2017

MADE EASY
WORKBOOK

Measurement & Instrumentation + Power Electronics

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Measurement & Instrumentation
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1 Error Analysis & Basics

Multiple Choice Questions

1. Match **List-I** with **List-II** and select the correct answer:

List-I

A. Precision
B. Accuracy
C. Resolution
D. Sensitivity

List-II

1. The smallest change in the input quantity which can be detected with its certainty.
2. Closeness of the reading with its true value.
3. Measure of reproducibility of the reading
4. Ratio of infinitesimal change in output to infinitesimal change in input.

Codes:

	A	B	C	D
(a)	2	3	1	4
(b)	3	2	4	1
(c)	3	2	1	4
(d)	2	3	4	1

[ESE-2001]

2. A 0 to 200 V voltmeter has a guaranteed accuracy of 1% of full scale reading. The voltage measured by this instrument is 50 V. What is the limiting error?

(a) 4% (b) 2%
(c) 1% (d) 0.25%

[ESE-2002]

3. A 0-100 V voltmeter has an accuracy of 1 percent at full-scale reading. What will be the error if it reads 50 V?

(a) 1 percent (b) 2 percent
(c) 0.5 percent (d) 4 percent

[ESE-2011]

4. The measured value of a capacitor is 205.5 μF; whereas its true value is 202.4 μF. The relative error is

(a) 1.87% (b) 1.94%
(c) 1.53% (d) 1.73%

[ESE-2011]

5. A resistance of 108 Ω is specified using significant figures as indicated below:

1. 108 Ω
2. 108.0 Ω
3. 0.000108 MΩ

Among these:

(a) 1 represents greater precision than 2 and 3
(b) 2 represents greater precision but 1 and 3 represents same precision
(c) 2 and 3 represent greater precision than 1
(d) 1, 2 and 3 represent the same precision

[ESE-2011]

6. **Assertion (A):** Random errors can be minimized by statistical methods.
Reason (R): These are caused by arithmetic error while taking readings.

(a) Both A & R are true but R is the correct explanation of A
(b) Both A and R are true and R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true

[ESE-2009]

7. What are the causes of gross error in the instruments?

1. Misreading of instruments.
2. Incorrect adjustment of instruments.
3. Errors due to defective instrument.
4. Errors due to effect of environment on the instrument.

(a) 1 and 2 (b) 2 and 3
(c) 3 and 1 (d) 4 and 1

[ESE-2011]

8. Consider the following:
1. Human errors
2. Improper application of instruments
3. Error due to worn parts of an instrument
4. Errors due to effects of environment

Which of the above come under the type of systematic errors?
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

[ESE-2009]

9. A set of independent current measurements taken by four observers was recorded as: 117.02 mA, 117.11 mA, 117.08 mA and 117.03 mA. What is the range of error ?
(a) ± 0.045 (b) ± 0.054
(c) ± 0.065 (d) ± 0.056

[ESE-2005]

10. A variable w is related to three other variables x, y, z as $w = xy/z$. The variables are measured with meters of accuracy ± 0.5% reading, ± 1% of full scale value and ± 1.5% reading. The actual readings of the three meters are 80, 20 and 50 with 100 being the full scale value for all three. The maximum percentage limiting error in the measurement of w will be
(a) ± 0.5% rdg (b) ± 5.5% rdg
(c) ± 6.7% rdg (d) ± 7.0% rdg

[GATE-2006]

11. A resistor R is measured using the V-I method, with V reads as 10.14 V and I as 5.07 mA. Which one of the following expresses the value of resistance?
(a) 2 kΩ (b) 2.00 kΩ
(c) 2000 Ω (d) 2.0 kΩ

[ESE-2004]

12. A resistance is measured by the voltmeter-ammeter method employing d.c. excitation and a voltmeter of very high resistance connected directly across the unknown resistance. If the voltmeter and ammeter readings are subject to maximum possible errors of ±2.4% and ±1.0% respectively, then the magnitude of the maximum possible percentage error in the value of resistance deduced from the measurement is nearly
(a) 1.4% (b) 1.7%
(c) 2.4% (d) 3.4%

[GATE-1992]

Numerical Data Type Questions

13. Two resistances with limiting values are; $R_1 = 10\ \Omega \pm 5\%$ and $R_2 = 15\ \Omega \pm 3\%$. $x\Omega \pm y\%$ is the limiting value of equivalent resistance if connected in parallel then $x + y$ is _____ .

14. Two equal resistances, each of 100 Ω ± 1% (standard deviation) are connected in parallel. The standard deviation of the parallel combination will be _____ .

[IAS-2002]

Conventional Questions

15. During the measurement of a capacitor, following ten readings were obtained:
10.03, 10.11, 10.12, 10.08
Calculate:
(i) the arithmetic mean
(ii) the deviation from the mean,
(iii) average deviation and
(iv) standard deviation

[ESE-2005]

Try Yourself

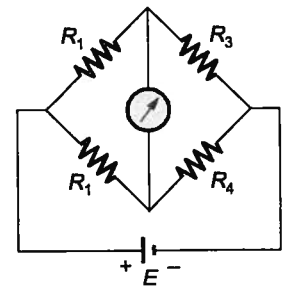
T1. The total current $I = I_1 + I_2$ in a circuit is measured as I_1 = 150 ± 1A, I_2 = 150 ± 2A, where the limits of error are given as standard deviations. I is measured as
(a) (300 ± 1.24) A (b) (300 ± 1.73) A
(c) (300 ± 2) A (d) (300 ± 2.24) A

[Ans: (d)]

T2. The measurement of a quantity
(a) is an act of comparism of an unknown quantity with another quantity.
(b) is an act of comparison of an unknown quantity with a known quantity whose accuracy may be known or may not be known.
(c) is an act of comparison of an unknown quantity with a predefined acceptable standard which is accurately known.
(d) none of the above

[Ans: (c)]

T3. In the following wheastone bridge are resistances are given:
$R_1 = 250 \pm 5\%$, $R_2 = 500 \pm 5\%$
$R_3 = 200 \pm 5\%$
Find R_4.



T4. Three resistances are given as:
$R_1 = 37 \pm 2\%$, $R_2 = 50 \pm 2\%$, $R_3 = 75 \pm 2\%$, when these are connected in series find the equivalent resistance.

2 Indicating Instruments

Multiple Choice Questions

1. An indicating instrument is more sensitive if its torque to weight ratio is
   (a) much larger than unity
   (b) of the order of unity
   (c) much less than unity
   (d) made deflection dependent
   [ESE-1998]

2. A 0-10 mA PMMC ammeter reads 4 mA in a circuit. Its bottom control spring snaps suddenly. The meter will now read nearly
   (a) 10 mA (b) 8 mA
   (c) 2 mA (d) Zero
   [GATE-1994]

3. A moving coil of a meter has 100 turns, and a length and depth of 10 mm and 20 mm respectively. It is positioned in a uniform radial flux density of 200 mT. The coil carries a current of 50 mA. The torque on the coil is
   (a) 200 μNm (b) 100 μNm
   (c) 2 μNm (d) 1 μNm
   [GATE-2004]

4. A sinusoidal voltage of 1 V r.m.s value at 10 Hz is applied across the two terminals of a PMMC type of voltmeter. What is the deflection of the pointer?
   (a) Zero volt
   (b) 1 volt
   (c) $\sqrt{2}$ volts
   (d) The pointer oscillates around zero volt
   [ESE-2006]

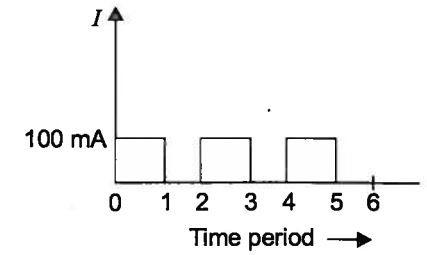
5. A PMMC voltmeter is connected across a series combination of a DC voltage source $V_1 = 2$ V and and AC voltage source $V_2(t) = 3 \sin(4t)$ V. The meter reads
   (a) 2 V (b) 5 V
   (c) $\left(2+\sqrt{3}/2\right)$V (d) $\left(\sqrt{17}/2\right)$V
   [GATE-2005]

6. A current $i = 5 + 14.14 \sin(314t + 45°)$ is passed through a centre-zero PMMC, hot-wire, and moving iron instrument, the respective readings are
   (a) –5, 15 and $\sqrt{125}$ (b) 5, $\sqrt{125}$ and $\sqrt{125}$
   (c) –5, $\sqrt{125}$ and 19.14 (d) 5, 10 and 10
   [ESE-2013]

7. A full wave rectifier is used to measure an alternating square wave of amplitude 100V.The meter reading is
   (a) 70.7 V (b) 111 V
   (c) 100 V (d) None of these

8. A current of $-8 + 6\sqrt{2}$ $(\sin \omega t + 30°)$ A is passed through three meters. They are a centre zero PMMC meter, a true rms meter and a moving iron instrument. The respective readings (in A) will be
   (a) 8, 6, 10 (b) 8, 6, 8
   (c) –8, 10, 10 (d) –8, 2, 2
   [GATE-2006]

9. A waveform shown in the figure below, is fed to a a.c. ammeter. What is the reading shown by the meter?

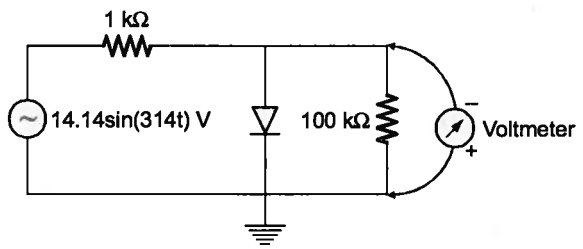


(a) zero (b) 50 mA
(c) $\frac{100}{\sqrt{2}}$ mA (d) 100 mA
[ESE-2008]

10. A symmetrical square wave voltage is applied to an average reading a.c voltmeter with scale calibrated in terms of rms value of a sinusoidal wave. The %error is
    (a) – 11% (b) 11%
    (c) – 3.9% (d) –10%

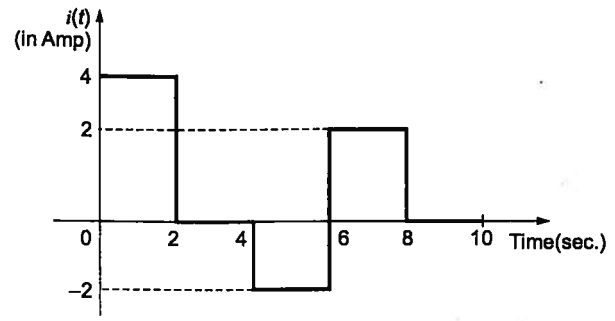
11. A saw tooth voltage has a peak value of 50 V and a time period of 3 sec , the percentage error when measuring this voltage with an average reading voltmeter calibrated in terms of rms value of a sinusoidal wave is
    (a) –4.05% (b) 4.05%
    (c) 10% (d) –3.9 %

12. The input impedance of the permanent magnet moving coil (PMMC) voltmeter is infinite. Assuming that the diode shown in the figure below is ideal, the reading of the voltmeter in Volts is



(a) 4.46 (b) 3.15
(c) 2.23 (d) 0
[GATE-2013]

13. The periodic voltage waveform is shown in figure below is applied to a true rms meter, Determine the reading of instrument.



(a) $\sqrt{2}$ V (b) $\sqrt{5.8}$ V
(c) $\sqrt{3}$ V (d) $3\sqrt{3}$ V

14. In a PMMC instrument, the central spring stiffness and the strength of the magnet decrease by 0.04% and 0.02% respectively due to a rise in temperature by 1°C. With a rise in temperature of 10° C, the instrument reading will
    (a) increase by 0.2%
    (b) decrease by 0.2%
    (c) increase by 0.6%
    (d) decrease by 0.6%
    [ESE-1999]

15. A Manganin swamp resistance is connected in series with a moving coil ammeter consisting of a milli-ammeter and a suitable shunt in order to
    (a) minimise the effect of temperature variation
    (b) obtain large deflecting torque
    (c) reduce the size of the meter
    (d) minimise the effect of stray magnetic fields
    [GATE-2003]

16. **Assertion (A):** A PMMC instrument is used for reading both d.c. and a.c. signals.
    Reason (R): The deflecting torque in a PMMC instrument is directly proportional to the current in the moving coil.
    (a) Both A & R are true but R is the correct explanation of A
    (b) Both A and R are true and R is NOT the correct explanation of A
    (c) A is true but R is false
    (d) A is false but R is true
    [ESE-2008]

17. **Assertion (A):** The PMMC type of indicating instruments are always critically damped.
Reason (R): A critically damped system directly moves to its steady state without oscillation.
(a) Both A & R are true but R is the correct explanation of A
(b) Both A and R are true and R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
[ESE-2005]

18. Two meters *X* and *Y* require 40 mA and 50 mA, respectively, to give full-scale deflection, then
(a) sensitivity can not be judged with given information
(b) both are equally sensitive
(c) *X* is more sensitive
(d) *Y* is more sensitive
[ESE-2002]

19. Torque/Weight ratio of an instrument indicates
(a) Selectivity (b) Accuracy
(c) Fidelity (d) Sensitivity
[ESE-2003]

20. Which one of the following decides the time of response of an indicating instrument ?
(a) Deflecting system
(b) Controlling system
(c) Damping system
(d) Pivot and Jewel bearing
[ESE-2004]

21. Due to which one of the following reasons bearings of PMMC Instrument are made of Jewel?
(a) To avoid wear and tear of the moving system
(b) To provide a small support
(c) It can be easily replaced
(d) To make the system robust
[ESE-2008]

22. Three d.c. voltmeters are connected in series across a 120 V d.c. supply. The voltmeters are specified as follows:
Voltmeter A : 100 V, 5 mA
Voltmeter B : 100 V, 250 ohms/V
Voltmeter C : 10 mA, 15,000 ohms
The voltages read by the meters A, B and C are respectively
(a) 40, 50 and 30 V (b) 40, 40 and 40 V
(c) 60, 30 and 30 V (d) 30, 60 and 30 V
[ESE-2003]

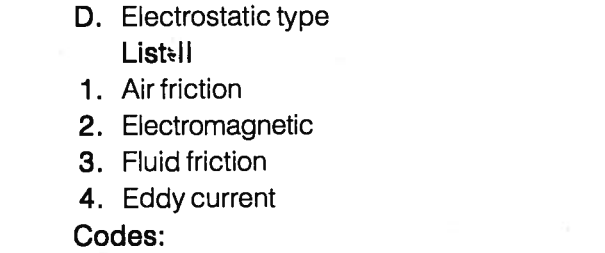
23. The sensitivity of 200 μA meter movement when it is used as a dc voltmeter is given by
(a) 500 Ω/mV (b) 5 Ω/V
(c) 0.5 Ω/mV (d) 5 Ω/mV
[ESE-2010]

24. A basic D'Arsonval movement with a full scale deflection of 50 μA and internal resistance of 500 Ω is used as voltmeter. The value of the multiplier resistance needed to employ this meter to measure a voltage range of (0 – 10) V is given by
(a) 100 kΩ (b) 500 kΩ
(c) 199.5 kΩ (d) 2×10^5 kΩ
[ESE-2010]

25. The value of a shunt resistance required to convert an ammeter of 1 mA with 100 Ω internal resistance into 0-100 mA ammeter is
(a) 2.2 Ω (b) 1.01 Ω
(c) 1.2 Ω (d) 1.1 Ω
[ESE-2011]

26. An ac voltmeter using full-wave rectification and having a sinusoidal input has an ac sensitivity equal to
(a) 1.414 times dc sensitivity
(b) dc sensitivity
(c) 0.90 times dc sensitivity
(d) 0.707 times dc sensitivity
[ESE-2001]

27. A rectifier type ac voltmeter consists of a series resistance R_s, an ideal full-wave rectifier bridge and a PMMC instrument as shown in figure. The internal resistance of the instrument is 100 Ω and a full scale deflection is produced by a dc current of 1 mA. The value of R_s required to obtain full scale deflection with an ac voltage of 100 V (rms) applied to the input terminals is



(a) 63.56 Ω (b) 69.93 Ω
(c) 89.93 kΩ (d) 141.3 kΩ
[GATE-2003]

28. A 100 kV, 50 Hz supply is fed to a rectifier ammeter (using a bridge rectifier) through a capacitor. The PMMC ammeter of the rectifier instrument reads 45×10^{-3} Amp. What is the value of the capacitor?
(a) 15.90×10^{-10} F (b) 15.90×10^{-12} F
(c) 17.66×10^{-9} F (d) 17.66×10^{-11} F
[ESE-2009]

29. Match **List-I** (Meters) with **List-II** (Damping) and select the correct answer using the code given below the lists:
List-I
A. Moving iron and hot wire type
B. Galvanometer
C. PMMC type
D. Electrostatic type
List-II
1. Air friction
2. Electromagnetic
3. Fluid friction
4. Eddy current
Codes:

	A	B	C	D
(a)	1	4	2	3
(b)	3	4	2	1
(c)	1	2	4	3
(d)	3	1	2	4

[ESE-2011]

30. The effect of stray magnetic fields on the actuating torque of a portable instrument is maximum when the operating field of the instrument and the stray fields are
(a) perpendicular (b) parallel
(c) inclined at 60° (d) inclined at 30°
[GATE-2003]

31. The inductance of a certain moving-iron ammeter is expressed as $L = 10 + 3\theta - (\theta^2/4)$ μH, where θ is the deflection in radians from the zero position. The control spring constant is 25×10^{-6} Nm/rad. The deflection of the pointer in radian when the meter carries a current of 5 A, is
(a) 2.4 (b) 2.0
(c) 1.2 (d) 1.0
[GATE-2003]

32. Consider the following statements about hot-wire instruments:
1. They read equally well on dc and/or ac circuits.
2. They are simple and robust in construction and power consumption is low.
3. They are quite suitable for measurement of currents at very high frequencies.
Which of these statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2, 3 and 4
[ESE-2010]

33. **Assertion (A) :** A thermocouple type of indicating instrument measures the true rms value of the current that passes through it.
Reason (R) : It uses a PMMC type of indicating instrument to measure the current.
(a) Both A and R are true but R is the correct explanation of A
(b) Both A and R are true and R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
[ESE-2010]

34. Match **List-I (Property)** with **List-II (Type of the Instrument)** and select the correct answer using the code given below the lists:
List-I
A. Linear scale
B. True r.m.s. up to RF range
C. R.m.s. only for sinusoidal input
D. Reads r.m.s. value using square law scale

List-II
1. Thermocouple type
2. Rectifier type
3. Moving iron type
4. Permanent magnet moving coil type

Codes:

	A	B	C	D
(a)	1	4	3	2
(b)	4	1	2	3
(c)	4	1	3	2
(d)	1	4	2	3

[ESE-2007]

35. Which one of the following statements is correct?
The deflection of hot wire instrument depends on
(a) rms value of the a.c. current
(b) rms value of the a.c. voltage
(c) average value of the a.c. current
(d) average value of the a.c. voltage
[ESE-2004]

36. The mutual impedance of a 25 A EDM type ammeter changes uniformly at a rate of 0.035 μH/degree. The spring constant is 1×10^{-6} Nm/degree. Find the angle of deflection at full scale is
(a) 2.18° (b) 25°
(c) 75° (d) 125°

Numerical Data Type Questions

37. The dc current flowing through a circuit is measured by two ammeters, one PMMC and another electrodynamometer type, connected in series. The PMMC meter contains 100 turns in the coil, the flux density in the air gap is 0.2 Wb/m^2, and the area of this coil is 80 mm^2. The electrodynamometer ammeter has a change in mutual inductance with respect to deflection of 0.5 mH/deg. The spring constants of both the meters are equal. The value of current, at which the deflections of the two meters are same, is ____.
[GATE-2014]

38. A rectifier type of instruments uses a basic PMMC movement of 50 μA and a resistance of 1000 Ω. It employs a full wave rectifier circuit with forward resistance of each diode being 1000 Ω. The reverse resistance of the diodes is infinite. The range of the instruments is 0 - 10 V ac sinusoidal. _____ kΩ is the series multiplier.

39. The mutual inductance of EDM ammeter varies is with deflection θ express in degrees. $M = -8\cos(\theta + 60°)$ mH the deflecting torque produced by a current of 25 mA corresponding to 30° deflection is _____ .

40. A dc voltage with ripple is given by
$v(t) = [100 + 10\sin(\omega t) - 5\sin(3\omega)\, t)]$ volts
Measurements of this voltage $v(t)$, made by moving-coil and moving-iron voltmeters, show readings of V_1 and V_2 respectively. The value of $V_2 - V_1$, in volts, is _____.

