Describe the gating sequence of Single Pulse Width Modulation.
3. Discuss the harmonic profile of sinusoidal pulse width modulation with necessary expressions & waveforms
4. What is third harmonic PWM technique. Discuss how it is injected with help of waveforms

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 3

Outcome Nos.: 3

Signature of HOD

Date:

Signature of faculty

Date:

ASSIGNMENT SHEET – 4

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This Assignment corresponds to Unit No. 4

1. Draw the switching matrix of three phase matrix converter
2. What is the output phase current relation of matrix converter
3. Discuss three phase – three phase matrix converters with input filter
4. Derive the input voltages and current expression of matric converter with input filter

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 4

Outcome Nos.: 4

Signature of HOD

Date:

Signature of faculty

Date:

ASSIGNMENT SHEET – 5

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 5

1. What are the sources of EMI
2. Draw a block diagram of Induction motor drive with feedback & PI controller
3. Draw the block diagram of induction motor drive with PI controller and discuss its operation.
4. How to minimize EMI interface in power electronic circuits

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 5

Outcome Nos.: 5

Signature of HOD

Date:

Signature of faculty

Date:

TUTORIAL SHEET – 1

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 1

1 Gate current most provide in MTO, the gate turn-off current whose typical peak amplitude is ____ of the current to be controlled.
a. 25% b. 30% c. 35% d. 40%
2 An MOS-controlled thyristor is a _____controlled fully controllable thyristor.
a. current b. voltage c. power d. dv/dt
3 IGCT draws out all the current from cathode into the gate in about ___ to ensure fast turn off
a. 1μs b. 2μs c. 0.5μs d. 1.5μs
4 MCTs are similar in operation to _____ thyristors
a. GTO b. MTO c. IGCT d. IGBT
5 Main drawback of GTOs is that they require a high-pulse current drive circuit for _____ impedance gate
a. Low b. High c. Very Low d. Very High

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 1

Outcome Nos.: 1

Signature of HOD Signature of faculty

Date: Date:

TUTORIAL SHEET – 2

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 2

1 An ETO is turned on by applying positive _____ to gates, gate 1 and gate 2
a. Voltage b. Current c. Power d. Harmonics
2 Similar to a GTO, the IGCT is turned on by applying the _____ to its gate
a. Turn-on Current b. Turn-off Current c. Turn-on Voltage d. Turn-off Voltage
3 In buck regulator the average output voltage is _____ than the input voltage
a. Less b. Greater c. Equal d. None
4 Buck regulator has efficiency greater than _____
a. 90% b. 95% c. 80% d. 85%
5 In buck-boost regulator peak to peak ripple current is
a. $\Delta I = \frac{V_S K}{fL}$ b. $\Delta I = \frac{V_O K}{fL}$ c. $\Delta I = \frac{V_S f}{KL}$ d. $\Delta I = \frac{V_O f}{KL}$

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 2

Outcome Nos.: 2

Signature of HOD Signature of faculty

Date: Date:

TUTORIAL SHEET – 3

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 3

1 Among all PWM techniques, the _____ PWM is commonly used for a voltage control.
a. Sinusoidal b. Trapezoidal c. 600 d. Single
2 Multiple PWM is also called as _____ PWM.
a. Uniform b. Sinusoidal c. Trapezoidal d. Non-Uniform
3 Frequency Modulation Ratio is defined as _____
a. fc / fo b. fo / fc c. 1 / (fc * fo) d. fc * fo
4 Sinusoidal pulse-width modulation is commonly used in _____ applications
a. Industrial b. Space c. BLDC fans d. none
5 To increase the fundamental output voltage, d must be increased beyond _____.
a. 1.0 b. 1.5 c. 2.0 d. 2.5

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 3

Outcome Nos.: 3

Signature of HOD

Date:

Signature of faculty

Date:

Gokaraju Rangaraju Institute of Engineering and Technology
(Autonomous)

Department of Electrical & Electronics Engineering

TUTORIAL SHEET – 4

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 4

1 The modulating (or reference) signal is generated by injecting selected harmonics to the _____
a. Sine Wave b. Cos Wave c. Trapezoidal d. 600

2 Matrix Converter is a type of _____ converter
a. ac-ac b. ac-dc c. dc-dc d. dc-ac

3 The matrix converter consists of ____ bi-directional switches that allow any output phase to be connected to any input phase
a. 09 b. 06 c. 03 d. None

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 4

Outcome Nos.: 4

Signature of HOD Signature of faculty

Date: Date:

TUTORIAL SHEET – 5

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

This tutorial corresponds to Unit No. 5

1. Relationship of Input & Output Currents in Matrix Converter is _____
a. Ii = TT * I0 b. Ii = T * I0 c. IO = TT * Ii d. IO = T * Ii

2. In matrix converter, the bidirectional switches work with _____ frequency
a. high switching b. low switching
c. Moderate switching d. higher switching

Please write the Questions / Problems / Exercises which you would like to give to the students and also mention the Objectives/Outcomes to which these Questions / Problems / Exercises are related.

Objective Nos.: 5

Outcome Nos.: 5

Signature of HOD Signature of faculty

Date: Date:

EVALUATION STRATEGY

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Target

a. Percentage of Pass : 95%

Method of Evaluation

a. Daily Attendance
b. Assignments
c. Online Quiz & Seminars
d. Internal Examinations
e. Semester / End Examination

List out any new topic(s) or any innovation you would like to introduce in teaching the subjects in this semester

Case Study of any one existing application

Signature of HOD

Date:

Signature of faculty

Date:

Gokaraju Rangaraju Institute of Engineering and Technology
(Autonomous)

Department of Electrical & Electronics Engineering

COURSE COMPLETION STATUS

Academic Year	: 2021-22	Semester	: I
Name of the Program	: I M.Tech - EEE (PE)		
Course	: Power Electronic Converters	Course Code	: GR20D5026
Name of the Faculty	: Dr. Suresh Kumar Tummala, Professor	Department	: EEE

Actual Date of Completion & Remarks if any

Units	Remarks	No. of Objectives Achieved	No. of Outcomes Achieved
Unit 1	completed on 07.12.2021	1	1
Unit 2	completed on 05.01.2022	2	2
Unit 3	completed on 08.02.2022	3	3
Unit 4	completed on 16.02.2022	4	4
Unit 5	completed on 02.03.2022	5	5

Signature of HOD

Date:

Signature of faculty

Date:

Note: After the completion of each unit mention the number of Objectives & Outcomes Achieved.

Name of the Course: Power Electronic Converter

Assessment methods:

1. Regular Attendance to Classes.
2. Mid Exam / Main Exam.
3. Written class tests clearly linked to learning objectives / Quiz through Moodle
4. Classroom assessment techniques via. Tutorials and assignments.
5. Seminars.

1. Program Educational Objectives (PEOs) – Vision/Mission Matrix

(Indicate the relationships by mark "X")

Vision / Mission / PEOs	Vision of the Institute	Mission of the Institute	Mission of the Program
1	X		X
2	X	X	X
3	X	X	X
4		X	X

2. Program Educational Objectives(PEOs)-Program Outcomes(POs) Relationship Matrix

(Indicate the relationships by mark "X")

P-Outcomes / PEOs	a	b	c	d	e	f	g	h	i	j	k	l
1	X	X	X	X	X			X	X	X	X	X
2	X	X	X	X	X			X	X	X	X	X
3		X	X	X		X	X	X	X	X		
4				X					X	X		X

3. Course Objectives-Course Outcomes Relationship Matrix

(Indicate the relationships by mark "X")

Course-Outcomes / Course-Objectives	1	2	3	4	5
1	X		X		
2		X		X	
3			X		X
4	X		X		
5	X		X		

4. Course Objectives-Program Outcomes (POs) Relationship Matrix

(Indicate the relationships by mark "X")

P-Outcomes / C-Objectives	a	b	c	d	e	f	g	h	i	j	k	l
1	X		X		X	X	X	X	X	X	X	
2	X	X	X		X	X	X	X			X	X
3	X	X	X		X	X	X	X	X		X	X
4	X	X		X	X		X	X		X	X	X
5	X	X		X	X		X	X		X	X	X

5. Course Outcomes-Program Outcomes (POs) Relationship Matrix

(Indicate the relationships by mark "X")

P-Outcomes / C-Outcomes	a	b	c	d	e	f	g	h	i	j	k	l
1	X				X	X	X	X	X		X	X
2	X	X	X	X	X		X	X	X		X	X
3	X	X		X	X		X	X	X	X	X	X
4		X	X				X			X		X
5			X		X		X		X			

6. Courses (with title & code)-Program Outcomes (POs) Relationship Matrix
(Indicate the relationships by mark "X")

P-Outcomes / Courses	a	b	c	d	e	f	g	h	i	j	k	l
PEC (GR20D5026)	X	X	X	X	X	X	X	X	X	X	X	X

7. Program Educational Objectives (PEOs)-Course Outcomes Relationship Matrix
(Indicate the relationships by mark "X")

P-Objectives (PEOs) / Course-Outcomes	1	2	3	4
1		X	X	X
2	X	X	X	X
3	X	X	X	X
4		X	X	X
5		X	X	X

8. Assignments & Assessments-Program Outcomes (POs) Relationship Matrix
(Indicate the relationships by mark "X")

P-Outcomes / Assessments	a	b	c	d	e	f	g	h	i	j	k	l
1	X			X	X	X	X	X	X	X		
2	X	X			X		X	X	X	X		
3	X				X	X			X			
4	X			X	X	X		X	X	X		X
5	X	X		X			X		X		X	

9. Assignments & Assessments-Program Educational Objectives (PEOs) Relationship Matrix
(Indicate the relationships by mark "X")

P-Objectives (PEOs) / Assessments	1	2	3	4
1		X	X	X
2	X	X	X	X
3	X	X		X
4		X		X
5	X	X	X	X

Rubric

Performance Criteria	Unsatisfactory	Developing	Satisfactory	Exemplary
	1	**2**	**3**	**4**
Research & Gather Information	Does not collect any information that relates to the topic	Collects very little information some relates to the topic	Collects some basic Information most relates to the topic	Collects a great deal of Information all relates to the topic
Fulfill team role's duty	Does not perform any duties of assigned team role.	Performs very little duties.	Performs nearly all duties.	Performs all duties of assigned team role.
Share Equally	Always relies on others to do the work.	Rarely does the assigned work - often needs reminding.	Usually does the assigned work - rarely needs reminding.	Always does the assigned work without having to be reminded
Listen to other team mates	Is always talking—never allows anyone else to speak.	Usually doing most of the talking-- rarely allows others to speak.	Listens, but sometimes talks too much.	Listens and speaks a fair amount.

