2 Controlled & Uncontrolled Rectifiers

Multiple Choice Questions

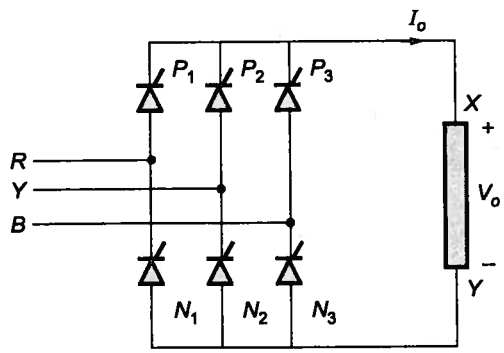
Q.1 A fully controlled natural commutated 3-phase bridge rectifier is operating with a firing angle $\alpha = 30°$. The peak to peak voltage ripple expressed as a ratio of the peak output dc voltage at the output of the converter bridge is

(a) 0.5 (b) $\sqrt{3}/2$

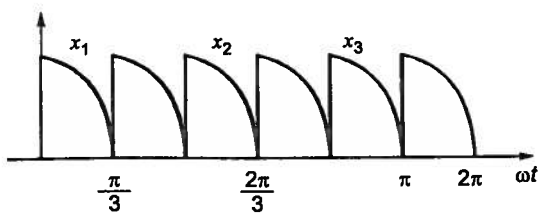
(c) $\left(1-\frac{\sqrt{3}}{2}\right)$ (d) $\sqrt{3}-1$

[GATE-2003]

Q.2 A 3-phase full converter supplying power to inductive load with ripple free current is shown in fig. All positive group devices are represented with P_1, P_2, P_3 and all negative group devices are represented with N_1, N_2, N_3 as shown below.



By assuming $v_{YB} = V_{ml} \sin\omega t$ and $\alpha = 60°$ the following load voltage is obtained.



Which of the following statement is true as per the given output voltage waveform?

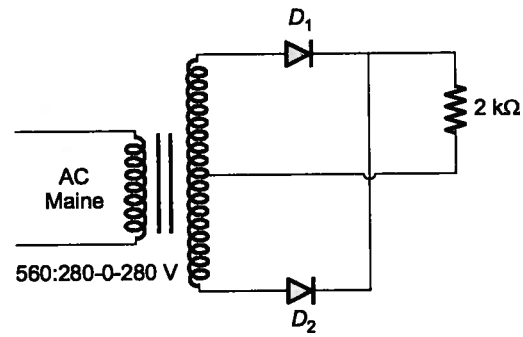
(a) $x_1 = v_{RB}$, $x_2 = v_{YR}$ and $x_3 = v_{YB}$

(b) $x_1 = v_{RY}$, $x_2 = v_{YB}$ and $x_3 = v_{BY}$

(c) $x_1 = v_{RB}$, $x_2 = v_{YR}$ and $x_3 = v_{BY}$

(d) $x_1 = v_{RY}$, $x_2 = v_{YB}$ and $x_3 = v_{BR}$

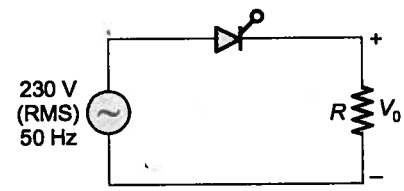
Q.3 The center-tap full-wave single-phase rectifier circuit uses 2 diodes as shown in the given figure. The rms voltage across each diode is



(a) 790.7 V (b) 395.3 V

(c) 280 V (d) 201.3 V

Q.4 Consider a phase-controlled converter shown in the figure. The thyristor is fired at an angle α in every positive half cycle of the input voltage. If the peak value of the instantaneous output voltage equals 230 V, the firing angle α is close to

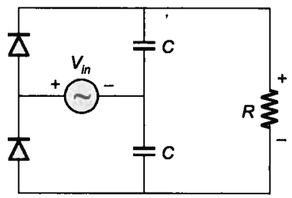


(a) 45° (b) 135°

(c) 90° (d) 83.6°

[GATE-2005]

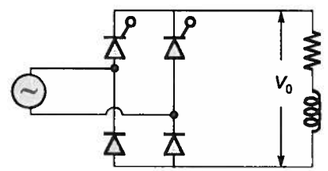
Q.5 In the following circuit, the input voltage V_{in} is 100sin(100pt). For 100pRC = 50, the average voltage across R(in Volts) under steady-state is nearest to



