POWER ELECTRONICS LAB MANUAL

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EXPT NO:1
1-PHASE FULLY CONTROLLED BRIDGE CONVERTER

AIM:
To convert AC supply to variable DC supply by changing the firing angles of thyristers.
To observe the input and output waveforms by using CRO & calculate voltage and currents for different firing angles.
To draw the input and output waveforms for different firing angles.

APPARATUS:
1. Thyristors-TYN612-4 no
2. Single phase fully controlled bridge firing kit
3. Rheostat-50 ohms
4. Loading inductor 10mH, 25mH & 50mH
5. CRO
6. Connecting wires

CIRCUIT DIAGRAM:
SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R-LOAD

![Circuit Diagram]
SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH RL-LOAD

230 V 50Hz 1-phase A.C. SUPPLY

Step down T/F 230:30V

R = 50 OHM

L

T1

T4

T3

T2
WAVE FORMS:
SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH R-LOAD
SINGLE PHASE FULLY CONTROLLED BRIDGE CONVERTER WITH RL-LOAD

Ig1

Ig2

Vs

Vo

T1, T2
T3, T4
T1, T2

α

π
π + α
2π

wt
**TABULAR COLUMN:**

\[ V_m = \underline{\hspace{2cm}} \]

<table>
<thead>
<tr>
<th>S.NO</th>
<th>FIRING ANGLE ((\alpha))</th>
<th>(V_{avg}) (practical)</th>
<th>(V_{avg}) (theoreticall)</th>
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**THEORETICAL CALCULATIONS:**

\[
V_{d.c} = V_{avg} = \frac{1}{T} \int_0^\pi V_m \sin \omega t \cos \omega t \quad \text{for R-Load}
\]

\[
= \frac{V_m}{\pi} (1 + \cos \alpha)
\]

\[
V_{d.c} = V_{avg} = \frac{1}{T} \int_0^{\pi + \alpha} V_m \sin \omega t \cos \omega t \quad \text{for RL-Load}
\]

\[
= \frac{2V_m}{\pi} \cos \alpha
\]
PRECAUTIONS:
1. Check the working condition of all the SCR’s before connecting them in the circuit.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

PROCEDURE:
1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is sitched ON.
4. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
5. The output wave forms are plotted on the graph sheet.
6. Similarly RL-load steps of the above are repeated.
7. Wave forms are observed in CRO.

RESULT:
The performance of Single phase Fully controlled bridge converter of R & RL-load are studied and output wave forms for different firing angles are drawn on the graph sheet.

CONCLUSION:
The Single phase Fully controlled bridge converter will act as a rectifier for firing angles 0< α <90 degrees, and act as a inverter for firing angles ranging from 90 < α < 180 degrees and output voltages of desired magnitude can be obtained by varying the firing angle α.

QUESTIONS FOR VIVA-VOCE:
1. How many quadrants does a Full controlled rectifier works?
2. What is meant by Line commutation?
3. How the thyristers get commutated?
4. When a full controlled rectifier work as inverter?
5. What is the change observed in wave forms for R-load & RL-load.
EXPT No: 2
1-PHASE AC VOLTAGE CONTROLLER

AIM: To study the performance of single phase A.C. Voltage controller.
To obtain the variable AC Voltage from the fixed AC Voltage by varying
the firing angles of thyristors.
To observe the magnitude & wave forms of input and output in CRO
To draw the wave forms of input and output on graph sheet.

APPARATUS:
1. Single phase A.C. Voltage controller kit
2. Single phase A.C. Voltage controller firing kit
3. Rheostat-50 ohms
4. Loading inductor
5. CRO
6. Connecting wires

CIRCUIT DIAGRAM:

A.C VOLTAGE CONTROLLER WITH R-LOAD
WAVE FORMS:

A.C VOLTAGE CONTROLLER WITH R-LOAD

\[ \text{Ig1} \]
\[ \text{Ig2} \]
\[ \text{Vs} \]
\[ \text{Vo} \]
\[ \text{Vtl} \]
\[ \text{Vtl2} \]
theoretical calculations:

\[ V_{a.c} = V_{rms} = \frac{1}{T} \left[ \int_{\alpha}^{\pi} V^2 \sin^2 \omega t \, dt + \int_{\pi + \alpha}^{2\pi} V^2 \sin^2 \omega t \, dt \right] \]

\[ = V_m \left[ \frac{\pi - \alpha}{\omega} + \frac{\sin 2\alpha}{4\pi} \right]^{1/2} \]

TABULAR COLUMN:

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<tr>
<th>S.NO</th>
<th>FIRING ANGLE ((\alpha))</th>
<th>(V_{rms}) (practical)</th>
<th>(V_{rms}) (theoretical)</th>
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<tr>
<td>5</td>
<td>150</td>
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PRECAUTIONS:
1. Check all the SCR’s for the performance before making connections.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

**PROCEDURE :**

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is sitched ON
4. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.

