1Ph_HW_Converter_R-Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE HALF WAVE CONTROLLED CONVERTER WITH R-LOAD

Objective:

After performing this lab exercise, learner will be able to:

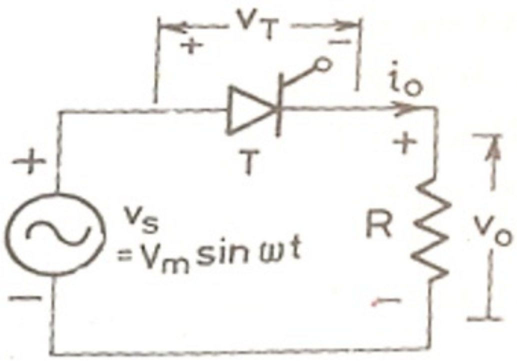
- Understand the working of 1-phase half wave control converter.
- Learn the role of Power Electronics in utility related applications, e.g. drives etc.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope

Circuit Diagram:

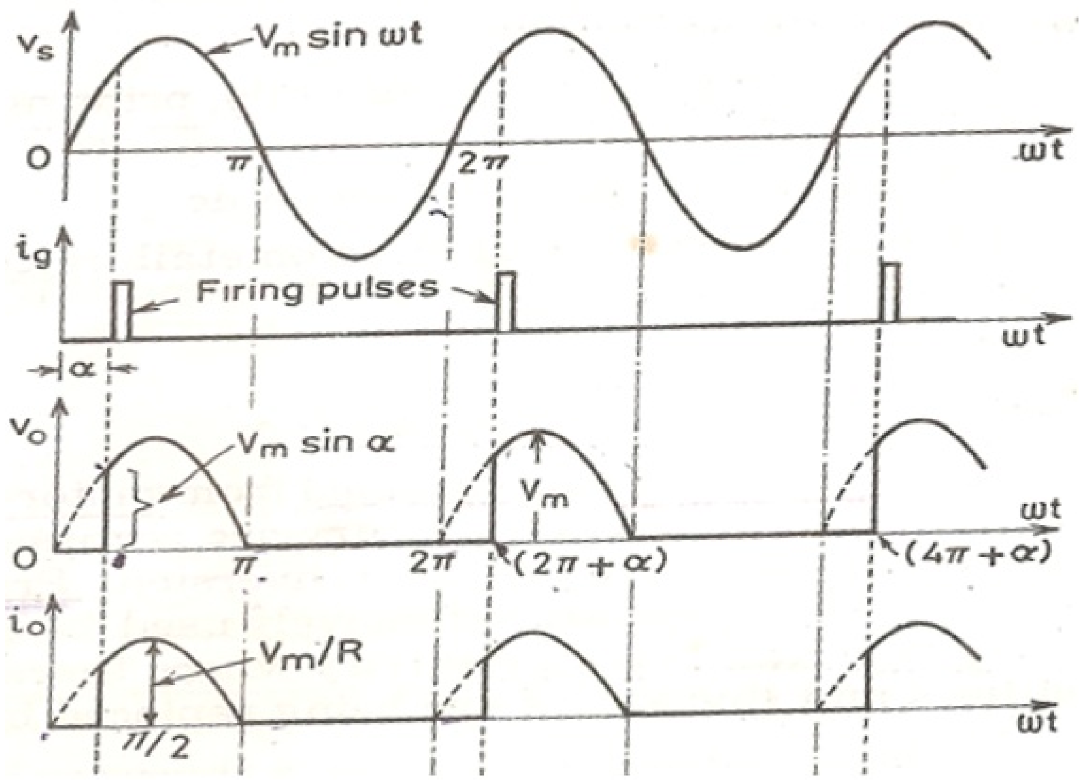


Theory:

- In the period $0 < \omega t < \pi$; the SCR is forward biased. Then current through the load and voltage drop across the load are zero, and all the supply voltage appears between the anode and cathode of the SCR.
- Let the SCR be triggered at an angle of α $(0 < \alpha < \pi)$.Then the supply terminals are connected to the load through the SCR

and the current starts flowing through the load via SCR. Therefore the supply appears across the load with a drop of R and the voltage drop across the SCR is zero (SCR is assumed ideal).

- In the period $\pi < \omega t < 2\pi$; the SCR is Reversed biased and the SCR cannot conduct. The voltage drop across the load is zero and the total supply voltage appears the SCR.
- Again during the third positive half cycle supply is positive again SCR is forward biased and if we give triggering pulse, then SCR starts conducting and this cycle repeats.
- Average Voltage V_0 across load R in terms of firing angle is given by : V_0=V_m/2π(1+cosα)
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_HW_Converter_R-Load -- Procedures

Step 1

Precautions:

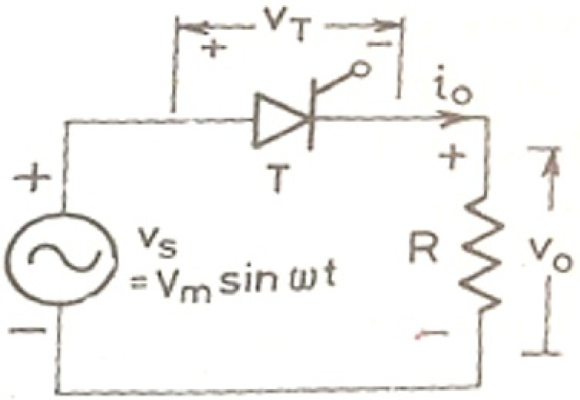
- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.

- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What will be RMS value when firing angle is - (a) 60 degree, (b) 90 degree?

Step 12

Switch off the power supply and disconnect from the power source.

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1-PHASE HALF WAVE CONTROLLED CONVERTER WITH R-L LOAD

Objective:

After performing this lab exercise, learner will be able to:

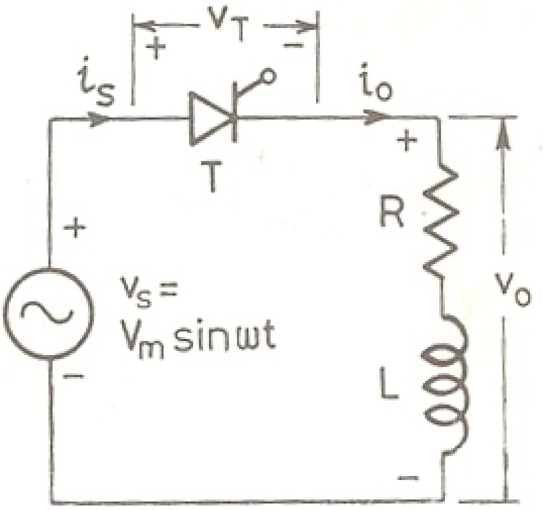
- Understand the working of 1-phase half wave control converter wit R-L load.
- Learn the role of Power Electronics in speed control of motors.
- Understand and design single-phase half wave converter with SCR.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:

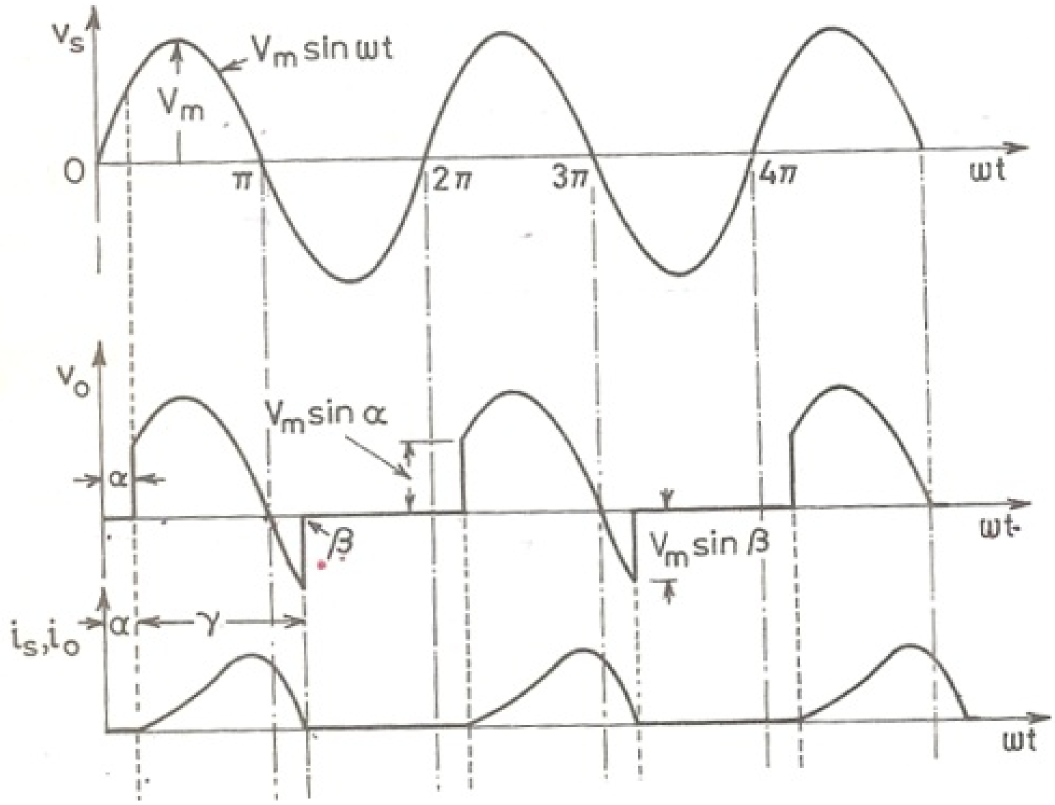


Theory:

- During first half of input application of gate pulse turns on thyristor when its anode is positive w.r.t. its cathode, and the forward voltage is greater than the threshold voltage. In this condition the voltage across the load is the same as the positive half cycle of the ac source.
- **During the interval 0 to π /2**
  - The source voltage Vs increases from zero to its positive maximum, while the voltage across the inductor VL opposes the change of current through the load. It must be noted that the current through an inductor cannot change instantaneously; hence the current gradually increases until it reaches its maximum value.
  - The current does not reach its peak when the voltage is at its maximum, which is consistent with the fact that the current through an inductor lags the voltage across it. During this time, energy is transferred from the ac source and is stored in the magnetic field of the inductor.
- **For the interval π/2 and π**
  - The source voltage decreases from its positive maximum to zero. The induced voltage in the inductor reverses polarity and opposes the associated decrease in current, thereby aiding the SCR forward current.
  - Therefore, the current starts decreasing gradually at a delayed time, becoming zero when all the energy stored by then inductor is released to the circuit.
  - Again this is consistent with the fact that current lags voltage in an inductive circuit. Hence, even after the source voltage has dropped past zero volts, there is still load current, which exists a little more than half a cycle.
- **For the interval greater than π**
  - At π, the source voltage reverses and starts to increase to its negative maximum. However, the voltage induced across the inductor is still positive and will sustain forward conduction of the diode until this induced voltage decreases to zero.
  - When this induced voltage falls to zero, the thyristor will now be reversed biased, but would have conducted forward current for an angle β, where β = α + γ.
- The average output voltage is given by:

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

- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_HW_Converter_R-L_Load -- Procedures

Step 1

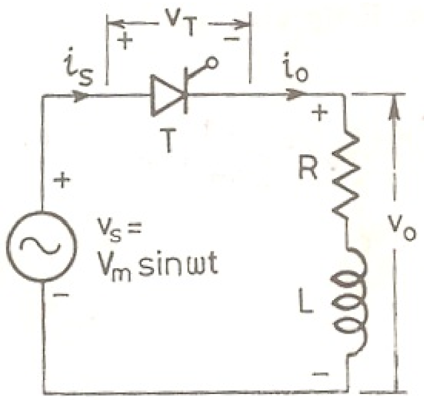
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don't touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What will be RMS value when firing angle is 60 degree?
- How different this value is for circuit with just R load?