Conventional Questions

41. Derive the general torque equation for the moving Iron instrument. The inductance of a Moving Iron ammeter is given by the following expression:
$L = (30 + 10\theta - 2\theta^2)$ μH, where θ is the deflection in radians . The control spring constant is 25 x 10^{-6} N-m/rad. Calculate the value of deflection for a current of 5 A .
[ESE-2010]

42. A moving coil ammeter has a fixed shunt of 0.02 Ω with a coil circuit resistance of $R = 1$ kΩ and needs potential difference of 0.5 V across it for full scale deflection.
(i) Calculate the current it corresponds to
(ii) Find the value of shunt when the total current is 10 A.
[ESE-2009]

Try Yourself

T1. A half wave rectifier type instrument 0 – 1 volt is to be used for the voltage range of 0 to 10 volt. _____ kΩ is the value of multiplier resistance, if full-scale deflection is 1 mA. Neglecting diode resistance i.e. ($r_d = 0$).
[Ans: 3.5]

T2. The current passing through a 10 ohm resistor in figure-1, has the waveform shown in figure-2. The reading of the MI voltmeter connected across the resistor is

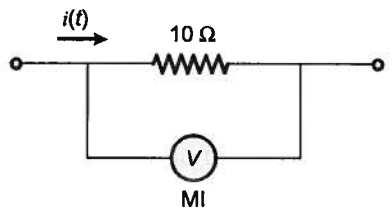


Figure-1

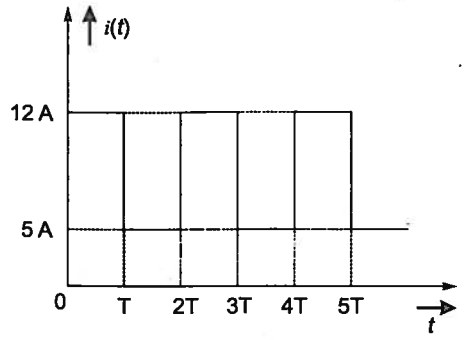


Figure-2

(a) 0 V (b) 75 V
(c) 85 V (d) 92 V
[Ans: (d)]

T3. The range of 2 kV electrostatic voltmeter is need to be extended to 20 kV. The voltmeter capacitance is 0.5 pF The additional capacitor is connected for this purpose is _____ pF with series to meter.
[Ans: (0.05) (0.04-0.06)]

3 Measurement of Power & Energy

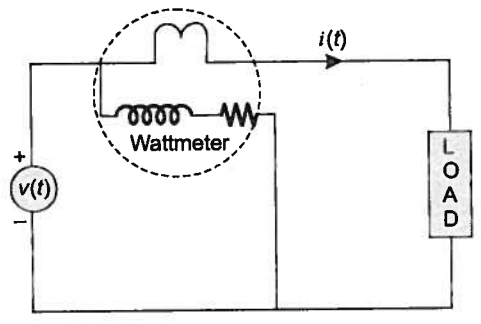
Multiple Choice Questions

1. For the circuit shown in the figure, the voltage and current expressions are

$$v(t) = E_1 \sin(\omega t) + E_3 \sin(3\omega t)$$

and $$i(t) = I_1 \sin(\omega t - \phi_1) + I_3 \sin(3\omega t - \phi_3) + I_5 \sin(5\omega t)$$

The average power measured by the wattmeter is



(a) $\frac{1}{2} E_1 I_1 \cos\phi_1$

(b) $\frac{1}{2}[E_1 I_1 \cos\phi_1 + E_1 I_3 \cos\phi_3 + E_1 I_5]$

(c) $\frac{1}{2}[E_1 I_1 \cos\phi_1 + E_3 I_3 \cos\phi_3]$

(d) $\frac{1}{2}[E_1 I_1 \cos\phi_1 + E_3 I_1 \cos\phi_1]$

[GATE-2012]

2. The pressure coil of a dynamometer type wattmeter is
(a) highly inductive (b) highly resistive
(c) purely resistive (d) purely inductive
[GATE-2009]

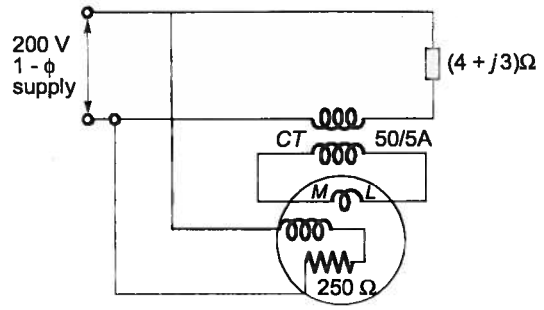
3. Two wattmeters, which are connected to measure the total power on a three-phase system supplying a balanced load, read 10.5 kW and –2.5 kW, respectively. The total power and the power factor, respectively, are
(a) 13.0 kW, 0.334 (b) 13.0 kW, 0.684
(c) 8.0 kW, 0.52 (d) 8.0 kW, 0.334
[GATE-2005]

4. In the measurement of power on balanced load by two-wattmeter method in a 3-phase circuit, the readings of the Watt meters are 3 kW and 1 kW respectively, the latter being obtained after reversing the connections to the current coil. The power factor of the load is
(a) 0.554 (b) 0.377
(c) 0.277 (d) 0.866
[ESE-2002]

5. Consider the following statements regarding measurement of 3-phase power by two-wattmeter method; one of the wattmeter reads negative implying:
1. Power factor is less than 0.5.
2. Power flow is in the reverse direction.
3. Load power factor angle is greater than 60°.
4. Load is unbalanced.
Which of the above statements are correct?
(a) 1 and 2 only (b) 2 and 3 only
(c) 1 and 3 only (d) 1, 2, 3 and 4
[ESE-2010]

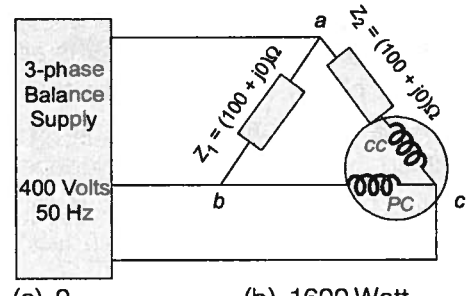
6. The current and potential coils of a dynamometer type wattmeter were accidentally interchanged while connecting. After energizing the circuit, it was observed that the wattmeter did not show the reading. This could be due to the
(a) Damage to potential coil
(b) Damage to current coil
(c) Damage to both the potential and current coil
(d) Loose contacts
[ESE-2011]

7. In the circuit shown in the given figure, the wattmeter reading will be



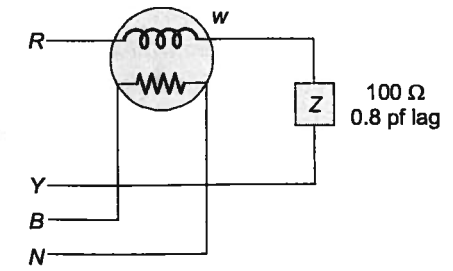
(a) 480 W (b) 640 W
(c) 800 W (d) 1000 W
[ESE-1999]

8. The figure shows a three-phase delta connected load supplied from a 400V, 50 Hz, 3-phase balanced source. The pressure coil (PC) and current coil (CC) of a wattmeter are connected to the load as shown, with the coil polarities suitably selected to ensure a positive deflection. The wattmeter reading will be



(a) 0 (b) 1600 Watt
(c) 800 Watt (d) 400 Watt
[GATE-2009]

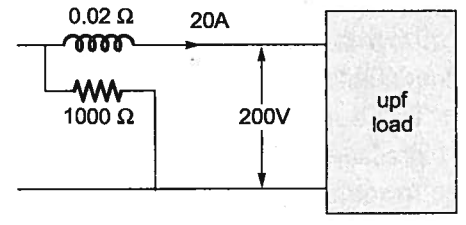
9. A single-phase load is connected between R and Y terminals of a 415 V, symmetrical, 3-phase, 4 wire system with phase sequence RYB. A wattmeter is connected in the system as shown in figure. The power factor of the load is 0.8 lagging. The wattmeter will read



(a) –795 W (b) –597 W
(c) +597 W (d) +795 W
[GATE-2004]

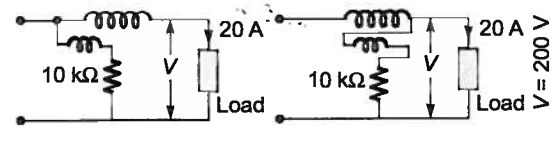
10. A wattmeter reads 400 W when its current coil is connected in the R phase and its pressure coil is connected between this phase and the neutral of a symmetrical 3-phase system supplying a balanced star connected 0.8 p.f. inductive load. Ths phase sequence is RYB. What will be the reading of this wattmeter if its pressure coil alone is reconnected between the B and Y phases, all other connections remaining as before?
(a) 400.0 (b) 519.6
(c) 300.0 (d) 692.8
[GATE-2003]

11. The circuit in figure is used to measure the power consumed by the load. The current coil and the voltage coil of the wattmeter have 0.02 Ω and 1000 Ω resistances respectively. The measured power compared to the load power will be



(a) 0.4% less (b) 0.2% less
(c) 0.2% more (d) 0.4% more
[GATE-2004]

12. Two types of connections of Wattmeter pressure coil are shown in the figures.



The value of the Wattmeter current coil resistance *r*, which makes the connection errors the same in the two cases is
(a) 0.05 Ω (b) 0.1 Ω
(c) 0.01 Ω (d) 0.125 Ω
[ESE-2002]

13. **Assertion (A):** General purpose dynamometer type Wattmeter cannot indicate the correct value of power at low power factors.
Reason (R): The presence of self-inductance in the pressure coil circuit introduces an error in the indicated value which increases appreciably with decrease in power factor.
(a) Both A and R are true but R is the correct explanation of A.
(b) Both A and R are true and R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false but R is true.
[ESE-2006]

14. Due to the effect of inductance in the pressure coil, a dynamometer type wattmeter
(a) Reads low on lagging power factor and high on leading power factor
(b) Reads high on lagging power factor and low on leading power factor
(c) Reading is independent of the power factor
(d) Always reads lower than actual value
[ESE-2011]

15. In a low power factor wattmeter, why is a compensating coil employed?
(a) To neutralize the capacitive effect of pressure coil
(b) To compensate for inductance of pressure coil
(c) To compensate for the error caused by power loss in the pressure coil
(d) To compensate for the error caused by eddy currents
[ESE-2007]

16. The magnetic field responsible for the production of the deflecting torque in an accurate dynamometer type wattmeter, being very weak, the accuracy of the measurement can be increased by providing a
(a) Magnetic shield around the instrument
(b) Compensating winding along with the pressure coil
(c) Astatic arrangement to the moving system of the instrument
(d) Capacitance shunt across a portion of the pressure coil
[ESE-2011]

Energy Meter

17. The pressure coil of energy meter is
(a) highly capacitive (b) highly Resistive
(c) highly Inductive (d) purely Inductive

18. Consider the following statements associated with an energy meter:
1. It is an integrating type instrument.
2. It is an induction type instrument.
3. It uses a permanent magnet for rotation of aluminium disc.
4. It employs a high control torque.
Which of these statements are correct?
(a) 1, 2, 3 and 4 (b) 1 and 2 only
(c) 2 and 3 only (d) 3 and 4 only
[ESE-2011]

19. The voltage-flux adjustment of a certain 1-phase 220 V induction watt-hour meter is altered so that the phase angle between the applied voltage and the flux due to it is 85° (instead of 90°). The errors introduced in the reading of this meter when the current is 5 A at power factors of unity and 0.5 lagging are respectively
(a) 3.8 mW, 77.4 mW
(b) –3.8 mW, –77.4 mW
(c) –4.2 W, –85.1 W
(d) 4.2 W, 85.1 W
[GATE-2003]

20. A 230 V, 10 A single-phase energy meter makes 90 revolutions in 3 minutes at half load rated voltage and unity pf. If the meter constant is 1800 revolutions/k Wh, then is error at half load will be
(a) 13.04% slow (b) 13.04% fast
(c) 15% slow (d) 15% fast
[ESE-1997]

21. Which one of the following is the main cause of creeping in the induction type energy meters?
(a) Friction compensation
(b) Lag/Lead compensation
(c) Overload compensation
(d) Braking torque producing system
[ESE-2007]

22. In a single phase induction type energy meter, the lag adjustment is done to ensure that
(a) Current coil flux lags the applied voltage by 90°
(b) Pressure coil flux lags the applied voltage by 90°
(c) Pressure coil flux in phase with applied voltage
(d) Current coil flux lags the pressure coil flux by 90° [IES -2000]

23. If an induction type energy meter runs fast, it can be slowed down by
(a) lag adjustment
(b) light load adjustment
(c) adjusting the position of braking magnet and moving it closer to the centre of the disc
(d) adjusting the position of braking magnet and moving it away from the centre of the disc
[ESE-2001]

24. The disc of a house service energy meter of 230 V, 1-ϕ, 50 Hz, 5 A, 2400 rev. per kWh creeps at 1 rev. per min. The creep error (in per cent) of full load unity pf is
(a) $+\frac{60}{2400} \times 100$
(b) $-\frac{60}{2400} \times 100$
(c) $+\frac{60}{1.15 \times 2400} \times 100$
(d) $-\frac{60}{1.15 \times 2400} \times 100$
[ESE-1999]

25. For testing of energy meter, phantom loading arrangement is used because
(a) the arrangement gives accurate results
(b) the power consumed in calibration work is minimum
(c) the method gives quick results
(d) the onsite calibration is possible
[ESE-2002]

26. The energy meter connected to an immersion heater (resistive) operating on an 230V, 50 Hz, AC single phase source reads 2.3 units (kWh) in 1 hour. The heater is removed from the supply and now connected to a 400 V peak to peak square wave source of 150 Hz. The power in kW dissipated by the heater will be
(a) 3.478 (b) 1.739
(c) 1.54 (d) 0.87
[GATE-2006]

27. For controlling the vibration of the disc of ac energy meter, damping torque produced by
(a) Eddy current
(b) Chemical effect
(c) Electrostatic effect
(d) magnetic effect
[ESE-2014]

Numerical Data Type Questions

28. An LPF wattmeter of power factor 0.2 is having three voltage settings 300 V, 150 V and 75 V, and two current settings 5 A and 10 A. The full scale reading is 150. If the wattmeter is used with 150 V voltage setting and 10 A current setting, the multiplying factor of the wattmeter is _____.
[GATE-2014]

29. An electrodynamic wattmeter is employed to measure power in a single phase circuit the load voltage is 220 V and the load current is 4 A, at a lagging power factor of 0.1. The wattmeter potential coil has a resistance of 10,000 Ω and an inductive reactance negligible compared to

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resistance. _____ percentage error will be in the wattmeter reading. When inductance of coil is 100 mH and pressure coil is connected on load side.

30. An energy meter, having meter constant of 1200 revolutions/kWh, makes 20 revolutions in 30 sec for a constant load. The load, in kW, is_____.

31. The voltage (V) and current (A) across a load are as follows.
$V(t) = 100 \sin(\omega t)$
$i(t) = 10 \sin(\omega t - 60°) + 2\sin(3\omega t) + 5 \sin(5\omega t)$
The average power consumed by the load, in W, is_____.

Conventional Questions

32. The inductive reactance of the pressure coil circuit of a dynamometer wattmeter is 0.4 % of its resistance at normal frequency (50 Hz) and the capacitance is negligible. Calculate the percentage error and correction factor due to the reactance for load at 0.707 p.f lagging.
[ESE-2010]

33. Prove that for electrodynamometer type of wattmeters:

$$\text{True power} = \frac{\cos\phi}{\cos\beta\cos(\phi-\beta)} \times \text{actual wattmeter reading}$$

Where ϕ = Power factor of the circuit

$$\beta = \tan^{-1}\frac{\omega L}{R}$$

where L and R are the inductance and resistance of the pressure coil.
Explain why errors are large when power factor is low. **[ESE-2007]**

34. Derive the expression for reading of a wattmeter having pressure coil inductance.

35. Explain, how a dynamometer-type wattmeter can be used to measure power in a circuit having low power factor?
[ESE-2004]

36. Sketch the circuit diagram for power measurement in a 3-phase circuit using two wattmeters and show that total power is given by the algebraic sum of the wattmeters readings using vector diagrams.
[ESE-2003]

Try Yourself

Linked Questions (T1 and T2):
The power flowing in a 3-ϕ, 3 wire balanced load system is measured by the two wattmeter method. The reading of wattmeter A is 500 watts and wattmeter B is –100 watts.

T1. The power factor of the system is
(a) 0.86 (b) 0.707
(c) 0.56 (d) 0.359
[Ans. (d)]

T2. If the voltage of the circuit is 440 volts. The value of capacitive reactance which must be introduced into each phase to cause the whole of the power measured to appear on wattmeter A is
(a) 44.13 Ω (b) 48.13 Ω
(c) 54.13 Ω (d) 60.13 Ω
[Ans. (c)]

T3. In a circuit of a single phase induction energy meter, the pressure coil lags the voltage by 88°, the errors while measuring power in two circuits having power factors of unity and 0.5 lagging are respectively.
(a) –0.061%, +6.1% (b) +0.061%, –6.1%
(c) –0.061%, –6.1% (d) –6.1%, –6.1%
[Ans. (c)]

4 Power Factor Meter, Potentiometer, Flux Meter, Instrumentation Transformers

Multiple Choice Questions

1. Which of the following statements are correct in case of a power factor meter?
1. The deflection is proportional to the phase angle between field coil and crossed coil.
2. The restoring torque is provided by a controlling torque.
3. It consists of two coils mounted at right angles to each other.
Select the correct answer using the code given below:
(a) 1 and 2 (b) 2 and 3
(c) 1 and 3 (d) 1, 2 and 3
[ESE-2007]

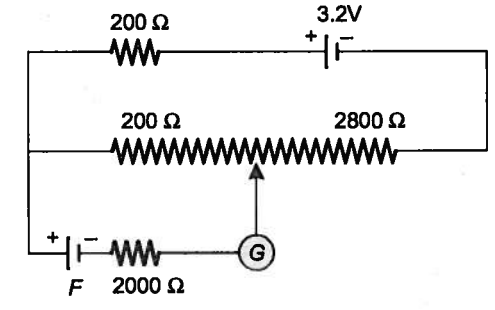
2. Which one of the following is used for the measurement of 3-phase power factor?
(a) Power factor meter
(b) Crossed-coil power factor meter
(c) Phase-angle watt hour meter
(d) Polarised-vane power factor meter
[ESE-2008]

3. A dc potentiometer is designed to measure up to about 2 V with a slide wire of 800 mm. A standard cell of emf 1.18 V obtains balance at 600 mm. A test cell is seen to obtain balance at 680 mm. The emf of the test cell is
(a) 1.00 V (b) 1.34 V
(c) 1.50 V (d) 1.70 V
[GATE-2004]

4. A single slide wire is used for the measurement of current in a circuit. The voltage drop across a standard resistance of 1.0 Ω is balanced at 70 cm. What is the magnitude of the current, if the standard cell having an e.m.f of 1.45 volts is balanced at 50 cm?
(a) 3.09 A (b) 2.65 A
(c) 2.03 A (d) 1.45 A
[ESE-2006]

5. Which one of the following instruments is used for standardization of a Drysdale a.c. potentiometer?
(a) Rectifier type ammeter
(b) PMMC ammeter
(c) Precision type electrodynamometer ammeter
(d) Thermocouple ammeter
[ESE-2007]

6. In the potentiometer circuit shown in the given figure, the value of unknown voltage 'E' under balanced condition will be



(a) 2.8 V (b) 200 mV
(c) 3 V (d) 3.2 V

7. Flux meter is a special type of ballistic galvanometer provided with which one of the following?
(a) Heavy electromagnetic damping and very small controlling torque.

(b) Heavy electromagnetic damping and very large controlling torque.
(c) Small electromagnetic damping and small controlling torque.
(d) Large controlling torque and small electromagnetic damping.

[ESE-2007]

8. What is the number of turns of wire needed to provide a potentiometer with a resolution of 0.05 percent?
(a) 200 turns (b) 2000 turns
(c) 20 turns (d) 20000 turns

[ESE-2014]

Instrumentation Transformer

9. A 500A/5A, 50 Hz current transformer has a bar primary. The secondary burden is a pure resistance of 1 Ω and it draws a current of 5 A. If the magnetic core requires 250 AT for magnetization, the percentage ratio error is
(a) 10.56 (b) –10.56
(c) 11.80 (d) –11.80

[GATE-2003]

10. A 50 Hz, bar primary CT has a secondary with 500 turns. The secondary supplies 5 A current into a purely resistive burden of 1 Ω. The magnetizing ampere-turns is 200. The phase angle between the primary and secondary current is
(a) 4.6° (b) 85.4°
(c) 94.6° (d) 175.4°

[GATE-2004]

11. A 200/1 Current transformer (CT) is wound with 200 turns on the secondary on a toroidal core. When it carries a current of 160 A on the primary, the ratio and phase errors of the CT are found to be –0.5% and 30 minutes respectively. If the number of secondary turns is reduced by 1 the new ratio error (%) and phase error (min) will be respectively
(a) 0.0, 30 (b) –0.5, 35
(c) –1.0, 30 (d) –1.0, 25

[GATE-2006]

12. Consider the following statements:
A current transformer is used for measurement of large currents to
1. isolate the instrument from a high voltage bus bar.
2. increase the accuracy of measurement.
3. decrease the cost of measuring arrangements.
4. extend the range of measurement of a conventional ammeter on a.c.

Which of these statements are correct?
(a) 1 and 2 (b) 2 and 3
(c) 3 and 4 (d) 1 and 4

[ESE-1999]

13. The ratio and phase angle errors in a well designed current transformer (CT) are kept within specified limits by using
(a) Ferrite core
(b) Strip wound core
(c) Some fractional turns
(d) In-built compensating capacitors

[GATE-1991]

14. Precautions are essential for ensuring that the secondary of a CT is not open circuited when the primary circuit carries a current because
(a) Dangerously high voltage might develop across the secondary
(b) The ferromagnetic core may develop residual magnetism
(c) The reflected impedance may prevent the flow of current in the primary circuit
(d) None of the above

[GATE-1991]

15. The primary mmf is least affected by the secondary terminal conditions in a
(a) power transformer
(b) potential transformer
(c) current transformer
(d) distribution transformer

[GATE-2015]

Numerical Data Type Questions

16. A 500/5 A, 50 Hz current transformer has a bar primary. The secondary burden is a pure resistance of 1 Ω and it draws a current of 5 A. If the magnetic core requires 250 AT for magnetization, the percentage ratio error is $-x$%. Then the value of x is _____.

Conventional Questions

17. Describe the constructional details and working of a single-phase electrodynamometer type of power factor meter. Prove that the displacement of the moving system is proportional to the phase angle of the system.