**RESULT :**

The performance of AC Voltage Controller of R -load are studied and out put wave forms for different firing angles are drawn on the graph sheet.

**CONCLUSION :**

The AC Voltage Controller gives variable AC Voltage by varying the firing angles from the fixed AC Voltage.

**QUESTIONS FOR VIVA-VOCE :**

1. What happens if the two thyristers applied from the same gate source ?
2. What is meant by Line commutation ?
3. How the thyristers get commutated ?
4. What is the expression for rms voltage of the output wave form ?
5. What is the difference between Transformer & AC voltage controller ?
6. What are the applications of a AC Voltage controller?
EXPT NO:3
1-PHASE CYCLO CONVERTER

AIM : To study the performance of single phase Cyclo converter.
To change the 50Hz A.C input supply to 25Hz,16.66Hz…
with out change in magnitude.

APPARATUS :
1. Single phase Cyclo Converter firing kit
2. Thyristors-TYN612-4 no
3. Rheostat-500 ohms
4. Loading inductor
5. CRO
6. Connecting wires

CIRCUIT DIAGRAM :

WAVE FORMS :
**PRECAUTIONS:**
1. Check all the SCR’s for the performance before making connections.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

**PROCEDURE:**
1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON
4. Wave forms across the load are observed in CRO values are noted down and tabulated
   For different frequencies $f_s/2, f_s/3, f_s/4,$ etc.,
5. The output wave forms are plotted on the graph sheet.

**THEORETICAL CALCULATIONS :**

We know that source frequency $(f_s) = 50$ Hz, i.e., $T_s = 20$ mSec.; \[ f = 1/T \]

\[
f_o = f_s/2 = 25 \text{ Hz}, \quad \text{i.e.,} \ T_o = 2 \ T_s = 40 \text{ mS } ;
\]

\[
f_o = f_s/3 = 16.66 \text{ Hz}, \quad \text{i.e.,} \ T_o = 3 \ T_s = 60 \text{ mS } ;
\]

**RESULT :**

The performance of Single phase Cyclo converter of R-load are studied and output wave forms for different frequencies are drawn on the graph sheet.

**CONCLUSION :**

The Single phase Cyclo converter will change the source frequency of 50Hz to 25Hz, 16.66Hz, etc., with out change in the amplitude level. Experiment conducted on Step-down cyclo converter, which uses the natural commutation.

**QUESTIONS FOR VIVA-VOCE :**

1. What is Step down & Step up Cyclo converter ?
2. What is meant by natural & Forced commutation ?
3. How the thyristers get commutated ?
4. What is relation between Time period & Frequency ?
5. How the frequency varies in Cyclo converter ?
6. What are the applications of a Cyclo Converter?
7. What is the importance of Center tap Transformer ?
EXPT NO:4

FORCED COMMUTATION CIRCUITS

AIM: To study the Construction And Operation of 4- Forced Commutation Circuits.
To commutate thyristor using Class-A or Load commutation
To commutate thyristor using Class-B or current commutation
To commutate thyristor using Class-C or Complimentary commutation
To commutate thyristor using Class-D or Voltage commutation

APPARATUS:
1. Forced Commutation Study Module
2. Rheostat-50 ohms
3. Loading Inductor
4. CRO
5. Connecting wires

CLASS-A COMMUTATION:

CIRCUIT DIAGRAM:
WAVE FORMS:

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR from the Trigger Pulse Generator.
3. The main supply is switched ON and D.C supply switched ON.
4. Wave forms across the Thyristor, load and Capacitor are observed in CRO values are noted down.
5. The output wave forms are plotted on the graph sheet.
CLASS-B COMMUTATION:

CIRCUIT DIAGRAM: 

![Circuit Diagram Image]
WAVE FORMS:

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR from the Trigger Pulse Generator.
3. The main supply is switched ON and D.C supply switched ON.
4. Wave forms across the Thyristor, load and Capacitor are observed in CRO values are noted down.
5. The output wave forms are plotted on the graph sheet.
CLASS-C COMMUTATION:

CIRCUIT DIAGRAM:

![Circuit Diagram]

\[ E_{dc} \]

\[ R1 \]

\[ R2 \]

\[ T1 \]

\[ T2 \]
WAVE FORMS:

