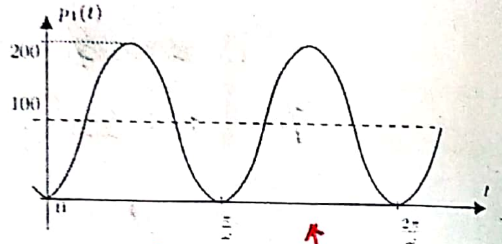
Sol^n

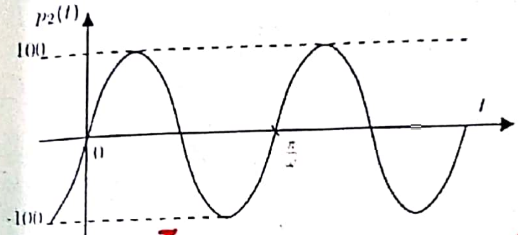
EE 334 Power Systems

Quiz 1, Date: 23.01.2020

1. The instantaneous power $p(t)$ flowing into a single phase ac circuit component is resolved into two components $p_1(t)$ and $p_2(t)$, i.e. $p(t) = p_1(t) + p_2(t)$. The plots of $p_1(t)$ and $p_2(t)$ versus ωt are shown below. The reactive power absorbed by the component is

   A. $\frac{100}{\sqrt{2}}$ B. 200 C. 100 D. $\frac{200}{\sqrt{2}}$





$P(t) = V_{rms} I_{rms} \left[\cos\phi\,(1-\cos(2\omega t)) - \sin\phi \sin(2\omega t)\right]$

So, $Q = V_{rms} I_{rms} \sin\phi = 100.$

2. A three-phase balanced star connected load is being supplied by a three-phase balanced 50-Hz supply. The expression for the total power drawn by the load is given by $\sqrt{3} V_L I_L \cos\phi$, where V_L is the line to line rms voltage and I_L is the rms line current. Here, ϕ is
   A. The angle between $\bar{V}_L$ and $\bar{I}_L$
   B. Equal to thrice the impedance angle
   C. Equal to $\frac{1}{3}$ of the impedance angle.
   D. The angle between $\bar{V}_{phase}$ and $\bar{I}_L$

3. A three phase balanced star connected load is being supplied by a three-phase balanced 50 Hz supply. The total instantaneous three-phase power
   A. pulsates at twice the supply frequency
   B. pulsates at half the supply frequency
   C. pulsates at the supply frequency.
   D. is constant

4. A three phase load consisting of one 100 W bulb in each phase is connected in star across a three phase supply, dissipating a power of 300 W. If the same bulbs are connected in delta across the same supply, then the power dissipated will be:
   (Assume that the bulbs have adequate voltage rating so that they can be connected either in star or delta.)
   A. 900 W
   B. 100 W
   C. 300 W
   D. $300\sqrt{3}$ W.

If V_{L-L} be line to line voltage, in star connection, in each lamp,

$$P_Y = \frac{(V_{LL}/\sqrt{3})^2}{R} = 100$$

In delta, in each lamp, $P_\Delta = \frac{V_{LL}^2}{R} = 300$ W.

Total $= 3 \times 300 = 900$ W.

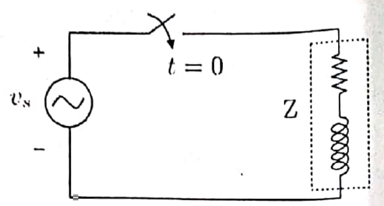
5. Consider the circuit shown in figure below. The voltage source is $v_s(t) = V_m \sin(\omega t + \phi)$ V, where $\omega = 2\pi \times 50$ rad/s, and the impedance Z of the R-L load at 50 Hz is $10\angle 22^o \Omega$. The initial current in the circuit is zero. The value of ϕ, such that the closing of switch at t=0 s does not result in any natural transients in the circuit is:

A. $\phi = 68^o$

B. $\phi = 22^o$

C. $\phi = -22^o$

D. $\phi = 0$.



For no natural transients, $\sin(\phi - \theta) = 0$.