Step 12

Switch off the power supply and disconnect from the power source.

1Ph_HW_Converter_R-L-E_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE HALF WAVE CONTROLLED CONVERTER WITH R-L-E LOAD

Objective:

After performing this lab exercise, learner will be able to:

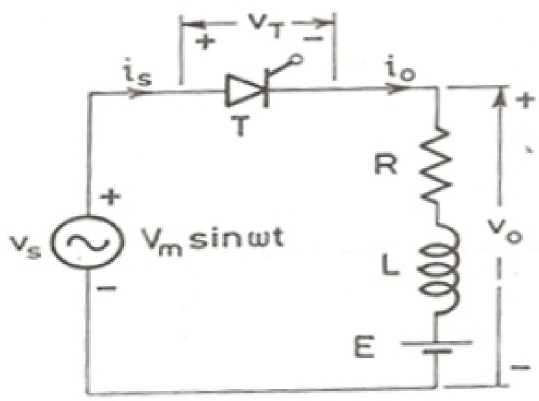
- Understand the working of 1-phase half wave control converter wit R-L-E load.
- Learn the role of Power Electronics in speed control of motors.
- Understand and design single-phase half wave converter with SCR.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



Theory:

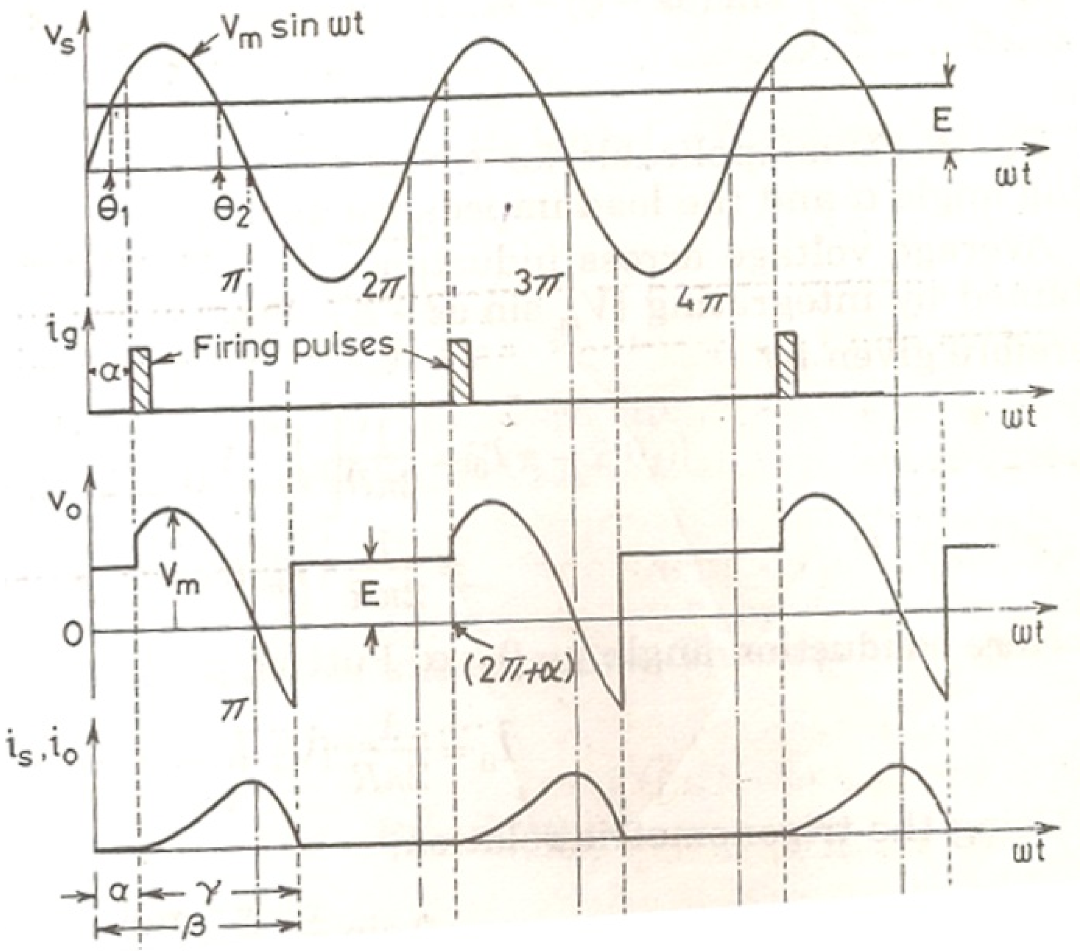
- The counter emf E in the load may be due to due to battery or a dc motor. The minimum value of firing angle is given by:

$$\alpha_{min} = sin^{-1}(\frac{E}{V_m})$$

- If thyristor is fired at an angle $\alpha < \alpha_{min}$ then E>Vs, SCR is reverse biased and therefore it will not turn on. Similarly maximum value of firing angle is $\alpha_{max} = \pi - \alpha_{min}$.
- For $\omega t > \pi/2$; the source voltage decreases from its positive maximum to zero. The induced voltage in the inductor reverses polarity and opposes the associated decrease in current, thereby aiding the diode forward current.
- Therefore, the current starts decreasing gradually at a delayed time, becoming zero when all the energy stored by then inductor is released to the circuit.
- Again this is consistent with the fact that current lags voltage in an inductive circuit. Hence, even after the source voltage has dropped past zero volts, there is still load current, which exists a little more than half a cycle.
- At π, the source voltage reverses and starts to increase to its negative maximum. However, the voltage induced across the inductor is still positive and will sustain forward conduction of the diode until this induced voltage decreases to zero.
- When this induced voltage falls to zero, the thyristor will now be reversed biased, but would have conducted forward current for an angle β, where $\beta = \alpha + \gamma$.
- The average output voltage is given by:

$$V_0 = \frac{1}{2\pi}\{V_m(cos\alpha - cos\beta) + E(2\pi + \alpha - \beta)\}$$

- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_HW_Converter_R-L-E_Load -- Procedures

Step 1

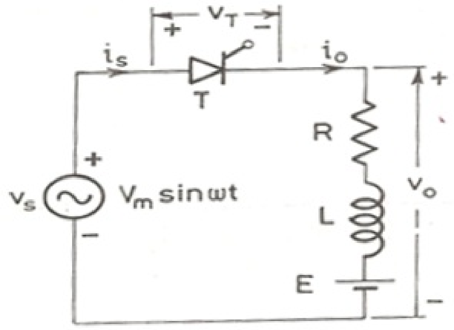
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What is the difference in V_0 waveform shape and its RMS Value when compared with that of circuit having only R load?

Step 12

Switch off the power supply and disconnect from the power source.

1Ph_FW_Converter_R-Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL WAVE CONTROLLED CONVERTER WITH R-LOAD

Objective:

After performing this lab exercise, learner will be able to:

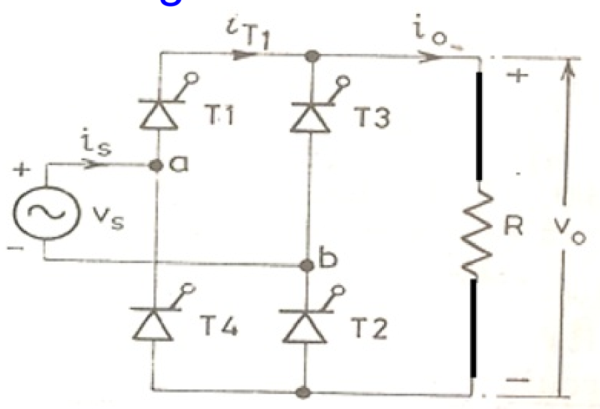
- Understand the working of 1-phase full wave control converter with R load.
- Learn the role of Power Electronics in speed control of motors.
- Understand and design single-phase full wave converter with SCR.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope

Circuit Diagram:



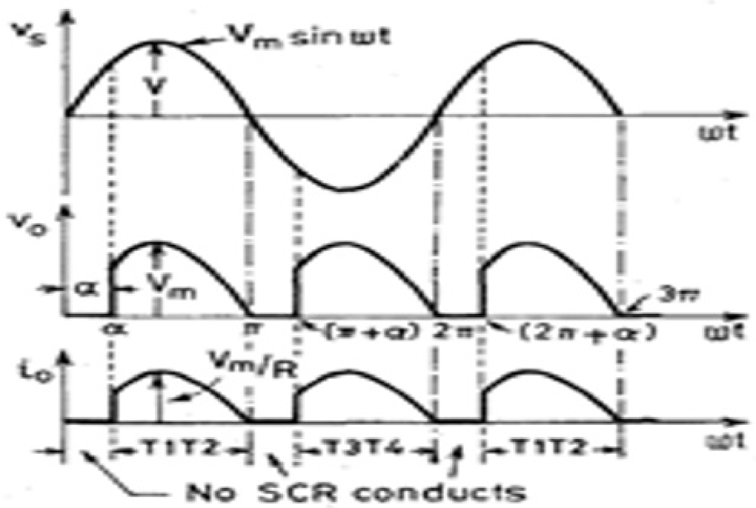
Theory:

- The circuit has four SCRs. For this circuit, Vs is a sinusoidal voltage source. When the supply voltage is positive, SCRs T1 and T2 triggered then current flows from Vs through SCR T1, load resistor R (from up to down), SCR T2 and back into the source.

- In the next half cycle, the other pair of SCRs T3 and T4 conducts when get pulse on their gates. Then current flows from Vs through SCR T3, load resistor R (from up to down), SCR T4 and back into the source.
- Even though the direction of current through the source alternates from one half-cycle to the other half-cycle, the current through the load remains unidirectional (from up to down).
- The main purpose of this circuit is to provide a controllable DC output voltage, which is brought about by varying the firing angle, α. Let Vs= Vm sin ωt, with 0 < ωt < 360 degree .
- If ωt= 30 degree when T1 and T2 are triggered, then the firing angle α is said to be 30 degree. In this instance, the other pair is triggered when ωt= 30+180=210 degrees
- When Vs changes from positive to negative value, the current through the load becomes zero at the instant ωt= π radians, since the load is purely resistive. After that there is no current flow till the other is triggered. The conduction through the load is discontinuous.
- Average Voltage V_0 across load R in terms of firing angle is given by :

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

- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_Converter_R-Load -- Procedures

Step 1

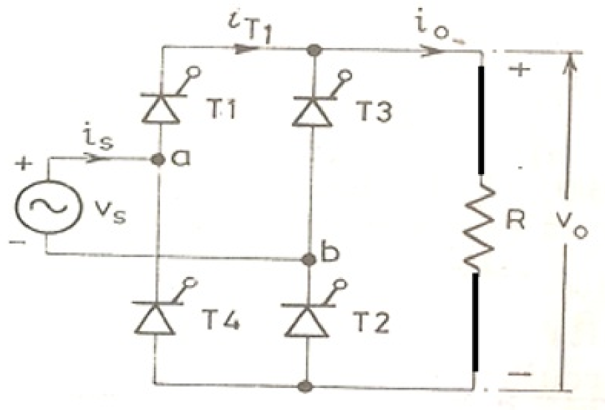
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don't touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What will be RMS value when firing angle is - (a) 60 degree, (b) 90 degree?

Step 12

Switch off the power supply and disconnect from the power source.