![Graph showing waveforms](image)

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the Trigger Pulse Generator.
3. The main supply is switched ON and D.C supply switched ON.
4. Wave forms across the Thyristor, load and Capacitor are observed in CRO values are noted down.
5. The out put wave forms are plotted on the graph sheet.
CLASS-D COMMUTATION:

CIRCUIT DIAGRAM:

- Diagram of a Class-D commutation circuit with components labeled.
- Components include capacitors, diodes, inductors, and a load resistor.
**WAVE FORMS:**

![Waveforms Diagram](image)

**PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the Trigger Pulse Generator.
3. The main supply is switched ON and D.C supply switched ON.
4. Wave forms across the Thyristor, load and Capacitor are observed in CRO values are noted down.
5. The output wave forms are plotted on the graph sheet.
**PRECAUTIONS:**
1. Check all the SCR’s for the performance before making connections.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

**RESULT:**

The wave forms are observed across the thyristers and capacitors and load for different circuits corresponding wave forms are drawn.

**CONCLUSION:**

After Conducting Experiments for different commutation circuits, We can conclude that class-A, class-B are self commutating type and class-C requires complimentary commutation and class-D requires an auxiliary thyristor.

**VIVA-VOCE:**

1. What is Commutation ?
2. What is Natural Commutation, current commutation, load commutation, Voltage Commutation, Current Commutation ?
3. What are the Commutating elements ?
4. What is Complementary Commutation ?
EXPT N0:5

1-PHASE HALF CONTROLLED CONVERTER

AIM: To study the performance of single phase Half controlled bridge converter.
To prove that the Half controlled converter works in only one quadrant.
To observe the magnitude & wave forms of input and output in CRO.
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. Single phase fully controlled bridge kit
2. Single phase fully controlled bridge firing kit
3. Thyristors-TYN612-2 no
4. Diodes–IN 4007-2 no
5. Rheostat-50 ohms
6. Loading inductor
7. CRO
8. Connecting wires

CIRCUIT DIAGRAM:

SINGLE PHASE HALF CONTROLLED BRIDGE CONVERTER WITH R-LOAD

[Diagram of the circuit diagram is included here, showing the connections for the converter.]
WAVE FORMS:

\[
\begin{align*}
\text{I}_{g1} & \quad \text{wt} \\
\text{I}_{g2} & \quad \text{wt} \\
V_s & \quad \text{wt} \\
V_o & \quad \text{wt}
\end{align*}
\]
**TABULAR COLUMN:**

\[ V_m = \_\_\_\_\_ \]

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<tr>
<th>S.NO</th>
<th>FIRING ANGLE (α)</th>
<th>( V_{avg} ) (practical)</th>
<th>( V_{avg} ) (theoretical)</th>
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**THEORETICAL CALCULATIONS:**

\[
V_{d.c} = V_{avg} = \frac{1}{T} \int_0^\pi V_m \sin \omega t \, dt \quad \text{for R-Load}
\]

\[
= \frac{V_m}{\pi} (1 + \cos \alpha)
\]
PRECAUTIONS:
1. Check all the SCR’s for the performance before making connections
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

PROCEDURE:
1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON.
4. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
5. The output wave forms are plotted on the graph sheet.
6. Similarly RL-load steps of the above are repeated.
7. Wave forms are observed in CRO.

RESULT:
The performance of Single phase Half controlled bridge converter of R & RL-load are studied and output wave forms for different firing angles are drawn on the graph sheet.

CONCLUSION:
The Single phase Half controlled bridge converter will act in I-quadrant only for firing angles $0 < \alpha < 180$ degrees.

QUESTIONS FOR VIVA-VOCE:
1. How many quadrants does a Half controlled rectifier works?
2. What is meant by Line commutation?
3. How the thyristers get commutated?
4. Does a Half controlled rectifier work as inverter?
5. What are the merits & demerits of Half controlled rectifier over fully controlled rectifier?
EXPT NO: 6  
JONES CHOPPER

AIM:
To study the performance of Jones Chopper and observe the wave forms at different duty cycles.
To observe the Chopped output across the load and its variation as duty ratio varies.
To study Voltage commutation.
To observe the magnitude & wave forms of input and output in CRO.
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. Jones Chopper study unit.
2. Jones Chopper Firing unit
3. Rheostat-500 ohms
4. CRO
5. Connecting wires

CIRCUIT DIAGRAM:
WAVE FORMS:

- $I_{g1}$
- $I_{g2}$
- $E_{t1}$
- $V_c$
- $V_o$
- $E_{t2}$
**PRECAUTIONS:**
1. Check all the SCR’s for the performance before making connections
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Keep all knobs at min. position before you switch ON the supply.
5. Show connections to the lab faculty before you start the experiment

**PROCEDURE :**

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON
4. Wave forms across the Main Thyristor, Auxiliary Thyristor, Capacitor and load are observed in CRO values are noted down and tabulated for different firing angles.
5. The out put wave forms are plotted on the graph sheet.

