Unit I - SWITCHING POWER SUPPLIES

PART A

1. **What is meant by dc chopper? [May/June 2012]**

   A dc chopper is a high speed static switch used to obtain variable dc voltage from a constant dc voltage.

2. **What are the applications of dc chopper? (Nov/Dec 2014)**

   - Battery operated vehicles
   - Traction motor control in electric traction
   - Trolley cars
   - Marine hoists
   - Mine haulers
   - Electric braking.

3. **What are the advantages of dc chopper? (Nov/Dec 2018)**

   - Chopper provides
   - High efficiency
   - Smooth acceleration
   - Fast dynamic response
   - Regeneration

4. **What is meant by duty-cycle? [May/June 2012]**

   Duty cycle is defined as the ratio of the on time of the chopper to the total time period of the chopper. It is denoted by α.

5. **What are the two types of control strategies? [May/June 2013]**

   - Time Ratio Control (TRC)
   - Current Limit Control method (CLC)

6. **What is meant by TRC? (April/May 2015)**

   In TRC, the value of Ton / T is varied in order to change the average output voltage.

7. **Write down the expression for the average output voltage for step down and step up chopper. [Nov/Dec 2011]**

   Average output voltage for step down chopper is VO = α VS. Average output voltage for step up chopper is VO = α VS x [1/ (1- α)].

8. Differentiate between constant frequency & variable frequency control [Nov 2012]

Strategies of varying the duty cycle of DC chopper.

Constant frequency control – Frequency of the chopper remains constant , but ON period is changed to vary the output.

Variable frequency control - Either Ton or Toff is kept constant & frequency is varied to change the output.

12. What are the advantages of SMPS over phase controlled rectifiers? [Nov/Dec 2011]

- Its smaller size, lighter weight, high efficiency and same power rating.
- Less sensitive to input voltage regulation.

13. What are the advantages of ZVS when compared to ZCS? [Nov/Dec 2010]

Sl.No	ZVS	ZCS
1.	Turn on and off at zero voltage	at zero current
2.	Constant load application	Variable load application
3.	preferred for high switching frequency	Medium
4.	Operates with constant off time control	Constant on time control

14. What are the disadvantages of frequency modulation control strategy? [Nov/Dec 2010]

- Filter design is very difficult for wide range of frequency variation.
- Its generate harmonics at unpredictable frequency.

15. What is meant by buck regulator? May/June 2014

It is also called as step down chopper. It means, the average output voltage is less than the input voltage.

16. What is SMPS and mention its two disadvantages? [Apr/May 2011]

Disadvantages:

- It has higher output ripple and its regulation poor.
- It's more complex circuit.

17. What is current limit control? [April/May 2011]

The chopper is switched ON and OFF so that the current in the load is maintained between two limits minimum and maximum.

18. What is the need for resonant converter? [May/June 2013]

- Switching losses are less
- Less electromagnetic interference
- Operating switching frequency is high
- Efficiency is high

19. Give the uses of resonant switching. [Nov/Dec 2011]

- Switching losses are less
- Less electromagnetic interference
- Operating switching frequency is high
- Efficiency is high

20. Define current limit control in DC–DC converter? (April/May 2015)

In this method, current is allowed to fluctuate or change only between 2 values i.e. maximum current (I max) and minimum current (I min). When the current is at minimum value, the chopper is switched ON. After this instance, the current starts increasing, and when it reaches up to maximum value, the chopper is switched off allowing the current to fall back to minimum value. This cycle continues again and again.

21. What are the advantages of MOSFET? [April/May 2019]

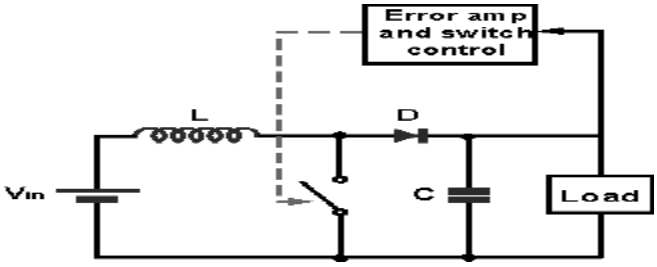
- Lower switching losses.
- No Secondary breakdown.
- Switching frequency high.
- It has positive temperature coefficient for resistance.

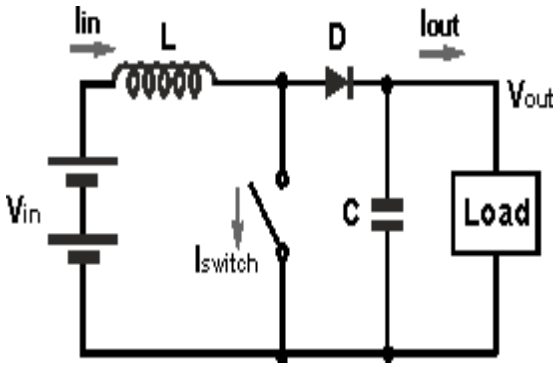
22. Define the term pinch off voltage of MOSFET. [May/June 2012]

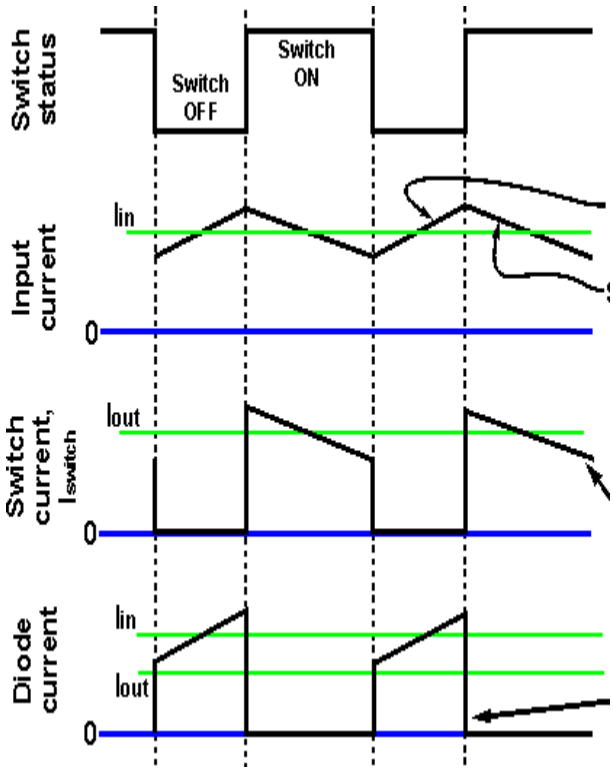
If the gate source voltage is made negative enough, the channel will be completely depleted, offering a high value of drain to source resistance and there will be no current flow from drain to source. The value of gate source voltage is called pinch offvoltage.

PART- B & C

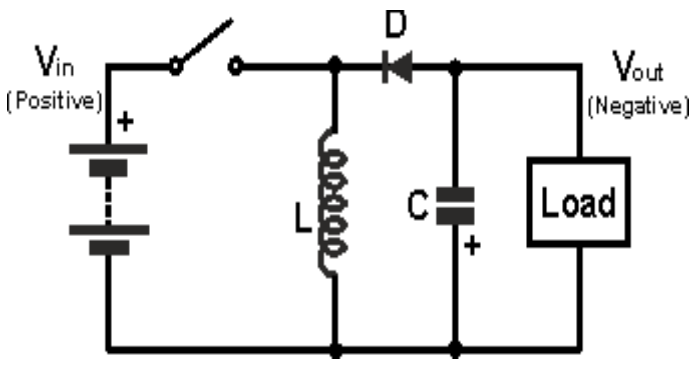
1. Explain the various modes of operation of Boost DC-DC converter with necessary waveforms. (16) **May/June 2011& Nov/Dec 2012**

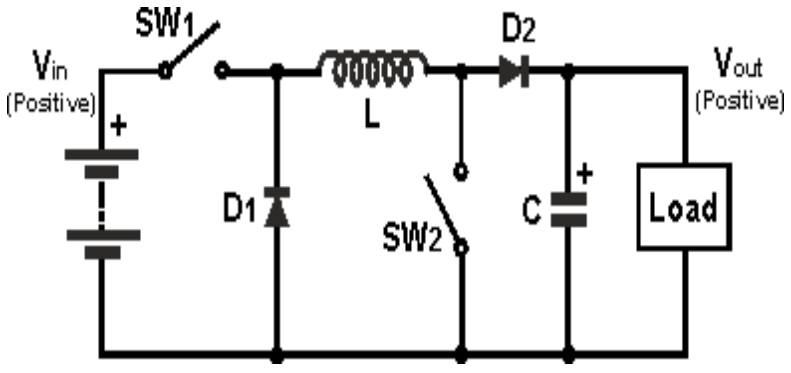






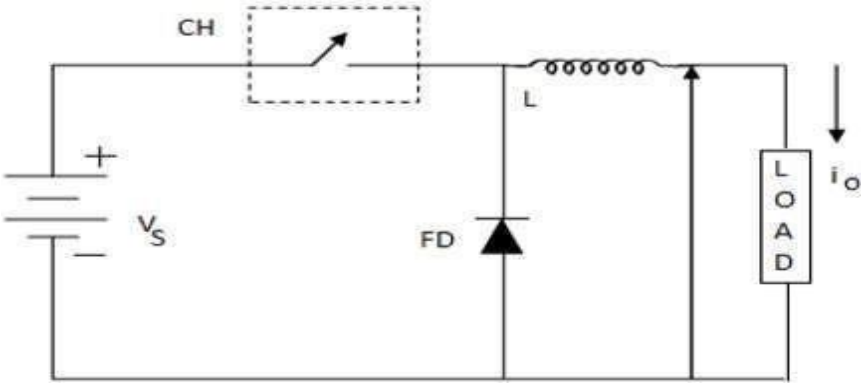
2. **Explain the working of Buck–Boost converter with sketch and waveforms and also drive the expression for I_S Nov/Dec 2011, (April/May 2015)**



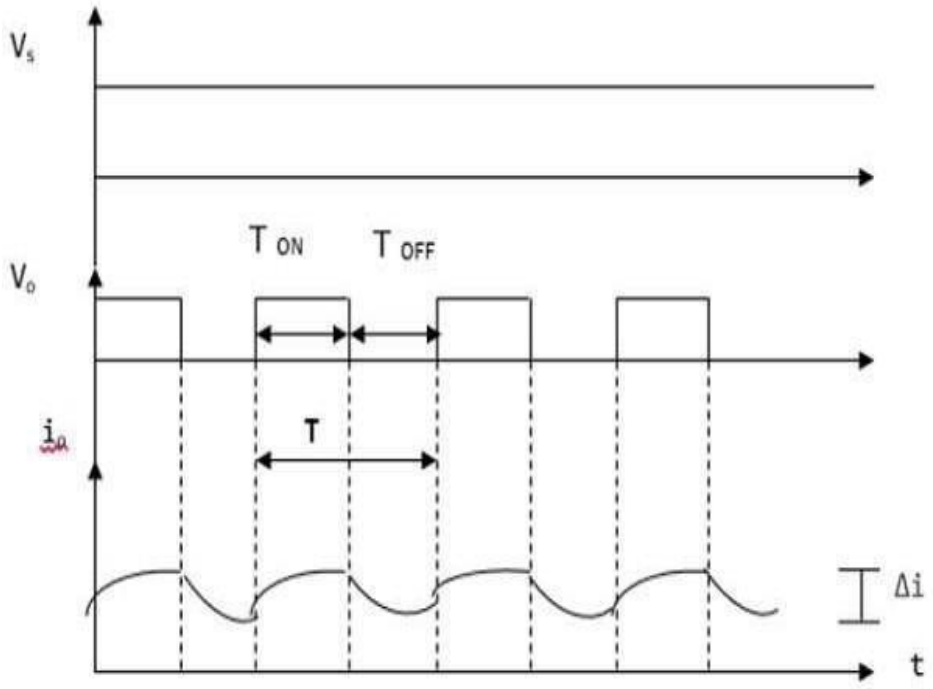


3. Discuss the principle of operation of DC-DC step down chopper with suitable waveform. Derive an expression for its average DC output voltage. (8) **Nov/Dec 2010.**

StepDownChopper



Step down chopper



Input and output waveforms

4. **In a dc chopper, the average load current is 30 Amps, chopping frequency is 250 Hz. Supply voltage is 110 volts. Calculate the ON and OFF periods of the chopper if the load resistance is 2 ohms.**

Solution:

$I_{dc} = 30$ Amps, f = 250 Hz, V = 110 V, $R = 2\Omega$

Chopping period, $T = \frac{1}{f} = \frac{1}{250} = 4\times10^{-3} = 4$ msecs

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

Therefore $I_{dc} = \frac{dV}{R}$

$d = \frac{I_{dc}R}{V} = \frac{30\times2}{110} = 0.545$

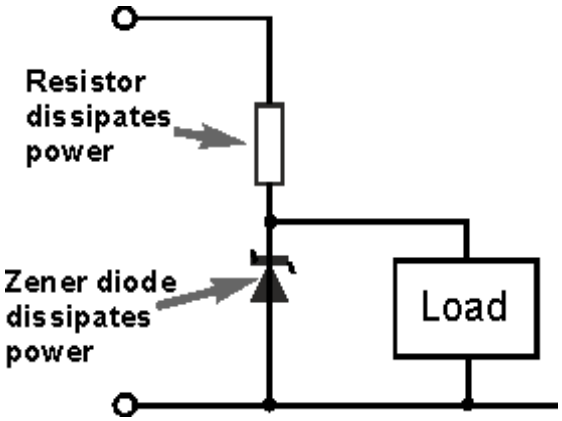
Chopper ON period, $t_{ON} = dT = 0.545\times4\times10^{-3} = 2.18$ msecs