$Z = |Z|\angle\theta$

$\therefore \phi = \theta = 22^o$.

6. Consider the circuit given in Figure A. The switch is in open condition and voltage v_{cb} is found to be $10\sin(2\pi \times 50t)$ V. The switch is replaced by a sinusoidal source $v_{cb} = 10\sin(2\pi \times 50t)$ V as shown in Figure B. The value of current i_s in the circuit of Figure B is :

A. $\frac{10}{\sqrt{(\omega L)^2 + R_2^2}} \sin\left(2\pi \times 50t - \text{atan}\frac{\omega L}{R_2}\right)$ A

B. 0 A

C. $\frac{10}{\sqrt{(\omega L)^2 + R_2^2}} \sin\left(2\pi \times 50t + \text{atan}\frac{\omega L}{R_2}\right)$ A

D. $\frac{10}{R_2}\sin(2\pi \times 50t)$ A.

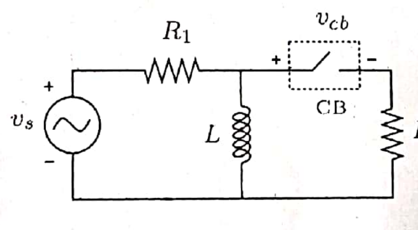


Figure A

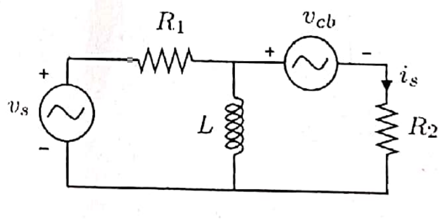


Figure B

7. A series R-L-C circuit below resonant frequency is

A. Resistive

B. capacitive

C. inductive

D. may be inductive or capacitive depending on the value of R

$R + j\omega L - j\frac{1}{\omega C}$

$= R + j\left(\omega L - \frac{1}{\omega C}\right)$

At resonant frequency, $\omega_r L = \frac{1}{\omega_r C}$

Below ω_r, $\omega L < \omega_r L$ and $\omega C < \omega_r C$.

$\therefore \omega L - \frac{1}{\omega C} < \omega_r L - \frac{1}{\omega_r C} < 0$. So, it is capacitive.

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8. The load impedance Z_L such that maximum real power is transferred to Z_L from the source is

A. $-j3\ \Omega$

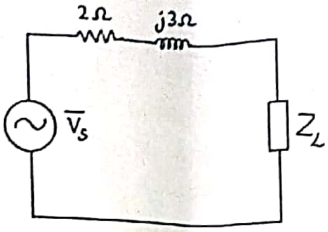
B. $3.6\ \Omega$

C. $2 - j3\ \Omega$

D. $2 + j3\ \Omega$.

Maximum power transfer theorem.

$Z_L = (Z_{th})^*$

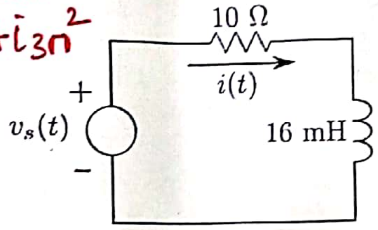


9. For the circuit shown in the figure, the voltage source $v_s(t)$ is given by
$v_s(t) = 5 + 10\sin(2\pi \times 50t + 30^o) + 3\sin(2\pi \times 150t - 60^o) + 0.5\sin(2\pi \times 300t)$ V,
the rms value of the current $i(t)$ in steady state is

$i_{rms} = \sqrt{i_{dc}^2 + i_{50}^2 + i_{150}^2 + i_{300}^2}$

$i_{dc} = \frac{5}{10}$ A.