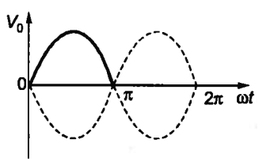
(a) 100 (b) 31.8
(c) 200 (d) 63.6

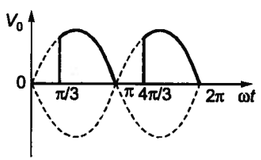
[2015 : 1 Mark, Set-2]

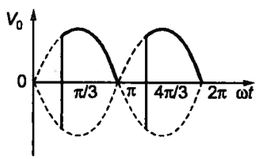
Q.6 A single-phase half controlled converter shown in the figure feeding power to highly inductive load. The converter is operating at a firing angle of 60°.

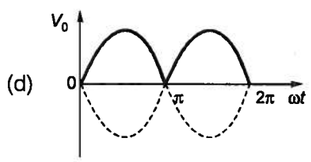


If the firing pulses are suddenly removed, the steady state voltage (V_0) waveform of the converter will become

(a) 

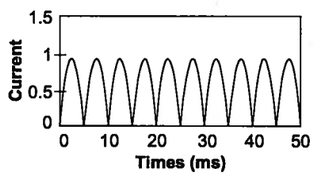
(b) 

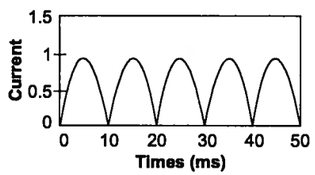
(c) 

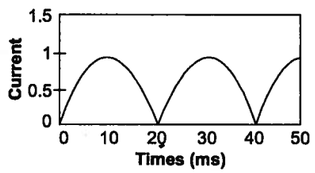
(d) 

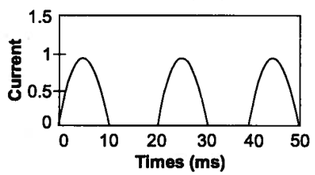
[GATE-2008]

Q.7 If the circuit consists of an ideal diode connected to a pure inductor and is connected to a purely sinusoidal 50 Hz voltage source. Under ideal conditions the current waveform through the inductor will look like

(a) 

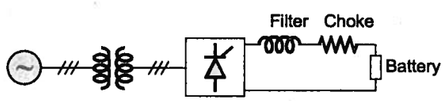
(b) 

(c) 

(d) 

[GATE-2009]

Q.8 A solar energy installation utilizes a three-phase bridge converter to feed energy into power system through a transformer of 400 V/400 V, as shown below.



The energy is collected in a bank of 400 V battery and is connected to converter through a large filter choke of resistance 10 Ω.
The maximum current through the battery will be
(a) 14 A (b) 40 A
(c) 80 A (d) 94 A

[GATE-2011]

Q.9 In the above question, the kVA rating of the input transformer is
(a) 53.2 kVA (b) 46.0 kVA
(c) 22.6 kVA (d) 19.6 kVA

[GATE-2011]

Q.10 The input voltage applied to the converter is

$$V = 100\sqrt{2}\sin(100\pi t)\ V$$

The current drawn by the converter is

$$i_i = \left[10\sqrt{2}\sin\left(100\pi t - \frac{\pi}{3}\right) + 5\sqrt{2}\sin\left(300\pi t + \frac{\pi}{4}\right) + 2\sqrt{2}\left(500\pi t - \frac{\pi}{6}\right)\right] A$$

The active power drawn by the converter is
(a) 181 W (b) 500 W
(c) 707 W (d) 887 W

Q.11 In the above question, the input power factor of the converter is
(a) 0.31 (b) 0.44
(c) 0.5 (d) 0.71

[GATE-2011]

Q.12 A 3 phase semi converter feeds the armature of a separately excited D.C. motor, supplying a non-zero torque. For steady state operation, the motor armature current is found to drop to zero at certain instances of time. At such instances, the output voltage assumes a value that is
(a) equal to the instantaneous value of the a.c. phase voltage
(b) equal to the instantaneous value of the motor back emf
(c) arbitrary
(d) zero

Q.13 The total harmonic distortion (THD) of a.c. supply input current of rectifiers is maximum for
(a) single phase diode rectifier with D.C. inductive filter.
(b) 3-phase diode rectifier with D.C. inductive filter.
(c) 3-phase thyristor rectifier with inductive filter.
(d) single phase diode rectifier with capacitive filter.