Chopper OFF period, $t_{OFF} = T - t_{ON}$

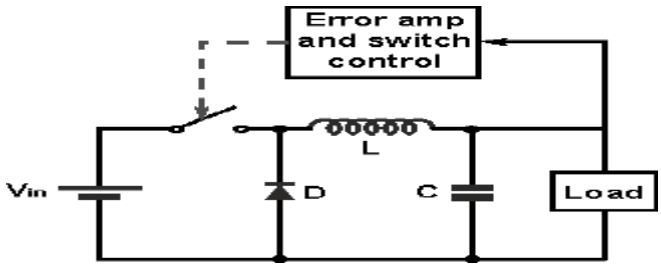
$t_{OFF} = 4\times10^{-3} - 2.18\times10^{-3}$

$t_{OFF} = 1.82\times10^{-3} = 1.82$ msec

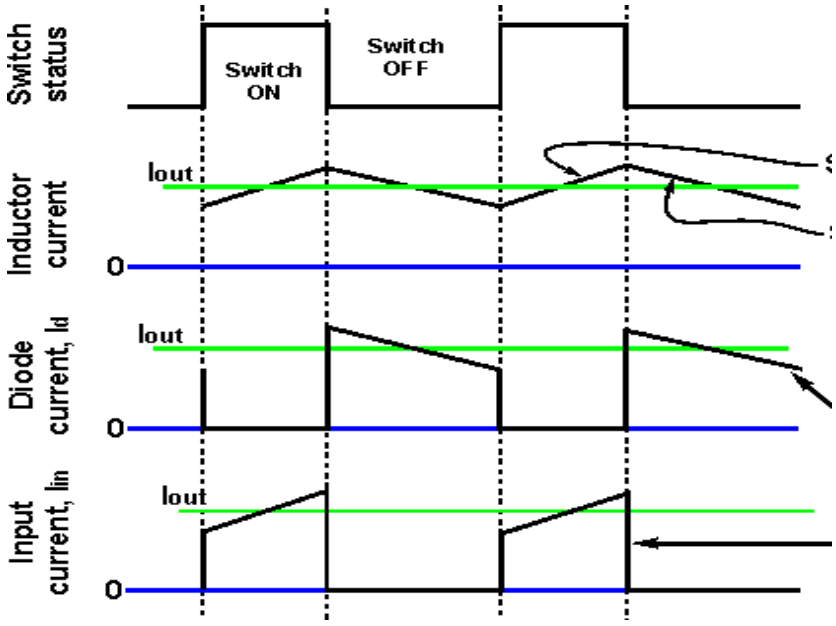
5. Draw the circuit of buck regulator and explain its working principle with necessary waveforms. Derive the expression for peak to peak ripple voltage of the capacitor that is present across the load. (16) **May/June 2013**



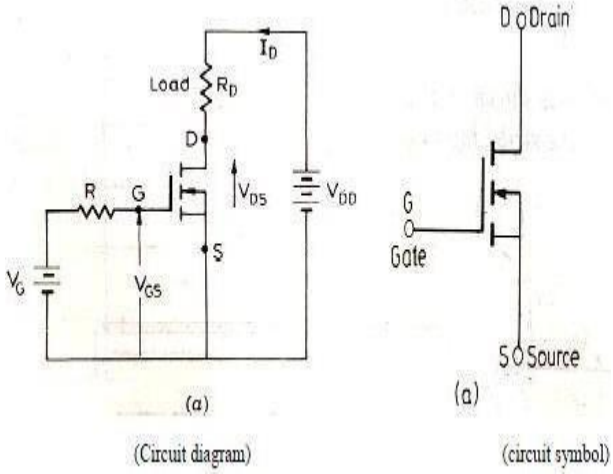
Potential divider circuits

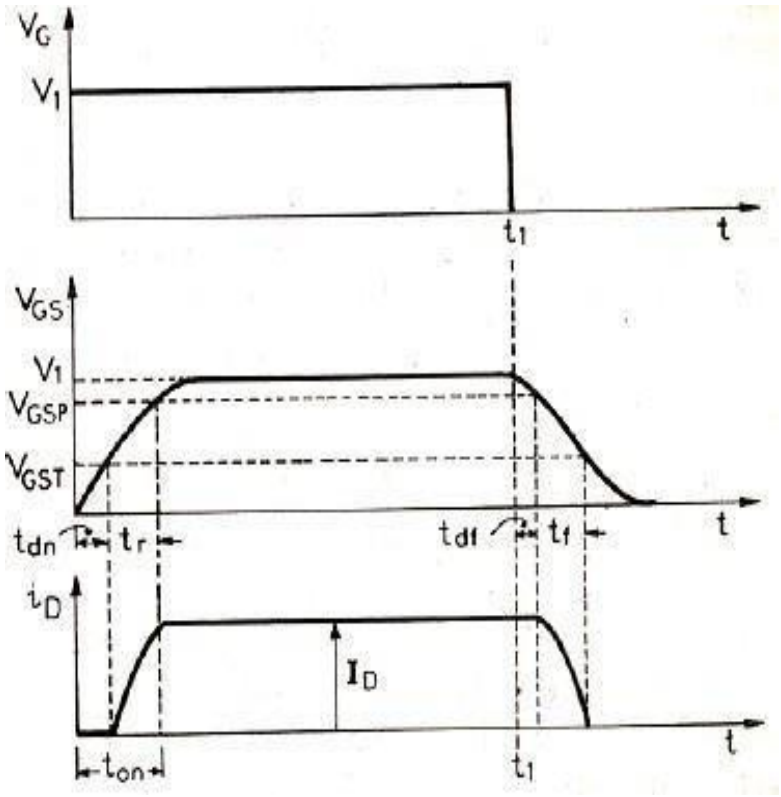


circuit diagram of Buck regulator



6. Explain the switching characteristics of power MOSFET. **April/May 2015,May/June 2014**





Unit 2 - INVERTERS

PART A

1. **What are the merits and demerits of CSI? [Apr/May 2011]**

Merits:

- CSI does not require any feedback diodes.
- Commutation circuit is simple as it involves only thyristors.

Demerits:

- The amplitude of output current does not depend on the load
- The magnitude of the output voltage and its waveform depends upon nature of the load impedance.

2. Define the term inverter gain. [May/June 2012]

It is defined as the ratio of the AC output voltage to DC input voltage.

3. What is meant by PWM control?

In this method, a fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the on and off periods of the inverter components. This is the most popular method of controlling the output voltage and this method is termed as PWM control.

4. What are the advantages of PWM control? [Nov/Dec 2012] May/June 2014

The output voltage can be obtained without any additional components. Lower order harmonics can be eliminated or minimized along with its output voltage control. As the higher order harmonics can be filtered easily, the filtering requirements are minimized.

5. What are the disadvantages of the harmonics present in the inverter system?

- Harmonic currents will lead to excessive heating in the induction motors. This will reduce the load carrying capacity of the motor.
- If the control and the regulating circuits are not properly shielded, harmonics from power ride can affect their operation and malfunctioning can result.
- Harmonic currents cause losses in the ac system and can even some time produce resonance in the system. Under resonant conditions, the instrumentation and metering can be affected.
- On critical loads, torque pulsation produced by the harmonic current can be useful.

6. What are the methods of reduction of harmonic content?

- Transformer connections
- Sinusoidal PWM

- Multiple commutation in each cycle
- Stepped wave inverters

7. What are the disadvantages of PWM control? (Nov/Dec 2017)

SCRs are expensive as they must possess low turn-on and turn-off times.

8. What is meant by VSI? (Nov/Dec 2014)

A VSI is one which the dc source has small or negligible impedance. In other words aVSI has stiff dc voltage source at its input terminals.

9. What is mean by CSI? [Nov/Dec2011 &2012]

A current fed inverter or CSI is fed with adjustable current from a dc source of high impedance is from a stiff dc current source.

10. What are the different methods of forced commutation employed in inverter circuits?

i) Auxillary commutation ii) complementary commutation

11. Differentiate VSI and CSI. [Nov/Dec 2010] May/June 2014

Sl.No	VSI	CSI
1.	Input voltage maintained constant	Current
2.	Output voltage is not depend on the load	Current
3.	Requires feed back diodes	Not required
4.	Commutation circuit is complex	Simple

12. Define modulation index. (April/May 2015)

Its defined as the ratio of the AC output voltage to DC input voltage.

13. What is meant by feedback diodes or return current diodes?

For RL loads current io will not be in phase with voltage & diodes connected in anti parallel with SCR will allow the current to flow when the main SCRs are turned off. These diodes are called feedback diodes.

14. What are the different types of PWM methods for voltage control within inverter? April/May 2011

- Single pulse width modulation
- Multiple pulse width modulation
- Sinusoidal pulse width modulation

15. How the thyristor inverters are classified?

According to the method of commutation

- Line commutated inveter
- Forced commutated inverter

According to the connection

- series inveter
- parallel inverter
- Bridge inverter

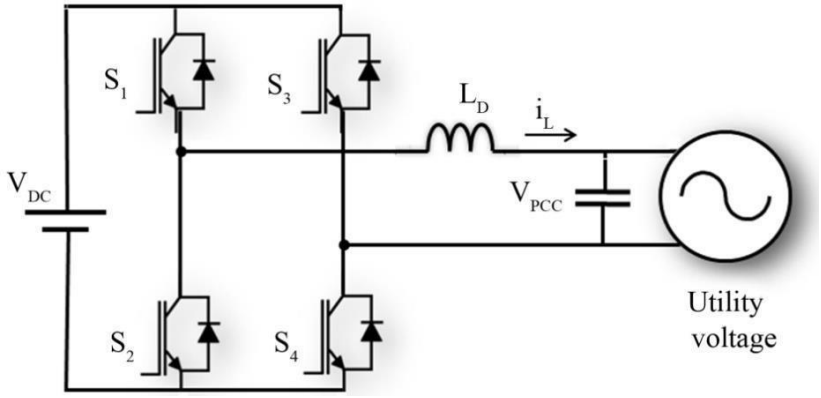
16. Why is series inverter called so? [Nov/Dec 2011]

The resonating components and switching devices are placed in series with load to form an under damped circuit. This circuit is called as series inverter.

17. What is space vector? [May/June 2013]

SVPWM is the most successful method to develop three phase sine wave voltage source inverter, in addition to control AC drives using vector control. SVM is becoming popular form of pulse width modulation for voltage fed converter drives because of its superior harmonic quality and extended linear range of operation.

18. Draw the circuit diagram of single phase current source inverter?(April/May 2015)



19. Write the advantage of resonant converters? (Nov/Dec 2014)

a. highest efficiencies
b. the impedance between the input and output of the circuit is at its minimum
c. Zero Voltage Switching (ZVS)

20. Why diodes should be connected in ant parallel with the thyristors in inverter circuits?

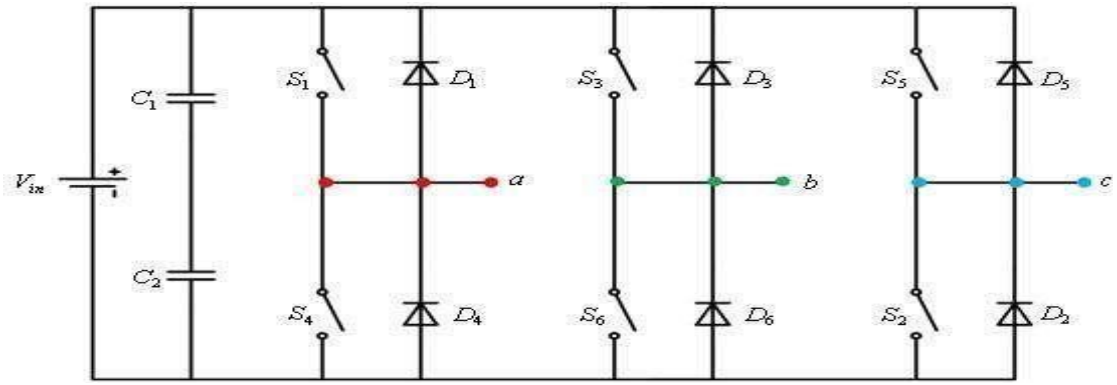
For RL loads, load current will not be in phase with load voltage and the diodes connected in ant parallel will allow the current to flow when the main thyristors are turned off. These diodes are called feedback diodes.

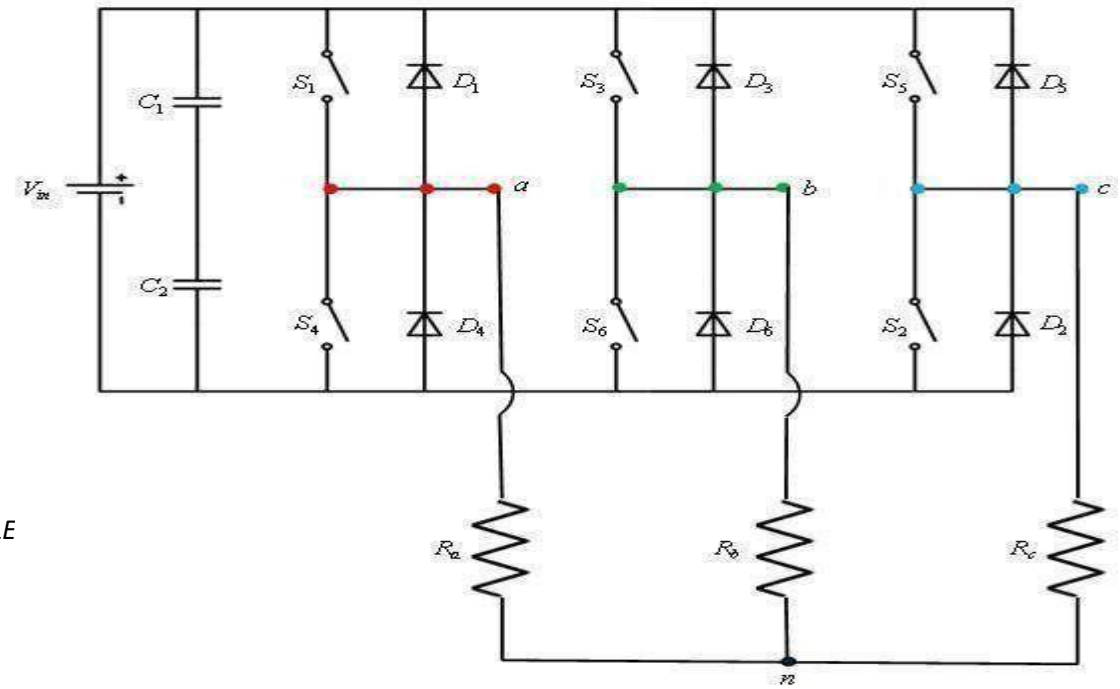
21. Specific features of IGBT ? [Nov/Dec 2019]