1Ph_FW_Converter_R-L_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
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1-PHASE FULL WAVE CONTROLLED CONVERTER WITH R-L LOAD

Objective:

After performing this lab exercise, learner will be able to:

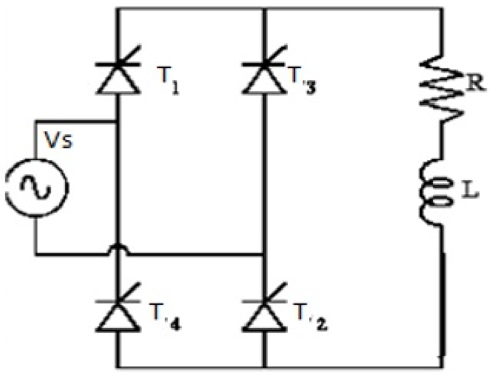
- Understand the working of 1-phase Full-Wave control converter wit R-L load.
- Learn the role of Power Electronics in speed control of motors.
- Understand and design single-phase full-wave converter with SCR.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



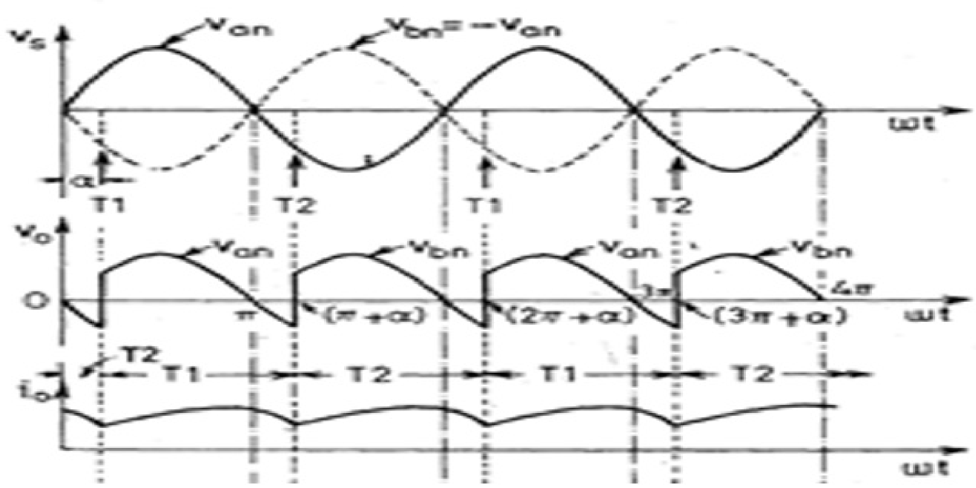
Theory:

- The circuit has four SCRs. For this circuit, Vs is a sinusoidal voltage source. When it is positive, the SCRs T1 and T2 triggered then current flows from +ve point of voltage source, Vs through SCR T1, load inductor L, load resistor R(from up to down), SCR T2 and back into the –ve point of voltage source.

- In the next half-cycle the current flows from –ve point of voltage source, Vs through SCR T3, load resistor R, load inductor L(from up to down), SCR T4 and back into the +ve point of voltage source.
- Even though the direction of current through the source alternates from one half-cycle to the other half-cycle, the current through the load remains unidirectional (from up to down).
- Let Vs = Vm sin ωt, with 0 < ωt< 360. If ωt= 30 degree, when T1 and T2 are triggered, then the firing angle is said to be 30 degree. In this instance the other pair is triggered when ωt= 210 degree.
- When Vs changes from a positive to a negative value, the current through the load does not fall to zero value at the instant ωt= π radians, since the load contains an inductor and the SCRs continue to conduct, with the inductor acting as a source.
- When the current through an inductor is falling, the voltage across it changes sign compared with the sign that occurs when its current is rising.
- When the current through the inductor is falling, its voltage is such that the inductor delivers power to the load resistor, feeds back some power to the AC source under certain conditions and keeps the SCRs in conduction forward-biased.
- If the firing angle is less than the load angle, the energy stored in the inductor is sufficient to maintain conduction till the next pair of SCRs is triggered. When the firing angle is greater than the load angle, the current through the load becomes zero and the conduction through the load becomes discontinuous.
- Usually the description of this circuit is based on the assumption that the load inductance is sufficiently large to keep the load current continuous and ripple-free.
- The average output voltage is given by:

$$V_0 = \frac{2V_m}{\pi} cos\alpha$$

- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_Converter_R-L_Load -- Procedures

Step 1

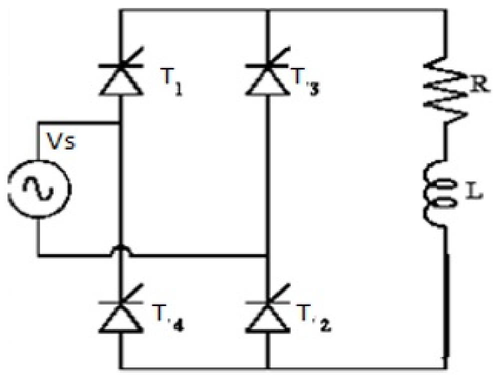
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What will be RMS value when firing angle is 60 degree?
- How different this value is for circuit with just R load?

Step 12

Switch off the power supply and disconnect from the power source.

1Ph_FW_Converter_R-L-E_Load -- Overview

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1-PHASE FULL WAVE CONTROLLED CONVERTER WITH R-L-E LOAD

Objective:

After performing this lab exercise, learner will be able to:

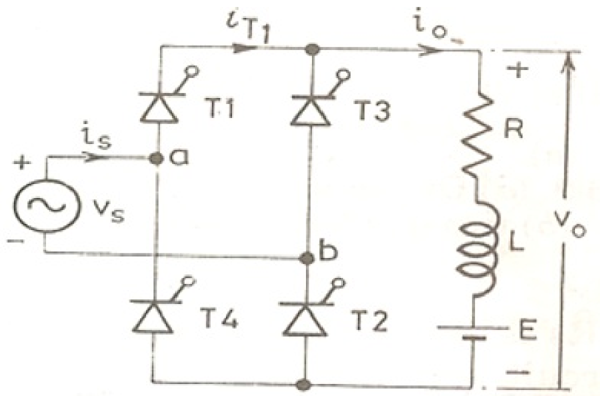
- Understand the working of 1-phase full-wave control converter wit R-L-E load.
- Learn the role of Power Electronics in speed control of motors.
- Understand and design single-phase full-wave converter with SCR.
- Analyze and interpret results.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Half wave controlled Converter Power circuit kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



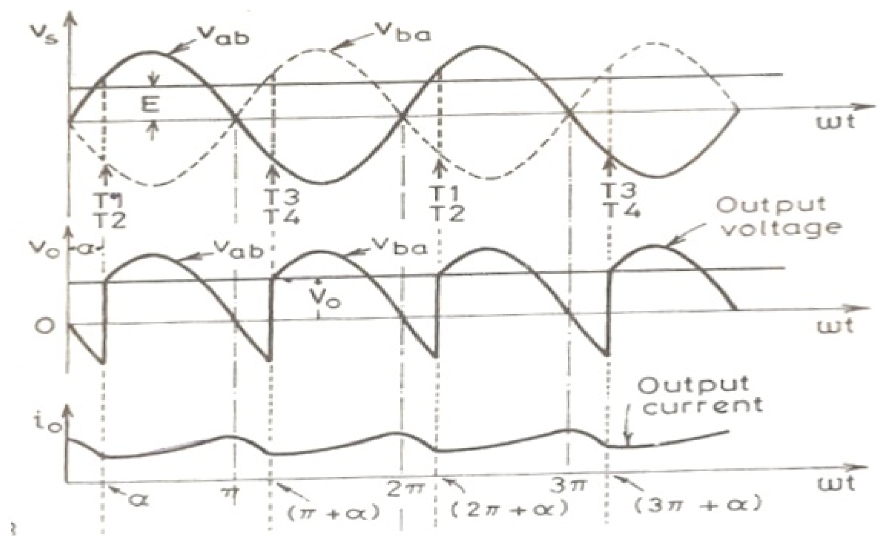
Theory:

- The circuit has four SCRs. For this circuit, Vs is a sinusoidal voltage source. The load is assumed to be of R-L-E type, where E is the load circuit EMF. This voltage may be a battery or may be the back emf of a DC motor.

- The SCRs T1 and T2 are simultaneously triggered and π radian later T3 and T4 are triggered together. When point a is positive w.r.t. b supply voltage is V_ab and when b is positive w.r.t. a supply voltage waveform is shown dotted as V_ba. Load current is assumed continuous over the range.
- Between ωt=0 and ωt=α; T1 and T2 are forward biased through already conducting SCRs T3 and T4 and block the forward voltage. For continuous conduction thyristors T3 and T4 conduct after ωt=0 eventhough these are reverse biased.
- Forward biased thyristors are triggered only when Vmsin ωt>E. When forward biased thyristors T1 and T2 are triggered at ωt=α, they get turned on.
- Hence supply voltage immediately appears across thyristors T3 and T4 as a reverse bias, therefore these are turned off by natural commutation. At the same time load current i_0 flowing in T3 and T4 is transferred to T1 and T2. T1 and T2 conducts for π radians i.e. from α to π+α. At ωt=π+α forward biased thyristors T3 and T4 are triggered.
- The supply voltage turns off T1 and T2 by natural commutation and the load current is transferred from T1 and T2 to T3 and T4.
- The average output voltage is given by:

$$V_0 = \frac{2V_m}{\pi} cos\alpha$$

- The ideal waveform of the experimental setup is shown in Figure below (for α<90 degree):

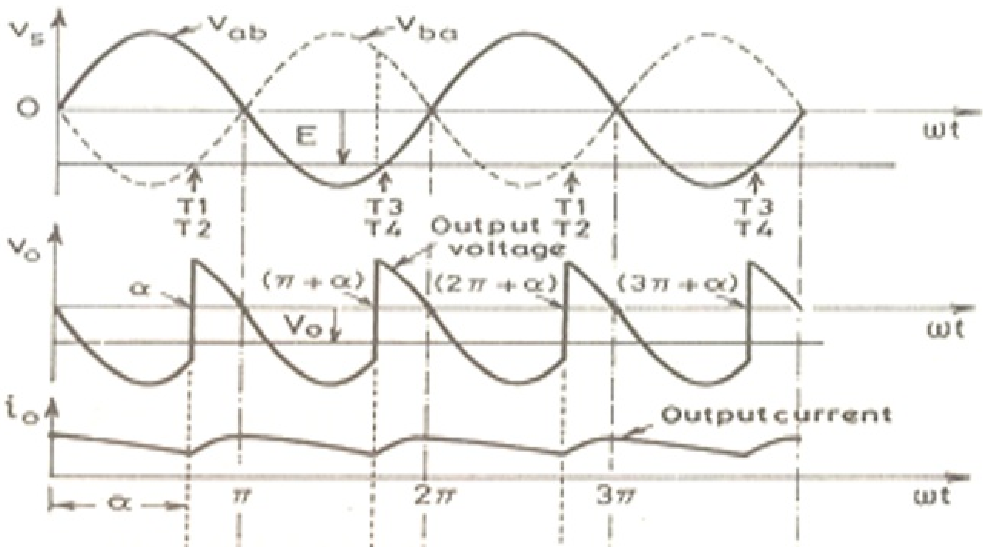


Inverter Mode:

- Inverter mode of operation if α>90 degree, output voltage is negative in this case. If the load circuit emf E is reversed and with α>90; then this dc source E will feed power back to ac source.
- This mode of operation of a full converter with α>90 degree is known as inverter operation and this full converter is known as

line commutated inverter.

