CMR
INSTITUTE OF
TECHNOLOGY

Internal Assesment Test – I –Scheme and Solution

Sub:	**Power Electronics**							Code:	**18EE53**
Date:	12.11.2021	Duration:	90 mins	Max Marks:	50	Sem:	V	Branch:	EEE

		Marks	OBE CO	OBE RBT
1a	Explain working of different types of power electronic converters with the help of circuit diagram, input and output waveforms.	6	CO1	L2

The power electronics circuits can be classified into six types:

1. Diode rectifiers
2. Ac–dc converters (controlled rectifiers)
3. Dc–dc converters (dc choppers)
4. Dc–ac converters (inverters)
5. Ac–ac converters (ac voltage controllers)
6. Static switches

1. Diode rectifiers

- **It converts AC Voltage into a FIXED DC Voltage**

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- Converts fixed ac voltage into fixed dc voltage
- Input could be either single or three phase
- Example circuit for single phase diode rectifier is shown

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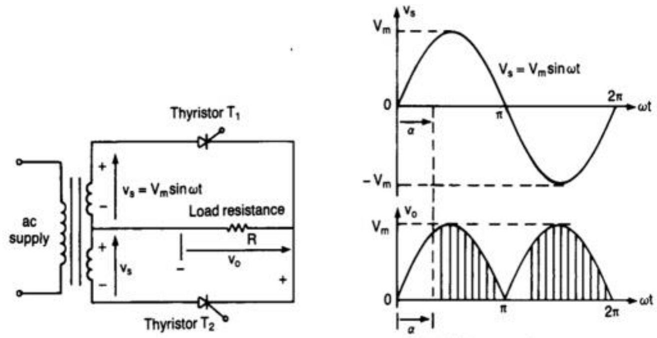
Ac–dc converters (controlled rectifiers)

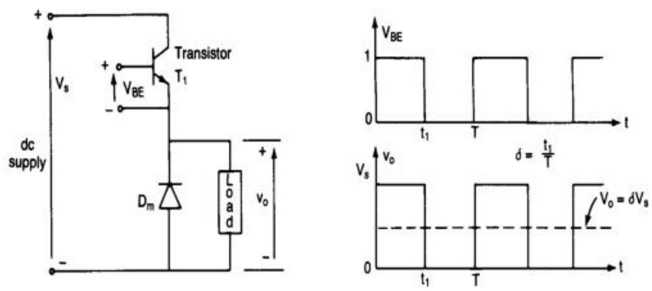
- **A single-phase** converter with two natural commutated thyristor is shown
- Average value of the output voltage can be controlled by varying the conduction time of thyristors
- This converters are also known as *controlled rectifiers*



(a) Circuit diagram (b) Voltage waveforms

Dc–dc converters (dc choppers)

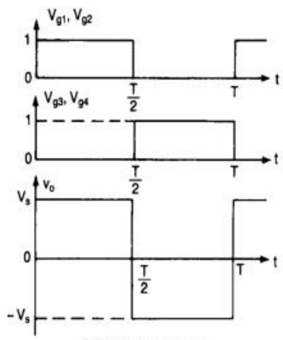
- Is also known as Chopper or Switching Regulator
- The average output voltage is controlled by varying the conduction of transistor, t1 .
- If T is the chopping period, then t1=δT
- δ is called as the duty cycle of chopper



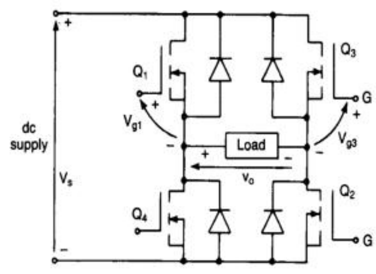
(a) Circuit diagram (b) Voltage waveforms

DC-AC Converters

- Is also known as Inverter
- If transistor Q1 and Q2 conduct for one-half period and Q3 and Q4 conduct the other half, the output voltage is of alternating form
- Fixed dc voltage to variable ac voltage
- Voltage control is obtained by controlling duty cycle
- Also known as inverter



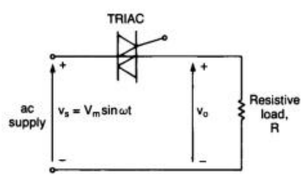
(b) Voltage waveforms



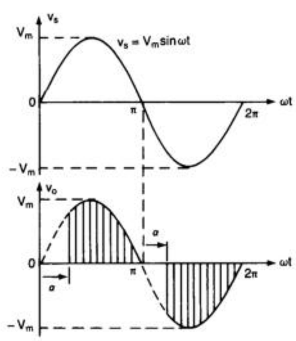
(a) Circuit diagram

AC-AC Converters

- AC Voltage Controller / Cyclo Converter
- **Fixed AC source** into **variable AC** output voltage
- a single-phase converter with a TRIAC is shown below



(a) Circuit diagram



(b) Voltage waveforms

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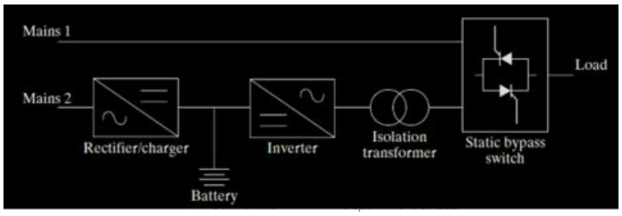
Static Switches

- Power devices can be operated as static switches or contactors
- Supply to these switches could **be either AC or DC**
- **The switches are called as *AC static switches or DC switches***
- Power electronic devices used as static switches in an UPS shown
- Mains 1 and 2 are connected to same supply
- Mains 1 supplies the load thro static bypass switch
- The rectifier charges the battery from Mains 2.
- The inverter supplies the emergency power to the load



CMRIT 9

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Explain the peripheral effects of power electronic equipments.