**RESULT :**

The performance of Jones chopper with R-load are studied and out put wave forms for different firing angles are drawn on the graph sheet.

**CONCLUSION :**

Jones Chopper is an example of Class-D Commutation. In this circuit Because of a charged capacitor momentarily reverse biases the conducting SCR and turns it OFF, so called as the circuit is working under Voltage Commutation.

**VIVA-VOCE :**

1. Define Chopper ?
2. Define Duty Cycle ?
3. What is Time Ratio Control ?
4. What is the Application of Jones Chopper ?
5. Which type of commutation used in Jones Chopper ?
6. What is the importance of Coupled Inductor in the Jones chopper circuit ?
EXPT NO: 7
SERIES INVERTER

AIM:  To study the performance of Series Inverter.
      To obtain AC output across load by using load commutation from DC input.
      To observe the magnitude & wave forms of input and output in CRO
      To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. Series Inverter kit
2. Rheostat-50 ohms
3. CRO
4. Connecting wires

CIRCUIT DIAGRAM:
WAVE FORMS:

\[ Ig1 \]
\[ 0 \]
\[ \theta \]
\[ \rightarrow \omega t \]

\[ Ig2 \]
\[ 0 \]
\[ \rightarrow \omega t \]

\[ Ec2 \]
\[ 0 \]
\[ \rightarrow \omega t \]

\[ Ec1 \]
\[ 0 \]
\[ \rightarrow \omega t \]

\[ Eco \]
\[ 0 \]
\[ \rightarrow \omega t \]

\[ T \]

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON.
4. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
5. The output wave forms are plotted on the graph sheet.
**PRECAUTIONS:**
1. Check all the SCR’s for the performance before making connections
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Keep all knobs at min. position before you switch ON the supply.
5. Show connections to the lab faculty before you start the experiment

**RESULT:**

The performance of Series Inverter of R-load are studied and output wave forms for different firing angles are drawn on the graph sheet.

**CONCLUSION:**

The Series Inverter gives the AC output and it works with the load commutation.

**VIVA-VOCE:**

1. Why it is called as Series Inverter?
2. What are the commutating elements?
3. What is the use of coupled inductor in the circuit?
4. Which type of commutation used in the series inverter?
5. What does it mean by under damped condition of the circuit & it’s importance?
EXPT NO:8

CHARACTERISTICS OF SCR, MOSFET AND IGBT

**AIM**: To study the characteristics of SCR, MOSFET and IGBT.
To draw the V-I characteristics of SCR and Break down voltage
To draw the input and output characteristics of MOSFET & IGBT

**APPARATUS**:
1. characteristics of SCR, MOSFET and IGBT study unit.
2. Ammeters 0-500mA-1 no
   Ammeters 0-50mA-2 no
   Ammeter 0-10mA-2 no
3. Voltmeter 0-50V-2no
4. CRO
5. Connecting wires

**V-I CHARACTERISTICS OF SCR**

**CIRCUIT DIAGRAM**:
WAVE FORMS:

TABULAR COLUMN:

I_G = _4___mA

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<th>S.NO</th>
<th>V_{AK}</th>
<th>I_A</th>
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PROCEDURE:
1. Connections are made as per the circuit diagram.
2. Gate current is kept at constant fixed value by varying the Gate source, potentiometer.
3. Anode Cathode source is varied from its min. value in steps and readings of $V_{AK}$ & $I_A$ are noted down at each step by observing the gate current $I_G$, At Break down voltage the gate current raises rapidly (to be observed in Ammeter $I_G$ ) and Anode Cathode Voltage is falls down suddenly (to be observed in Volt meter $V_{AK}$).
4. The Break down voltage, Anode current at which sudden rising starts will be noted .
5. Repeat the steps 2-4 for other constant gate current.
6. Graph is drawn between $V_{AK}$ & $I_A$ for different values of gate currents $I_{G1}$ & $I_{G2}$.

CHARACTERISTICS OF MOSFET

CIRCUIT DIAGRAM:
WAVE FORMS:

[Graphs showing transfer and drain characteristics]

TABULAR COLUMN:

\[ V_{DS} = \_4\_ V \]

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<th>S.NO</th>
<th>( V_{GS} )</th>
<th>( I_D )</th>
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\[ V_{GS} = \_4\_ V \]

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</table>

PROCEDURE:
1. Connections are made as per the circuit diagram.

