



INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

COURSE CONTENT

POWER ELECTRONICS LABORATORY								
V Semester: EEE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P		C	CIA	SEE
AEEC21	Core	-	-	3	1	40	60	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45			Total Classes: 45			
Prerequisite: There are no prerequisites to take this course								

I. COURSE OVERVIEW:

This course is to provide a practical learning environment for students and researchers to understand the principles of power electronics. The laboratory enables hands-on learning experiences, allowing students to build, test, and troubleshoot power electronic circuits and systems. Power electronics is widely used in motor drives for controlling the speed and torque of electric motors. This is essential in various industries, including manufacturing and transportation.

II. COURSES OBJECTIVES:

The students will try to learn

1. The fundamental of power electronics concepts, including semiconductor devices, power semiconductor switches, and basic converter topologies.
2. The circuit design, simulation power electronic circuits and systems using appropriate software tools
3. The design analysis of prototype power electronic circuits using power diodes, thyristors, transistors, and integrated circuits.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

- CO 1: Understand the operation of SCR, MOSFET and IGBT for obtaining static voltage - current characteristics.
- CO 2: Utilize the forced commutation circuits and gate firing circuits for turning off and on of the SCR.
- CO 3: Analyze the input and output waveforms of controlled rectifier circuits for determining the output voltages.
- CO 4: Construct the various inverter circuits for direct current to Alternating current conversion.
- CO 5: Demonstrate the performance characteristics of ac-to-ac converters for getting variable output voltage using hard ware and modern tools.
- CO 6: Develop the chopper circuits for measuring output voltage and current.

DO's

1. Once the operation is completed pull the plug itself rather chord attached to it.
2. To repair the equipment switch-off the supply and go on.
3. To operate the equipment on supply, see that hands are dry, if that is not possibly hide the hand in the pockets.
4. If a person comes in contact with current unexpectedly don't touch the person with hands but immediately use any insulator material and shut down the power (like leather belts, wood and plastic bars etc).
5. If water is nozzles on the equipment, immediately shunt down the power using circuit breaker or pull out the plug.
6. Use the connecting wires of good continuity, short circuit of connecting wire leads damage of circuit parameters

DON'Ts

1. Do not wear loose clothing and do not hold any conducting materials in contact with skin when the power is on.
2. Do not pull out the connections until unless all the currents are dead.
3. Do not wait for switches to de-magnetize when there is a delay but pull out the plug.
4. Do not overload the circuit by plugging in too many appliances.
5. If you are mentally and physically stressed don't operate the power equipment.
6. Never operate the equipment under wet conditions.
7. Do not interconnect two or more wires, take appropriate length of wire.

SAFETY NORMS

1. The lab must be equipped with fire extinguisher.
2. See that the connections are made tight.
3. Use single plug for each equipment.
4. Cover the body completely to avoid arc effect.
5. To change the connections during the experiment, switch off the supply and carry on.
6. Used equipment may get heated, so take care handling the equipment after it is used.
7. Do the wiring, all set ups and check the circuit connections before the supply is on

IV. COURSE SYLLABUS:

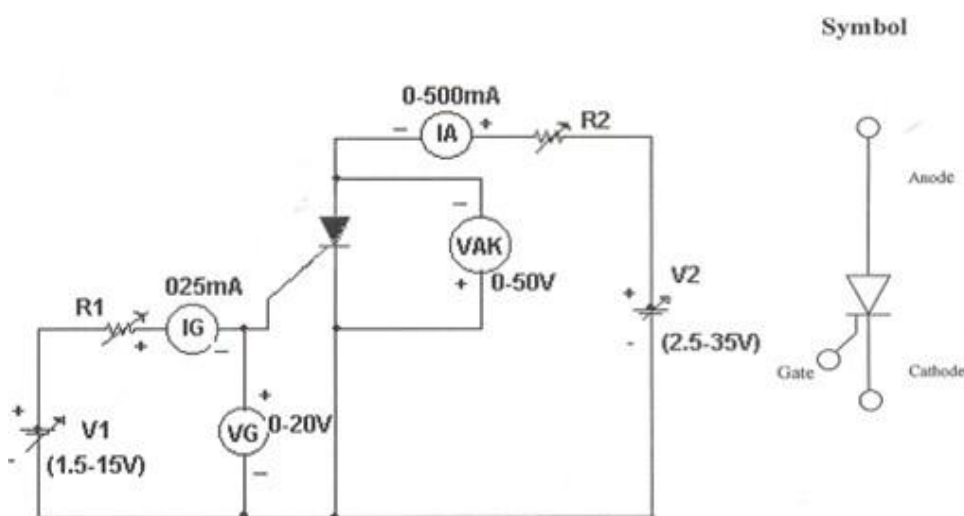
EXERCISES FOR ELECTRICAL CIRCUITS LABORATORY

Note: Students are encouraged to bring their own laptops for laboratory practice session

1. Getting Started Exercises

1.1 Study the characteristics of SCR

1. Understand operating four modes of SCR: forward blocking, forward conduction, reverse blocking, and reverse conduction.