Harmonics

- **Harmonics** are unwanted higher frequencies which superimposed on the fundamental waveform (50 Hz) creating a distorted wave pattern.
- **Harmonic** is a
  - voltage or current waveforms at a multiple of the fundamental frequency of the system,
  - produced by the action of non-linear loads such as rectifiers, discharge lighting, or saturated magnetic devices.
- "harmonics" are multiples of the fundamental frequency *f* and can therefore be expressed as: 2*f*, 3*f*, 4*f*, etc.

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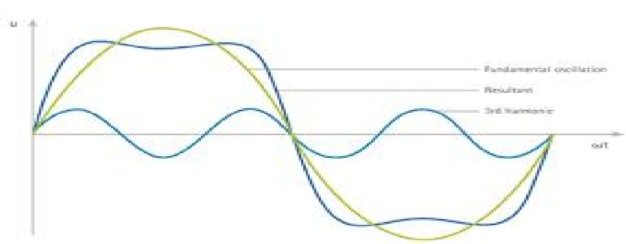

Need for Filter

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Effects of Harmonics

The operations of the power converters are based mainly on the switching of power semiconductor devices

- As a result the converters **introduce current and voltage harmonics into the supply system and on the output of the converters.** These can cause
  - **Problems of distortion of the output voltage and current**
  - **harmonic generation into the supply system**
  - **Interference with the communication and signalling circuits.**
  - Harmonic frequencies in the power grid are a frequent cause of power quality problems.
  - Increased heating in the equipment and conductors
  - Misfiring in variable speed drives
  - Torque pulsations in motors.

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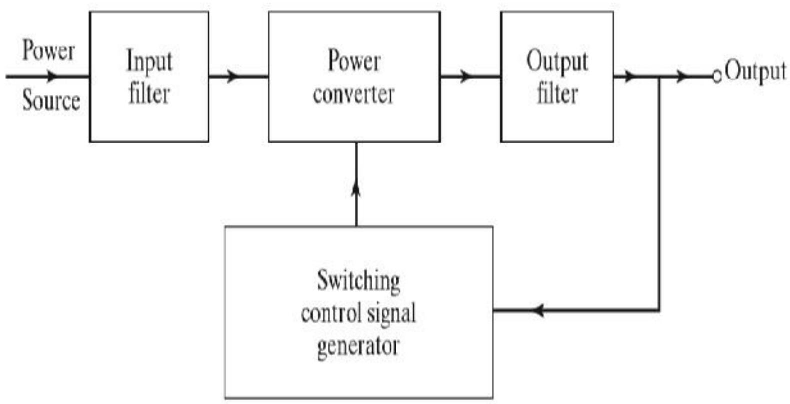
Need for filter

- It is normally necessary to introduce filters on the input and output of a converter system to reduce the harmonic level to an acceptable magnitude.

Generalized Power Converter System



2a	Analyze the reverse recovery characterstics of power diode with the help of waveforms and also obtain an expression for peak reverse current.	7	CO1	L3

Q2. a. Describe reverse recovery characteristics of diode. (6 marks)

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Reverse Recovery Characteristics

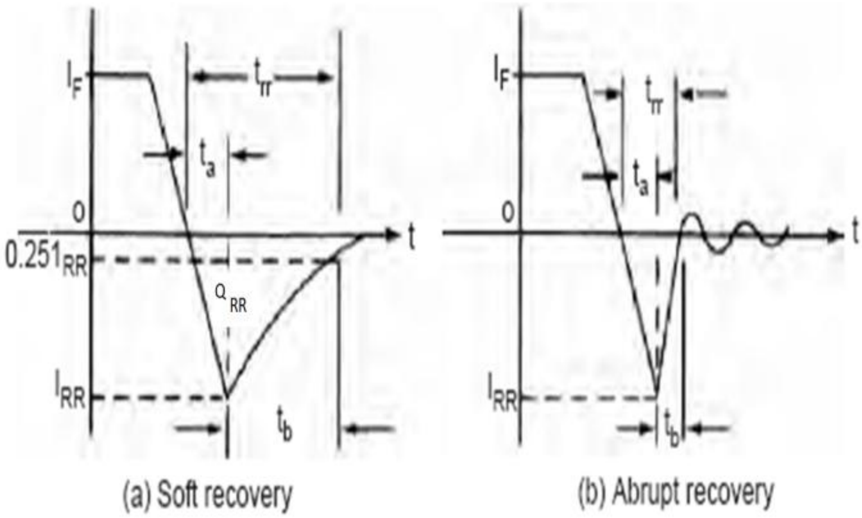
- The current in a forward-biased junction diode is due to the net effect of majority and minority carriers.
- Once a diode is in a forward conduction mode and then its forward current is reduced to zero (due to the natural behavior of the diode circuit or application of a reverse voltage), the diode continues to conduct due to minority carriers that remain stored in the pn-junction and the bulk semiconductor material.
- The minority carriers require a certain time to recombine with opposite charges and to be neutralized.
- This time is called the reverse recovery time of the diode.