[ESE-2002]

Q.14 In a single-phase semiconverter with discontinuous conduction and extinction angle $\beta < \pi$, freewheeling action
(a) α (b) $\alpha - \beta$
(c) $\beta - \pi$ (d) zero

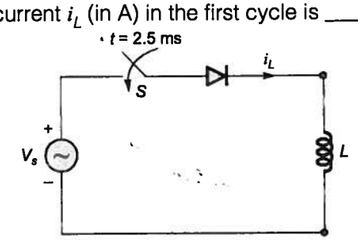
[ESE-2011]

Q.15 A 3-phase Semiconverter, for firing angle less than or equal to 60°, freewheeling diode conducts for
(a) 90° (b) 60°
(c) 30° (d) 0° **[ESE-2011]**

Q.16 In a single-phase semiconverter with resistive load and for a firing angle α, each SCR conduction and free-wheeling action take place respectively, for
(a) α, 0° (b) $\pi - \alpha$, α
(c) $\pi + \alpha$, α (d) $\pi - \alpha$, 0°

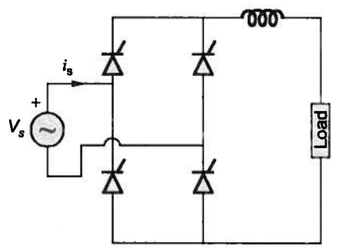
Numerical Data Type Questions

Q.17 A diode circuit feeds an ideal inductor as shown in the figure. Given V_s = 100 sin(ωt) V, where ω = 100π rad/s, and L = 31.83 mH. The initial value of inductor current is zero. Switch S is closed at t = 2.5 ms. The peak value of inductor current i_L (in A) in the first cycle is _____ .



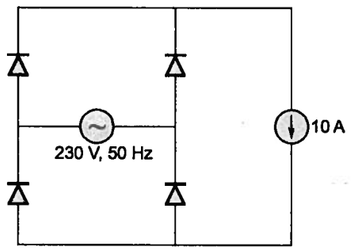
[GATE-2014]

Q.18 A fully controlled converter bridge feeds a highly inductive load with ripple free load current. The input supply (v_s) to the bridge is a sinusoidal source. Triggering angle of the bridge converter is $\alpha = 30°$. The input power factor of the bridge is _____ .



[GATE-2014]

Q.19 The figure shows the circuit of a rectifier fed from a 230 V (rms), 50 Hz sinusoidal voltage source. If we want to replace the current source with a resistor so that the rms value of the current supplied by the voltage source remains unchanged, the value of the resistance (in ohms) is _____. (Assume diodes to be ideal).

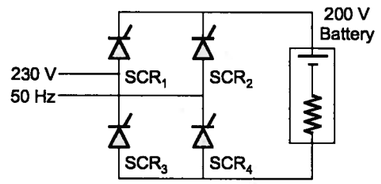


[GATE-2014]

Q.20 A solar cell of 350 V is feeding power to an ac supply of 440 V, 50 Hz through a 3-phase fully controlled bridge converter. A large inductance is connected in the dc circuit to maintain the dc current at 20 A. If the solar cell resistance is 0.5 Ω, then each thyristor will be reverse biased for a period of_____ (elec degrees).

[GATE-2006]

Q.21 A single-phase bridge converter is used to charge a battery of 200 V having an internal resistance of 2 Ω as shown in figure. The SCRs are triggered by a constant dc signal. If SCR 2 gets open circuited, the average charging current is _____ A.



[GATE-2006]

Q.22 A single-phase fully controlled thyristor bridge ac-dc converter is operating at a firing angle of 25°, overlap angle of 10° and a constant dc output current of 20 A. The fundamental power factor (displacement factor) at input ac mains is _____ . [GATE-2007]

Q.23 The time required to deliver a charge of 200 A hr through a single-phase half-wave diode rectifier with an output current of 100 A rms and with sinusoidal input voltage is_____ hours. Assume diode conduction over a half-cycle.