- During 0 to α, ac source voltage is positive but ac source current is negative, power therefore flows from dc source to ac source.
- From α to π both ac source voltage and ac source current are positive hence power flows from ac source to dc source. But the net power flow is from dc source to ac source, because (π-α)< α.
- The ideal waveform of the experimental setup is shown in Figure below (for α > 90 degree):



1Ph_FW_Converter_R-L-E_Load -- Procedures

Step 1

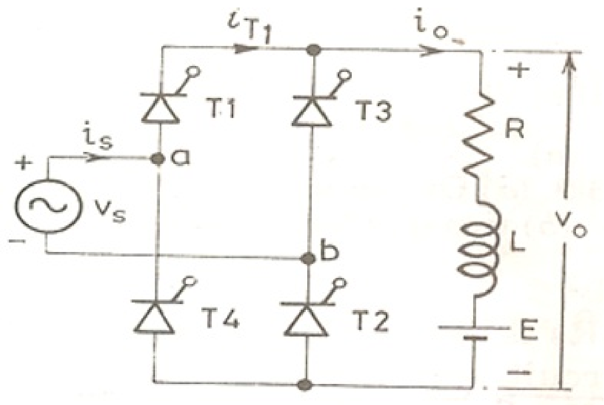
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What is the difference in V_0 waveform shape and its RMS Value when compared with that of circuit having only R load?

Step 12

Switch off the power supply and disconnect from the power source.

3Ph_FW_Converter_R-L-E_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

3-PHASE FULL WAVE CONTROLLED CONVERTER WITH R-L-E LOAD

Objective:

After performing this lab exercise, learner will be able to:

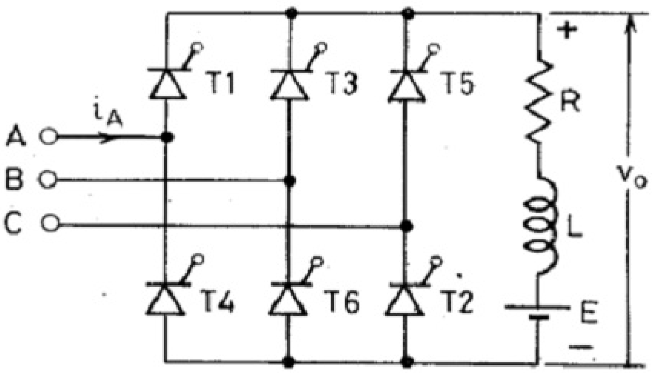
- Understand the concept of Line and Phase voltage in three phase circuit
- Understand the working of 3-phase full wave control converter wit R-L-E load.
- Learn the role of Power Electronics in speed control of induction motors.
- Understand and design three-phase full wave converter with SCR.
- Work with a digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Three-phase full wave controlled Converter Power circuit kit
- SCR firing circuit kit, 3-phase, 230V, 10A
- Patch chords
- Load (100 ohm /10A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



Theory:

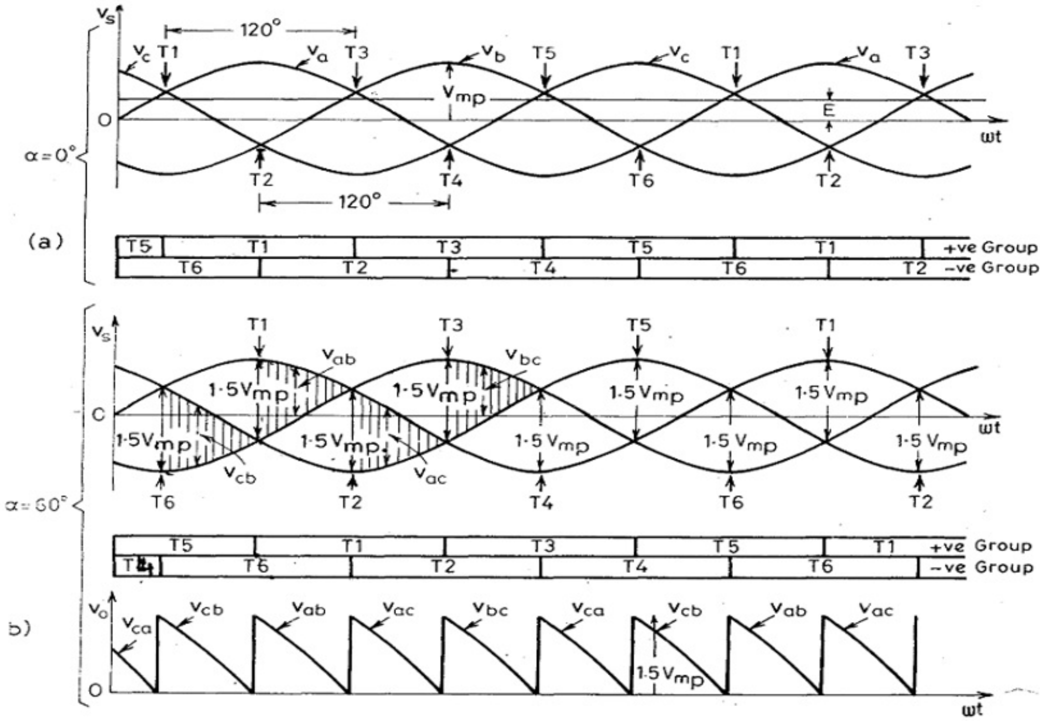
- Three phase input supply is connected to terminals A,B and C and the load R-L-E is connected across the output terminals. The counter emf E in the load may be due to due to battery or a dc motor. Thyristors 1,3,5 are the positive group thyristors and 2,4,6 are the negative group thyristors.

- For α =0 degree; T1,T2,……T6 behave like diodes. For α =0 degree, T1 is triggered at ωt=π/6, T2 at 90 degree, T3 at 150 degree and so on. For α =60 degree, T1 is triggered at ωt=30 + 60=90 degree, T2 at 90 + 60=150 degree and so on.
- Each SCR conducts for 120 degree, when T1 is triggered, reverse biased thyristor T5 is turned off and T1 is urned on.T6 is already conducting. As T1 is connected to A and T6 to B, voltage Vab, appears across load. When T2 is turned on, T6 is commutated from the negative group.T1 is already conducting.
- As T1 and T2 are connected to A and C respectively, voltage Vac appears across load. Value of Vab and Vac varies from 1.5Vmp to zero. Vmp is the maximum value of phase voltage. This sequence of triggering is continued for other SCRs.
- Similar to positive group SCRs negative group SCRs are also fired at an interval of 120 degree. At any time, two SCRs, one from positive group and one from negative group, must conduct together for the source to energise the load. For ABC phase sequence of the three phase supply, thyristors conduct in pairs; T1 and T2, T2 and T3, T3 and T4, T4 and T5 and so on.
- Just like single phase converter for 0 <α ≤ 90 degree circuit works as three phase ac to dc converter and for 90 < α < 180 degre it works as a line commutated inverter.
- It can work in inverter mode only if the load has a direct emf E due to a battery or a dc motor. It should be noted that direction of current for both converter and inverter operation remains fixed but the polarity of output voltage reverses.
- Output voltage of the three phase full converter is given by:

$$V_0 = \frac{3V_{ml}}{\pi} cos\alpha$$

where V_ml is Maximum line voltage

- The ideal waveform of the experimental setup is shown in Figure below:



3Ph_FW_Converter_R-L-E_Load -- Procedures

Step 1

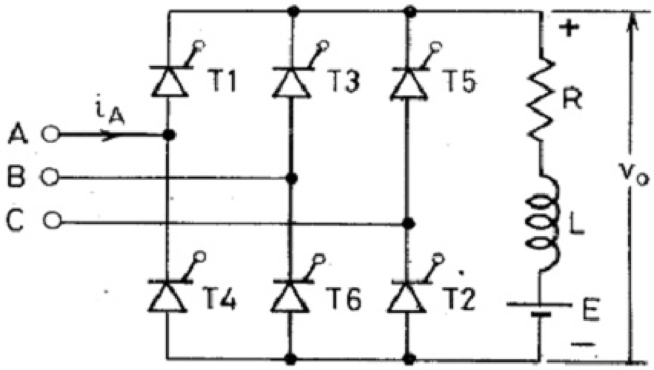
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe at Sine wave input (signal generator) source and across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the firing angle to 0 degree and capture input and output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 8

Now change the firing angle to 30 degree.

Step 9

Measure the RMS value of the output and take screenshot of input and output waveform.

Step 10

Continue Step # 8 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Open Question:

- What is the difference in V_0 waveform shape and its RMS Value when compared with that of 1 phase circuit with similar load?

Step 12

Switch off the power supply and disconnect from the power source.

Step_Down_Chopper -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

STEP-DOWN CHOPPER (DC-DC CONVERTER)

Objective:

After performing this lab exercise, learner will be able to:

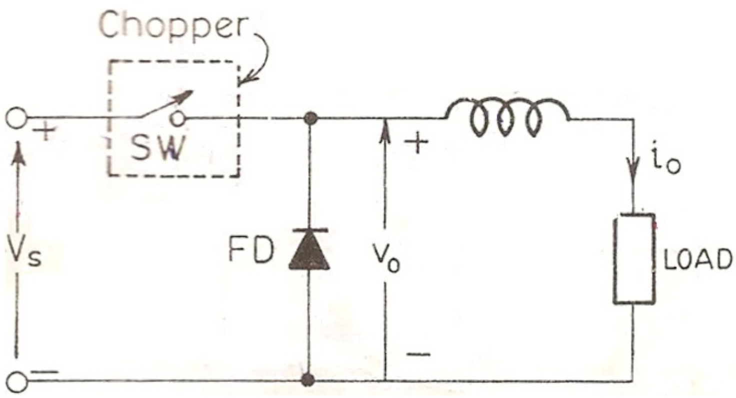
- Understand the working of DC-DC converter.
- Understand and design single-phase Step Down Chopper.
- Analyze and interpret results.
- Learn the role of Power Electronics in utility related applications, e.g. UPS, SMPS etc.
- Work with digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Single Phase DC-DC converter Kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



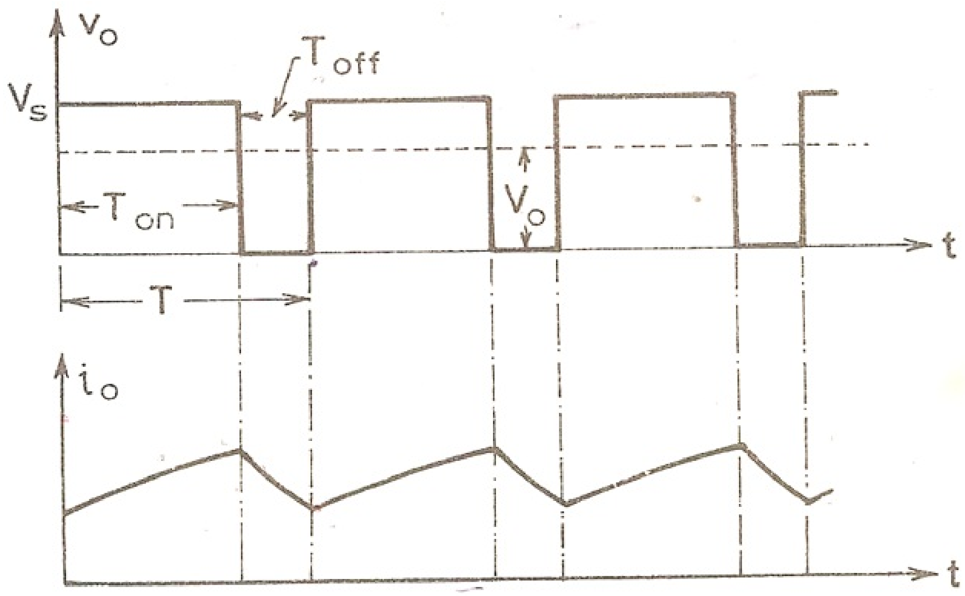
Theory:

- A chopper is a high speed ON/OFF switch. It connects source to load and disconnect the load from the source at very fast speed. Hence a chopped output voltage is obtained from a constant DC supply.
- During the period T_on, chopper is ON and load voltage is equal to source voltage Vs.