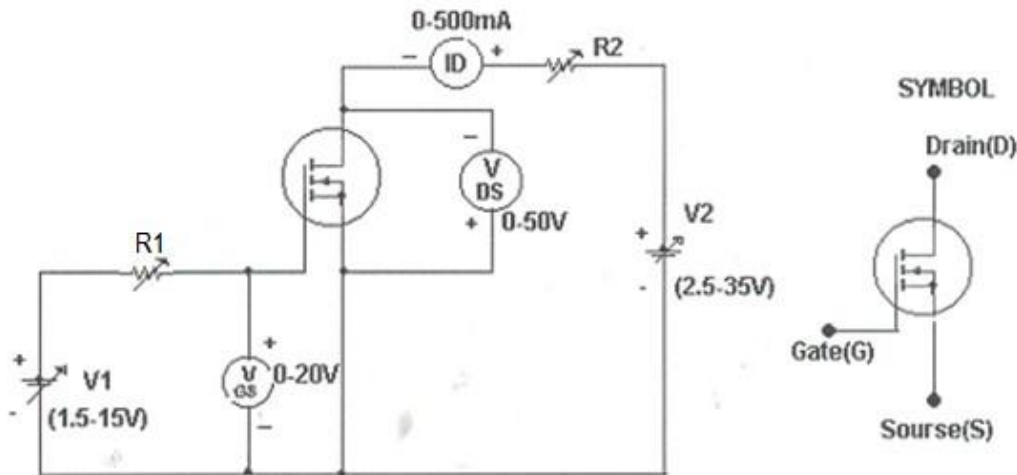


Try

1. Examine the V-I Characteristics of SCR at different values of gate currents ($I_g=2A$, $4A$, $6A$ and $8A$)

1.2 Study the characteristics of MOSFET

1. MOSFET is a voltage-controlled device with three terminals: gate, source, and drain.
2. It operates based on the voltage applied to the gate, modulating the conductivity between the source and drain.

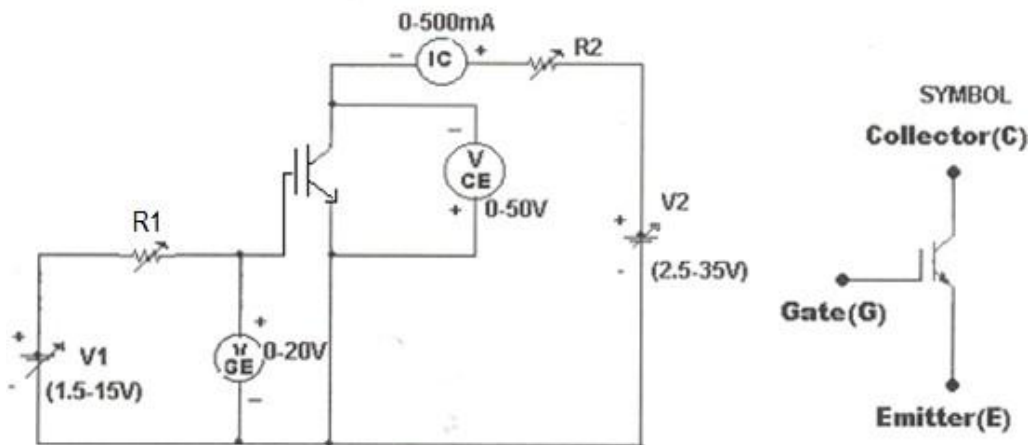


Try

1. Draw the transfer characteristics by varying Gate source voltage V_{GS} (10v,20v and 30v) and Note down I_D and V_{DS} readings for each step.
2. Draw the output characteristics by varying Drain source voltage V_{DS} (10v,20v and 30v) and Note down I_D and V_{GS} readings for each step

1.3 Study the characteristics of IGBT

1. IGBT combines the voltage-controlled operation of a MOSFET with the current-carrying capability of a bipolar transistor.



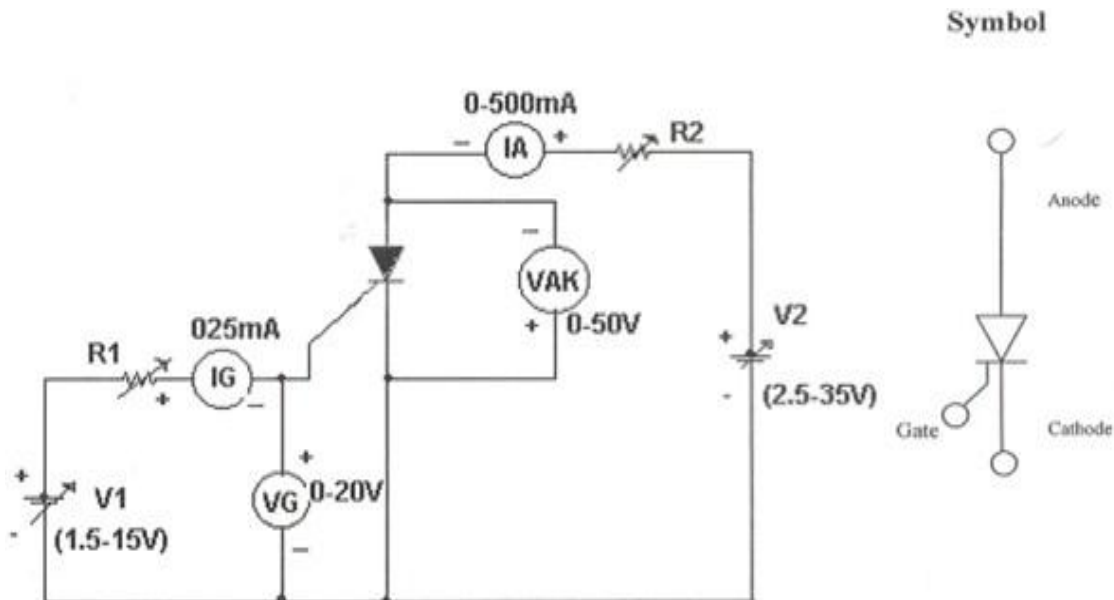
Try

1. Draw the transfer characteristics by varying Gate emitter voltage V_{GE} (10v,20v and 30v) and Note down I_C and V_{CE} readings for each step.
2. Draw the output characteristics by varying Drain source voltage V_{CE} (10v,20v and 30v) and Note down I_C and V_{GE} readings for each step

2. Gate firing circuits for SCRS

2.1 R-C Triggering

R-C Triggering is the turning on process of SCR, it Combines a resistor (R) and a capacitor (C) to form an RC network.