There are two types of recovery:

- ✓ soft recovery
- ✓ hard (or abrupt) recovery.

The soft-recovery type is more common.

Reverse Recovery Characteristics



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The Reverse recovery time t_{rr}

- The reverse recovery time trr is measured from the initial zero crossing of the diode current to 25% of maximum (or peak) reverse current IRR.
- During the changeover from forward conduction to reverse blocking condition

The trr consists of two components, ta and tb.

✓ Parameter t_a is the interval between the initial zero crossing of the diode current and peak (maximum) reverse current I_{RR}. ta is due to charge storage in the depletion region of the junction

✓ Parameter t_b is the time interval between the maximum reverse recovery current to 25% of maximum (or peak) reverse current IRR. The tb is due to charge storage in the bulk semiconductor material.

✓ The lower t_{rr} means fast diode switching.

Softness factor SF = t_b / t_a

✓ The ratio of the two parameters t_b and t_a is known as the softness factor SF.

	• Reverse Recovery time t_{rr} $t_{rr} = t_a + t_b$ • Peak Reverse Current I_{RR} $$I_{RR} = t_a \frac{di}{dt}$$ • Reverse Recovery Charge Q_{RR} $$Q_{RR} = Q_1 + Q_2 \cong \frac{1}{2} I_{RR} t_a + \frac{1}{2} I_{RR} t_b = \frac{1}{2} I_{RR} t_{rr} \quad \text{or} \quad I_{RR} \cong \frac{2Q_{RR}}{t_{rr}}$$ ✓ Reverse Recovery Charge Q_{RR} is the amount charge carriers that flows across the diode in the reverse direction due to change over from forward conduction to reverse blocking condition. ✓ Its value is determined from the area enclosed by the curve of the reverse recovery current. $$Q_{RR} = \frac{1}{2} I_{RR} t_a + \frac{1}{2} I_{RR} t_b = \frac{1}{2} I_{RR} t_{rr}$$ $$I_{RR} = \frac{2Q_{RR}}{t_{rr}} = t_a \frac{di}{dt}$$ $$t_{rr} t_a = \frac{2Q_{RR}}{di/dt}$$ t_b is negligible compared to t_a $\quad t_{rr}^2 = \frac{2Q_{RR}}{di/dt}$ t_a $$t_{rr} \cong \sqrt{\frac{2Q_{RR}}{di/dt}}$$ $$I_{RR} = \sqrt{2Q_{RR} \frac{di}{dt}}$$	3		
2b	The reverse recovery time of a diode is 5μs and rate of fall of the diode current is 80A/ μs. Determine (i) Storage charge Q_{RR} (ii) Peak reverse current I_{RR} Given Data Reverse recovery time of a diode trr = 5μs Rate of fall of the diode current di/dt = 80A/ μs **1. To find QRR** $$Q_{RR} = \frac{1}{2} \frac{di}{dt} t_{rr}^2$$ QRR = $\frac{1}{2} \frac{80}{10^{-6}} (5 * 10^{-6})^2$ = **1000 μc**	3 1 1	CO1	L3

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2. Peak reverse current IRR

$$I_{RR} = \sqrt{2Q_{RR}\frac{di}{dt}}$$

$$\text{IRR} = \sqrt{2 * 1000 * 10^{-6} * \frac{80}{10^{-6}}}$$

IRR = 400 A

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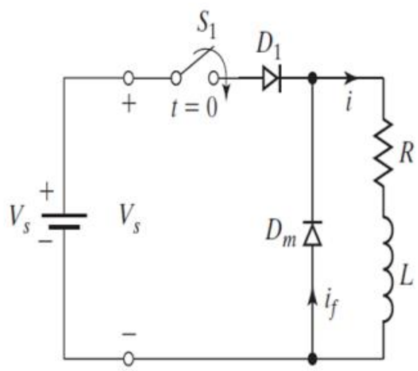
Explain the function of a freewheeling diode in a switched RL load with the help of circuit diagram and waveforms.

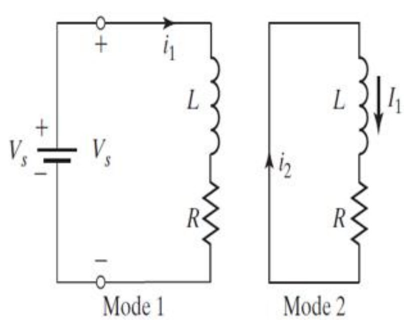
Freewheeling diodes with RL Load



(a) Circuit diagram

- If switch $S1$ is closed for time $t1$, a current is established through the load;
- If the switch is opened, a path must be provided for the current in the inductive load.
- Otherwise, the inductive energy induces a very high voltage and this energy is dissipated as heat across the switch as sparks.
- This is normally done by connecting a diode Dm as shown in Figure, and this diode is usually called a *freewheeling diode.*
- Diode Dm is needed to prove a path for the inductive load current.
- Diode $D1$ is connected in series with the switch and it will prevent any negative current flow through the switch if there is an ac input supply voltage.
- But for dc supply, there is no need for $D1$.