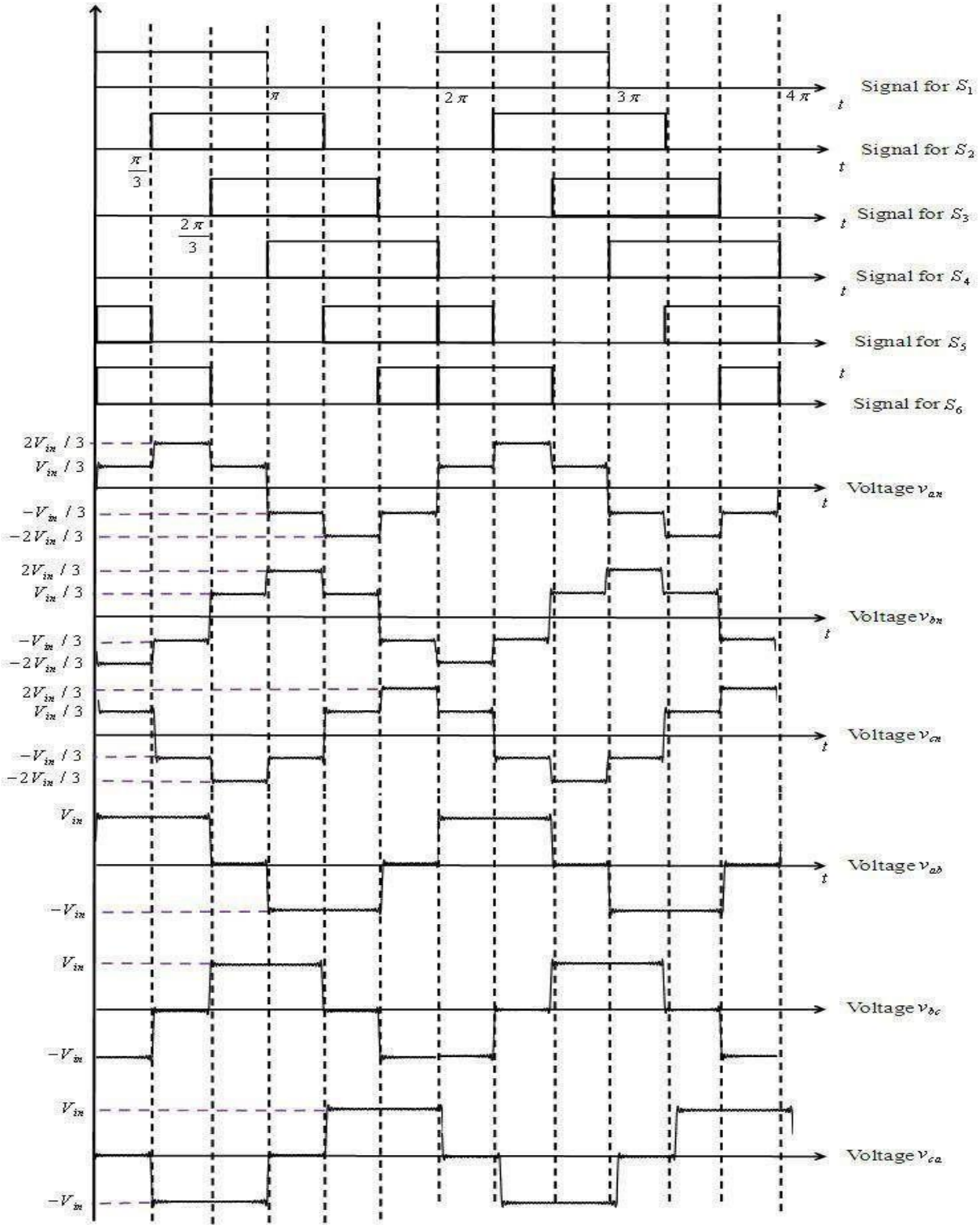
- Lower hate requirements.
- Lower switching losses.
- Smaller snubber circuits requirements.

PART- B & C

1. With a neat sketch and output voltage waveforms, explain the working of three phase bridge inverter in 180 degree mode of operation. (16) **Nov/Dec 2011, (April/May 2015) (Nov/Dec 2014)**



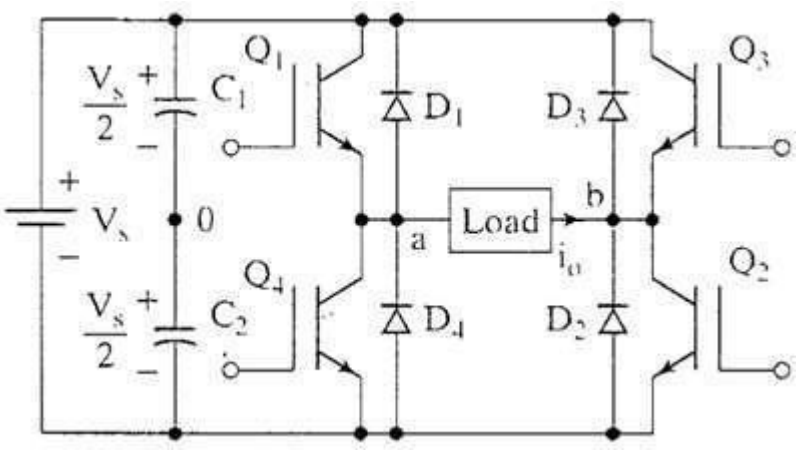




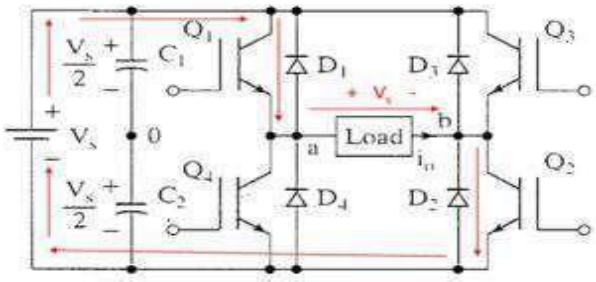
Line and phase voltages of three phase bridge inverter

2. Describe the working of a 1-φ full bridge inverter with relevant circuit and waveforms. (8) **Nov/Dec 2010**

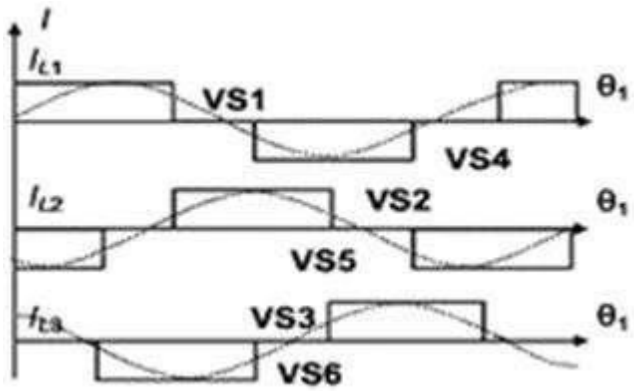
Operation of single phase full bridge inverter



Single phase Full Bridge DC-AC inverter with R load

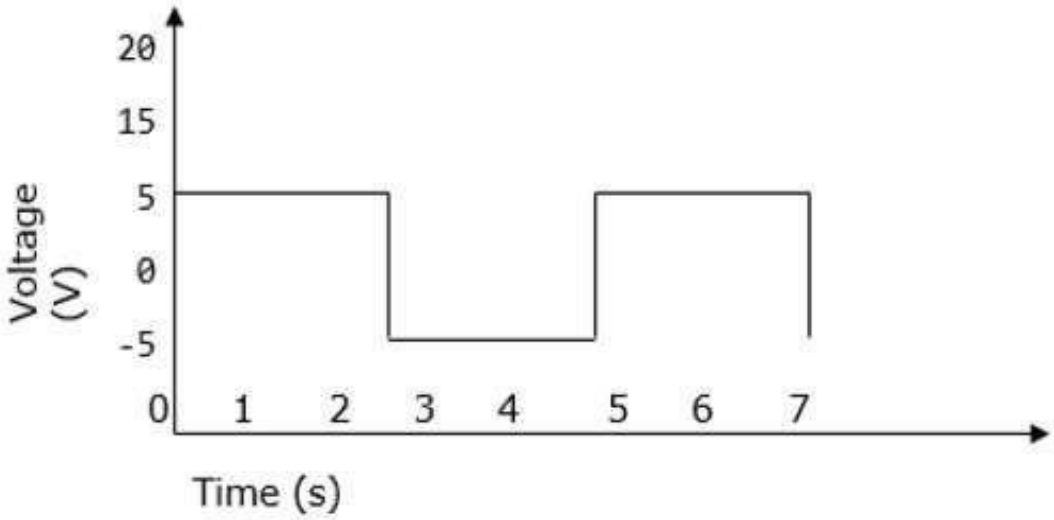


Single phase Full Bridge DC-AC inverter with R load



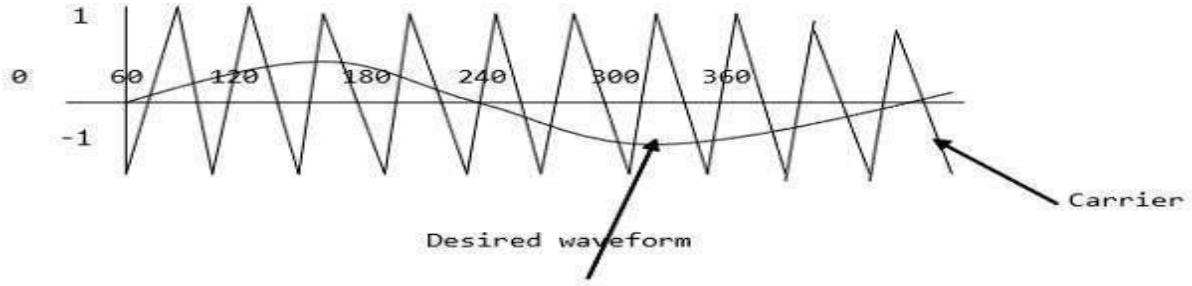
3. What is PWM? List the various PWM techniques and explain any one of them. (8) **Nov/Dec 2010,Nov/Dec 2014**