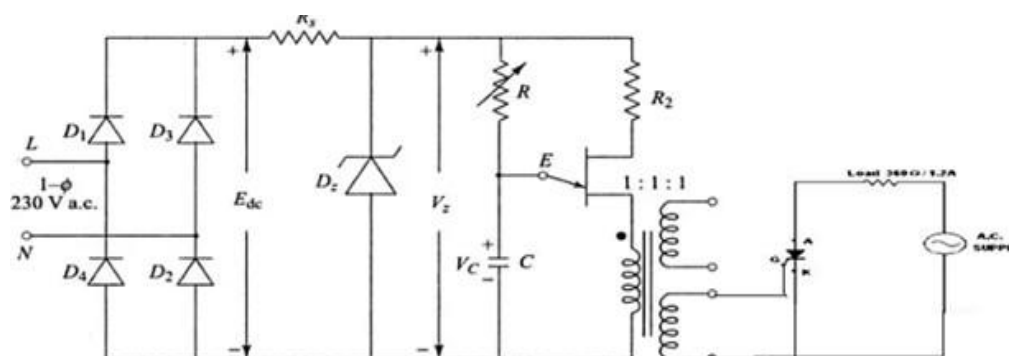


Try

1. Slowly vary the control Resistor R_C , that firing angle can vary from 0° - 180° .
2. Observe various voltage waveforms across load, SCR and other points, by varying the Load Resistance and Firing RC part.

2.2 UJT Triggering

The UJT generates a voltage pulse when triggered by an external voltage and this pulse is used to trigger the SCR



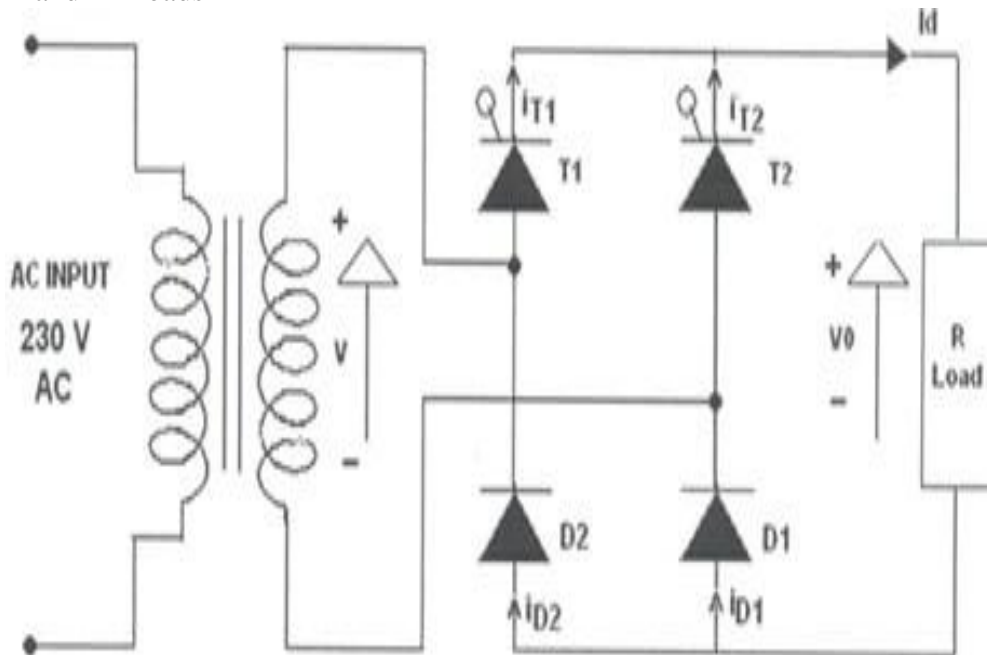
Try

1. Varying the variable resistor R_C and resistance load, observe firing angle of SCR. Check the waveforms for large value of R_C and small value of R_C and also triggering points of SCR.

3. Single phase half-controlled bridge converter

Half bridge converter

Examine the waveforms and operation of single-phase half-controlled bridge converter with R and RL loads



Try:

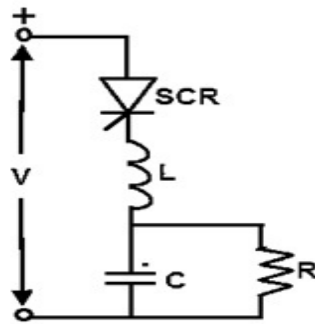
1. Conduct experiment on single phase half bridge rectifier at different firing angles ($\alpha=30^\circ, 60^\circ$ and 90°) and observe the waveforms
2. Determine output voltage and currents with different loads (R, R-L and R-L-E)

4. Forced commutation circuits

1. Forced commutation circuits are used in power electronics to turn off or commute semiconductor devices like thyristors (SCRs) and ensure their controlled turn-off.
2. Commutation is the process of turning off a semiconductor device after it has been turned on.
3. Forced commutation is necessary in applications where natural commutation methods are not sufficient or not possible.

4.1 Class – A Commutation

1. If thyristor is triggered or turned on, then anode current will flow by charging capacitor C with dot as positive.
2. The second-order under-damped circuit is formed by the inductor or AC resistor, capacitor, and resistor.
3. If the current builds up through SCR and completes the half-cycle, then the inductor current will flow through the SCR in the reverse direction which will turn off the thyristor.

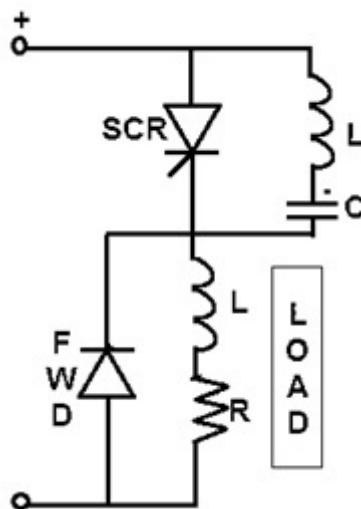


Try:

1. Observe the voltage waveform across load by varying frequency potentiometer.
2. Observe the voltage waveforms for different values of L, C and R.

