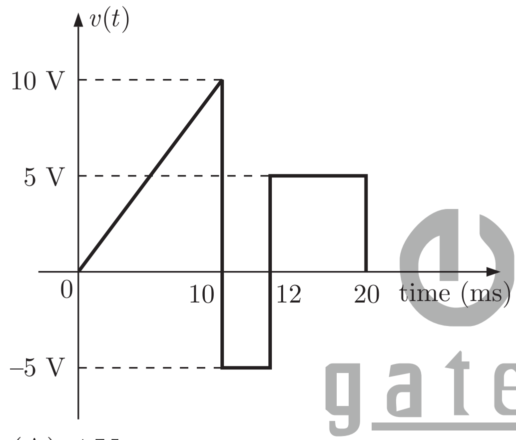
CHAPTER 7

ELECTRICAL & ELECTRONIC MEASUREMENTS

YEAR 2012 **ONE MARK**

MCQ 7.1 A periodic voltage waveform observed on an oscilloscope across a load is shown. A permanent magnet moving coil (PMMC) meter connected across the same load reads



(A) 4 V (B) 5 V

(C) 8 V (D) 10 V

MCQ 7.2 The bridge method commonly used for finding mutual inductance is

(A) Heaviside Campbell bridge (B) Schering bridge

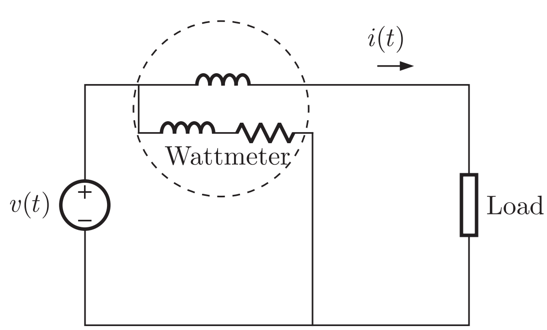
(C) De Sauty bridge (D) Wien bridge

MCQ 7.3 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



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(A) $\frac{1}{2}E_1I_1\cos\phi_1$

(B) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_1I_3\cos\phi_3 + E_1I_5]$

(C) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_3I_3\cos\phi_3]$

(D) $\frac{1}{2}[E_1I_1\cos\phi_1 + E_3I_1\cos\phi_1]$

YEAR 2012 TWO MARKS

MCQ 7.4 An analog voltmeter uses external multiplier settings. With a multiplier setting of $20\,\text{k}\Omega$, it reads $440\,\text{V}$ and with a multiplier setting of $80\,\text{k}\Omega$, it reads $352\,\text{V}$. For a multiplier setting of $40\,\text{k}\Omega$, the voltmeter reads

(A) 371 V
(B) 383 V
(C) 394 V
(D) 406 V

YEAR 2011 ONE MARK

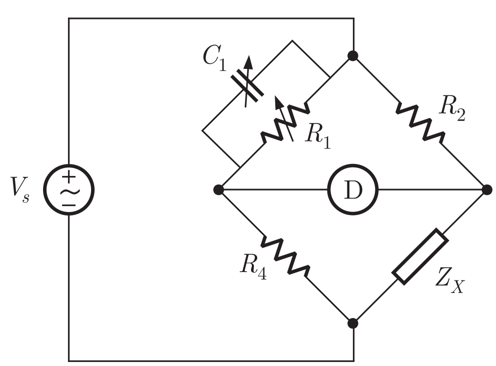
MCQ 7.5 Consider the following statement

(1) The compensating coil of a low power factor wattmeter compensates the effect of the impedance of the current coil.

(2) The compensating coil of a low power factor wattmeter compensates the effect of the impedance of the voltage coil circuit.

(A) (1) is true but (2) is false
(B) (1) is false but (2) is true
(C) both (1) and (2) are true
(D) both (1) and (2) are false

MCQ 7.6 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

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MCQ 7.7 A dual trace oscilloscope is set to operate in the ALTernate mode. The control input of the multiplexer used 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) haif the frequency of the time base (sweep) oscillator

YEAR 2011 TWO MARKS

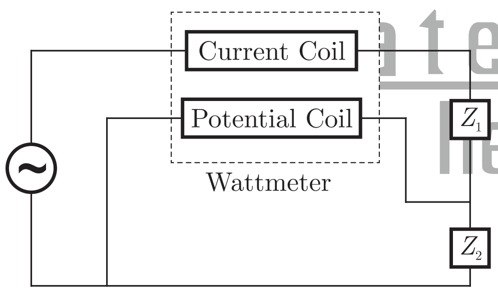
MCQ 7.8 A $4\frac{1}{2}$ digit DMM has the error specification as: 0.2% of reading + 10 counts. If a dc voltage of 100 V is read on its 200 V full scale, the maximum error that can be expected in the reading is

(A) $\pm 0.1\%$ (B) $\pm 0.2\%$

(C) $\pm 0.3\%$ (D) $\pm 0.4\%$

YEAR 2010 ONE MARK

MCQ 7.9 A wattmeter is connected as shown in figure. The wattmeter reads.



(A) Zero always

(B) Total power consumed by Z_1 and Z_2

(C) Power consumed by Z_1

(D) Power consumed by Z_2

MCQ 7.10 An ammeter has a current range of 0-5 A, and its internal resistance is 0.2 Ω. In order to change the range to 0-25 A, we need to add a resistance of

(A) 0.8 Ω in series with the meter

(B) 1.0 Ω in series with the meter

(C) 0.04 Ω in parallel with the meter

(D) 0.05 Ω in parallel with the meter

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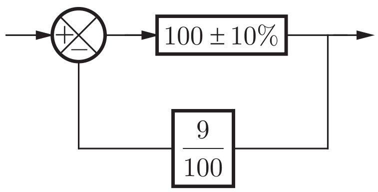
MCQ 7.11 As shown in the figure, a negative feedback system has an amplifier of gain 100 with $\pm 10\%$ tolerance in the forward path, and an attenuator of value 9/100 in the feedback path. The overall system gain is approximately :

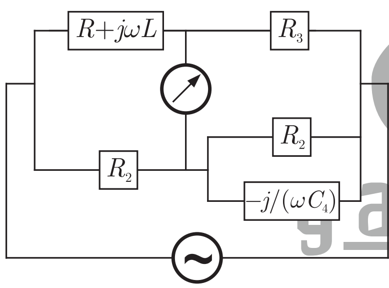


(A) $10 \pm 1\%$ (B) $10 \pm 2\%$

(C) $10 \pm 5\%$ (D) $10 \pm 10\%$

YEAR 2010 **TWO MARKS**

MCQ 7.12 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) $L = R_4/R_2R_3, R = 1/(C_4R_2R_3)$

YEAR 2009 **ONE MARK**

MCQ 7.13 The pressure coil of a dynamometer type wattmeter is

(A) Highly inductive (B) Highly resistive

(C) Purely resistive (D) Purely inductive

MCQ 7.14 The two inputs of a CRO are fed with two stationary periodic signals. In the X-Y mode, the screen shows a figure which changes from ellipse to circle and back to ellipse with its major axis changing orientation slowly and repeatedly. The following inference can be made from this.

(A) The signals are not sinusoidal

(B) The amplitudes of the signals are very close but not equal

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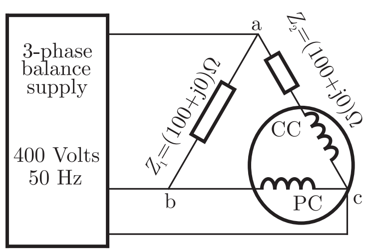
(C) The signals are sinusoidal with their frequencies very close but not equal

(D) There is a constant but small phase difference between the signals

YEAR 2009 **TWO MARKS**

MCQ 7.15 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

MCQ 7.16 An average-reading digital multi-meter reads 10 V when fed with a triangular wave, symmetric about the time-axis. For the same input an rms-reading meter will read

(A) $\frac{20}{\sqrt{3}}$ (B) $\frac{10}{\sqrt{3}}$

(C) $20\sqrt{3}$ (D) $10\sqrt{3}$

YEAR 2008 **ONE MARK**

MCQ 7.17 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 by the two ADCs will respectively, be

(A) T_A, T_B (B) $T_A/2, T_B$

(C) $T_A, T_B/2$ (D) $T_A/2, T_B/2$

YEAR 2008 **TWO MARKS**

MCQ 7.18 Two sinusoidal signals $p(\omega_1, t) = A\sin\omega_1 t$ and $q(\omega_2 t)$ are applied to X and Y inputs of a dual channel CRO. The Lissajous figure displayed on the screen shown below :

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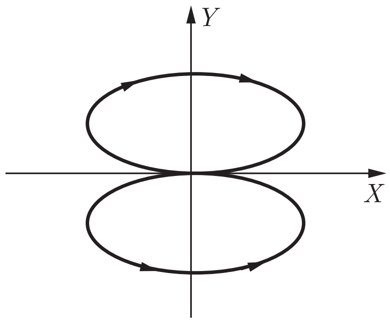
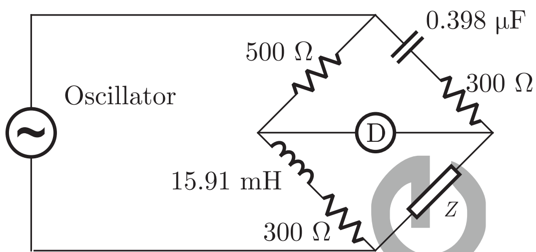
The signal $q(\omega_2 t)$ will be represented as



(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) $q(\omega_2 t) = A\cos\omega_2 t, \omega_2 = \omega_1/2$

MCQ 7.19 The ac bridge shown in the figure is used to measure the impedance Z.