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of EEE

M. Tech (Power Electronics) I-Sem **I-Mid** **Marks: 5M**

Time: 15 Minutes **Date of Exam: 16-03-2021**

Subject: **Power Electronic Converters (GR20D5026)**

Name: **Roll Number:**

Note: Answer all questions. All questions carry equal marks. **Total: 5M**

1.	Gate current most provide in MTO, the gate turn-off current whose typical peak amplitude is ____ of the current to be controlled. a. 25% b. 30% c. 35% d. 40%	[c]
2.	An MOS-controlled thyristor is a _____controlled fully controllable thyristor. a. current b. voltage c. power d. dv/dt	[b]
3.	IGCT draws out all the current from cathode into the gate in about ___ to ensure fast turn off a. 1μs b. 2μs c. 0.5μs d. 1.5μs	[a]
4.	MCTs are similar in operation to _____ thyristors a. GTO b. MTO c. IGCT d. IGBT	[a]
5.	Main drawback of GTOs is that they require a high-pulse current drive circuit for _____ impedance gate a. Low b. High c. Very Low d. Very High	[a]
6.	An ETO is turned on by applying positive _____ to gates, gate 1 and gate 2 a. Voltage b. Current c. Power d. Harmonics	[a]
7.	Similar to a GTO, the IGCT is turned on by applying the _____ to its gate a. Turn-on Current b. Turn-off Current c. Turn-on Voltage d. Turn-off Voltage	[a]
8.	In buck regulator the average output voltage is _____ than the input voltage a. Less b. Greater c. Equal d. None	[a]
9.	Buck regulator has efficiency greater than _____ a. 90% b. 95% c. 80% d. 85%	[a]
10.	In buck-boost regulator peak to peak ripple current is a. $\Delta I = \frac{V_S K}{fL}$ b. $\Delta I = \frac{V_O K}{fL}$ c. $\Delta I = \frac{V_S f}{KL}$ d. $\Delta I = \frac{V_O f}{KL}$	[a]

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of EEE

M. Tech (Power Electronics) I-Sem **I-Mid** **Marks: 15M**

Time: 75 Minutes **Date of Exam: 16-03-2021**

Subject: **Power Electronic Converters (GR20D5026)**

Note: Answer all questions. All questions carry equal marks. **Total: 3 x 5 = 15M**

1.	Draw the structure of ETO. Explain turn-on mechanism of ETO	(CO-1)
	OR	
2.	Draw the structure of MCT and explain in brief	(CO-1)
3.	Discuss the principle of operation of IGCT with a neat schematic structure	(CO-1)
	OR	
4.	A boost regulator has an input voltage of 5V. The average output voltage is 15V and the average load current is 0.5A. The switching frequency is 25kHz. If L=150microH and C=220microF, determine duty cycle, ripple current of inductor and ripple voltage of filter capacitor.	(CO-2)
5.	Explain the modes of operation of Buck-Boost regulator with necessary waveforms	(CO-2)
	OR	
6.	Derive the peak-to-peak ripple current of a boost regulator with circuit diagram	(CO-2)

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of EEE

M. Tech (Power Electronics) I-Sem **II-Mid** **Marks: 5M**

Time: 15 Minutes **Date of Exam: 10-03-2021**

Subject: **Power Electronic Converters (GR20D5026)**

Name: **Roll Number:**

Note: Answer all questions. All questions carry equal marks. **Total: 5M**

1.	Among all PWM techniques, the _____ PWM is commonly used for a voltage control. a. Sinusoidal b. Trapezoidal c. 60^0 d. Single	[a]
2.	Multiple PWM is also called as _____ PWM. a. Uniform b. Sinusoidal c. Trapezoidal d. Non-Uniform	[a]
3.	Frequency Modulation Ratio is defined as _____ a. f_c / f_o b. f_o / f_c c. $1 / (f_c * f_o)$ d. $f_c * f_o$	[a]
4.	Sinusoidal pulse-width modulation is commonly used in _____ applications a. Industrial b. Space c. BLDC fans d. none	[a]
5.	To increase the fundamental output voltage, d must be increased beyond _____. a. 1.0 b. 1.5 c. 2.0 d. 2.5	[a]
6.	The modulating (or reference) signal is generated by injecting selected harmonics to the _____ a. Sine Wave b. Cos Wave c. Trapezoidal d. 60^0	[a]
7.	Matrix Converter is a type of _____ converter a. ac-ac b. ac-dc c. dc-dc d. dc-ac	[a]
8.	The matrix converter consists of ____ bi-directional switches that allow any output phase to be connected to any input phase a. 09 b. 06 c. 03 d. None	[a]
9.	Relationship of Input & Output Currents in Matrix Converter is _____ a. $I_i = T^T * I_0$ b. $I_i = T * I_0$ c. $I_O = T^T * I_i$ d. $I_O = T * I_i$	[a]
10.	In matrix converter, the bidirectional switches work with _____ frequency a. high switching b. low switching c. Moderate switching d. higher switching	[a]

GOKARAJU RANGARAJU INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
Department of EEE

M. Tech (Power Electronics) I-Sem **II-Mid** **Marks: 15M**

Time: 75 Minutes **Date of Exam: 10-03-2021**

Subject: **Power Electronic Converters (GR20D5026)**

Note: Answer all questions. All questions carry equal marks. **Total: 3 x 5 = 15M**

1.	Explain Single Pulse PWM Technique with a neat sketch	(CO-3)
	OR	
2.	Draw Multiple Pulse PWM and explain in brief	(CO-3)
3.	Discuss Sinusoidal Pulse Width Modulation Technique with a neat sketch	(CO-3)
	OR	
4.	Discuss 60^0 Pulse Width Modulation Technique with a neat sketch	(CO-3)
5.	Explain three phase – three phase matrix converter	(CO-4)
	OR	
6.	Draw a schematic representation of a matrix converter adjustable speed drive	(CO-4)

2021-22 M.Tech Power Electronics - Power Electronic Converters

S.No	Roll No	Name	Mid-I		
			Obj (5M)	Des (15M)	Total (20M)
1	21241D4301	D Pujitha	3.00	15.00	18
4	21241D4302	K Malini	3.00	15.00	18
2	21241D4303	Moshina Begum	4.50	14.00	19
3	21241D4304	Surya Prakash Yadav	4.00	14.00	18

2021-22 M.Tech Power Electronics - Power Electronic Converters

S.No	Roll No	Name	Mid-II		
			Obj (5M)	Des (15M)	Total (20M)
1	21241D4301	D Pujitha	1.50	7.00	9
4	21241D4302	K Malini	2.00	11.00	13
2	21241D4303	Moshina Begum	3.00	10.00	13
3	21241D4304	Surya Prakash Yadav	2.50	12.00	15

Power Electronic Converters

M.Tech – PE (2021-22)

Dr. Suresh Kumar T
Professor, EEE Department, GRIET

1

UNIT-1

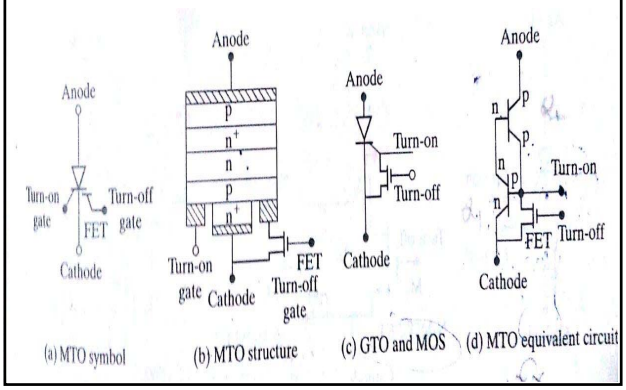
2

Modern Power Semi Conductor Devices

1.MTO (MOS Turn OFF Thyristor)
2.ETO (Emitter Turn OFF Thyristor)
3.IGCTs (Integrated Gate Commutated Thyristor)
4.MCTs (MOS-Controlled Thyristors)
5.IGBT (Insulated Gate Bipolar Transistor)

3

1.MTOs



4

EXPLANATION

1.The MTO was developed by silicon power company(SPCO).
2.It is a combination of a GTO and an MOSFET, which together over come the limitations of the GTO turnoff ability.
3. the gate current most provide the gate turn-off current whose typical peak amplitude 35% of the current to be controlled.
4. The MTO provides the same functionality as the GTO But uses a gate drive that needs to supply only the signal level voltage necessary to turn MOS thyristor ON and OFF.

5

- TURN-ON: MTO is turned on by applying gate current pulse to the turn-on gate.turnon the NPN-TransistorQ_1,whichthen turns on the PNP-TransistorQ_2 and latches on the MTO.
- TURN-OFF:MTO is turnoff with a gate pulse voltage is applyed to the MOSFETgate turning on the MOSFETS shorts the emitter and base the NPN transistor Q_1 there by stoping the latchingprocess.
- the MTO turns off much faster than a GTO.the MTO has a higher dv/dt and require much smaller snubber components.

6

- SPECIFICATIONS:
- voltage: upto 10KV
- Current: upto 4000A
- ADVANTAGE:
- MTOS can be used in high power applications ranging from 1 to 20 MVA.
- DRAWBACK:
- The main drawback of GTOs is that they require a high-pulse- current drive circuit for the low impedence gate.

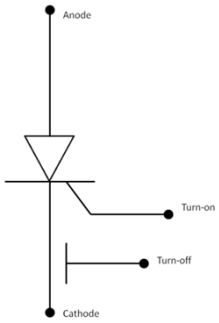
7

Emitter Turn Off Thyristor

ETO

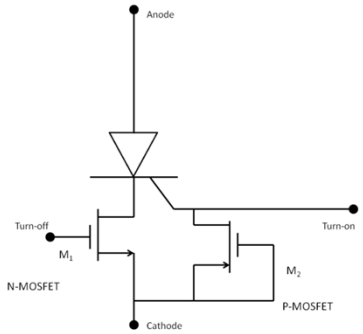
8

ETO - Symbol



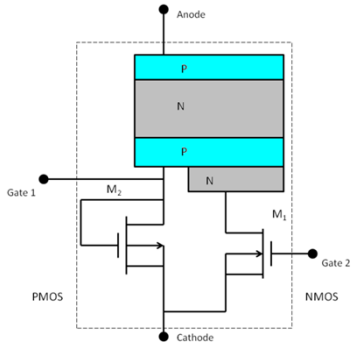
9

Equivalent Circuit



10

Structure



11

Turn On

An ETO is turned ON by applying positive voltages to gates, gate 1 and gate 2.

When a positive voltage is applied to the gate 2, it turns on the MOSFET that is connected in series with the cathode terminal of the PNPN thyristor structure.

The positive voltage applied to the gate 1 turns off the MOSFET connected to the gate terminal of the thyristor.

12

Turn Off

When a turn-off negative voltage signal is applied to the MOSFET connected to the cathode, it turns off and transfers all the current away from the cathode into the base gate via MOSFET connected to the gate of the thyristor.

This stops regenerative latching process and results in a fast turn-off.

Both the MOSFET connected to the cathode and MOSFET connected to the gate of the thyristor are not subjected to high-voltage stresses irrespective of the magnitude of the voltage on the ETO, due to the internal structure of the thyristor containing a P-N junction.

Similar to a GTO, the ETO has a long turn-off tail of current at the end of the turn-off and the next turn-on must wait until the residual charge on the anode side is dissipated through the recombination process.

13

IGCT
(Integrated Gate Commutated Thyristor)

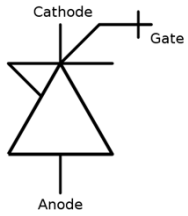
Integrated GCT (Gate Commutated Thyristor) with a multi layered printed circuit board gate drive

GCT is a hard switched GTO with a very fast and large gate current pulse.