4.2 Class – B Commutation

1. If sinusoidal current flows through the resonant L-C circuit, then the capacitor C is charged up with dot as negative at the end of the half-cycle.
2. The total current flowing through the SCR becomes zero with the reverse current flowing through the SCR opposing the load current for a small fraction of the negative swing. If the resonant circuit current or reverse current becomes just greater than the load current, then the SCR will be turned OFF.

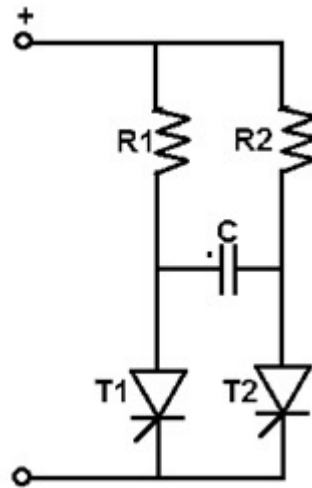


Try:

1. Observe the voltage waveform across load by varying frequency potentiometer.
2. Observe the voltage waveforms for different values of L, C and R.

4.3 Class – C Commutation

1. If the thyristor T2 is triggered, then the capacitor will be charged up. If the thyristor T1 is triggered, then the capacitor will discharge and this discharge current of C will oppose the flow of load current in T2 as the capacitor is switched across T2 via T1.

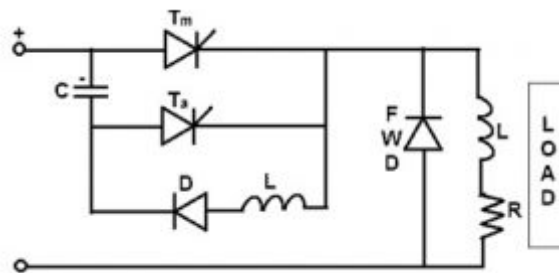


Try:

1. Observe the waveforms across R1, R2 and C by varying frequency and also duty cycle potentiometer
2. Observe the voltage waveforms for different values of L, C and R.

4.4 Class – D Commutation

1. By triggering the Ta (auxiliary thyristor) the capacitor is charged up to supply voltage and then the Ta will turn OFF. The extra voltage if any, due to substantial inductance in the input lines will be discharged through the diode-inductor-load circuit.
2. If the Tm (main thyristor) is triggered, then the current will flow in two paths: commutating current will flow through the C-Tm-L-D path, and load current will flow through the load. If the charge on the capacitor is reversed and held at that level using the diode and if Ta is re-triggered, then the voltage across the capacitor will appear across the Tm via Ta. Thus, the main thyristor Tm will be turned off.

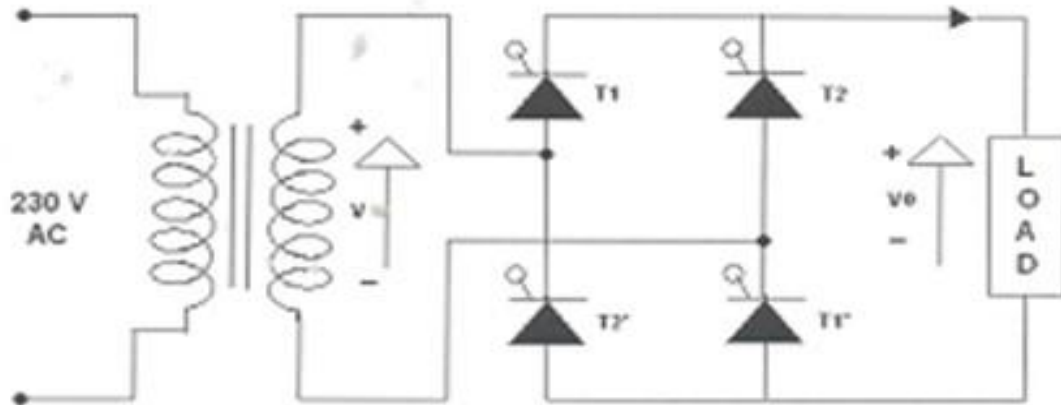


1. Observe the waveforms across thyristors with different loads
2. Observe the voltage waveforms for different values of L, C and R

5. Single phase full controlled bridge converter

1. In a fully controlled converter, the output voltage can be controlled by controlling the firing delay angle of the thyristors. Thyristors T1 and T2 are fired together while T3 and T4 are fired 180 after T1 and T2.

- Depending on the load condition and the firing angle a fully controlled bridge converter can operate either in the continuous conduction mode or in the discontinuous conduction mode. Find load or unknown current through RL resistor using Norton's equivalent circuit.

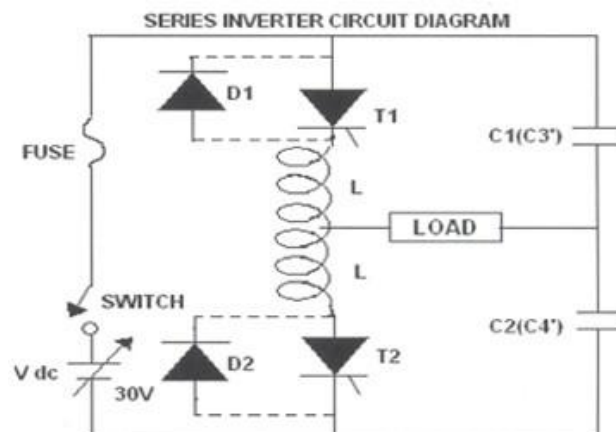


Try

- Conduct experiment on single phase half bridge rectifier at different firing angles ($\alpha=30^\circ, 60^\circ$ and 90°) and observe the waveforms
- Determine output voltage and currents with different loads (R, R-L and R-L-E)

6. Series Inverter

Inverter is used to convert the direct current (DC) to alternating Current (AC) of required voltage. In series inverter, the commutating elements L and C are connected in series with the load. This constitutes a series RLC resonant circuit and waveforms of series inverter with R and RL loads are observed.