- During interval T_off, copper is OFF, load current flows through freewheeling diode. As a result load terminal are short circuited by FD and load voltage is therefore zero during T_off.
- In this manner a chopped dc voltage is produced at the load terminals. During T_on, load current rises, whereas during T_off, load current decays.
- The average load voltage of the chopper can be given by:

$$V_0 = \frac{T_{ON}}{T_{ON} + T_{OFF}} V_s = \alpha V_s$$ Where α is the duty cycle

- The ideal waveform of the experimental setup is shown in Figure below:



Step_Down_Chopper -- Procedures

Step 1

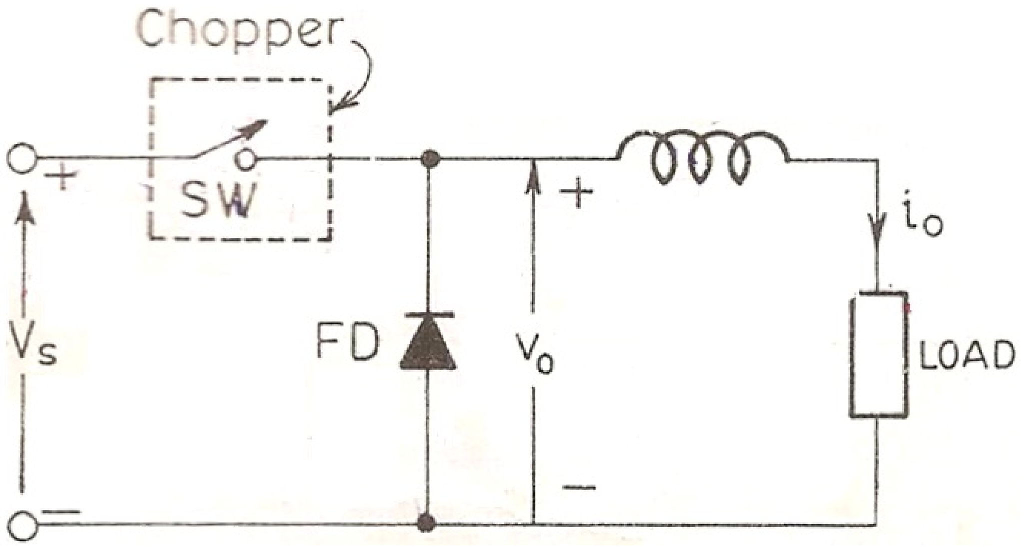
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the duty cycle (duty ratio) to 0.1 (10%) and capture output waveforms on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of output waveform.

Step 8

Now change the duty cycle to 0.2 (20%).

Step 9

Measure the RMS value of the output and take screenshot of output waveform.

Step 10

Continue Step # 8 for different values of duty cycle like 30%, 40%... till 90%.

Step 11

Open Question:

- What is the relationship of RMS value of output with the duty cycle?
- What happens to RMS value of the output when duty cycle is increased from 10% to 90%?

Step 12

Switch off the power supply and disconnect from the power source.

Step_Up_Chopper -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

STEP-UP CHOPPER (DC-DC CONVERTER)

Objective:

After performing this lab exercise, learner will be able to:

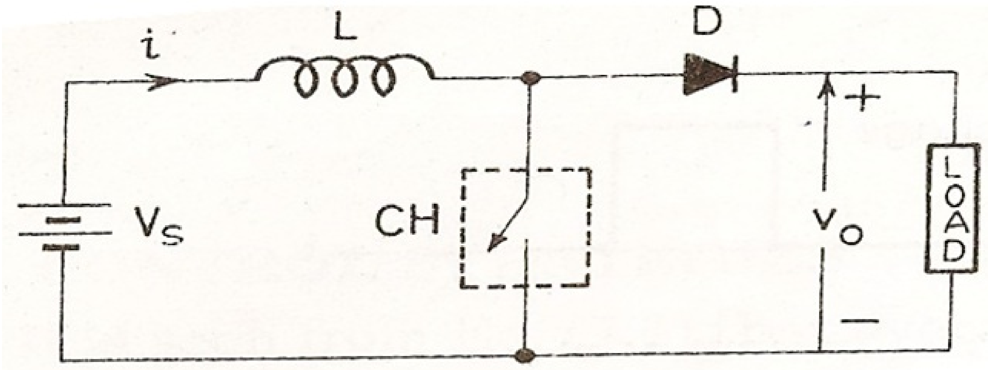
- Understand the working of DC-DC converter.
- Understand and design single-phase Step Up Chopper.
- Analyze and interpret results.
- Learn the role of Power Electronics in utility related applications, e.g. UPS, SMPS etc.
- Work with digital oscilloscope to debug circuit and analyze signals.

Equipment:

To carry out this experiment, you will need:

- Single Phase DC-DC converter Kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load
- Digital Oscilloscope (TBS1000B-EDU from Tektronix)

Circuit Diagram:



Theory:

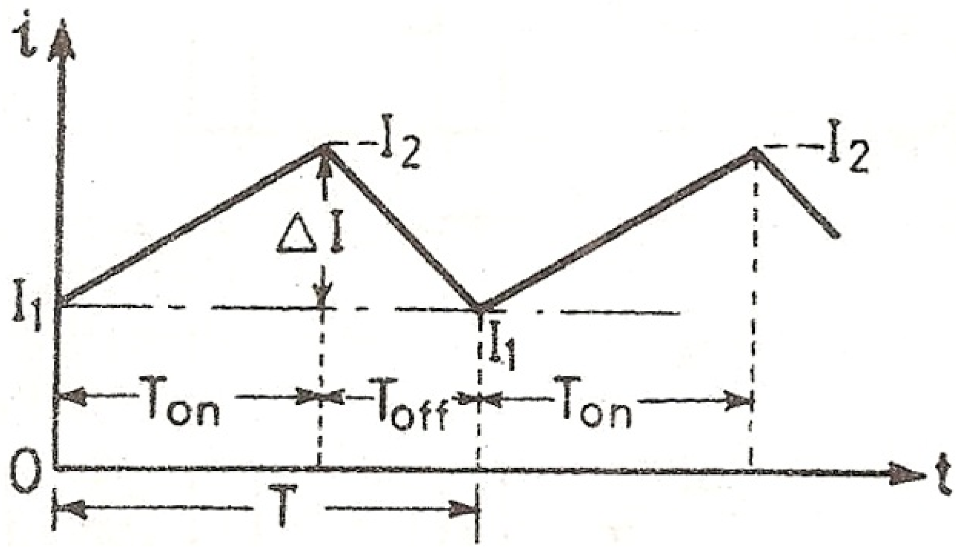
- A chopper is a high speed ON/OFF switch. It connects source to load and disconnect the load from the source at very fast speed. Hence a chopped output voltage is obtained from a constant DC supply.
- If in a chopper average output voltage Vo is greater than the input voltage Vs, then this type of chopper is called as step up

chopper.

- In this chopper, a large inductor is in series with with source voltage. When chopper CH is ON, the path is closed and inductor store energy during this period.
- When CH is OFF, as the inductor current cannot die down instantaneously, this current is forced to flow through the diode and load for time T_off.
- As the current tends to decrease, polarity of the induced EMF in L is reversed. As a result voltage across the load, given by Vo = Vs + L (di/dt), exceeds the source voltage Vs. In this manner, circuit acts as a step up the chopper.
- The average load voltage of the chopper can be given by:

$$V_0 = \frac{T}{T_{OFF}} V_s = \frac{1}{1-\alpha} V_s$$ Where α is the duty cycle

- The ideal waveform of the experimental setup is shown in Figure below:



Step_Up_Chopper -- Procedures

Step 1

Precautions:

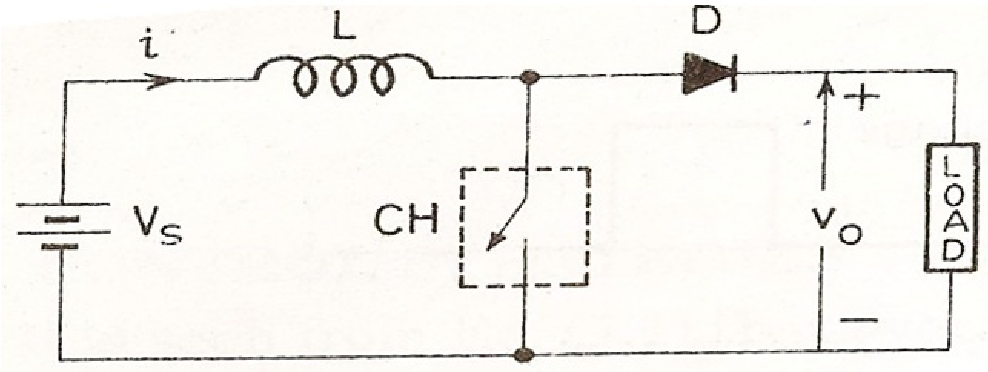
- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor

present in the circuit, if any.
- Don't touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

Set the duty cycle (duty ratio) to 0.1 (10%) and capture output waveform on oscilloscope

Step 7

Measure the RMS value of the output and take screenshot of output waveform.

Step 8

Now change the duty cycle to 0.2 (20%).

Step 9

Measure the RMS value of the output and take screenshot of output waveform.

Step 10

Continue Step # 8 for different values of duty cycle like 30%, 40%... till 90%.

Step 11

Open Question:

- What is the relationship of RMS value of output with the duty cycle?
- What would be the expected output voltage (Vo) in terms of Vs for duty cycle of 50%? Verify the actual value against expected.

Step 12

Switch off the power supply and disconnect from the power source.

1Ph_HW_Inverter -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE HALF WAVE INVERTER WITH R-LOAD

Objective:

After performing this lab exercise, learner will be able to:

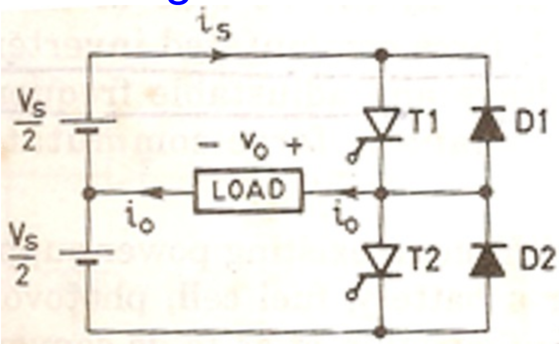
- Understand the working of DC-AC inverter
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Half Wave Inverter.
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase inverter kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope

Circuit Diagram:

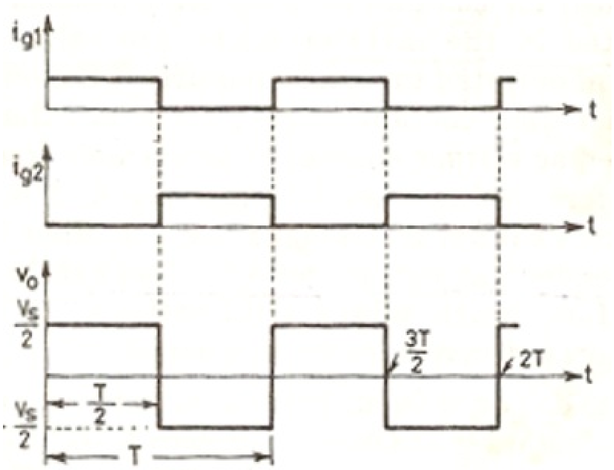


Theory:

- A device that converts DC power into AC power at desired output voltage and frequency is called an inverter.
- The single phase half bridge consists of two SCRs and two diodes and three wire supply. For $0 < t \leq T/2$, thyristor T1 conducts and load is subjected to a voltage Vs/2 due to upper voltage source Vs/2.
- At t = T/2, thyristor T1 commuted and T2 is gated on. During the period $T/2 < t \leq T$, thyristor T2 conducts and load is subjected to

a voltage (-Vs/2) due to lower voltage source Vs/2.