2. $V_{GS}$ is kept at constant fixed value by varying the Gate supply.

3. Drain Source supply is varied from its min. value in steps and readings of $V_{DS}$ & $I_D$ are noted down at each step by observing the $V_{GS}$ constant.

4. Graph is drawn between $V_{DS}$ & $I_D$ for different values of Gate Source Voltages $V_{GS1}$ & $V_{GS2}$.

4. $V_{DS}$ is kept at constant fixed value by varying the Drain resistance using potentiometer.

5. Gate Source supply is varied from its min. value in steps and readings of $V_{GS}$ & $I_D$ are noted down at each step by observing the $V_{DS}$ constant.

6. Graph is drawn between $V_{GS}$ & $I_D$ for different values of Drain Source Voltages $V_{DS1}$ & $V_{DS2}$.

**CHARACTERISTICS OF IGBT**

**CIRCUIT DIAGRAM:**

![Circuit Diagram of IGBT](image)
WAVE FORMS:

![Graph of Vce vs Vge](image)

TRANSFER CHARACTERISTICS

![Graph of Ic vs Vce](image)

COLLECTOR CHARACTERISTICS

TABULAR COLUMN:

\[ V_{CE} = \_4\_ \text{V} \]

<table>
<thead>
<tr>
<th>S.NO</th>
<th>( V_{GE} )</th>
<th>( V_{CE} )</th>
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</table>

\[ V_{GE} = \_4\_ \text{V} \]

<table>
<thead>
<tr>
<th>S.NO</th>
<th>( V_{CE} )</th>
<th>( I_{C} )</th>
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**PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. \( V_{GE} \) is kept at constant fixed value by varying the Gate supply.
3. Drain Source supply is varied from its min. value in steps and readings of \( V_{CE} \) & \( I_C \) are noted down at each step by observing the \( V_{GE} \) constant.
4. Graph is drawn between \( V_{CE} \) & \( I_C \) for different values of Gate Emitter Voltages \( V_{GE1} \& V_{GE2} \).
5. \( V_{CE} \) is kept at constant fixed value by varying the Drain resistance using potentiometer.
6. Gate Source supply is varied from its min. value in steps and readings of \( V_{GE} \) & \( I_C \) are noted down at each step by observing the \( V_{CE} \) constant.
7. Graph is drawn between \( V_{GE} \) & \( I_C \) for different values of Collector Emitter Voltages \( V_{CE1} \& V_{CE2} \).

**PRECAUTIONS:**

1. Check the SCR, MOSFET & IGBT for the performance before making connections.
2. Check the Battery supplies \( V_1 \& V_2, R_1 \& R_2 \).
3. Make fresh connections before you make a new experiment.
4. Keep all knobs at min. position before you switch ON the supply.
5. Show connections to the lab faculty before you start the experiment.

**RESULT:**

The Characteristics of SCR, MOSFET and IGBT are studied and the graphs were plotted.

**CONCLUSION:**

1. Break down voltage of SCR, Anode current sudden raise is observed.
2. MOSFET input & output characteristics as per the graph is observed.
3. IGBT ‘s transfer & collector characteristics are observed.

**VIVA-VOCE:**

1. What is difference between SCR & Thyristor?
2. What is meant by Triggering?
3. What is holding current, Latching current?
4. What is Depletion mode in MOSFET?
5. What are the differences between SCR, MOSFET & IGBT?
6. What are the advantages of IGBT over BJT & MOSFET?
EXPT No: 9

1-PHASE DUAL CONVERTER

AIM:
To study the performance of single phase dual converter.
To prove that the dual converter works in all four quadrants.
To study simultaneous mode & non simultaneous mode of dual converter.
To observe the magnitude & wave forms of input and output in CRO.
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. Single phase dual converter kit
2. Single phase dual converter firing kit
3. Thyristors-TYN612-8 no
4. Rheostat-50 ohms
5. Loading inductor
6. Ammeter 0-5A
7. Dual volt meter 300V-0-300V
8. CRO
9. Connecting wires

CIRCUIT DIAGRAM:

SINGLE PHASE DUAL CONVERTER WITH NON SIMULTANEOUS MODE
SINGLE PHASE DUAL CONVERTER WITH SIMULTANEOUS MODE

![Circuit Diagram]

**TABULAR COLUMN:**

\[ V_m = \ldots \]