[ESE-2010]

Try Yourself

T1. A current transformer having ratio 1000/5 A. The magnetizing and loss component of exciting current are 11 A and 6.5 A respectively. The secondary winding p.f. angle is 30°. What is the phase angle error?
(a) 0.295° (b) 3.2°
(c) 0.359° (d) 0.423° **[Ans. (c)]**

T2. A 50 Hz, bar primary CT has a secondary with 300 turns. The secondary supplies 5 A current into a burden which consists of a resistance and a reactance of 1.5 Ω and 1.0 Ω respectively. The magnetizing mmf is 100 A and the iron loss is 1.2 W. The phase angle between the primary and secondary is
(a) 0.847° (b) 2.34°
(c) 4.025° (d) 11.7° **[Ans. (b)]**

5 Measurement of R, L, C Bridges

Multiple Choice Questions

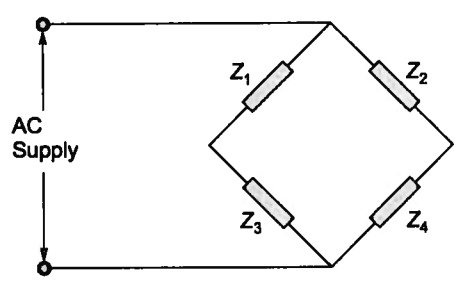
1. The three impedances of an a.c. bridge shown below are:

$Z_1 = 200\ \angle 60°\ \Omega$

$Z_2 = 400\ \angle 90°\ \Omega$

$Z_3 = 300\ \angle 0°\ \Omega$

The value of Z_4 for the balanced bridge is



(a) $150\angle 150°\ \Omega$ (b) $150\angle -30°\ \Omega$

(c) $600\angle -30°\ \Omega$ (d) $600\angle 30°\ \Omega$

[IAS-1998]

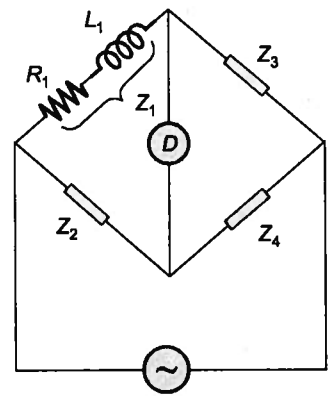
2. Vibration galvanometers, tuneable amplifiers and head phones are used in

(a) d.c. bridges
(b) a.c. bridges
(c) Both d.c. and a.c. bridges
(d) kelvin double bridge.

[ESE-2003]

3. Consider the following statements regarding the balanced ac bridge shown in the given figure for measurement of a coil Z_1:

1. $Z_2 = R_2$ in series with L_2, $Z_3 = R_3$ and $Z_4 = R_4$.
2. $Z_2 = R_2$, $Z_3 = R_3$ and $Z_4 = R_4$ in parallel with L_4.
3. $Z_2 = R_2$, $Z_3 = R_3$ and $Z_4 = R_4$ in series with L_4
4. $Z_2 = R_2$ in parallel with L_2, $Z_3 = R_3$ and $Z_4 = R_4$.



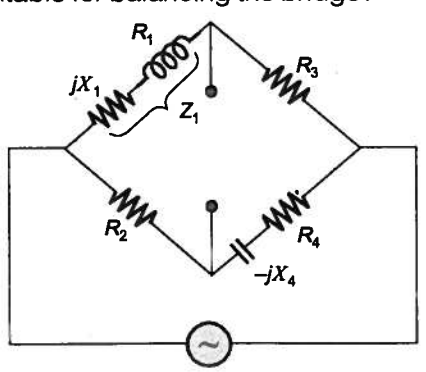
Which of these statements are correct?

(a) 1 and 4 (b) 1 and 2

(c) 2 and 3 (d) 3 and 4

[ESE-1999]

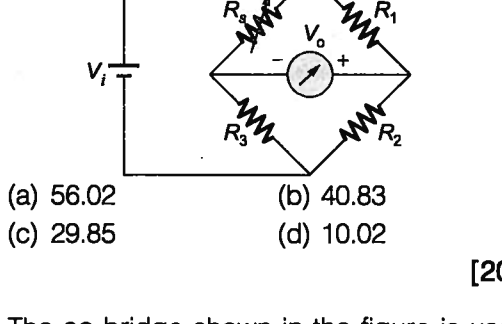
4. A bridge circuit is shown in the figure below. Which one of the sequence given below is most suitable for balancing the bridge?



(a) First adjust R_4, and then adjust R_1
(b) First adjust R_2, and then adjust R_3
(c) First adjust R_2, and then adjust R_4
(d) First adjust R_4 and then adjust R_2

[GATE-2007]

5. In the balanced Wheatstone bridge shown in the figure if the value of R_6 is increased, the current I_2



(a) will increase
(b) will decrease
(c) will remain unchanged
(d) may increase or decrease depending upon the values of the other five resistances

[ESE-1998]

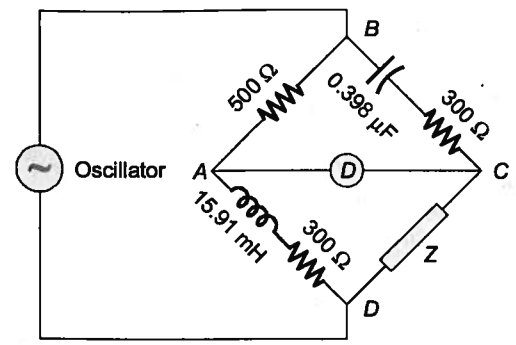
6. A strain gauge forms one arm of the bridge shown in the figure below and has a nominal resistance without any load as $R_s = 300\ \Omega$. Other bridge resistances are $R_1 = R_2 = R_3 = 300\ \Omega$. The maximum permissible current through the strain gauge is 20 mA. During certain measurement when the bridge is excited by maximum permissible voltage and the strain gauge resistance is increased by 1% over the nominal value, the output voltage V_0 in mV is

(a) 56.02 (b) 40.83

(c) 29.85 (d) 10.02

[2013]

7. The ac bridge shown in the figure is used to measure the impedance Z.



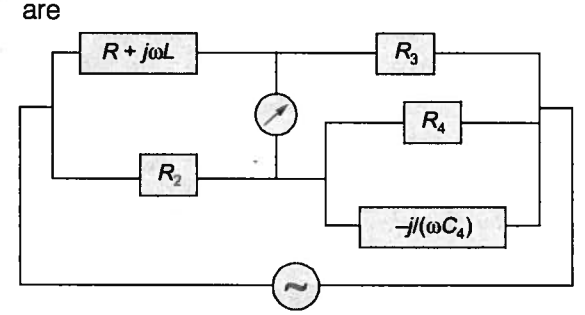
If the bridge is balanced for oscillator frequency $f = 2$ kHz, then the impedance Z will be

(a) $(260 + j0)\Omega$ (b) $(0 + j200)\Omega$

(c) $(260 - j200)\Omega$ (d) $(260 + j200)\Omega$

[GATE-2008]

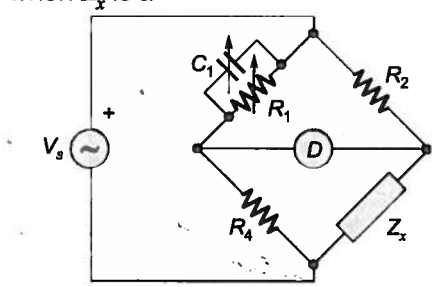
8. The Maxwell's bridge shown in the figure is at balance. The parameters of the inductive coil are



(a) $R = R_2R_3/R_4$, $L = C_4R_2R_3$
(b) $L = R_2R_3/R_4$, $R = C_4R_2R_3$
(c) $R = R_4/R_2R_3$, $L = 1/(C_4R_2R_3)$
(d) $L = R_4/R_2R_3$, $R = 1/(C_4R_2R_3)$

[GATE-2010]

9. The bridge circuit shown in the figure below is used for the measurement of an unknown element Z_x. The bridge circuit is best suited when Z_x is a



(a) low resistance (b) high resistance

(c) low Q inductor (d) lossy capacitor

[GATE-2011]

10. Match **List-I** with **List-II** and select the correct answer using the code given below the lists:

List-I	List-II
A. Hay bridge	1. Medium resistance
B. Wheatstone bridge	2. Frequency
C. Wein bridge	3. Capacitance
D. Schering bridge	4. High Q-inductance

Codes:

	A	B	C	D
(a)	4	2	1	3
(b)	3	2	1	4
(c)	4	1	2	3
(d)	3	1	2	4

[ESE-2011]

11. The items in **List-I** represent the various types of measurements to be made with a reasonable accuracy using a suitable bridge. The items in **List-II** represent the various bridges available for this purpose. Select the correct choice of the item in List-II for the corresponding item in List-I from the following

List-I

A. Resistance in the milli-Ohm range
B. Low values of Capacitance
C. Comparison of resistances which are nearly equal
D. Inductance of a coil with a large time-constant

List-II

1. Wheatstone Bridge
2. Kelvin Double Bridge
3. Schering Bridge
4. Wien's Bridge
5. Hay's Bridge
6. Carey-Foster Bridge

Codes:

	A	B	C	D
(a)	2	3	6	5
(b)	2	6	4	5
(c)	2	3	5	4
(d)	1	3	2	6

[GATE-2003]

12. The accuracy of Kelvin's double bridge for the measurement of low resistance is high because the bridge
(a) uses two pairs of resistance arms
(b) has medium value resistance in the ratio arms
(c) uses a low resistance link between standard and test resistances
(d) uses a null indicating galvanometer

[ESE-2002]

13. For low resistance (from few micro ohms to one ohm) measurement, which bridge is used?
(a) Wheatstone bridge
(b) Kelvin bridge
(c) Guarded Wheatstone bridge
(d) Maxwell bridge

[ESE-2008]

14. A Wien-bridge is used to measure the frequency of the input signal. However, the input signal has 10% third harmonic distortion. Specifically the signal is $2\sin 400\pi t + 0.2\sin 1200\pi t$ (with t in sec.). With this input the balance will
(a) Lead to a null indication and setting will correspond to a frequency of 200 Hz
(b) Lead to a null indication and setting will correspond to 260 Hz
(c) Lead to a null indication and setting will correspond to 400 Hz
(d) Not lead to null indication

[ESE-2003]

15. Wagner Earth devices in *AC* bridge circuits are used for
(a) Shielding all the bridge elements from external magnetic field
(b) Eliminating the effect of stray capacitance
(c) Minimizing the effect of inter-component capacitance
(d) Eliminating all the node to earth capacitances

[ESE-2005]

16. What should be the main characteristic (s) of the null detector in a bridge measurement?
1. Accuracy 2. Precision
3. Sensitivity 4. Resolution

Select the correct answer using the code given below:
(a) Only 1 and 2 (b) Only 2 and 3
(c) Only 3 and 4 (d) Only 3

[ESE-2006]

17. The dielectric loss of a capacitor can be measured by which one of the following?
(a) Wien bridge (b) Owen bridge
(c) Schering bridge (d) Maxwell bridge

[ESE-2008]

18. Which one of the following is a frequency sensitive bridge?
(a) De-Sauty bridge (b) Schering bridge
(c) Wien's bridge (d) Maxwell's bridge

[ESE-2009]

19. Match **List-I** (Bridge) with **List-II** (Parameter to be measured) and select the correct answer :

List-I

A. Maxwell's bridge
B. Hay's bridge
C. Schering bridge
D. Wein bridge

List-II

1. Frequency
2. Inductance of medium *Q*-coils ($1 < Q < 10$)
3. Inductance of high *Q*-coils ($Q > 10$)
4. Capacitance

Codes:

	A	B	C	D
(a)	4	3	2	1
(b)	4	1	2	3
(c)	2	1	4	3
(d)	2	3	4	1

[ESE-2001]

20. Dissipation factor, $\tan\delta$, of a capacitor is measured by which bridge?
(a) Anderson bridge (b) Hay bridge
(c) Schering bridge (d) Wien bridge

[ESE-2009]

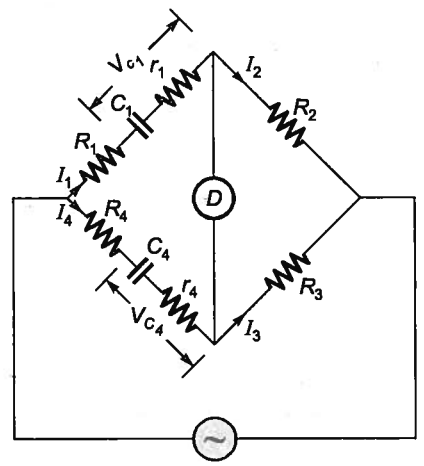
21. Which one of the following techniques reduces the residual inductance of standard resistance?
(a) Using high resistivity material
(b) Using material of low temperature coefficient of resistance
(c) Using proper shielding
(d) Making a bifilar winding on a card

[ESE-2008]

22. The materials to be used in the manufacture of a standard resistance should be of
(a) high resistivity and low temperature coefficient
(b) low resistivity
(c) high temperature coefficient
(d) low resistivity and high temperature coefficient

[ESE-2006]

23. The arms of an ac bridge shown in figure below are arranged, for balance as follows: $R_1 = 0$; $R_2 = 2000\ \Omega$; $R_3 = 2850\ \Omega$, $r_4 = 0.4\ \Omega$; $C_4 = 0.5\ \mu F$ and $R_4 = 4.8\ \Omega$.
The supply frequency is 450 Hz. Determine the loss angle of condenser.



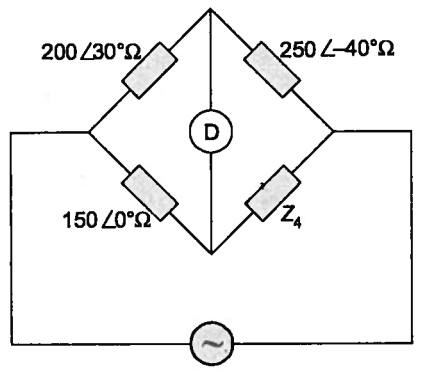
(a) 0.22° (b) 0.32°
(c) 0.42° (d) 0.52°

24. In De Sauty Bridge (unmodified form) it is possible to obtain balance.
(a) Even if both the capacitors are imperfect.
(b) If one of the capacitors is perfect.
(c) Only if both the capacitors are perfect.
(d) All of the above

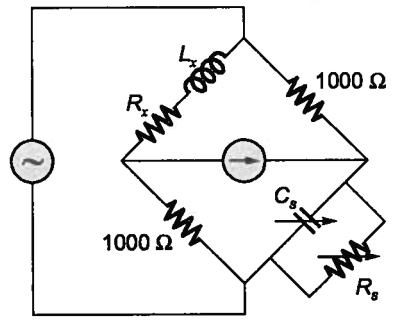
[ESE-2014]

Numerical Data Type Questions

25. At the balance condition of the ac bridge shown in the figure below, the value of z_4 would be _____ $\angle -70°\ \Omega$.

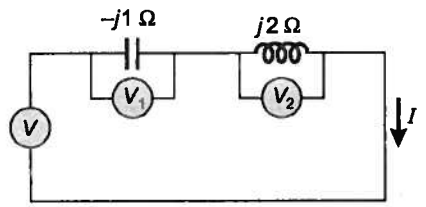


26. In the bridge circuit shown below, at balance condition, the value of C_s = 0.5 μf and R_s = 1000 Ω



then the value of inductance L_x is ____ H.

27. Three moving iron type voltmeters are connected as shown below. Voltmeter readings are V, V_1 and V_2, as indicated. The correct relation among the voltmeter readings is ____ .



[GATE-2013]

Conventional Questions

28. Draw a circuit diagram of De Sauty Bridge for the measurement of capacitance and obtain an expression for the unknown capacitance. What are the defects of this bridge?

[ESE-2012]

29. Explain, with a diagram, how wien's bridge can be used for experimental determination of frequency. Derive the expression for frequency in terms of bridge parameters.

[ESE-2011]

30. With the help of circuit diagram explain the principle and operation of owens bridge for the measurement of incremental inductance.

[ESE-2010]

31. Draw the circuit of Anderson Bridge .Derive the Null condition . [ESE-2009]

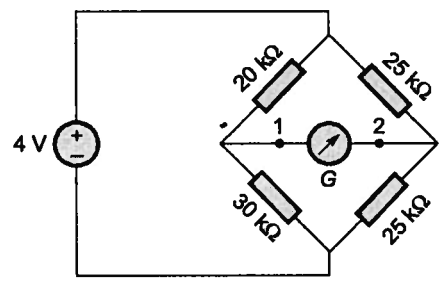
32. Describe the circuit of a Kelvin Double ratio arm bridge and show how the effect of lead resistance is eliminated?

[ESE-2009, ESE-2007]

33. For measurement by ammeter and voltmeter method, what should be the accuracy of the instruments so that the overall measurement error is minimum?

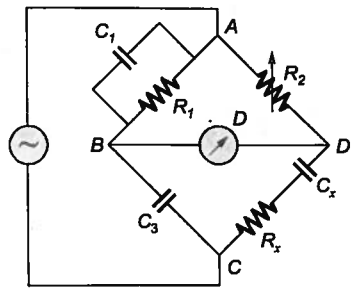
[ESE-2006]

34. Find the output voltage across terminal 1 and 2.



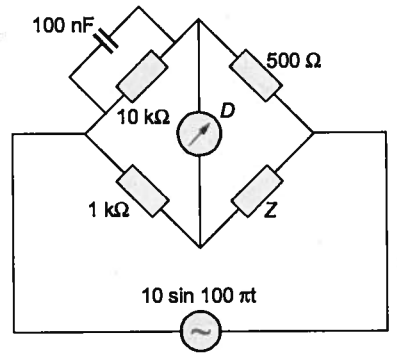
Try Yourself

T1. An AC bridge shown below has the following specifications C_1 = 0.5 μF and R_1 = 1 kΩ, R_2 = 2 kΩ, C_3 = 0.5 μF. If the supply frequency is 1 kHz, determine the dissipation factor.



[Ans: 3.142]

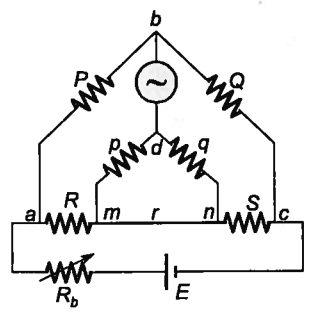
T2. In the *AC* bridge shown in figure below, the detector *D* shows zero deflection. Then the impedance *Z* is made of



(a) 50 mH in parallel with 50 Ω.
(b) 50 mH in series with 50 Ω.
(c) 50 nF in series with 10 kΩ.
(d) 50 nF in parallel with 5 kΩ

[Ans: (b)]

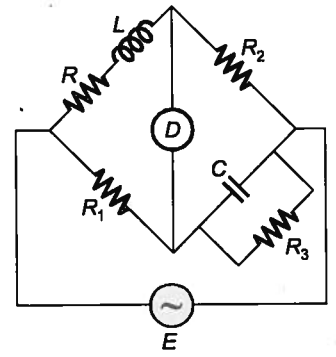
T3. A kelvin double bridge shown in figure below have each of the ratio arm. $P = Q = p = q$ = 100 Ω. The emf of the battery is 100V and a resistance of 5 Ω is included in the battery circuit. The galvanometer has a resistance of 500 Ω and the resistance of the link connecting the unknown resistance to the standard may be neglected. The bridge is balanced when the standard resistance S = 0.001 Ω.



The current (approximate value) through the unknown resistance *R* at balance will be ____ A.

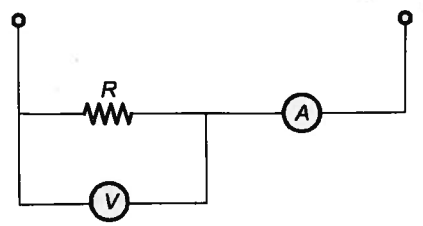
[Ans: (20)]

T4. In a maxwell bridge, the fixed-value bridge components have the following values; R_3 = 5 Ω, C = 1 mF. If R_1 = 160 Ω and R_2 = 20 Ω at balance. ____ is the *Q* factor for the unknown impedance at a supply frequency of 50 Hz.



[Ans: (1.57)]

T5. The set-up in the figure is used to measure resistance *R*. The ammeter and voltmeter resistances are 0.01 Ω and 2000 Ω, respectively. Their readings are 2 A and 180 V, respectively, giving a measured resistance of 90 Ω. The percentage error in the measurement is ____ .