$i_{50} = \frac{10/\sqrt{2}}{\sqrt{10^2 + (100\pi \times 16\times10^{-3})^2}}$ A



A. 0.893 A

B. 0.814 A

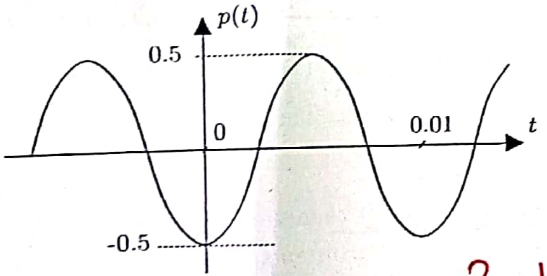
C. 0.707 A

D. 0.632 A

$i_{300} = \frac{0.5/\sqrt{2}}{\sqrt{10^2 + (600\pi \times 16\times10^{-3})^2}}$

$i_{150} = \frac{3/\sqrt{2}}{\sqrt{10^2 + (300\pi \times 16\times10^{-3})^2}}$ A.

10. The waveform of instantaneous power in a single-phase ac circuit is shown below. The magnitudes of real and reactive power respectively are:



A. $1/\sqrt{2}$ and $1/\sqrt{2}$

B. Zero and 0.5

C. Zero and $0.5/\sqrt{2}$

D. $0.5/\sqrt{2}$ and $0.5/\sqrt{2}$

Real power = Average of $p(t)$
$= 0$.

So, $p(t) = V_{rms} I_{rms} \sin\phi \sin 2\omega t$.

So, Q = peak of $p(t)$
$= 0.5$

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$v_b - v_c = \sqrt{3} V \sin(\omega t - 90^\circ)$

$i_a = I \sin(\omega t - \phi)$

$\frac{1}{T}\int_0^T (v_b - v_c)\, i_a\, dt = \sqrt{3} V I \sin\phi$. Check.

11. In a balanced, star-connected three-phase circuit with phase to neutral voltages v_a, v_b and v_c, the rms value of phase-neutral voltage is V, rms value of line current i_a is I, and the phase angle between v_a and i_a is ϕ. The average value of $(v_b - v_c)i_a$ over a cycle is:

$v_a = V\angle 0$

$v_b = V\angle -120$

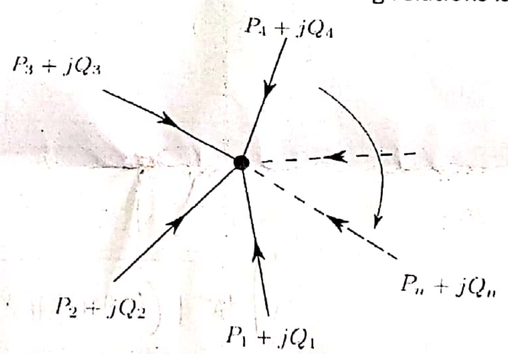
$v_c = V\angle 120$

$v_b - v_c = \sqrt{3}V\angle -90^\circ$

   A. Zero
   B. $\sqrt{3}VI \sin\phi$
   C. $\sqrt{3}VI \cos\phi$
   D. $3VI \sin\phi$

12. For a single phase linear circuit at sinusoidal steady state, real power defined as $P = Real\{\bar{V}.\bar{I}^*\}$ where $\bar{V}$ is voltage phasor and $\bar{I}$ is current phasor, denotes:
   A. The instantaneous value of power
   B. The average power drawn over a cycle
   C. The rms value of power over a cycle.
   D. The peak value of power over a cycle

13. In a single-phase ac circuit in steady state, $\Sigma\bar{S}_n = \Sigma P_n + j\Sigma Q_n$ denotes the total complex power injected at a node by the branches incident on it., as shown in the figure, P is the real power and Q is the reactive power. Which of the following relations is TRUE?



$\Sigma I_i = 0$

$\Rightarrow \Sigma I_i^* = 0$

$\Rightarrow V\Sigma I_i^* = 0$

KCL.