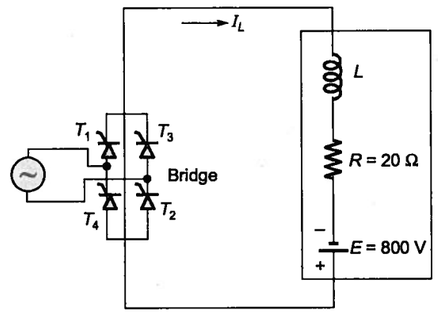
Q.24 A single-phase, 230 V, 50 Hz ac mains fed step down transformer (4 : 1) is supplying power to a half-wave uncontrolled ac-dc converter used for charging a battery (12 V dc) with the series limiting resistor being 19.04 Ω. The charging current is _____ A.

Q.25 A 3-ϕ dual converter, operating in the circulating current mode, has the following data:
per phase supply voltage = 230 V, f = 50 Hz,
$\alpha_1 = 60°$, current limiting reactor, L = 15 mH
The peak value of circulating current is ____ A.

Q.26 A three-phase diode bridge rectifier is feeding a constant DC current of 100 A to a highly inductive load. If three-phase, 415 V, 50 Hz AC source is supplying to this bridge rectifier then the rms value of the current in each diode, in ampere, is _____.

[GATE-2016]

Q.27 A full-bridge converter supplying an RLE load is shown in figure. The firing angle of the bridge converter is 120°. The supply voltage, $v_m(t) = 200\,\pi \sin(100\pi t)$ V, $R = 20\ \Omega$, $E = 800$ V. The inductor L is large enough to make the output current I_L a smooth dc current. Switches are lossless. The real power feedback to the source, in kW, is_____.



[GATE-2016]

Conventional Questions

Q.28 A 3-phase half wave rectifier is operated from a 3-phase 230 V, 50 Hz supply with load resistance $R = 10\ \Omega$. An average output voltage of 50% of the maximum possible output voltage is required. Determine:
(a) Firing angle
(b) Average and rms values of load current
(c) Rectification efficiency

Q.29 A 2 pulse converter feeds a constant, ripple free load current at all firing angles. At $\alpha = 0°$, $\mu_0 = 30°$. Determine μ at
(i) $\alpha = 30°$ (ii) $\alpha = 60°$

Q.30 A single-phase bridge converter feeds a highly inductive load of RLE, where $R = 1\ \Omega$, $E_g = 80$ V and L, B sufficiently large for perfect smoothening. The source voltage is 120 V at 50 Hz. The source inductance is 1 mH. For a firing angle of 110°, determine the overlap angle?

Q.31 The input voltage given to a converter and current drawn by converter are expresses as

$$V_i(t) = 300\sin(100\pi t) + 100\sin(300\pi t)$$

$$I_i(t) = 10\sin\left(100\pi t - \frac{\pi}{3}\right) + 5\sin\left(300\pi t + \frac{\pi}{4}\right) + 2\sin\left(500\pi t - \frac{\pi}{6}\right)$$

Find input power factor of the converter
(a) 0.44 lag (b) 0.6 lag
(c) 0.707 lag (d) 0.522 lag

Q.32 A line commulated inverter transfers energy into a 440 V, 50 Hz three-phase supply from a battery of 500 V. The battery is linked to the converter through a large filter choke of resistance 12.4 Ω.

It is desired to transfer 5 kW power into the system.
(*i*) Calculate the firing angle at which inverter is to be operated. Also, determine
  (a) input power factor,
  (b) RMS value of fundamental ac current,
  (c) Efficiency of energy transfer.
(*ii*) What is the maximum usable value of the SCR firing angle?
(*iii*) Calculate the SCR voltage and rms current rating.

[ESE-2014]

Try Yourself

T1. A 3-ϕ halfwave controlled converter is fed from 3 phase, 400 V, 50 Hz source and is connected to load taking a constant current of 36 A. Thyristor have a voltage drop of 1.4 V. The average power dissipated in each thyristor is,
(a) 15.2 W (b) 16.8 W
(c) 17.6 W (d) 18.4 W

[Ans: (b)]

T2. A single phase full converter, connected to 230 V, 50 Hz source, is feeding a load $R = 10\ \Omega$ in series with a large inductance that makes the load current ripple free. For a firing angle of 45° the reactive power input is

(a) 2001 VAr (b) 2143 VAr
(c) 2316 VAr (d) 2413 VAr

[Ans: (b)]

T3. In a single phase full wave diode bridge rectifier, the diodes have a reverse recovery time of 40 μs. For an ac input voltage of 230 V and f = 2500 Hz, the percentage reduction in average output voltage due to the effect of reverse recovery time is _____ %.