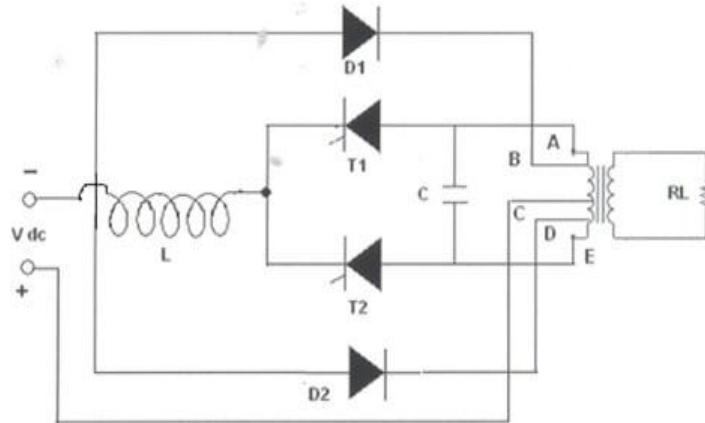


Try

- By varying the frequency potentiometer, observe related waveforms.
- If the inverter frequency is increases above the resonant frequency of the power circuit commutation fails. Then switch OFF the DC supply, reduce the inverter frequency and try again.
- Observe the waveforms for different value of L, C loads with and without fly wheel diodes.

7. Parallel Inverter

Inverter is used to convert the direct current (DC) to alternating Current (AC) of required voltage. In parallel inverter, the commutating elements L and C are connected in parallel with the load. This constitutes a parallel RLC resonant circuit and waveforms of series inverter with R and RL loads are observed.



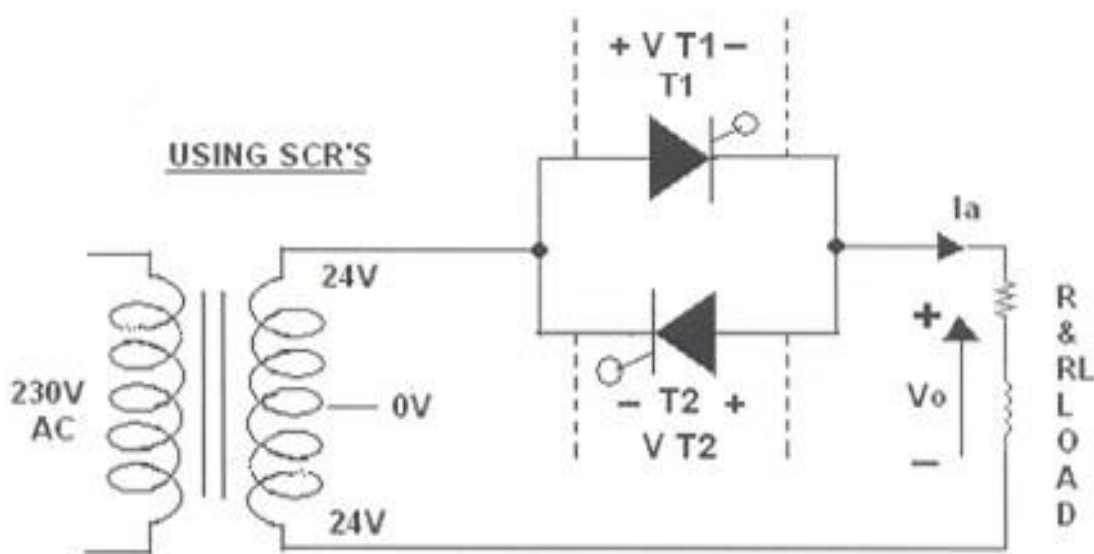
Try

1. Observe the output voltage waveforms across load by varying the frequency potentiometer.
2. Observe the waveforms for different value of L, C load values.

8. Single phase A.C. voltage controller

A.C. Voltage Controller

Single Phase AC Voltage Controller is a device which converts fixed single phase alternating voltage directly to a variable alternating voltage without a change in frequency. Output waveforms of Single-phase AC Voltage Controller with R and RL loads are observed.

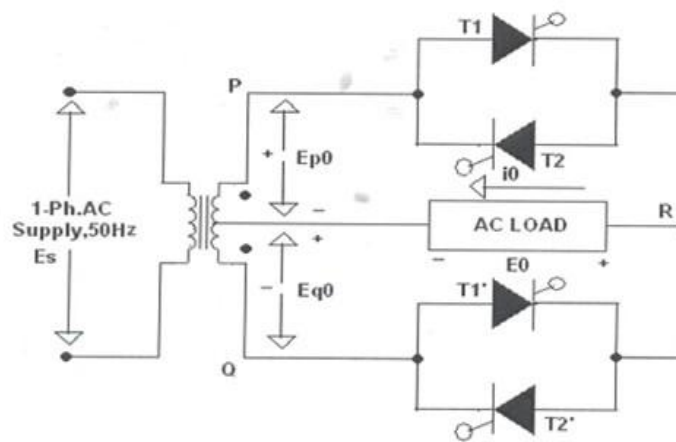


Try

1. Examine AC Voltage Controller at different firing angles ($\alpha=30^\circ, 60^\circ$ and 90°) and observe the waveforms
2. Determine output voltage and currents with different loads (R, R-L and R-L-E)

9. Single phase cycloconverter

The Cycloconverter has four thyristors divided into a positive and negative bank of two thyristors each. When positive current flows in the load, the output voltage is controlled by phase control of the two positive bank thyristors whilst the negative bank thyristors are kept off and vice versa when negative current flows in the load. Observe the waveforms of Single Phase cycloconverter with R and RL loads.