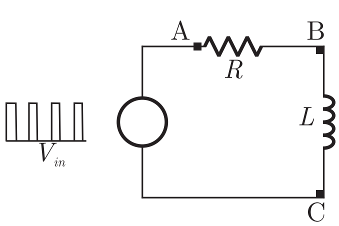


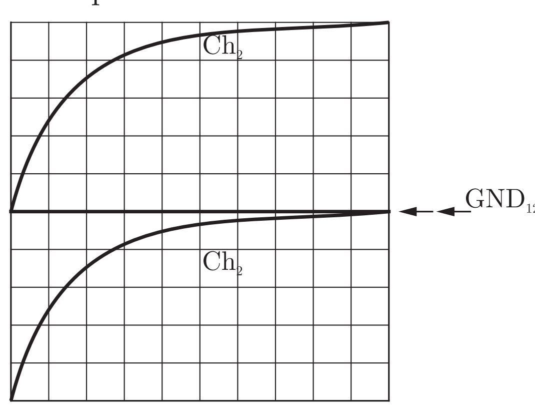
If the bridge is balanced for oscillator frequency $f = 2$ kHz, then the impedance Z will be

(A) $(260 + j0)\,\Omega$
(B) $(0 + j200)\,\Omega$
(C) $(260 - j200)\,\Omega$
(D) $(260 + j200)\,\Omega$

YEAR 2007 **ONE MARK**

MCQ 7.20 The probes of a non-isolated, two channel oscillocope are clipped to points A, B and C in the circuit of the adjacent figure. V_{in} is a square wave of a suitable low frequency. The display on Ch_1 and Ch_2 are as shown on the right. Then the "Signal" and "Ground" probes S_1, G_1 and S_2, G_2 of Ch_1 and Ch_2 respectively are connected to points :





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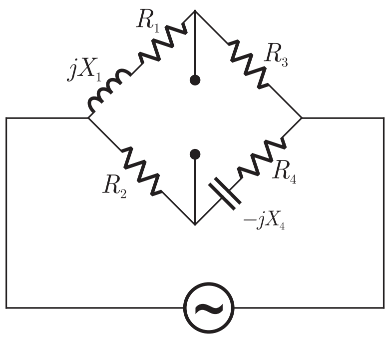
(A) A, B, C, A
(B) A, B, C, B
(C) C, B, A, B
(D) B, A, B, C

YEAR 2007 **TWO MARKS**

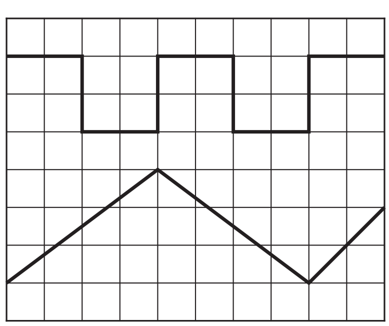
MCQ 7.21 A bridge circuit is shown in the figure below. Which one of the sequence given below is most suitable for balancing the bridge ?



(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

YEAR 2006 **ONE MARK**

MCQ 7.22 The time/div and voltage/div axes of an oscilloscope have been erased. A student connects a 1 kHz, 5 V 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

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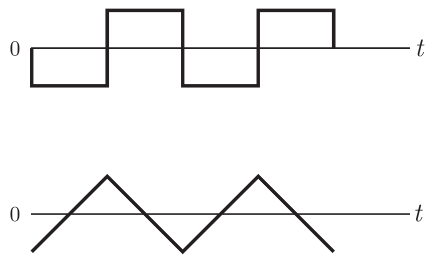
MCQ 7.23 A sampling wattmeter (that computes power from simultaneously sampled values of voltage and current) is used to measure the average power of a load. The peak to peak voltage of the square wave is 10 V and the current is a triangular wave of 5 A p-p as shown in the figure. The period is 20 ms. The reading in W will be



(A) 0 W (B) 25 W
(C) 50 W (D) 100 W

YEAR 2006 TWO MARKS

MCQ 7.24 A current of $-8+6\sqrt{2}(\sin\omega t+30^{\circ})$ A is passed through three meters. They are a centre zero PMMC meter, a true rms meter and a moving iron instrument. The respective reading (in A) will be

(A) 8, 6, 10 (B) 8, 6, 8
(C) -8,10,10 (D) -8,2,2

MCQ 7.25 A variable w is related to three other variables x,y,z as $w=xy/z$. The variables are measured with meters of accuracy $\pm0.5\%$ reading, $\pm1\%$ of full scale value and $\pm1.5\%$ 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 uncertainty in the measurement of w will be

(A) $\pm0.5\%$ rdg (B) $\pm5.5\%$ rdg
(C) ±6.7 rdg (D) ±7.0 rdg

MCQ 7.26 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 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

MCQ 7.27 R_1 and R_4 are the opposite arms of a Wheatstone bridge as are R_3 and R_2. The source voltage is applied across R_1 and R_3. Under balanced conditions which one of the following is true

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(A) $R_1 = R_3 R_4 / R_2$
(B) $R_1 = R_2 R_3 / R_4$
(C) $R_1 = R_2 R_4 / R_3$
(D) $R_1 = R_2 + R_3 + R_4$

YEAR 2005 ONE MARK

MCQ 7.28 The Q-meter works on the principle of
(A) mutual inductance (B) self inductance
(C) series resonance (D) parallel resonance

MCQ 7.29 A PMMC voltmeter is connected across a series combination of DC voltage source $V_1 = 2$ V and AC voltage source $V_2(t) = 3\sin(4t)$ V. The meter reads
(A) 2 V (B) 5 V
(C) $(2 + \sqrt{3}/2)$ V (D) $(\sqrt{17}/2)\ V$

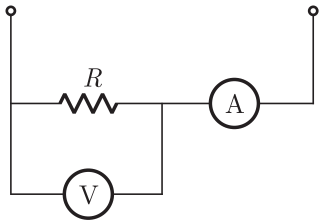
MCQ 7.30 A digital-to-analog converter with a full-scale output voltage of 3.5 V has a resolution close to 14 mV. Its bit size is
(A) 4 (B) 8
(C) 16 (D) 32

YEAR 2005 TWO MARKS

MCQ 7.31 The simultaneous application of signals $x(t)$ and $y(t)$ to the horizontal and vertical plates, respectively, of an oscilloscope, produces a vertical figure-of-8 display. If P and Q are constants and $x(t) = \text{P}\sin(4t + 30^\circ)$, then $y(t)$ is equal to
(A) $\text{Q}\sin(4t - 30^\circ)$ (B) $\text{Q}\sin(2t + 15^\circ)$
(C) $\text{Q}\sin(8t + 60^\circ)$ (D) $\text{Q}\sin(4t + 30^\circ)$

MCQ 7.32 A DC ammeter has a resistance of 0.1 Ω and its current range is 0-100 A. If the range is to be extended to 0-500 A, then meter required the following shunt resistance
(A) 0.010 Ω (B) 0.011 Ω
(C) 0.025 Ω (D) 1.0 Ω

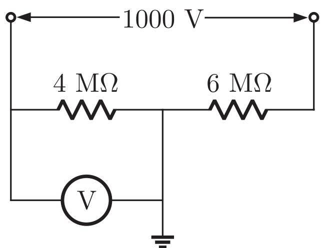
MCQ 7.33 The set-up in the figure is used to measure resistance R .The ammeter and voltmeter resistances are 0.01Ω and 2000 Ω, respectively. Their readings are 2 A and 180 V, respectively, giving a measured resistances of 90 Ω The percentage error in the measurement is



(A) 2.25% (B) 2.35%

(C) 4.5% (D) 4.71%

MCQ 7.34 A 1000 V DC supply has two 1-core cables as its positive and negative leads : their insulation resistances to earth are 4 MΩ and 6 MΩ, respectively, as shown in the figure. A voltmeter with resistance 50 kΩ is used to measure the insulation of the cable. When connected between the positive core and earth, then voltmeter reads



(A) 8 V (B) 16 V

(C) 24 V (D) 40 V

MCQ 7.35 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

YEAR 2004 **ONE MARK**

MCQ 7.36 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

MCQ 7.37 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

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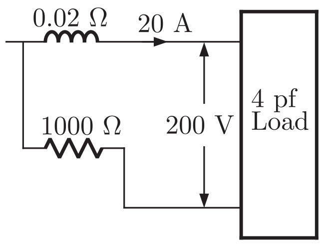


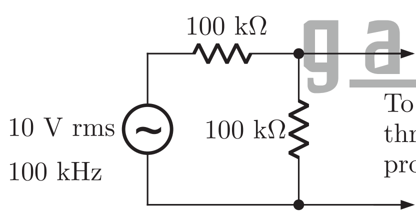
(A) 0.4 % less
(B) 0.2% less
(C) 0.2% more
(D) 0.4% more

MCQ 7.38 A galvanometer with a full scale current of 10 mA has a resistance of 1000 Ω. The multiplying power (the ratio of measured current to galvanometer current) of 100 Ω shunt with this galvanometer is

(A) 110
(B) 100
(C) 11
(D) 10

YEAR 2004 **TWO MARKS**

MCQ 7.39 A CRO probe has an impedance of 500 kΩ in parallel with a capacitance of 10 pF. The probe is used to measure the voltage between P and Q as shown in figure. The measured voltage will be



(A) 3.53 V
(B) 4.37 V
(C) 4.54 V
(D) 5.00 V

MCQ 7.40 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

MCQ 7.41 A dc A-h meter is rated for 15 A, 250 V. The meter constant is 14.4 A-sec/rev. The meter constant at rated voltage may be expressed as

(A) 3750 rev/kWh
(B) 3600 rev/kWh
(C) 1000 rev/kWh
(D) 960 rev/kWh

MCQ 7.42 A moving iron ammeter produces a full scale torque of 240 μNm with a deflection of 120° at a current of 10 A . The rate of change of self induction

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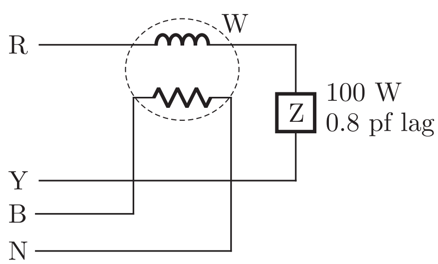
(μH/radian) of the instrument at full scale is

(A) 2.0 μH/radian (B) 4.8 μH/radian

(C) 12.0 μH/radian (D) 114.6 μH/radian

MCQ 7.43 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

MCQ 7.44 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 second current is

(A) 4.6° (B) 85.4°

(C) 94.6° (D) 175.4°

MCQ 7.45 The core flux in the CT of Prob Q.44, under the given operating conditions is