Pulse width modulation techniqu

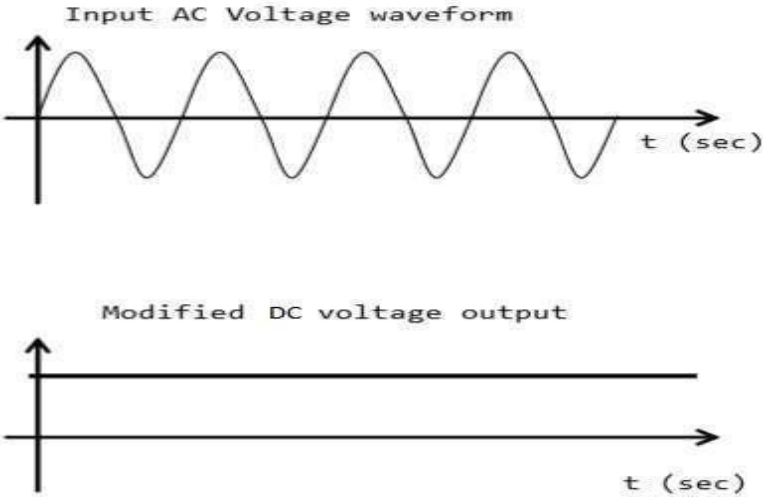


Square waveform used for PWM technique

SinusoidalPulseWidthModulation

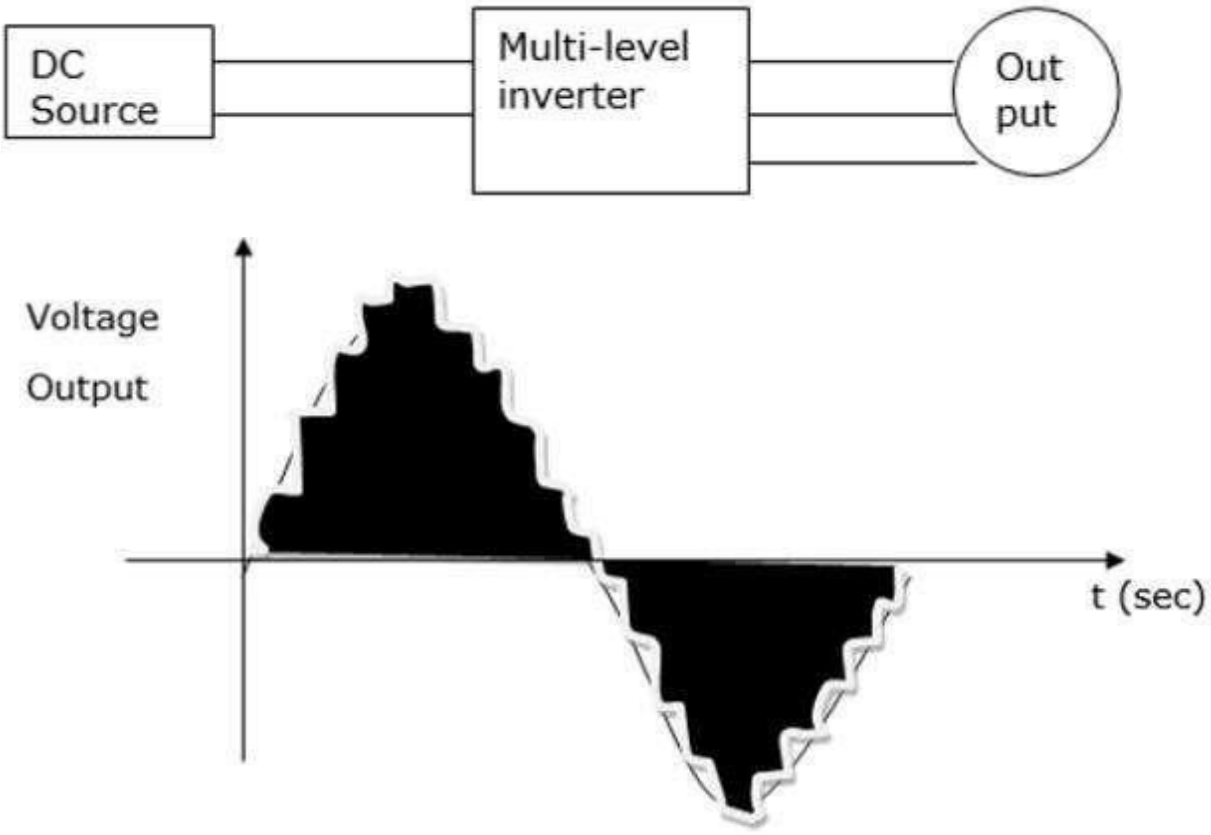


Sinusoidal PWM waveform



Modified sinusoidal PWM waveform

MultiplePWM



Operation of sinusoidal pulse width modulation

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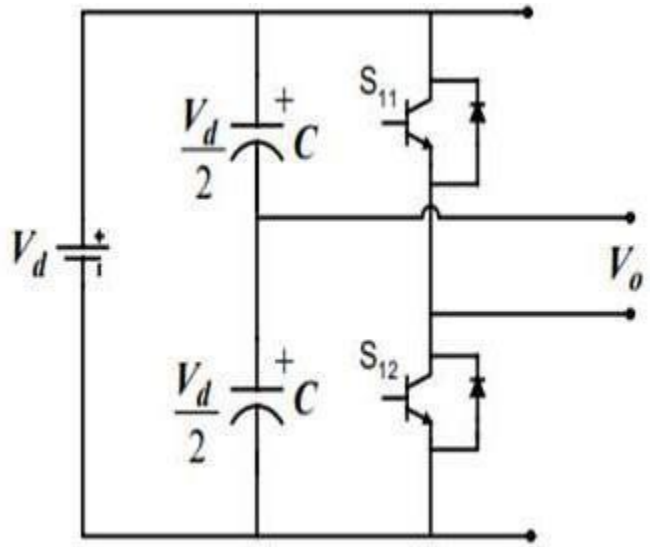
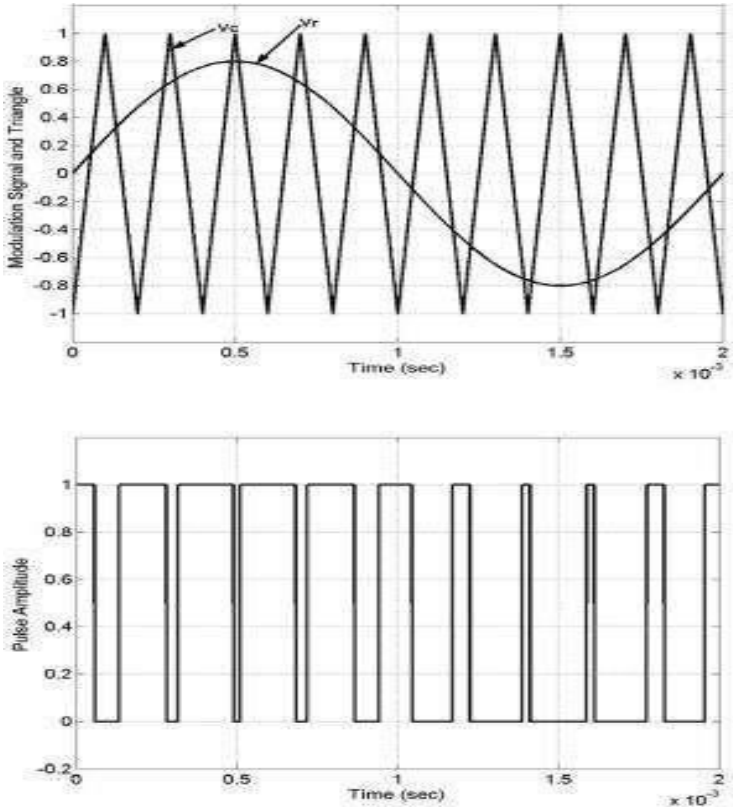
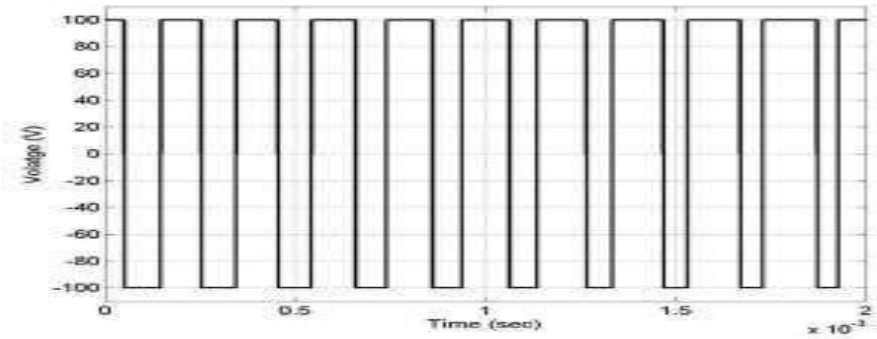


schematic diagram of Half bridge PWM inverte

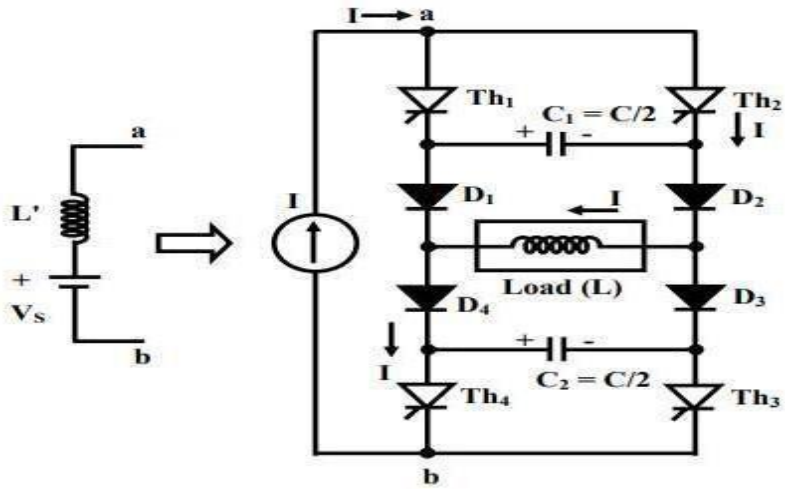


Sine-Triangle Comparison and switching pulses of half bridge PWM inverter

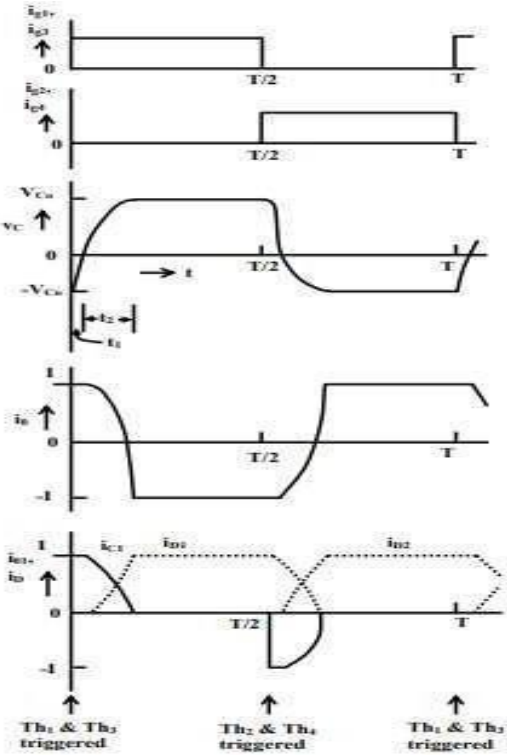


4. Describe the operation of single phase auto sequential commutated current source inverter with power circuit and waveforms. (16) **May/June 2011**

Single-phase Current Source Inverter

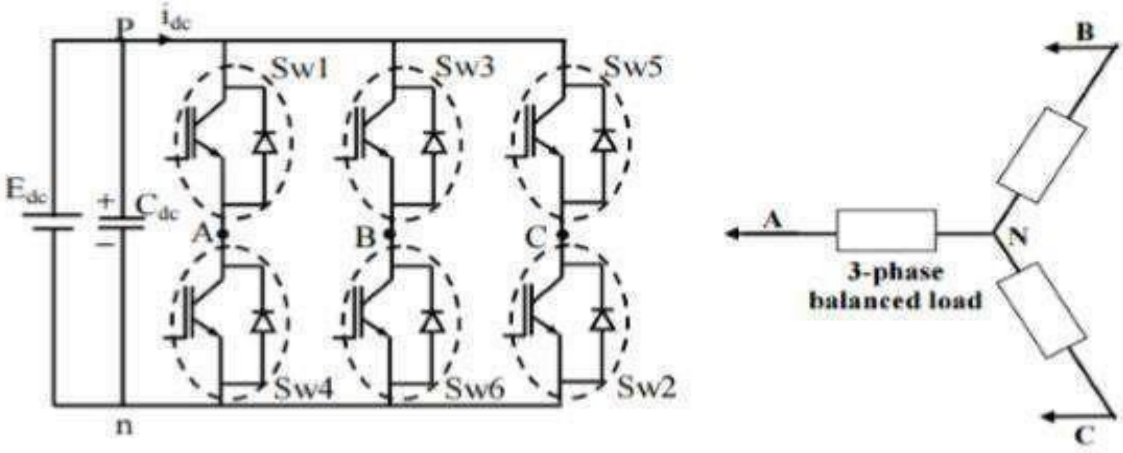


Single phase current source inverter (CSI) of ASCI type

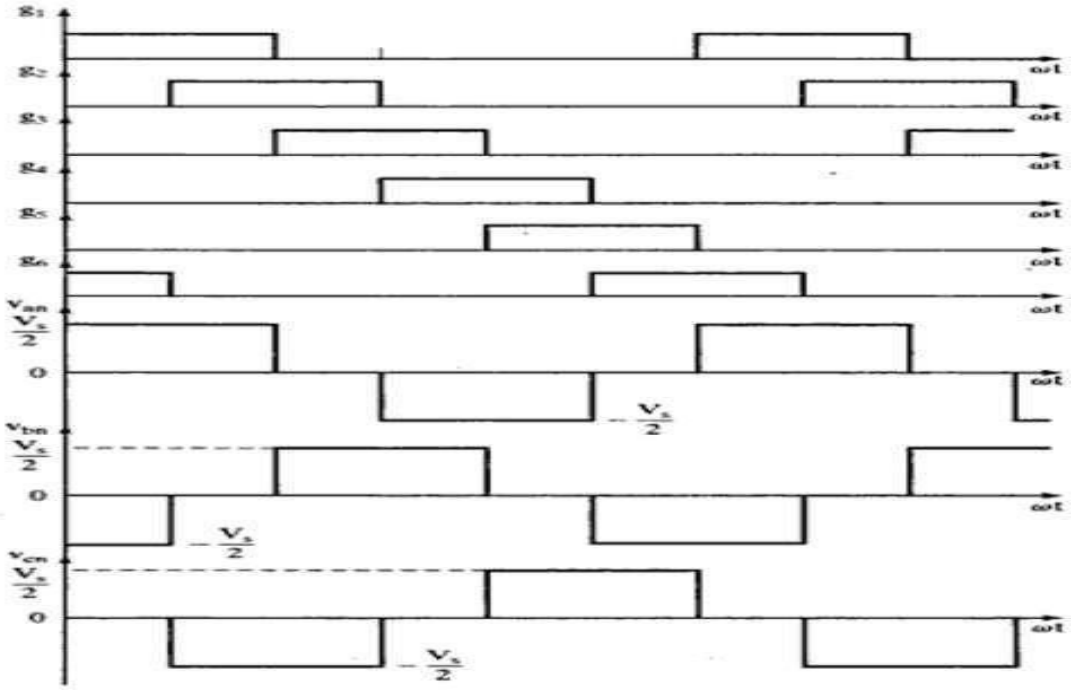


5. Describe the operation of three phase voltage source inverter with 120° mode of operation. (16) **May/June 2013 ,Nov/Dec 2012& May/June 2011 May/June 2014**