- Load voltage is an alternating voltage of amplitude of Vs/2 and of frequency 1/T Hz.
- The frequency of the inverter output voltage can be changed by controlling T.
- The main drawback of half-bridge inverter is that it requires 3-wire DC supply
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_HW_Inverter -- Procedures

Step 1

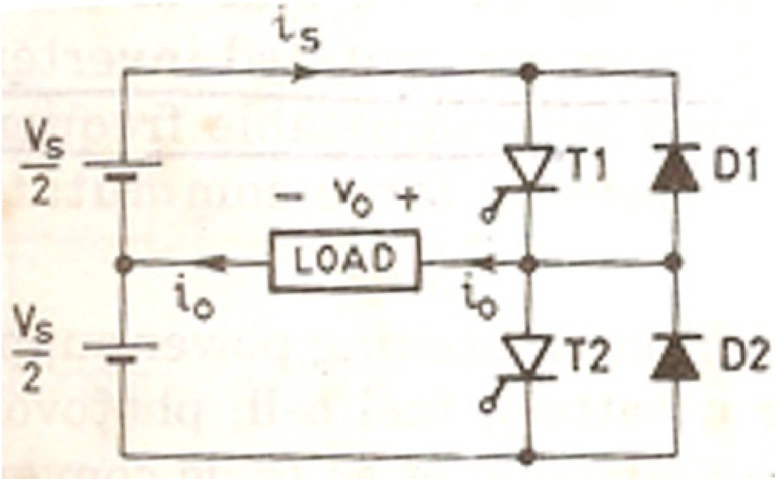
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the duty cycle to 50%
- Capture output waveforms on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

Switch off the power supply and disconnect from the power source.

1Ph_FW_Inverter -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL WAVE INVERTER WITH R-LOAD

Objective:

After performing this lab exercise, learner will be able to:

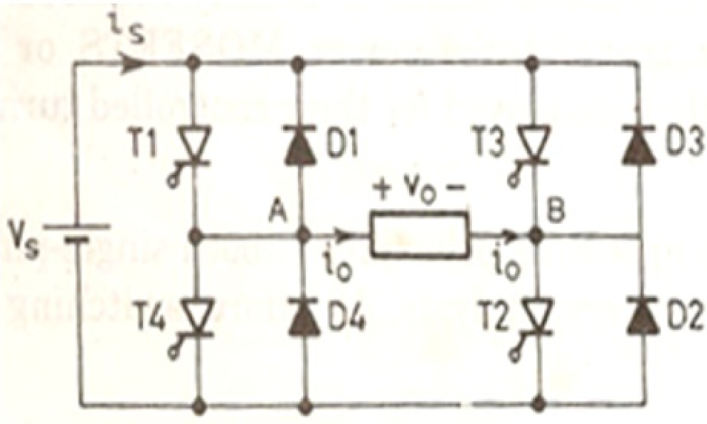
- Understand the working of DC-AC inverter
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Full Wave Inverter.
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase inverter kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load (100 ohm / 2A)
- Digital Oscilloscope

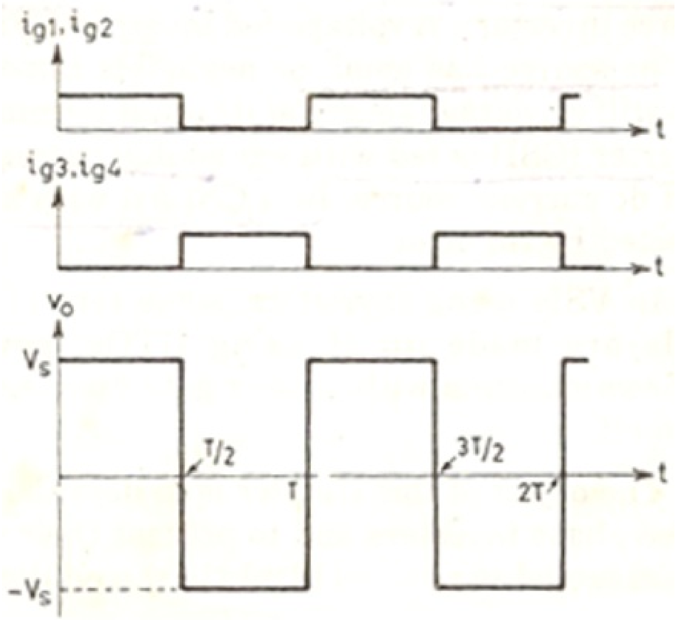
Circuit Diagram:



Theory:

- A device that converts DC power into AC power at desired output voltage and frequency is called an inverter.
- For Full bridge inverter when T1, T2 conduct, load voltage is Vs and T3, T4 conduct load voltage is –Vs.
- Frequency of output voltage can be controlled by varying the periodic time T.

- During inverter operation it should be ensured that two thyristors in the same branch should not conduct simultaneously as this would lead to a direct short circuit of the source.
- For resistive load voltage and load current would always be in phase with each other. Due to this reason diodes will not come into action.
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_Inverter -- Procedures

Step 1

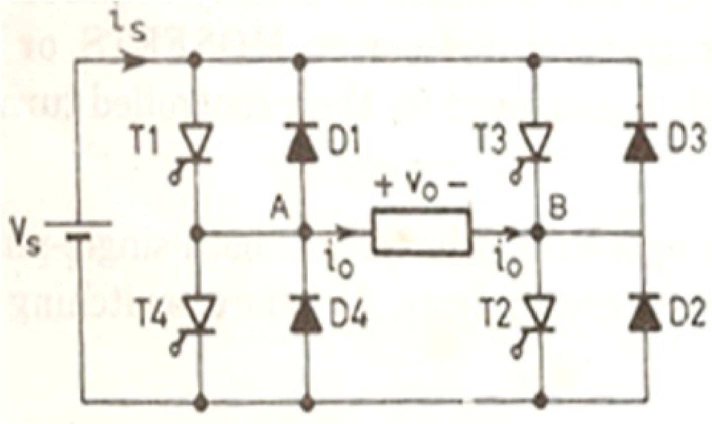
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the duty cycle to 50%
- Capture output waveforms on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

Switch off the power supply and disconnect from the power source.

1Ph_FW_Inverter_R-L_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL-WAVE INVERTER WITH R-L LOAD

Objective:

After performing this lab exercise, learner will be able to:

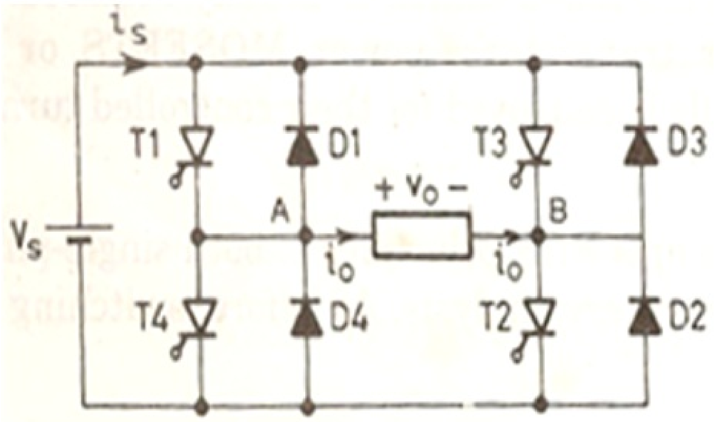
- Understand the working of DC-AC inverter
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Full Wave Inverter with R-L Load.
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase inverter kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load
- Digital Oscilloscope

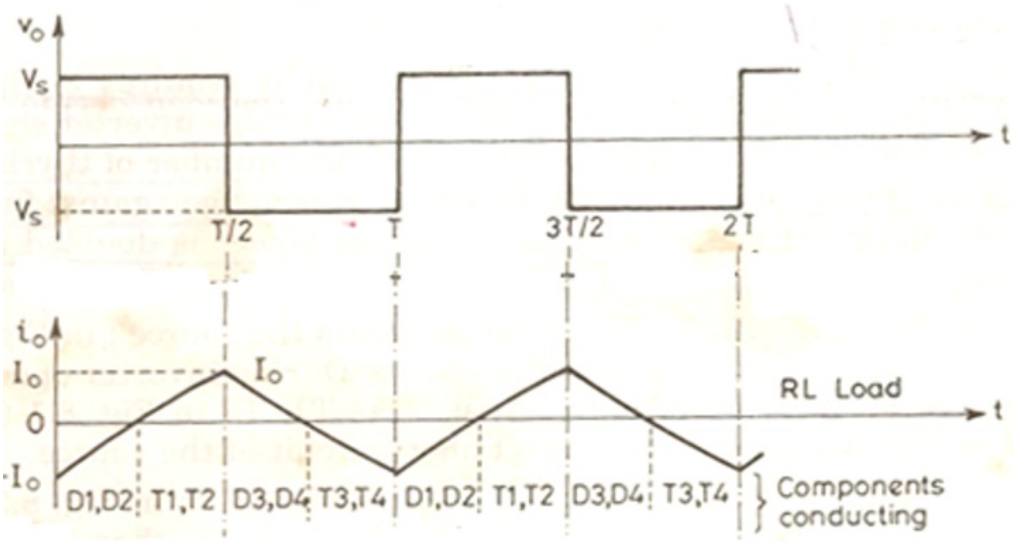
Circuit Diagram:



Theory:

- Single phase full bridge inverter consists of four SCRs and four diodes. For Full bridge inverter when T1, T2 conduct, load voltage is Vs and T3, T4 conduct load voltage is –Vs.