[GATE-2005]

6 CRO, Q-meter

Multiple Choice Questions

1. The *Q*-meter works on the principle of
   (a) mutual inductance
   (b) self inductance
   (c) series resonance
   (d) parallel resonance
   [GATE-2005]

2. A reading of 120 is obtained when standard inductor was connected. The circuit of a *Q*-meter and the variable capacitor is adjusted to a value of 300 pF. A lossless capacitor of unknown value C_x is then connected in parallel with the variable capacitor and the same reading was obtained when the variable capacitor is readjusted to a value of 200 pF. The value of C_x in pF is
   (a) 100 (b) 200
   (c) 300 (d) 500
   [GATE-2003]

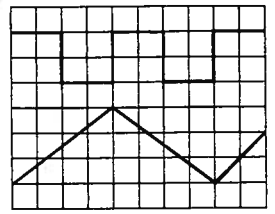
3. **Assertion (A)** : The *Q*-meter measures the *Q*-factor of a coil when the circuit is in resonance.
   Reason (R) : The *Q*-factor of a coil depends only on its inductance and not on its resistance.
   (a) Both A & R are true but R is the correct explanation of A.
   (b) Both A and R are true and R is NOT the correct explanation of A.
   (c) A is true but R is false.
   (d) A is false but R is true.
   [ESE-2010]

4. In a *Q*-meter, a small resistance R_{SH} is added to the series resonance circuit of inject the oscillatory voltage to the circuit. If *R* is the apparent series resistance of the circuit at resonance, then the value of the actual *Q* will be equal to
   (a) observed $Q\dfrac{1}{1+\dfrac{R}{R_{sh}}}$
   (b) observed $Q\left(1+\dfrac{R}{R_{sh}}\right)$
   (c) observed $Q\dfrac{1}{1+\dfrac{R_{sh}}{R}}$
   (d) observed $Q\left(1+\dfrac{R_{sh}}{R}\right)$ **[ESE-1998]**

5. In a *Q*-meter measurement to determine the self capacitance of a coil, the first resonance occur at f_1 with C_1 = 300 pF. The second resonance occur at $f_2 = 2f_1$, with C_2 = 60 pF. The self capacitance of coil works out to be
   (a) 240 pF (b) 60 pF
   (c) 360 pF (d) 20 pF

6. A C.R.O. is operated with *X* and *Y* settings of 0.5 ms/cm and 100 mV/cm. The screen of the C.R.O. is 10 cm × 8 cm (*X* and *Y*). A sine wave of frequency 200 Hz and r.m.s. amplitude of 300 mV is applied to the *Y*-input. The screen will show
   (a) One cycle of the undistorted sine wave
   (b) Two cycles of the undistorted sine wave
   (c) One cycle of the sine wave with clipped amplitude
   (d) Two cycles of the sine wave with clipped amplitude
   [ESE-2003]

7. The time/div and voltage/div axes of an oscilloscope have been erased. A student connects a 1 kHz, 5V p-p square wave calibration pulse to channel 1 of the scope and observes the screen to be as shown in the upper trace of the figure. An unknown signal is connected to channel 2 (lower trace) of the scope. It the time/div and V/div on both channels are the same, the amplitude (p-p) and period of the unknown signal are respectively



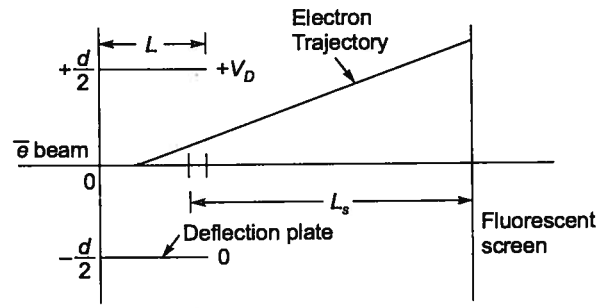
   (a) 5 V, 1 ms (b) 5 V, 2 ms
   (c) 7.5 V, 2 ms (d) 10 V, 1 ms
   [GATE-2006]

8. If the bandwidth of an oscilloscope is given as direct current to 10 MHz, what is the fastest rise time a sine wave can have to be produced accurately by the oscilloscope?
   (a) 35 nsec (b) 10 nsec
   (c) 3.5 nsec (d) 0.035 nsec
   [ESE-2009]

9. The oscilloscope has an input capacitance of 50 pF and a resistance of 2 MΩ and the voltage divider ratio (*k*) of 10. What are the parameters of a high-impedance probe?
   (a) C_1 = 5.55 pF and R_1 = 9 MΩ
   (b) C_1 = 5.55 pF and R_1 = 18 MΩ
   (c) C_1 = 3.33 pF and R_1 = 9 MΩ
   (d) C_1 = 1.11 pF and R_1 = 18 MΩ
   [ESE-2009]

10. **Assertion (A):** Cathode ray oscilloscopes using CRT employing electrostatic deflection are used in laboratories for scientific measurements
    Reason (R): CRT using electrostatic deflection systems have more deflection sensitivity as compared to CRT employing magnetic deflecting system.
    (a) Both A & R are true but R is the correct explanation of A
    (b) Both A and R are true and R is NOT the correct explanation of A
    (c) A is true but R is false
    (d) A is false but R is true
    [ESE-2004]

11. Figure shows the electrostatic vertical deflection system of CRT. Given that V_A is the accelerating voltage, the deflection sensitivity (deflection/volt) is proportional to

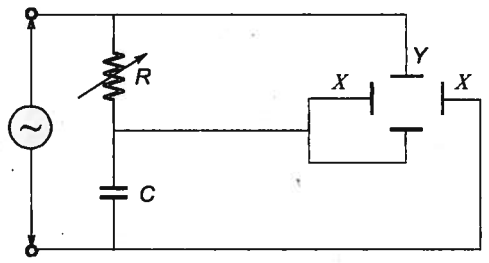


    (a) $\dfrac{LL_s}{dV_A}$ (b) $\dfrac{LL_s V_D}{dV_A}$
    (c) $\dfrac{L_s}{d}V_A$ (d) $\dfrac{dL_s}{LV_A}$
    [GATE-1998]

12. When 30 V dc is applied to the vertical deflection plates of a cathode ray tube, the bright spot moves 1 cm away from the centre. If 30 V (rms) as is applied, then the movement of the spot will be nearly
    (a) 1 cm (b) 1.5 cm
    (c) 2 cm (d) 3 cm
    [IAS-1998]

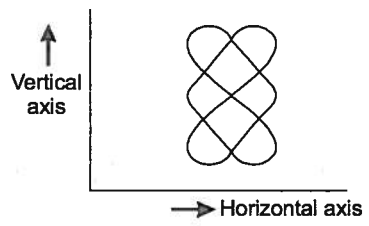
13. Two equal voltages of same frequency applied to the *X* and *Y* plates of a CRO, produce a circle on the screen. The phase difference between the two voltages is
    (a) 30° (b) 60°
    (c) 90° (d) 150° **[ESE-1999]**

14. In the CRO plate connection shown in the given figure the supply frequency is 500 Hz and the capacitance '*C*' is $(0.2/\pi)$ μF. The value or resistance '*R*' required to obtain a circle on the CRO screen (*X* and *Y* plates have equal sensitivities) is



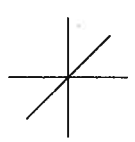
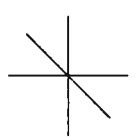
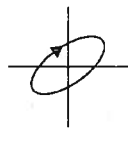
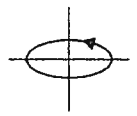
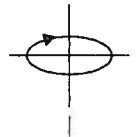
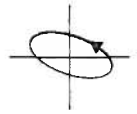
(a) 2 kΩ (b) 5 kΩ
(c) 7 kΩ (d) 10 kΩ **[ESE-2000]**

15. A screen pattern oscillogram, shown in the given figure is obtained when a sine-wave signal of unknown frequency is connected to the vertical input terminals, and at the same time, a 600 Hz sine-wave voltage is connected to the horizontal input terminals of an oscilloscope.



What is the value of unknown frequency?
(a) 300 Hz (b) 400 Hz
(c) 600 Hz (d) 900 Hz **[ESE-2002]**

16. List-I represents the figures obtained on a CRO screen when the voltage signals $V_x = V_{xm} \sin \omega t$ and $V_y = V_{ym} \sin(\omega t + \Phi)$ are given to its X and Y plates respectively and Φ is changed. Choose the correct value of Φ from **List-I** to match with the corresponding figure of **List-II**.

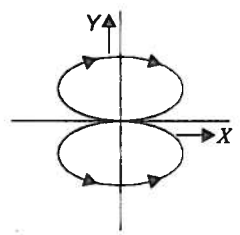
List-I	List-II
A. $\Phi = 0$	1. 
B. $\Phi = \pi/2$	2. 
C. $\pi < \Phi < 3\pi/2$	3. 
D. $\Phi = 3\pi/2$	4. 
	5. 
	6. 

Codes:

	A	B	C	D
(a)	1	3	6	5
(b)	2	6	4	5
(c)	2	3	5	4
(d)	1	5	6	4

[GATE-2003]

17. Two sinsuodial signals $\rho(\omega_1, t) = A \sin \omega_1 t$ and $q(\omega_2, t)$ are appllied to X and Y inputs of a dual channel CRO. The Lissajous figure displyed on the screen is shown below:
The signal $q(\omega_2, t)$ will be represented as



(a) $q(\omega_2 t) = A \sin \omega_2 t, \omega_2 = 2\omega_1$
(b) $q(\omega_2 t) = A \sin \omega_2 t, \omega_2 = \omega_1/2$
(c) $q(\omega_2 t) = A \cos \omega_2 t, \omega_2 = 2\omega_1$
(d) $q(\omega_2 t) = A \cos \omega_2 t, \omega_2 = \omega_1/2$

[GATE-2008]

18. A dual trace oscilloscope is set to operate in the Alternate mode. The control input of the multiplexer use in the y-circuit is fed with a signal having a frequency equal to
(a) the highest frequency that the multiplexer can operate properly
(b) twice the frequency of the time base (sweep) oscillator
(c) the frequency of the time base (sweep) oscillator
(d) half the frequency of the time base (sweep) oscillator

[GATE-2011]

19. Which one of the following statements correctly represents the post acceleration in a Cathode-Ray Tube?
(a) It provides deflection of the beam
(b) It increases the brightness of the trace if the signal frequency is higher than 10 MHz
(c) It accelerates the beam before deflection
(d) It increases the brightness of the trace of low frequency signal

[ESE-2001]

20. In a two-channel oscilloscope operating in x-y mode, two in phase 50 Hz sinusoidal waveforms of equal amplitude are fed to the two channel. What will be the resultant pattern on the screen?
(a) An ellipse
(b) A parabola
(c) Straight line inclined at 45° with respect to x-axis
(d) A circle **[ESE-2014]**

Numerical Data Type Questions

Common Data Questions (21 and 22):
A CRO with a rise time of 15 ns measures the rise time of an unknown signal as 20 ns. The horizontal deflection sensitivity of a CRO is 0.02 mm/V. If an unknown voltage is applied to the horizontal plates, the spot shifts 4.0 mm horizontally.

21. The actual rise time of the unknown signal is _____ ns.

22. _____ V is the value of the unknown voltage.

23. In a CRT, 3×10^{17} electrons are accelerated through a potential difference of 10,000 V over a distance of 40 mm per minute. The average power supplied to the electrons is _____ Watts.

Conventional Questions

24. Explain how you would use a CRO to measure the phase between two sinusoidal signals.
[ESE-1987]

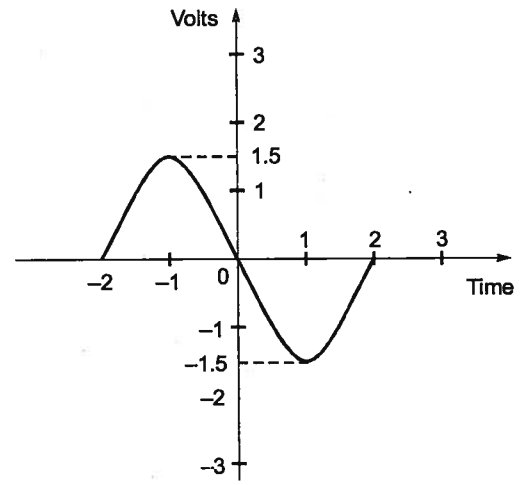
25. Describe with diagrams the working of-
(i) Electrostatic focusing arrangement
(ii) Internal and external synchronization in CRO.
[ESE-1989]

26. Draw a neat sketch of a cathode ray tube marking thereon its various parts. Describe briefly the functions and working of following parts:
(i) Electron gun assembly
(ii) Deflection system assembly.
[ESE-1990]

27. The self-capacitance of a coil is determined by the following measurements. The first measurement is at $f_1 = 1$ MHz and $C_1 = 500$ pF. The second measurement is at $f_2 = 2$ MHz and $C_2 = 110$ pF, find the distributed capacitance and the value of L respectively.

Try Yourself

Common Data Questions (T1 and T2):
The waveform shown in the figure given below is observed on the screen of an oscilloscope. If the vertical attenuation is set to 0.5 V/div,



T1. _____ V is the peak to peak amplitude of the signal.

[Ans: 1.5]

T2. If the time/div control is set to 2 μs/div when the waveform in the given figure above is displayed on the CRT screen, _____ kHz is the frequency of the signal.

[Ans: 125]

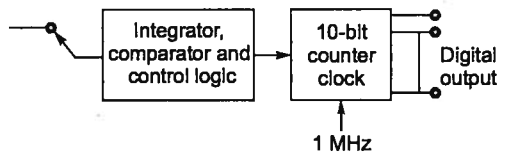
7 Digital Meter

Multiple Choice Questions

1. In a dual slope integrating type digital voltmeter the first integration is carried out for 10 periods of the supply frequency of 50 Hz. If the reference voltage used is 2 V, the total conversion time for an input 1 V is _____ sec.
   (a) 1 Sec (b) 1 m Sec
   (c) 0.1 Sec (d) None of these
   [GATE-1992]

2. For a dual ADC type 3 1/2 digit DVM, the reference voltage is 100 mV and the first integration time is set to 300 ms. For some input voltage, the "deintegration" period is 370.2 ms. The DVM will indicate
   (a) 123.4 (b) 199.9
   (c) 100.0 (d) 1.414 **[GATE-1999]**

3. The simplified block diagram of a 10-bit *A/D* converter of dual slope integrator type is shown in figure. The 10-bit counter at the output is clocked by a 1 MHz clock. Assuming negligible timing overhead for the control logic, the maximum frequency of the analog signal that can be conveted using this *A/D* converter is approximately



   (a) 2 kHz (b) 1 kHz
   (c) 500 Hz (d) 250 Hz
   [GATE-2004]

4. The reference voltage and the input voltage are sequentially connected to the integrator with the help of a switch in a
   (a) Successive approximation *A/D* converter
   (b) Dual slope integration *A/D* converter
   (c) Voltage to time converter
   (d) Voltage to frequency converter
   [ESE-2005]

5. The successive approximation *A/D* output for a 4-bit converter to a 8.217 volt input (if the reference is 5 V) will be
   (a) 1101 (b) 0110
   (c) 1010 (d) 1001
   [ESE-2008]

6. A 7-bit successive approximation DVM will convert the analog input into digital output in a period of
   (a) 7 clock pulses
   (b) 8 clock pulses
   (c) $\frac{\text{input signal amplitude}}{\text{full-scale output amplitude}} \times 7$ clock pulses
   (d) $\frac{\text{input signal amplitude}}{\text{full-scale output amplitude}} \times 8$ clock pulses
   [ESE-1997]

7. Two 8-bit ADCs, one of single slope integrating type and other of successive approximate type, take T_A and T_B times to convert 5 V analog input signal to equivalent digital output. if the input analog signal is reduced to 2.5 V, the approximate time taken two ADCs will respectively, be
   (a) T_A, T_B (b) $T_A/2$, T_B
   (c) T_A, $T_B/2$ (d) $T_A/2$, $T_B/2$
   [GATE-2008]

8. Consider the following statement. The *A* to *D* converter used in a digital instrument could be
   1. Successive approximation converter type.
   2. Flash converter type.
   3. Dual slope converter type.
   The correct sequence in the increasing order of the conversion time taken by these types is
   (a) 1, 2 and 3 (b) 2, 1 and 3
   (c) 1,3 and 2 (d) 2, 3 and 1
   [ESE-2010]

9. What is the range for a $3\frac{1}{2}$ digital meter?
   (a) 0 to 1999 (b) 0 to 1500
   (c) 0 to 999 (d) 0 to 19999
   [ESE-2006]

10. In a digital voltmeter, the oscillator frequency is 400 kHz. The ramp voltage falls from 8 V to 0 V in 20 ms. What is the number of pulses counted by the counter?
    (a) 8000 (b) 4000
    (c) 3200 (d) 1600
    [ESE-2009]

11. A 4-digit DVM (digital voltmeter) with a 100 mV lowest full-scale range would have a sensitivity of how much value while resolution of this DVM is 0.0001?
    (a) 1 mV (b) 10 mV
    (c) 0.1 mV (d) 0.01 mV
    [ESE-2010]

12. A $4\frac{1}{2}$ digit DMM has the error specification as: 0.2% of reading + 10 counts. If a dc voltage of 100 V is read on its 200 V full scale, the maximum error that can be expected in the reading is
    (a) ± 0.1% (b) ± 0.2%
    (c) ± 0.3% (d) ± 0.4%
    [GATE-2011]

13. In modern electronic multimeter a FET or MOSFET is preferred over BJT because
    (a) Its input resistance is low
    (b) Its input resistance is high
    (c) Its input resistance is high and does not vary with the change of range
    (d) It is cheaper
    [ESE-2005]

14. An electronic voltmeter gives more accurate readings in high-resistance circuits as compared to a non-electronic voltmeter because of its
    (a) low meter resistance
    (b) high kΩ/V rating
    (c) high V/kΩ rating
    (d) high resolution **[ESE-2012]**

15. A $4\frac{1}{2}$ digit voltmeter is used to measure the voltage value of 0.3861 V on a 1 V range. It would be display
    (a) | 0 | .3 | 8 | 6 | 1 |
    (b) | 0 | 0 | .3 | 8 | 6 |
    (c) | 0 | 0 | 0 | .3 | 8 |
    (d) | .3 | 8 | 6 | 1 | 0 |

Numerical Data Type Questions

16. In a dual slope integrating type digital voltmeter, the first integration is carried out for 10 periods of the supply frequency of 50 Hz. If the reference voltage used is 2 V, the total conversion time for an output of 1 V is _____ sec.

Conventional Questions

17. What are the advantages of digital voltmeters and limitations compared to analog indicating type voltmeters?
    Explain with the help of a block diagram, the configuration of counter ramp type DVM.
    [ESE-2007]

18. Mention the various types of analog to digital converters in the increasing order of speed of operation. Why is a dual slope ADC preferred in a digital voltmeter?
    [ESE-2005]

19. Explain with the help of circuit diagram , the working of a dual slope ADC ?
    [ESE-2004]

8 Transducers

Multiple Choice Questions

1. Which one of the following is not a self-generating type transducer?
   (a) Thermocouple and thermopile
   (b) Piezoelectric pick-up
   (c) Photovoltaic cell
   (d) Magnetostriction gauge
   [ESE-2011]

2. The strain gauge with a resistance of 250 ohm undergoes a change of 0.15 ohm. During a test the strain is 1.5×10^{-4}. What is the gauge factor?
   (a) 4.7 (b) 4.0
   (c) 3.5 (d) 2.0
   [ESE-2009]

3. A strain gauge having a resistance of 500 ohm and a gauge factor 3.0 is bonded on a member of structure undergoing tensile stress. If the change in resistance of the gauge is accurately measured as 1.5 ohm, what is the value of strain suffered by the member?
   (a) 0.01 (b) 0.001
   (c) 0.1 (d) 0.003 **[ESE-2009]**

4. A resistance strain gauge with gauge factor (S_f) of 2 is bonded to a steel member, which is subjected to a strain of 1×10^{-6}. The original resistance value of this strain gauge is 120. The change in resistance due to the applied strain is
   (a) 60 Ω (b) 240×10^{-6} Ω
   (c) 240 Ω (d) 60×10^{-6} Ω
   [ESE-2010]

5. Two strain gauges are employed for the measurement of strain in a cantilever. One gauge is mounted on top of the cantilever and the other is placed at the bottom. The two strain gauges form two arms of a voltage sensitive wheatstone bridge. What is this bridge configuration?
   (a) Full bridge (b) Half bridge
   (c) Quarter bridge (d) Null bridge
   [IAS-2007]

6. In strain gauge torque transducers, the strain gauges are mounted at which one of the following?
   (a) 0° to the shaft axis
   (b) 45° to the shaft axis
   (c) 90° to the shaft axis
   (d) at any angle with the shaft axis
   [ESE-2007]

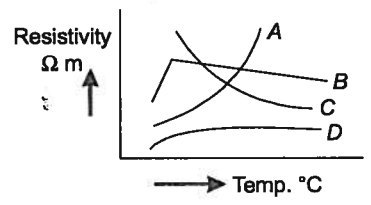
7. A piezoelectric crystal has a thickness of 2.5 mm and a voltage sensitivity of 0.05 Vm/N. The piezoelectric crystal is subjected to an external pressure of 1.6×10^6 N/m^2, then the corresponding output voltage is
   (a) 200 volts
   (b) 3.2×10^9 volts/m of thickness
   (c) 0.07×10^9 V/(m^3/New)
   (d) 200 m volts
   [ESE-2010]

8. Consider the following statements Piezoelectric materials serve as
   1. A source of ultrasonic waves.
   2. When electric field is applied, the mechanical dimensions of the substances are not at all altered.
   3. Converts electrical energy to mechanical and vice versa.
   4. Converts thermal energy to electrical energy.

   Which of these statement/s is/are correct?
   (a) 1 only (b) 2 and 3 only
   (c) 1 and 3 only (d) 1, 2, 3 and 4
   [ESE-2010]

9. A piezoelectric transducer has the following parameter values
   Crystal capacitance = 10^{-9} F
   Cable capacitance = 2×10^{-10} F
   Charge sensitivity = 4×10^{-6} coulomb/cm
   If the oscilloscope used for read-out has an input resistance of 1 MΩ in parallel with $C = 4 \times 10^{-10}$ F, then the voltage sensitivity constant will be
   (a) 2500 V/cm (b) 3334 V/cm
   (c) 4000 V/cm (d) 4500 V/cm
   [ESE-1997]

10. Which curve in the given figure represents resistance temperature characteristics of a thermistor ?



    (a) Curve *A* (b) Curve *B*
    (c) Curve *C* (d) Curve *D*
    [ESE-2002]

11. Measurement of flow, thermal conductivity and liquid level using thermistors make use of
    (a) Resistance decrease with temperature
    (b) Resistance increase with temperature
    (c) Self-heating phenomenon
    (d) Change of resistivity
    [ESE-2003]

12. The emf is measured for a junction temperature difference of 20° C by thermocouples made from materials *A*, *B* and *C*. The pair *A* – *B* gives an emf of 165 μV, with the end of *A* being positive. The pair *B* – *C* gives 100 μV, with the end of *C* being positive. The pair *A* – *C* will give
    (a) 265 μV with the end of *A* being positive
    (b) 265 μV with the end of *C* being positive
    (c) 65 μV with the end of *A* being positive
    (d) 65 μV with the end of *C* being positive
    [ESE-1999]

13. The dead zone in a pyrometer is 0.12 percent of the span. The instrument is calibrated from 500°C to 2000°C. What temperature change must occur before it can be detected in degree Centigrade?
    (a) 187.5 (b) 1.875
    (c) 18.75 (d) 0.1875
    [ESE-2009]

14. Match **List-I** (Transducer) with **List-II** (Range of temperature) and select the correct answer:
    List-I
    A. Mercury in glass thermometer
    B. Platinum resistance thermometer
    C. Thermocouple with lead compensation
    D. Optical radiation pyrometer

    List-II
    1. Can be used upto 300°C in normal conditions
    2. Can be used upto 900°C with sufficient accuracy
    3. Can be used upto 1400°C
    4. Can be used for temperatures upto several thousand degrees.