Three Phase DC-AC Converters with 120 degree conduction mode

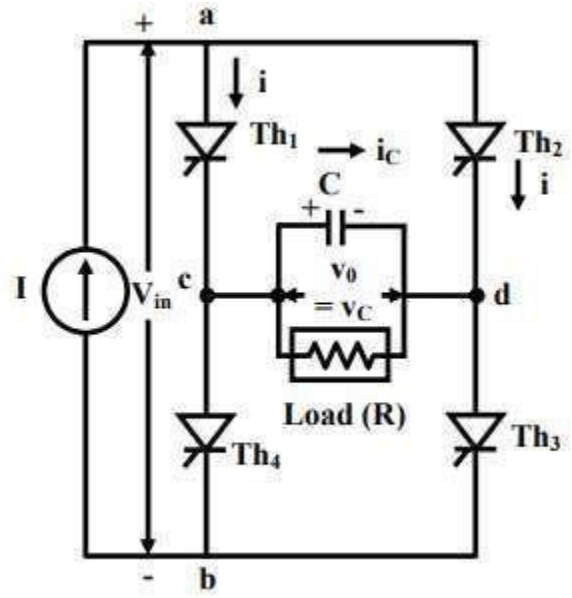


Circuit diagram of three phase bridge inverter

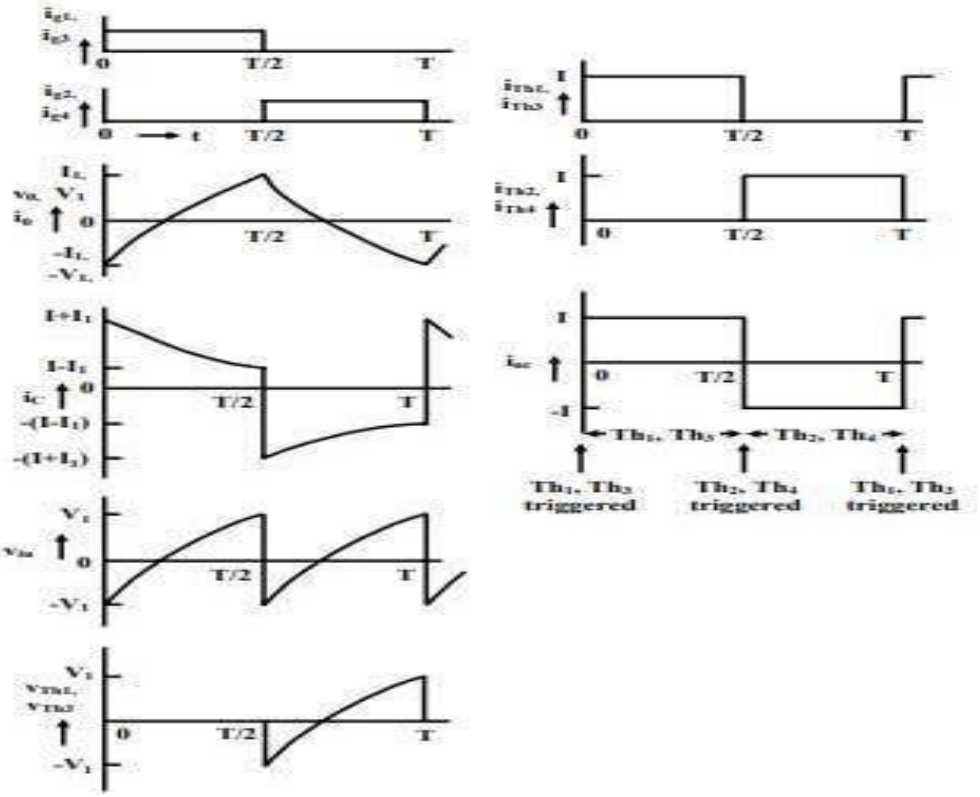


6. With a neat circuit and relevant waveforms discuss the operation of an ideal single phase load commutated CSI.

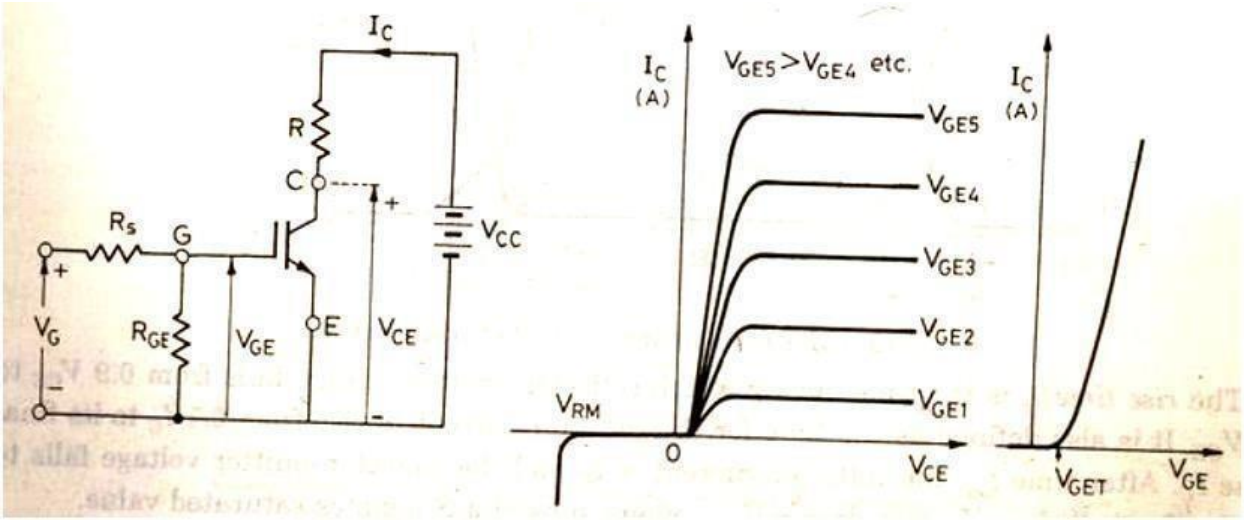
Load Commutated CSI

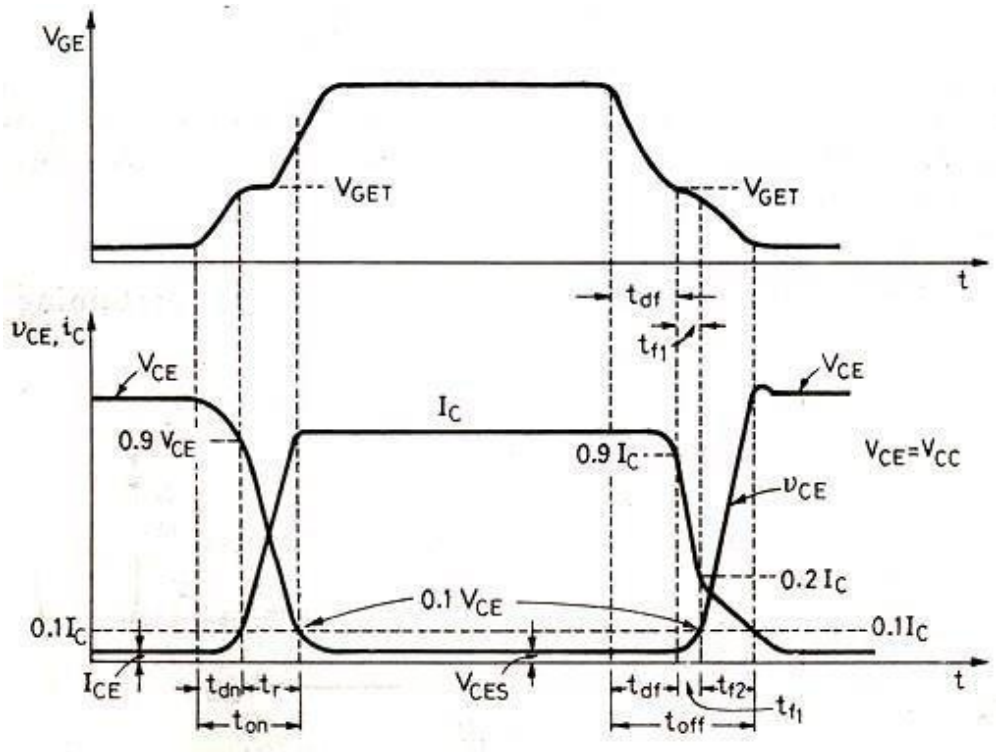


Circuit diagram of load commutated CSI



7. Explain the switching characteristics of power IGBT with neat circuit diagram and waveforms. May/June 2011, (April/May 2015) Nov/Dec 2012.





UNIT III

UNCONTROLLED RECTIFIERS

1. **What is meant by uncontrolled rectifier?**

   The principal circuit operations of the various configurations of rectifier circuits are similar, whether half- or full-wave, single-phase or three-phase. Such circuits are said to be uncontrolled since the rectified output voltage and current are a function only of the applied excitation, with no mechanism for varying the output level. In suchcircuits, regardless of the configuration, diodes are almost always used to achieve rec-tification.

2. **What are the applications of diodes?**

   Some Common Applications of Diodes are:

   - Rectifiers
   - Voltage Multipliers
   - Clipper Circuit
   - Clamping Circuit
   - Protection Circuit
   - In Logic Gates
   - Flyback Circuits
   - Light Emission

3. **What are the parameters involved in switching loss of power device? [April/May 2011]**
   - ✓ Forward conduction loss
   - ✓ Loss due to leakage current during forward and reverse blocking
   - ✓ Switching losses at turn-on and turn-off.
   - ✓ Gate triggering loss.

4. **Define reverse break over voltage. [April/May 2015]**

When cathode is positive w.r.to anode with gate current open, the junction J1 & J3 are reverse biased but J2 is forward biased. When the reverse voltage is increased junctions J1 & J3 will have an avalanche breakdown at a voltage. This voltage is called as critical breakdown voltage Vbr.

5. **State the advantages of bridge rectifier**.

   The advantages of bridge rectifier are,
   1.There is no need to tap the secondary of the transformer,
   2.Transformer Utilisation Factor (TUF) is high (81.1%),
   3.It can be used for high voltage applications.

6. **How many types are in fully controlled rectifier?**

   There are two types of fully controlled rectifier,
   1. Mid point controller
   2. Bridge controlled

7. **compare between half wave and full wave rectifiers.**

   The efficiency of a full wave rectifier is double that of a half wave rectifier. The ripple factor is large and frequency of voltage is lo! in a half wave rectifier, hence the waveform cannot

be easily smoothed whereas in full wave rectifier, the frequency is large therefore can be filtered easily with simple filtering circuits.

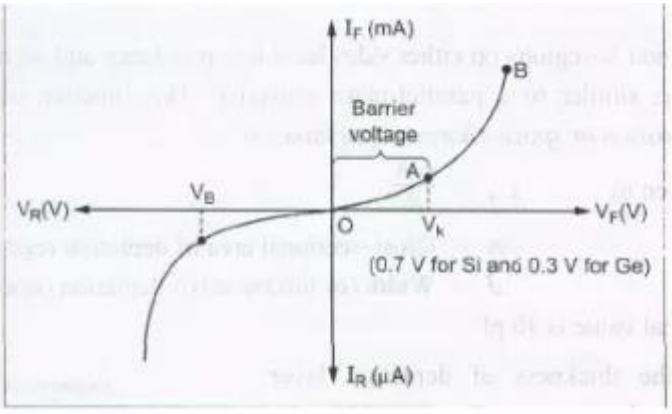
8. List the advantages of full bridge rectifier.

- ✓ Centre tapped transformer is not needed
- ✓ for the same secondary voltage, the output is doubled than that of the center tap circuit.

9. Define rectifier efficience?

The rectification efficiency tells us !hat percent of total input ac power is converted into useful dc output power. Thus rectification efficiency is defined as.

10. Draw the circuit diagram of PN Diode



11. Define reverse recovery time?
It is maximum time taken by the device to switch from oN to off stage.

12. list the PN diode switchin6 times.

- ✓ recovery Time
- ✓ forward recovery Time
- ✓ reverse recovery Time
- ✓ storage and Transition Times

PART- B & C

1. Consider the half-wave rectifier circuit of Fig. 7.2(a) with a resistive load of 25 Ω and a 60 Hzac source of 110 V rms.

(a) Calculate the average values of v_o and i_o.
(b) Calculate the rms values of v_o and i_o.
(c) Calculate the average power delivered to the load.
(d) Repeat part (c) by assuming that the source has a resistance of 60 Ω.

Solution:

v_o =49.52 V

i_o = 1.98 A

$V_{0,\,rms}$ = 77.78 V.

$I_{o,rms}$=3.11 A

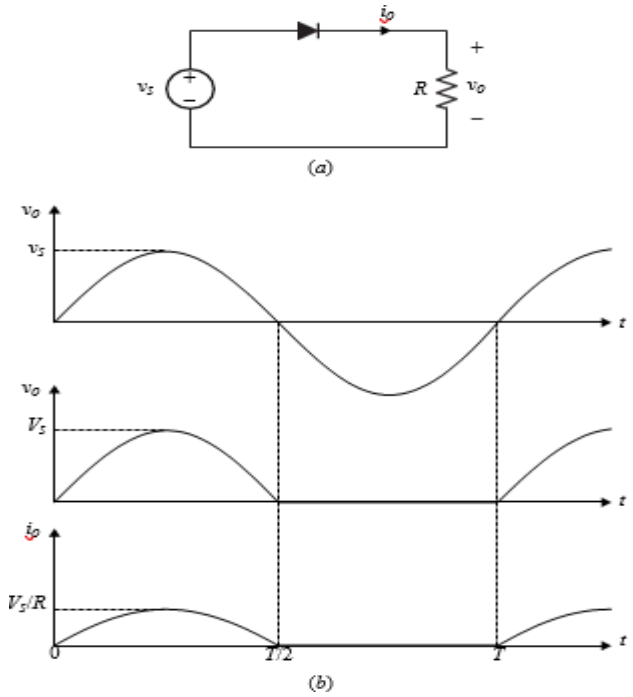
c).The average power delivered to the load over one cycle is obtained from the followingrelation:

$$= 242 \text{ W}$$

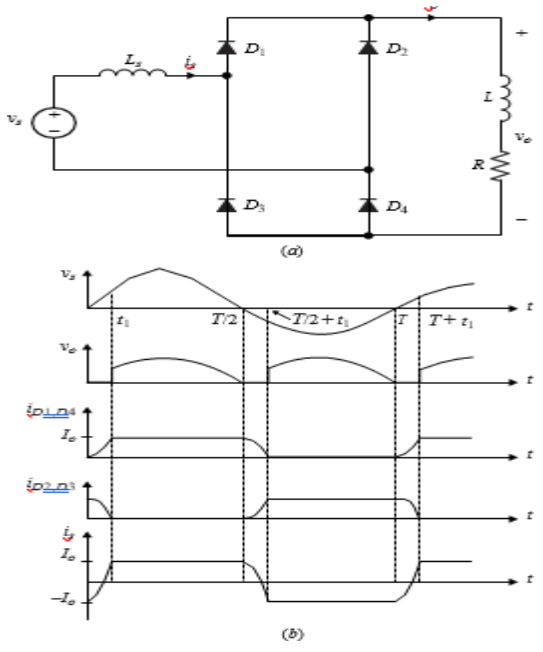
d).With a 60 Ω source resistance, R_s, the average power is given by

$$= 20.93\text{W}$$

2. Explain the details of single phase half controlled rectifier with RL load.



3. Draw a neat waveform of single phase fully controlled rectifier with RL load?



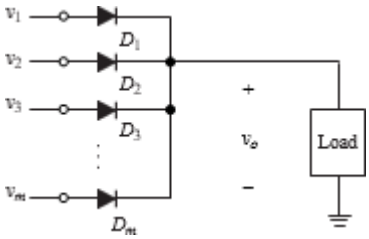
4. Consider the center-tap full-wave rectifier of Fig. 7.23(a) with N1 = 10, N2 = 5, N3 = 15, Lk = 10 μH, Io = 20 A, and vs = 100 sin 2π_60□t . Assume the diodes have no forward volt- age drops.