(A) 0 (B) 45.0 μWb

(C) 22.5 mWb (D) 100.0 mWb

YEAR 2003 ONE MARK

MCQ 7.46 A Manganin swap 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

MCQ 7.47 The effect of stray magnetic field 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

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(C) inclined at 60˚ (D) inclined at 30˚

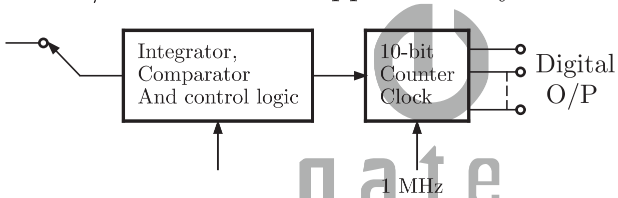
MCQ 7.48 A reading of 120 is obtained when standard inductor was connected in the circuit of a Q-meter and the variable capacitor is adjusted to value of 300 pF. A lossless capacitor of unknown value C_x is then connected in parallel with the variable capacitor and the same reading was obtained when 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

YEAR 2003 TWO MARKS

MCQ 7.49 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 converted using this A/D converter is approximately



(A) 2 kHz (B) 1 kHz

(C) 500 Hz (D) 250 Hz

MCQ 7.50 The items in Group-I represent the various types of measurements to be made with a reasonable accuracy using a suitable bridge. The items in Group-II represent the various bridges available for this purpose. Select the correct choice of the item in Group-II for the corresponding item in Group-I from the following

	List-I		List-II
P.	Resistance in the milli-ohm range	**1.**	Wheatstone Bridge
Q.	Low values of Capacitance	**2.**	Kelvin Double Bridge
R.	Comparison of resistance which are nearly equal	**3.**	Schering Bridge
S.	Inductance of a coil with a large time-constant	**4.**	Wien's Bridge
		5.	Hay's Bridge
		6.	Carey-Foster Bridge

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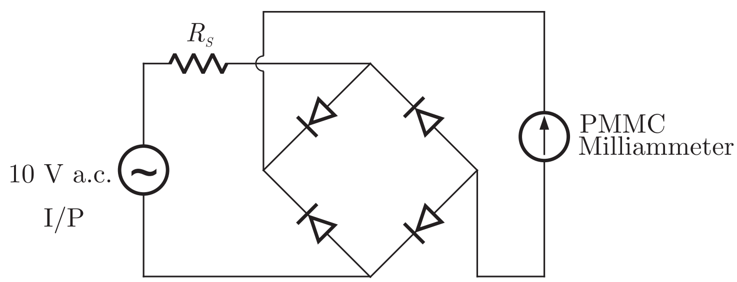
Codes :

(A) P=2, Q=3, R=6, S=5
(B) P=2, Q=6, R=4, S=5
(C) P=2, Q= 3, R=5, S=4
(D) P=1, Q=3, R=2, S=6

MCQ 7.51 A rectifier type ac voltmeter 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 Ω
(D) 141.3 kΩ

MCQ 7.52 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. This 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

MCQ 7.53 The inductance of a certain moving-iron ammeter is expressed as $L = 10 + 3\theta - (\theta^2/4)\,\mu H$, where θ is the deflection in radians from the zero position. The control spring torque is 25×10^{-6} Nm/radian. 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

MCQ 7.54 A 500A/5A, 50 Hz 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

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MCQ 7.55 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 factor 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

MCQ 7.56 Group-II 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 Group-I to match with the corresponding figure of Group-II.

Group-I

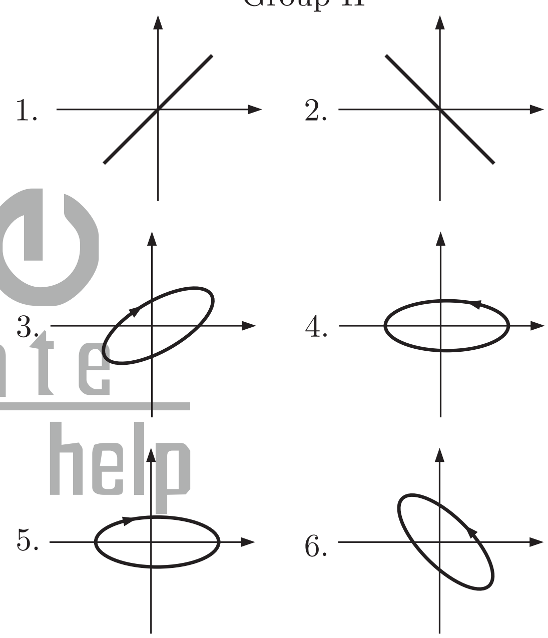
P. $\Phi = 0$

Q. $\Phi = \pi/2$

R. $\pi < \Phi < 3\pi/2$

S. $\Phi = 3\pi/2$

Group-II



Codes :

(A) P=1, Q= 3, R=6, S=5
(B) P=2, Q=6, R=4, S=5
(C) P=2, Q= 3, R=5, S=4
(D) P=1, Q=5, R=6, S=4

YEAR 2002 **ONE MARK**

MCQ 7.57 Two in-phase, 50 Hz sinusoidal waveforms of unit amplitude are fed into channel-1 and channel-2 respectively of an oscilloscope. Assuming that the voltage scale, time scale and other settings are exactly the same for both the channels, what would be observed if the oscilloscope is operated in X-Y mode ?

(A) A circle of unit radius
(B) An ellipse
(C) A parabola

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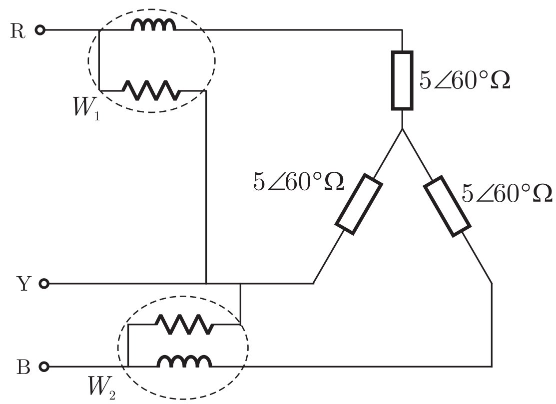
(D) A straight line inclined at 45° with respect to the x-axis.

MCQ 7.58 The line-to-line input voltage to the 3-phase, 50 Hz, ac circuit shown in Figure is 100 V rms. Assuming that the phase sequence is RYB, the wattmeters would read.



(A) W_1=886 W and W_2=886 W
(B) W_1=500 W and W_2 =500 W
(C) W_1=0 W and W_2=1000 W
(D) W_1 =250 W and W_2 =750 W

YEAR 2001 **ONE MARK**

MCQ 7.59 If an energy meter disc makes 10 revolutions in 100 seconds when a load of 450 W is connected to it, the meter constant (in rev/kWh) is

(A) 1000
(B) 500
(C) 1600
(D) 800

MCQ 7.60 The minimum number of wattmeter(s) required to measure 3-phase, 2-wire balanced or unbalanced power is

(A) 1
(B) 2
(C) 3
(D) 4

MCQ 7.61 A $100\,\mu A$ ammeter has an internal resistance of $100\,\Omega$. For extending its range to measure 500 μA, the shunt required is of resistance (in Ω)

(A) 20.0
(B) 22.22
(C) 25.0
(D) 50.0

MCQ 7.62 Resistance R_1 and R_2 have, respectively, nominal values of $10\,\Omega$ and $5\,\Omega$, and tolerance of $\pm 5\%$ and $\pm 10\%$. The range of values for the parallel combination of R_1 and R_2 is

(A) 3.077 Ω to 3.636 Ω
(B) 2.805 Ω to 3.371 Ω
(C) 3.237 Ω to 3.678 Ω
(D) 3.192 Ω to 3.435 Ω

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SOLUTIONS

SOL 7.1 Option (A) is correct.

PMMC instrument reads average (dc) value.

$$V_{avg} = \frac{1}{T}\int_0^T v(t)\,dt = \frac{1}{20\times 10^{-3}}\int_0^{20} v(t)\,dt$$

$$= \frac{1}{20}\left[\int_0^{10} t\,dt + \int_{10}^{12}(-5)\,dt + \int_{12}^{20} 5\,dt\right]$$

$$= \frac{1}{20}\left(\left[\frac{t^2}{2}\right]_0^{10} - 5[t]_{10}^{12} + 5[t]_{12}^{20}\right)$$

$$= \frac{1}{20}[50 - 5(2) + 5(8)] = \frac{80}{20} = 4\text{ V}$$

SOL 7.2 Option (A) is correct.

Heaviside mutual inductance bridge measures mutual inductance is terms of a known self-inductance.

SOL 7.3 Option (C) is correct.

Let $\omega t = \theta$, we have instaneous voltage and current as follows.

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

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

We know that wattmeter reads the average power, which is gives as

$$P = \frac{1}{2\pi}\int_0^{2\pi} v(t)\,i(t)\,d\theta \qquad \text{...(i)}$$

We can solve this integration using following results.

(i) $\frac{1}{2\pi}\int_0^{2\pi} A\sin(\theta+\alpha)\cdot B\sin(\theta+\beta)\,d\theta = \frac{1}{2}AB\cos(\alpha-\beta)$

(ii) $\frac{1}{2\pi}\int_0^{2\pi} A\sin(\theta+\alpha)\cdot B\cos(\theta+\alpha)\,d\theta = \frac{1}{2}AB\sin(\alpha-\beta)$

(iii) $\frac{1}{2\pi}\int_0^{2\pi} A\sin(m\theta+\alpha)\cdot B\cos(n\theta+\beta)\,d\theta = 0$

(iv) $\frac{1}{2\pi}\int_0^{2\pi} A\sin(m\theta+\alpha)\cdot B\cos(n\theta+\beta)\,d\theta = 0$

Result (iii) and (iv) implies that power is transferred between same harmonics of voltages and currents. Thus integration of equation (i) gives.

$$P = \frac{1}{2}E_1 I_1 \cos\phi + \frac{1}{2}E_3 I_3 \cos\phi_3$$

SOL 7.4 Option (D) is correct.