Draws out all the current from cathode into the gate in about 1µs to ensure fast turn off

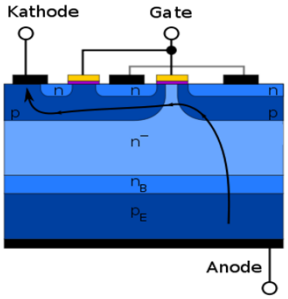
14

IGCT - Symbol



15

IGCT - Structure



16

IGCT can be turned on and off by a gate signal, have lower conduction loss as compared to GTOs, and withstand higher rates of voltage rise (dv/dt), such that no Snubber is required for most applications.

In an IGCT, the gate turn-off current is greater than the anode current. This results in a complete elimination of minority carrier injection from the lower PN junction and faster turn-off times

17

The main differences are

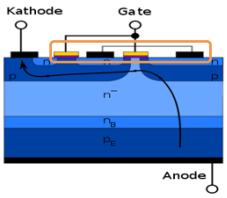
a reduction in cell size, and a much more substantial gate connection with much lower inductance in the gate drive circuit and drive circuit connection.

The very high gate currents and fast di/dt rise of the gate current mean that regular wires can not be used to connect the gate drive to the IGCT

18

The drive circuit PCB is integrated into the package of the device.

The drive circuit surrounds the device and a large circular conductor attaching to the edge of the IGCT is used. The large contact area and short distance reduce both the inductance and resistance of the connection.



19

IGCT are available with or without reverse blocking capability.

Reverse blocking capability adds to the forward voltage drop because of the need to have a long, low-doped P1 region.

IGCTs capable of blocking reverse voltage are known as symmetrical IGCT, abbreviated S-IGCT.

Usually, the reverse blocking voltage rating and forward blocking voltage rating are the same. The typical application for symmetrical IGCTs is in current source inverters.

20

IGCTs incapable of blocking reverse voltage are known as asymmetrical IGCT, abbreviated A-IGCT.

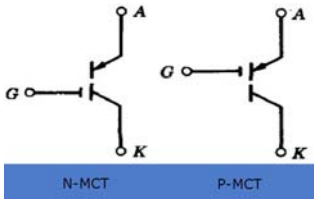
They typically have a reverse breakdown rating in the tens of volts.

A-IGCTs are used where either a reverse conducting diode is applied in parallel (for example, in voltage source inverters) or where reverse voltage would never occur (for example, in switching power supplies or DC traction choppers).

Asymmetrical IGCTs can be fabricated with a reverse conducting diode in the same package. These are known as RC-IGCT, for reverse conducting IGCT.

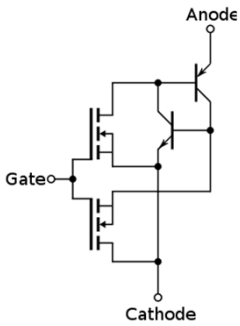
21

MCT
(MOS Controlled Thyristor)



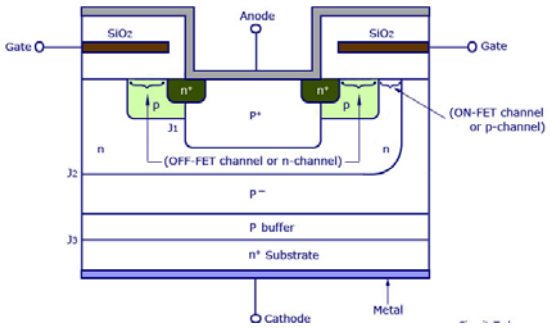
22

MCT – Equivalent Circuit



23

MCT – Structure



24

An **MOS-controlled thyristor (MCT)** is a voltage-controlled fully controllable thyristor.

MCTs are similar in operation to GTO thyristors,

but have voltage controlled insulated gates.

They have two MOSFETs of opposite conductivity types in their equivalent circuits.

25

One is responsible for turn-on and the other for turn-off.

A thyristor with only one MOSFET in its equivalent circuit, which can only be turned on (like normal SCRs), is called an **MOS-gated thyristor**.

26

The device is turned ON by a negative voltage pulse at the gate with respect to the anode.

For turning ON MCT, gate is made negative with respect to anode by the voltage pulse between gate and anode.

So, MCT must be initially forward biased, and then only a negative voltage be applied.

With the application of this negative voltage pulse, ON-FET gets turned ON whereas OFF-FET is already OFF.

With ON-FET ON, current begins to flow from anode A, through ON-FET and then as the base current and emitter of n-p-n transistor and then to cathode K.
This turns on n-p-n transistor.

27

This causes the collector current to flow in n-p-n transistor.

As OFF FET is OFF, this collector current of npn transistor acts as the base current of p-n-p transistor.

Subsequently, p-n-p transistor is also turned ON.

If both the transistors are ON, regenerative action of the connection scheme takes place and the MCT is turned ON.

28

The device is turned OFF by applying a positive voltage pulse at the gate.

The positive voltage pulse causes the OFF-FET to turn ON and ON-FET to turn OFF.

After OFF-FET is turned ON, emitter based terminals of p-n-p transistor are short circuited by OFF-FET.

So, now anode current begins to flow through OFF-FET and thus base current of p-n-p transistor begins to decrease.

The device has the disadvantage of reverse voltage blocking capability.

29

MCT – Advantages

Low forward conduction drop

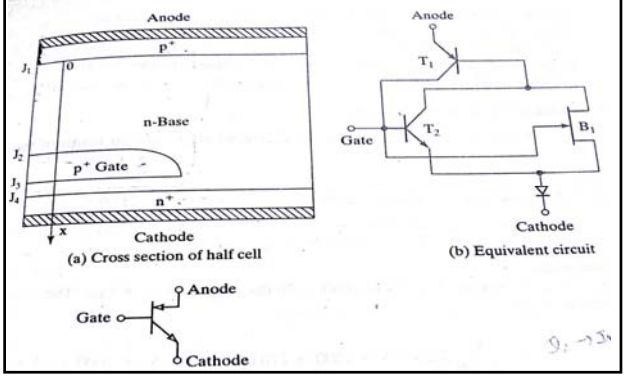
Fast TURN-ON and then OFF times

Low switching losses

High gate input impedance

30

STATIC INDUCTION CIRCUIT



31

EXPLANATION

- The SITH also known as field controlled diode first introduced by teszner in 1960's.It is a minority carrier device.
- SITH has low on state resistance or voltage drop and it can be made with higher voltage and current rattings.

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- TURNON:
- A SITH is normally turned on by applying positive gate voltage with respect to the cathode. The electrons from the n^-cathode region into the base region p^+ thus modulating the channel resistivity.
- When electrons reach the junction j_1 the p^+ anode begins to inject the holes into the base providing the base current of transistor Q_2 as the base current increases Q_2 is driven into saturation and the junction j_2 is eventually forward biased the device is fully turned on.

33

- TURN OFF:
- An SITH is normally turned off by applying a negative gate voltage with respect to the cathode if a sufficiently negative voltage is applied to the gate, a depletion layer forms around the p^+ gate the depletion layer at j_2 gradually extends into the channel.
- If the gate voltage is sufficiently large, the depletion layer of adjacent gate region merge in the channel and eventually turnoff of the electron current flow in the channel. Eventually the depletion layer fully cuts off the channel.

34

- SPECIFICATIONS:
- voltage:2500V
- current:500A
- ADVANTAGE:
- It has fast switching speed and high dv/dt and di/dt capabilities

35

Unit – 2

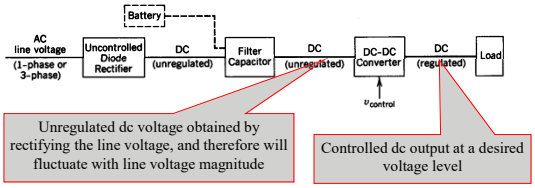
DC – DC Converters (Choppers)

1

DC - DC Converters:

- Step-down (buck) converter
- Step-up (boost) converter
- Step-down/step-up (buck-boost) converter
- Cuk converter

Functional Block Diagram of DC-DC Converter System



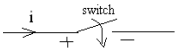
Unregulated dc voltage obtained by rectifying the line voltage, and therefore will fluctuate with line voltage magnitude

Controlled dc output at a desired voltage level

2

Introduction

- Chopper is a static device.
- Equivalently represented as a switch



- It is used to obtain a variable dc voltage from a constant dc voltage source.

- DC chopper is also known as dc-to-dc converter.

3

Applications

- Speed control of DC-Motor.
- Battery chargers
- Regulated switch mode dc power supplies
- Laptop chargers
- Mobile chargers
- Traction systems
- SMPS

4

Classification of choppers

Based on input and output voltage:-

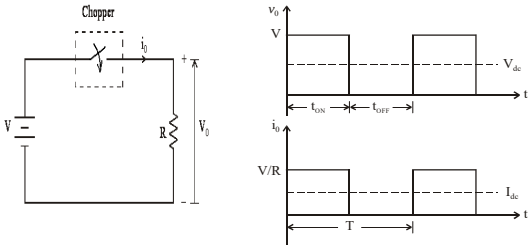
- ➢ Step-down choppers. (Buck Converter)
- ➢ Step-up choppers. (Boost Converter)

Based on quadrant operation :-

- ❖ First quadrant chopper
- ❖ Second quadrant chopper
- ❖ Two quadrant choppers
- ❖ Four quadrant chopper

5

Principle of Step-down Chopper



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V_{dc} = Average value of output or load voltage.

I_{dc} = Average value of output or load current.

t_{ON} = Time interval for which SCR conducts.

t_{OFF} = Time interval for which SCR is OFF.

$T = t_{ON} + t_{OFF}$ = Period of switching or chopping period.

$f = \frac{1}{T}$ = Freq. of chopper switching or chopping freq.

7

Average Output Voltage

$$V_{dc} = V\left(\frac{t_{ON}}{t_{ON} + t_{OFF}}\right)$$

$$V_{dc} = V\left(\frac{t_{ON}}{T}\right) = V.d$$

$$but\ \left(\frac{t_{ON}}{t}\right) = d = \text{duty cycle}$$

The output voltage can be varied by varying the duty cycle.

8

Average Output Current

$$I_{dc} = \frac{V_{dc}}{R}$$

$$I_{dc} = \frac{V}{R}\left(\frac{t_{ON}}{T}\right) = \frac{V}{R}d$$

RMS value of output voltage

$$V_O = \sqrt{\frac{1}{T}\int_0^{t_{ON}} v_o^2 dt}$$

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But during t_{ON}, $v_o = V$

Therefore RMS output voltage

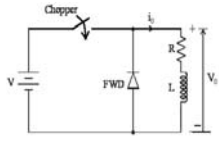
$$V_O = \sqrt{\frac{1}{T}\int_0^{t_{ON}} V^2 dt}$$

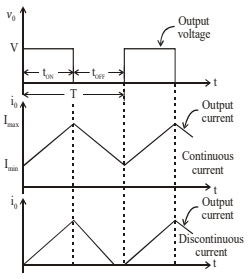
$$V_O = \sqrt{\frac{V^2}{T}t_{ON}} = \sqrt{\frac{t_{ON}}{T}}.V$$

$$V_O = \sqrt{d}.V$$

10

Step-down Chopper with R-L Load





•When chopper is ON, supply is connected across load. Current flows from supply to load.

•When chopper is OFF, load current continues to flow in the same direction through FWD due to energy stored in inductor *'L'*.