<table>
<thead>
<tr>
<th>S.NO</th>
<th>FIRING ANGLE ((\alpha))</th>
<th>(V_{dc\ 1}) (Theoretical)</th>
<th>(V_{dc\ 1}) (Practical)</th>
<th>(V_{dc\ 2}) (Theoretical)</th>
<th>(V_{dc\ 2}) (Practical)</th>
<th>(I_L)</th>
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</table>
WAVE FORMS:
THEORETICAL CALCULATIONS:

\[
V_{d.c1} = V_{avg} = \frac{1}{T} \int_{\alpha}^{\pi+\alpha} V_m \sin \omega t \cdot d\omega \\
= \frac{2V_m}{\pi} \cos \alpha
\]

\[
V_{d.c2} = V_{avg} = \frac{1}{T} \int_{\alpha}^{\pi+\alpha} V_m \sin \omega t \cdot d\omega \\
= \frac{2V_m}{\pi} \cos \alpha
\]

PRECAUTIONS:
1. Check all the SCR’s for the performance before making connections.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.

PROCEDURE:
Non simultaneous mode (non circulating current mode):

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON.
4. Observe out put wave forms across load.
5. Wave forms across the load are observed in CRO, Volt meter, Ammeter values are noted down and tabulated for different firing angles.
6. The out put wave forms are plotted on the graph sheet.
Simultaneous mode (circulating current mode):

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON.
4. Observe output waveforms across load.
5. Waveforms across the load are observed in CRO, Volt meter, Ammeter values are noted down and tabulated for different firing angles.
6. The output waveforms are plotted on the graph sheet.

RESULT:

The performance of Single phase dual converter of R-load are studied and output waveforms for different firing angles are drawn on the graph sheet.

CONCLUSION:

The Single phase dual converter will act in two modes, and that will act in all four quadrants.

VIVA-VOCE:

1. What is Simultaneous mode & Non-Simultaneous mode?
2. What is circulating current and how it is reduced?
3. What is condition to be satisfied in Simultaneous mode?
4. What is importance of inductance in Simultaneous mode?
5. How many quadrants does a dual converter works?
EXPT N0:10
GATE FIRING CIRCUITS
(R, RC & UJT)

AIM: To study the performance of various turn-on methods of thyristers by its gate terminal.
To prove that the firing angle range for R-triggering is 0 to 90°
To prove that the firing angle range for RC-triggering is 0 to 180°
To prove that the firing angle range for UJT-triggering ramp triggering.
To observe the magnitude & wave forms of input and output in CRO
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. RC-Firing circuit study unit.
2. UJT-Firing circuit study unit
3. Thyristor-TYN612-1 no
4. Rheostat-50 ohms
5. CRO
6. Connecting wires

R-FIRING CIRCUIT

CIRCUIT DIAGRAM:

[Diagram showing the R-firing circuit with labeled components such as load, R, R2, A, K, D, 145OHM/1.8A, 220 OHM, and RG]
**WAVE FORMS :**

![Waveforms diagram]

**PROCEDURE :**

1. Connections are made as per the circuit diagram.
2. The main supply is switched ON and triggering circuit is switched ON.
3. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
4. The output wave forms are plotted on the graph sheet.
TABULAR COLUMN:

\[ V_m = \ldots \]

<table>
<thead>
<tr>
<th>s.no</th>
<th>Firing angle ((\alpha))</th>
<th>(V_{dc}) (theoretical)</th>
<th>(V_{dc}) (Practical)</th>
<th>(V_{rms}) (theoretical)</th>
<th>(V_{rms}) (Practical)</th>
</tr>
</thead>
<tbody>
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</tbody>
</table>

THEORETICAL CALCULATIONS:

\[
V_{d,c} = V_{avg} = \frac{1}{T} \int_{-\alpha}^{\pi} V_m \sin \omega t \, dt
= \frac{V_m}{2\pi} (1 + \cos \alpha)
\]

\[
V_{a,c} = V_{rms} = \sqrt{\frac{1}{T} \int_{-\alpha}^{\pi} \left( V_m \sin \omega t \right)^2 \, dt}
= \frac{V_m}{2\sqrt{\pi}} \left[ (\pi - \alpha) + \frac{\sin 2\alpha}{2} \right]^{1/2}
\]
RC-FIRING CIRCUIT

CIRCUIT DIAGRAM:

WAVE FORMS:

\[ V_s(t) \]

\[ V_o(t) \]

\[ V_t(t) \]
**TABULAR COLUMN:**

\[ V_m = \underline{\text{______}} \]