A voltmeter with a multiplier is shown in figure below.

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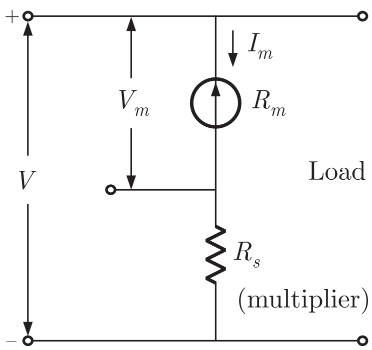

Here $\quad I_m =$ Fully scale deflection current of meter.

$R_m =$ Internal resistance of meter

$R_s =$ Voltage across the meter

$V =$ Full range voltage of instrument

$$V_m = I_m R_m$$

$$V = I_m(R_m + R_s)$$

$$\frac{V}{V_m} = \frac{R_m + R_s}{R_m} = 1 + \frac{R_s}{R_m}$$

Here when, $\quad R_{s1} = 20\text{ k}\Omega,\ V_{m1} = 440\text{ V}$

So, $$\frac{V}{440} = 1 + \frac{20\text{k}}{R_m} \quad \text{...(i)}$$

When, $\quad R_{s2} = 80\text{ k}\Omega,\ V_{m2} = 352\text{ V}$

So, $$\frac{V}{352} = 1 + \frac{80\text{ k}}{R_m} \quad \text{...(ii)}$$

Solving equation (i) and (ii), we get

$$V = 480\text{ V},\ R_m = 220\text{ k}\Omega$$

So when $\quad R_{s3} = 40\text{ k}\Omega,\ V_{m3} = ?$

$$\frac{480}{V_{m3}} = 1 + \frac{40\text{k}}{220\text{k}} \quad \Rightarrow \quad V_{m2} \simeq 406\text{ V}$$

SOL 7.5 Option (A) is correct.

The compensating coil compensation the effect of impedance of current coil.

SOL 7.6 Option (C) is correct.

Let $\quad Z_1 = R_1 || j\omega C_1$

so admittance $\quad Y_1 = \frac{1}{Z_1} = \frac{1}{R_1} + j\omega C_1$

$$Z_2 = R_2 \text{ and } Z_4 = R_4$$

Let $\quad Z_X = R_X + j\omega L_X$ (Unknown impedance)

For current balance condition of the Bridge

$$Z_2 Z_4 = Z_X Z_1 = \frac{Z_X}{Y_1}$$

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Let $$Z_X = Z_2 Z_4 Y_1$$

$$R_X + j\omega L_X = R_2 R_4 \left(\frac{1}{R_1} + j\omega C_1\right)$$

Equating imaginary and real parts

$$R_X = \frac{R_2 R_4}{R_1} \quad \text{and} \quad L_X = R_2 R_4 C_1$$

Quality factor of inductance which is being measured

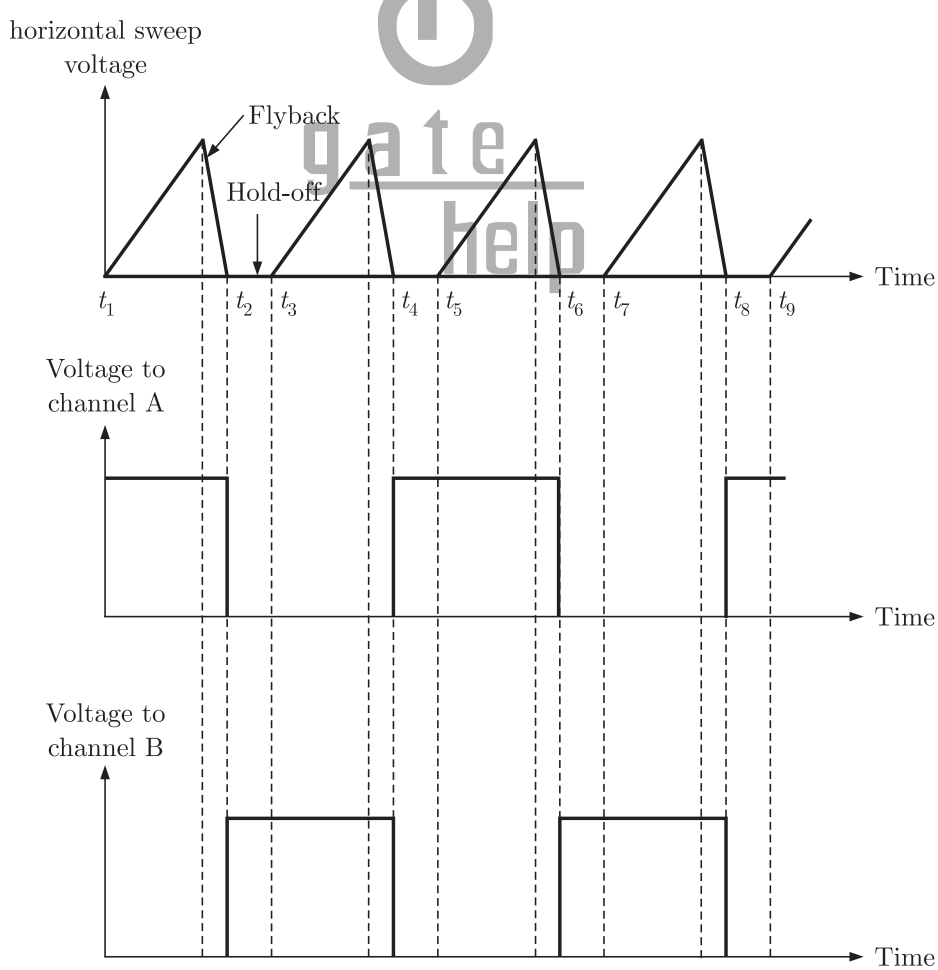
$$Q = \frac{\omega L_X}{R_X} = \omega R_1 C_1$$

From above equation we can see that for measuring high values of Q we need a large value of resistance R_4 which is not suitable. This bridge is used for measuring low Q coils.r

Note: We can observe directly that this is a maxwell's bridge which is suitable for low values of Q(i.e. $Q < 10$)

SOL 7.7 Option (C) is correct.

In the alternate mode it switches between channel A and channel B, letting each through for one cycle of horizontal sweep as shown in the figure.



SOL 7.8 Option (C) is correct.

$4\frac{1}{2}$ digit display will read from 000.00 to 199.99 So error of 10 counts is equal to $= \pm 0.10$ V

For 100 V, the maximum error is

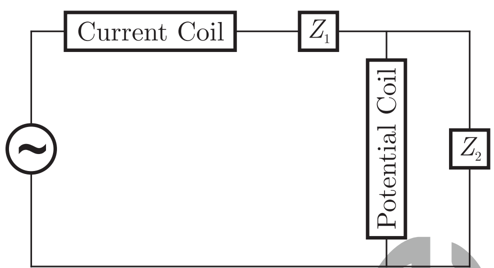
$$e = \pm (100 \times 0.002 + 0.1) = \pm 0.3 \text{ V}$$

Percentage error

$$= \pm \frac{0.3 \times 100}{100}\% = \pm 0.3\% \text{ of reading}$$

SOL 7.9 Option (D) is correct.

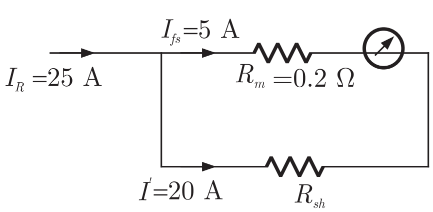
Since potential coil is applied across Z_2 as shown below



Wattmeter read power consumed by Z_2

SOL 7.10 Option (D) is correct.

Given that full scale current is 5 A



$$\text{Current in shunt } I' = I_R - I_{fs} = 25 - 5 = 20 \text{ A}$$

$$20 \times R_{sh} = 5 \times 0.2$$

$$R_{sh} = \frac{1}{20} = .05\,\Omega$$

SOL 7.11 Option (A) is correct.

Overall gain of the system is

$$g = \frac{100}{1 + 100\left(\frac{9}{100}\right)} = 10 \text{ (zero error)}$$

Gain with error

$$g = \frac{100 + 10\%}{1 + (100 + 10\%)\left(\frac{9}{100}\right)} = \frac{110}{1 + \frac{110 \times 9}{100}} = 10.091$$

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$$\text{error } \triangle g = 10.091 - 10 \simeq 0.1$$

Similarly

$$g = \frac{100 - 10\%}{1 + (100 - 10\%)\frac{9}{100}} = \frac{90}{1 + 90 \times \frac{9}{100}}$$

$$= 9.89$$

$$\text{error } \triangle g = 9.89 - 10 \simeq -0.1$$

$$\text{So gain } g = 10 \pm 0.1 = 10 \pm 1\%$$

SOL 7.12 Option (A) is correct.

At balance condition

$$(R + j\omega L)\left(R_4 \parallel \frac{-j}{\omega C_4}\right) = R_2 R_3$$

$$(R + j\omega L)\frac{\frac{-jR_4}{\omega C_4}}{\left(R_4 - \frac{j}{\omega C_4}\right)} = R_2 R_3$$

$$\frac{-jRR_4}{\omega C_4} + \frac{\omega L R_4}{\omega C_4} = R_2 R_3 R_4 - \frac{jR_2 R_3}{\omega C_4}$$

$$\frac{-jRR_4}{\omega C_4} + \frac{LR_4}{C_4} = R_2 R_3 R_4 - \frac{jR_2 R_3}{\omega C_4}$$

Comparing real & imaginary parts.

$$\frac{RR_4}{\omega C_4} = \frac{R_2 R_3}{\omega C_4}$$

$$R = \frac{R_2 R_3}{R_4}$$

Similarly,

$$\frac{LR_4}{C_4} = R_2 R_3 R_4$$

$$L = R_2 R_3 C_4$$

SOL 7.13 Option (B) is correct.

Since Potential coil is connected across the load terminal, so it should be highly resistive, so that all the voltage appears across load.

SOL 7.14 Option (D) is correct.

A circle is produced when there is a 90° phase difference between vertical and horizontal inputs.