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- Load current can be continuous or discontinuous depending on the values of *'L'* and duty cycle *'d'*
- For a continuous current operation, load current varies between two limits I_{max} and I_{min}
- For a discontinuous current operation, load current varies between two limits I_{max} and *zero*
- When current becomes equal to I_{max} the chopper is turned-off and it is turned-on when current reduces to I_{min}.

12

Average Output Voltage

$$V_{dc} = V\left(\frac{t_{ON}}{t_{ON}+t_{OFF}}\right)$$

$$V_{dc} = V\left(\frac{t_{ON}}{T}\right) = V.d$$

$$but\ \left(\frac{t_{ON}}{t}\right) = d = \text{duty cycle}$$

The output voltage can be varied by varying the duty cycle.

RMS value of output voltage

$$V_O = \sqrt{\frac{1}{T}\int_0^{t_{ON}} v_o^2 dt}$$

But during t_{ON}, $v_o = V$

Therefore RMS output voltage

$$V_O = \sqrt{\frac{1}{T}\int_0^{t_{ON}} V^2 dt}$$

$$V_O = \sqrt{\frac{V^2}{T}t_{ON}} = \sqrt{\frac{t_{ON}}{T}}V$$

$$V_O = \sqrt{d}\,V$$

Output power $P_O = V_O I_O$

But $I_O = \frac{V_O}{R}$

Therefore output power $P_O = \frac{V_O^2}{R}$

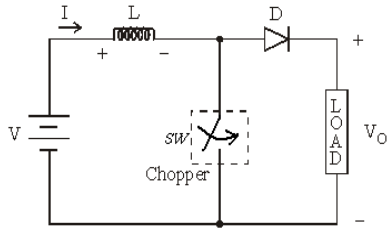
$$P_O = \frac{dV^2}{R}$$

$$I_{\min} = \frac{V}{R}\left[\frac{e^{\frac{dRT}{L}}-1}{e^{\frac{RT}{L}}-1}\right] - \frac{E}{R} \qquad I_{\max} = \frac{V}{R}\left[\frac{1-e^{-\frac{dRT}{L}}}{1-e^{-\frac{RT}{L}}}\right] - \frac{E}{R}$$

$$I_{\min} = \frac{V}{R}\left[\frac{e^{\frac{dRT}{L}}-1}{e^{\frac{RT}{L}}-1}\right] \qquad I_{\max} = \frac{V}{R}\left[\frac{1-e^{-\frac{dRT}{L}}}{1-e^{-\frac{RT}{L}}}\right]$$

$$I_{dc(approx)} = \frac{I_{\max}+I_{\min}}{2}$$

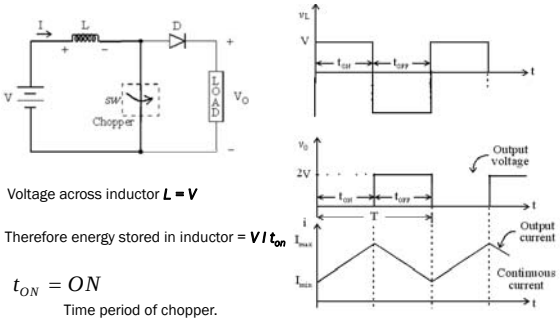
Principle Of Step-up Chopper



- Step-up chopper is used to obtain a load voltage higher than the input voltage *V*.
- The value of *L* is chosen depending upon the requirement of output voltage and current.
- When the chopper is *ON*, the inductor *L* is connected across the supply.
- The inductor current *'I'* rises and the inductor stores energy during the *ON* time of the chopper, t_{ON}.

- When the chopper is off, the inductor current *I* is forced to flow through the diode *D* and load for a period, t_{OFF}.
- The current tends to decrease resulting in reversing the polarity of induced EMF in *L*.
- Diode D prevents any current flow from load to the source. If any capacitive filter is used at output

When Switch is ON



Voltage across inductor $L = V$

Therefore energy stored in inductor = $V I t_{on}$

$t_{ON} = ON$

Time period of chopper.

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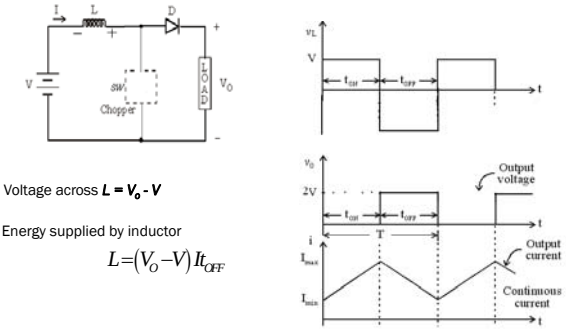
When Switch is OFF



Voltage across $L = V_o - V$

Energy supplied by inductor

$$L = (V_O - V) I t_{OFF}$$

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For Lossless System

Energy stored in Inductor = Energy supplied by Inductor

$$\therefore \quad V I t_{ON} = (V_O - V) I t_{OFF}$$

$$V_O = \frac{V[t_{ON} + t_{OFF}]}{t_{OFF}}$$

$$V_O = V\left(\frac{T}{T - t_{ON}}\right)$$

Where

T = Chopping period or period of switching.

For variation of duty cycle 'd' in the range of $0 < d < 1$ the output voltage V_O will vary in the range $V < V_O < \infty$

21

Methods of Control

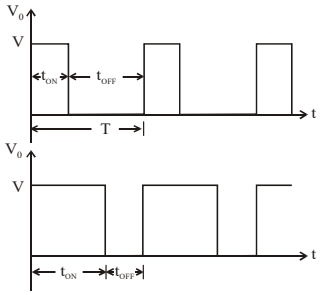
- The average output dc voltage can be varied by controlling the duty cycle
- The duty cycle can be controlled by using two methods
  1. Time ratio control(TRC)
  2. Current limit control

- Time ratio control(TRC)
  in time ratio control the value of TON/T is varied
  - *With Pulse width modulation (PWM) control or constant frequency operation.*
  - *With Variable frequency control.*

22

Pulse Width Modulation

- t_{ON} is varied by keeping chopping frequency '*f*' or chopping period 'T' constant.
- Output voltage is varied by varying the ON time t_{ON}



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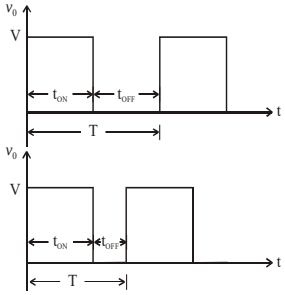
Variable Frequency Control

- Chopping frequency '*f*' is varied by keeping either t_{ON} or t_{OFF} constant.
- in this Chopping frequency '*f*' is varied keeping t_{ON} constant.
- To obtain full output voltage range, frequency has to be varied over a wide range.
- This method produces harmonics in the output and for large t_{OFF} load current may become discontinuous



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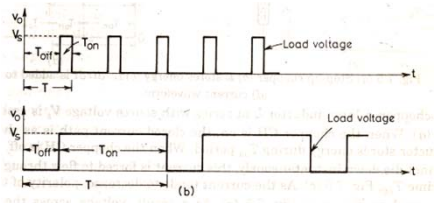
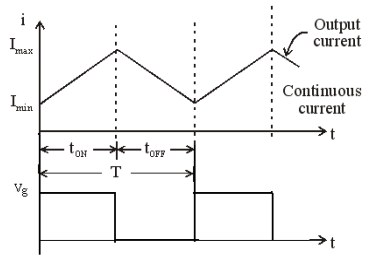
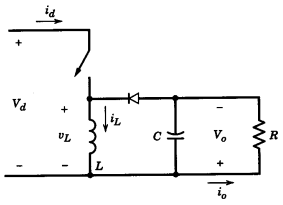
Chopping frequency '*f*' is varied by keeping t_{OFF} is constant.



Current limit control



Buck-Boost Converter



- This converter can be obtained by the cascade connection of two converters: the step-down converter and the step-up converter
- The output voltage can be higher or lower than the input voltage
- Used in regulated dc power supplies where a negative polarity output may be desired with respect to the common terminal of the input voltage

Buck-Boost Converter

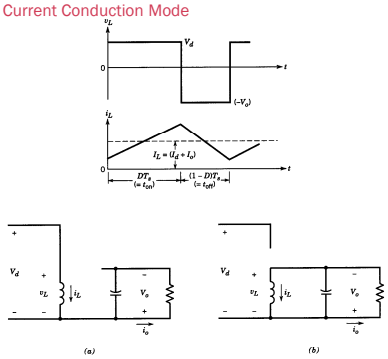
- The output to input voltage conversion ratio

$$\frac{V_0}{V_d} = D\frac{1}{1-D}$$

- This allows V_0 to be higher or lower than V_d
- When the switch is ON:
  diode is reversed biased
  output circuit is thus isolated
  inductor is charged
- When the switch is OFF:
  the output stage received energy from the inductor

Buck-Boost Converter

Continuous Current Conduction Mode



Buck-Boost Converter

Continuous Current Conduction Mode

- Inductor current i_L flows continuously
- Average inductor voltage over a time period must be zero

$$V_d\, DT_s + (-V_0)(1-D)T_s = 0$$

$$\therefore \quad \frac{V_0}{V_d} = \frac{D}{1-D}$$

Assuming a lossless circuit

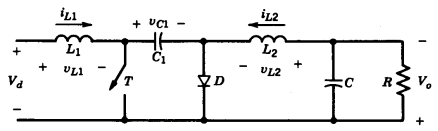
$$V_d I_d = V_0 I_0$$

and

$$\frac{I_0}{I_d} = \frac{(1-D)}{D}$$

- Depending on the duty ratio, the output voltage can be either higher or lower than the input

Cuk Converter



- Named after its inventor
- The output voltage can be higher or lower than the input voltage
- Provides a negative polarity output voltage with respect to the common terminal of the input voltage
- C_1 acts as the primary means of storing and transferring energy from the input to the output
- In the steady-state, average inductor voltages, V_{L1} and V_{L2} are zero, therefore, $V_{C1} = V_d + V_0$

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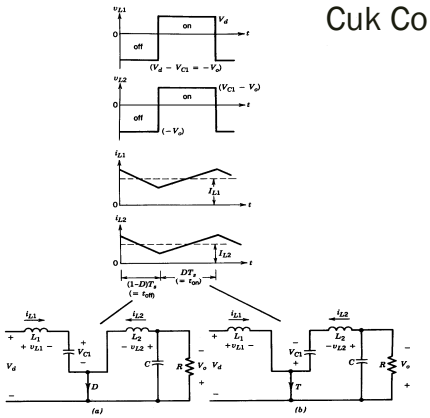
Cuk Converter



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Cuk Converter

- When the switch is OFF:
  - i_{L1} and i_{L2} flow through the diode
  - C_1 is charged through the diode by energy from both the input and L_1
  - energy stored in L_2 feeds the output
- When the switch is ON:
  - V_{c1} reverse biases the diode
  - i_{L1} and i_{L2} flow through the switch
  - since $V_{c1} > V_0$, C_1 discharges through the switch, transferring energy to the output and L_2
  - Therefore, i_{L2} increases
  - Input feeds energy to L_1 causing i_{L1} to increase