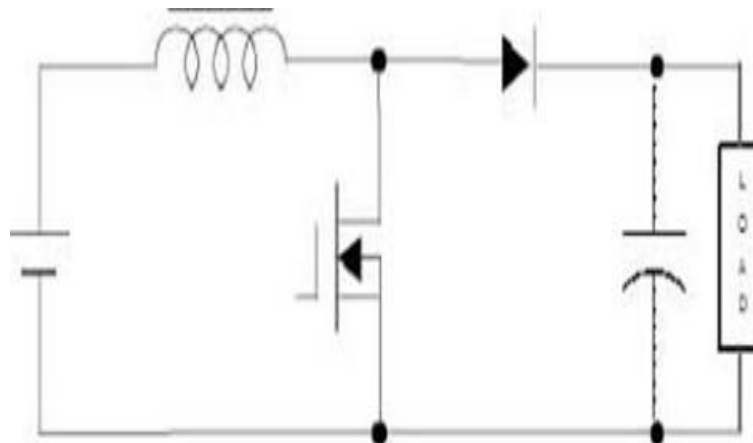


Try

1. Examine Cycloconverter at different firing angles ($\alpha=30^\circ, 60^\circ$ and 90°) and observe the waveforms
2. Determine output voltage and currents with different loads (R, R-L and R-L-E)

10. Operation of MOSFET based chopper

Choppers are used to step up and step down the DC power. They change the fixed DC power to variable DC power. Using these, DC power supplied to the devices can be adjusted to the required amount. Output Waveforms of MOSFET based chopper circuit at different loads observed.

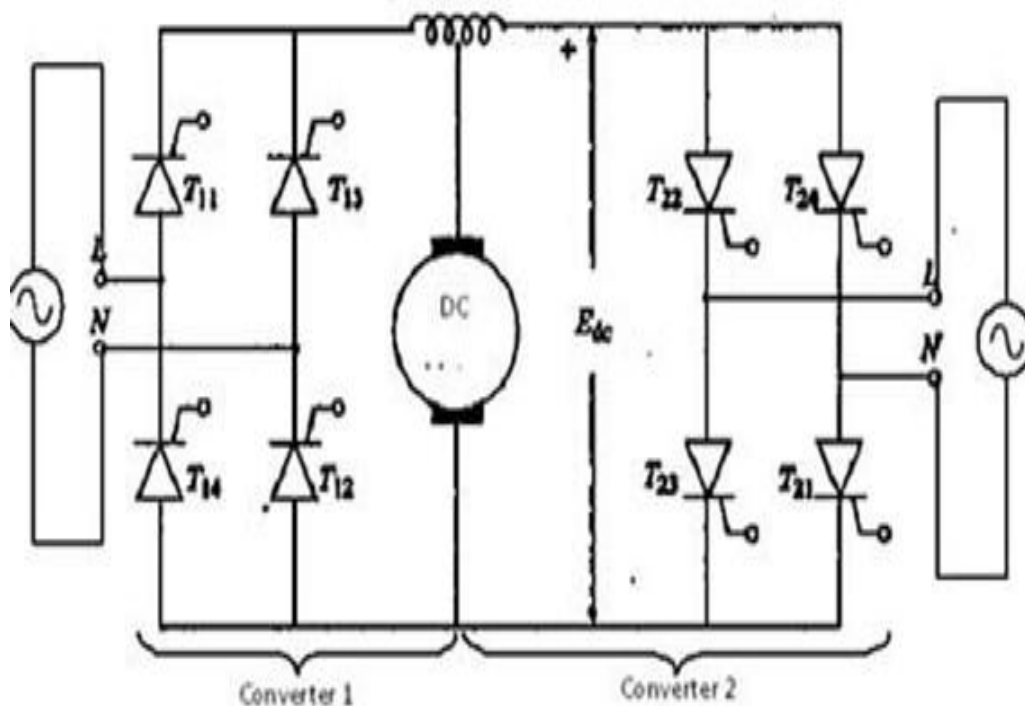


Try

1. Keep the duty cycle at mid position and vary the frequency from minimum to maximum and record the output voltage readings.
2. Keep the frequency at mid position, vary duty cycle from minimum to maximum and output voltage readings

11. Single phase dual converter

Dual Converter is an Electronic Device or Circuit made by the combination of two bridges. One of them works as Rectifier (Converts A.C. to D.C.) and other bridge works as Inverter (converts D.C. into A.C.). Thus, an electronic circuit or device, in which two processes take place at same time, is known as Dual Converter. Observe the output waveforms of single-phase dual converter at different loads.