[Ans: (9.55)]

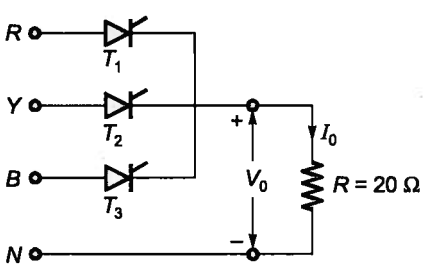
T4. In a 3-phase bridge rectifier fed from the star-connected secondary of a transformer, let the voltage to the neutral of the A-phase (phase sequence A, B, C) be $V_m \sin\omega t$. At the instant when the voltage of A-phase is maximum, the output voltage at the rectifier terminals will be

(a) $1.5\,V_m$ (b) $\sqrt{3}\,V_m$

(c) $\dfrac{V_m}{\sqrt{2}}$ (d) V_m

[Ans: (a)]

T5. A three-phase half-wave controlled rectifier circuit is shown in the figure. It is operated from 3-ϕ star-connected, supply transformer with a line to line ac supply voltage of 440 volts rms, at 50 Hz. The thyristor are triggered at a delay angle of α = 30°. Assume continuous ripple free current.



The average output current is

(a) 12.86 A (b) 14.24 A
(c) 15.12 A (d) 16.71 A

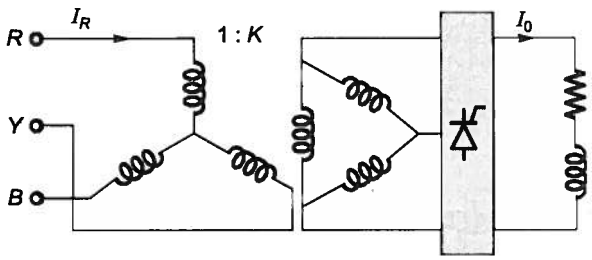
[Ans: (a)]

T6. A load of R = 60 Ω is fed from 1-phase, 230 V, 50 Hz supply through a step-up transformer and then one diode. The transformer turns ratio is two.

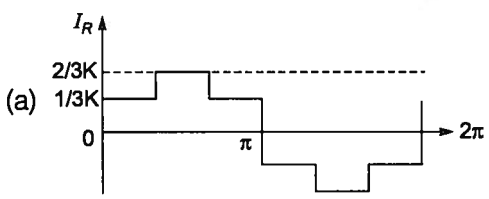
The VA rating of transformer will be _____ kVA. (TUF for 1 - ϕ half wave diode rectifier is 0.2865)

[Ans: (2.50)]

T7. A three-phase fully controlled bridge converter is fed through star-delta transformer as shown in the figure.



The converter is operated at a firing angle of 30°. Assuming the load current (I_0) to be virtually constant at 1 pu and transformer to be an ideal one, the input phase current waveform is

(a)


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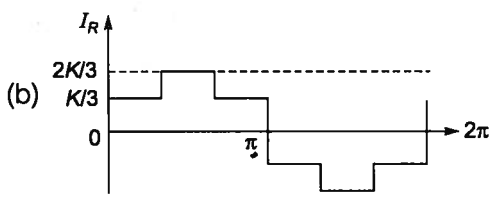

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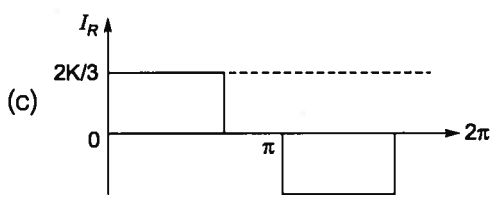

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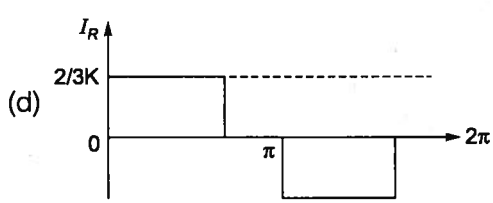

[Ans: (b)]