    Codes:

	A	B	C	D
(a)	3	2	1	4
(b)	1	4	3	2
(c)	3	4	1	2
(d)	1	2	3	4

    [ESE-2002]

15. A fixed resistor of suitable value is usually connected across a thermistor to
    (a) decrease its resistance
    (b) increase its sensitivity
    (c) improve linearity
    (d) compensate its self-heating effect
    [ESE-1999]

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16. The principle of Hall effect is made use of in the construction of which one of the following?
(a) Ammeter (b) Voltmeter
(c) Gaussmeter (d) Galvanometer
[ESE-2008]

17. The measurement of Hall coefficient of a semiconductor with one type of charge carrier gives the information about
(a) sign of charge carrier
(b) density of charge carrier
(c) both sign and density of charge carrier
(d) mass of the charge carrier
[ESE-2010]

18. **Assertion (A):** Capacitive transducers can be used for measurement of both static and dynamic phenomena.
Reason (R): Capacitive transducers are extremely sensitive.
(a) Both A and R are true but R is the correct explanation of A
(b) Both A and R are true and R is NOT the correct explanation of A
(c) A is true but R is false
(d) A is false but R is true
[ESE-2008]

19. Which displacement transducer is used for accurate and linear measurement?
(a) LVDT
(b) Strain gauge
(c) Potentiometer
(d) Capacitive displacernent transducer
[ESE-2008]

20. Match **List-I** with **List-II** and select the correct answer using the code given below the lists:
List-I
A. Variable capacitance device
B. Orifice meter
C. Thermistors
List-II
1. Flow measurement
2. Temperature measurement
3. Pressure transducer
4. Force and torque measurement
Codes:

	A	B	C
(a)	3	1	2
(b)	2	4	3
(c)	2	1	3
(d)	3	4	2

[ESE-2008]

21. Which of the following can be used/modified for measurement of angular speed?
1. LVDT
2. Magnetic pick-up
3. Tacho-generator
4. Strain gauge
Select the correct answer using the code given below:
(a) Only 1 and **2** (b) Only 2 and 3
(c) Only 3 (d) Only 2, 3 and 4
[ESE-2006]

22. Consider the following units for the measurement of pressure directly:
1. Rota meter 2. Bourdon tube
3. Plani meter 4. Vanes
Of these, the pressure can be measured by
(a) 1 and **2** only (b) 3 and 4 only
(c) 2 only (d) 1, 2, 3 and 4
[ESE-2010]

23. Consider the following statements:
1. The main shortcomings of diaphragms are that they are prone to shock vibrations.
2. Diaphragms have the advantages of high accuracy and good dynamic response.
3. Selection of material for diaphragms mainly, depends upon temperature range and chemical nature of fluid coming in contact with diaphragm during pressure measurement.
Which of these statements is/are correct?
(a) 1, 2 and 3 (b) 2 and 3 only
(c) 1 only (d) 1 and 2 only
[ESE-2010]

24. Consider the following statements:
1. Electromagnetic flowmeter is independent of liquid density.
2. Electromagnetic flowmeter cannot be employed for measuring flow of non-conducting fluids.
Which of these statements is/are correct?
(a) 1 only (b) Both 1 and 2
(c) 2 only (d) Neither 1 nor 2
[ESE-2010]

25. In an electrometer, the movable plate is 11 cm in diameter. When 12 kV is applied between the movable plate and the fixed plate, the force is 0.006 N. The change in capacitance for 1.5 mm movement of the movable plate is
(a) 0.44×10^{-12} F (b) 0.37×10^{-6} F
(c) 0.125×10^{-12} F (d) 12.5×10^{-12} F
[ESE-2008]

26. In a stroboscopic method of rotational speed measurement of a machine shaft,
N = the machine shaft speed of rotation of the shaft in revolutions/min
n = No. of points on the circuit pattern
F = No. of flash per min.
The speed of rotation N will be
(a) $N = F + n$ (b) $N = F - n$
(c) $N = F/n$ (d) $N = F \cdot n$
[ESE-2002]

27. When compared with other transducers measuring temperature, a four-lead platinum RTD
1. has better linearity over a wide operating range.
2. has better accuracy and precision.
3. has better stability at high temperature.
4. is inexpensive.
Which of these are correct?
(a) 1, 2 and 3 (b) 1, 2 and 4
(c) 1, 3 and 4 (d) 2, 3 and 4
[ESE-2012]

Conventional Questions

28. How does a 'Piezo-Electric Transducer' work? What are the common materials used for it? Derive an expression for its (i) voltage and (ii) charge sensitivities. Draw an equivalent circuit for this transducer. Write uses of Pizeo-electric materials and transducers.
[ESE-2006, ESE-2001]

29. What is LVDT? Explain its working with necessary diagram and characteristics. What are its advantages and uses?
[ESE-2004]

30. Name transducers for sensing flow rate. Explain and generate principle of their working. Explain working, construction, advantage and limitations of electro-magnetic flow meter.
[ESE-2004]

31. Explain how thermistor can be used for temperature measurement.
The resistance at temperature T Kelvin is given by
$$R_T = R_0 e^{\beta\left(\frac{1}{T}-\frac{1}{T_0}\right)}$$
where $R_0 = 1050\ \Omega$ at 27° C, the corresponding $\beta = 3140$.
What is the temperature when the thermistor resistance is 2330 Ω?
[ESE-2003]

9 Miscellaneous

1. Which one of the following definition correctly represents a Data Acquisition System (DAS)?
   (a) DAS is a group of electronic devices that are connected to perform the measurement and quantization of electrical signals for digital processing
   (b) DAS is a group of devices that are connected to store different signals
   (c) DAS is a system to control a process
   (d) DAS is a signal conditioner
   [ESE-2004]

2. Digital data acquisition systems are used
   1. Only when the output of the transducers is in digital form
   2. When physical process being monitored is slowly varying (narrow bandwidth)
   3. When low accuracy can be tolerated
   4. When high accuracy and low per channel cost is required

   Which of these statements are correct?
   (a) 1, 2 and 3 (b) 1, 3 and 4
   (b) 1 and 3 (d) 2 and 4 **[ESE-2001]**

3. In an analog Data Acquisition System (DAS), what is the correct sequence of the blocks (therein) starting from the input?
   (a) Transducer – recorder – filter – signal conditioner
   (b) Transducer – signal conditioner – recorder
   (c) Signal conditioner – transducer – recorder
   (d) Signal conditioner – filter – transducer – recorder. **[ESE-2007]**

4. A voltage of $\{200\sqrt{2}\ \sin 314t + 6\sqrt{2}\ \sin(942t + 30°) + 8\sqrt{2}\ \cos(1570t + 30°)\}$V is given to a harmonic distortion meter. The meter will indicate a total harmonic distortion of approximately
   (a) 5% (b) 6.5%
   (c) 7.5% (d) 8.5% **[ESE-2000]**

5. In microwave telemetry, repeater stations are required at every
   (a) 2 km (b) 5 km
   (c) 40 km (d) 100 km
   [ESE-2006]

6. Match **List-I** with **List-II** and select the correct answer using the code given below the lists:
   List-I
   A. Digital Counter
   B. Schering Bridge
   C. Megger
   D. Spectrum Analyzer
   List-II
   1. Measurement of harmonics
   2. Measurement of frequency
   3. Measurement of dielectric loss
   4. Measurement of insulation resistance
   Codes:

	A	B	C	D
(a)	1	3	4	2
(b)	2	4	3	1
(c)	1	4	3	2
(d)	2	3	4	1

   [ESE-2006]

7. Spectrum analyser is a combination of
   (a) narrow band superheterodyne receiver and CRO
   (b) signal generator and CRO
   (c) oscillator and wave analyser
   (d) VTVM and CRO **[ESE-2001]**

■■■■

2017

MADE EASY **WORKBOOK**

Measurement & Instrumentation + Power Electronics

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○○○○

Power Electronics
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  - Static and Switching characteristics
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  - Triggering circuits
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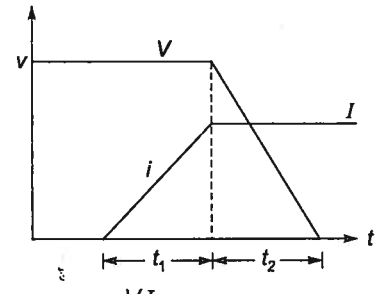
- Power supplies
- Bidirectional AC to DC voltage source converters
- Workbook

1 Power Semiconductor Devices

Multiple Choice Questions

Q.1 The figure shows the voltage across a power semiconductor device and the current through the device during a switching transitions. The transition shown in the graph is a turn on transition or turn off transition and what is the energy lost during the transition?



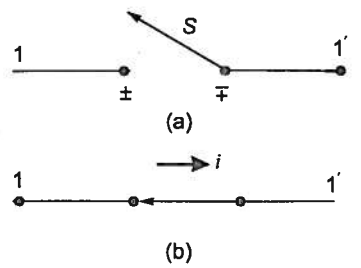
(a) Turn ON, $\frac{VI}{2}(t_1 + t_2)$

(b) Turn OFF, $VI(t_1 + t_2)$

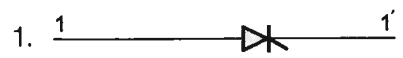
(c) Turn ON, $VI(t_1 + t_2)$

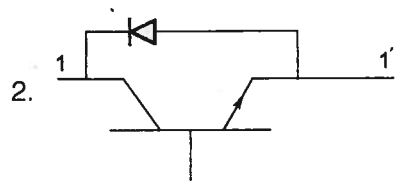
(d) Turn OFF, $\frac{VI}{2}(t_1 + t_2)$ **[GATE-2005]**

Q.2 An electronics switch S is required to block voltage of either polarity during its OFF state as shown in the figure (a). This switch is required to conduct in only one direction its ON state as shown in the figure (b).

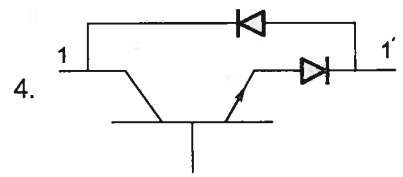


Which of the following are valid realizations of the switch S?

1. 

2. 

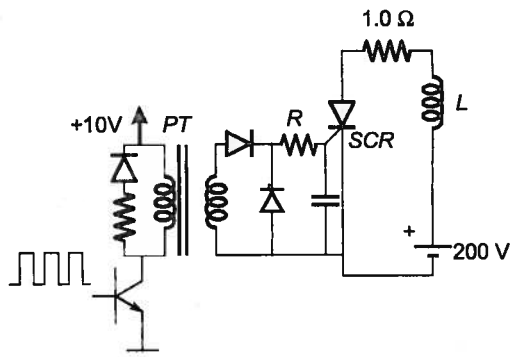
3. 

4. 

(a) Only 1 (b) 1 and 2
(c) 1 and 3 (d) 3 and 4

[GATE-2005]

Q.3 A 1:1 Pulse transformer (*PT*) is used to trigger the SCR in the figure. The SCR is rated at 1.5 kV, 250 A with I_L = 250 mA, I_H = 150 mA, and I_{Gmax} = 150 mA with I_L =250 mA, I_{Gmin} = 100 mA. The SCR is connected to an inductive load, where L =150 mH in series with a small resistance and the supply voltage is 200 V dc. The forward drops of all transistors /diodes and gate-cathode junction during ON state are 1.0 V. The resistance R should be



(a) 4.7 kΩ (b) 470 kΩ
(c) 47 Ω (d) 4.7 Ω

Q.4 In the above question, the minimum approximate volt-second rating of the pulse transformer suitable for triggering the SCR should be: (Volt-second rating is the maximum of product of the voltage and the width of the pulse that may be applied)
(a) 2000 μV-s (b) 200 μV-s
(c) 20 μV-s (d) 2 μV-s
[GATE-2007]

Q.5 Consider the following statements
When gate triggering is employed, a thyristor can withstand higher values of di/dt (rate of change of forward current), if
1. the gate current is increased.
2. the rate of rise of gate current is increased.
3. the gate current is decreased.
4. the rate of rise of gate current is decreased.

Of these statements:
(a) 3 and 4 are correct
(b) 1 and 4 are correct
(c) 2 and 3 are correct
(d) 1 and 2 are correct **[IAS-1994]**

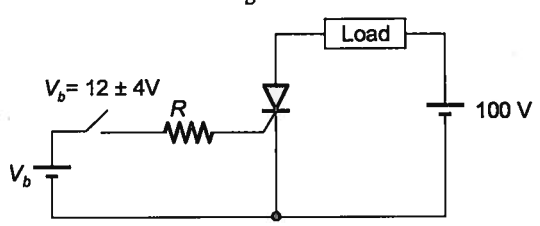
Q.6 Which one of the following is necessary for a triggering system for thyristors in a line commutator converter?
(a) It must use separate power supply
(b) It should provide a train of pulses
(c) It should be synchronized with the mains supply providing a single pulse of suitable value
(d) It should be synchronized with mains providing a train of pulses
[IAS-1998]

Q.7 Which of the following statements are correct when a positive voltage is applied to the gate of a reverse biased SCR?
(a) This injects more electrons into junction J_1
(b) This increases reverse leakage current into anode
(c) Heating of junction is unaffected
(d) Failure of junction occurs due to thermal runway
(a) (a) and (c) (b) (a) and (b)
(c) (b) and (c) (d) (b) and (d)

Q.8 If a diode is connected in antiparallel with a thyristor, then
(a) both turnoff power loss and turnoff time decrease
(b) turnoff power loss decreases, but turnoff time increases
(c) turnoff power loss increases, but turnoff time decreases
(d) none of the above
[GATE-1997]

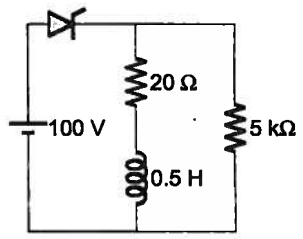
Numerical Data Type Questions

Q.9 The triggering circuit of a thyristor is shown in figure. The thyristor requires a gate current of 10 mA, for guaranteed turn-on. The value of R required for the thyristor to turn on reliably under all conditions of V_b variation is_____ Ω.



[GATE-2004]

Q.10 An SCR having a turn ON time of 5 μsec, latching current of 50 mA and holding current of 40 mA is triggered by a short duration pulse and is used in the circuit shown in figure. The minimum pulse width required to turn the SCR ON will be _____ μsec.

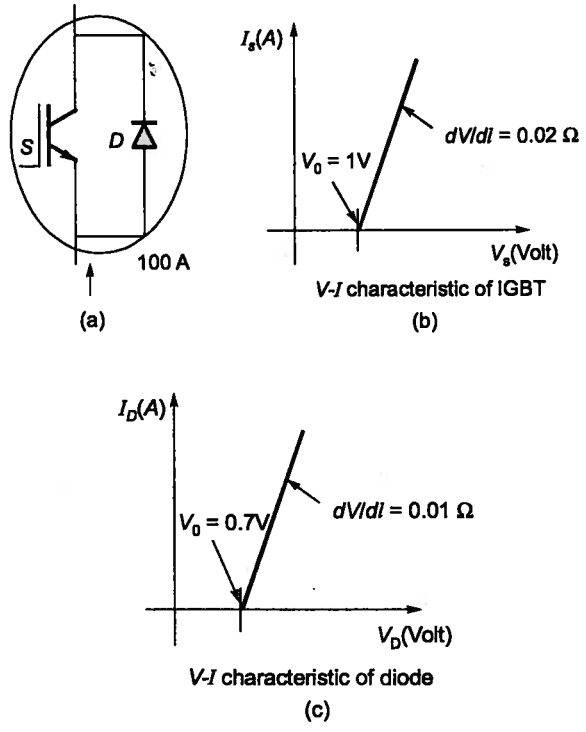


[GATE-2006]

Q.11 An SCR has half cycle surge current rating of 3000A for 50 Hz supply. One cycle surge current rating will be _____ A.

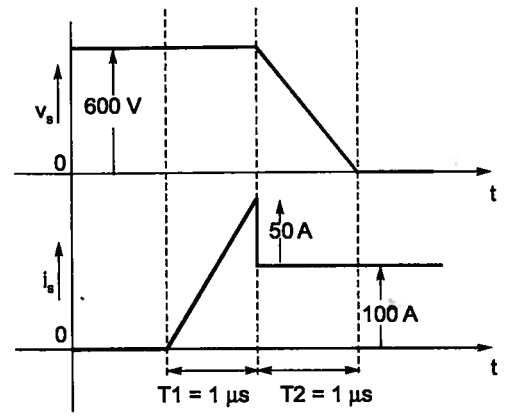
Q.12 An SCR gives maximum rms on-state current as 35A. If this SCR is used in resistance circuit, complete average on-state current rating for half-sinewave current for conduction angles of 30° is _____ A.

Q.13 A steady dc current of 100 A is flowing through a power module (*S*, *D*) as shown in Figure (a). The V-I characteristics of the IGBT (*S*) and the diode (*D*) are shown in Figures (b) and (c), respectively. The conduction power loss in the power module (*S*, *D*), in watts, is _____.



[GATE-2016]

Q.14 The voltage (v_s) across and the current (i_s) through a semiconductor switch during a turn-ON transition are shown in figure. The energy dissipated during the turn-ON transition, in mJ, is

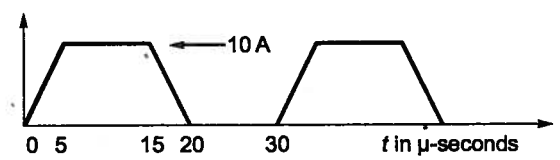


[GATE-2016]

Conventional Questions

Q.15 For a thyristor maximum junction temperature is 125°C. The thermal resistance for thyristor-sink combination are θ_{jc} = 0.16 and θ_{cs} = 0.08°c/W. For a heat sink temperature of 70°C, compute the total average power loss in the thyristor sink combination. In case the heat sink is brought down to 60°C by forced cooling, find the percentage increase in the device rating.
[ESE-2006]

Q.16 The periodic current through a power-switching device in a switching converter application is shown in Fig.



Q.17 (a) Discuss the power loss in a diode during the reverse recovery transients.
(b) The forward characteristic of a power diode can be represented by $v_f = 0.88 + 0.015\, i_f$.

Determine the average power loss and rms current for a constant current of 50 A for 2/3 of a cycle.

[Hint. (b) With T as the time of a cycle, average power loss

$$= \frac{1}{T}\int_0^{2T/3} v_f . I_f dt = \frac{2}{3} v_f I_f \text{ etc.}$$

Q.18 A thyristor operating from a peak supply voltage of 400 V has the following specifications: Repetitive peak current,

I_p = 200 A, $\left(\frac{di}{dt}\right)_{max}$ = 50 A/ s, $\left(\frac{dv}{dt}\right)_{max}$ = 200 V/ s.

Choosing a factor of safety of 2 for I_p, $\left(\frac{di}{dt}\right)_{max}$ and $\left(\frac{dv}{dt}\right)_{max}$, design a suitable snubber circuit.

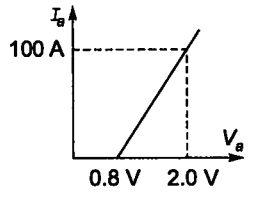
The minimum value of load resistance is 10 Ω.

Try Yourself

T1. Latching current for an SCR, inserted in between a dc voltage source of 200 V and the load, is 100 mA. The minimum width of gate pulse current required to turn on this SCR in case the load consists of R = 20 Ω in series with L = 0.2 H is ____ μs.

[Ans: 100.50]

T2. During forward conduction, a thyristor has static I-V characteristic as shown below.

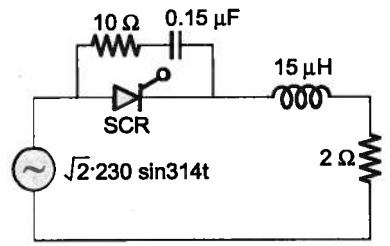


The average powerloss in the thyristor and its rms current rating if the load condition is a constant current of 80 A for one half cycle is

(a) 70.4 W and 42.18 A
(b) 64.75 W and 56.57 A
(c) 70.4 W and 56.57 A
(d) 64.75 W and 42.18 A

[Ans: (c)]

T3. In the circuit shown below

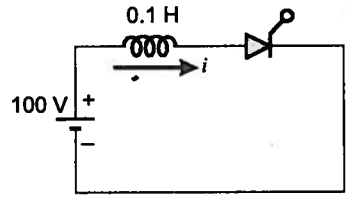


the maximum value of $\frac{dv}{dt}$ for the SCR is

(a) 164 V/μsec (b) 202 V/μsec
(c) 185 V/μsec (d) 216.85 V/μsec

[Ans: (d)]

T4. In the circuit shown below, if the Latching current of the thyristor is 4 mA then the minimum width of the gate pulse required to properly turn on the SCR is



(a) 1 μs (b) 2 μs
(c) 3 μs (d) 4 μs

[Ans: (d)]

2 Controlled & Uncontrolled Rectifiers

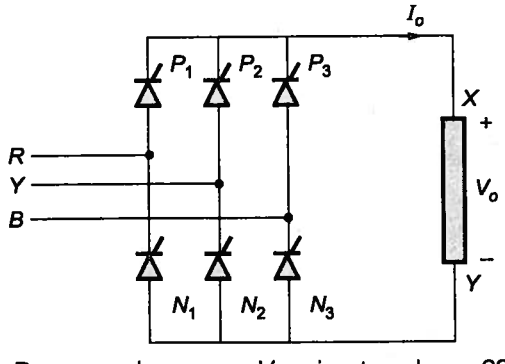
Multiple Choice Questions

Q.1 A fully controlled natural commutated 3-phase bridge rectifier is operating with a firing angle α = 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

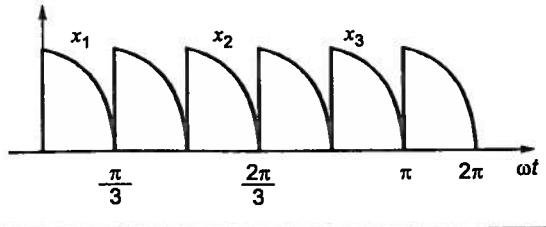
(a) 0.5 (b) $\sqrt{3}/2$
(c) $\left(1-\frac{\sqrt{3}}{2}\right)$ (d) $\sqrt{3}-1$

[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.