33

Steady-state current and voltage equations

V_{c1} is constant and average voltages across L_1 and L_2 over a time period must be zero

$$L_1: \quad V_d DT_s - (V_d - V_{c1})(1-D)T_s = 0$$

$$\therefore \quad V_{c1} = \frac{1}{1-D} V_d$$

$$L_2: \quad (V_{c1} - V_d)DT_s + (-V_0)(1-D)T_s = 0$$

$$\therefore \quad V_{c1} = \frac{1}{D} V_0$$

Equating the above two equations,

$$\frac{V_0}{V_d} = \frac{I_d}{I_0} = \frac{D}{1-D}$$

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Comparison of Converters

- Buck converter: step-down, has one switch, simple, high efficiency greater than 90%, provides one polarity output voltage and unidirectional output current
- Boost converter: step-down, has one switch, simple, high efficiency, provides one polarity output voltage and unidirectional output current, requires a larger filter capacitor and a larger inductor than those of a buck converter
- Buck-boost converter: step-up/step-down, has one switch, simple, high efficiency, provides output voltage polarity reversal
- Cuk converter: step-up/step-down, has one switch, simple, high efficiency, provides output voltage polarity reversal, additional capacitor and inductor needed
- Full-bridge converter: four-quadrant operation, has multiple switches, can be used in regenerative braking

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Four Quadrant Operation of DC Motor Drive

There are four mode of operation

1) Forward Motoring
2) Forward Braking
3) Reverse Motoring
4) Reverse Braking

The dc motor can operate in either of these mode

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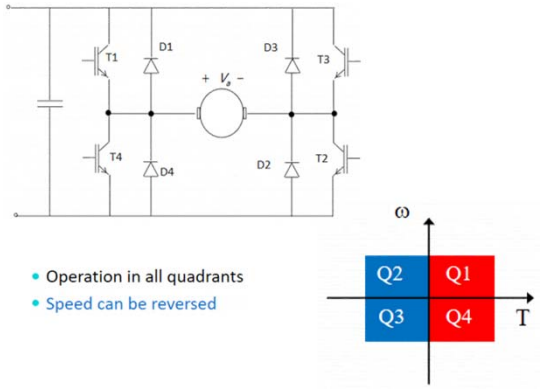
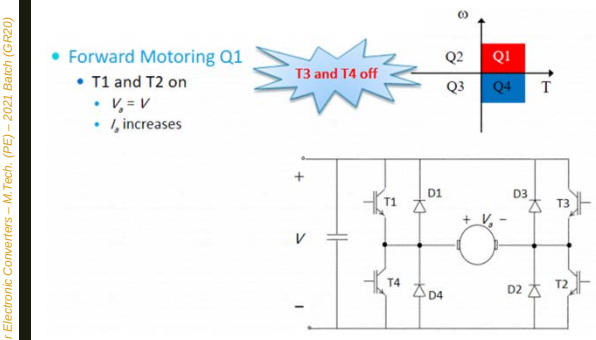


- Operation in all quadrants
- Speed can be reversed

37

- Forward Motoring Q1
  - T1 and T2 on
    - $V_a = V$
    - I_a increases

T3 and T4 off



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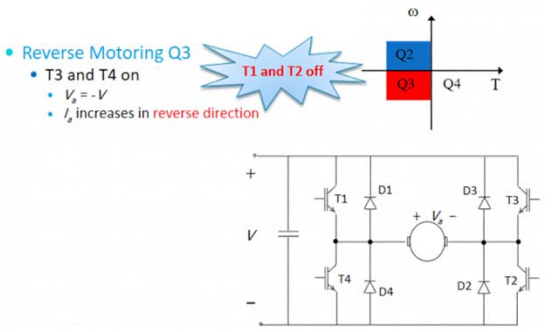
- Reverse Motoring Q3
  - T3 and T4 on
    - $V_a = -V$
    - I_a increases in reverse direction

T1 and T2 off



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Four quadrant operation of dc motor can be use for variable speed application.

- DC motor speed control is easy and smooth.
- DC motor can be use for both motoring and generating purpose.
- Direction of rotation of dc motor can be change by reversing the terminal polarity.
- So it can be use for clockwise and anti clockwise purpose.
- In first and third quadrant it act as motor in second and fourth quadrant it act as generator.
- Speed is varied by varying voltage level and direction can be control by changing polarities.
- The torque of a separately excited dc motor is directly proportional to the armature current .
- We can control positive or negative torque by controlling voltage.
- There are two e.m.f. one is terminal voltage and other is back e.m.f. .

40

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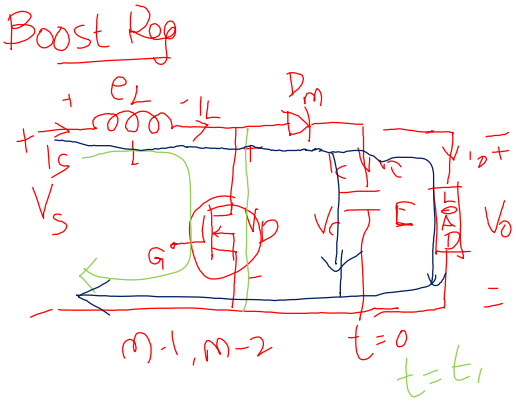

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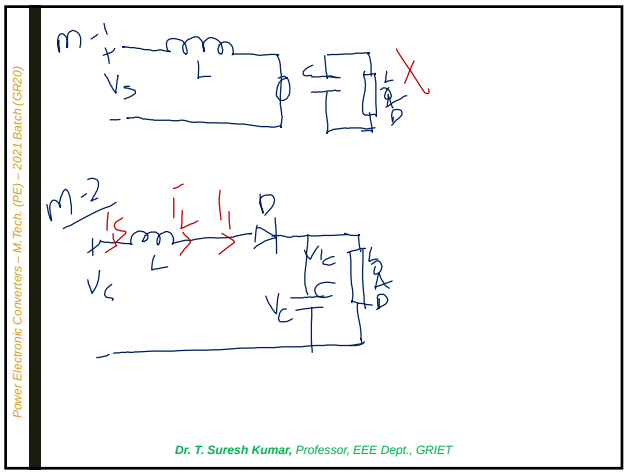

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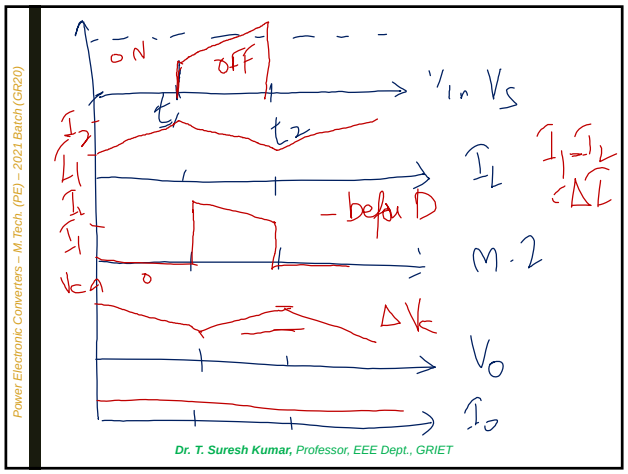

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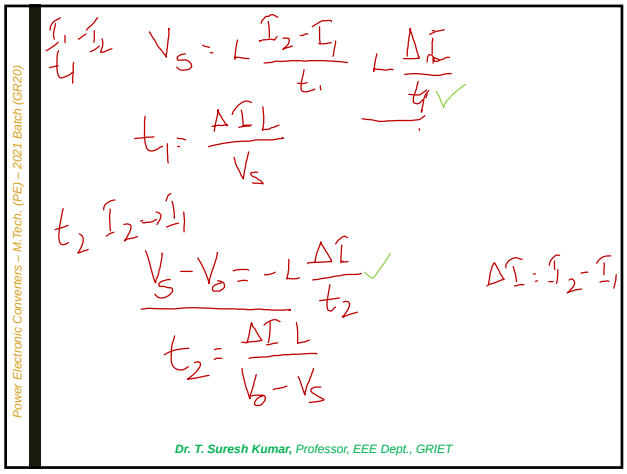


$$V_s = L\frac{I_2 - I_1}{t_1} = L\frac{\Delta I}{t_1}$$

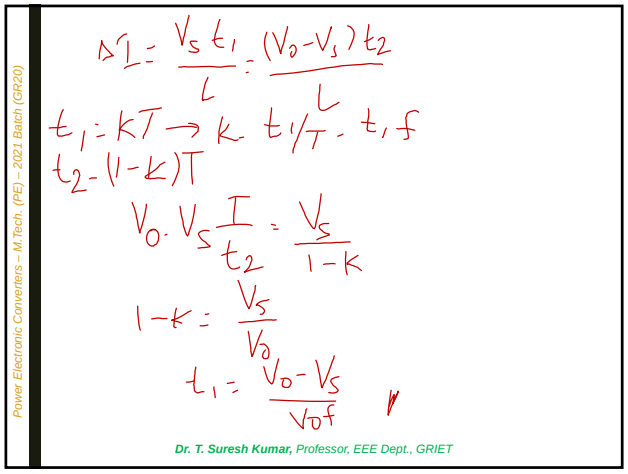
$$t_1 = \frac{\Delta I L}{V_s}$$

$$V_s - V_0 = -L\frac{\Delta I}{t_2}$$

$$t_2 = \frac{\Delta I L}{V_0 - V_s}$$

$\Delta I = I_2 - I_1$

45



$$\Delta I = \frac{V_s t_1}{L} = \frac{(V_0 - V_s) t_2}{L}$$

$t_1 = kT \rightarrow k = t_1/T$, $t_1 f$

$t_2 = (1-k)T$

$$\frac{V_0 \cdot V_s I}{t_2} = \frac{V_s}{1-k}$$

$$1-k = \frac{V_s}{V_0}$$

$$t_1 = \frac{V_0 - V_s}{V_0 f}$$

46

$$V_s I_s = V_0 I_0$$

$$= \frac{V_s I_0}{1-k}$$

$$I_s = \frac{I_0}{1-k}$$

$$T = \frac{1}{f} = t_1 + t_2 = \frac{\Delta I L}{V_s} + \frac{\Delta I L}{V_0 - V_s}$$

$$T = \frac{\Delta I L V_0}{V_s (V_0 - V_s)}$$

47

$$\Delta I = \frac{V_s (V_0 - V_s)}{f L V_0}$$

$$I_C = I_0 \quad \frac{\Delta I}{} = \frac{V_s (V_0 - V_s)}{f L}$$

$$\Delta V_C = v_c - v_c' \quad (t = t_1)$$

$$= \frac{1}{C}\int_0^{t_1} I_C dt = \frac{1}{C}\int_0^{t_1} I_0 = \frac{I_0 t_1}{C}$$

48

$$\Delta V_c = \frac{I_o(V_o - V_s)}{V_o f C}$$

$$\Delta V_c = \frac{I_o k}{fC}$$

Cont $\Delta I = 2 I_L$

$$\frac{k V_s}{fL} = 2 I_L = 2 I_o = \frac{2 V_s}{(1-k)R}$$

49

$$L_c = L = \frac{k(1-k)R}{2f}$$

$$\Delta V_c = 2 V_o$$

$$\frac{I_o k}{Cf} = 2 V_o = 2 I_o R$$

$$C_c = C = \frac{k}{2fR}$$

50

A boost regulator has a input voltage of 5V. The average output voltage is 15V and the average load current is 0.5A. The switching frequency is 25kHz. If L is 150microH and C is 220microF determine duty cycle (k), ripple current of inductor, peak current of inductor, ripple voltage of filter capacitor and critical values of L & C