D1 – Normal Diode
Dm – Freewheeling Diode



(b) Equivalent circuits

- The circuit operation can be divided into Two modes.
- Mode 1 begins when the switch is closed at $t = 0$
- Mode 2 begins when the switch is opened.
- The equivalent circuits for the modes are shown in Figure.
- Variables $i1$ and $i2$ are defined as the instantaneous currents for mode 1 and mode 2, respectively;
- $t1$ and $t2$ are the corresponding durations of these modes.

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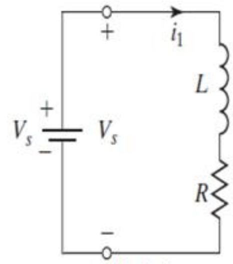
Mode 1

2

- Diode current i1

$$i_1(t) = \frac{V_s}{R}\left(1 - e^{-tR/L}\right)$$



Mode 1

- When the switch is opened at $t = t1$ (at the end of this mode),
- Diode current i1 at $t = t1$ becomes

$$I_1 = i_1(t = t_1) = \frac{V_s}{R}\left(1 - e^{-tR/L}\right)$$

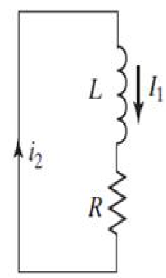
- If the time $t1$ is sufficiently long, the current practically reaches a steady-state current of $Is = Vs/R$ flows through the load.

Mode 2

2

- This mode begins when the switch is opened and the load current starts to flow through the freewheeling diode *Dm*.
- Redefining the time origin at the beginning of this mode, th freewheeling diode is found f

$$0 = L\frac{di_2}{dt} + Ri_2$$



Mode 2

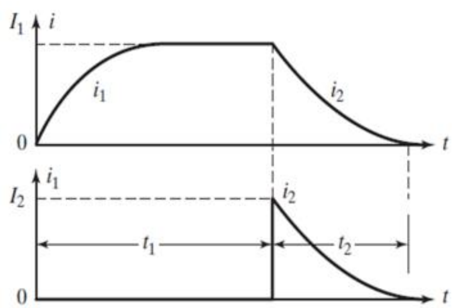
- with initial condition *i2 (t = t1) = I1.*
- *the free i2 is given by*

$$i_2(t) = I_1 e^{-tR/L}$$

- at *t = t2 this current decays exponentially to practically zero provided that t2 > L/R.*

Waveforms of Currents

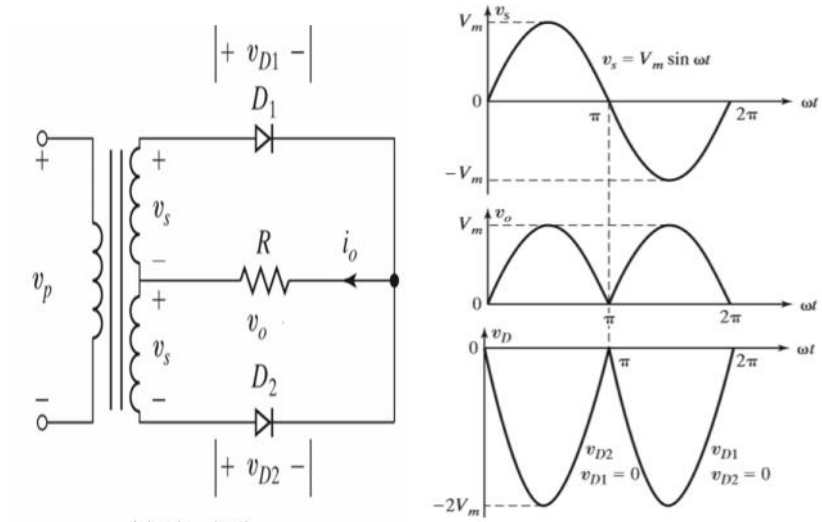
2



(c) Waveforms

4	A single-phase full-wave rectifier with center-tapped transformer has a purely resistive load of R, Determine (a) Average voltage and current (b)RMS voltage and current (c) dc output power (d) ac output power (e) the efficiency (f) Ripple factor (g) Form Factor (h) TUF (i) the input power factor PF, (j) CF of the input current.	10 1	CO1	L3

Center-tapped Full wave Rectifier



(a) Circuit diagram

(b) Waveforms

During the positive half-cycle of the input voltage

- Diode D1 conducts and diode D2 is in a blocking condition.
- The input voltage appears across the load.

During the negative half-cycle of the input voltage

- Diode D2 conducts while diode D1 is in a blocking condition.
- The negative portion of the input voltage appears across the load as a positive voltage.