SOL 7.15 Option (C) is correct.

$$\text{Wattmeter reading } P = V_{PC} I_{CC}$$

$V_{PC} \rightarrow$ Voltage across potential coil.

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$I_{CC} \rightarrow$ Current in current coil.

$$V_{PC} = V_{bc} = 400\angle -120^\circ$$

$$I_{CC} = I_{ac} = \frac{400\angle 120^\circ}{100} = 4\angle 120^\circ$$

Power $$P = 400\angle -120^\circ \times 4\angle 120^\circ$$

$$= 1600\angle 240^\circ = 1600 \times \frac{1}{2} = 800 \text{ Watt}$$

SOL 7.16 Option (D) is correct.

Average value of a triangular wave

$$V_{av} = \frac{V_m}{3}$$

rms value $$V_{ms} = \frac{V_m}{\sqrt{3}}$$

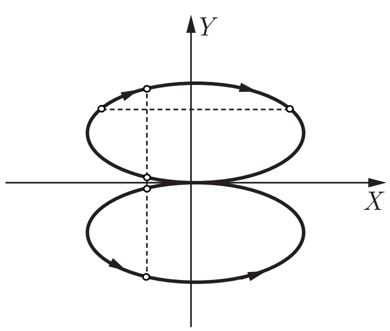
Given that $$V_{av} = \frac{V_m}{3} = 10 \text{ V}$$

So $$V_{rms} = \frac{V_m}{\sqrt{3}} = \sqrt{3}\, V_{av} = 10\sqrt{3} \text{ V}$$

SOL 7.17 Option (A) is correct.

Conversion time does not depend on input voltage so it remains same for both type of ADCs.

SOL 7.18 Option (D) is correct.



Frequency ratio $$\frac{f_Y}{f_X} = \frac{\text{meeting points of horizontal tangents}}{\text{meeting points of vertical tangents}}$$

$$\frac{f_Y}{f_X} = \frac{2}{4}$$

$$f_Y = \frac{1}{2}(f_X)$$

$$\omega_2 = \omega_1/2$$

Since the Lissajous figures are ellipse, so there is a phase difference of 90° exists between vertical and horizontal inputs.

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So $q(\omega_2 t) = A\cos\omega_2 t,\ \omega_2 = \omega_1/2$

SOL 7.19 Option (A) is correct.

Impedance of different branches is given as

$$Z_{AB} = 500\ \Omega$$

$$Z_{BC} = \frac{1}{j \times 2\pi \times 2 \times 10^3 \times 0.398\,\mu F} + 300\ \Omega$$

$$\simeq (-200j + 300)\ \Omega$$

$$Z_{AD} = j \times 2\pi \times 2 \times 10^3 \times 15.91\,\text{mH} + 300\,\Omega$$

$$\simeq (200j + 300)\ \Omega$$

To balance the bridge

$$Z_{AB} Z_{CD} = Z_{AD} Z_{BC}$$

$$500Z = (200j + 300)(-200j + 300)$$

$$500Z = 130000$$

$$Z = (260 + j0)\ \Omega$$

SOL 7.20 Option (B) is correct.

Since both the waveform appeared across resistor and inductor are same so the common point is B. Signal Probe S_1 is connecte with A, S_2 is connected with C and both the grount probes G_1 and G_2 are connected with common point B.

SOL 7.21 Option (A) is correct.

To balance the bridge

$$(R_1 + jX_1)(R_4 - jX_4) = R_2 R_3$$

$$(R_1 R_4 + X_1 X_4) + j(X_1 R_4 - R_1 X_4) = R_2 R_3$$

comparing real and imaginary parts on both sides of equations

$$R_1 R_4 + X_1 X_4 = R_2 R_3 \qquad ...(1)$$

$$X_1 R_4 - R_1 X_4 = 0 \Rightarrow \frac{X_1}{X_4} = \frac{R_1}{R_4} \qquad ...(2)$$

from eq(1) and (2) it is clear that for balancing the bridge first balance R_4 and then R_1.

SOL 7.22 Option (C) is correct.

From the Calibration pulse we can obtain

$$\frac{\text{Voltage}}{\text{Division}}(\triangle\ V) = \frac{5}{2} = 2.5\ V$$

$$\frac{\text{Time}}{\text{Division}}(\triangle\ T) = \frac{1\ \text{ms}}{4} = \frac{1}{4}\ \text{msec}$$

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So amplitude (p-p) of unknown signal is

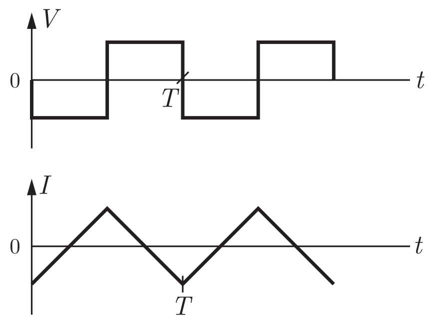
$$V_{P-P} = \triangle \text{ V} \times 5 = 2.5 \times 5 = 7.5 \text{ V}$$

$$\text{Time period } T = \triangle \text{ T} \times 8 = \frac{1}{4} \times 8 = 2 \text{ ms}$$

SOL 7.23 Option (A) is correct.

Reading of wattmeter (Power) in the circuit

$$P_{av} = \frac{1}{T}\int_0^T VIdt = \text{Common are between } V - I$$



total common area = 0 (Positive and negative area are equal)

So $P_{av} = 0$

SOL 7.24 Option (C) is correct.

PMMC instrument reads only dc value so

$$I_{\text{PMMC}} = -8 \text{ A}$$

rms meter reads rms value so

$$I_{rms} = \sqrt{(-8)^2 + \frac{(6\sqrt{2})^2}{2}}$$

$$= \sqrt{64 + 36} = 10 \text{ A}$$

Moving iron instrument also reads rms value of current So

$$I_{\text{MI}} = 10 \text{ mA}$$

Reading are $(I_{\text{PMMC}}, I_{rms}, I_{\text{MI}}) = (-8 \text{ A}, 10 \text{ A}, 10 \text{ A})$

SOL 7.25 Option (D) is correct.

$$\text{Given that } \omega = \frac{xy}{z}$$

$$\log \omega = \log x + \log y - \log z$$

Maximum error in ω

$$\% \frac{d\omega}{\omega} = \pm \frac{dx}{x} \pm \frac{dy}{y} \pm \frac{dz}{z}$$

$$\frac{dx}{x} = \pm 0.5\% \text{ reading}$$

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$$\frac{dy}{y} = \pm\, 1\% \text{ full scale}$$

$$= \pm \frac{1}{100} \times 100 = \pm\, 1$$

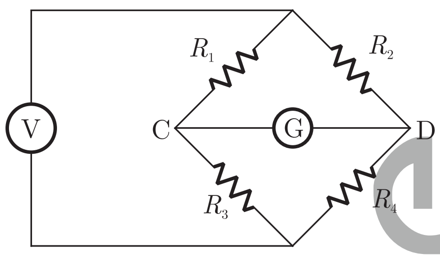
$$\frac{dy}{y} = \pm \frac{1}{20} \times 100 = \pm\, 5\% \text{ reading}$$

$$\frac{dz}{z} = 1.5\% \text{ reading}$$

So $$\%\frac{d\omega}{\omega} = \pm\, 0.5\% \pm 5\% \pm 1.5\% = \pm\, 7\%$$

SOL 7.26 Option ( ) is correct.

SOL 7.27 Option (B) is correct.



In balanced condition there is no current in CD arm so $V_C = V_D$
Writing node equation at C and D

$$\frac{V_C - V}{R_1} + \frac{V_C}{R_3} = 0 \Rightarrow V_C = V\left(\frac{R_3}{R_1 + R_3}\right)$$

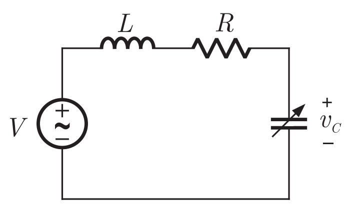
$$\frac{V_0 - V}{R_2} + \frac{V_D}{R_4} = 0 \Rightarrow V_D = V\left(\frac{R_4}{R_2 + R_4}\right)$$

So $$V\left(\frac{R_3}{R_1 + R_3}\right) = V\left(\frac{R_4}{R_2 + R_4}\right)$$

$$R_2R_3 + R_3R_4 = R_1R_4 + R_3R_4$$

$$R_1 = R_2R_3/R_4$$

SOL 7.28 Option (C) is correct.
Q-meter works on the principle of series resonance.



At resonance $V_C = V_L$

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$$\text{and } I = \frac{V}{R}$$

$$\text{Quality factor Q} = \frac{\omega L}{R} = \frac{1}{\omega CR} = \frac{\omega L \times I}{R \times I} = \frac{V_L}{E} = \frac{V_C}{E}$$

Thus, we can obtain Q

SOL 7.29 Option (A) is correct.

PMMC instruments reads DC value only so it reads 2 V.

SOL 7.30 Option (B) is correct.

$$\text{Resolution of n-bit DAC} = \frac{V_{fs}}{2^n - 1}$$

So

$$14\,mv = \frac{3.5\text{ V}}{2^n - 1}$$

$$2^n - 1 = \frac{3.5}{14 \times 10^{-3}}$$

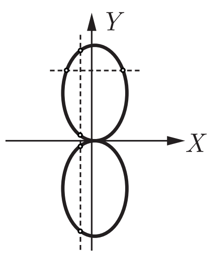
$$2^n - 1 = 250$$

$$2^n = 251$$

$$n = 8 \text{ bit}$$

SOL 7.31 Option (B) is correct.

We can obtain the frequency ratio as following



$$\frac{f_Y}{f_X} = \frac{\text{meeting points of horizontal tangents}}{\text{meeting points of vertical tangents}}$$

$$\frac{f_Y}{f_X} = \frac{2}{4}$$

$$f_Y = \frac{1}{2} f_X$$

There should exist a phase difference(15°) also to produce exact figure of-8.

SOL 7.32 Option (C) is correct.