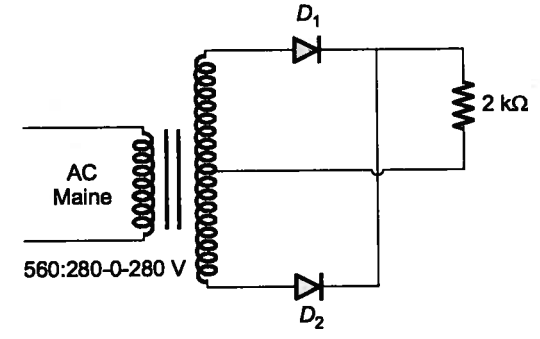
By assuming $v_{YB} = V_{ml} \sin\omega t$ and α = 60° the following load voltage is obtained.



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

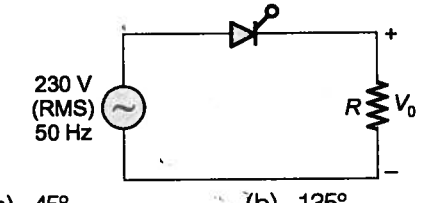
(a) $x_1 = v_{RB}$, $x_2 = v_{YR}$ and $x_3 = v_{YB}$
(b) $x_1 = v_{RY}$, $x_2 = v_{YB}$ and $x_3 = v_{BY}$
(c) $x_1 = v_{RB}$, $x_2 = v_{YR}$ and $x_3 = v_{BY}$
(d) $x_1 = v_{RY}$, $x_2 = v_{YB}$ and $x_3 = v_{BR}$

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

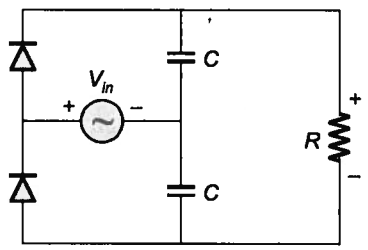
Q.4 Consider a phase-controlled converter shown in the figure. The thyristor is fired at an angle α in every positive half cycle of the input voltage. If the peak value of the instantaneous output voltage equals 230 V, the firing angle α is close to



(a) 45° (b) 135°
(c) 90° (d) 83.6°

[GATE-2005]

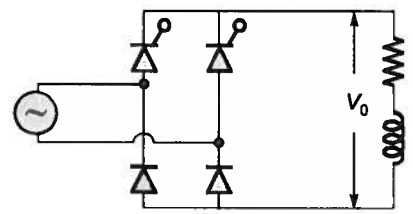
Q.5 In the following circuit, the input voltage V_{in} is 100sin(100pt). For 100pRC = 50, the average voltage across R(in Volts) under steady-state is nearest to



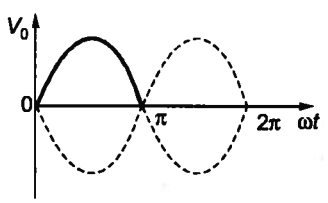
(a) 100 (b) 31.8
(c) 200 (d) 63.6

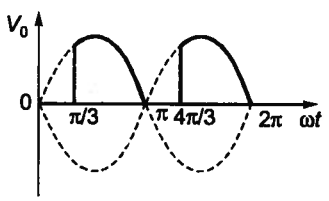
[2015 : 1 Mark, Set-2]

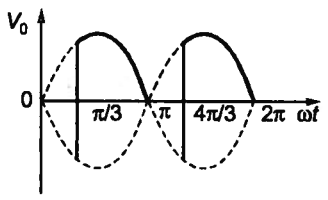
Q.6 A single-phase half controlled converter shown in the figure feeding power to highly inductive load. The converter is operating at a firing angle of 60°.

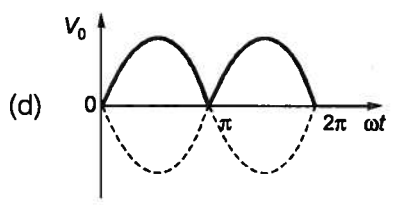


If the firing pulses are suddenly removed, the steady state voltage (V_0) waveform of the converter will become

(a) 

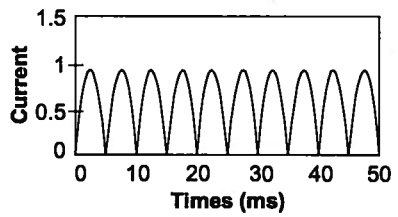
(b) 

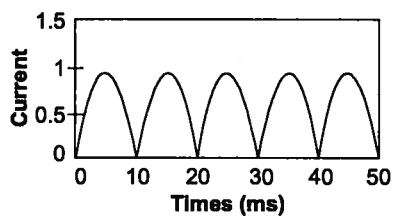
(c) 

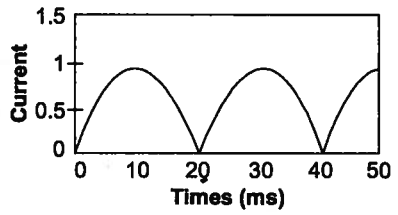
(d) 

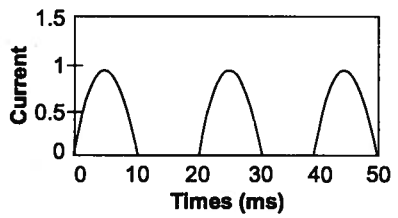
[GATE-2008]

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) 

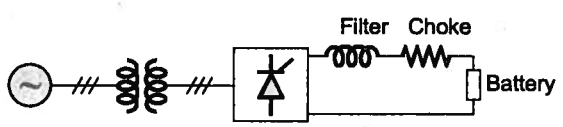
(b) 

(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

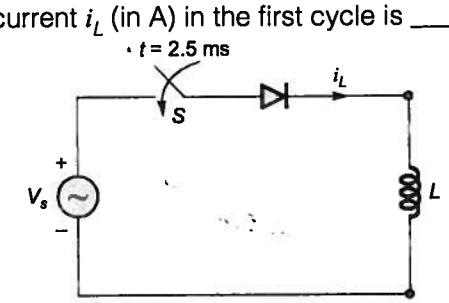
[ESE-2011]

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°

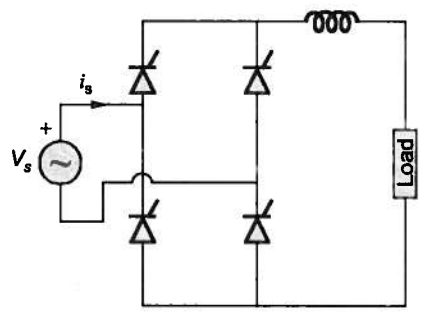
Numerical Data Type Questions

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 _____ .



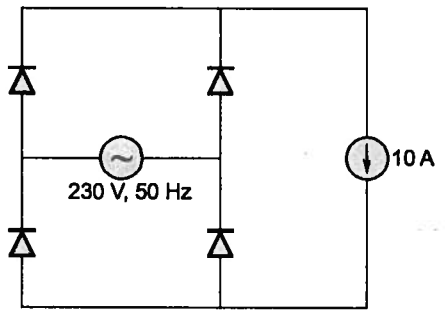
[GATE-2014]

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).

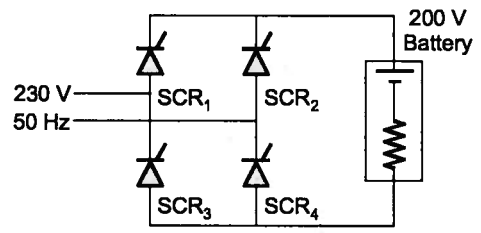


[GATE-2014]

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.

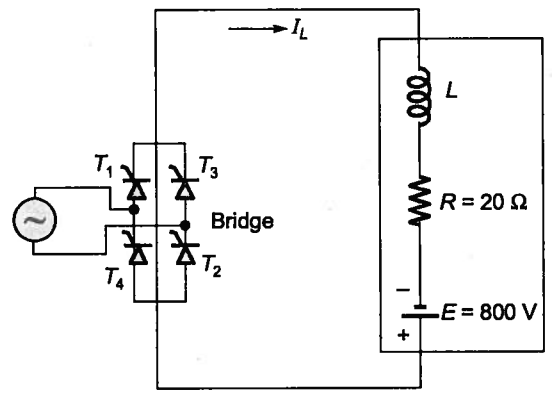
Q.24 A single-phase, 230 V, 50 Hz ac mains fed step down transformer (4 : 1) is supplying power to a half-wave uncontrolled ac-dc converter used for charging a battery (12 V dc) with the series limiting resistor being 19.04 Ω. The charging current is _____ A.

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 _____ %.

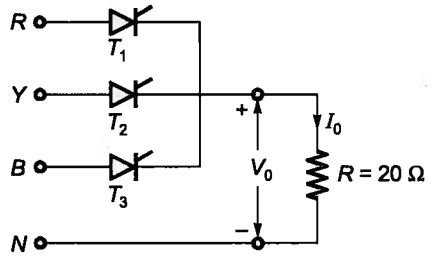
[Ans: (9.55)]

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) $\frac{V_m}{\sqrt{2}}$ (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

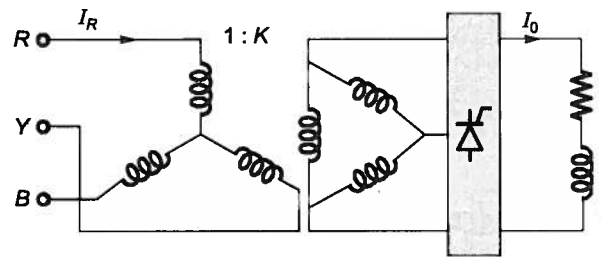
[Ans: (a)]

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.

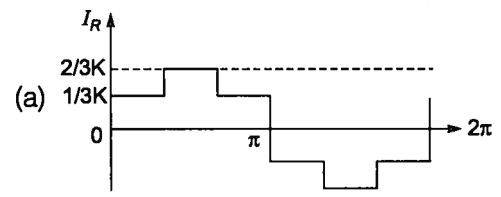
The VA rating of transformer will be _____ kVA. (TUF for 1 - ϕ half wave diode rectifier is 0.2865)

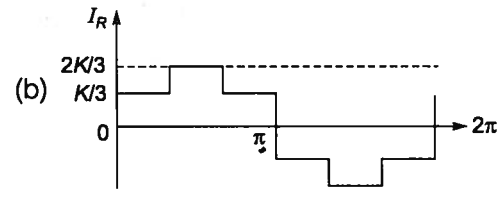
[Ans: (2.50)]

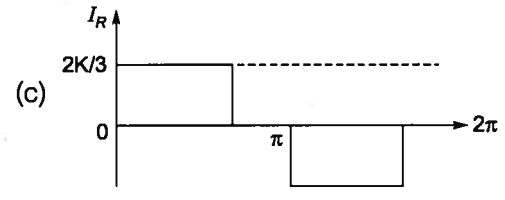
T7. A three-phase fully controlled bridge converter is fed through star-delta transformer as shown in the figure.

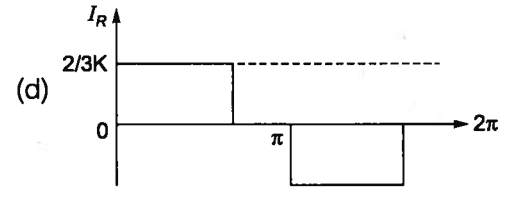


The converter is operated at a firing angle of 30°. Assuming the load current (I_0) to be virtually constant at 1 pu and transformer to be an ideal one, the input phase current waveform is

(a)


(b)


(c)


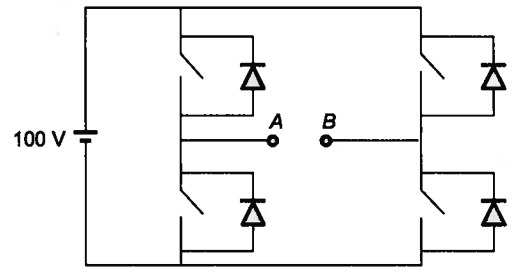
(d)


[Ans: (b)]

3 Inverters

Multiple Choice Questions

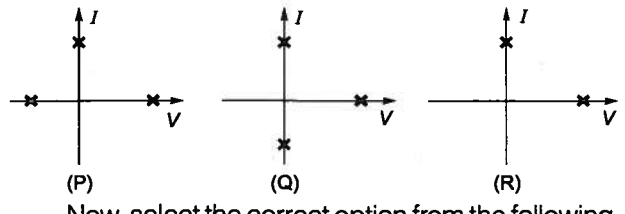
Q.1 A single phase full bridge VSI is operating in 180° square operation. The phase angle between the pole voltages is 45°. The RMS value of the output voltage between two poles is



(a) 100 V (b) $100\frac{\pi}{4}$ V
(c) 200 V (d) 50 V

Q.2 The operating points of three power electronic switches on VI plane is shown below Consider the following statements regarding the switches P, Q, R.

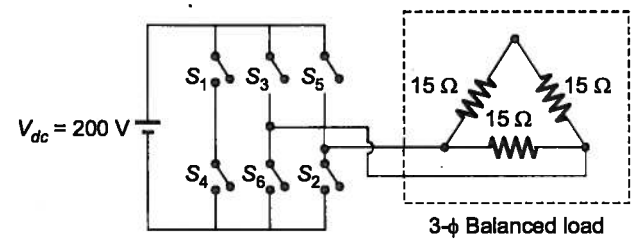
1. P is most suitable for VSI
2. P is most suitable for CSI
3. Q is the most suitable for VSI
4. Q is most suitable for CSI
5. P, Q and R can be used in either VSI or CSI



Now, select the correct option from the following.

(a) Only 2 and 3 are correct
(b) only 1 & 4 are correct
(c) 2, 3 and 5 are correct
(d) All are correct

Q.3 In the 3-ϕ inverter circuit shown, the load is balanced and gating scheme is 120° conduction mode. All the switches are ideal. If the dc source voltage is 200 V, the power consumed by 3-ϕ load is



(a) 5.33 kW (b) 3 kW
(c) 4 kW (d) 1.33 kW

Q.4 A single-phase voltages source inverter is controlled in a single pulse-width modulated mode with a pulse width of 150° in each half cycle. Total harmonic distortion is defined as

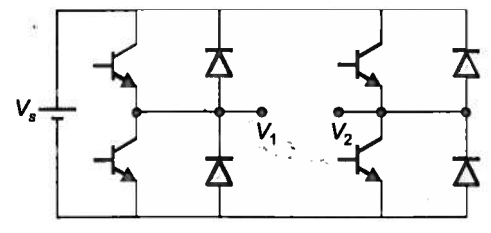
$$\text{THD} = \frac{\sqrt{V_{rms}^2 - V_1^2}}{V_1} \times 100$$

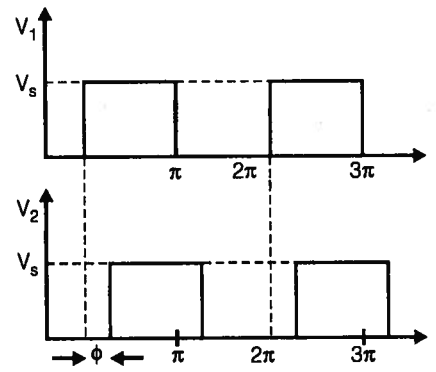
where V_1 is the rms value of the fundamental component of the output voltage. The THD of output ac voltage waveform is

(a) 65.65% (b) 48.42%
(c) 31.83% (d) 30.49%

[GATE-2007]

Q.5





The rms value of the pole to pole voltage V_{12} —

(a) $\frac{V_s.\phi}{\pi\sqrt{2}}$ (b) $V_s\sqrt{\frac{\phi}{\pi}}$

(c) $V_s\sqrt{\frac{\phi}{2\pi}}$ (d) $\frac{V_s}{\pi}$

[GATE-2002]

Q.6 A 3 phase VSI, supplies a purely inductive 3-ϕ load. Upon fourier analysis, the output voltage waveform is found to have an n^{th} order harmonic of magnitude α_n times that of the fundamental component ($\alpha_n < 1$). The load current would then have an n^{th} order harmonic of magnitude

(a) Zero

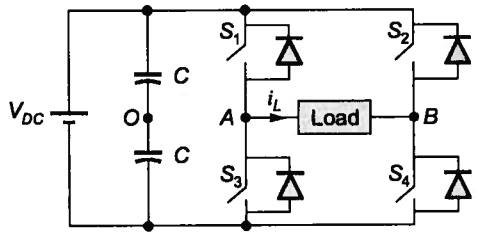
(b) α_n times the fundamental frequency component

(c) $n\alpha_n$ times the fundamental frequency component

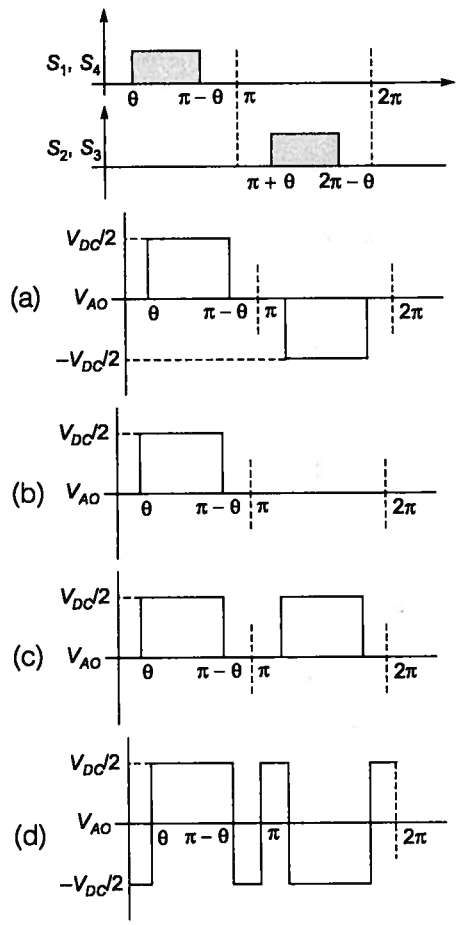
(d) $\frac{\alpha_n}{n}$ times the fundamental frequency component

[GATE-2000]

Q.7 A single-phase voltage source inverter shown in figure is feeding power to a load. The triggering pulses of the devices are also shown in the figure.

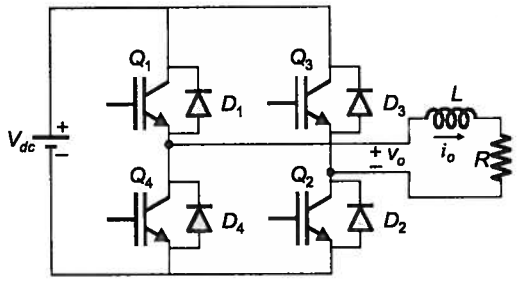


If the load current is sinusoidal and is zero at 0, π, 2π..., the node voltage V_{AO} has the waveform.



[GATE-2014]

Q.8 The Voltage Source Inverter (VSI) shown in the figure below is switched to provide a 50 Hz, square-wave ac output voltage (v_o) across an *R-L* load. Reference polarity of v_o and reference direction of the output current i_o are indicated in the figure. It is given that $R = 3\ \Omega$, $L = 9.55$ mH.



In the interval when $v_o < 0$ and $i_o > 0$ the pair of devices which conducts the load current is

(a) Q_1, Q_2 (b) Q_3, Q_4

(c) D_1, D_2 (d) D_3, D_4

[GATE-2013]

Q.9 The output voltage of a 3-phase voltage source inverter contains 5th and 7th harmonics. Assume the output is balanced.

If $V_a = V_{1m}\sin(\omega t) + V_{5m}\sin(5\omega t) + V_{7m}\sin(7\omega t)$ Volt, then V_b can be expressed as

(a) $V_b = V_{1m}\sin\left(\omega t - \frac{2\pi}{3}\right) + V_{5m}\sin(5\omega t) + V_{7m}\sin(7\omega t)$ Volt

(b) $V_b = V_{1m}\sin\left(\omega t - \frac{2\pi}{3}\right) + V_{5m}\sin\left(5\omega t + \frac{2\pi}{3}\right) + V_{7m}\sin\left(7\omega t - \frac{2\pi}{3}\right)$ Volt

(c) $V_b = V_{1m}\sin\left(\omega t - \frac{2\pi}{3}\right) + V_{5m}\sin\left(5\omega t - \frac{2\pi}{3}\right) + V_{7m}\sin\left(7\omega t + \frac{2\pi}{3}\right)$ Volt

(d) None of the above

Q.10 A voltage source inverter will have better performance if its

(a) load inductance is small and source inductance is large

(b) both load and source inductances are small

(c) both load and source inductances are large

(d) load inductance is large and source inductance is small

Q.11 Use of reverse conducting thyristor in place of antiparallel combination of thyristor and feedback diode in an inverter

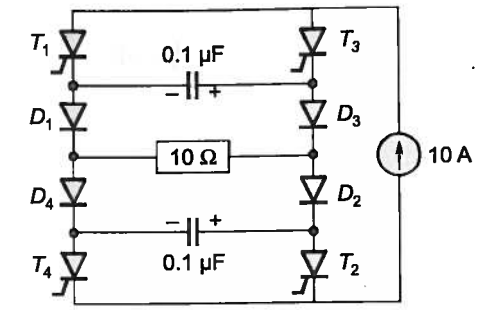
(a) effectively minimizes the peak commutating current

(b) decreases the operating frequency of operation

(c) minimizes the effects of load inductances on the commutation performance

(d) causes deterioration in the commutation performance

Q.12 The current source Inverter shown in figure is operated by alternately turning on thyristor pairs (T_1, T_2) and (T_3, T_4). If the load is purely resistive, the theoretical maximum output frequency obtainable will be

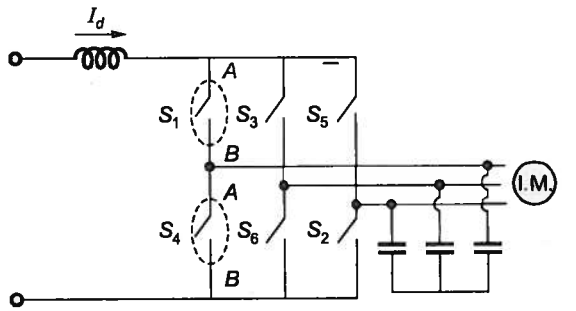


(a) 125 kHz (b) 250 kHz

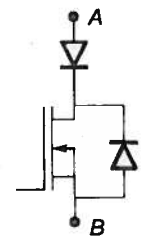
(c) 500 kHz (d) 50 kHz

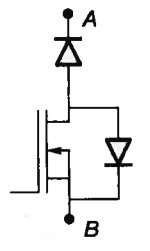
[GATE-2009]

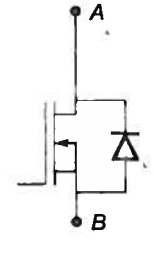
Q.13 A three-phase current source inverter used for the speed control of an induction motor is to be realized using MOSFET switches as shown below. Switches S_1 to S_6 are identical switches.