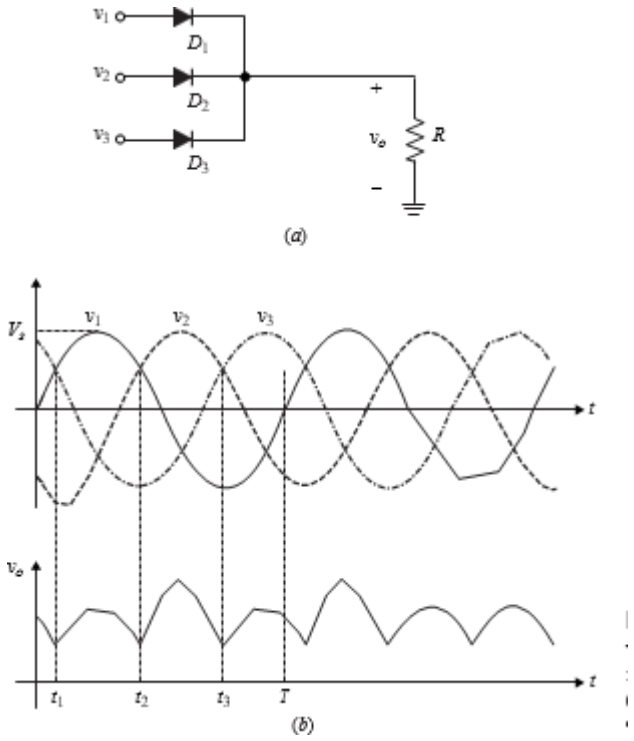
(a) Determine the average output voltage.

(b) Repeat part (a) by assuming each diode has a 1 V forward drop.

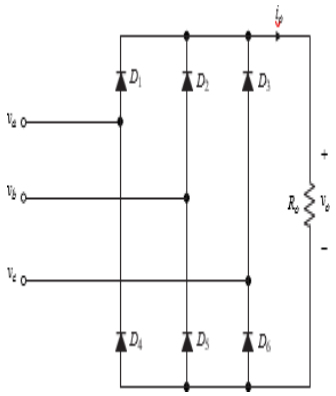
ANSWER 63.61 V, 62.63 V

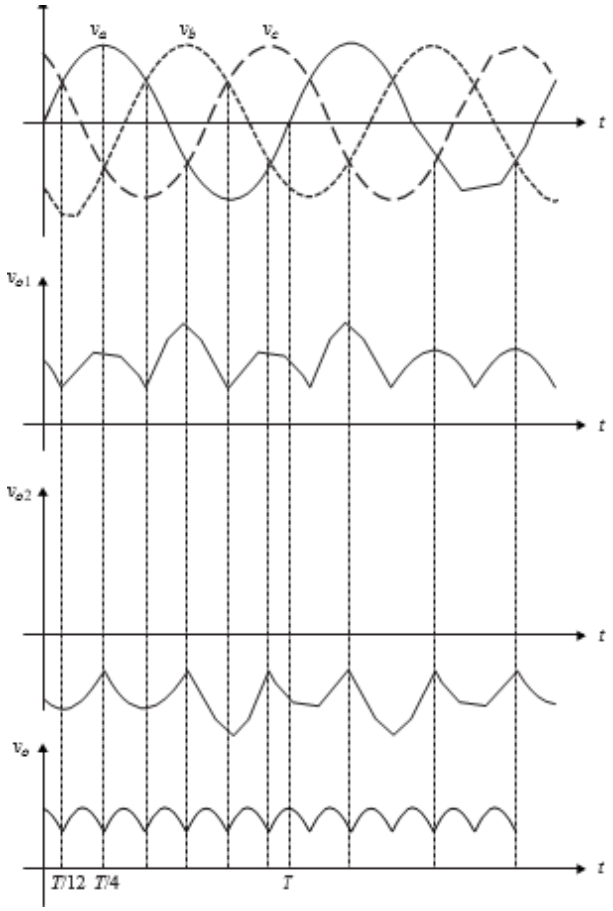
5. draw neat sketch and explain the details of Three-Phase Half-Wave Rectifier.





6. draw neat sketch and explain the details of Three-Phase Full-Wave Rectifier.





Unit 4 - CONTROLLED RECTIFIERS

PART A

1. **What is meant by phase-controlled rectifier? (Nov/Dec 2014)**

   It converts fixed ac voltage into variable dc voltage.

2. **Give any two differences single phase full and semi converter? [Nov/Dec 2011] May/June 2014**

Sl.No	Full Converter	Half controlled converter
1.	Thyristors only	Mixture of diodes and thyristors
2.	Two Quadrant Converter	One Quadrant converter
3.	Power factor is less	power factor is more

3. **Define the term voltage ripple factor and current ripple factor.** [**Nov/Dec 2010]**

   It is the ratio of the net harmonic content of the output voltage to the average output voltage.

4. **What is dual converter? [April/May 2011] May/June 2014**

   It consists of two similar single phase or three phase fully controlled converter which are connected in parallel at the input side and are connected inverse parallel at the output side.

5. **Define Total Harmonics distortion. [April/May 2012]**

   It is defined as the ratio of the total harmonic content to the fundamental component.

6. **What is the function of freewheeling diodes in controlled rectifier? [April/May 2012]**

   - It prevents the output voltage from becoming negative.
   - The load current is transferred from the main thyristors to the freewheeling diode, thereby allowing all of its thyristors to regain their blocking states.

7. **What are the advantages of freewheeling diodes in a controlled rectifier? [April/May 2018]**

   - Input power factor is improved.
   - Load current waveform is improved and thus the load performance is better.

8. **What is meant by delay angle? [Nov/Dec 2012]**

   The delay angle is defined as the angle between the zero crossing of the input voltage and the instant the thyristor is fired.

9. What is commutation angle or overlap angle? [**May/June 2013]**

The commutation period when outgoing and incoming thyristors are conducting is known as overlap period. The angular period, when both devices share conduction is known as the commutation angle or overlap angle.

10. What is meant by inversion mode? [April/May 2012,Nov/Dec 2012]

In single phase full converter a > 90 the voltage at the dc terminal is negative. Therefore, power flows from load to source & the converter operates as line commutated inverter. Source voltage Vs is negative & Current is positive. This is known as inversion mode or synchronous mode.

11. What is the difference between half controlled & fully controlled bridge rectifier? [April/May 2018]

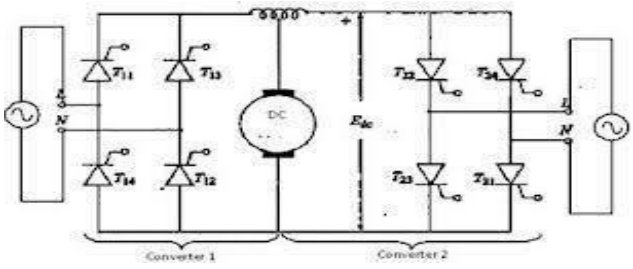
Half Controlled Bridge Rectifier

- Power circuit consists of mixture of diodes & SCRs
- It is one quadrant Converter
- The Dc output voltage has limited control level.
- Input power factor is more.

Full Controlled Bridge Rectifier

- Power circuit consists of SCRs only
- It is 2 quadrant Converter
- The Dc output voltage has wider control level.
- Input power factor is less.

12. Draw the circuit diagram of single phase dual converter. [Nov/Dec 2010]



13. What is displacement factor for two pulse converter? [**May/June 2013]**

The input displacement factor is defined as the cosine of the input displacement angle.

14. What is turn off time for two pulse converter? [May/June 2013]

50-100 micro second

15. Why is power factor of semi converter better than full converter? [Nov/Dec 2012] (Nov/Dec 2014)

For supplying given load, the semi converter receives less reactive power due to freewheeling action when compared with full converter. Therefore, the power factor is better in semi converter.

16. What is the effect of source impedance on the performance converter? [April/May 2015]

The input ac power sources supplying an ac to dc power converter have been assumed to be ideal with no source impedance. Although this assumption simplifies the analysis of the converters, in most practical situations, they are not fully justified. The converter output voltage and input current waveforms also change significantly. In this lesson a quantitative analysis of these effects will be taken up in some detail.

17. Mention some of the applications of controlled rectifier.

- Steel rolling mills, printing press, textile mills and paper mills employing dc motor drives.
- DC traction
- chemical and electro-metallurgical process
- Portable hand tool drives
- Magnet power supplies
- HVDC

18. Write any four parameters of phase controlled converter?

- Input displacement factor.
- Input power factor.
- Input harmonic factor.
- Current ripple factor

19. What is commutation angle or overlap angle?

The commutation period when outgoing and incoming thyristors are conducting is known as overlap period. The angular period, when both devices share conduction is known as the commutation angle or overlap angle

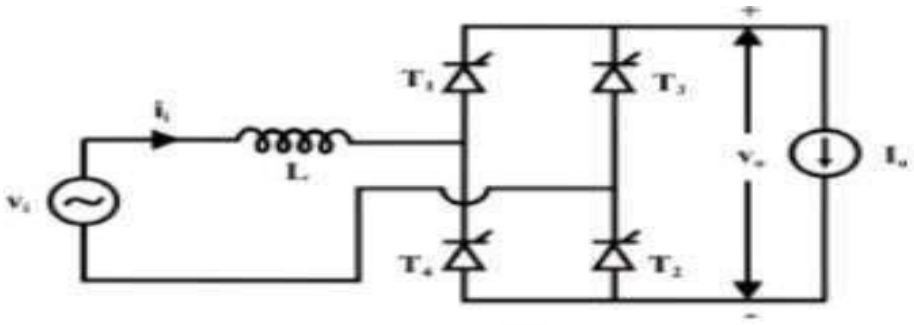
20. What are the advantages of six-pulse converter?

- Commutation is made simple.
- Distortion on the ac side is reduced due to the reduction in lower order harmonics.
- Inductance reduced in series is considerably reduced.

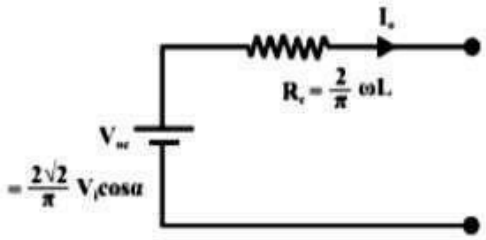
PART- B & C

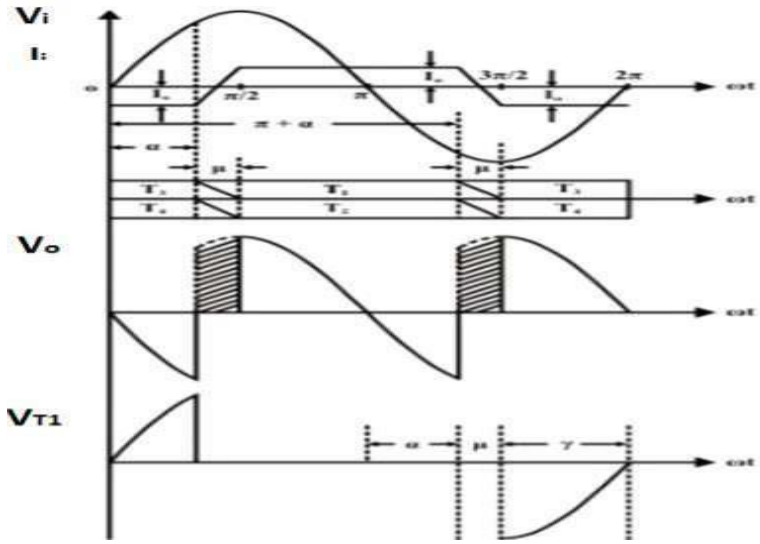
1. Describe the effect of source inductance on the performance of a single-phase full converter indicating clearly the conduction of various thyristors during one cycle. Derive the expression for its output voltage. **May/June 2013 & May/June 2011, May/June 2014**

Effect of source inductance in single phase rectifier



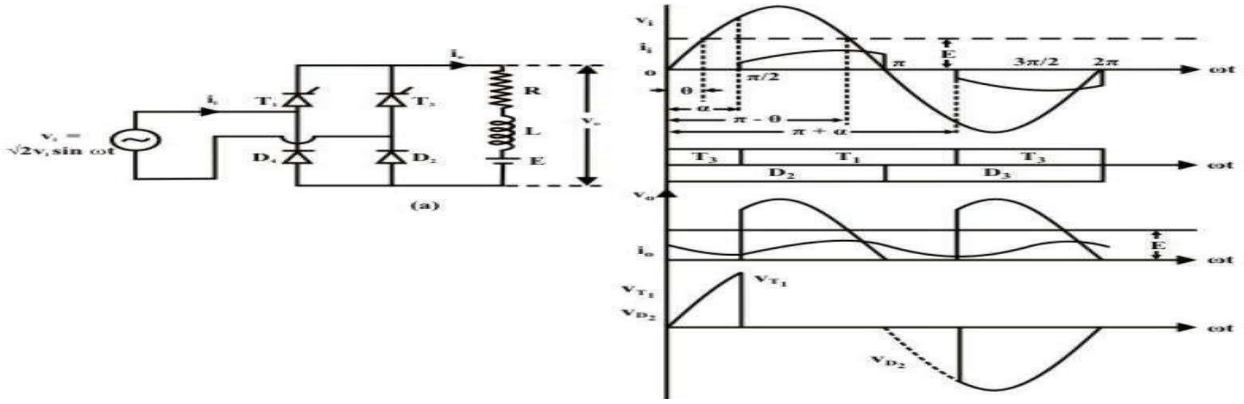
single phase full converter circuit with source inductance