- The peak inverse voltage of a diode is 2Vm
- PIV of diode, D2 = Vm + Vm

Performance Parameters for Full wave Rectifier

1. **Average value of the output voltage, V_{dc}**

$$V_{dc} = \frac{2}{T}\int_0^{T/2} V_m \sin \omega t \, dt \qquad T = 2\pi$$

$$V_{dc} = \frac{1}{\pi}\int_0^{\pi} V_m sin\omega t \, d\omega t :$$

$$= \frac{V_m}{\pi}\left(-cos\,\omega t\right)_0^{\pi}$$

$$= \frac{V_m}{\pi}\left(-cos\pi + cos0^o\right)$$

$$V_{dc} = \frac{2V_m}{\pi} = 0.6366V_m$$

2. Average value of the output current (Load), Idc

$$I_{dc} = \frac{V_{dc}}{R} = \frac{0.6366V_m}{R}$$

3. Output dc power, P_{dc}

1

$$P_{dc} = V_{dc}I_{dc}$$

$$P_{dc} = (0.6366V_m)^2/R$$

4. RMS value of the output voltage, V_{rms}

$$V_{rms} = \left[\frac{2}{T}\int_0^{T/2} (V_m \sin \omega t)^2 \, dt\right]^{1/2}$$

$T = 2\pi$

The rms value of the load voltage V_{rms} can be calculated as follows:

$$V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} v_s^2(\omega t) d\omega t}$$

$$= \sqrt{\frac{1}{\pi}\int_0^{\pi} (V_m sin\omega t)^2 \, d\omega t}$$

$$= \sqrt{\frac{(V_m)^2}{\pi}\int_0^{\pi} \frac{1}{2}(1 - cos2\omega t) d\omega t} = \frac{V_m}{\sqrt{2}}$$

$$V_{rms} = \frac{V_m}{\sqrt{2}} = 0.707 V_m$$

5. RMS value of the output Current, I_{rms}

$$I_{rms} = \frac{V_{rms}}{R} = \frac{0.707 V_m}{R}$$

6. Output ac power, P_{ac}

			2

$P_{ac} = V_{rms} I_{rms}$

$$P_{ac} = (0.707 V_m)^2 / R.$$

7. Efficiency, η (Rectification Ratio)

1

$\eta = P_{dc}/P_{ac}$

efficiency $\eta = (0.6366V_m)^2/(0.707V_m)^2 = 81\%$.

8. AC component of Output Voltage

Output voltage consists of 1. DC component 2. AC comp

$$V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

9. Form factor, FF – Measure of the shape of the output vo

1

$$FF = \frac{V_{rms}}{V_{dc}}$$

$$FF = 0.707V_m/0.6366V_m = 1.11.$$

10. Ripple factor, RF – Measure of Ripple content

$$RF = \frac{V_{ac}}{V_{dc}} \qquad V_{ac} = \sqrt{V_{rms}^2 - V_{dc}^2}$$

$$RF = \sqrt{\left(\frac{V_{rms}}{V_{dc}}\right)^2 - 1} = \sqrt{FF^2 - 1}$$

1

$$RF = \sqrt{1.11^2 - 1} = 0.482 \text{ or } 48.2\%.$$

11. Peak Inverse Voltage

1

Center tapped Full wave Rectifier : 2 Vm

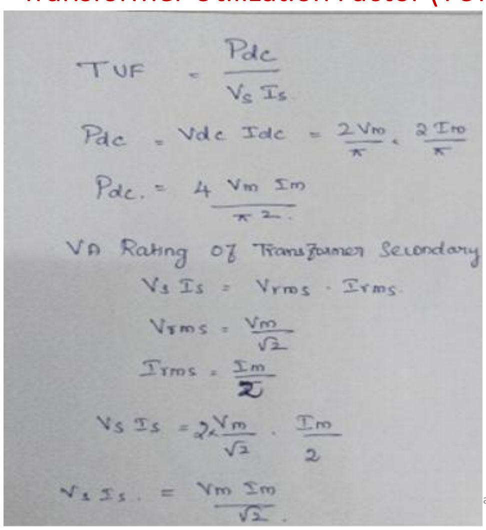
Bridge type Full wave Rectifier : Vm

12. Transformer utilization factor, TUF

- TUF indicates how effectively the transformer capacity is used in delivering dc power to load for a given ac power.
- It is the ratio of dc power delivered to the load to ac power rating of secondary winding of the transformer.
- $TUF = P_{dc}/V_sI_s = P_{dc}/V_{rms}I_{rms\,(transformer\,secondary)}$
- V_s, I_s are rms voltage and current of the transformer secondary
- TUF for Center tapped full wave rectifier = 0.693 = 69.3%
- TUF for bridge type full wave rectifier = 0.812 = 81.2%

2

Transformer Utilization Factor (TUF) of center-tapped Full Wave Rectifier



$TUF = \frac{P_{dc}}{V_s I_s}$

$P_{dc} = V_{dc} I_{dc} = \frac{2V_m}{\pi} \cdot \frac{2I_m}{\pi}$

$P_{dc} = \frac{4 V_m I_m}{\pi^2}$

VA Rating of Transformer Secondary

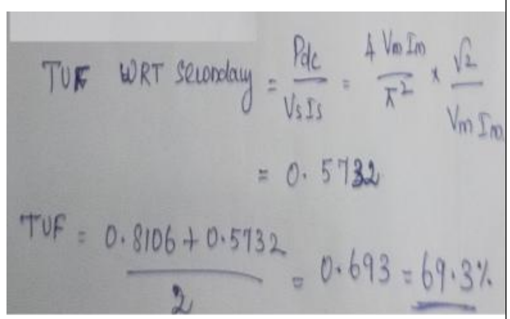
$V_s I_s = V_{rms} \cdot I_{rms}$

$V_{rms} = \frac{V_m}{\sqrt{2}}$

$I_{rms} = \frac{I_m}{2}$

$V_s I_s = 2 \times \frac{V_m}{\sqrt{2}} \cdot \frac{I_m}{2}$

$V_s I_s = \frac{V_m I_m}{\sqrt{2}}$



$TUF \text{ WRT Secondary} = \frac{P_{dc}}{V_s I_s} = \frac{4 V_m I_m}{\pi^2} \times \frac{\sqrt{2}}{V_m I_m}$