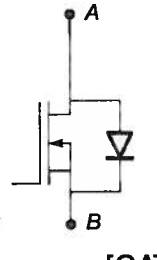


The proper configuration for realizing switches S_1 to S_6 is

(a) 

(b) 

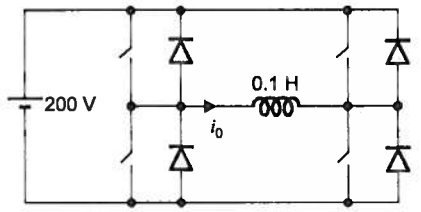
(c) 

(d) 

[GATE-2011]

Numerical Data Type Questions

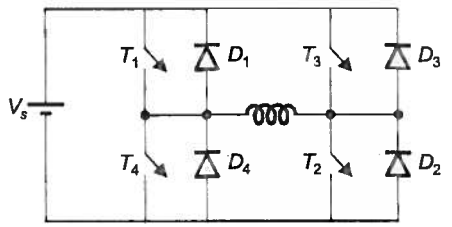
Q.14 A single phase voltage source inverter is feeding a purely inductive load as shown in the figure



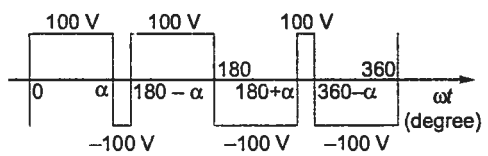
The inverter is operated at 50 Hz in 180° square wave mode. Assume that the load current does not have any dc component. The peak value of the inductor current i_0 will be _____ A.

[GATE-2008]

Q.15 A single-phase full bridge VSI feeds a purely inductive load as shown in the figure. The inverter is operated in square wave mode with a frequency of 50 Hz. If the average load curent is 0, the time duration of conduction of each feedback diode in a cycle is _____ ms.

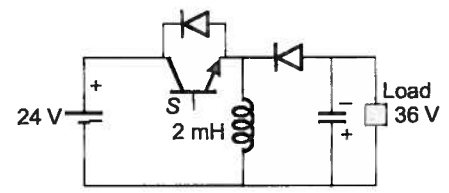


Q.16 The figure shows one period of the output voltage of an inverter. α should be chosen such that $60° < \alpha < 90°$. If rms value of the fundamental component is 50 V, then α in degree is _____.



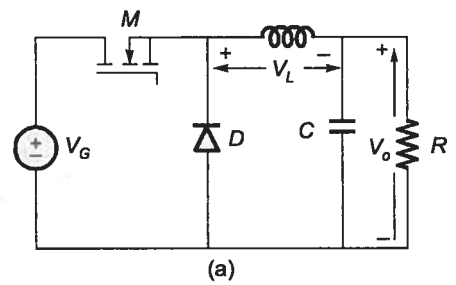
[GATE-2014]

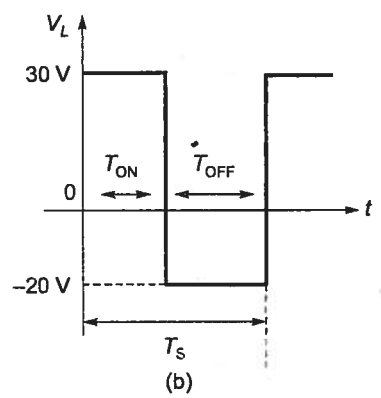
Q.17 A buck-boost DC-DC converter, shown in the figure below, is used to convert 24 V battery voltage to 36 V DC voltage to feed a load of 72 W. It is operated at 20 kHz with an inductor of 2 mH and output capacitor of 1000 µF. All devices are considered to be ideal. The peak voltage across the solid-state switch (S), in volt, is _____.



[GATE-2016]

Q.18 A buck converter, as shown in Figure (a) below, is working in steady state. The output voltage and the inductor current can be assumed to be ripple free. Figure (b) shows the inductor voltage V_L during a complete switching interval. Assuming all devices are ideal, the duty cycle of the buck converter is _____.





[GATE-2016]

Conventional Questions

Q.19 A single-phase full bridge inverter delivers power to RLC load with $R = 3\ \Omega$ and $X_L = 12\ \Omega$. The bridge operates with a periodicity of 0.2 ms. Calculate the value of C so that load commutation is achieved for the thyristors. Turnoff time for thyristors is 12 µs. Factor of safety is 2. Assume the load current to contain only fundamental component.

Q.20 A star connected load of 15 Ω per phase is fed from 420 V d.c. source through a 3-phase bridge inverter. For both (a) 180° and (b) 120°.

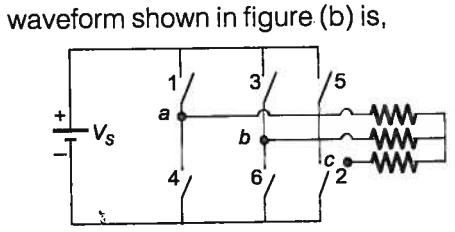
Determine:

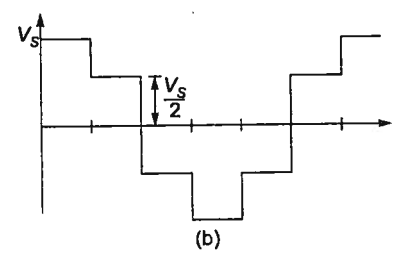
(*i*) rms value of load current
(*ii*) rms value of thyristor current
(*iii*) load power

Also find above parameters for Δ connected load $R = 15\ \Omega$.

Try Yourself

T1. Figure (a) shows a 3-ϕ inverter fed by a constant voltage source V_s and connected to a balanced resistive load at the output. Each switching device may conduct for 120° or for 180°. The waveform shown in figure (b) is,





(a) line voltage with 120° firing
(b) load phase voltage with 120° firing
(c) line voltage with 180° firing
(d) load phase voltage with 180° firing

[Ans: (a)]

T2. A single phase full bridge inverter is fed from a dc source such that fundamental component of output voltage is 230 V. The rms value of thyristor current if the load is $R = 2\ \Omega$, $X_L = 8\ \Omega$ and $X_C = 6\ \Omega$ is _____ A.

[Ans: (54.82)]

T3. A single-phase full bridge inverter has RLC load of $R = 4\ \Omega$, $L = 35$ mH and $C = 155$ µF. The dc input voltage is 230 V and output frequency is 50 Hz. The 3rd harmonic component in load current is

(a) 1.6 A (b) 2.24 A
(c) 1.98 A (d) 2.61 A

[Ans: (d)]

T4. For a single-phase full-bridge inverter, $V_s = 230$ V dc, $T = 1$ ms. The load consists of RLC in series with $R = 1\ \Omega$, $\omega L = 6\ \Omega$ and $\frac{1}{\omega C} = 7\ \Omega$.

(a) Sketch the waveforms for load voltage V_0, fundamental component of load current i_{01}, source, current i_s and voltage across thyristor 1. Indicate the devices under conduction during different intervals of one cycle.
(b) Find the power delivered to load due to fundamental component.
(c) Check whether forced commutation is required or not. Take thyristor turn-off time as 100 µs.

[Ans: (b) 21.443 kW]

T5. A single-phase full bridge inverter, employing transistors, is fed from 220 V DC and output frequency is 50 Hz. Load is RLC with $R = 6\ \Omega$, $L = 30$ mH and $C = 180$ µF.

(a) Calculate THD of the output voltage and its distortion factor.
(b) Obtain an expression for load current in Fourier series. also compute
(c) THD of the load current and its distortion factor
(d) Load power and average DC source current.

Considering only the fundamental component of load current, calculate :

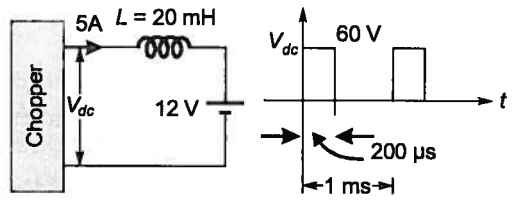
(e) conduction time of each transistor and diode and
(f) peak and rms current of each transistor.

[Ans: (a) 48.34%, 0.9, (c) 15.55%, 0.988, (d) 2314.4 W, 10.52 A, (e) 7 ms, 3 ms, (f) 27.44 A, 12.66 A]

4 Choppers

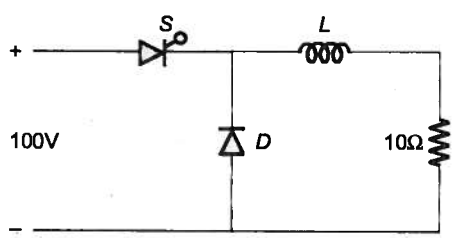
Multiple Choice Questions

Q.1 A chopper is employed to charge a battery as shown in figure. The charging current is 5 A. The duty ratio is 0.2. The chopper output voltage is also shown in figure. The peak to peak ripple current in the charging current is



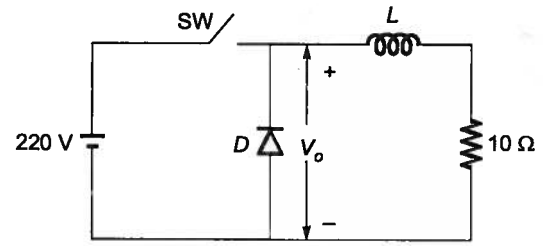
(a) 0.48 A (b) 1.2 A
(c) 2.4 A (d) 1 A **[GATE-2003]**

Q.2 Figure shows a chopper operating from a 100 V dc input. The duty ratio of the main switch S is 0.8. The load is sufficiently inductive so that the load current is ripple free. The average current through the diode *D* under steady state is



(a) 1.6 A (b) 6.4 A
(c) 8.0 A (d) 10.0 A **[GATE-2004]**

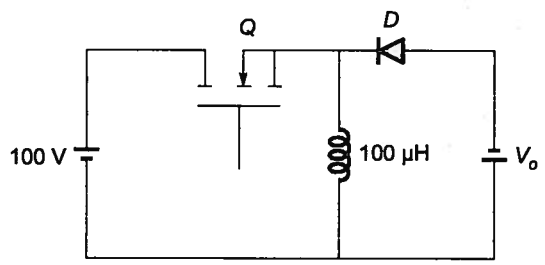
Q.3 The following chopper circuit is operating at a switching frequency of 1 kHz with a duty cycle ratio of 50%. Assume a voltage drop of 2 V across the switch when it is ON. Find the converter circuit efficiency.



(a) 95% (b) 98%
(c) 100% (d) 99%

Q.4 In the above question, the minimum average output voltage of the chopper will be
(a) 70 V (b) 47.5 V
(c) 35 V (d) 0 V **[GATE-2006]**

Q.5 In the following circuit, MOSFET Q is switched at 100 kHz with a duty ratio of 0.5. MOSFET is having an ON state resistance of 1 Ω when it is ON. Find average conduction losses in MOSFET

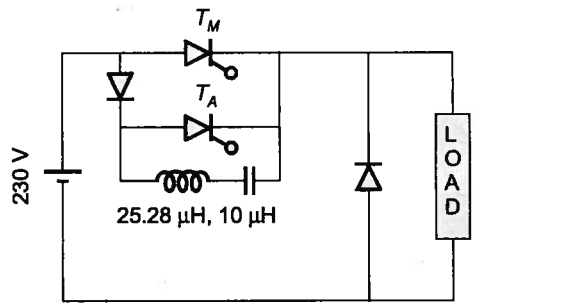


(a) 20.41 W (b) 41.67 W
(c) 12.5 W (d) 4.1667 W

Q.6 The average load current of a D.C. chopper feeding a pure resistive load is I amps. If a variable inductance connected in the load circuit is progressively increased from zero value, keeping the duty ratio unchanged, then the average load current will
(a) increase starting from I
(b) decrease with a starting value of I
(c) remain the same at I
(d) increase to some highest value of current and then decrease again to I **[IAS-1998]**

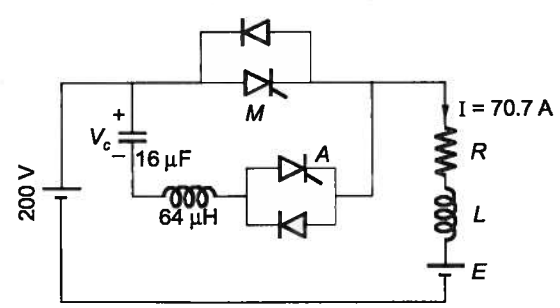
Q.7 In a step down chopper, for eliminating 5th harmonic from the output voltage wave, the ripple factor sould be
(a) 1 (b) 2
(c) 3 (d) 4

Q.8 The circuit in the figure is a current commutated dc - dc chopper where T_M is the main SCR and T_A is the auxiliary SCR. The load current is constant at 10 A. T_M is ON. T_A is triggered at $t = 0$. T_M is turned off between



(a) 0 μs < t < 25 μs (b) 25 μs < t < 50 μs
(c) 50 μs < t ≤ 75 μs (d) 75 μs < t < 100 μs **[GATE-2007]**

Q.9 The capacitor is charged with 200 V before the main thyristor is ON. The maximum current in the main SCR can be



(a) 200 A (b) 170.7 A
(c) 141.14 A (d) 70.7 A

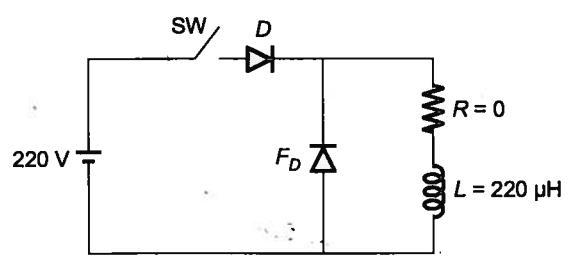
Q.10 The stepdown chopper operates from a D.C. voltage source V_s and feeds a D.C. motor with a back emf E_b. From oscilloscope traces it is found that the current increases for time t_r, falls to zero over time t_f and remains zero for time t_0, in every chopping cycle. Then the average D.C. voltage across the free-wheeling diode is

(a) $\frac{V_s t_r}{t_r + t_f + t_0}$ (b) $\frac{V_s t_r + E_b t_f}{t_r + t_f + t_0}$

(c) $\frac{V_s t_r + E_b t_0}{t_r + t_f + t_0}$ (d) $\frac{V_s t_r + E_b (t_f + t_0)}{t_r + t_f + t_0}$ **[GATE-2000]**

Q.11 A D.C. to D.C. transistor chopper supplied from a fixed voltage D.C. source feeds a fixed RL load with freewheeling diode. The chopper operates at 1 kHz and 50% duty cycle. Without changing the value of the average D.C. current through the load, if it is desired to reduce the ripple content of the load current, the control action needed will be to
(a) increase the chopper frequency keeping its duty cycle constant.
(b) increase the chopper frequency and duty cycle in equal ratio.
(c) decrease only the chopper frequency.
(d) decrease only the duty cycle. **[ESE-2010]**

Q.12 An RL load is connected to DC voltage source of 220 V through a diode as shown below. A free wheeling diode is connected across the load to recover the trapped energy. Assume that switch is closed for 100 ms and then opened. Find the final energy stored in the inductor by assuming negligible load resistance.



(a) 1 J (b) 0.5 J
(c) 1.5 J (d) 1.1 J

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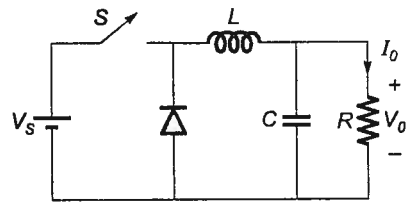
Q.13 In the above question, the PEAK-TO-PEAK source current ripple in Amps is

(a) 0.96 (b) 0.144

(c) 0.192 (d) 0.288

[GATE-2013]

Q.14 In a buck converter, as shown in the figure:



The ripple in the output voltage depends on

(a) C, α (b) C, α, f

(c) L, C, α, f (d) L, α, f

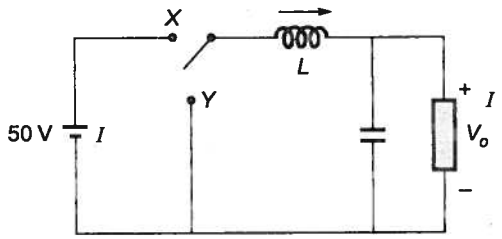
Q.15 What is the waveform of the current flowing through the diode in a buck-boost converter?

(a) square wave (b) triangular wave

(c) trapezoidal wave (d) sinusoidal wave

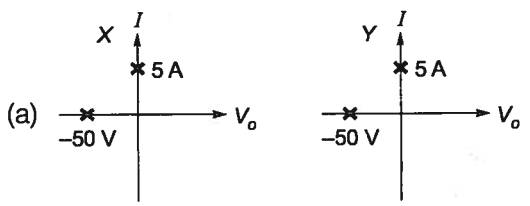
[ESE-2011]

Q.16 A Power converter is shown in the figure has two power switching devices namely *X* and *Y*. The source voltage is 50 V. The inductor current is steady 5 A without any ripple.

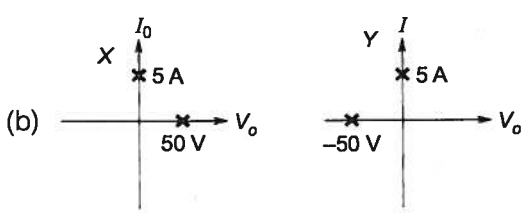


On the V-I plane, identify the correct operating points of switches from the given options.

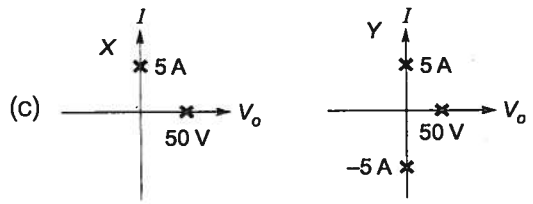
(a)



(b)

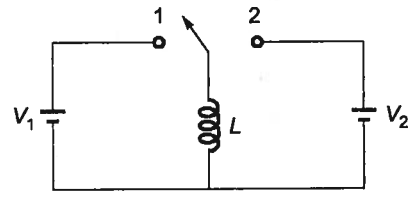


(c)



(d) None

Q.17 In the following DC-DC converter circuit the switch is operating at frequency 10 kHz. When the switch is at position 1, the inductor stores energy for a period of 50 μs and release energy is 20 μs when the switch is moved to position 2. Find ratio of V_1/V_2.

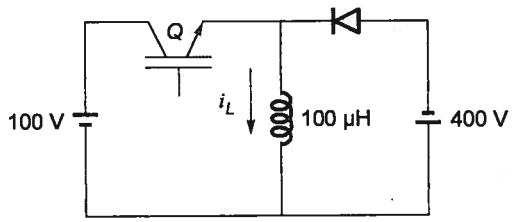


(a) $\frac{2}{5}$ (b) $\frac{5}{2}$

(c) $\frac{7}{2}$ (d) $\frac{2}{7}$

Numerical Data Type Questions

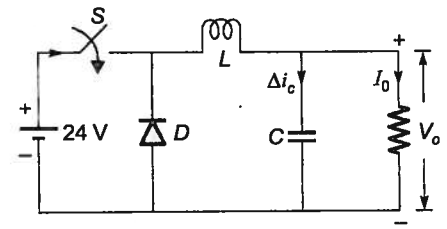
Q.18 In the following chopper circuit, The IGBT Q is switched at 10 kHz. The circuit is operated in steady state at the boundary of continuous and discontinuous inductor current. If IGBT has a constant voltage drop of 0.5 V when it is ON, Find the conduction loss in IGBT.



(a) 853 W (b) 16 W

(c) 32 W (d) None

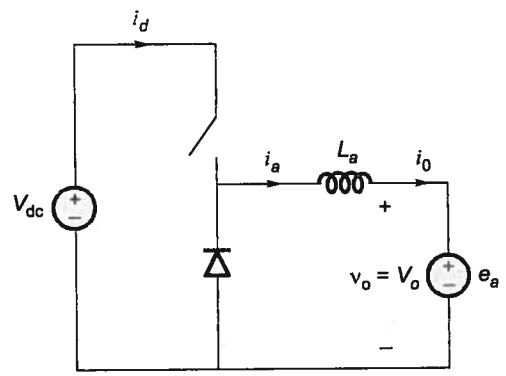
Q.19 In the circuit shown below, an ideal switch *S* is operated at 100 Hz with a duty ratio of 50%. Given that ΔI_C = 1.6 A peak to peak and I_0 is 5 A D.C., the peak current in *S* is _____ A.