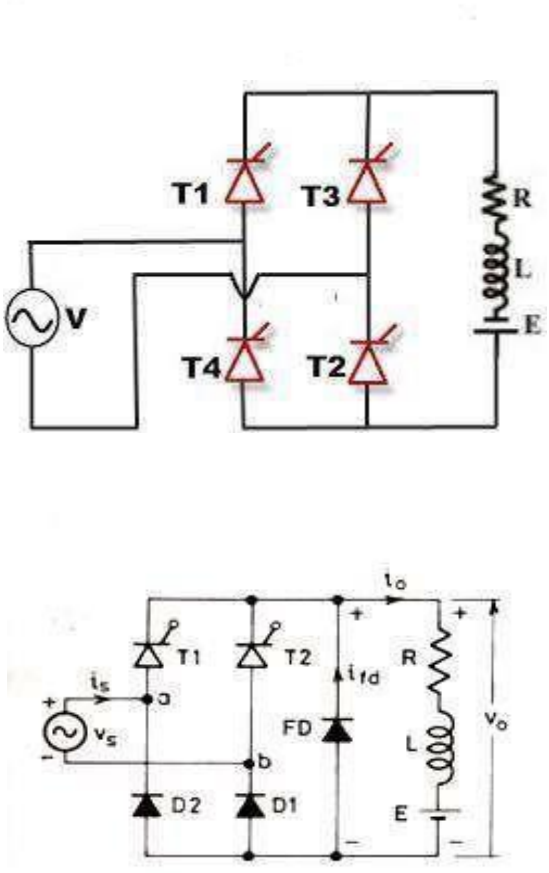


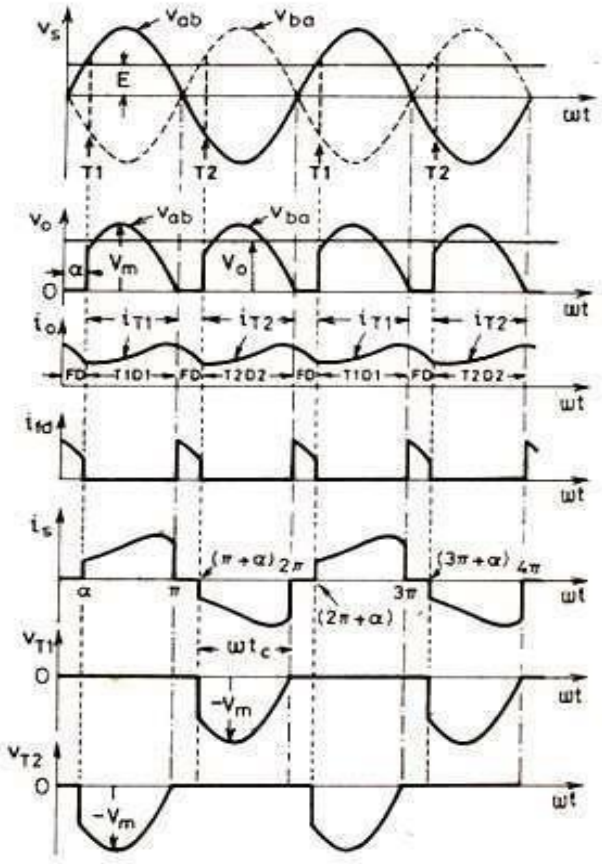
2. Explain the principle of operation of single phase with freewheeling diode converter with neat power circuit diagram. **May/June 2013& May/June 2011, (April/May 2015) (Nov/Dec 2014) May/June 2014**

The diode D2 and D4 conducts for the positive and negative half cycle of the input voltage



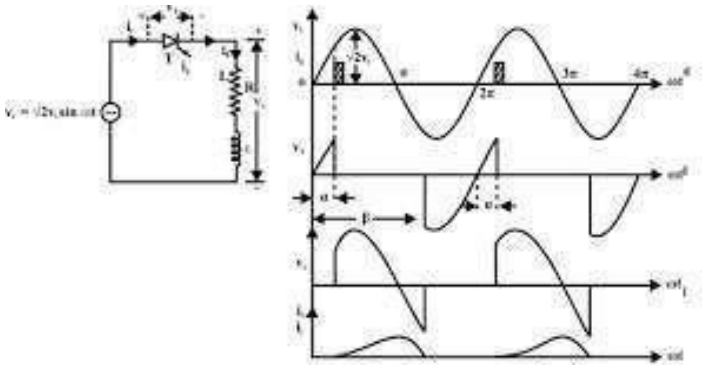
3. Explain the operation of a single phase full bridge converter with RLE load for continuous and discontinuous load currents. Nov/Dec 2011, (April/May 2015)





4. Explain the operation of single phase half controlled rectifier with inductive load. Also derive an expression for the average output voltage.

Single Phase Half Wave Controlled Rectifier with 'RL' load:



5. For the single phase fully controlled bridge is connected to RLE load. The source voltage is 230 V, 50 Hz. The average load current of 10A continuous over the working range. For R= 0.4 Ω andL = 2mH, Compute (a) firing angle for E = 120V (b) firing angle for E = -120V (c) in case outputcurrent is constant find the input power factors for both parts a and b

Solution:

a) For E = 120 the full converter is operating as a controlled rectifier

$$\frac{2Vm}{\pi} cos\alpha = E+I_0R$$

$$\frac{2\sqrt{2}.230}{\pi} cos\alpha = 120+ 10X0.4 = 124V$$

$$\alpha = 53.21^0$$

For $\alpha = 53.21^0$ power flows from ac source to DC load.

b) For E = -120 the full converter is operating as a controlled rectifier

$$\frac{2Vm}{\pi} cos\alpha = E+I_0R$$

$$\alpha = 124.1^0$$

For $\alpha = 124.1^0$

c) For constant load current, rms value of load current is

$$I_{or} = I_o = 10A$$

$$V_s I_{or} \cos\Phi = EI_o+I_o^2R$$

For $\alpha = 53.21^0$ $\cos\Phi = \frac{120\times10+10^2\times0.4}{230\times10} = 0.5391$ lag

For $\alpha = 124.1^0$ $\cos\Phi = \frac{120\times10-10^2\times0.4}{230\times10} = 0.5043$ lag

6. Explain the operation of 3 phase half controlled converter with neat waveforms. also derive an expression for the average output voltage **Nov/Dec 2012**

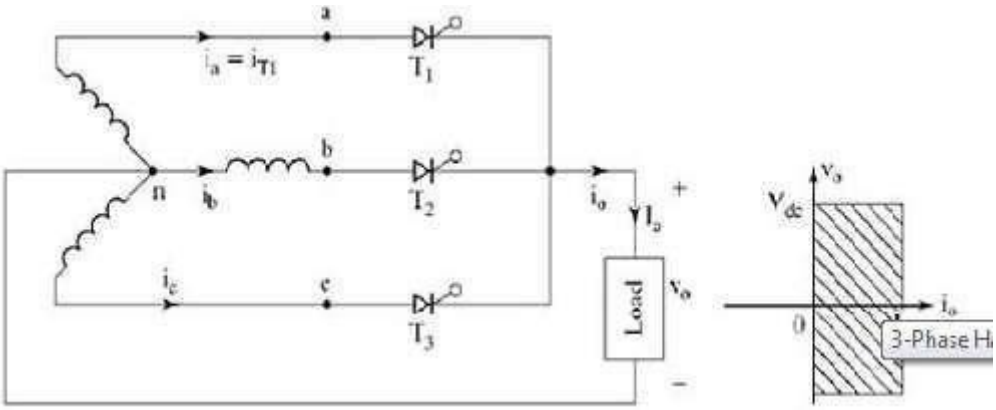
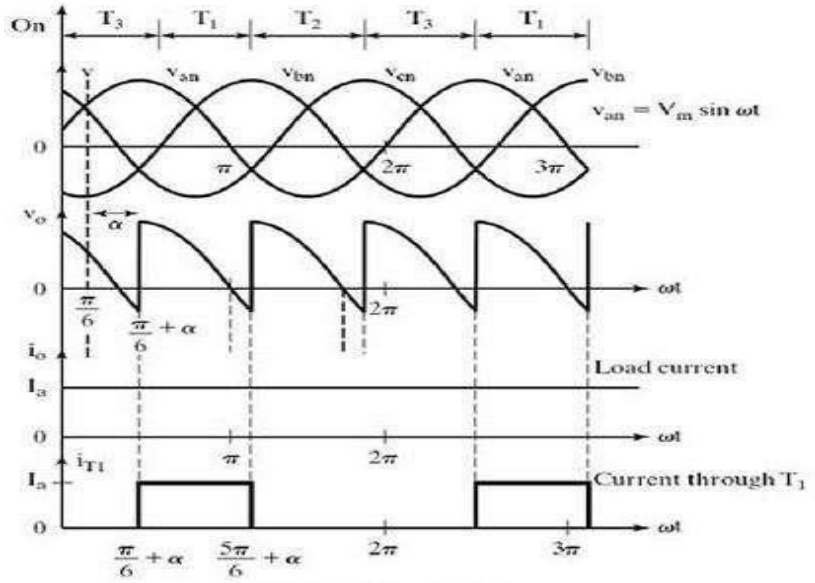
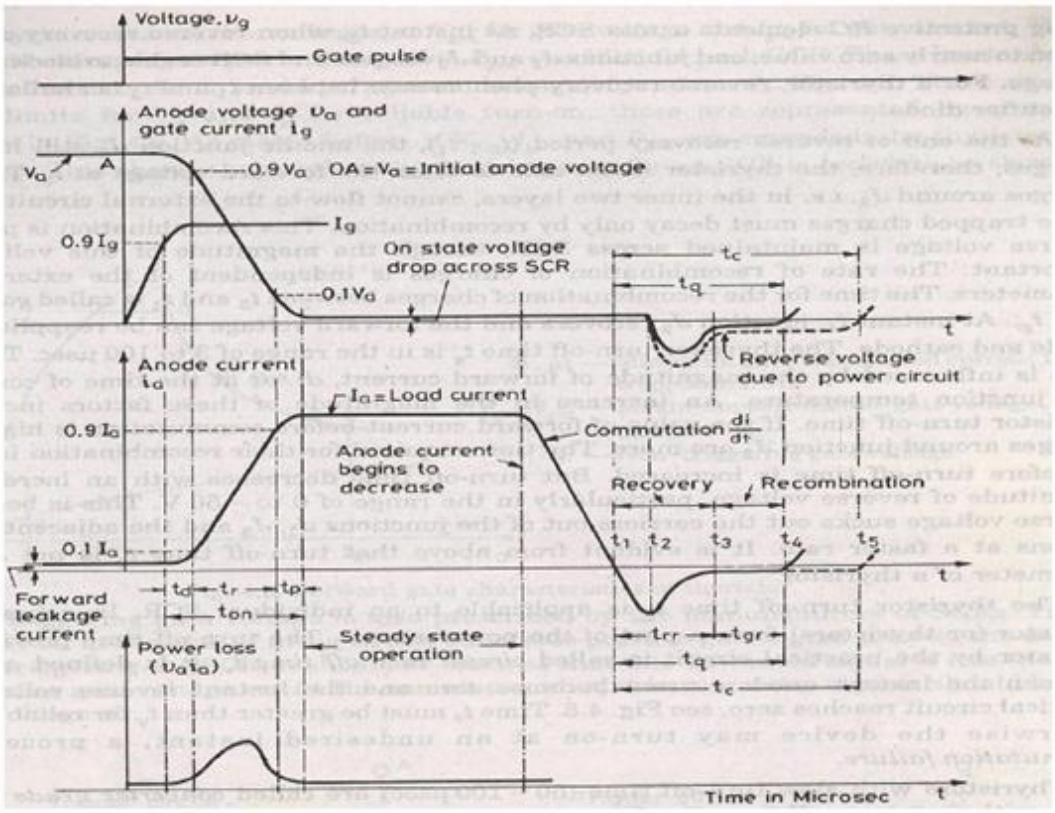


Figure: 2.16 circuit diagram three phase half wave rectifier



7. With neat sketch explain the turn on and turn off characteristic of SCR. May/June 2013Nov/Dec 2011 ,Nov/Dec 2014, May/June 2014.



8.

Unit 5 – AC PHASE CONTROLLERS

PART A

1. What is Integral cycle or ON-OFF control? [Nov/Dec 2011 & May/June 2012] (Nov/Dec 2014)

ON-OFF control: In this method, the thyristors are employed as switches to connect the load circuit to the source for a few cycles of the load voltage and disconnect it for another few cycles.

2. What is the duty cycle in ON-OFF control method? (April/May 2015)

Duty cycle K = n/ (n + m), where n = no. of ON cycles, m = no. of OFF cycles.

3. What are the types of ac voltage controller? [May/June 2013]

- 1ϕ Uni directional or half wave ac voltage controller
- 1ϕ Bidirectional or full wave ac voltage controller
- 3ϕ half wave ac voltage controller
- 3ϕ full wave ac voltage controller

4. What is the control range of firing angle in ac voltage controller with RL load? May/June 2014

The control range is F < a <180°, where F = load power factor angle.

5. What is meant by cyclo-converter? [Nov/Dec 2010, Nov/Dec 2012& May/June 2012](Nov/Dec 2014)

It converts input power at one frequency to output power at another frequency with one-stage conversion. Cycloconverter is also known as frequency changer.

6. What are the two types of cyclo-converters? [May/June 2011]

a. Step-up cyclo-converters

b. Step-down cyclo-converters

7. What are the applications of cyclo-converter? [Nov/Dec 2011]

a. Induction heating

b. Speed control of high power ac drives

c. Static VAR generation

d. Power supply in aircraft or ship boards

8. What are the applications of phase controlled converter or ac voltage controllers? [Nov/Dec 2012 & 2010]

- Domestic and industrial heating
- Lighting control
- Speed control of single phase and three phase ac motors
- Transformer tap changing

9. What are the advantages of ac voltage controllers?

- High efficiency
- Flexibility in control
- Less maintenance

10. What are the disadvantages of ac voltage controllers?

The main draw back is the introduction of harmonics in the supply current and the load voltage waveforms particularly at low output voltages.