$= 0.5732$

$TUF = \frac{0.8106 + 0.5732}{2} = 0.693 = 69.3\%$

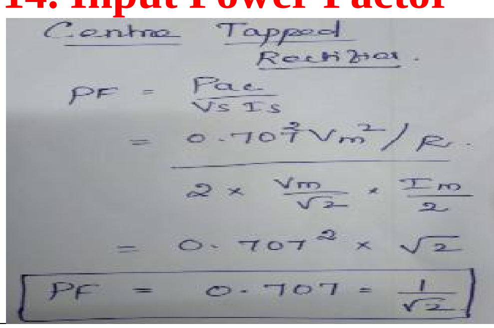
13. Crest Factor

Crest factor (CF), which is a measure of the peak input current $I_{s(peak)}$ as compared with its rms value I_s, is often of interest to specify the peak current ratings of devices and components. CF of the input current is defined by

$$CF = \frac{I_{s(peak)}}{I_s}$$

1

14. Input Power Factor



Centre Tapped Rectifier.

$PF = \frac{P_{ac}}{V_s I_s}$

$= \frac{0.707^2 V_m^2 / R}{2 \times \frac{V_m}{\sqrt{2}} \times \frac{I_m}{2}}$

$= 0.707^2 \times \sqrt{2}$

$PF = 0.707 = \frac{1}{\sqrt{2}}$

5a	Explain different types of power diodes. **Types of Power Diodes** • Depending on the recovery characteristics, on state drop and manufacturing techniques, the power diodes can be classified into the following categories: 1. General-purpose diodes or Standard diodes 2. Fast-recovery diodes 3. Schottky diodes Special Diodes 4. Silicon Carbide Diodes 5. Silicon Carbide Schottky Diodes 6. Freewheeling diodes **1. General-Purpose Diodes (standard diodes)** • General-purpose diodes are available up to 5000 V, 4500 A • The general-purpose rectifier diodes have relatively high reverse recovery time trr, typically 25 µs • Used in low-speed applications, where recovery time is not critical • (e.g., diode rectifiers and converters for a low-input frequency up to 1-kHz applications and line-commutated converters). • Current ratings from less than 1 A to several thousands of amperes • Voltage ratings from 50 V to around 5 kV. • These diodes are generally manufactured by diffusion. 1 **2. Fast-Recovery Diodes** • The fast-recovery diodes have low recovery time, normally less than 5µs. • They are used in dc–dc and dc–ac converter circuits, where the speed of recovery is often of critical importance. • Voltage rating from 50 V to around 3 kV • Current rating less than 1 A to hundreds of amperes. • For voltage ratings above 400 V, fast-recovery diodes are generally made by diffusion and the recovery time is controlled by platinum or gold diffusion. • For voltage ratings below 400 V, epitaxial diodes provide faster switching speeds than those of diffused diodes. • The epitaxial diodes have fast recovery time of as low as 50 ns. 22	6 3 3	CO1	L2

Schottky Diodes

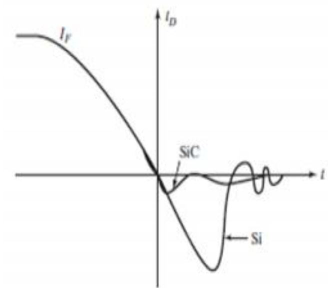
- The charge storage problem of a *pn*-junction can be eliminated (or minimized) in a Schottky diode.
- It is accomplished by setting up a "barrier potential" with a contact between a metal and a semiconductor.
- A layer of metal is deposited on a thin epitaxial layer of *n*-type silicon.
- The rectifying action depends on the majority carriers only, and as a result there are no excess minority carriers to recombine.
- The recovery effect is due to the **self capacitance of the semiconductor junction.**
- The recovered charge of a Schottky diode is much less than that of an equivalent *pn* junction diode. Because it is due only to the junction capacitance, it is largely independent of the reverse *di/dt*.
- A Schottky diode has a relatively low forward voltage drop.
- The leakage current of a Schottky diode is higher than that of a *pn*-junction diode.
- A Schottky diode with relatively low-conduction voltage has relatively high leakage current, and vice versa.
- As a result, the maximum allowable voltage of this diode is generally limited to 100 V.
- The current ratings of Schottky diodes vary from 1 to 400 A.
- The Schottky diodes are ideal for high-current and low-voltage dc power supplies.
- However, these diodes are also used in low-current power supplies for increased efficiency.

Advantages of Schottky diode

- The capacitance of the diode is low as the depletion region of the diode is negligible.
- The reverse recovery time of the diode is very fast, that is the change from ON to OFF state is fast.
- The current density of the diode is high as the depletion region is negligible.
- The turn-on voltage of the diode is 0.2 to 0.3 volts, which is very low.

4. Silicon Carbide Diodes

- Silicon carbide (SiC) is a new material for power electronics.
- Its physical properties outperform Silicon (Si) and Gallium Arsenide GaAs by far.
- The typical storage charge *QRR* is
  - ✓ 21 nC for a 600-V, 6-A diode
  - ✓ 23 nC for a 600-V, 10-A device.