- Frequency of output voltage can be controlled by varying the periodic time T.
- During inverter operation it should be ensured that two thyristors in the same branch should not conduct simultaneously as this would lead to a direct short circuit of the source.
- For inductive load, load voltage and load current will not be in phase with each other. In this case diodes D1, D2, D3 and D4 connected in antiparallel will thyristors will allow the current to flow when main thyristors are turned off. As the energy is fed back to the dc source when these diodes conduct, these are called feedback diodes.
- Before t = 0, thyristors T3 and T4 are conducting and load current i0 is flowing from B to A, i.e. in reverse direction. This current is –i_o at t =0.
- After T3 and T4 are turned off at t = 0, current i0 cannot change its direction immediately because if the nature of load.
- As a result diodes D1 and D2 starts conducting after t = 0 and allow i_o to flow against the supply voltage Vs. A soon as D1 and D2 begin to conduct, load is subjected to Vs.
- Though T1 and T2 are gated at t = 0, these SCRs will not turn on as these are reverse biased by voltage drop across diodes D and D2.
- When Load current through D1 and D2 falls to zero, T1 and T2 becomes forward biased by source voltage Vs.
- Now T1 and T2 get turned on as these are gated for the period of T/2 seconds. Now load current i0 flows in the positive direction from A to B. At t = T/2; T1 and T2 are turned off by forced commutation and as load current cannot reverse immediately, diodes D3 and D4 come into conduction to allow the flow of current i_o after T/2.
- Thyristor T3 and T4 though gated will not turn on as these are reverse biased by the voltage drop in diodes D3 and D4. When current in diodes D3 and D4 drops to zero; T3 and T4 are turned on as these are already gated.
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_Inverter_R-L_Load -- Procedures

Step 1

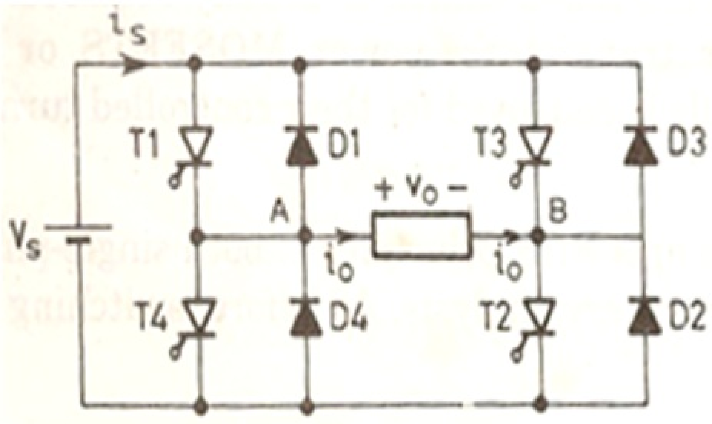
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the duty cycle to 50%
- Capture output waveform on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

Switch off the power supply and disconnect from the power source.

1Ph_FW_Inverter_RLC_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL-WAVE INVERTER WITH R-L-C LOAD

Objective:

After performing this lab exercise, learner will be able to:

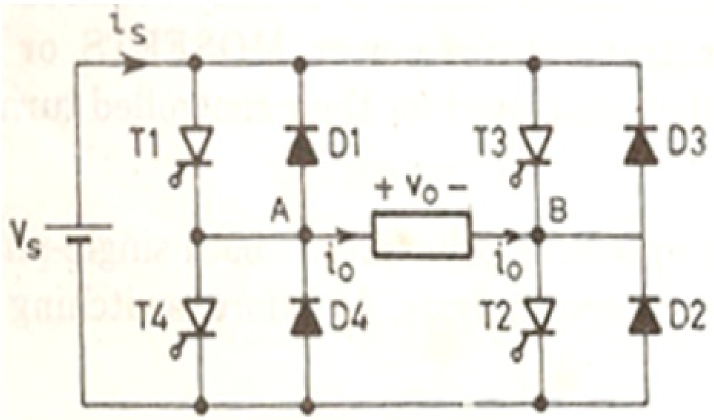
- Understand the working of DC-AC inverter
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Full Wave Inverter.
- Understand the concept of underdamping and over-damping
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase inverter kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load
- Digital Oscilloscope

Circuit Diagram:

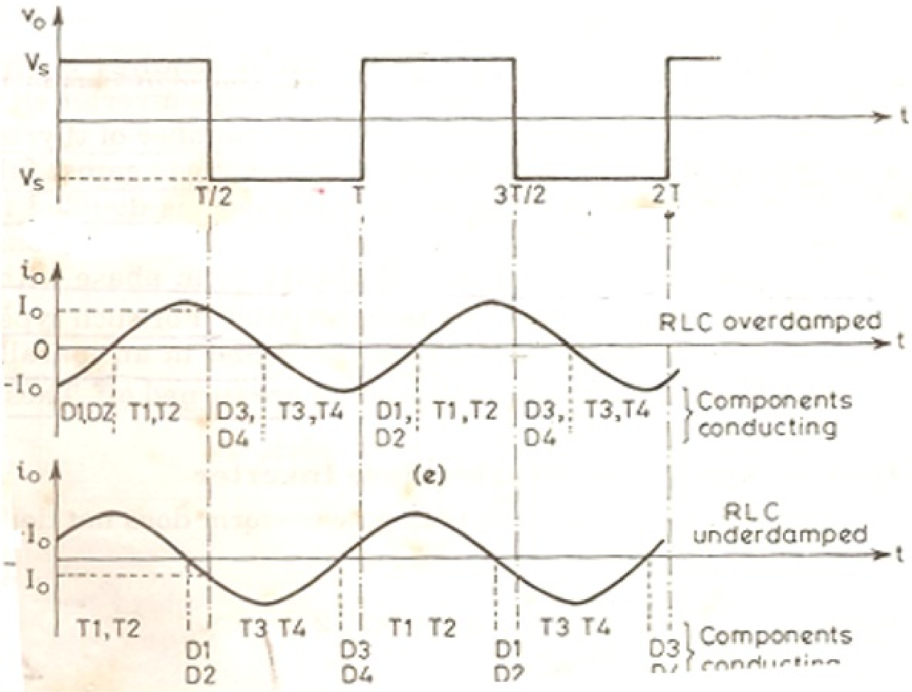


Theory:

- Single phase full bridge inverter consists of four SCRs and four diodes. For Full bridge inverter when T1, T2 conduct, load voltage is Vs and T3, T4 conduct load voltage is –Vs.

- Frequency of output voltage can be controlled by varying the periodic time T.
- During inverter operation it should be ensured that two thyristors in the same branch should not conduct simultaneously as this would lead to a direct short circuit of the source.
- For inductive load, load voltage and load current will not be in phase with each other. In this case diodes D1, D2, D3 and D4 connected in antiparallel will thyristors will allow the current to flow when main thyristors are turned off. As the energy is fed back to the dc source when these diodes conduct, these are called feedback diodes.
- Operation of series R-L-C load can be explained for R-L-C under damped and over damped load.
- R-L-C Over Damped Load:
    - Before t = 0, thyristors T3 and T4 are conducting and load current i0 is flowing from B to A, i.e. in reverse direction. This current is –I_o at t =0.
    - After T3 and T4 are turned off at t = 0, current i_o cannot change its direction immediately because if the nature of load. As a result diodes D1 and D2 starts conducting after t = 0 and allow i0 to flow against the supply voltage Vs. A soon as D1 and D2 begin to conduct, the load is subjected to Vs.
    - Though T1 and T2 are gated at t = 0, these SCRs will not turn on as these are reverse biased by the voltage drop across the diodes D1 and D2. When Load current through D1 and D2 falls to zero, T1 and T2 becomes forward biased by source voltage Vs.
    - Now T1 and T2 get turned on as these are gated for the period of T/2 seconds. Now load current i_o flows in the positive direction from A to B. At t = T/2; T1 and T2 are turned off by forced commutation and as load current cannot reverse immediately, diodes D3 and D4 come into conduction to allow the flow of current i0 after T/2.
    - Thyristor T3 and T4 though gated will not turn on as these are reverse biased by the voltage drop in diodes D3 and D4. When the current in diodes D3 and D4 drops to zero; T3 and T4 are turned on as these are already gated
- R-L-C Over Damped Load:
    - For R-L-C under damped load after t = 0, thyristor T1 and T2 are carrying load current i_o. As io through T1 and T2 reduces to zero at t1, these SCRs are turned off before T3 and T4 are gated.
    - As T1 and T2 stops conducting, current through the load reverses and now is carried by diodes D1 and D2 as T3 and T4 are not yet gated.
    - The diodes D1 and D2 are connected in antiparallel to T1 and T2; the voltage drop in these diodes appears as a

reverse bias across T1 and T2.
    - If the duration of reverse bias is more than the SCR turn off time; T1 and T2 will get commutated naturally and therefore no commutation circuitry is needed.
    - This method of commutation is known as load commutation.
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_Inverter_RLC_Load -- Procedures

Step 1

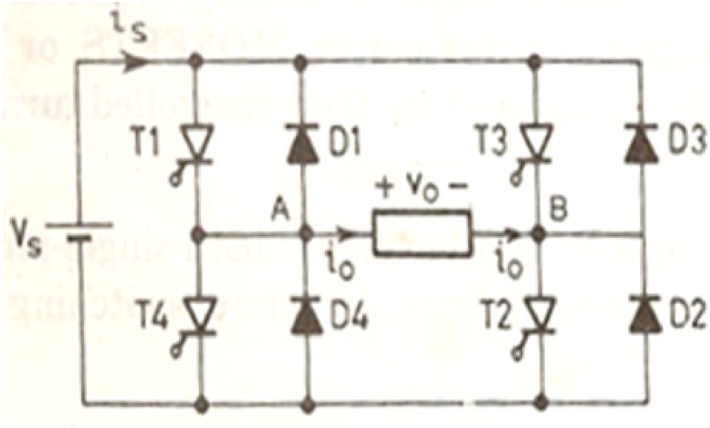
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO's probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the duty cycle to 50%
- Capture output waveform on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

Switch off the power supply and disconnect from the power source.

1Ph_FW_AC-Controller_R-Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL-WAVE AC CONTROLLER WITH RESISTIVE LOAD

Objective:

After performing this lab exercise, learner will be able to:

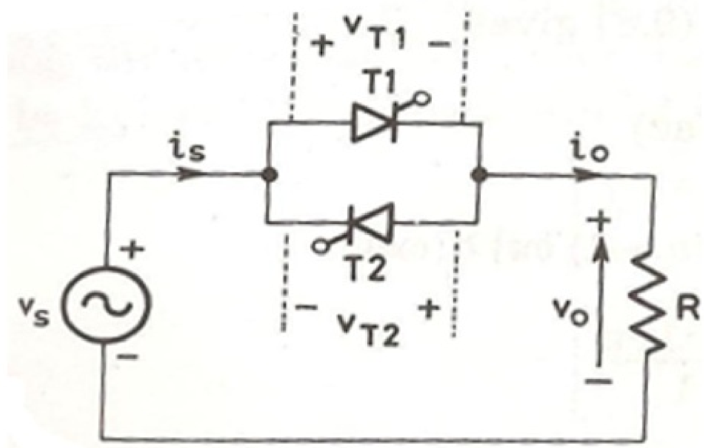
- Understand the working of AC-AC converter
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Full Wave AC voltage controller.
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase AC Voltage Controller kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load
- Digital Oscilloscope

Circuit Diagram:

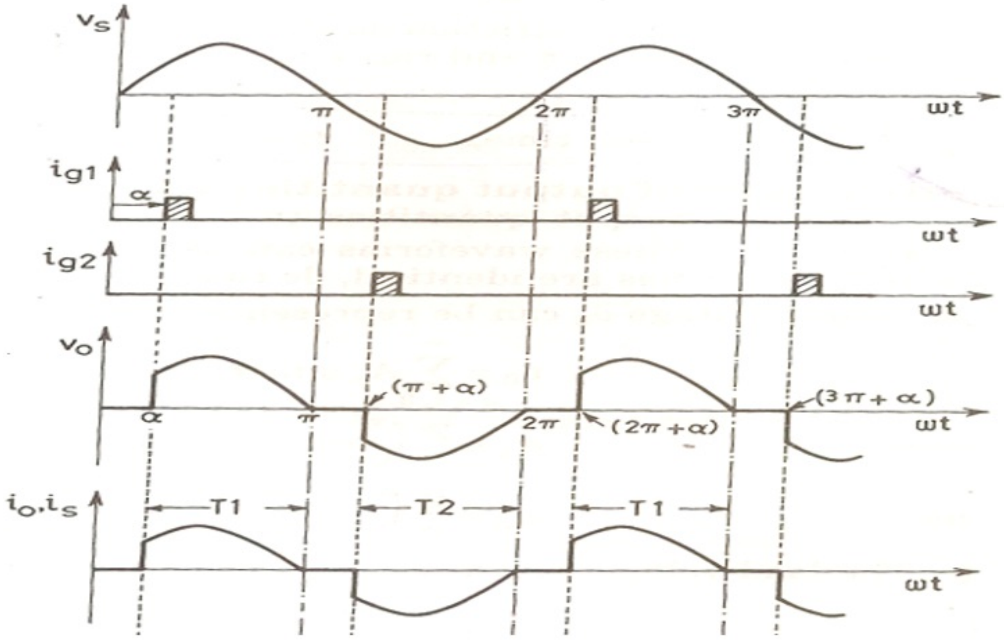


Theory:

- Single phase full wave voltage controller consists of two SCRs connected in antiparallel.
- Thyristors T1 and T2 are forward biased during positive and

negative half cycles respectively.