$\Rightarrow \Sigma V I_i^* = 0$

$\Rightarrow \Sigma \bar{S}_n = 0.$

   A. $\Sigma\bar{S}_n$ is never zero
   B. $\Sigma\bar{S}_n = 0$ always
   C. $\Sigma P_n = 0$, but ΣQ_n need not be zero
   D. $\Sigma Q_n = 0$, but ΣP_n need not be zero

14. A three phase unbalanced star connected passive load is being supplied by a three-phase balanced 50 Hz supply. The total instantaneous three-phase power
   A. Is constant
   B. Pulsates at half the supply frequency
   C. Pulsates at the supply frequency.
   D. Pulsates at twice the supply frequency

15. If the voltage applied to a 415 V rated capacitor drops by 10%, its VAr (reactive power) output drops by

A. 10%
B. 19%
C. 87%
D. 23%

$Q = \omega C V^2$, If $V_{new}/V_{old} = 0.9$, then $Q_{new} = 0.81 Q_{old}$.

$\therefore Q \propto V^2$

$\therefore Q_{new} = Q_{old} \times \left(\frac{V_{new}}{V_{old}}\right)^2$

16. Consider a voltage source v_s connected to a linear circuit as shown in the figure. It is observed that for

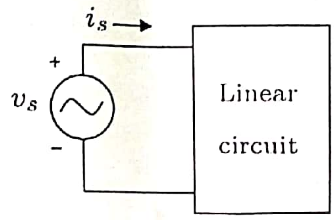
$$v_s(t) = 100\sin(2\pi \times 50t + 30^o) + 20\cos(2\pi \times 100t)\ V,$$

the current

$$i_s(t) = 10\sin(2\pi \times 50t) + 0.2\sin(2\pi \times 100t + 45^o)\ A$$

in steady state. The input voltage v_s, if the steady state current is

$$i_s(t) = 5\sin(2\pi \times 50t) + 0.1\sin(2\pi \times 100t + 30^o)\ A \text{ is:}$$



A. $v_s(t) = 50\sin(2\pi \times 50t + 30^o) + 10\sin(2\pi \times 100t - 60^o)$ V
B. $v_s(t) = 50\sin(2\pi \times 50t + 30^o) + 10\sin(2\pi \times 100t + 75^o)$ V.
C. $v_s(t) = 50\sin(2\pi \times 50t + 30^o) + 10\sin(2\pi \times 100t - 15^o)$ V
D. $v_s(t) = 50\sin(2\pi \times 50t - 60^o) + 10\sin(2\pi \times 100t + 75^o)$ V

For 50 Hz,

$Z_{50} = 10\angle 30^\circ$,

For 100 Hz,

$Z_{100} = 100\angle 45^\circ$.

$\therefore V_{50} = 5\angle 0 \times 10\angle 30 = 50\angle 30^\circ$

$V_{100} = 0.1\angle 30^\circ \times 100\angle 45^\circ = 10\angle 75^\circ$.

17. The voltage $v(t)$ across a circuit element is

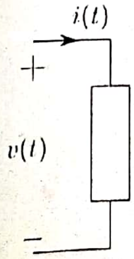
$$v(t) = 5 + 10\sin(2\pi \times 50t) + 2\sin(2\pi \times 100t + 10^o)\ \text{V}$$

and the current through the element is

$$i(t) = \cos(2\pi \times 50t + 45^o) + 0.4\sin(2\pi \times 100t - 35^o)\ \text{A}.$$

The average power supplied to the element is

A. $\frac{-4.6}{\sqrt{2}}$ W
B. $\frac{0.4}{\sqrt{2}}$ W
C. $\frac{10.4}{\sqrt{2}}$ W
D. $\frac{4.6}{\sqrt{2}}$ W



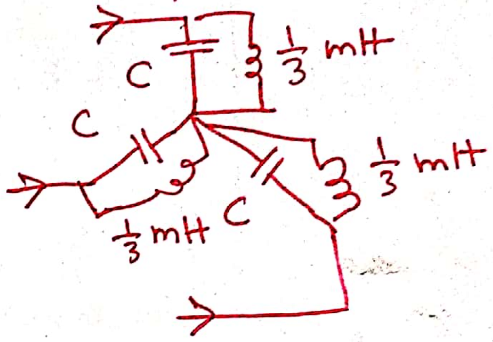
$P_{50} = \frac{10 \times 1}{2} \cos(135^\circ)$ $\quad P_{100} = \frac{2 \times 0.4}{2} \sin(45^\circ)$