The configuration is shown below

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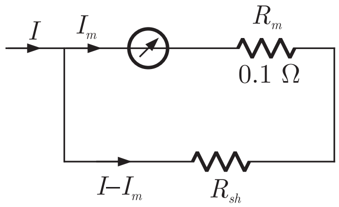


It is given that $I_m = 100$ A

Range is to be extended to $0 - 500$ A,

$$I = 500 \text{ A}$$

So,

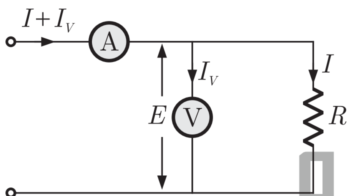
$$I_m R_m = (I - I_m) R_{sh}$$

$$100 \times 0.1 = (500 - 100) R_{sh}$$

$$R_{sh} = \frac{100 \times 0.1}{400} = 0.025 \ \Omega$$

SOL 7.33 Option (D) is correct.

The configuration is shown below



Current in voltmeter is given by

$$I_V = \frac{E}{2000} = \frac{180}{2000} = .09 \text{ A}$$

$$I + I_V = 2 \text{ amp}$$

So $$\text{I} = 2 - .09 = 1.91 \text{ V}$$

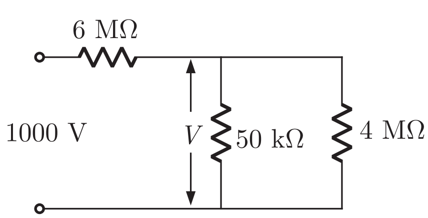
$$R = \frac{E}{I} = \frac{180}{1.91} = 94.24 \ \Omega$$

Ideally $$R_0 = \frac{180}{2} = 90 \ \Omega$$

$$\% \text{ error} = \frac{R - R_0}{R_0} \times 100 = \frac{94.24 - 90 \times 100}{90} = 4.71\%$$

SOL 7.34 Option (A) is correct.

The measurement system is shown below



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Voltmeter reading

$$V = \left(\frac{1000}{6\,\text{M}\Omega + 50\,\text{k}\Omega \parallel 4\,\text{M}\Omega}\right)(50\,\text{k}\Omega \parallel 4\,\text{M}\Omega)$$

$$= \frac{1000}{6 + .049} \times .049 = 8.10\ \text{V}$$

SOL 7.35 Option (D) is correct.

$$\text{Total power } P = P_1 + P_2 = 10.5 - 2.5 = 8\ \text{kW}$$

$$\text{Power factor} = \cos\theta$$

Where

$$\theta = \tan^{-1}\left[\sqrt{3}\left(\frac{P_2 - P_1}{P_2 + P_1}\right)\right] = \tan^{-1}\left[\sqrt{3} \times \frac{-13}{8}\right]$$

$$= -70.43^\circ$$

$$\text{Power factor} = \cos\theta = 0.334$$

SOL 7.36 Option (B) is correct.

CHECK

for the dc potentiometer $E \propto l$

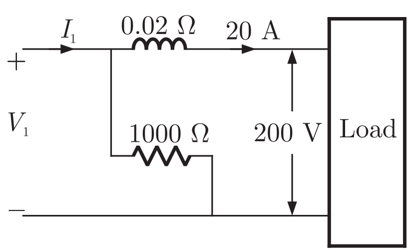
so,

$$\frac{E_1}{E_2} = \frac{l_1}{l_2}$$

$$E_2 = E_1\left(\frac{l_1}{l_2}\right) = (1.18) \times \frac{680}{600} = 1.34\ \text{V}$$

SOL 7.37 Option (C) is correct.

Let the actual voltage and current are I_1 and V_1 respectively, then



Current in CC is 20 A

$$20 = I_1\left(\frac{1000}{1000 + 0.02}\right)$$

$$I_1 = 20.0004\ \text{A} \simeq 20\ \text{A}$$

$$200 = V_1 - .02 \times 20 = 200.40$$

$$\text{Power measured } P_m = V_1 I_1 = 20(200.40) = 4008\ \text{W}$$

$$\text{Load power} \quad P_L = 20 \times 200 = 4000\ \text{W}$$

$$\%\ \text{Change} = \frac{P_m - P_L}{P_L} = \frac{4008 - 4000}{4000} \times 100$$

$$= 0.2\%\ \text{more}$$

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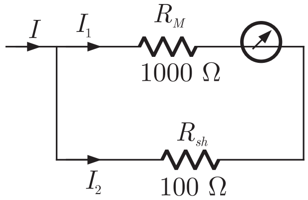
SOL 7.38 Option (C) is correct.

We have to obtain $n = \frac{I}{I_1}$



$$\frac{I_1}{I_2} = \frac{R_{sh}}{R_m} = \frac{100}{1000} = \frac{1}{10}$$

$$I_1 + I_2 = I$$

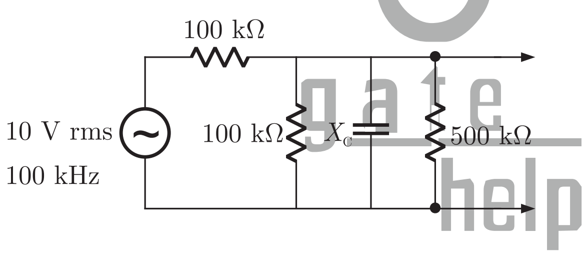
$$I_1 + 10I_1 = I$$

$$11I_1 = I$$

$$n = \frac{I}{I_1} = 11$$

SOL 7.39 Option (B) is correct.

In the following configuration



Rectance $X_c = \frac{1}{j\omega C} = \frac{1}{2\pi \times 100 \times 10^3 \times 10 \times 10^{-12}}$

writing node equation at P

$$\frac{V_P - 10}{100} + V_P\left(\frac{1}{100} + \frac{1}{500} - \frac{j}{159}\right) = 0$$

$$10 - V_P = V_P(1.2 - j0.628)$$

$$10 = (2.2 - j0.628)\, V_P$$

$$V_P \frac{10}{2.28} = 4.38 \text{ V}$$

SOL 7.40 Option (A) is correct.

The torque on the coil is given by

$$\tau = NIBA$$

$N \rightarrow$ no. of turns, N = 100

$I \rightarrow$ current, I = 50 mA

$B \rightarrow$ magnetic field, B = 200 mT$A \rightarrow$ Area,

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$$A = 10\text{ mm} \times 20\text{ mm}$$

So, $$\tau = 100 \times 50 \times 10^{-3} \times 200 \times 10^{-3} \times 200 \times 10^{-3} \times 10^{-3}$$
$$= 200 \times 10^{-6}\text{ Nm}$$

SOL 7.41 Option (C) is correct.

Meter constant (A-sec/rev) is given by

$$14.4 = \frac{I}{\text{speed}}$$

$$14.4 = \frac{I}{K \times \text{Power}}$$

Where 'K' is the meter constant in rev/kWh.

$$14.4 = \frac{I}{K \times VI}$$

$$14.4 = \frac{15}{K \times 15 \times 250}$$

$$K = \frac{1}{250 \times 14.4}$$

$$K = \frac{1}{\left(\frac{250 \times 14.4}{1000 \times 3600}\right)} = \frac{1000 \times 3600}{3600} = 1000\text{ rev/kWh.}$$

SOL 7.42 Option (B) is correct.

For moving iron ameter full scale torque is given by

$$\tau_C = \frac{1}{2} I^2 \frac{dL}{d\theta}$$

$$240 \times 10^{-6} = \frac{1}{2}(10)^2 \frac{dL}{d\theta}$$

Change in inductance

$$\frac{dL}{d\theta} = 4.8\ \mu\text{H/radian}$$

SOL 7.43 Option (B) is correct.

In the figure

$$V_{RY} = 415\angle 30^\circ$$

$$V_{BN} = \frac{415}{\sqrt{3}}\angle 120^\circ$$

Current in current coil

$$I_C = \frac{V_{RY}}{Z} = \frac{415\angle 30^\circ}{100\angle 36.87^\circ}$$

$\therefore$ power factor $= 0.8$

$\cos\phi = 0.8 \Rightarrow \phi = 36.87^\circ$

$$= 4.15\angle -6.87$$

$$\text{Power} = VI^* = \frac{415}{\sqrt{3}}\angle 120^\circ \times 4.15\angle 6.87^\circ$$

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$$= 994.3\angle 126.87^{\circ}$$

Reading of wattmeter

$$P = 994.3(\cos 126.87^{\circ}) = 994.3(-0.60) = -597 \text{ W}$$

SOL 7.44 Option (A) is correct.

For small values of phase angle

$$\frac{I_P}{I_S} = n\phi, \quad \phi \to \text{Phase angle (radians)}$$
$$n \to \text{turns ratio}$$

Magnetizing ampere-turns $= 200$

So primary current $I_P = 200 \times 1 = 200$ amp

Turns ratio $n = 500$

Secondary current $I_S = 5$ amp

So $$\frac{200}{5} = 500\phi$$

$$\phi \text{ (in degrees)} = \left(\frac{180}{\pi}\right)\left(\frac{200}{5 \times 500}\right)$$
$$\simeq 4.58^{\circ}$$

SOL 7.45 Option (B) is correct.

Voltage appeared at secondary winding

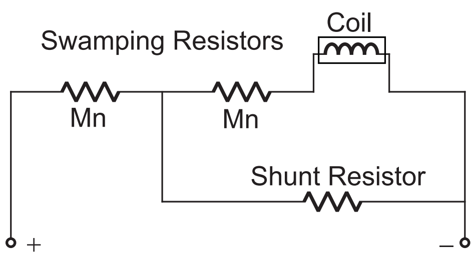
$$E_S = I_S \times Z_L = 5 \times 1 = 5 \text{ Volts}$$

Voltage induced is given by

$$E_S = \sqrt{2}\,\pi f N\phi, \quad \phi \to \text{flux}$$
$$5 = \sqrt{2} \times 3.14 \times 50 \times 500 \times \phi$$
$$\phi = \frac{5}{\sqrt{2} \times 3.14 \times 25 \times 10^3} = 45 \times 10^{-6} \text{ wb}$$

SOL 7.46 Option (A) is correct.

In PMCC instruments, as temperature increases the coil resistance increases. Swamp resistors are connected in series with the moving coil to provide temperature compensation. Swamping resistors is made of magnin, which has a zero-temperature coefficient.