$V_s = 5V$

$V_o = 15V$

$I_o = 0.5A$

$f = 25kHz$

$L = 150\mu H$

$C = 220\mu F$

$$V_o = \frac{V_s}{1-k}$$

$$15 = \frac{5}{1-k}$$

$k = 0.667$ 66.67%

51

$$\Delta I = \frac{V_s(V_o - V_s)}{f L V_o} = \frac{5(15-5)}{25000 \times 150 \times 10^{-6} \times 15} = 0.89A$$

$$I_s = \frac{I_o}{1-k} = \frac{0.5}{1-0.667}$$

$$I = I_s + \frac{\Delta I}{2} = 1.5A + \frac{0.89}{2} = 1.945A$$

52

$$\Delta V_c = \frac{I_o k}{fC} = \frac{0.5 \times 0.6667}{25000 \times 220 \times 10^{-6}} = 60.61mV$$

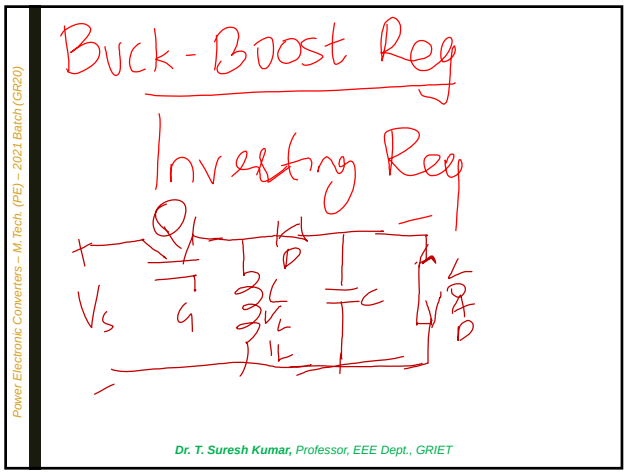
$$R = \frac{V_o}{I_o} = \frac{15}{0.5} = 30\Omega$$

53

$$L_c = \frac{k(1-k)R}{2f} = \frac{0.6667(1-0.6667) \times 30}{2 \times 25000} = 133\mu H$$

$$C = \frac{k}{2fR} = \frac{0.6667}{4 \times 25000 \times 30} = 0.44\mu F$$

54



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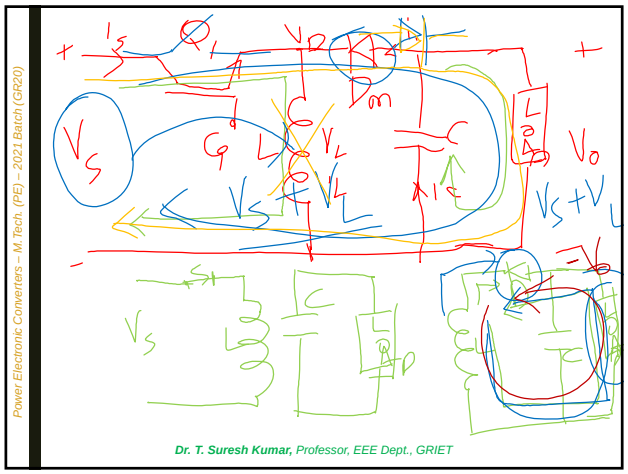

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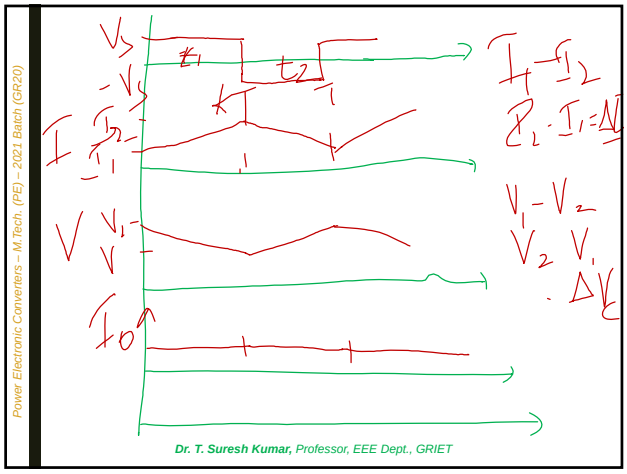

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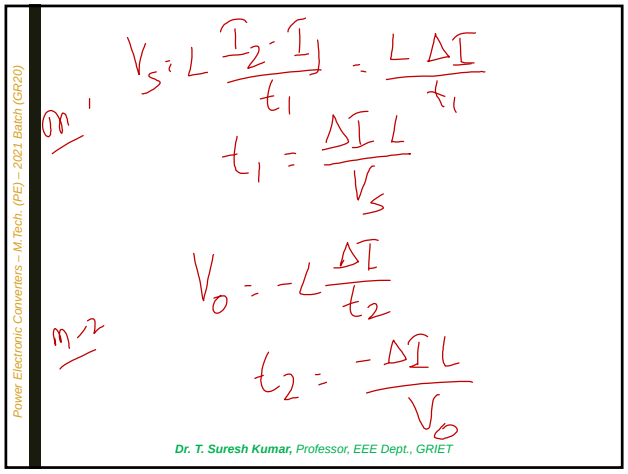

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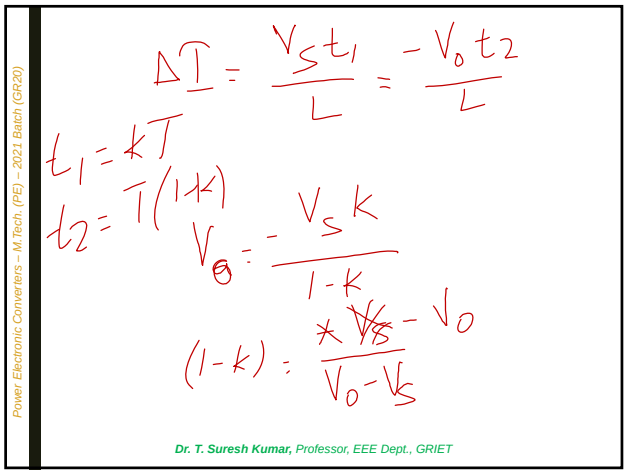

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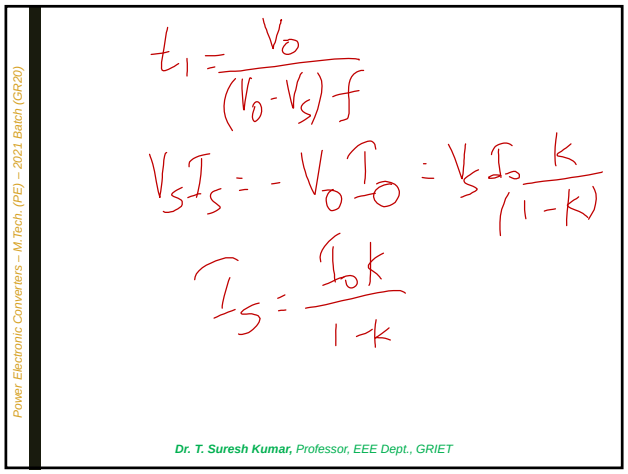


60

$$T = \frac{1}{f} = t_1 + t_2 = \frac{\Delta I L}{V_s} + \frac{\Delta I L}{V_0}$$

$$\frac{1}{f} = \frac{\Delta I L (V_0 - V_s)}{V_s V_0}$$

$$\Delta I = \frac{V_s V_0}{f L (V_0 - V_s)}$$

$$\Delta I = \frac{V_s k}{f L}$$

61

$$\Delta V_c = \frac{1}{C}\int_0^{t_1} I_0 \, dt$$

$$= \frac{1}{C}\int_0^{t_1} I_0 \, dt = \frac{I_0}{C} t_1$$

$$t_1 = \frac{V_0}{(V_0 - V_s) f} \qquad \Delta V_c = \frac{I_0 V_0}{(V_0 - V_s) f C}$$

$$\Delta V_c = \frac{I_0 k}{fC}$$

62

$$\Delta I = 2 I_L$$

$$\frac{k V_s}{f L} = 2 I_L = 2 I_0 = \frac{2 k V_s}{(1-k) R}$$

$$L_c = L = \frac{(1-k) R}{2 f}$$

63

$$\Delta V_c = 2 V_0$$

$$\frac{I_0 k}{Cf} = 2 V_0 = 2 I_0 R$$

$$C_c = C = \frac{k}{2 f R}$$

64

The buck regulator has an input voltage of 12V. The required average output voltage is 5V at R of 500 ohm and the peak to peak output ripple voltage is 20mV. The switching frequency is 25kHz. IF the peak to peak ripple current of inductor is limited to 0.8A determine

a. Duty cycle
b. Filter inductance
c. Filter capacitance
d. The critical values of L & C

$V_s = 12V$ $\quad \Delta V_c = 10mV$ $\quad f = 25kHz$ $\quad \Delta I = 0.8A$ $\quad R = 500\Omega$ $\quad V_0 = 5V$

$$k = \frac{V_0}{V_s} = \frac{5}{12} = 0.4167 = 41.67\%$$

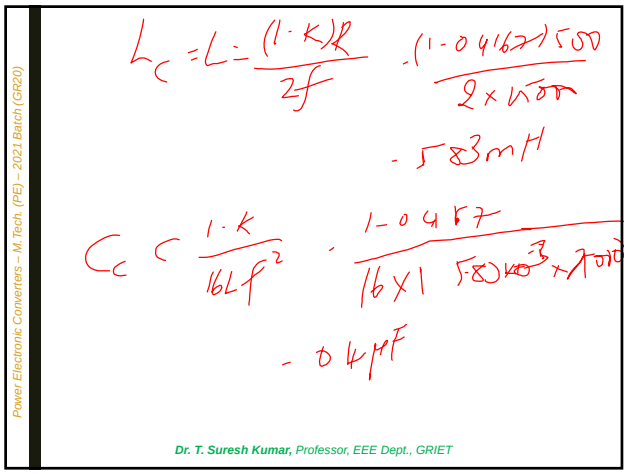
65

$$\Delta I = \frac{V_0 (V_s - V_0)}{f L V_s}$$

$$L = \frac{5(12-5)}{25000 \times 0.8 \times 12} = 145 \mu H$$

$$\Delta V_c = \frac{\Delta I}{8 f C} = \frac{0.8}{20 \times 10^{-3} \times 25000 \times 8} = 200 \mu F$$

66



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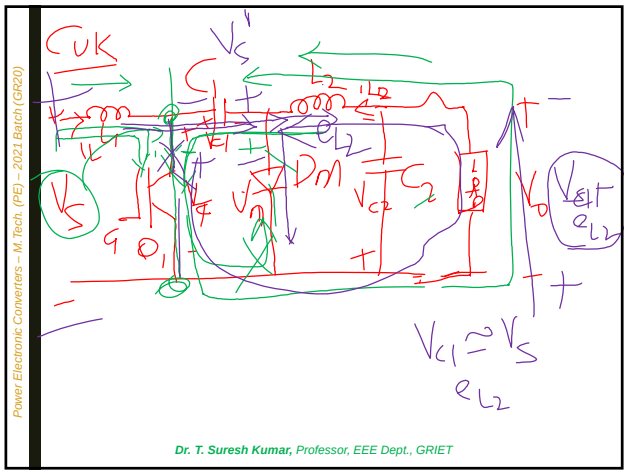