<table>
<thead>
<tr>
<th>s.no</th>
<th>Firing angle ((\alpha))</th>
<th>(V_{dc}) (theoretical)</th>
<th>(V_{dc}) (Practical)</th>
<th>(V_{rms}) (theoretical)</th>
<th>(V_{rms}) (Practical)</th>
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</table>

**PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. The main supply is switched ON and triggering circuit is switched ON
3. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
4. The output wave forms are plotted on the graph sheet.
UJT-FIRING CIRCUIT

CIRCUIT DIAGRAM:

[Diagram of the UJT-FIRING CIRCUIT with labeled components and connections.]
WAVE FORMS:

![Waveform Diagram]

PROCEDURE:
1. Connections are made as per the circuit diagram.
2. The main supply is switched ON and triggering circuit is switched ON.
3. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
4. The output wave forms are plotted on the graph sheet.

PRECAUTIONS:
1. Check all the SCR’s for the performance before making connections.
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Preferably work at low voltages (30-40V) for every new connections after careful verification raised to the max. ratings.
5. Keep all knobs at min. position before you switch ON the supply.
6. Show connections to the lab faculty before you start the experiment.
RESULT:

The performance of R, RC & UJT Firing circuits with R-load are studied and output waveforms for different firing angles are drawn on the graph sheet.

CONCLUSION:

R-Triggering circuit works for firing angle range 0 to 90 degrees, RC-Triggering circuit works for firing angle range 0 to 180 degrees and UJT Firing circuit works for instant triggering.

VIVA-VOCE:

1. What is the range of firing angle in R-Triggering?
2. What is the range of firing angle in RC-Triggering?
3. What is meant by Ramp Triggering?
4. What are the advantages of UJT-firing circuit over R & RC-triggering?
5. What is the importance of 1:1 pulse transformer?
EXPT N0:11
PARALLEL INVERTER

AIM:
To study the performance of Parallel Inverter.
To obtain AC output across the capacitor from the DC input
To observe the magnitude & wave forms of input and output in CRO
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. Parallel Inverter kit
2. Rheostat-500 ohms
3. CRO
4. Connecting wires

CIRCUIT DIAGRAM

![Circuit Diagram](image-url)
WAVE FORMS:

PRECAUTIONS:
1. Check all the SCR’s for the performance before making connections
2. Check the firing circuit trigger outputs and its relative phase sequence.
3. Make fresh connections before you make a new experiment.
4. Keep all knobs at min. position before you switch ON the supply.
5. Show connections to the lab faculty before you start the experiment
**PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. Firing pulses are applied for the respective SCR’s from the firing circuit.
3. The main supply is switched ON and triggering circuit is switched ON
4. Wave forms across the load are observed in CRO values are noted down and tabulated for different firing angles.
5. The output wave forms are plotted on the graph sheet.

**RESULT:**

The performance of Parallel Inverter of R-load are studied and output wave forms for different firing angles are drawn on the graph sheet.

**CONCLUSION:**

Alternately switching the two SCR’s, the D.C source is connected in alternative sense of the two halves of Transformer primary. There by inducing the voltage across the load in transformer secondary. Other than resistive load, the load current will be out of phase with the voltage. For this condition, two diodes are connected parallel across the SCR’s as feed back the stored energy during those periods when the load current reverses relative to the voltage.

**VIVA-VOCE:**

1. Why it is called as parallel inverter?
2. Which type of commutation used in parallel inverter?
3. What is the difference between series & parallel inverter?
EXPT N0:12

1-Ø BRIDGE INVERTER USING SPWM

AIM: To study the performance of 1-Ø Bridge Inverter using SPWM.
To obtain the A.C wave form from D.C input by using Sinusoidal Pulse
Width Modulation.
To observe how the output varies as modulation index varies.
To observe the magnitude & wave forms of input and output in CRO
To draw the wave forms of input and output drawn on graph sheet.

APPARATUS:
1. 1-Ø Bridge Inverter kit
2. Rheostat-0-350 ohm/1.2 A
3. Inductor
4. Isolation Transformer
5. Voltmeter 0-400 V
6. Ammeter 0-5 A
7. Connecting wires

CIRCUIT DIAGRAM:
WAVE FORMS:

![Waveform Diagram]

Expected graph:

![Graph Diagram]
PRECAUTIONS:
1. Ensure that the C.B & pulse release ON/OFF switch are in OFF position before starting the experiment.
2. Show the connections to lab faculty before you start the experiment.