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SOL 7.47 Option () is correct.
Effect of stray magnetic field is maximum when the operating field and stray fields are parallel.

SOL 7.48 Option (A) is correct.

Let $$C_1 = 300 \text{ pF}$$

$$Q = 120 = \frac{1}{\omega C_1 R}$$

Now when C_x is connected in parallel with variable resistor $C_1' = 200$ pF

$$Q = 120 = \frac{1}{\omega(C_1' + C_x) R}$$

So $$C_1 = C_1' + C_x$$

$$300 = 200 + C_x$$

$$C_x = 100 \text{ pF}$$

SOL 7.49 Option (B) is correct.
Maximum frequency of input in dual slop A/D converter is given as

$$T_m = 2^n T_C$$

where $$f_m = \frac{1}{T_m} \rightarrow \text{maximum frquency of input}$$

$$f_C = \frac{1}{T_C} \rightarrow \text{clock frequency}$$

so $$f_m = \frac{f_C}{2^n}, \quad n = 10$$

$$= \frac{10^6}{1024} = 1\,\text{kHz (approax)}$$

SOL 7.50 Option (A) is correct.
Kelvin Double bridge is used for measuring low values of resistances. (P → 2)
Low values of capacitances is precisely measured by schering bridge (Q → 3)
Inductance of a coil with large time constant or high quality factor is measured by hay's bridge ($R \rightarrow 5$)

SOL 7.51 Option (C) is correct.
Full scale deflection is produced by a dc current of 1 mA

$$(I_{dc})_{fs} = 1 \text{ mA}$$

For full wave reactifier

$$(I_{dc})_{fs} = \frac{2I_m}{\pi}, \quad I_m \rightarrow \text{peak value of ac current}$$

$$1 \text{ mA} = \frac{2I_m}{3.14}$$

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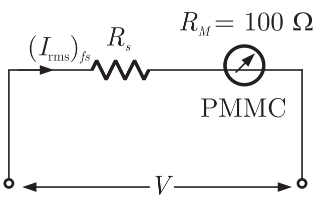
$$I_m = 1.57 \text{ mA}$$

Full scale ac current

$$(I_{rms})_{fs} = \frac{1.57}{\sqrt{2}} = 1.11 \text{ mA}$$



$$V = (R_s + R_m)(I_{rms})_{fs}$$

$$100 = (R_s + 100)(1.11 \text{ mA})$$

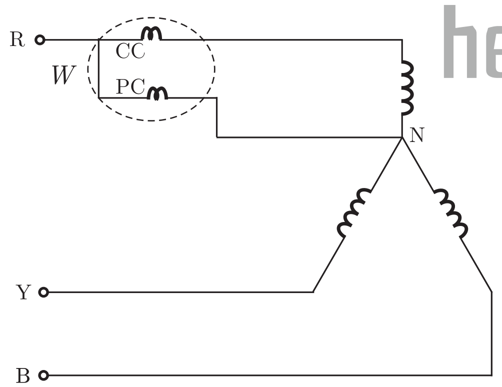
$$\frac{100}{(1.11 \text{ mA})} = R_s + 100$$

$$100 \times 900 = R_s + 100$$

$$R_s = 89.9 \text{ k}\Omega$$

SOL 7.52 Option (B) is correct.

First the current coil is connected in R-phase and pressure coil is connected between this phase and the neutral as shown below



reading of wattmeter

$$W_1 = I_P V_P \cos\theta_1, \ \cos\theta_1 = 0.8 \Rightarrow \theta_1 = 36.86^\circ$$

$$400 = I_L \frac{V_L}{\sqrt{3}} \cos\theta_1$$

$$400 = \frac{I_L V_L}{\sqrt{3}} \times 0.8 \qquad ...(1)$$

Now when pressure coil is connected between B and Y-phases, the circuit is

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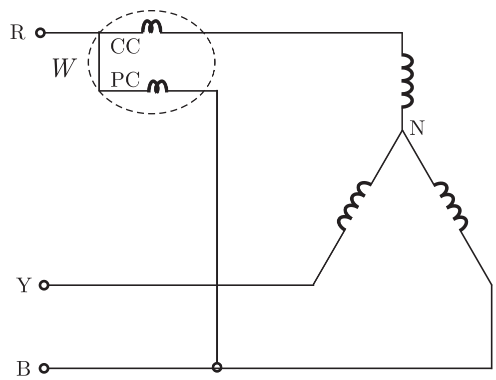
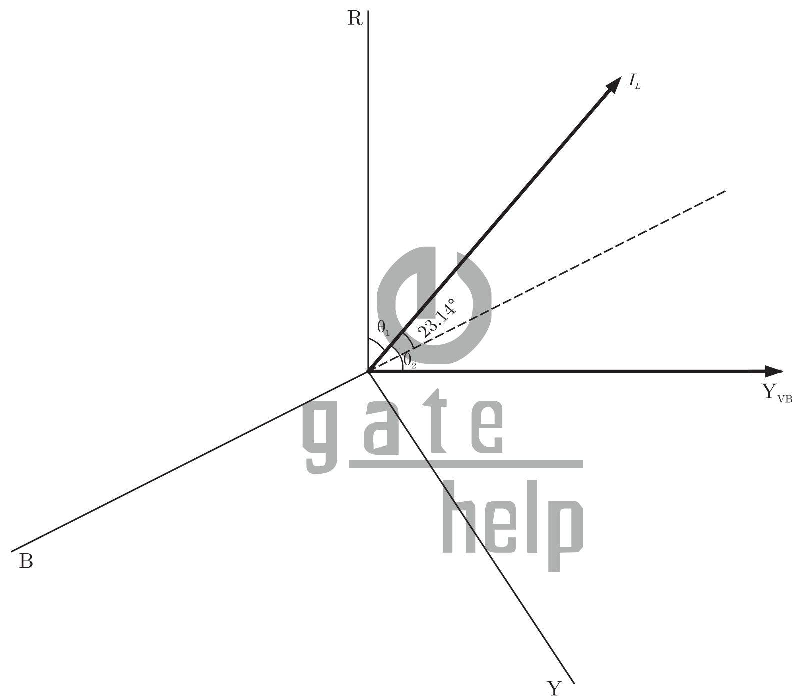


phasor diagram



angle $\theta_2 = 23.14^\circ + 30^\circ = 54.14^\circ 2$

now wattmeter reading $W_2 = V_{YB} I_L \cos\theta_2$

from equation (1) $V_L I_L = \dfrac{400 \times \sqrt{3}}{0.8}$

so $W_2 = \dfrac{400}{0.8} \times \sqrt{3} \times \cos 53.14^\circ$

$= 519.5 \text{ W}$

SOL 7.53 Option (C) is correct.

In a moving-iron ammeter control torque is given as

$$\tau_c = K\theta = \frac{1}{2} I^2 \frac{dL}{d\theta}$$

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Where

$K \rightarrow$ control spring constant

$\theta \rightarrow$ deflection

$$\text{Given that } L = 10 + 3\theta - \frac{\theta^2}{4}$$

$$\frac{dL}{d\theta} = \left(3 - \frac{\theta}{2}\right) \mu\text{H/rad}$$

So,

$$\tau_c = (25 \times 10^{-6})\theta = \frac{1}{2}(5)^2\left(3 - \frac{\theta}{2}\right) \times 10^{-6}$$

$$2\theta = 3 - \frac{\theta}{2}$$

$$\frac{5\theta}{2} = 3 \Rightarrow \theta = \frac{6}{5} = 1.2 \text{ rad.}$$

SOL 7.54 Option (B) is correct.

$$\text{Magnetizing current } I_m = \frac{250}{1} = 250 \text{ amp}$$

$$\text{Primary current } I_p = 500 \text{ amp}$$

$$\text{Secondary current } I_s = 5 \text{ amp}$$

$$\text{Turn ratio } n = \frac{I_p}{I_s} = \frac{500}{5} = 100$$

$$\text{Total primary current } (I_T) = \sqrt{[\text{primary current}(I_p)]^2} + \sqrt{[\text{magnetising current}(I_m)]^2}$$

$$I_T = \sqrt{I_p^2 + I_m^2}$$

$$= \sqrt{(500)^2 + (250)^2} = 559.01 \text{ amp}$$

$$\text{Turn ratio } n' = \frac{I_T}{I_s} = \frac{559.01}{5} = 111.80$$

$$\text{Percentage ratio error } \Delta n = \frac{n - n'}{n'} \times 100$$

$$= \frac{100 - 111.80}{111.80} \times 100 = -10.55\%$$

SOL 7.55 Option (C) is correct.

Power read by meter $P_m = VI\sin(\Delta - \phi)$

Where

$\Delta \rightarrow$ Phase angle between supply voltage and pressure coil flux.