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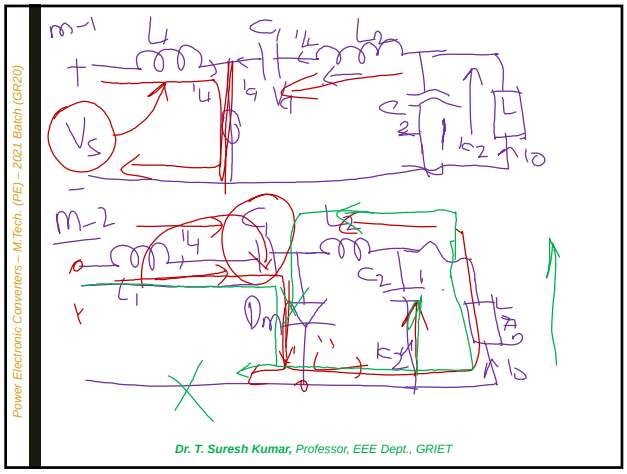

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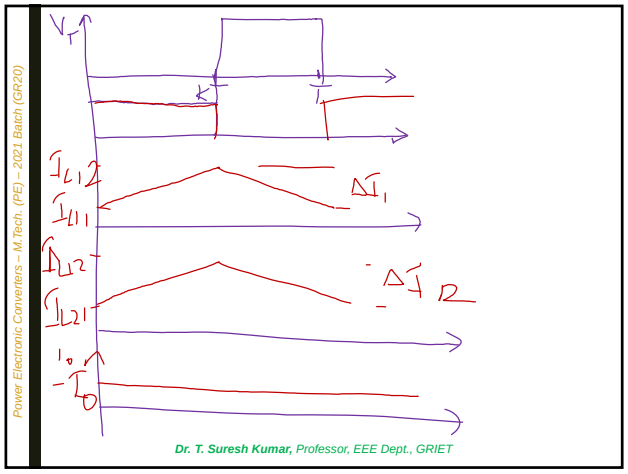

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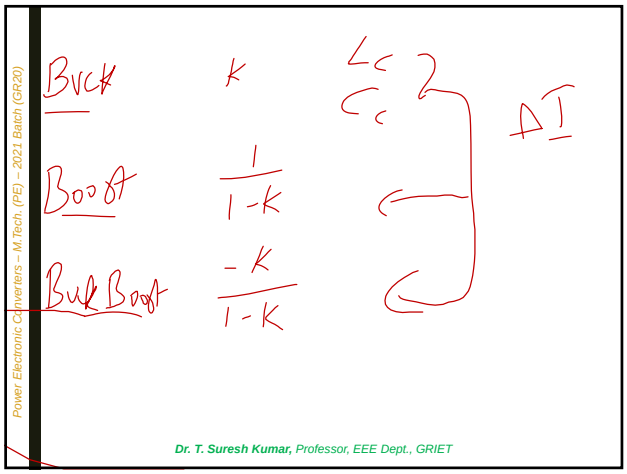

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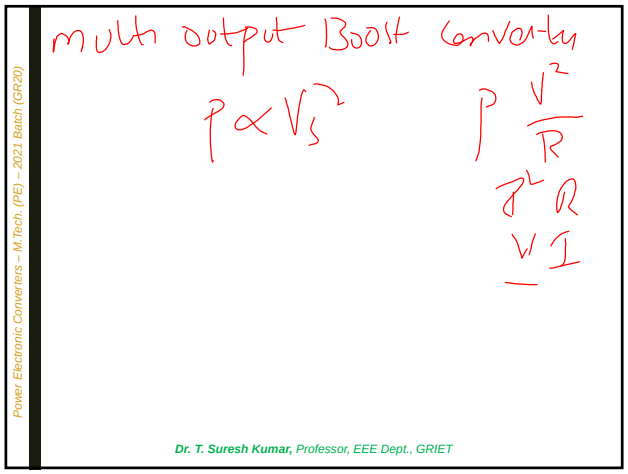

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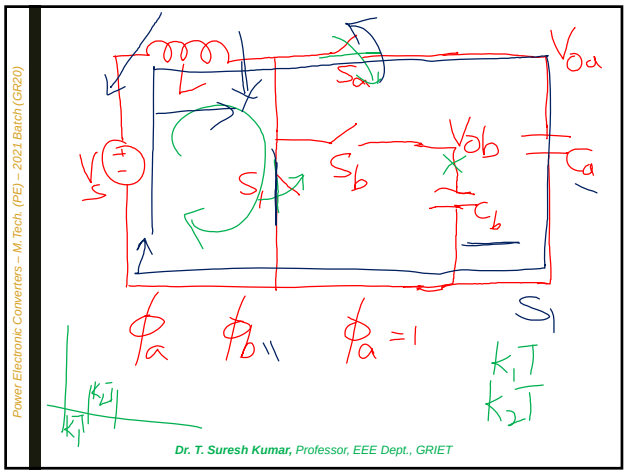
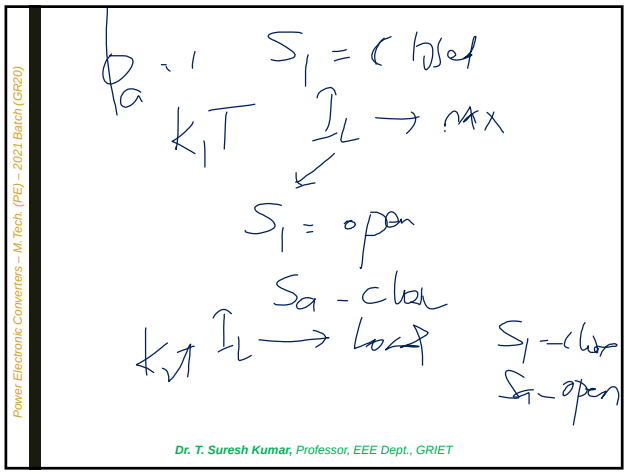
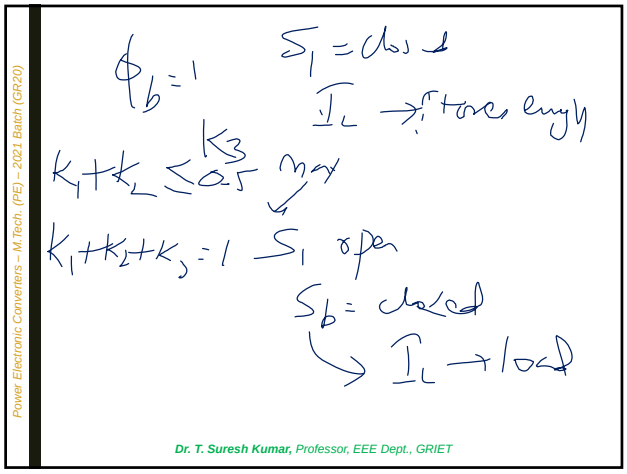
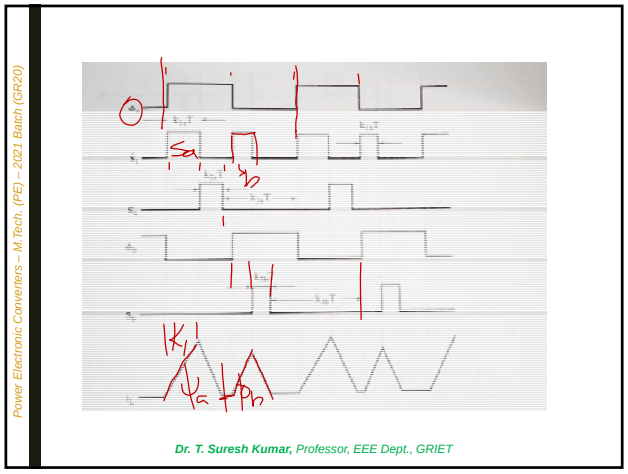

L
Sa
Vs
Sb
Vab
Cb
Ca
ϕ_a
$\phi_b = 1$
$\phi_a = 1$
S_1
k_1T
k_2T


$\phi_a = 1$
S_1 = closed
k_1T
$I_L \rightarrow$ max
S_1 = open
S_a - close
$k_1 \uparrow$ $I_L \rightarrow$ load
S_1 - close
S_a - open


$\phi_b = 1$
S_1 = closed
$I_L \rightarrow$ increasingly
$k_1 + k_2 \leq k_3$ max
$k_1 + k_2 + k_3 = 1$
S_1 open
S_b = closed
$I_L \rightarrow$ load


S_a
S_b
k_1
ϕ_a
ϕ_b

79

80

81

82

83

84

85

86

87

88

89

Unit – 3

PWM Techniques

Dr. T. Suresh Kumar, Professor, EEE Dept., GRIET

1

1. Single PWM
2. multiple PWM
3. Sinusoidal PWM
4. modified Sin PWM
5. Phase displacement Control

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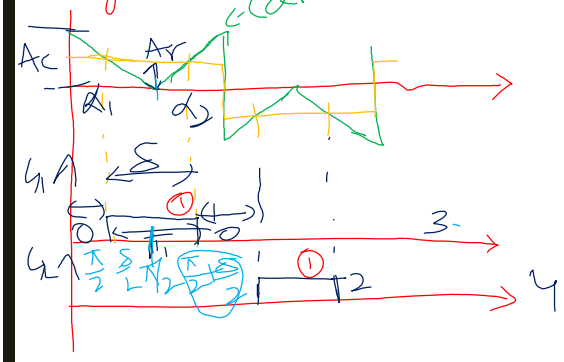
2

Single PWM — Carrier Wave



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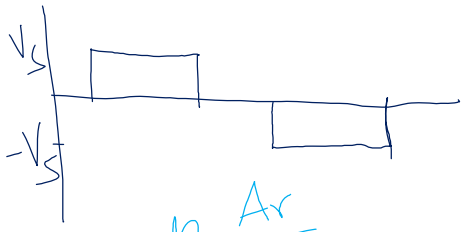
3



$$M = \frac{A_r}{A_c}$$

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4

$$V_0 = \left(\frac{2}{2\pi} \int_{\frac{\pi-\delta}{2}}^{\frac{\pi+\delta}{2}} V_s^2 \, d\omega t \right)^{1/2}$$

$$= V_s \sqrt{\frac{\delta}{\pi}}$$

$A_r \rightarrow 0$ to A_c

$\delta \rightarrow 0$ to π

0 to V_s

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5

$$V_0(t) = \sum_{n=1,3,5,\ldots}^{\infty} \frac{4V_s}{n\pi} \sin\frac{n\delta}{2} \sin n\omega t$$

$$d = \frac{\delta}{\omega} = t_2 - t_1 = MT_s$$

$$T_s = T/2$$

$$d = \frac{MT}{2} = \frac{\delta}{\omega}$$

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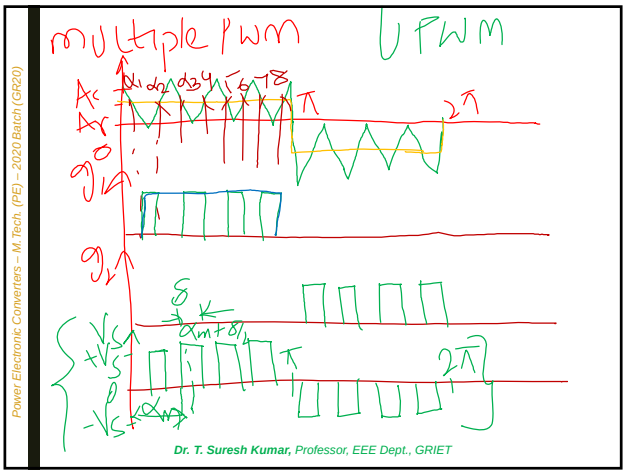
6