- They have the following features:

➢ No reverse recovery time;

➢ Ultrafast switching behavior;

➢ No temperature influence on the switching behavior.

Advantages

- Low reverse recovery current.
- SiC power devices enable increased efficiency
- Reduced size
- higher switching frequency
- produce significant less electromagnetic interference (EMI) in a variety of applications.
- silicon-carbide diodes show four times better dynamic characteristics with 15% less forward voltage (V_F) than standard silicon diodes

Applications

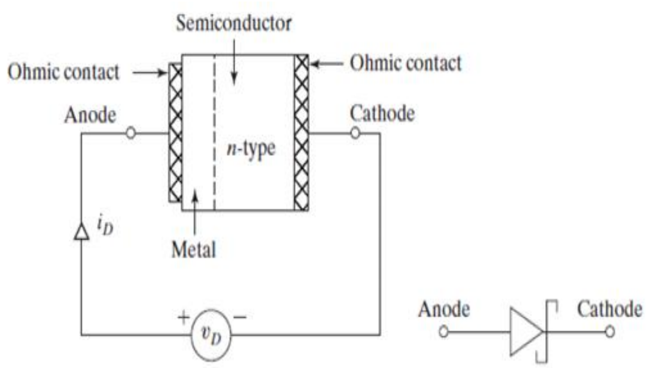
- power supplies, solar energy conversion, transportations, and other applications such as welding equipment and air conditioners.

Features of SiC Schottky diodes

- Lowest switching losses due to low reverse recovery charge;
- Fully surge-current stable, high reliability, and ruggedness;
- Lower system costs due to reduced cooling requirements;
- Higher frequency designs and increased power density solutions.

- These devices also have low device capacitance that enhances overall system efficiency, especially at higher switching frequencies.

Basic Structure of Schottky Diodes

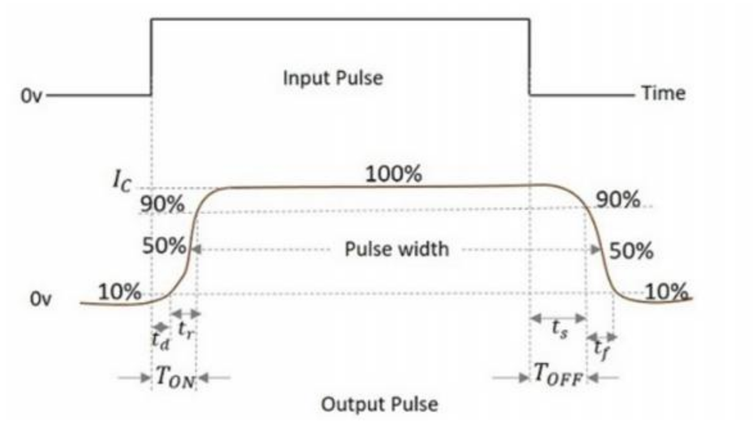


(a) (b)

	Freewheeling diodes • A freewheeling diode is basically a diode connected across the inductive load terminals to prevent the development of high voltage across the switch. • When the inductive circuit is switched off, this diode gives a short circuit path for the flow of inductor decay current and hence dissipation of stored energy in the inductor. • This diode is also called Flywheel or Flyback diode. • The main purpose of **freewheeling** or flyback **diode** is to free wheel the stored energy in inductor by providing a short **circuit** path. • This is necessary else a sudden decay in **circuit** current will give rise to high voltage across the switch contacts and **diode**. 32			
5b	Discuss the major industrial applications of power electronic converter circuits **INDUSTRIAL APPLICATIONS** Pumps, compressors, blowers, fans, Machine tools, arc furnaces, induction furnaces, lighting control circuits, industrial lasers, induction heating, welding equipments.	4	CO1	L2
6a	Explain the characterstics of practical devices with the help of voltage and current waveforms. **Characteristics of Practical Devices** ✓ Practical Devices requires a finite delay time (td), rise time (tr), storage time (ts), and fall time (tf). ✓ As the device current i_{sw} rises during turn-on, the voltage across the device v_{sw} falls. ✓ As the device current falls during turn-off, the voltage across the device rises. ✓ The turn-on time (ton) of a device is the sum of the delay time and the rise time ton = td + tr ✓ The turn-off time (toff) of a device is the sum of the storage time and the fall time. toff = ts + tf ✓ Practical switching device dissipates some energy when conducting and switching, but ideal switches are lossless ✓ Voltage drop across a conducting power device is at least on the order of 1 V, but can often be higher, up to several volts. ✓ The goal of any new device is to improve the limitations imposed by the switching parameters.	6 2	CO1	L2

Characteristics of Practical Devices

2



2

- **Time delay(t_d)** – The time taken by the collector current to reach from its initial value to 10% of its final value is called as the **Time Delay**.
- **Rise time(t_r)** – The time taken for the collector current to reach from 10% of its initial value to 90% of its final value is called as the **Rise Time**.
- **Turn-on time (T_{ON})** – The sum of time delay (t_d) and rise time (t_r) is called as **Turn-on time**.