[GATE-2012]

Statement for Linked Answer Questions (20 and 21):

The chopper below controls a dc machine with an armature inductance L_a = 0.2 mH. The armature resistance can be neglected. The armature current is 5 A. f_s = 30 kHz and D = 0.8.



Q.20 The average output voltage V_0, equals to 200 V. Calculate the ripple in armature current.

(a) 8.332 A (b) 2.5 A

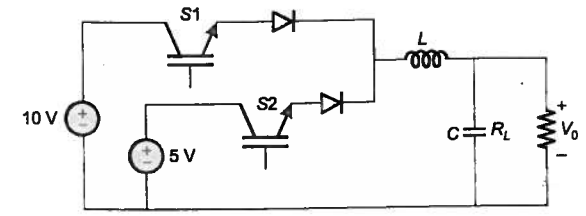
(c) 6.667 A (d) 1.6675 A

Q.21 The load on the dc machine is now reduced and $I_{a,max}$ = 2 A. The current is now discontinuous. What is the back emf voltage E_a?

(a) 250 V (b) 200 V

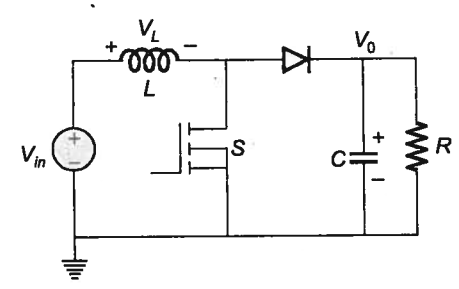
(c) 175 V (d) 235 V

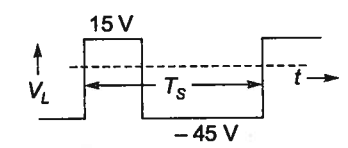
Q.22 The circuit shown is meant to supply a resistive load R_L from two separate DC voltage sources. The switches *S*1 and *S*2 are controlled so that only one of them is ON at any instant. *S*1 is turned on for 0.2 ms and *S*2 is turned on for 0.3 ms in a 0.5 ms switching cycle time period. Assuming continues conduction of the inductor current and negligible ripple on the capacitor voltage, the output voltage V_0 (in Volt) across R_L is _____.



[2015 : 2 Marks, Set-1]

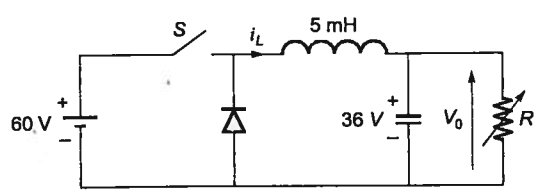
Q.23 For the switching converter shown in the following figure, assume steady-state operation. Also assume that the components are ideal, the inductor current is always positive and continuous and switching period is T_s. If the voltage V_L is as shown, the duty cycle of the switch *S* is _____.





[2015 : 2 Marks, Set-2]

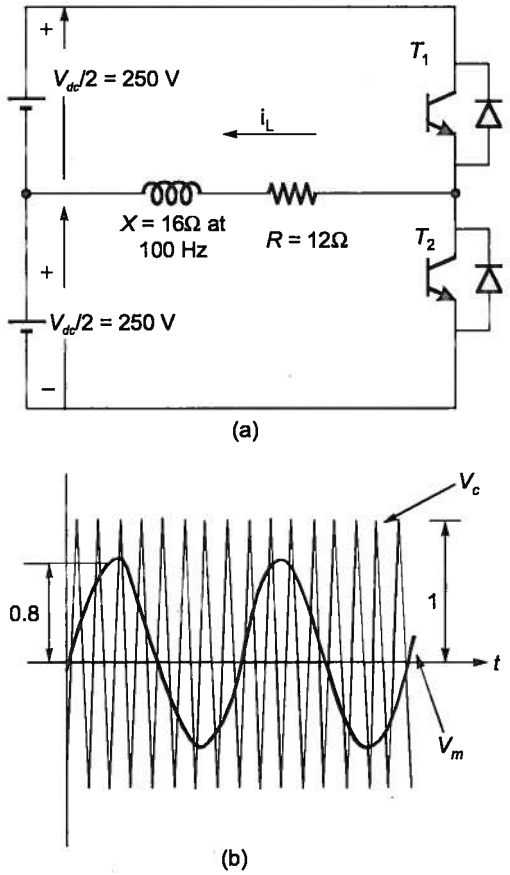
Q.24 A buck converter feeding a variable resistive load is shown in the figure. The switching frequency of the switch *S* is 100 kHz and the duty ratio is 0.6. The output voltage V_0 is 36 V. Assume that all the components are ideal, and that the output voltage is ripple-free. The value of *R* (in Ohm) that will make the inductor current (i_L) just continuous is _____.



[2015 : 2 Marks, Set-2]

Q.25 The switches T1 and T2 in Figure (a) are switched in a complementary fashion with sinusoidal pulse width modulation technique.

The modulating voltage $v_m(t) = 0.8 \sin(200\pi t)$ V and the triangular carrier voltage (v_c) are as shown in Figure (b). The carrier frequency is 5 kHz. The peak value of the 100 Hz component of the load current (i_L), in ampere is _____.

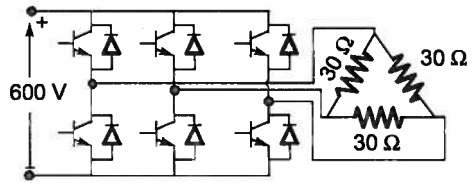


[GATE-2016]

Q.26 A single-phase full-bridge voltage source inverter (VSI) is fed from a 300 V battery. A pulse of 120° duration is used to trigger the appropriate devices in each half-cycle. The rms value of the fundamental component of the output voltage, in volts, is

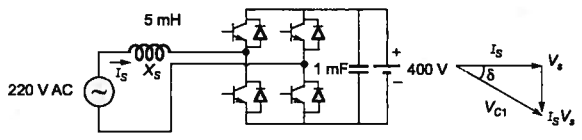
(a) 234 (b) 245
(c) 300 (d) 331 **[GATE-2016]**

Q.27 A three-phase Voltage Source Inverter (VSI) as shown in the figure is feeding a delta connected resistive load of 30 Ω/phase. If it is fed from a 600 V battery, with 180° conduction of solid-state devices, the power consumed by the load, in kW, is_____.



[GATE-2016]

Q.28 A single-phase bi-directional voltage source converter (VSC) is shown in the figure below. All devices are ideal. It is used to charge a battery at 400 V with power of 5 kW from a source V_s = 220 V (rms), 50 Hz sinusoidal AC mains at unity p.f. If its AC side interfacing inductor is 5 mH and the switches are operated at 20 kHz, then the phase shift (δ) between AC mains voltage (V_s) and fundamental AC rms VSC voltage (VC1), in degree, is _____.



[GATE-2016]

Conventional Questions

Q.29 A voltage commutated chopper has the following parameters:

V_s = 220 V, Load circuit parameters, R = 0.5 Ω, L = 2 mH, E = 40 V

Commutation circuit parameters

L = 20 μH, C = 50 μH

T_{ON} = 800 μs, T = 2000 μs

For a constant load current of 80 A, compute the following:

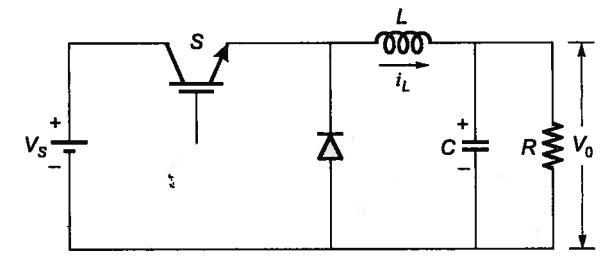
(a) effective on period
(b) peak currents through main thyristor 'T_m' and auxiliary thyristor T_A
(c) turnoff times of T_m and T_A
(d) total commutation interval
(e) capacitor voltage 150 μs after T_A is triggered

Q.30 A step down D.C. chopper has load resistance of 20 Ω. Chopper input voltage is 200 V (D.C). The chopper switch has the voltage drop of 1.5 V when conducting. If the chopper frequency is 2 kHz. Find the input and output power of the chopper at the duty cycle of 0.5. Also find chopper efficiency.

[ESE-2009]

Try Yourself

T1. In the chopper circuit shown in figure, the input dc voltage has a constant value V_s. The output voltage V_0 is assumed ripple free. The switch S is operated with a switching time period T and a duty ratio D. What is the value of critical inductance (L_C) at the boundary of continuous and discontinuous conduction of the inductor current i_L?

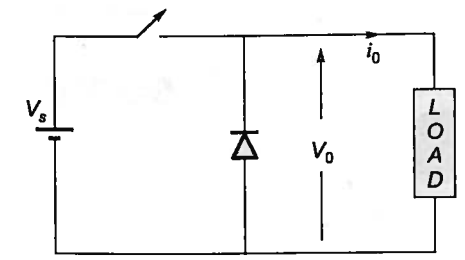


(a) $L_C = \frac{\alpha V_s(1-\alpha)}{2I_0 f}$ (b) $L_C = \frac{V_0(2f I_0)}{(1-\alpha)I_0^2}$

(c) $L_C = \frac{V_0(1-f)}{2\alpha I_0}$ (d) $L_C = \frac{V_s(1-\alpha^2)}{2I_0 f}$

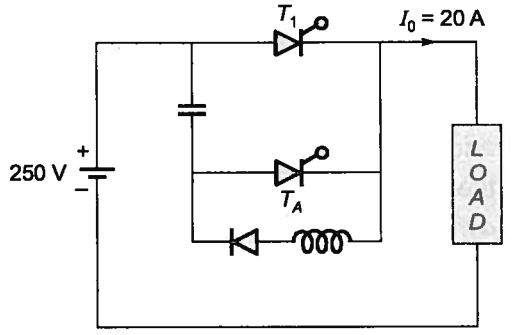
[Ans: (a)]

T2. A chopper circuit shown below has input DC voltage of 200 V and a load of R = 10 Ω. In series with L = 80 mH. If load current varies linearly between 12 A and 16 A, then time ratio $\frac{T_{ON}}{T_{OFF}}$ for this chopper is _____.



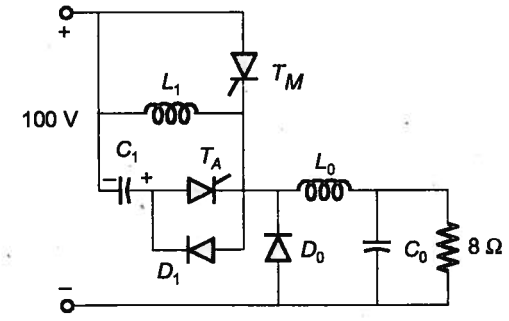
[Ans: (2.33)]

T3. In a voltage commutated chopper DC voltage input V = 250 V, constant load current I_0 = 20 A, chopper frequency = 250 Hz, commutating components L = 1.25 mH and C = 8 μF.
The maximum load or output voltage is ____ V.



[Ans: (250)]

T4. In the chopper circuit shown, the main thyristor (T_M) is operated at a duty ratio of 0.8 which is much larger the commutation interval. If the maximum allowable reapplied dv/dt on T_M is 50 V/μs, what should be the theoretical minimum value of C_1? Assume current ripple through L_0 to be negligible.



(a) 0.2 μF (b) 0.02 μF
(c) 2 μF (d) 20 μF

[Ans: (a)]

5 Resonant Converters & Power Electronics Applications (Drives, SMPS)

Multiple Choice Questions

Q.1 A 3-phase wound rotor induction motor is controlled by a chopper-controlled resistance in its rotor circuit. A resistance of 2 Ω is connected in the rotor circuit and a resistance of 4 Ω is additionally connected during OFF periods of the chopper. The OFF period of the chopper is 4 ms. The average resistance in the rotor circuit for the chopper frequency of 200 Hz is

(a) 26/5 Ω (b) 24/5 Ω
(c) 18/5 Ω (d) 16/5 Ω

[ESE-2001]

Q.2 For low-speed high-power reversible operation, the most suitable drives are

(a) Voltage source inverter fed A.C. drives
(b) Current source inverter fed A.C. drives
(c) Dual converted fed D.C. drives
(d) Cycloconverter fed A.C. drives

[ESE-2011]

Q.3 In a switched mode power supply (SMPS), after conversion of A.C. supply to a highly filtered D.C. voltage, a switching transistor is switched ON and OFF at a very high speed by a pulse width modulator (PWM) which generates very high frequency square pulses. The frequency of the pulses is typically in the range of

(a) 100 Hz - 200 Hz (b) 500 Hz - 1 kHz
(c) 2 kHZ - 5 kHz (d) 20 kHz - 50 kHz

[ESE-2002]

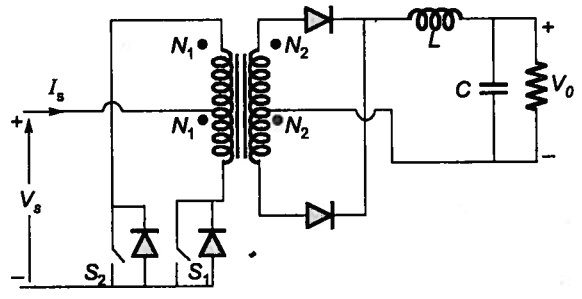
Q.4 What are the advantages of switching power supplies over linear power supplies?

1. The devices operate in linear/active region.
2. The devices operate as switches.
3. Power losses are less.

Select the correct answer using the code given below:

(a) 1 and 3 (b) 2 and 3
(c) 1 and 2 (d) 1, 2 and 3

Q.5 In push-pull type DC-DC converter the output voltage V_0 is given by



(a) $V_0 = 2\frac{N_2}{N_1}V_s\left(\frac{t_{ON}}{t_{ON}+t_{OFF}}\right)$

(b) $V_0 = \frac{N_2}{N_1}V_s\left(\frac{t_{ON}}{t_{ON}+t_{OFF}}\right)$

(c) $V_0 = 2\frac{N_2}{N_1}V_s\left(\frac{t_{ON}}{t_{OFF}}\right)$

(d) $V_0 = \frac{N_2}{N_1}\cdot V_s\left(\frac{t_{ON}}{t_{OFF}}\right)$

[ESE-2010]

Q.6 Resonant mode power supplies in comparison to square mode ones

(a) have smaller component count
(b) have negligible power loss
(c) do not cause over voltages
(d) slower in control action

Q.7 Resonant converters are basically used to

(a) generate large peak voltages
(b) reduce the switching losses
(c) eliminate harmonics
(d) convert a square wave into a sine wave

Numerical Data Type Questions

Q.8 An ac induction motor is used for a speed control application. It is driven from an inverter with a constant *V/f* control. The motor name-plate details are as follows (number of poles = 2)
V: 415 V, Ph : 3, *f*: 50 Hz, *N*: 2850 rpm.
The motor is run with the inverter output frequency set at 40 Hz, and with half the rated slip. The running speed of the motor is ___ rpm.

[GATE-2003]

Q.9 A three-phase, 440 V, 50 Hz A.C. mains fed thyristor bridge is feeding a 440 V D.C., 15 kW 1500 rpm separately excited D.C. motor with a ripple free continuous current in the D.C. link under all conditions, neglecting the losses, the power factor of the A.C. mains at half the rated speed is _____ . **[GATE-2007]**

Q.10 A D.C. chopper is used in regenerative braking mode of a D.C. series motor. The D.C. supply is 600 V, the duty cycle is 70%. The average value of armature current is 100 A. It is continuous and ripple free. The value of power feedback to the supply is _____ kW.

[ESE-2009]

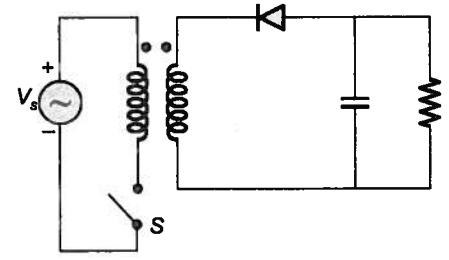
Q.11 A D.C. series motor has parameter $R_a = 3\ \Omega$ and $R_f = 3\ \Omega$. The motor speed is varied by a semi controlled bridge rectifier. The firing angle is 45° and average speed of the motor is 1450 rpm. The applied A.C. voltage to the bridge is 330 sinωt. If the armature current of motor is 5 A, the torque of the motor is _____ N-m.

Q.12 A separately excited D.C. motor of 220 V, 100 A, 2100 rpm has armature resistance as 0.1 Ω and inductance as 5 mH. The motor is fed by a chopper which is operating from a D.C. supply of 250 V. If the chopper operating with 0.4 duty ratio, the speed of motor at rated torque is _____ rpm.

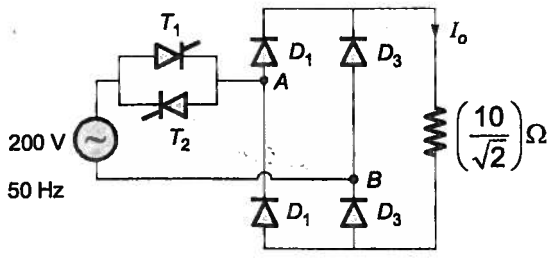
Q.13 A six pulse cyclo-converter, fed from 3-phase, 400 V, 50 Hz source, is delivering a load current of 40 A to a single-phase resistive load. The source has an inductance of 1.2 mH per phase. The rms value of load voltage for firing angle delay of 0° is _____ V.

Q.14 A separately-excited dc motor, operating from a single-phase half-controlled bridge at a speed of 1400 rpm, has an input voltage of 330 sin 314t and a back emf 80 V. The SCRs are fired symmetrically at $\alpha = 30°$ in every half cycle and the armature has a resistance of 4 Ω. The motor torque will be _____ Nm.

Q.15 For the isolated buck boost converter as shown in the circuit below, the output voltage is to be 35 V at a duty cycle of 30%. The DC input is obtained from a front end rectifier without voltage doubling fed from a 115 V AC. The peak forward blocking voltage of the switching element is ___ V.



Q.16 In the following circuit. The RMS value of load current in amps by assuming $\alpha = 90°$ is ____ (in amp).



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Conventional Questions

Q.17 A capacitor is connected across an ac regulator feeding inductor (TCR). Input is at 230 V, 50 Hz and inductive reactance (X_L) = 10 Ω; capacitive reactance (X_C) = 10 Ω. Calculate the net VAR supplied by the circuit at $\alpha = 135°$.

[ESE-2013]

Q.18 Explain forward converter with relevant waveforms. What is the need of tertiary winding in the forward converter?

Q.19 A 250 V separately excited DC motor has armature resistance of 2.5 ohms. When driving a load at 600 r.p.m. with constant torque, the armature takes 20 A. The motor is controlled by a DC chopper operating with a frequency of 400 Hz and an input voltage of 250 V DC. What should be the value of duty ratio, if it is desired to reduce the speed from 600 r.pm. to 400 r.p.m.? Also find the motor speed at rated current and a duty ratio of 0.5, if the motor is regenerating.

[ESE-2002]

Try Yourself

T1. In a 3-ϕ to 1-ϕ cyclo converter employing 3-pulse positive and negative group converters, if the input voltage is 200 V per phase, the fundamental rms value of output voltage would be

(a) $\frac{600}{\pi}$ V (b) $300\sqrt{3}$ V

(c) $\frac{300\sqrt{3}}{\pi}$ V (d) $\frac{300}{\pi}$ V

[Ans: (c)]

T2. A six pulse cyclo-converter, fed from 3-phase, 400 V, 50 Hz source, is delivering a load current of 40 A to a single-phase resistive load. The source has an inductance of 1.2 mH per phase. The rms value of load voltage for firing angle delay of 0° is _____.

(a) 320.42 V (b) 371.78 V

(c) 346.12 V (d) 399.24 V

[Ans: (b)]

T3. A single phase voltage controller has input voltage of 230 V, 50 Hz and a load of $R = 15\ \Omega$. For 8 cycles ON and 6 cycles OFF the average thyristor currents is

(a) 4.2 A (b) 3.9 A

(c) 3.24 A (d) 6.4 A

[Ans: (b)]

T4. A DC chopper is used for regenerative braking of a separately excited dc motor. The dc supply voltage is 400 V. The motor has $r_a = 0.2\ \Omega$, $K_m = 1.2$ V-s/rad. The average armature current during regenerative braking is kept constant at 300 A with negligible ripple. If the duty cycle of chopper is 60% then the minimum and maximum permissible braking speeds are respectively

(a) 477 rpm and 3660 rpm

(b) 314 rpm and 4126 rpm

(c) 512 rpm and 3660 rpm

(d) 477 rpm and 4126 rpm

[Ans: (c)]

T5. In a speed controlled dc drive, the load torque is 40 N-m. At time $t = 0$, the operation is under steady state and the speed is 500 rpm. Under this condition at $t = 0^+$, the generated torque is instantly increased to 100 Nm. The inertia of the drive is 0.01 Nm-sec²/rad. The friction is negligible.

The time taken for the speed to reach 1000 rpm is _____ ms.

[Ans: (87.30)]

T6. A 220 V, 1500 rpm, 10 A separately excited dc motor has an armature resistance of 1 Ω. It is fed from a single phase fully controlled bridge rectifier with an ac source voltage of 230 V, 50 Hz. Assuming continuous load current, the motor speed at the firing angle of 30° and torque of 5 Nm is _____ rpm.

[Ans: (1254)]

T7. SMPSs are superior to linear power supplies in respect of

(a) size and efficiency

(b) efficiency and regulation

(c) regulation and noise

(d) noise and cost.

[Ans: (a)]

T8. Consider the following statements:

Switched mode power supplies are preferred over the continuous types, because these are

1. suitable for use in both AC and DC
2. more efficient
3. suitable for low power circuits
4. suitable for high power circuits

Of these statements, the correct is

(a) 1 and 2 (b) 1 and 3

(c) 2 and 3 (d) 2 and 4

[Ans: (c)]