$\phi \rightarrow$ Phase angle of load

Here

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$\Delta = 85°, \phi = 60°$ $\{\because \cos\phi = 0.5$

So measured power

$$P_m = 200 \times 5\sin(85° - 60°)$$
$$= 1100\sin 25°$$
$$= 464.88 \text{ W}$$

Actual power $P_O = VI\cos\phi = 220 \times 5 \times 0.5 = 550$ W

Error in measurement $= P_m - P_O = 464.88 - 550 = -85.12$ W

For unity power factor $\cos\phi = 1$

$$\phi = 0°$$

So $P_m = 220 \times 5\sin(85° - 0°) = 1095.81$ W

$$P_O = 220 \times 5\cos 0° = 1100$$

Error in Measurement

$$= 1095.81 - 1100 = -4.19 \text{ W}$$

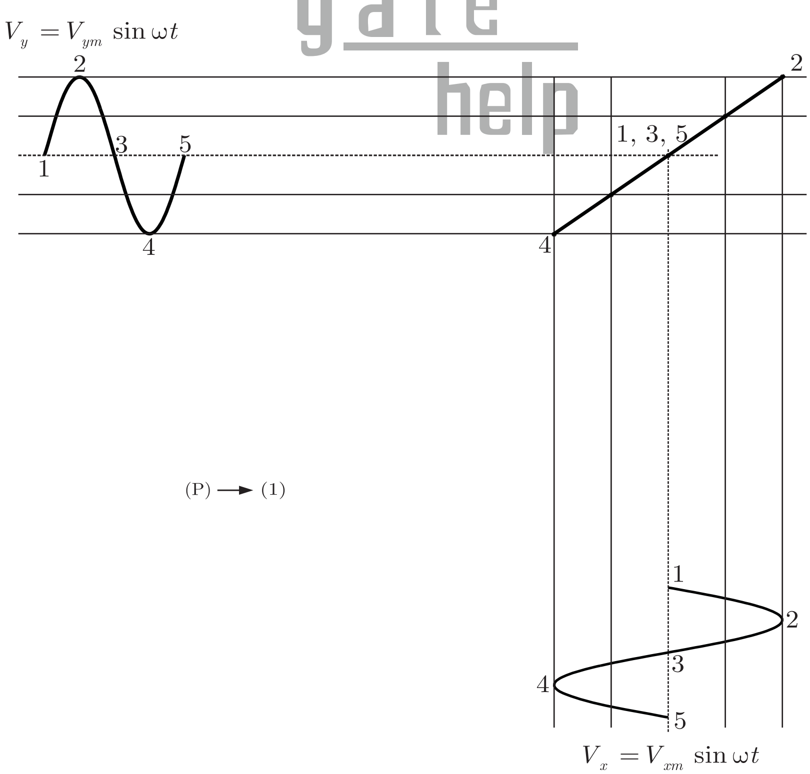
SOL 7.56 Option (A) is correct.

We can obtain the Lissaju pattern (in X-Y mode) by following method.

For $\phi = 0°$, $V_x = V_{xm}\sin\omega t$

$$V_y = V_{ym}\sin(\omega t + 0°) = \sin\omega t$$

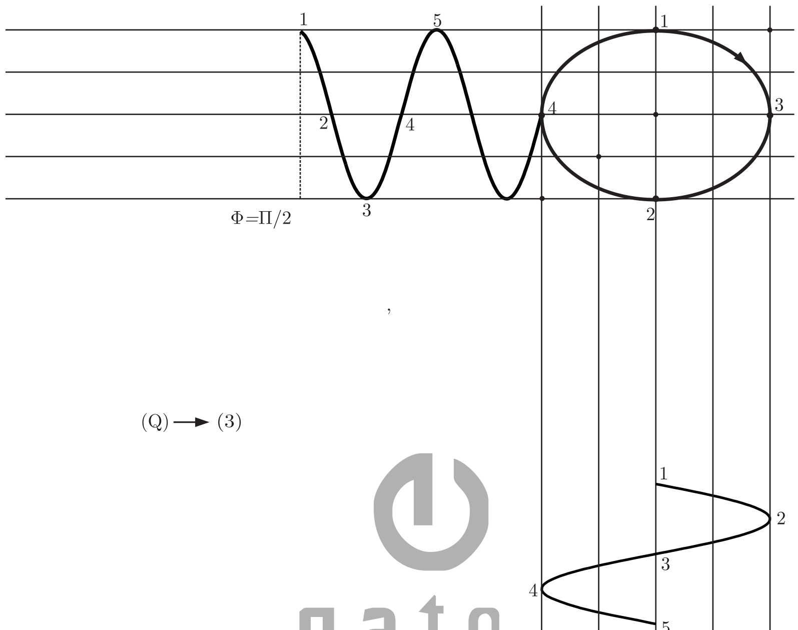
Draw V_x and V_y as shown below



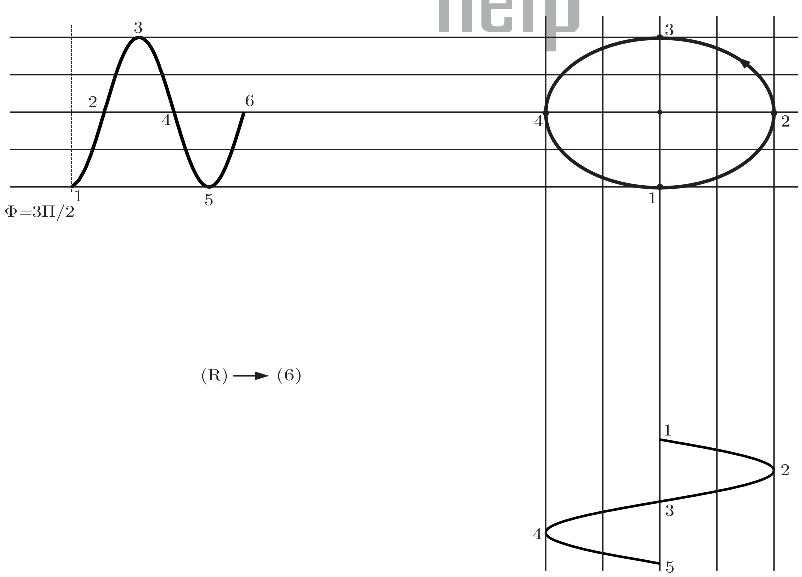
Divide both V_y and V_x equal parts and match the corresponding points on the screen.

Similarly for $\phi = 90^\circ$

$$V_x = V_{xm}\sin\omega t$$
$$V_y = V_{ym}\sin(\omega t + 90^\circ)$$



Similarly for $\phi = \frac{3\pi}{2}$



we can also obtain for $0 < \phi < \frac{3\pi}{2}$

SOL 7.57 Option (D) is correct.

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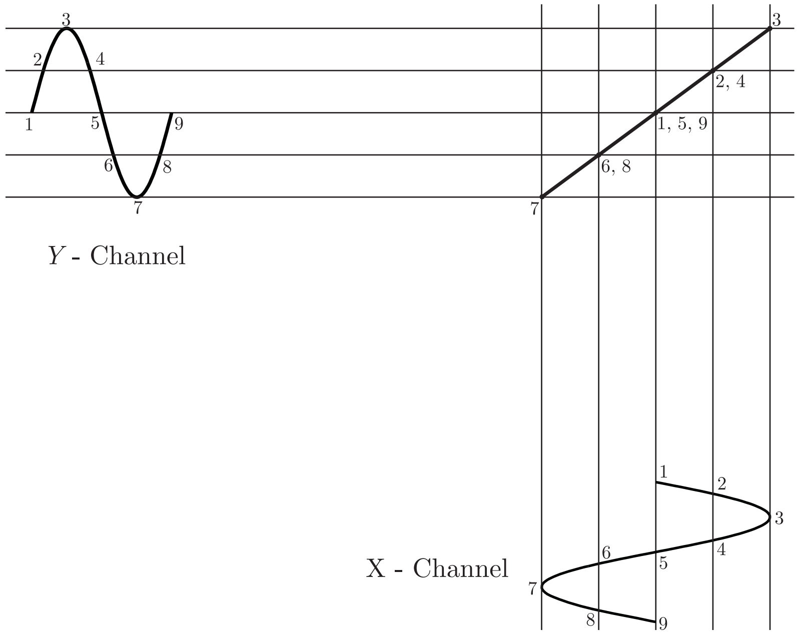
We can obtain the Lissaju pattern (in X-Y made) by following method.



Divide the wave forms appearing an channel X and channel Y in equal parts, match the corresponding points on the screen. We would get a straight line in X – Y mode.

SOL 7.58 Option (C) is correct.

In two wattmeters method angle between phase voltage and phase current is given by

$$\phi = \tan^{-1}\left(\sqrt{3}\frac{W_2 - W_1}{W_2 + W_1}\right)$$

here $\phi = -60^\circ$

readings in option (C) only satisfies this equation.

$$\phi = \tan^{-1}\left(\sqrt{3}\frac{0 - 1000}{0 + 1000}\right) = -60^\circ$$

SOL 7.59 Option (D) is correct.

Speed (rev/sec) of the energy meter is given.

$$S = K \times \text{power}$$

$$K \to \text{meter constant}$$

$$S = \frac{10\,rev}{100\,\text{sec}} = K \times 450$$

$$K = \frac{10\text{ rev}}{\left(\frac{100 \times 450}{1000 \times 3600}\right)\text{kWh}} = \frac{10 \times 1000 \times 3600}{100 \times 450}$$

$$= 800\text{ rev/kWh}$$

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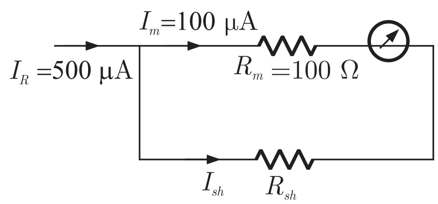
SOL 7.60 Option (B) is correct.

Power in a 3-phase three wire system, with balanced load can be measured by using two wattmeters. The load may be star or delta connected.

SOL 7.61 Option (C) is correct.

Ameter configuration is given below



Here

$$I_R = I_m + I_{sh}$$

$$500 = 100 + I_{sh}$$

$$I_{sn} = 400 \ \mu\text{A}$$

$$\frac{I_m}{I_{sh}} = \frac{R_{sh}}{R_m}$$

$$\frac{100}{400} = \frac{R_{sh}}{100}$$

$$R_{sh} = 25\,\Omega$$

SOL 7.62 Option (A) is correct.

Equivalent resistance when connected in parallel is

$$R = \frac{R_1 R_2}{R_1 + R_2}$$

Let $R_1 + R_2 = R_{\text{sum}}$

So $R = \dfrac{R_1 R_2}{R_{\text{sum}}} = \dfrac{10 \times 5}{15} = 3.33\,\Omega$

$$\%\ \text{error in } R = \Delta R_1(\%) + \Delta R_2(\%) - \Delta R_{\text{sum}}(\%)$$

$$\Delta R_{\text{sum}} = (10 \pm 5\%) + (5 \pm 10\%)$$

$$= (10 \pm 0.5) + (5 \pm 0.5) = 15 \pm 0.1$$

$$\Delta R_{\text{sum}}(\%) = 15 \pm \frac{1}{15} \times 100\% = 15 \pm 6.66\%$$

$$\%\ \text{error in } R = 5\% + 10\% - 6.66\% = 8.33\%$$

$$\text{value of } R = 3.33 \pm 8.33\% = 3.05\,\Omega \text{ to } 3.61\,\Omega$$

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