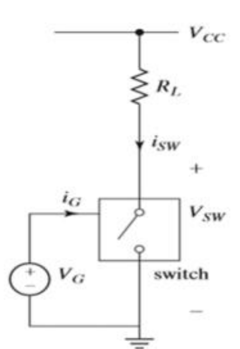
$$T_{ON} = t_d + t_r$$

- **Storage time (t_s)** – The time interval between the trailing edge of the input pulse to the 90% of the maximum value of the output, is called as the **Storage time**.
- **Fall time (t_f)** – The time taken for the collector current to reach from 90% of its maximum value to 10% of its initial value is called as the **Fall Time**.
- **Turn-off time (T_{OFF})** – The sum of storage time (t_s) and fall time (t_f) is defined as the **Turn-off time**.

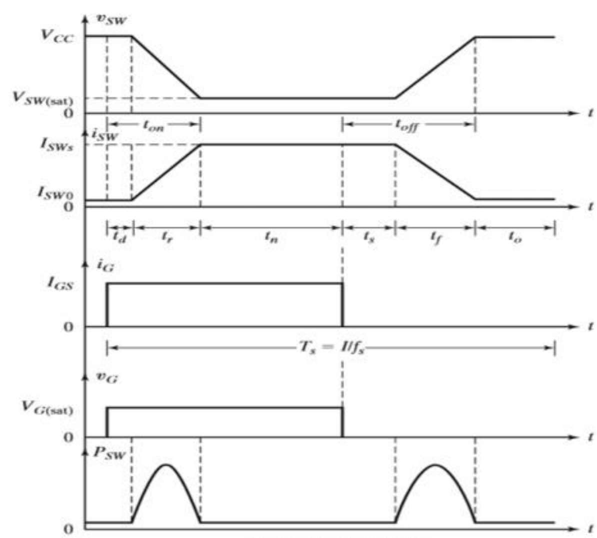
$$T_{OFF} = t_s + t_f$$

- **Pulse Width(W)** – The time duration of the output pulse measured between two 50% levels of rising and falling waveform is defined as **Pulse Width**.

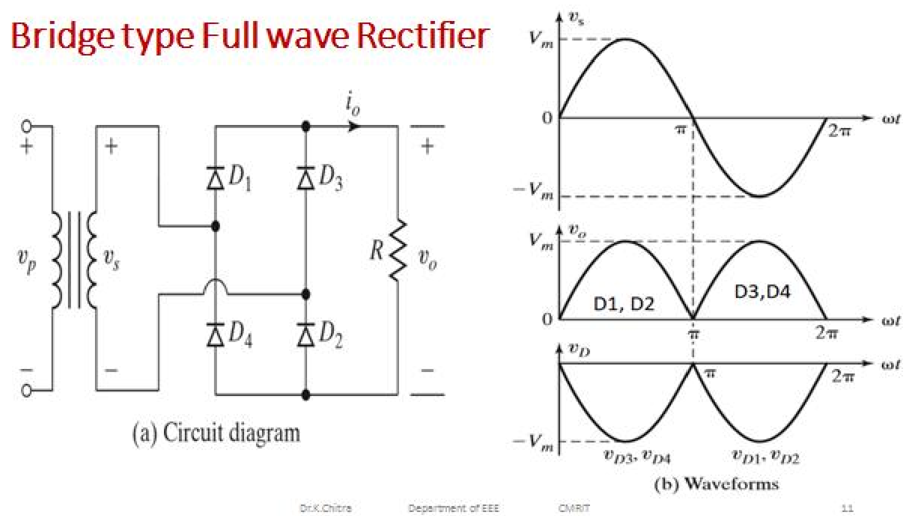
Characteristics of Practical Devices



(a) Controlled switch



(b) Switch waveforms

6b	List out the switch specifications. **Switch Specifications** 1. Voltage ratings 2. Current ratings 3. Switching speed or frequency fs 4. di/dt rating 5. dv/dt rating 6. Switching losses 7. Gate-drive requirements 8. Safe operating area (SOA) 9. I^2t for fusing 10. Temperatures 11. Thermal resistance	4 4	CO1	L1
7a	With circuit diagram and waveforms, explain uncontrolled single-phase bridge type full wave rectifier with R load.  **During the positive half-cycle of the input voltage** • Diodes D1 and D2 forward biased and conduct. • Diodes D3 and D4 reverse biased • Output current flows from Vs+, D1, R load, D2, Vs- **During the negative cycle of the input voltage** • Diodes D3 and D4 forward biased and conduct. • Diodes D1 and D2 reverse biased. • Output current flows from Vs+, D3, R load, D4, Vs- ➢ The peak inverse voltage of a diode is only Vm. ➢ This circuit is known as a bridge rectifier ➢ It is commonly used in industrial applications	5 3 2	CO1	L2
7b	Compare the advantages and disadvantages of bridge rectifier and rectifier with center tapped transformer.	5	CO1	L2

Advantages and Disadvantages of Center-Tapped and Bridge Rectifiers		
	Advantages	Disadvantages
Center-tapped transformer	Simple, only two diodes	Limited low power supply, less than 100 W
	Ripple frequency is twice the supply frequency	Increased cost due to the center-tapped transformer
	Provides an electrical isolation	Dc current flowing through each side of the second-ary will increase the transformer cost and size
Bridge rectifier	Suitable for industrial applications up to 100 kW	The load cannot be grounded without an input-side transformer
	Ripple frequency is twice the supply frequency	Although an input-side transformer is not needed for the operation of the rectifier, one is normally connected to isolate the load electrically from the supply
	Simple to use in commercially available units	