- During positive half cycle, T1 is triggered at firing angle α, it conducts from ωt = α to π and source voltage is applied to load.
- At π both source voltage and source current fall to zero. Just after π, T1 is reverse biased and therefore turned off.
- During negative half cycle T2 is triggered at ωt = π+ α, it conducts from π+ α to 2π.
- Soon after 2π, T2 is subjected to a reverse bias, it is therefore commutated. Load and source currents have same waveforms.
- The ideal waveform of the experimental setup is shown in Figure below:



1Ph_FW_AC-Controller_R-Load -- Procedures

Step 1

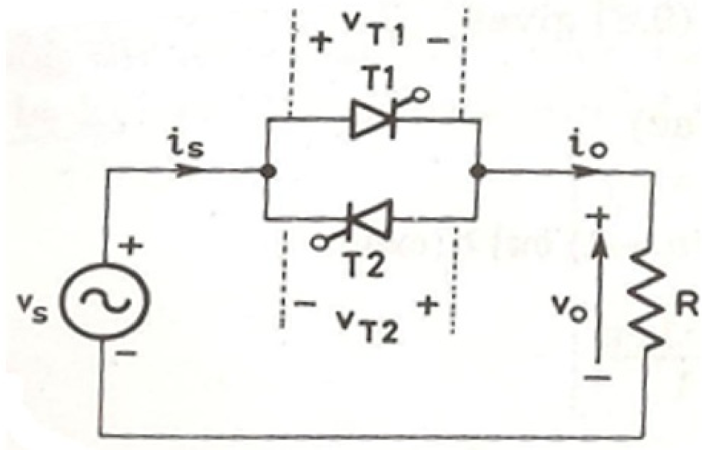
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don’t touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the firing angle to 0 degree
- Capture output waveform on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

- Set the firing angle to 30 degree
- Capture output waveform on oscilloscope

Step 9

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 10

Continue Step # 8 and 9 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Switch off the power supply and disconnect from the power source.

1Ph_FW_AC-Controller_R-L_Load -- Overview

Dr. Ashish Shrivastava (Professor & HoD)
Vikas Singh Bhadoria (Asst. Professor)
Electrical Engineering Department
JRE Group of Institution, Gr.Noida (UP)

1-PHASE FULL-WAVE AC CONTROLLER WITH R-L LOAD

Objective:

After performing this lab exercise, learner will be able to:

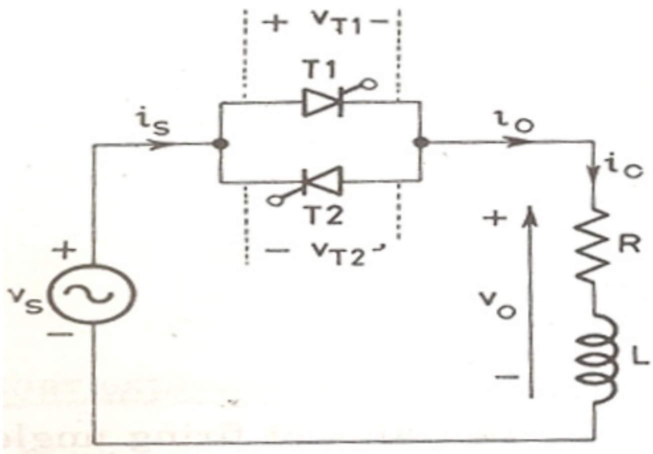
- Understand the working of AC-AC converter with R-L Load
- Learn the role of Power Electronics in utility related applications.
- Understand and design single-phase Full Wave AC voltage controller.
- Analyze and interpret results
- Work with digital oscilloscope to debug circuit and analyze signals

Equipment:

To carry out this experiment, you will need:

- Single phase AC Voltage Controller kit
- SCR firing circuit kit, 1-phase, 230V, 5A
- Patch chords
- Load
- Digital Oscilloscope

Circuit Diagram:

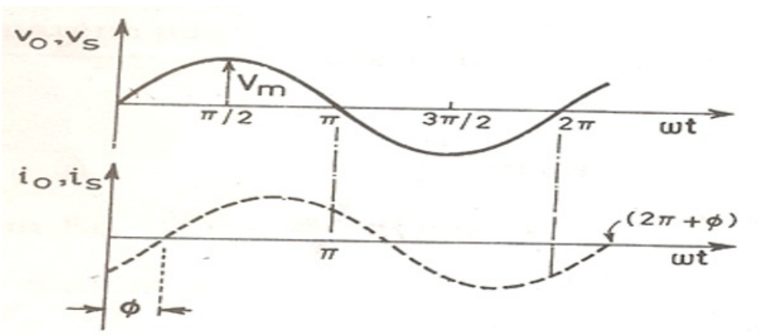


Theory:

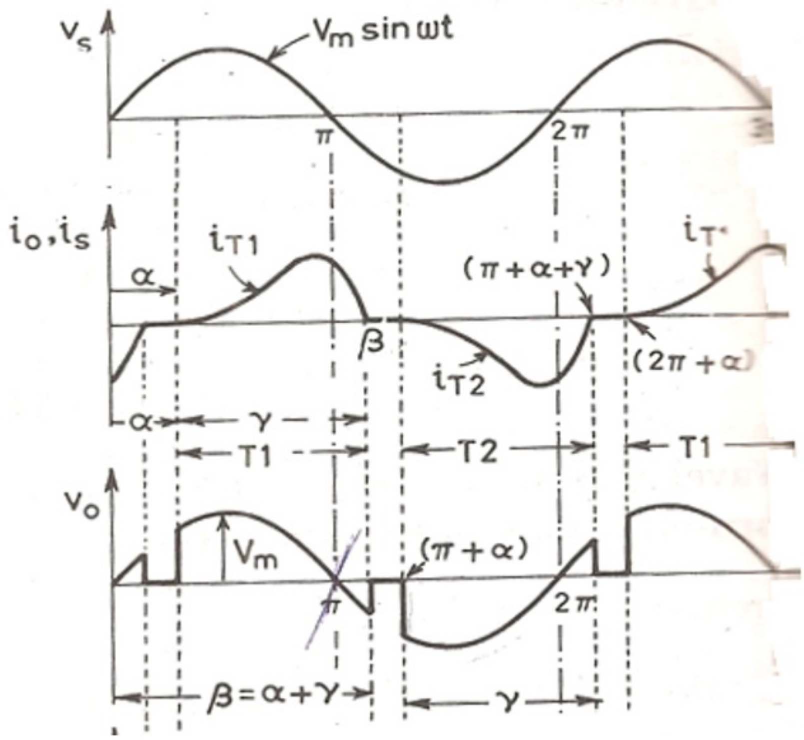
- Single phase full wave voltage controller consists of two SCRs connected in antiparallel.
- Thyristors T1 and T2 are forward biased during positive and

negative half cycles respectively.

- During positive half cycle, T1 is triggered at firing angle α, it conducts and i_o starts building up through load.
- At π, load and source voltages are zero but the current is not zero because of presence of inductance in load circuit.
- At β >π, load current reduces to zero. Angle β is called the extinction angle.
- Just after π, T1 has been reverse biased, but does not turn off because i_o is not zero.
- At β only, when i_o is zero, T1 is turned off as it is already reverse biased.
- After the commutation of T1 at β, a voltage magnitude (Vm sinβ) at once appears as a reverse bias across T1 and forward bias across T2.
- From β to π + α, no current exists in the power circuit, therefore output voltage is zero.
- Thyristor T2 is triggered at (π+ α) >β. Current i_o starts building in reverse direction through the load.
- At 2π input and output voltages are zero, but output current is not zero. At (π +α + γ) T2 turns off because it is already reverse biased.
- At (π +α + γ), Vm sin(π +α + γ) appears across as a forward bias across T1 and as a reverse bias across T2.
- From (π +α + γ) to (2π +α), no current exists in the power circuit. At (2π +α), T1 is turned on and current starts building up as before.
- The ideal waveform of the experimental setup is shown in Figure below:



For α < ϕ



For $\alpha > \phi$

1Ph_FW_AC-Controller_R-L_Load -- Procedures

Step 1

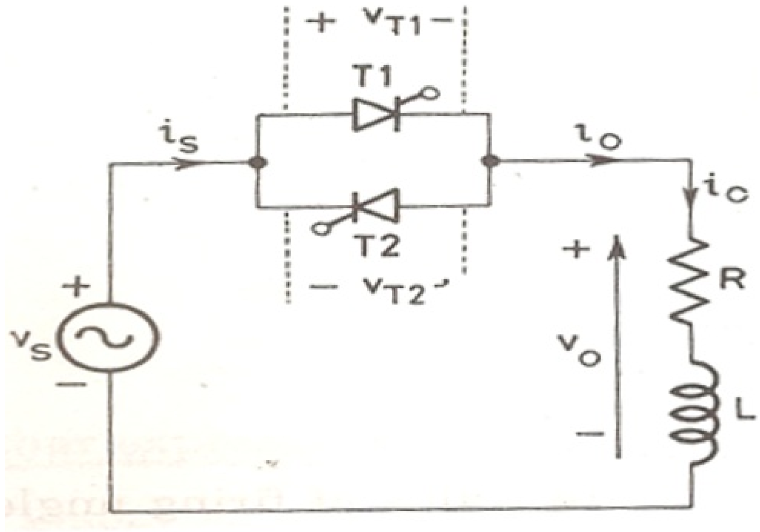
Precautions:

- A main switch should be included in whole circuit, so that in case of any emergency main supply can be disconnected from the circuit.
- Check all the connection before switching ON the power supply.
- Apply low voltages or low power to check the proper functionality of circuits.
- Load should be remained connected to the experimental setup for discharging the energy stored in the inductor or capacitor present in the circuit, if any.
- Don't touch live wires.

Step 2

Circuit Setup:

Build the circuit as shown below:



Step 3

Probe across load resistance (V_0)

Step 4

Keep the multiplication factor of the CRO’s probe at the maximum position (10X or 100X - whichever is available)

Step 5

Switch on the experimental kit and firing circuit kit.

Step 6

- Set the firing angle to 0 degree
- Capture output waveform on oscilloscope

Step 7

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 8

- Set the firing angle to 30 degree
- Capture output waveform on oscilloscope

Step 9

- Measure the RMS value of the output
- Take screenshot of output waveform.

Step 10

Continue Step # 8 and 9 for different values of firing angle like 45, 60 and 90 degrees.

Step 11

Switch off the power supply and disconnect from the power source.