PROCEDURE:

1. Connections are made as per the circuit diagram.
2. Connect the ammeter & voltmeter to measure load current & load voltage.
3. Connect AC i/p terminals L & N provided in the front anel.
4. With the C.B & pulse release ON/OFF switch are in OFF position give power to the Inverter module. This will ensure the control power supply to all the control circuitry.
5. Set the amplitude of the reference sin wave to the min. position
6. Keeping the pulse release switch in OFF position, switch ON the power supply to the bridge rectifier
7. Release the gating signals to the inverter by switching ON the pulse release ON/Off switch.
8. Observe the triangular carrier & ref. sin wave in the CRO. Measure the amplitude of carrier wave & ref. wave and note it down in the tabular column.
9. Observe the wave forms across the RL-load in the CRO, & note down the readings.
10. Repeat the steps 8-9 by increasing the ref. wave amplitude in steps.
11. Calculate the modulation index value at each step
12. Plot the load & carrier wave s in the graph sheet, also draw the characteristics as mentioned.

TABULAR COLUMN:

<table>
<thead>
<tr>
<th>S.NO</th>
<th>$V_c$ (carrier signal)</th>
<th>$V_{sin}$ (ref.signal)</th>
<th>$m_a$ (modulation index)</th>
<th>$V_o$ (across load)</th>
<th>Time (Sec)</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>
THEORETICAL CALCULATIONS:

\[ m_a = \frac{V \sin}{V_{\text{car}}} = \frac{\text{Amplitude of the reference signal}}{\text{Amplitude of the carrier signal}} \]

\[ V_o = m \frac{V}{\sqrt{2}} \]

\[ \text{rms. value of output voltage, } V_o = \left[ \frac{2}{T} \int_{0}^{T/2} V_s^2 \, dt \right]^{1/2} = V_s \]

RESULT:

The performance of 1-φ Bridge Inverter using SPWM of RL-load are studied and output wave forms are drawn on the graph sheet.

CONCLUSION:

The 1-φ Bridge Inverter using SPWM gives the AC output and it varies as the modulation index or reference sine wave magnitude varies.

VIVA VOICE:

1. What is PWM?
2. What are the various methods of PWM?
3. What is the difference between SPWM and other PWM techniques?
4. What is the difference between six step inverter & PWM inverter?
EXPT N0:13

3-Ø IGBT PWM INVERTER

**AIM:** To study the performance of 3-Ø IGBT PWM Inverter.
To obtain the 3-Ø IGBT PWM Inverter stepped wave AC output.
To observe that each IGBT conducts for duration of $T/2$ and for every $T/6$ period other sequential IGBT comes into conduction.

**APPARATUS:**
1. 3-Ø Bridge Inverter kit
2. Rheostat-0-350 ohm/1.2 A
3. Rheostat-0-450 ohm/2 A
4. Isolation Transformer
5. Voltmeter 0-400 V
6. Ammeter 0-5 A
7. Connecting wires

**CIRCUIT DIAGRAM:**
WAVE FORMS:
180° conduction mode:

\[ \begin{align*}
  &60° &60° &60° &60° &60° &60° \\
  A------& T1 & T1 & T1 & T4 & T4 & T4 \\
  B------& T6 & T6 & T3 & T3 & T3 & T6 \\
  C------& T5 & T2 & T2 & T2 & T5 & T5
\end{align*} \]

**PRECAUTIONS:**
1. Ensure that the C.B & pulse release ON/OFF switch are in OFF position before starting the experiment.
2. Show the connections to lab faculty before you start the experiment.

**PROCEDURE:**

1. Connections are made as per the circuit diagram.
2. Initially keep the main switch in OFF position
4. Make sure the freq. & Amplitude knob in min. position & pulse releasing switch in Off position.
5. Connect the isolation T/F to the i/p side of the bridge rectifier
6. Connect the break resistance across RB1 & RB2
7. Connect star connected resistive load across U, V & W. Make sure that the connections are completed.
8. Now switch ON the supply, Switch ON the pulse release switch, keep the freq. switch SW1 in the max. position.
9. Observe the wave forms at various test points through CRO.
10. 3-phase input supply is switched ON to the bridge rectifier. Now switch ON the MCB
11. Trace out the wave forms of phase voltages across the star connected load.

**RESULT:**

The performance of 3-Φ IGBT PWM Inverter with star connected load are studied and output wave forms are drawn on the graph sheet.
CONCLUSION:

The 3-φ IGBT PWM Inverter gives the stepped AC output and it is observed that each IGBT conducts for duration of T/2 and for every T/6 period other sequential IGBT comes into conduction.

VIVA_VOCE:
1. What is PWM?
2. What are the various methods of PWM?
3. What is the difference between SPWM and other PWM techniques?
4. What is modulation index?