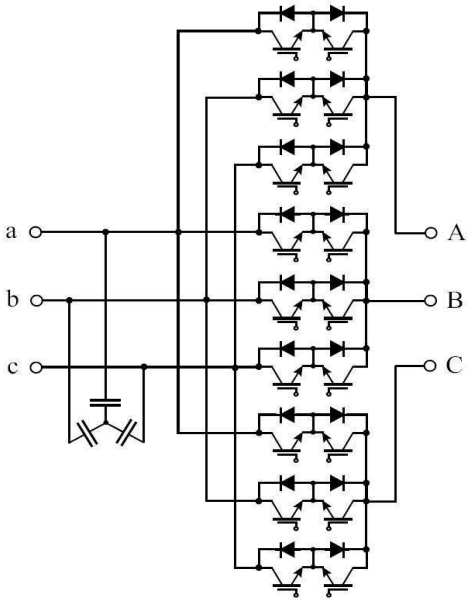
11. What are the two methods of control in ac voltage controllers?

- ON-OFF control
- Phase control

12. What is Matrix converter? [May/June 2011 &2013] May/June 2014

It is a capable of direct conversion from AC to AC by using bidirectional fully controlled switches.

13. Draw matrix converter circuit? (April/May 2015)



14. What is meant by positive converter group in a cyclo converter?

The part of the cycloconverter circuit that permits the flow of current during Positive half cycle of output current is called positive converter group.

15. What is meant by negative converter group in a cyclo converter?

The part of the cyclo converter circuit that permits the flow of current during negative half cycle of output current is called negative converter group.

16. What does ac voltage controller mean?

It is device, which converts fixed alternating voltage into a variable voltage without change in frequency.

17. What are the advantages of ac voltage controllers?

- High efficiency
- Flexibility in control
- Less maintenance

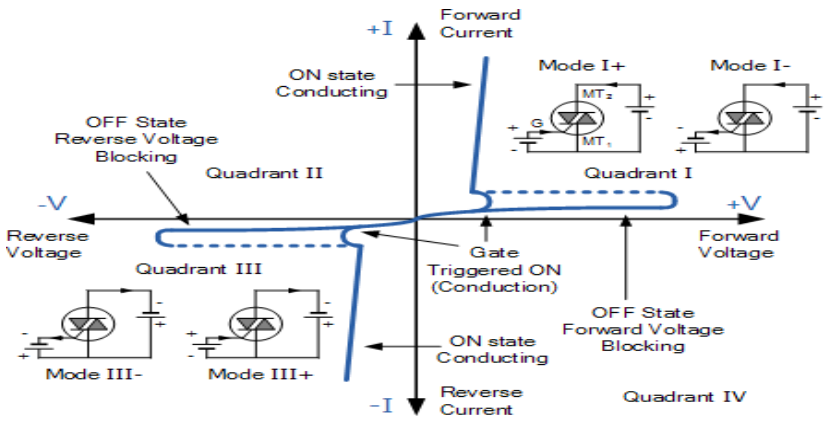
18. What are the disadvantages of ac voltage controllers?

The main draw back is the introduction of harmonics in the supply current and the load voltage waveforms particularly at low output voltages.

19. What are the two methods of control in ac voltage controllers?

- ON-OFF control
- Phase control

20. Draw the turn on characteristics of TRIAC and mark the td, tr and ton. [Nov/Dec 2010] [April/May 2015]



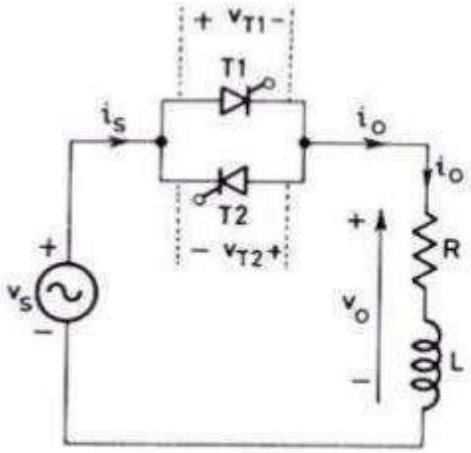
21. Distinguish between SCR and TRIAC? (Nov/Dec 2014)

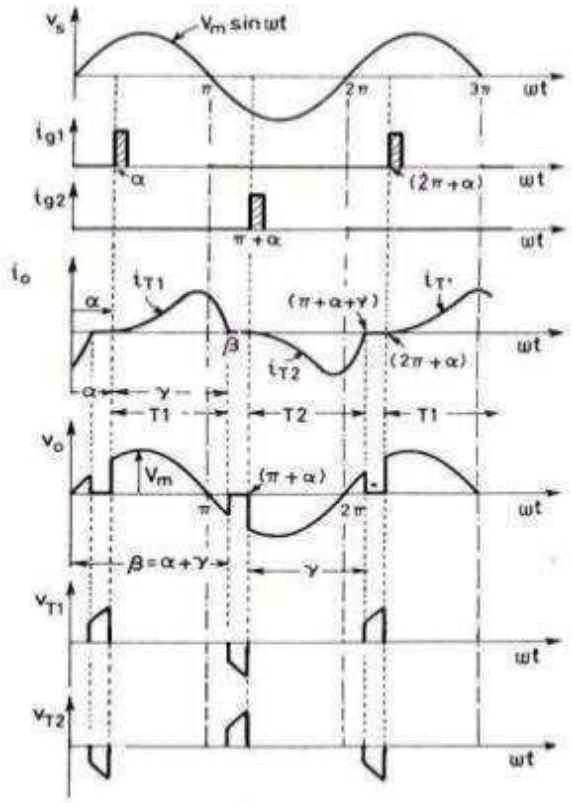
SCR is unidirectional device, gate current is positive, one VI characteristics
Triac is bidirectional device; gate current is positive or negative, two VI characteristics

PART- B & C

1. Explain the operation of 1- φ AC voltage controller with RL load. **(April/May 2015)**

Single phase AC voltage controller with RL load





2. A single phase voltage controller is employed for controlling the power flow from 230V, 50Hz source into a load circuit consisting of R=3 Ω and ωL=4 Ω. Calculate

(i) the range of firing angle

(ii) the maximum value of rms load current

(iii) the maximum power and power factor

(iv) The maximum values of average and rms thyristor currents.

Solution:

i. For controlling the load the minimum value of firing angle α = load phase angle

$$\varphi = tan^{-1}\frac{wL}{R} = tan^{-1}\frac{4}{3} = 53.13\ ^\circ$$

The maximum possible value of α is 180^0

So the firing angle control range is $53.13\ ^\circ \leq \alpha \leq 180^\circ$

ii. The maximum value of rms value of load current occurs when α = Φ = 53.13^0

$$= \frac{230}{\sqrt{3^2+4^2}} = 46A$$

$$I_0 = \frac{230}{\sqrt{R^2+(wL)^2}}$$

i. Maximum power = $I^2xR = 46^2x3 = 6348W$

Power factor = $\frac{I0^2 xR}{VsIo} = \frac{46x3}{230} = 0.6$

iv. Average thyristor current is maximum when α = Φ and conduction angle $\gamma = M$

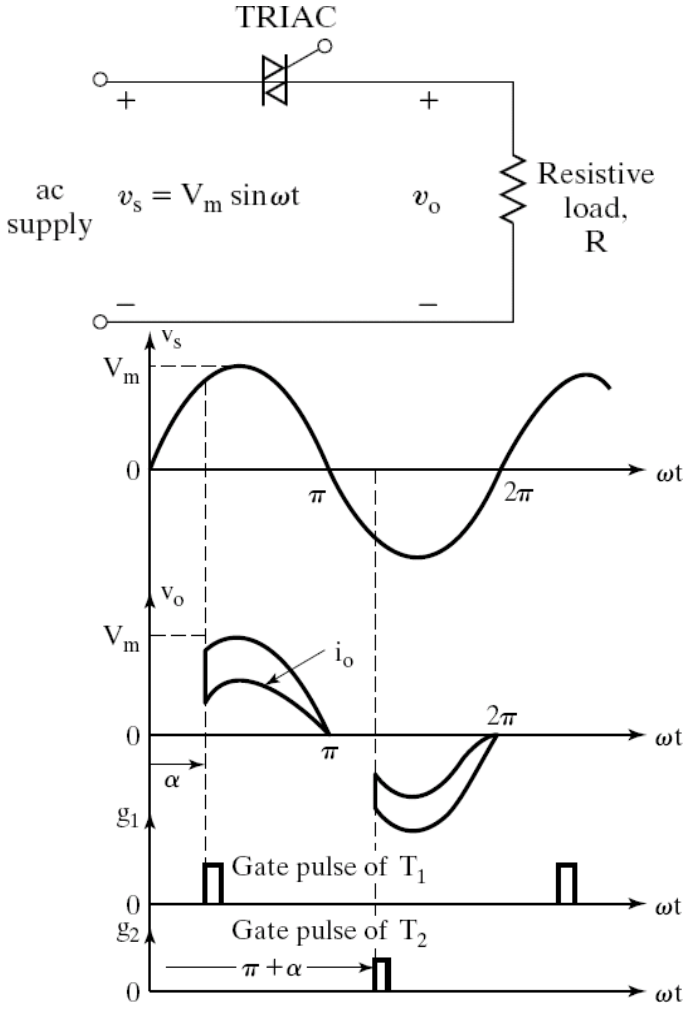
$$I_{TAVG} = \frac{1}{2\pi}\int_{\alpha}^{\alpha+\pi}\frac{Vm}{Z}\sin(wt-\varphi)\,d(wt)$$

$$= \frac{Vm}{\pi Z} = \frac{\sqrt{2}\times 230}{\pi\times\sqrt{3^2+4^2}} = 20.707A$$

Similarly maximum value of thyristor current is

$$= 32.527A$$

3. Explain the operation of 1- φ TRIAC based AC voltage controller with R load.



4. A single phase half-wave ac voltage controller has a load resistance $R = 50\Lambda$; input acsupply voltage is 230V RMS at 50Hz. The input supply transformer has a turn's ratio of 1:1. If the thyristor T is triggered at$\alpha = 60^0$. Calculate

1

(a) RMS output voltage.
(b) Output power.
(c) RMS load current and average load current.
(d) Input power factor.
(e) Average and RMS thyristor current.

- **RMS Value of Output (Load) Voltage** $V_{O(RMS)}$

=218.74 v

- $I_{O(RMS)} = 4.36939$ *Amps*

- $P_O = 0.9545799\ KW$
- PF=0.9498
- VO(avg)= -25.88V

5. A single phase voltage controller is employed for controlling the power flow from 220 V,50 Hz source into a load circuit consisting of R = 4 Ω and L = 6 mH. Calculate the following

a. Control range of firing angle
b. Maximum value of RMS load current
c. Maximum power and power factor
d. Maximum value of average and RMS thyristor current.

Solution

$$I_o = \frac{V_s}{Z} = \frac{220}{\sqrt{4^2+6^2}} = 30.5085 \text{ Amps}$$

$$\textbf{Maximum Power } P_o = I^2 R = (30.5085)^2 \times 4 = 3723.077 \text{ W}$$

$$\textbf{Input Volt-Amp} = V_s I_o = 220 \times 30.5085 = 6711.87 \text{ W}$$

$$\text{Power Factor} = \frac{P_o}{Input\ VA} = \frac{3723.077}{6711.87} = 0.5547$$

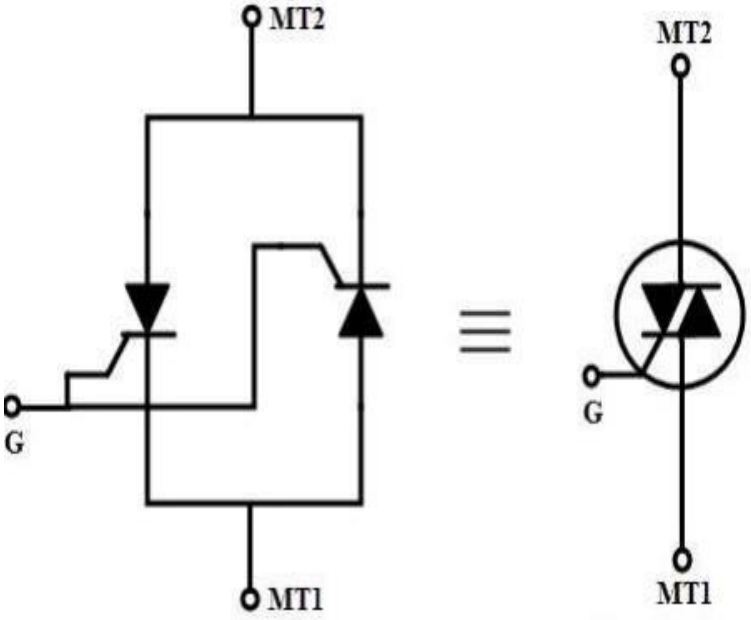
$$\therefore I_{T(Avg)} = \frac{V_m}{\pi Z} = \frac{\sqrt{2} \times 220}{\pi \sqrt{4^2+6^2}} = 13.7336 \text{ Amps}$$

$$I_{TM} = \sqrt{\frac{V_m^2}{4\pi Z^2}\left[\omega t - \frac{\sin(2\omega t - 2\theta)}{2}\right]_{\alpha}^{\pi+\alpha}}$$

$$I_{TM} = \sqrt{\frac{V_m^2}{4\pi Z^2}[\pi + \alpha - \alpha - 0]}$$

$$I_{TM} = \frac{V_m}{2Z} = \frac{\sqrt{2} \times 220}{2\sqrt{4^2+6^2}} = 21.57277 \text{ Amps}$$

6. Explain the modes of operation of TRIAC.



Working and Operation of TRIAC

It is possible to connect various combinations of negative and positive voltages to the triac terminals because it is a bidirectional device. The four possible electrode potential combinations which make the triac to operate four different operating quadrants or modes are given as.

1. MT2 is positive with respect to MT1 with a gate polarity positive with respect to MT1.
2. MT2 is positive with respect to MT1 with a gate polarity negative with respect to MT1.
3. MT2 is negative with respect to MT1 with a gate polarity negative with respect to MT1.
4. MT2 is negative with respect to MT1 with a gate polarity positive with respect to MT1.