$P = P_{50} + P_{100} = \frac{-5 + 0.4}{\sqrt{2}} = -\frac{4.6}{\sqrt{2}}$

18. In the balanced three-phase 50 Hz circuit shown below, the value of the inductance (L) is 1 mH. The value of the capacitance (C) for which all the line currents are zero when the circuit is connected to a 50 Hz three-phase voltage source:

A. Line currents can never be made zero.
B. 30.39 mF
C. 10.13 mF
D. 3.377 mF

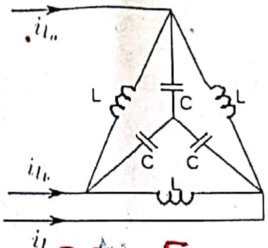
Using star delta transformation,



For zero line current,

$$j\omega C \bar{V} + \frac{\bar{V}}{j\omega L} = 0.$$

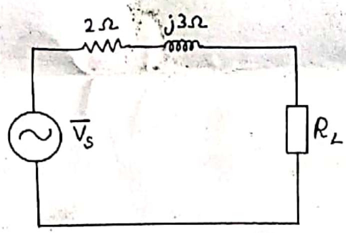
or, $$\omega C = \frac{1}{\omega L}$$



$\therefore C_1 = 1/\omega^2 L = 30.39$ mF.

19. The load resistance R_L such that maximum real power is transferred to R_L from the source is

A. 5.5 Ω
B. 3.6 Ω
C. 3 Ω
D. 2 Ω.

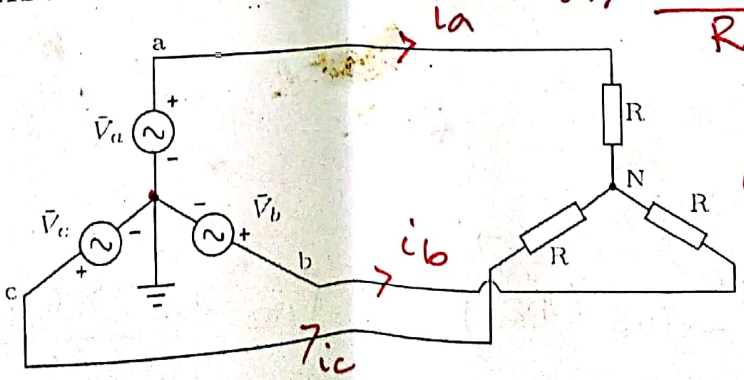


If $Z_L = (Z_{th})^*$ is not possible, then maximum power transfer occurs if $|Z_L| = |Z_{th}|$

$$\therefore R_L = \sqrt{2^2 + 3^2} = 3.6\,\Omega.$$

20. Consider a three-phase circuit as shown. The load is balanced whereas the source is unbalanced with the rms phase voltages as $\bar{V_a} = 10\angle 0^o$ V, $\bar{V_b} = 9\angle -115^o$ V and $\bar{V_c} = 10\angle 110^o$ V respectively. The magnitude of the rms voltage of the load's neutral point N with respect to the ground is

A. 3.04 V
B. 9.12 V
C. 0 V
D. 4.12 V



Applying KCL,

$$i_a + i_b + i_c = 0.$$

or, $$\frac{\bar{V_a} - \bar{V_N}}{R} + \frac{\bar{V_b} - \bar{V_N}}{R} + \frac{\bar{V_c} - \bar{V_N}}{R} = 0.$$

or, $$3\bar{V_N} = \bar{V_a} + \bar{V_b} + \bar{V_c}$$

$$\therefore \bar{V_N} = \frac{1}{3}(\bar{V_a} + \bar{V_b} + \bar{V_c})$$

1.014 V

$\therefore$ RMS value ≈

Note: none of the options were correct.