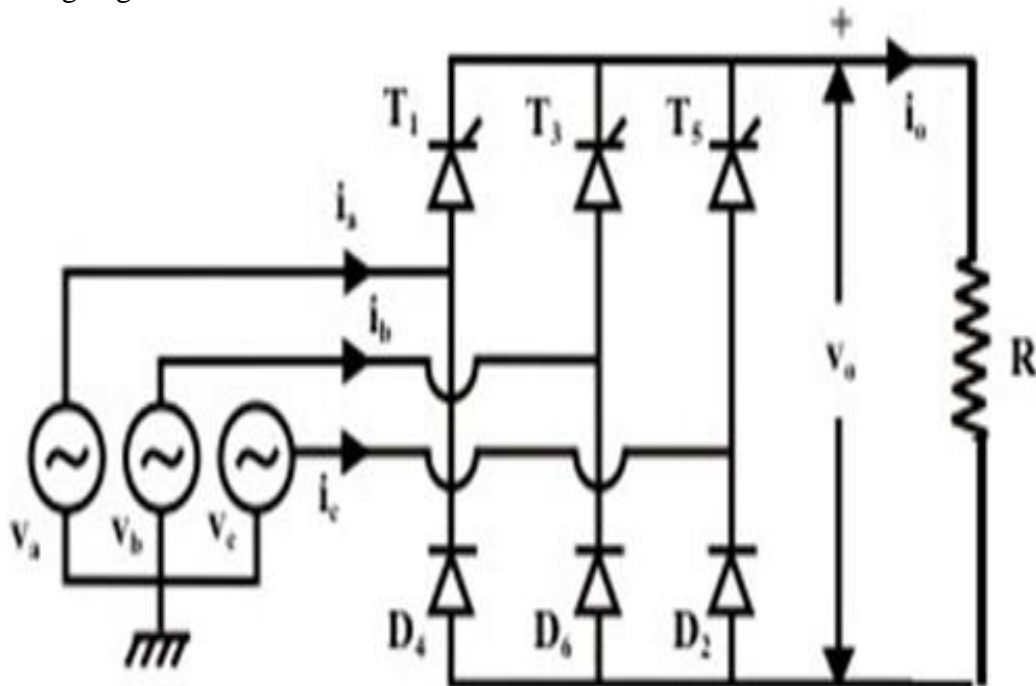


Try

1. By varying firing angle gradually from 0° to 180° and observe related waveforms.
2. Determine output voltage and currents with different loads (R, R-L and R-L-E)

12. Three phase half-controlled bridge converter

Calculate Output voltage and load current of three phase half-controlled rectifier at various firing angles at different loads.

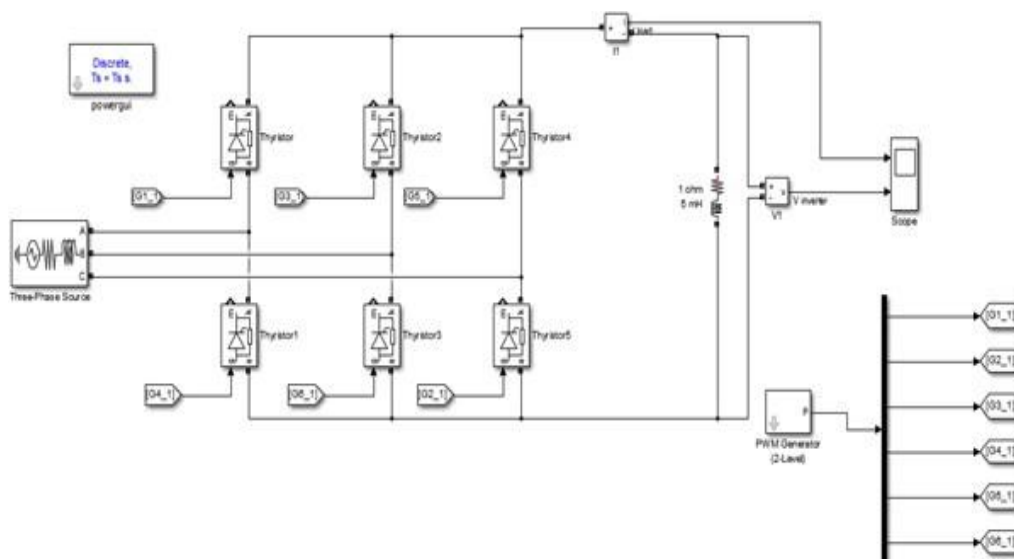


Try

1. Conduct experiment on Three phase half bridge rectifier at different firing angles ($\alpha=30^\circ, 60^\circ$ and 90°) and observe the waveforms
2. Determine output voltage and currents with different loads (R, R-L and R-L-E)

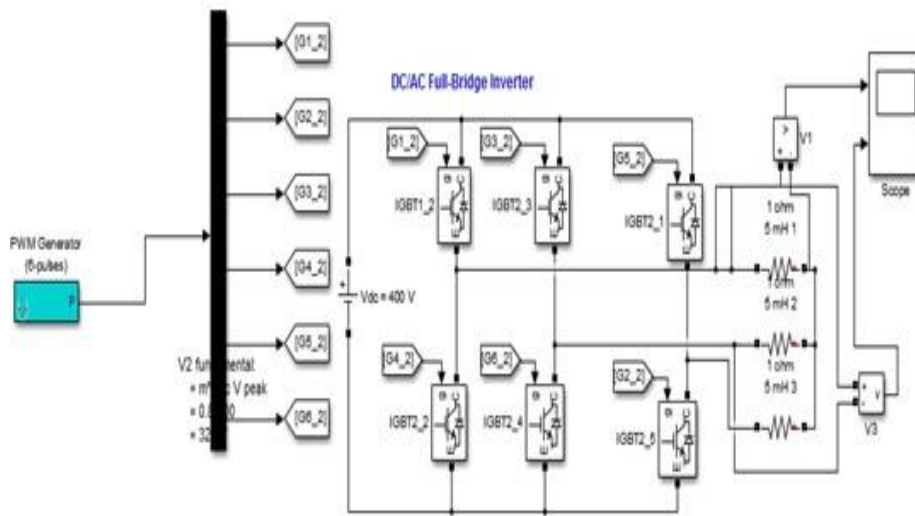
13. Simulation of Three phase full -converter and PWM Inverter

The Inverters based on the PWM technology are more superior to the conventional inverters. Observe the waveforms of three phase full converter and PWM inverter.