1 Gen triangle Carrier signal
$T_1 = T/2$
Compare Carrier with ref signal
$V_p = V_c - V_r$
g_1 [illegible]

7



8

$P = \frac{f_c}{2f_0} = \frac{m_f}{2}$

$m_f = \frac{f_c}{f_0}$ + ve mod ratio

$V_0 = V_s(g_1 - g_2)$

9

$V_0 = \left[\frac{2p}{2\pi}\int_{(\pi/p-\delta)/2}^{(\pi/p+\delta)/2} V_s^2\, d\omega t\right]^{1/2}$

$= V_s\sqrt{\frac{p\delta}{\pi}}$

m → control of T/p $(0 \text{ to } \frac{\pi}{p})$

$V_0 = 0$ to V_s

10

$v_0(t) = \sum_{n=1,3,5} B_n \sin n\omega t$

$\omega t = \alpha_m$

$b_n = \frac{2}{\pi}\left[\int_{\alpha_m+\frac{\delta}{2}}^{\alpha_m+\delta} \sin n\omega t\, d\omega t - \int_{\pi+\alpha_m}^{\pi+\alpha_m+\frac{\delta}{2}} \sin n\omega t\, d\omega t\right]$

$= \frac{4V_s}{n\pi}\sin\frac{n\delta}{4}\left[\sin n\left(\alpha_m + \frac{3\delta}{4}\right) - \sin n\left(\pi + \alpha_m + \frac{\delta}{4}\right)\right]$

11

$B_n = \sum_{m=1}^{2p} \frac{4V_s}{n\pi}\sin\frac{n\delta}{4}\left[\sin n\left(\alpha_m + \frac{3\delta}{4}\right) - \sin n\left(\pi + \alpha_m + \frac{\delta}{4}\right)\right]$

1, 3, 5, 7

2, 4, 6, 8 → absent

$v_0(t) = \sum A_n \cos n\omega t + B_n \sin n\omega t$

$A_n = 0$

1, 3, →

12

$t_m = \frac{\alpha_m}{\omega} = (m-M)\frac{T_s}{2}$

$m = 1, 3, \ldots 2p$

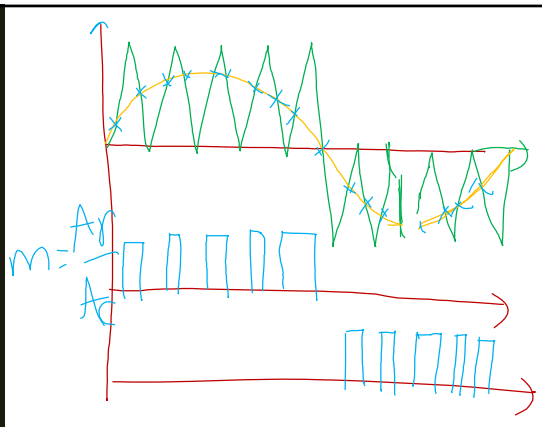
$\alpha = \frac{\delta}{\omega} = t_{m+1} - t_m$

$= MT_s$

$T_s = T/2p$

13

14



15

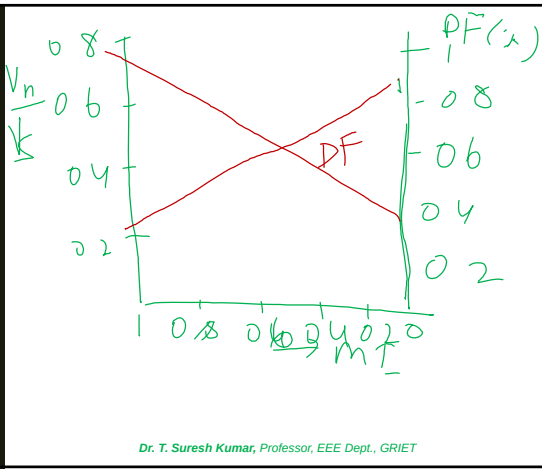
$V_o = V_s(g_1 - g_2)$

$V_o = V_s\left(\sum_{m=1}^{2p}\frac{\delta_m}{\pi}\right)^{1/2}$

$B_n = \sum_{m=1}^{2p}\frac{4V_s}{n\pi}\sin\frac{n\delta_m}{4}\left[\sin n\left(\alpha_{m+}\frac{3\delta_m}{4}\right) - \sin n\left(\pi+\alpha_{m+}\frac{\delta_m}{4}\right)\right]$

$n = 1, 3, 5$

16



17

MATRIX CONVERTER

(AC-AC CONVERTER)

1

PRESENTATION OUTLINE

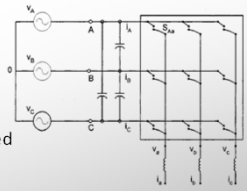
1. Introduction
2. Advantages
3. Fundamental of Operation
4. Practical Issue
5. Conclusion

2

2

INTRODUCTION

- Matrix converter is a type of direct ac-ac converter
- Does not need any large energy storage elements
- Uses an array of bi-directional fully controlled switches
- Does not use dc-link circuit
- Replaces multiple power conversion into a single power conversion stage



3

3

ADVANTAGES

- ✓ Simple and compact power circuit
- ✓ No limit on output frequency and amplitude
- ✓ Sinusoidal input and output waveforms, with minimal higher order of harmonics
- ✓ Input power factor can be fully controlled
- ✓ Inherent bidirectional energy flow capability

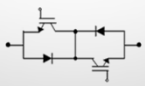
4

4

FUNDAMENTAL OF MATRIX CONVERTER

- Bidirectional switch topology
  - capable of blocking voltage and conducting current in both directions
  - type of switches:-

Diode bridge with a single diode



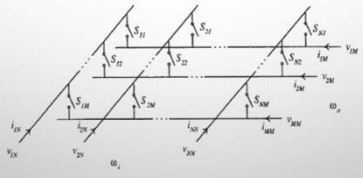
Two anti-parallel IGBT with series diode

Two anti-parallel NPN-IGBT's with reverse blocking capability

5

5

- Matrix converter topology
  - n*m bidirectional power switches; n-phase voltage source to m-phase load



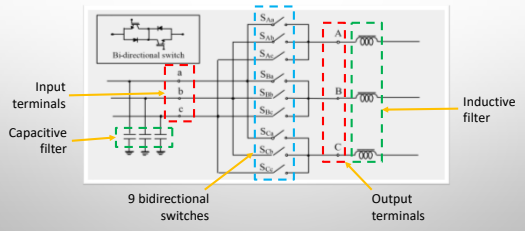
6

6

- Type of configuration
  (based on number of input and output phases) :-
  - Single phase
  - Three phase to single phase
  - **Three phase to three phase**

7

3-PHASE TO 3-PHASE MATRIX CONVERTER



8

- Due to switching states combinations, two basic rules have to apply:-
  - ✓ Input phase should never be short-circuited
  - ✓ Output current should not be interrupted
- This imply that only one bidirectional switch per output phase must be switched on at any instant and thus, only 27 switches are allowed in the switching combinations.

9

- Operation system
  - Relationship between input and output voltages:-
    $V_o = T * V_i$;where T = instantaneous transition matrix

$$\begin{pmatrix} V_A(t) \\ V_B(t) \\ V_C(t) \end{pmatrix} = \begin{pmatrix} S_{aA}(t) & S_{bC}(t) & S_{cA}(t) \\ S_{aB}(t) & S_{bB}(t) & S_{cB}(t) \\ S_{aC}(t) & S_{bC}(t) & S_{cC}(t) \end{pmatrix} \begin{pmatrix} V_a(t) \\ V_b(t) \\ V_c(t) \end{pmatrix}$$

10

- Relationship between input and output current:-
  $I_i = T^T * I_o$;where T^T = transpose matrix of T

$$\begin{pmatrix} I_a(t) \\ I_b(t) \\ I_c(t) \end{pmatrix} = \begin{pmatrix} S_{aA}(t) & S_{aB}(t) & S_{aC}(t) \\ S_{bA}(t) & S_{bB}(t) & S_{bC}(t) \\ S_{cA}(t) & S_{cB}(t) & S_{cC}(t) \end{pmatrix} \begin{pmatrix} I_A(t) \\ I_B(t) \\ I_C(t) \end{pmatrix}$$

11

- Defining the switching function of a single switch:-

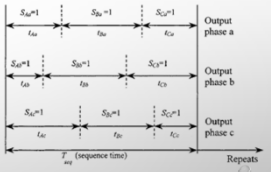
$$S_{ij} = \begin{cases} 1 \text{ ; switch closed} \\ 0 \text{ ; switch opened} \end{cases}$$

  where i = (a, b, c) and j = (A, B, C)
- Then expressed as $S_{aj} + S_{bj} + S_{cj} = 1$ (avoid short-circuited)

12

SWITCHING PATTERN

- In order to derive the modulation rules, consider the switching pattern.
- Note that the bidirectional switches work with high switching frequency.
- Hence, low frequency output voltage can be produced by modulated the cycle of the switch S_{ij} using respective switching functions.



Switching pattern typical form

13

13

- Low frequency transfer matrix can be defined by;

$$M(t) = \begin{pmatrix} m_{aA}(t) & m_{bA}(t) & m_{cA}(t) \\ m_{aB}(t) & m_{bB}(t) & m_{cB}(t) \\ M_{aC}(t) & m_{bC}(t) & m_{cC}(t) \end{pmatrix}$$

- Low frequency component of output phase voltage;

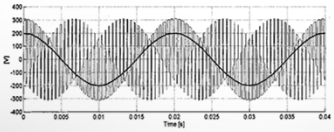
$$V'_o(t) = M(t) * V_i(t)$$

- Low frequency component of input current;

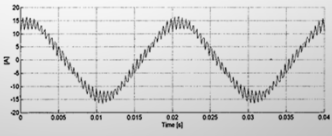
$$I'_i(t) = M^T(t) * I_o(t)$$

14

14



Waveform of output phase voltage



Waveform of input current

15

15

PRACTICAL ISSUE

1. Input Filters

   Filter Must be used at input to reduce switching harmonics present in the input current

   - Have Cutoff frequency lower than switching frequency
   - To minimize its reactive power at the grid frequency
   - To minimize the volume and weight for capacitor and chokes

16

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2. Overvoltage Protection
   - Appear from input, originated by line distresses.
   - Appear at output side, cause by overcurrent fault.
   - When switch off, load current interrupted, energy stored in motor inductance has to discharged without creating dangerous over voltages.

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CONCLUSION

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