Circuit diagram for three phase full converter

Discrete,
Ts = Ts s.
powergui



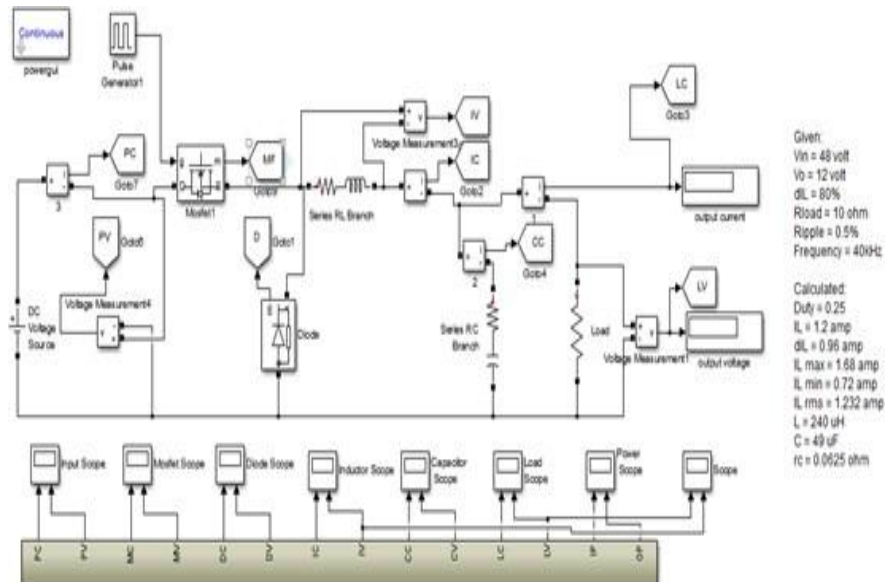
Circuit diagram for PWM Inverter

Try

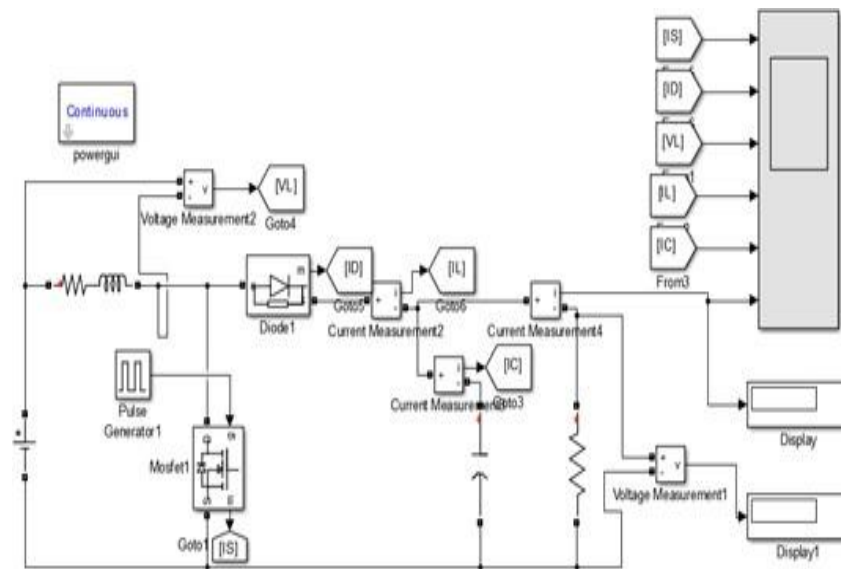
1. Set the parameters in PWM generator for firing the switches observe the output waveforms.
2. Set the values for different loads and observe the observe the output waveforms.

14. Simulation of buck – boost chopper

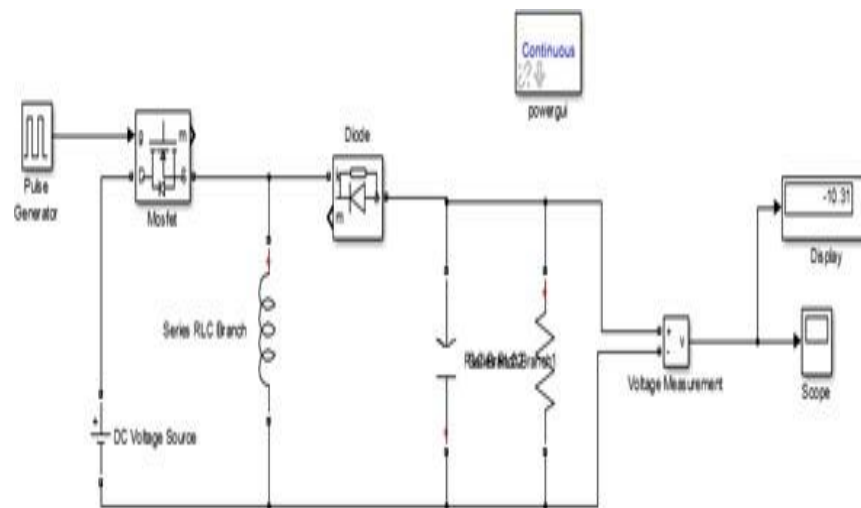
Design boost, buck, buck boost converter in MATLAB with R and RL loads and simulate observe the waveforms



circuit diagram for Buck converter



circuit diagram for boost converter



circuit diagram of buck boost converter

Try

1. Set the parameters in PWM generator for firing the switches observe the output waveforms.
2. Set the values for different loads and observe the observe the output waveforms.

V. TEXT BOOKS:

1. M D Singh, K B Kanchandhani, "Power Electronics", Tata Mc Graw Hill Publishing Company, 2nd Edition, 1998.
2. Dr. P S Bimbhra, "Power Electronics", Khanna Publishers, 5th Edition, 2012.

VI. REFERENCE BOOKS:

1. Vedam Subramanyam, “Power Electronics”, New Age International Limited, 2nd Edition, 2006..
2. G K Dubey, S R Doradra, A Joshi, R M K Sinha, “Thyristorised Power Controllers”, New Age International Limited, 2nd Edition, 2008.

VII. ELECTRONICS RESOURCES:

1. <https://www.allaboutpowerelectronics.com/textbook/>
2. https://onlinecourses.nptel.ac.in/noc22_ee93/preview
3. <https://www.iare.ac.in>

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual