Group IV	June 4,2013
EE 3303	Engr.Kenneth F. Fajilan

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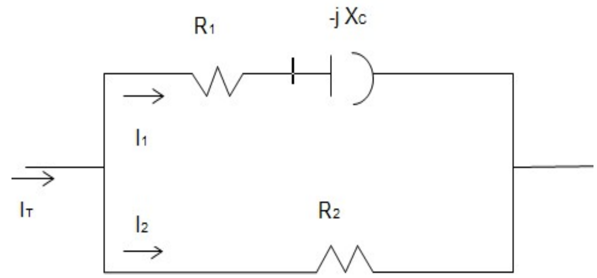
1) In the circuit shown below, the total effective current is 30 amperes. Determine the power relations.



Given: $R_1 = 5\Omega$; $R_2 = 4\ \Omega$; $-jx_1 = -j3\ \Omega$; $I_T = 30\angle 0°$ A

Solution:

$I_2 = (30\angle 0°)\ [(5\text{-}j3)] \div [(9\text{-}j3)] = 18.45\angle -12.55°$ A

$I_1 = (30\angle 0°)\ [(4)\div(9\text{-}j3)] = 12.7\angle 18.45°$ A

$P = I_2{}^2 R_2 + I_1{}^2 R_1$

$P = (18.45)^2(4) + (12.7)^2(5)$

P= 2165 W

$Q = I_1{}^2 X_1$

$Q = (12.7)^2(3)$

Q= 483 VAR (Leading)

S= P-jQ

S= 2165-j483

$S = 2210\angle -12.6°$

P.f.= P / S

P.f. = 2165/ 2210

P.f = 0.98 Leading

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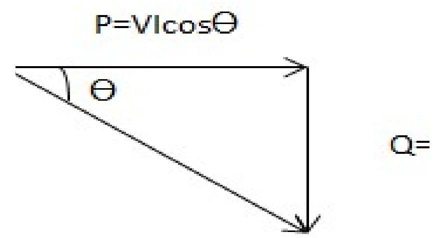
2) A two circuit element is connected in a series; R=5Ω and X_L= 15Ω has an effective voltage across the resistor of 31.6V. Determine the power triangle



Solution:

$I = V_R / R$

$I = 31.6 / 5$

$I = 6.32$ A

$Z_L = R + jX_L$

$Z_L = 5 + j15$

$Z_L = 15.81 \angle 71.56°$

$\tan \theta = X_L / R = 15/5$

$\theta = \tan^{-1} (3)$

$\theta = 71.56°$

Apparent Power = $VI = I^2Z = (6.32)^2(15.81 \angle 71.56°)$

$S = 631.48 \angle 71.56°$ VA

$S = 200 + j600$ VA

Reactive Power = $I^2X_L = (6.32)^2(15)$

Q = 600 VAR Lagging

Real Power = $I^2R = (6.32)^2(5)$

P = 200 Watts

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3) A series circuit of R = 8Ω and X_C=6Ω has an applied phasor voltage V = $50\angle-90°$. Find the complete phasor information.

Given: R= 8Ω; X_C= 6Ω; V=$50\angle-90°$

Solution:

$Z_C = R - j X_C$

$Z_C = 8 - j6$

$Z_C = 10\angle-36.86°$

$I = V / Z_C$

$I = (50\angle-90°) / (10\angle-36.86°)$

$I = 5\angle-53.13°$ A

$S = I^2 Z$

$S = (5\angle-53.13°)^2 (10\angle-36.86°)$

$S = 250\angle-143.14°$ VA

$S = -200-j150$ VA

$P = I^2 R$

$P = (5)^2 (8)$

$P = 200$ W

$Q = I^2 X_C$

$Q = (5)^2 (6)$

$Q = 150$ VAR

P.f= Cos θ

P.f= cos 36.86°

P.f= 0.8 Leading

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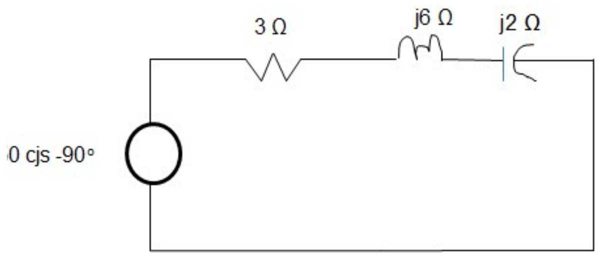
4)Given the series circuit of figure below, determine the power triangle.



Solution:

From the figure $Z = (3 + j6 - j2)\ \Omega$

$= 3 + j4\Omega$

$= 5\angle 53.1°$

$I = V/Z$

$I = (50\angle -90°) / (5\angle 53.1°)$

$I = 10\angle -143.1°$ A

$S = VI$

$S = (50\angle -90°)(10\angle -143.1°)$

$S = 500\angle 53.1°$ VA

$S = 300 + j400$ VA

Therefore the components are:

$P = 300$ W

$Q = 400$ VAR Lagging

$S = 500$ VA

P.f = cos 53.1° = 0.6 Lagging

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5) Determine the power triangles for each branch the parallel circuit and add them to obtain the power triangle for the entire circuit.

Given: $Z_1 = 4\angle 30°\ \Omega$; $Z_2 = 5\angle 60°\ \Omega$

Solution:

For branch 1

$I_1 = V/Z_1$
$I_1 = (20\angle 60°) / (4\angle 30°)$
$I_1 = 5\angle 30°$ A

$S_1 = VI_1$
$S_1 = (20\angle 60°) / (5\angle -30°)$
$S_1 = 100\angle 30°$ VA
$S_1 = 86.6 + j50$ VA

Then; $P_1 = 86.6$ W ; $Q_1 = 50$ VAR Lagging ; $S_1 = 100$ VA ; P.F = 0.866

For branch 2

$I_2 = V/Z_2$
$I_2 = (20\angle 60°) / (5\angle 60°)$
$I_2 = 4\angle 0°$ A

$S_2 = VI_2$
$S_2 = (20\angle 60°) / (4\angle 0°)$
$S_2 = 80\angle 60°$ VA
$S_2 = 40 + j69.2$ VA

Then; $P_2 = 40$ W ; $Q_2 = 69.2$ VAR Lagging ; $S_2 = 80$ VA ; P.F = 0.5

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Therefore;

$P_T = P_1 + P_2$
$P_T = 86.6\ W + 40\ W$
$P_T = 126.6\ W$

$Q_T = Q_1 + Q_2$
$Q_T = 50\ VAR + 69.2\ VAR$
$Q_T = 119.2\ VAR$ (Lagging)

$S_T = P_T + jQ_T$
$S_T = 126.6 + j119.2$
$S_T = 174.0 \angle 43.4°\ VA$

$P.F._T = P_T / S_T$
$P.F._T = 126.6 / 174$
$P.F._T = 0.727$ Lagging

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6) An induction motor with a 2HP output has an efficiency of 85%. At this load the power factor is 0.8 lagging. Determine the complete input power information,

Given: P_O= 2HP ; Eff. = 85%

Solution:

P_{IN}= P_O / Eff
P_{IN}=[(2Hp)(746 Watts / 1 Hp)] / 0.85
P_{IN}= 1755 Watts

Cos θ = 0.8
θ = cos $^{-1}$ 0.8
θ = 36.9°

Cos θ = P/S ; S = P/Cos θ

Therefore;
S= 1755 / 0.8
S= 2190 VA

Cos θ = Q/S
Q= 2190 sin 36.9°
Q= 1315 VAR

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7) Determine the total power triangle for the parallel circuit of figure below if the power in the 2Ω resistor is 20 Watts.

Given:

P_1= 20 Watts

Z_1= 2-j5 Ω = 5.38∟-68.2°

Z_2= 1 + j1 Ω

Solution:

$P = I_1^2 R_1$

$I_1 = \sqrt{\frac{P}{R}}$

$I_1 = \sqrt{\frac{20}{2}}$

I_1= 3.16 A

$V = I_1 Z_1$

V= (3.16)(5.38)

V= 17 Volts

Let V= 17∟0° then,

I_1= 3.16 ∟68.2° A

I_2=(17∟0°) / ($\sqrt{2}$ ∟45°)

I_2= 12 ∟-45° A

$I_T = I_1 + I_2$

I_T= 3.16 ∟68.2° + 12 ∟-45°

I_T= 11.1 ∟-29.8° A

$S_T = VI_T$

S_T= (17∟0°)(11.1 ∟-29.8°)

S_T= 189 ∟29.8° A

S_T= 164+ j94 VA

P.F= 164/189 = 0.868 Lagging

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8) Determine the power component of a combination of the three individual loads specified as follows: load 1: 250 VA, p.f.= 0.5 lagging; Load2: 180W, p.f.=0.8 leading; Load3: 300 VA, 100 VAR lagging. Calculate the unknown average power and reactive power of each load.

Given:

Load 1 : 250 VA , p.f = 0.5 leading
Load 2 : 180 W , p.f = 0.8 leading
Load 3 : 300 VA , 100 VAR lagging

Solution:

For Load 1,

$\cos\theta = 0.5$

$\theta = \cos^{-1} 0.5$

$\theta = 60°$

$P = S\cos\theta$

P=(250)(0.5)
P= 125 W

$Q = S\sin\theta$

Q=(250)(sin60)
Q= 216 VAR

For Load 2,

$\cos\theta = 0.8$

$\theta = \cos^{-1} 0.8$

$\theta = 36.9°$

$S = P/\cos\theta$

S=(180) / (0.8)
S= 225 VA

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For Load 3,

$\theta = \sin^{-1} (Q / S)$

$\theta = \sin^{-1} (100 / 300)$

$\theta = 19.5°$

$P = S \cos \theta$

$P = (300)(\cos 19.5°)$

$P = 283$ W

Therefore,

$P_T = P_1 + P_2 + P_3$

$P_T = 125 + 180 + 283$

$P_T = 588$ Watts

$Q_T = Q_1 + Q_2 + Q_3$

$Q_T = 216 + (-135) + 100$

$Q_T = 181$ VAR Lagging

Since $S_T = P_{ST} + j\, Q_{ST}$

Therefore,

$S_T = 588 + j181$

$S_T = 616 \angle 17.1°$ VA

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9) A two element series circuit with an instantaneous current i = 4.24 sin (5000t + 45°). Has a power of 180 Watts and a power factor of 0.8 lagging. Find the circuit constants.

Given:

i = 4.24 sin (5000t + 45°) A

P= 180 W

Cos θ = 0.8

Solution:

The effective value of current = (4.24) / $\sqrt{2}$ = 3.0A

$P= I^2R$

$R=(180) / (3)^2$

Impedance angle θ = $\cos^{-1} 0.8 = 36.87°$

Number 2 element is an inductor, using power triangle,

$(Q / P) = \tan 36.87° = [(I_{eff})^2 (X_L)] / 180$

$X_L = (180 \tan 36.87°) / 3^2$

$X_L = 15.0\ \Omega$

Since $X_L = 2\pi fL$

$\omega = 2\pi f = 5000$

15 = 5000L

L = 15 / 5000

L = 3 mH

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10) Two impedances $Z_1 = 5.83 \angle -59° \Omega$ and $Z_2 = 8.95 \angle 63.4°$ are in series and pass an effective current of a 5 amp. Determine the complete power information.

Given: $Z_1 = 5.83 \angle -59° \Omega$; $Z_2 = 8.95 \angle 63.4°$

Solution:

For series impedances; $z_T = z_1 + z_2$

$z_T = (5.83 \angle -59°) + (8.95 \angle 63.4°)$

$z_T = 7.0 + j\,3\ \Omega$

$P_T = I^2 R$

$P_T = (5)^2(7)$

$P_T = 175W$

$Q_T = I^2 X_L$

$Q_T = (5)^2(3)$

$Q_T = 75VAR$

$S_T = \sqrt{P_T^2 + Q_T^2}$

$S_T = \sqrt{(175)^2 + (75)^2}$

$S_T = 190.4\ VA$

$P.f = P_T / S_T$

$P.f = 175 / 190.4$

$P.f = 0.918$ lagging

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11) A 500 kVA transformer is at full load with an overall power factor of 0.6 lagging. The power factor is improved by adding capacitors until the overall power factor becomes 0.9 lagging. Determine the kVAR of capacitors required after correction of the power factor, what percentage of full load is the transformer carrying?

Solution:

Cos θ = P/S ; S= 500VA

P= 500 Cos θ

P= 500 (0.6)
P= 300 kW

θ = $\cos^{-1}$ 0.6

θ = 53.1°

Q= VIsin θ

Q=500 sin 53.1°
Q= 400 kVAR lagging

When

Cos θ =0.9 lagging,

θ ‘ = $\cos^{-1}$ 0.9

θ ‘ = 26°

S ‘ = 300 / 0.9
S ‘ =333 kVA

Q ‘ = 333 sin 26°
Q ‘ =146 kVAR

Capacitor kVAR = Q – Q’ = 400 – 146
Q = 254 leading

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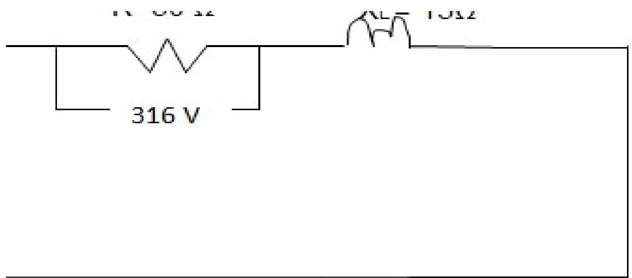
12) A two-element series circuit with R = 5 Ω and X_L= 15Ω has an effective voltage of 31.6 volt across the resistor. Find the complex power and the power factor.



Given:

$R = 5\ \Omega$

$X_L = 15\ \Omega$

$E_R = 31.6V$

Solution:

$I = V_R / R$

$I = 31.6 / 5$

$I = 6.32\ A$

$P_R = I^2 R$

$P_R = (6.32)^2 (5)$

$P_R = 200\ W$

$Q_L = I^2 X_L$

$Q_L = (6.32)^2 (15)$

$Q_L = 600\ VARS$

Complex Power = 200 +j 600

Power Factor= P/ S

Power Factor= $200 / \sqrt{(200)^2+(600)^2}$

Power Factor= 0.316 lagging

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13) A circuit with impedance z=8-j6 Ω has an applied phasor voltage V= 70.7 ∟ -90°. Obtain the power triangle.

Given:

Z= 8-j6 Ω
V= 70.7 ∟ -90° V

Solution:

Z= 8-j6
Z= R- j X_C
Effective Voltage = (Phase Voltage) / $\sqrt{2}$ = (70.7) / $\sqrt{2}$
= 50 V
$I_{effective}$ = 50 / 10 = 5 A

P= I^2R
P= $(5)^2(8)$
P= 200 Watts

$Q_C = I^2 X_C$
$Q_C = (5)^2(6)$
Q_C=150 VAR

P.f.= P/S
P.f.= 200 / $\sqrt{(200)^2+(150)^2}$
P.f.= 0.8 leading

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14) Determine the circuit impedance which has a complex power of S = 5031 ∟ -26.57° for an applied phasor voltage 212.1 ∟ 0° V.

Given:

S = 5031 ∟ -26.57°
V = 212.1 ∟ 0° V

Solution:

Effective Voltage = (212.2) / $\sqrt{2}$ = 150 V

S = 4500 – j2250
P= 4500 W
Q_C= 2250 VAR

P.f = 4500 / 5031
P.f = 0.894 Leading

P = EIcos θ

I= 4500 / (150)(0.894)
I= 33.55 A

P =I^2R
R= 4500 / $(33.55)^2$
R= 4Ω

Q_C= I^2X_C
X_C = 2250 / $(33.55)^2$
X_C =2.0 Ω

z= R - jX_C
z= 4 – j 2 Ω

15) Determine the impedance corresponding to apparent power 3,500 VA, power factor of 0.76 lagging and effective current of 18.0A.

Given:

$P_{apparent}$= 3,500 VA

$\cos\theta$ = 0.76 lagging

$I_{effective}$ = 18.0 A

Solution:

$\theta = \cos^{-1} 0.76$

θ = 40.53 °

S= 3500 ∟40.53°

S= 2660.23 + j2274.46; P = 2660.23 W ; Q_L= 2274.46 VAR

P= I^2R

R=2660.23 / $(18)^2$

R= 8.21Ω

$Q_L = I^2X_L$

X_L =2274.46 / $(18)^2$

X_L = 7.018Ω

z= R + j X_L

z=8.21 + j 7.018

z= 10.8 ∟40.52° Ω

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16) A two branch parallel circuit has a branch impedances of z_1= 2.0 – j5.0 Ω , z_2= 1+j1 Ω. Obtain the complete power triangle for the circuit if the two ohms resistor consumes 20 W.

Given:

z_1= 2.0 – j5.0 Ω
z_2= 1+j1 Ω
$P_{2\Omega}$ = 20 Watts

Solution:

z_1= 2 – j5 = 5.385∟-68.2°
R_1=2Ω
X_C=5Ω
z_2= 1+j1 Ω = 1.414∟45°

I= $\sqrt{20/2}$

I=3.16 A

E= E_{z1}=E_{z2} = 3.16 (5.385)
E= 17.017V

I_2=17.017V / z_2
I_2=(17.017) / (1.414)
I_2= 12.03 A

Total Power = $P_{2\Omega}$ + $P_{1\Omega}$
= 20 + I_2^2(1)
= 20 + $(12.03)^2$(1)
= 164.7 W

Q_C= I_1^2(5) = $(3.16)^2$(5) = 49.928 VAR
Q_L= I_2^2(1) = $(12.03)^2$(1) = 144.72 VAR

Q_{NET}= Q_L – Q_C = 144.72 – 49.928 = 94.79 VAR (Inductive)

P.F.= P / $\sqrt{P^2+Q_{NET}^2}$

P.F.= P / $\sqrt{(164.7)^2+(95)^2}$

P.F.= 0.866 Leading

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17) A two branch parallel circuit with impedances $z_1 = 4\angle -30°$ and $z_2 = 5\angle 60°\ \Omega$ has an effective voltage of 20V. Obtain the power triangles for the branches and combine them to obtain the power triangle.

Given:

$Z_1 = 4\angle -30°\ \Omega$

$z_2 = 5\angle 60°\ \Omega$

$E = 20\text{ V} = E_{z1} = E_{z2}$

Solution:

$I_1 = E_{z1} / z_1$

$I_1 = 20/4$

$I_1 = 5\text{A}$

$I_2 = E_{z2} / z_2$

$I_2 = 20 / 5$

$I_2 = 4\text{ A}$

$Z_1 = 4\angle -30° = 3.46 - j2$

$P_1 = I_1^2(3.46)$

$P_1 = (5)^2(3.46)$

$P_1 = 86.5\text{ W}$

$z_2 = 5\angle 60° = 2.5 + j4.33$

$P_2 = I_2^2(2.5)$

$P_2 = (2.5)^2(2.5)$

$P_2 = 40\text{W}$

Total Power $= P_1 + P_2$

$= 86.5 + 40$

$= 126.5\text{ W}$

$Q_C = I_1^2(2)$

$Q_C = (5)^2(2)$

$Q_C = 50\text{ VARS}$

$Q_L = I_2^2(4.33)$

$Q_L = (4)^2(4.33)$

$Q_L = 69.28\text{ VARS}$

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$Q_{NET} = Q_L - Q_C$
$Q_{NET} = 69.28 - 50$
$Q_{NET} = 15.28$ VARS Inductive

Total Power Triangle:

$S^2 = P_T^2 + Q_{net}^2$

$S = \sqrt{(126.5)^2 + (19.28)^2}$

S = 127.9 VA

$\cos\theta = P.F. = P_T / S$
P.f. = 126.5 / 127.9
P.f. = 0.988

$S = 127.9 \angle 0.988°$

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18) Obtain the complex power for the complete circuit below if branch 1 takes 8 kVAR.

Given:

Q_L=8 kVAR
X_{L1}= j5Ω
R_2= 4Ω
X_{L2}= j2Ω

Solution:

Q_L=8000 VAR (inductive)
$Q_L= I_1^2 X_L$
$I_1^2 = 8000/ j5$
$I_1 = 40$ A

$E= I_1 X_L$
E= (40)(5)
E= 200 Volts

$Z_2 = 4 + j2\Omega$
$Z_2 = 4.47 \angle\ 26.56° \ \Omega$

I_2= 200 / 4.47
I_2= 44.47 A

$P_1=I_2^2$ (4)
$P_1=(44.47)^2$ (4)
P_1=8,006.0 W

$Q_L=I_2^2\ X_L$
$Q_L=(44.74)^2$ (2)
Q_L=4,003.3 VAR

Total Power = 8,006.6 W

$Q_{NET}=P_T + Q_L$
Q_{NET}= 8,000 + 4,003.3
Q_{NET}= 12,003.3 VAR

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$S^2 = P_T^2 + Q_{net}^2$

$S = \sqrt{(8{,}006.6)^2 + (12{,}003.3)^2}$

S = 14,428.6 VA

$\cos\theta$ = P.F. = P_T / S

P.f. = 8,006.6 / 14,428.6

P.f. = 0.555 Lagging

S = 14,428.6 ∟56.28°

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19) A two element series circuit has average power of 940W and a power factor of 0.707 leading. Determine the circuit elements if the applied voltage V = 99.0 cos (6000t + 30°) V.

Given:

P_{ave}= 940 W ; p.f= 0.707

Solution:

$E_{Effective}$ = 99.0 / $\sqrt{2}$ = 70.0

P= V_{eff} x I_{eff} cos θ

I_{eff}= 940 / [(70)(0.707)]

I_{eff}=19.0 A

I_{eff}^2 R= 940

R= 940/19^2

R= 2.6Ω

For leading power factor ,

θ = $\cos^{-1}$ (0.707)

θ = -45°

z= R – jX_C ; X_C = 2.6 tan 45°

Therefore,

2.60 = 1 / ω C

C = 1 / [(2.60)(2 π)(60)]

C = 64.1 μ F

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20) A two branch parallel circuit has a corresponding phasor diagram as shown below. Find the branch impedances Z_1 and Z_2.

Solution using V_1 as reference phasor
$I_1 = 4.95\angle -82.87°$ A ; $I_2=6.67\angle 90°$ A

$Z_1= V/I_1$
$Z_1=(100\angle 0°) / (4.95\angle -82.87°)$
$Z_1=20.2\angle 82.87°$
$Z_1= 2.5 + j20\ \Omega$

$R_1= 2.5\Omega$
$X_{L1}= 20\Omega$

$Z_2=V/I_2$
$Z_2=(100\angle 0°) / (6.67\angle 90°)$
$Z_2=15\angle -90°\Omega$
$Z_2= 0-j15\Omega$

$R_2= 0\Omega$
$X_{C2}= 15\Omega$

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21) A two branch parallel circuit has an applied voltage and resulting currents as given in the phasordigram shown in the figure. Find the branch impedances Z_1 and $Z_{2.}$

Given:

I_1= 6.5A
I_2= 5 A
V= 150V

Solution:

Using X as reference phasor

V_1= 150∟-30°
I_1= 6.5 ∟30°
I_2= 5∟-53.1°

Z_1= V/ I_1
Z_1= (150∟-30°)/(6.5 ∟30°)
Z_1= 23.07∟-60°
Z_1= 11.53-j20Ω

Z_2= V/ I_2
Z_2= (150∟-30°)/(5∟-53.1°)
Z_2= 30∟23.1°
Z_2= 27.6+j11.77Ω

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22. Given $I_1 = 2\angle -30°$ and $I_T = 4.47\angle 33.4°$ A. Find Z_2

Solution:

$I_2 = I_T - I_1$
$I_2 = (4.47\angle 33.4°) – (2\angle -30°)$
$I_2 = 2 + j3.46$
$I_2 = 4\angle 60°$

$I_1 Z_1 = I_2 Z_2$
$Z_2 = (I_1 Z_1) / I_2$
$Z_2 = [(2\angle -30°)(10)] / (4\angle 60°)$
$Z_2 = 0 – j5\Omega$

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23. Use admittances to obtain Y_{eq} and Z_{eq} for the four branch parallel circuit shown in figure below. Compute I_T from the equivalent circuit.

Given:

Z_1= 0+j5Ω = 5∟90°
Z_2= 5+j8.66 = 10∟60°
Z_3= 15+j0 = 15∟90°
Z_4= 0-j10 = 10∟-90°

$Y_{eq}= (z_1)^{-1} + (z_2)^{-1} + (z_3)^{-1} + (z_4)^{-1}$
$Y_{eq}= (5∟90°)^{-1} + (10∟60°)^{-1} + (15∟90°)^{-1} + (10∟-90°)^{-1}$
Y_{eq}= 0.22∟ -58°

$Z_{eq} = Y_{eq}^{-1}$
$Z_{eq}= (0.22∟ -58°)^{-1}$
Z_{eq}= 4.545∟ 58°

$I_T= V/ Z_{eq}$
I_T= (150∟ 45°)/ (4.545∟ 58°)
I_T= 33∟-13°

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24) Find the equivalent admittances and impedance of the three branchparallel circuit shown below.

Given:
$Z_1 = 10+j5 = 11.18\angle 26.56°$
$Z_2 = 5\Omega = 5\angle 0°$
$Z_3 = 2+j8 = 8.24\angle 76°$

Solution:

$Y_{eq} = (Z_1)^{-1} + (Z_2)^{-1} + (Z_3)^{-1}$
$Y_{eq} = (11.18\angle 26.56°)^{-1} + (5\angle 0°)^{-1} + (8.24\angle 76°)^{-1}$
$Y_{eq} = 0.346\angle -27°$

$Z_{eq} = Y_{eq}^{-1}$
$Z_{eq} = (0.346\angle -27°)^{-1}$

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25) Given: V= 50∟30°; I_T= 27.9∟57.8° A. Determine the value of Z_1 in the given figure.

Solution:

Z_{ab}= (Z_2 x Z_3)/ (Z_2 + Z_3)
Z_{ab}= (2-j2)x(10) / (2-j2)+(10)
Z_{ab}= 2.325∟-35.53°Ω

I”=V / Z_{ab}
I”= (100∟90°)/ (2.325∟-35.53°Ω)
I”= -25+j35 A

I’= I_T – I”
I’=(-10.86 + j49) – (-25+j35)
I’= 20∟44.2° A

Z=V / I’
Z=(100∟90°)/ (20∟44.2°)
Z= 5∟45.8°Ω

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26) Referring to figure below, determine the constants R and X_L if the total effective current is 29.9A, the current in the pure resistor is 8A and the current in the parallel R_L is 22.3 A.

Given:
I_T= 29.9A
I_1= 22.3A
I_2=8A

Solution:

Z_{ab}= (Z_2 x Z_3)/ (Z_2 + Z_3)
Z_{ab}= (3-j4)x(5) / (3-j4)+(5)
Z_{ab}= 2.79∟-26.56°Ω

I”=V / Z_{ab}
I”= (50∟30°)/ (= 2.79∟-26.56°Ω)
I”= 17.92∟56.56A

I’= I_T – I”
I’=(27.9∟57.8°) – (17.92∟56.56)
I’= 9.98∟60° A

Z=V / I’
Z=(50∟30°)/ (9.98∟60°)
Z= 5∟-30°Ω

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27) If V= 100∟90° and I_T =50.2∟102.5° in the figure below, determine the value of Z_1.

Given:
Z_2= 2-j2 Ω
Z_3= 10Ω

Solution:

For resistive circuit, the current is in phase with the voltage thus;

I_2=8∟0°
I_1=22.3A

$\cos \varnothing = [8^2 + (22.3)^2 – (29.9)^2] / (2)(8)(22.3)$

$\varnothing = \cos^{1-} (-0.9325)$

$\varnothing = 158.82°$

I_1= 22.3∟-21.18°

Z_1= V / I_1
Z_1= [(8)(15∟0°)] /(22.3∟-21.18°)
Z_1= 5.38∟21.18°

Y_1= z_1^{-1}
Y_1= $(5.38∟21.18°)^{-1}$
Y_1= 0.1733 + j0.067

R = 1/ 0.1733
R= 5.8Ω

X_L= 1/ 0,067
X_L= 14.9Ω
`

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28) A voltmeter placed across the 3 ohms resistor shown, if the voltmeter reads 45 volts. What is the ammeter reading?

Solution:

$I_{3\Omega}$ = 4.5 / 3 = 15A

R_{bc} = (5x2)/(5+2) = 1.43Ω

Z_1= R_{ab}+10
Z_1= 1.43 + 10
Z_1= 11.43Ω

Z_{eq}= $(Z_1Z_2)/(Z_1 + Z_2)$
Z_{eq}= (1.43)(3+j3)/(1.43)+ (3+j3)
Z_{eq}=3.28∟-33.25°

I_{ac}= (15)(3+j3)/ 11.43
I_{ac}= 3.92 +j3.92

Ammeter Reading

I_{am}= $I_{3\Omega}$ + I_{ac}
I_{am}= 15 +(3.92+j3.92)
I_{am}= 19.4∟11.71°

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29. In the circuit of figure below, the effective voltage between points A & B is 25V. Find the corresponding effective values of V and I_T (Hint: assume any convenient V' and determine the corresponding V_{AB} ; Then (V/25) = (V'/V_{ab}'))

Given:
V_{ab}= 25V
Z_1= 5+j3Ω = 5.83∟30.96°
Z_2= 10+j0 = 10∟0°

Solution:
Let V'= 120V
I_1=(120)/ (5.83∟30.96°)
I_1= 20.58∟-30.96°A

I_2= (120∟0°)/ 10
I_2= 12∟0° A

V_{AB}'= -I_1(5) + I_2(6)
V_{AB}'=[-(20.58∟-30.96°A)(5)] / [(12∟0°)(6)]
V_{AB}'=55.36∟-107.05° V

Then;

V= 25(120/ 55.36)
V= 54.2 V

Z_T=[(10)(5.38∟30.96°)] / (15+j3)
Z_T= 3.81∟19.65° Ω

I_T= V/z_T
I_T= 54.2/3.81
I_T= 14.22 A

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30. A single-phase AC voltage of 240V is applied to series circuit whose impedance is $10\angle 60°\Omega$. Find R,X,P,Q and the power factor.

Solution:

$R = 10\cos 60°$
$R = 5.0\ \Omega$

$X = 10 \sin 60°$
$X = 8.66\ \Omega$

$I = (240\angle 0°) / (10\angle 60°)$
$I = 24\angle -60°\ A$

$P = (24)^2\ (5)$
$P = 2880W$

$Q = (24)^2\ (8.66)$
$Q = 4988\ VAR$

$p.f = \cos [\tan^{-1}(Q/P)]$
$p.f = \cos [\tan^{-1}(4988/2880)]$
$p.f = 0.5$

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31. If a capacitor is connected in parallel with the circuit of the previous problem and if this capacitor supplies 1250 VAR, find the P and Q supplied by the 240V source, and find the resultant power factor.

Given:

P = 2880W
Q = 4988 VAR

Solution:

Q= 4988 – 1250
Q= 3738 VAR

Power factor = cos [$\tan^{-1}$(Q/P)]
p.f = cos [$\tan^{-1}$(3738/2880)]
p.f = 0.61

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32. Find the equivalent impedance and equivalent admittance for the two branch parallel circuit shown in fig. below. Compute the current from each equivalent circuit.

Given:

$Z_L = 10 + j20\Omega = 22.36\angle 63.43°$
$Z_C = 15 - j15\Omega = 21.21\angle -45°$

Solution:

$Z_{eq} = (Z_L \times Z_C) / (Z_L + Z_C)$
$Z_{eq} = (22.36\angle 63.43° \times 21.21\angle -45°) / (22.36\angle 63.43° + 21.21\angle -45°)$
$Z_{eq} = (474.25 \angle 18.43°) / (25.5\angle 11.319°)$
$Z_{eq} = 18.6\angle 7.12°$

$Y_{eq} = Z_{eq}^{-1}$
$Y_{eq} = (18.6\angle 7.12°)^{-1}$
$Y_{eq} = 0.0538\angle -7.12°$

$I_1 = V/Z_L$
$I_1 = 200\angle 0°/(22.36\angle 63.43°)$
$I_1 = 8.94\angle -63.43°$
$I_1 = 4 - j8$ A

$I_2 = V/Z_C$
$I_2 = 200\angle 0°/(21.21\angle -45°)$
$I_2 = 9.43\angle 45°$
$I_2 = 6.66 + j6.66$A

$I_T = I_1 + I_2$
$I_T = (4 - j8) + (6.66 + j6.66)$
$I_T = 10.66 - j1.34$
$I_T = 10.74\angle -7.16°$

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33. Find I_T in the two branch parallel circuit shown in figure below. Find the equivalent impedance from the ratio V/I_T and compare this with $Z_{eq} = Z_1Z_2 / Z_1+Z_2$

Given:

Z_1= 4- j4 =5.65∟-45°
Z_2 = 5+j8.66 =9.99∟59.99°

Solution:

I_1= V/z_1
I_1= (100∟30°)/(5.65∟-45°)
I_1= 17.7∟75°

I_2= V/z_2
I_2= (100∟30°)/(9.99∟59.99°)
I_2= 10∟-30°

I_T = I_1 + I_2
I_T=(17.7∟75°) + (10∟-30°)
I_T= 13.24 + j12.09
I_T= 17.9∟42.4°

Z_{eq}= (Z_L x Z_C) / (Z_L + Z_C)
Z_{eq}=[(5.65∟-45°) x(9.99∟59.99°)] / [(5.65∟-45°) +(9.99∟59.99°)]
Z_{eq}= 5.57∟-12.4°

I= V/ Z_{eq}
I= (100∟30°)/(5.57∟-12.4°)
I= 17.9∟42.4°A

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34. A resistor and an inductor are connected in parallel to a 120 volt 60 cycles source. If the total current and power in the circuit are 17A and 1800 Watts , calculate the values of R and L.

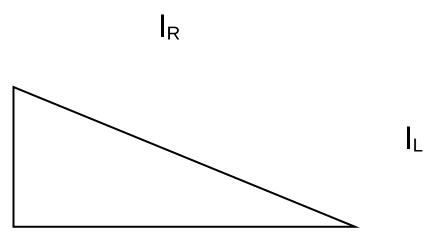
Given:

I_T= 17A
P_T= 1800W
V_T= 120V = V_R

Solution:

$P_T = V_T I_T \cos\theta$
$\theta = \cos^{-1} [(120 \times 17)/ 1800]$
$\theta = 28.0725°$

$\cos\theta° = I_R / I_T$
I_R= (17) cos 28.0725°
I_R= 15A



$V_R = I_R R$
120= (15A)R
R = 8Ω

$\sin\theta = I_L / I_T$
I_L= (17) sin 28.0725°
I_L= 8A

$X_L = 2\pi fL$
X_L= 15Ω
$L = (2\pi)(60) / 15$
L = 0.0398 H

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35. A single-phase inductive load draws 10 MW at 0.6 power factor lagging. Draw the power triangle and determine the reactive power of a capacitor to be connected in parallel with the load to raise the power factor to 0.85

Solution:

$(10 / 0.6) \sin (\cos^{-1} 0.6) = 13.33$
$\text{Cos}^{-1} (0.85) = 31.79°$
$10 \tan 31.79° = 6.2$ VAR

$Q_C = - (13.33 – 6.2)$
$Q_C = -7.13$ Mvar

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36. A resistor R are connected in parallel to an inductive resistance jX_L and the combination is connected in parallel to a 4 ohm resistor. The total current is 30A, the current through the parallel R and jX_L is 18 A while current through the 4 ohm resistor is 15A. Determine the unknown R and jX_L.

Solution:

$\theta = 180 - \cos^{-1}[(I_1^2 + I_2^2 - I_T^2)] /(2I_1 I_2)$

$\theta = 180 - \cos^{-1}[(18^2 + 15^2 - 30^2)] /(2)(18) (15)$

$\theta = 49.4584°$

$V_T = 4(15A)$

$V = 60V$

$I_R = I_1 \cos \theta$

$I_R = 18 \cos 49.4584°$

$I_R = 11.7A$

$I_L = I_1 \sin \theta$

$I_L = 18 \sin 49.4584°$

$I_L = 13.687A$

$R = V_T / I_R$

$R = 60V / 11.7A$

$R = 5.1282\ \Omega$

$X_L = V_T / I_L$

$X_L = 60V / 13.687A$

$X_L = 4.3837\ \Omega$

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37. A series combination of R and C is in parallel with a 20Ω resistor. A 60 Hz source resulting in a total current of 7.02A, a current through the 20Ω resistor is 6A and the current in the RC branch is 2.3A. Determine the R and C.

Solution:

$\theta = \cos^{-1}[(I_T^2 - I_R^2 - I_Z^2)] /(2I_R I_z)$

$\theta = \cos^{-1}[(7.02^2 - 6^2 - 2.3^2)] /(2)(6) (2.3)$

$\theta = 73.1715°$

$V_T = (20\Omega)(6A)$
V= 120V

$Z=V_T / I_z$
Z=120V/ 2.3A
$Z=52.1739 \angle \theta \ \Omega$
$Z=52.1739 \angle 73.1715° \ \Omega$
Z=15.1048 + j 49.9396

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38) A load of 300kW with a power factor of 0.65 lagging has the power factor improved to 0.90 lagging by the addition of parallel capacitors. What kVAR of capacitors does require to improved the power factor?

Given:
P= 300kW
Pf_i = 0.65 lagging
Pf_f= 0.90 lagging

Solution:

$\theta_i = \cos^{-1} 0.65$

$\theta_i = 49.4584°$

$\theta_f = \cos^{-1} 0.90$

$\theta_f = 25.8419°$

Q_{req}= P [tan θ_{I} – tan θ_f]
Q_{req} 300kW (tan49.4584° - tan25.8419°)
Q_{req}= 205.4425kVAR (leading)

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39) A 20 ohm resistor is connected in series with a parallel combination of a capacitance C and 15mH pure inductance. At angular frequency ω = 1000rad/s, find C such that the line current is 45° out of phase with the line voltage.

Given:

R= 20Ω
L = 15mH
ω = 1000rad/s
C =?

Solution:

Z= R $\pm$ jX
Z_T = 20 + [(j15)(-jX_C)] / (15- X_C) j

Z_{T}= ∞

0 = 20 + [(j15)(-jX_C)] / (15- X_C) j
X_C = 60Ω

C= 1/ (2 π fX_C)

C = 1/ [(1000)(60)]

C = 16.6667 μ F

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40) An inductive coil consumes 500W of power at 10A and 110V and 60Hz. Determine the resistance and the inductance of the coil.

Given:
P= 500W
I = 10A

Solution:

$P_T = V_T I_T \cos\theta$

$\theta = \text{Cos}^{-1}$ [(110 x 10)/ 500]

θ = 62.9643 °

$z_T = V_T / I_T$
z_T= 110/10
z_T= 11Ω

Z_T= 11∟62.9643 °
Z_T= 5 + j.7980

X_L= 9.7980

$X_L = 2\pi fL$

X_L= 9.7980

L = 9.7980 / (2 π)(60)

L = 25. 9900H

R = 5Ω

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41) An inductive coil having a 30 ohm resistance and unknown reactance is connected in parallel with 100 ohm resistor. The combination is connected across a 100V 50/ π Hz source. If the power delivered by the source is 400W, find the value of the inductance.

Solution;

$P_T = P_1 + P_2$
$P_T = (I_1^2 R) + (V^2/R)$
$400 = (I_1^2 (30) + (100^2/100)$
$I_1 = 3.1623$ A

$Z = V_2 / I_2$
$Z = 100 / 3.1623$
$Z = 31.6266\ \Omega$

$Z^2 = R^2 + X^2$
$(31.6266)^2 = 30^2 + X^2$
$X_L = 10$

$X_L = 2 \pi fL$

$L = 10 / (2 \pi)(50 / \pi)$

$L = 0.1H$

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42) A 250VA 0.5 lagging power factor load is connected in parallel to 180W 0.8 leading power factor load and the combination to 300VA 100 VAR inductive load. Determine the complex power for the combination of the three loads.

Given:

Load 1: 250VA, p.f 0.5 lagging
Load2: 180W, p.f 0.8 leading
Load 3: 300VA 100 VAR

Solution:

$\theta_1 = \text{Cos}^{-1}\, 0.5$

$\theta_1 = 60°$

$\theta_2 = \text{Cos}^{-1}\, 0.8$

$\theta_2 = 36.8699°$

$S_2 = P_2 / \cos \theta_2$
$S_2 = 180 / \cos 36.8699°$
$S_2 = 225$ VA

$\theta_1 = \sin^{-1} Q/S$

$\theta_1 = \sin^{-1} 100/300$

$\theta_1 = 19.4712°$

$S_T = S_1 + S_2 + S_3$
$S_T = (250 \angle 60°) + (225 \angle -36.8699°) + (300 \angle 19.4712°)$
$S_T = 587.8427 + j\, 181.5062$
$S_T = 615.\ 2265 \angle 17.1589°$

$S_T = 615.\ 2265$ VA
P = 587.8427 W
Q = 181.5062 lagging

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43. A given load takes 40kVaat 0.5 lagging power factor while another load connected in parallel across the same source takes 80 kVa at 0.88 lagging power factor. Find the total reactive power.

Solution:

S_1 =40 kVa @ 0.5 lagging

S_2 =80 kVa @ 0.88 lagging

S_T = S_1 + S_2

S_T =40 └- $\cos^{-1}$ 0.5 + 80 └- $\cos^{-1}$ 0.88

S_T =40 └-60 + 80 └-28.357

S_T =90400.42217-j72638.12866° kVa

Q_T = 72638.9108 VAR

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44. An inductive reactance of 10Ω is connected in parallel with capacitive reasctance of 30Ω. If the combination is connected in series with 10 Ω resistance, solve for the total impedance of the circuit.

Solution:

$$z_T = \left[\frac{1}{0+jX_L}+\frac{1}{0-jX_L}\right]^{-1} +10$$

$$Z_T = \left[-j\frac{1}{X_L}+j\frac{1}{X_C}\right]^{-1} +10$$

$$Z_T = \left[-j\frac{1}{10}+j\frac{1}{30}\right]^{-1} +10$$

$$Z_T = j15 +10$$

$$Z_T = 18.03 \angle 56.31°$$

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45. Two impedances Z_1 =3+j4, Z_2 =5-j8.66 Ω respectively are connected in parallel. If the combination is connected across a 240 V ac source, how much is the total power?

Solution:

Z_1 =3+j4 = 5 └ 53.13°

Z_2 =5-j8.66 = 9.99977 └ -59.9993°

$I_1 = \frac{E}{Z_1}$

$I_1 = \frac{240 \llcorner 0}{5 \llcorner 53.13°}$

I_1 = 48 └-53.13°

$P_1 = I_1^2$ R

$P_1 = 48^2$ (3)

P_1 =6912W

$I_2 = \frac{E}{Z_2}$

$I_2 = \frac{240 \llcorner 0}{9.99977 \llcorner -59.9993°}$

I_2 = 24 └-59.9993°

$P_2 = I_2^2$ R

$P_1 = 24^2$ (5)

P_1 =2880W

$P_T = P_1 + P_2$

P_T = 9792 W

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46. A coil having a resistance of 30Ω and an inductance L is connected in parallel with a resistor having a resistance o 100Ω. The combination is connected across a 100V, 60 Hz source. If the power delivered by the source is 400 W, find the value of L.

Solution:

$$Y_T = \frac{1}{R_1 + jX_L} + \frac{1}{R_2}$$

$$Y_T = \frac{R_1 - jX_L}{R_1^2 + X_L^2} + \frac{1}{R_2}$$

$$Y_T = \left[\frac{R_1}{R_1^2 + X_L^2} + \frac{1}{R_2}\right] - \frac{jX_L}{R_1^2 + X_L^2}$$

$$Y_T = G_T - j\beta_T$$

$$Y_T = \left[\frac{30}{30^2 + X_L^2} + \frac{1}{100}\right] - j\frac{X_L}{30^2 + X_L^2}$$

$$P_T = E^2 G_T$$

$$400W = (100^2 ¿ \left(\frac{30}{30^2 + X_L^2} + \frac{1}{100}\right)$$

X_L =10Ω

$X_L = 2\pi fL$; $L = \frac{X_L}{(2\pi f)}$

$$L = \frac{10}{(2\pi)(60)}$$

L=0.0265 H

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47. A parallel circuit consists of a resistor having a conductance of 4 mhos, an inductive reactor having a susceptance of 8 mhos and a capacitive reactor having a susceptance of 6 mhos. What is the impedance of the circuit?

Solutiuon:

G_T =4Ω

β_{TL} =8Ω

β_{TC} =6Ω

Y_T =4-j8+j6

Y_T =4-j2

$Z_T = \frac{1}{4-j2}$

Z_T =0.2236 └26.57°

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48. Two parallel branches have admittances of 0.3+j0.4 and 0.2-j0.5 respectively. If the current in the first branch is 11 A, determine the total current supplied to the combination.

Solution:

$Y_T = Y_1 + Y_2$

$Y_T = 0.3 + j0.4 + 0.2 - j0.5$

$Y_T = 0.5 - j0.1$

$Z_1 = 2 \angle -53.13°$

E=IZ

E=(11)($2 \angle -53.13°$)

E= $22 \angle -53.13°$

$Y_T = 0.5099 \angle -11.31°$

$I_T = E X_T$

$I_T = ¿ 22 \angle -53.13°$][$0.5099 \angle -11.31° ¿$

$I_T = 11.2178 \angle = 64.44°$

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49. Two impedances Z_1 =3+j4 and Z_2 =R+j0 are connected in parallel. Determine R so that the power factor of the circuit is 0.9 lagging.

Solution:

$$Y_T = \frac{1}{3+j4} + \frac{1}{R_2}$$

$$Y_T = \frac{1}{R_1 + jX_L} + \frac{1}{R_2}$$

$$Y_T = \frac{R_1 - jX_L}{{R_1}^2 + {X_L}^2} + \frac{1}{R_2}$$

$$Y_T = \left[\frac{R_1}{{R_1}^2 + {X_L}^2} + \frac{1}{R_2}\right] - j\frac{X_L}{{R_1}^2 + {X_L}^2}$$

$$Y_T = \left[\frac{3}{3^2 + 4^2} + \frac{1}{R_2}\right] - j\frac{4}{3^2 + 4^2}$$

Y_T = G_T -j β_T

$$Y_T = 0.12 + \frac{1}{R_2} - j0.16$$

Tan 25.84° = $\dfrac{0.16}{0.12 + \frac{1}{R_2}}$

R=4.75Ω

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50. An inductive coil with a resistance R and inductance L is connected in parallel with a 30 Ω resistor. The combination is then connected across a 60 Hz source. If the currents in the coil, resistor and total are 6,4 and 8 A respectively. Determine the inductance of the coil.

Solution:

$$E=(30)(4)$$

$$E=120\,V$$

$$\beta=\cos^{-1}[\frac{6^2+4^2-8^2}{(2)(6)(4)}]$$

$$\beta=104.4775°$$

$$\theta=180-\beta$$

$$\theta=75.52°$$

$$I=\frac{E}{Z};Z=\frac{120}{6}=20\,\Omega$$

$$Z=20\,\llcorner 75.52°$$

$$Z=5.0008+j\,19.36$$

$$R=5.0008\,\Omega$$

$$X_L=19.36\Omega$$

$$L=\frac{19.36}{(2\pi)(60)}$$

$$L=0.0514\,H$$

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51. Two circuits, the impedance of which are given by $Z_1 = 10 + j15$ and $Z_2 = 6 – j8$ ohms are connected in parallel. If the total current supplied is 15A, what is the power taken by each branch? Find also the p.f. of individual circuits and of combination. Draw the vector diagram.

Solution:

Let $I = 15 \text{ cjs } 0° \text{ A}$; $Z_1 = 10 + j15 = 18 \text{ cjs } 57° \ \Omega$

$Z_2 = 6 – j8 = 10 \text{ cjs } -53.1° \ \Omega$

Getting the total impedance:

$$Z_T = Z_1 Z_2 \ / \ (Z_1 + Z_2) = [(10 + j15) (6 – j8)] / (16 + j17)$$

$$Z_T = 9.67 – j3.6 \ \Omega = 10.3 \text{ cjs } -20.4° \ \Omega$$

Applied voltage is given by:

$$V = IZ_T = (15 \text{ cjs } 0°) (10.3 \text{ cjs } -20.4°) = 154.5 \text{ cjs } -20.4° \text{ V}$$

$$I_1 = V / Z_1 = (154.5 \text{ cjs } -20.4°) / (18 \text{ cjs } 57°) = 8.58 \text{ cjs } -77.4° \text{ A}$$

$$I_2 = V / Z_2 = (154.5 \text{ cjs } -20.4°) / (10 \text{ cjs } -53.1°) = 15.45 \text{ cjs } 32.7° \text{ A}$$

We could also find branch currents as under:

$$I_1 = (IZ_2) / (Z_1 + Z_2) \quad \text{and} \quad I_2 = (IZ_1) / (Z_1 + Z_2)$$

It is seen from the phasor diagram that I_1 lags behind V by (77.4° - 20.4°) = 57° and I_2 leads it by (32.7° + 20.4°) = 53.1°

Therefore:

$$P_1 = I_1^2 R_1 = (8.58)^2 \times 10 = 736 \text{ W; p.f.} = \cos 57° = 0.544 \text{ (lag)}$$

$$P_2 = I_2^2 R_2 = (15.45)^2 \times 6 = 1432 \text{ W; p.f.} = \cos 53.1° = 0.6$$

Combined p.f.:

$$\text{p.f.} = \cos 20.4° = 0.937 \text{ (lead)}$$

52. Two impedance $Z_1 = 8 + j6\ \Omega$ and $Z_2 = 3 - j4\ \Omega$ are in parallel. If the total current of the combination is 25 A, find the current taken and power consumed by each impedance.

Solution:

$Z_1 = (8 + j6) = 10\ \text{cjs}\ 36.87°\ \Omega$

$Z_2 = (3 - j4) = 5\ \text{cjs}\ -53.1°\ \Omega$

$Z_T = Z_1 Z_2 / (Z_1 + Z_2) = [(8 + j6)(3 - j4)] / (11 + j2)$

$Z_T = (50\ \text{cjs}\ -16.23°) / (11.18\ \text{cjs}\ 10.3°) = 4.47\ \text{cjs}\ -26.53°\ \Omega$

Let: $I_T = 25\ A$

$V = I_T Z_T = (25\ \text{cjs}\ 0°)(4.47\ \text{cjs}\ -26.53°) = 111.75\ \text{cjs}\ -26.53°\ V$

$I_1 = V / Z_1 = (111.75\ \text{cjs}\ -26.53°) / (10\ \text{cjs}\ 36.87°) = 11.175\ \text{cjs}\ -63.4°\ A$

$I_2 = V / Z_2 = (111.75\ \text{cjs}\ -26.53°) / (5\ \text{cjs}\ -53.1°) = 22.35\ \text{cjs}\ 26.57°\ A$

The phase difference between V and I_1 is (63.4° - 26.53°) = 36.87° with the current lagging. Hence, $\cos Ø_1 = \cos 36.87° = 0.8$.

Power consumed in $Z_1 = VI_1 \cos Ø_1 = [(11.175)(111.75)(0.8)] = 990\ W$

Similarly, $Ø_2 = 26.57° - (-26.53°) = 53.1°$

$\cos Ø_2 = \cos 53.1° = 0.6$

Power consumed in $Z_2 = VI_2 \cos Ø_2 = [(111.75)(22.35)(0.6)] = 1499W$

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53. A mercury vapour lamp unit consist of a 25 μF condenser in parallel with a series circuit containing the resistive lamp and a reactor of negligible resistance. The whole unit takes 400 W at 240 V, 50 Hz at unity p.f.. What is the voltage across the lamp?

Solution:

$X_C = [1 / (2\pi fC)] = [1 / (2\pi) (50) (25 \times 10^{-6})] = 127.3\ \Omega$

$I_C = V / X_C = (240 / 127.3) = 1.885\ A$

$W = VI \cos Ø = VI$

$I = (W / V) = (400 / 240) = 1.667\ A$

Since the vector sum of I_C and $Ø_1$ gives the total current I. it is understood that $\tan Ø_1 = I_C / I = 1.885 / 1.667 = 1.13077$. Hence, $Ø_1 = 48.5°$ lag. The applied voltage V is the vector sum of the drop across the resistive lamp which is in phase with I_1 and drop across the coil which leads I_1 by 90°.

Voltage across the lamp:

$V = V \cos Ø_1 = 240 \times \cos 48.5° = 240 \times 0.662 = 159\ V$

54. The currents in each branch of a two-branched parallel circuit are riven by the expression i_a = 7.07 sin (314t – π/4) and i_b = 21.2 sin (314t + π/3). The supply voltage is given by the expression v = 354 sin 314t. derive a similar expression for the supply current and calculate the ohmic value of the component, assuming two pure components in each branch. State whether the reactive components are inductive or capacitive.

Solution:

By inspection, we find that i_a lags the voltage by π/4 radian or 45° and i_b leads it by π/3 radian or 60°. Hence, branch A consists of a resistance in series with a pure inductive reactance. Branch B consists of a resistance in series with pure capacitive reactance.

Maximum value of current in branch A is 7.07 A and in branch B is 21.2 A. the resultant current can be found vectorially.

X_{comp} = (21.2 cos 60°) + (7.07 cos 45°) = 15.6 A

Y_{comp} = (21.2 sin 60°) – (7.07 sin 45°) = 13.36 A

Maximum value of the resultant current is:

$I_R^2 = (15.6)^2 + (13.36)^2$

I_R = 20.55 A

Ø = $\tan^{-1}$ (13.36 / 15.6) = $\tan^{-1}$ (0.856) = 40.5° (leading)

Hence, the expression for the supply current is I = 20.55 sin (314t + 40.5°

Z_A = 354/7.07 = 50 Ω ; cos $Ø_A$ = cos 45° = 0.7071

R_A = Z_A cos $Ø_A$ = (50) (0.7071) = 35.4 Ω

X_L = Z_A cos $Ø_A$ = (50) (0.7071) = 35.4 Ω

Z_B = 354/20.2 = 17.5 Ω

R_B = 17.5 x cos 60° = 8.75 Ω

X_C = 17.5 x sin 60° = 15.16 Ω

55. A total current of 10 A flows through the parallel combination of three impedances: (2 – j5)Ω, (6 + j3) Ω, and (3 + j4)Ω. Calculate the current flowing through each branch. Find also the p.f. of the combination.

Solution:

Let $Z_1 = (2 – j5)$ Ω , $Z_2 = (6 + j3)$ Ω , and $Z_3 = (3 + j4)$ Ω

$Z_1Z_2 = (2 – j5) (6 + j3) = 27 – j24$ Ω

$Z_2Z_3 = (6 + j3) (3 + j4) = 6 + j33$ Ω

$Z_3Z_1 = (3 + j4) (2 – j5) = 26 – j7$ Ω

$Z_1Z_2 + Z_2Z_3 + Z_3Z_1 = (27 – j24) + (6 + j33) + (26 – j7) = 59 + j2$ Ω

Getting the currents:

$I_1 = I .\{(Z_2Z_3) / [(Z_1Z_2) + (Z_2Z_3) + (Z_3Z_1)]\} = [(10 + j0) (6 + j33) / (59 + j2)] = 1.21 + j5.55$ A

$I_2 = I .\{(Z_1Z_3) / [(Z_1Z_2) + (Z_2Z_3) + (Z_3Z_1)]\} = [(10 + j0) (26 – j7) / (59 + j2)] = 4.36 – j1.33$ A

$I_1 = I .\{(Z_2Z_1) / [(Z_1Z_2) + (Z_2Z_3) + (Z_3Z_1)]\} = [(10 + j0) (27 – j24) / (59 + j2)] = 4.43 – j4.22$ A

For the total impedance:

$Z_T = \{(Z_1Z_2Z_3) / [(Z_1Z_2) + (Z_2Z_3) + (Z_3Z_1)]\} = [(2 – j5) (6 + j33)] / (59 + j2) = 3.01 + j0.51$ Ω

V = (10 cjs 0°) (3.05 cjs 9.6°) = 30.5 cjs 9.6°

Combination p.f.:

p.f. = cos 9.6° = 0.986 (lag)

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56. Two impedances Z_1 = (6 – j8) ohms and Z_2 = (16 + j12) ohms are connected in parallel. If the total current of the combination is (20 + j10) A. Find the complexor for power taken by each impedance.

Solution:

Finding out the applied voltage:

$Y = Y_1 + Y_2$ = [1 / (6 – j8)] + [1 / (16 + j 12)] = (0.06 + j0.08) + (0.04 + j0.03) = 0.01+ j0.05 = 0.1118 cjs 26°34'

I = 20 + j10 = 22.36 cjs 26°34' A

V = I / Y = (22.36 cjs 26°34') / (0.1118 cjs 26°34')

57. The power factor for the circuit, overall, has been substantially improved. The main current has been decreased from 1.41 amps to 994.7 milliamps, while the power dissipated at the load resistor remains unchanged at 119.365 watts. The power factor
is much closer to being 1:

Solution:

P.f. =true power / apparent power
P.f. = 119.365W / 119.366 VA
P.f. = 0.9999887

impedance (polar) angle = 0.272
cos 0.272 = 0.9999887

58. Calculate the current in this circuit, and also the amount of mechanical power (in units of "horsepower") required to turn this alternator (assume 100% efficiency): given, volts and 3.4 resistance.

Solution:

$I = V / R$
$I = 480/ 3.4$
$I = 141.18$ A

59. A 50-microfarad is connected in series with a coil 50 ohms resistance and 150-mh inductance. The source voltage is 100 sin (wt – 30) V. What is the maximum power?

Solution:

$X_L = wL = 377(0.150) = 56.55\Omega$

$X_C = \frac{1}{wC} = \frac{1}{377(50 x 10^{-6})} = 53.05\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2}$

$Z = \sqrt{50^2 + (56.55 - 53.05)^2}$

$Z = 50.122\Omega$

$\Theta_L = \cos^{-} \frac{R}{Z} = \cos^{-} \left(\frac{50}{50.122} \right) = 3.998^\circ$

$\Theta_L \approx 4^\circ$

$I_m = \frac{E_M}{Z} = \frac{100 < -30^\circ}{50.122 < 4^\circ} = 1.995 < -34^\circ$

$P_m = E_m I_m \cos \Theta = (100)(1.995) \cos 4^\circ$

$P_m = 199\ W$

60.

A load of 20 + j35 is connected across a 220 volts source. Determine the power factor and the VARS.

Solution:

Z = 20 + j35 = 40.31 < 60.255°
pf = cos ϴ = cos 60.255° = 0.496

pf = 49.6 %

Q = EI sin ϴ = $\frac{E^2}{Z}$ sin ϴ = $\frac{220^2}{40.31}$ sin 60.255°

Q = 1042.25 VARS

61. The network is part of the schematic describing an industrial electronic sensing device. What is the total impedance of the circuit at 2 kHz?

Solution:

Z_1 = 50 + 1/jωC = 50 + 1/(2π)(2x10^3)(2x10^{-6})
= 50 – j39.79
Z_2 = 80 + jωL = j(2π)(2x10^3)(2x10^{-6})
= 80 + j125.66
Z_3 = 100

1/Z = 1/Z_1 + 1/Z_2 + 1/Z_3
1/Z= 10^{-3} (10 12.24+ j9.745 +3.605- j5.663)
Z= (25.85 + j4.082) ×10^{-3}
= 26.17×10^{-3}∠8.97°

Z = 38.21∠-8.97°Ω

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62. Two electric units are connected across a source whose frequency is 50 cps. If the voltage drop across the units are 115 and 90 volts and they are out of phase by 90°, what is the equation of the voltage across the source?

Solution:

$E_T = \sqrt{E_1^2 + E_2^2}$

$= \sqrt{115^2 + 90^2}$

$E_T = 5\sqrt{853} = 146.031$

$\Theta = \tan^{-}\left(\frac{90}{115}\right)$

$\Theta = 38.0470°$

$E_{Mt} = E_T\sqrt{2}$

$= 146.031\left(\sqrt{2}\right)$

$E_{Mt} = 206.5188$ V

$\omega = 2\pi f$

$= 2\pi\,(50)$

$\omega = 314$

$E_t = 206.52 \sin(314t + 38.05°)$ V

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63. An impedance draws a current of 24 A at 0.8 lagging power factor from a source voltage of 240V, 60 Hz. What is the current when resistance is reduced by 50%?

Solution:

Z = $\frac{e}{i}$ = $\frac{240}{24}$ = 10Ω

Pf = $\frac{R}{Z}$

R = Z (Pf) = (10) (0.8) = 8Ω

X_L = $\sqrt{Z^2 - R^2}$

= $\sqrt{10^2 - 8^2}$

X_L = 6Ω

When R = 4Ω

Z = $\sqrt{R - X_L{}^2}$

= $\sqrt{4^2 - 6^2}$

Z = 2 $\sqrt{13}$ Ω

I = $\frac{e}{z}$ = Z = $\frac{240\,V}{2\sqrt{13}\,\Omega}$

I = 33.2820 A

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64. A single phase load takes 60 kW at 80% pf lagging from a 220 V, 50 Hz supply. If the supply is made 60 Hz, with the voltage remaining the same, what will be the kW load at 60 Hz?

Solution:

At 50 Hz:

Z= $\frac{E^2 cos\theta}{p} = \frac{(220)^2(0.8)}{60000} = 0.645\, ohms$

$\theta = \cos^{-1} 0.8 = 36.869°$

R=Z cos θ =0.645(0.8)=0.516 ohms

X_L=Z sin θ =0.645(sin36.869 $°$)=0.387 ohms

L= $\frac{Xl}{2\pi f} = \frac{0.387}{2\pi(50)} = 1.232\, mH$

At 60 Hz:

X_L=2 π fL=2 π (60)(1.232x10^{-3})=0.464 ohms

Z= $\sqrt{R^2 + Xl^2} = \sqrt{(0.516)^2 + (0.464)^2} = 0.694\, ohms$

Cos θ = $\frac{R}{Z} = \frac{0.516}{0.694} = 0.744$

P= $\frac{E^2 cos\theta}{Z} = \frac{(220)^2(0.744)}{0.694} = ¿$ 51,887.03 W

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65. An inductive coil takes a current of 2 A and consumes 200 W when connected to a 220 v AC supply. A second coil when connected across the same supply takes 3 A and 300 W. Find the total power when the two coil are connected in series to this supply.

Solution:

$R_a = \frac{Pa}{I a^2} = \frac{200}{2^2} = 50\, ohms$

$Z_a = \frac{E}{Ia} = \frac{220}{2} = 110\, ohms$

$X_a = \sqrt{Z a^2 - R a^2} = \sqrt{110^2 - 50^2} = 97.980\, ohms$

$R_b = \frac{Pb}{I b^2} = \frac{300}{3^2} = 33.333\, ohms$

$Z_b = \frac{E}{Ib} = \frac{220}{3} = 73.333\, ohms$

$X_b = \sqrt{Z b^2 - R b^2} = \sqrt{73.333^2 - 33.333^2} = 65.320\, ohms$

$Z_t = \sqrt{(Ra + Rb)^2 + (Xa + Xb)^2}$

$Z_t = \sqrt{(50 + 33.333)^2 + (97.980 + 65.320)^2}$

Z_t=183.333 ohms

$I_t = \frac{E}{Zt} = \frac{220}{183.333} = 1.20\, A$

$P_t = I_t^2 R_t = (1.20)^2 (50+33.333)$

P_T = 120 W

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66. A current of 10 A and a power factor of 0.8 lagging is taken from a single phase 250 volt supply. The reactive power of the system is?

Solution:

$$\theta = \cos^{-1} 0.8 = 36.869°$$

$Q = EI\sin\theta$

$Q = (250)(10)\sin 36.869°$

Q = 1500 VARS

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67. A coil of 50-ohm resistance and of 150 mH inductance is connected in parallel with a 50 μF capacitor. What is the power factor of the circuit?

Solution:

$X_L = \omega L = (377)(0.15) = 56.55\ \Omega$

$X_C = 1 / \omega C = 1 / (377)(50 \times 10^{-6}) = 53.05\Omega$

$(1 / Z_T) = (1 / Z_1) + (1 / Z_2) = [1 / (50 + j56.55)] + (1 / -j53.05)$

$(1 / Z_T) = [1 / (0.0125 \text{ cjs } 45.744°)]$

$Z_T = 80 \text{ cjs } – 45.744°\ \Omega$

Pf = cos -45.744°

Pf = 0.7

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68. The impedance Z_1 = (6 + j8) Ω, Z_2 = (8 – j6) Ω, Z_3 = (10 + j0) Ω measured at 50 Hz, form three branches of a parallel circuit. This circuit is fed from a 100 V, 50 Hz supply. A purely reactive (inductive or capacitive) circuit is added as the fourth parallel branch to the above three-branched parallel circuit so as to draw minimum current from the source. Determine the value of L or C to be used in the fourth branch and also find the minimum current.

Solution:

Total admittance of the three-branched parallel circuit:

Y = [1 / (6 + j8)] + [1 / (8 – j6)] + [1 / (10 + j0)] = 0.06 – j0.08 + 0.08 + j0.06 + 0.1 = 0.24 – j0.02 Siemens

Current taken would be minimum when net susceptance is zero. Since combined susceptance is inductive, it means that we must add capacitive susceptance to neutralize it. Hence, we must connect a pure capacitor in parallel with the above circuit such that its susceptance equals +j0.02 S.

I / X_C = 0.02 or 2π / C = 0.02; C = 0.2/314 = 63.7 μF

Admittance of four parallel branches = (0.24 – j0.02) + j0.02 = 0.24 S

Minimum current drawn by the circuit = 100 x 0.24 = 24 A

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69.

A current of 8 A and a power factor of 0.8 lagging is taken from a single phase 220 volt supply. The reactive power of the system is?

Solution:

$$\theta = \cos^{-1} 0.8 = 36.869°$$

Q=E sin θ

Q= (220)(8)sin36.869 °

Q=1055.98 VARS

70. A single phase load takes 55 kW at 70% pf lagging from a 240 V, 50 Hz supply. If the supply is made 60 Hz, with the voltage remaining the same, what will be the kW load at 60 Hz?

Solution:

At 50 Hz:

Z= $\frac{E^2 cos\theta}{p}=\frac{(240)^2(0.7)}{55000}=0.733\,ohms$

$\theta=\cos^{-1}0.7=45.57°$

R=Zcos θ =0.733(0.7)=0.513 ohms

X_L=Zsin θ =0.733(sin45.57 °)=0.523

L= $\frac{Xl}{2\pi f}=\frac{0.523}{2\pi(50)}=1.66\,mH$

At 60 Hz:

X_L=2 π fL=2 π (60)(1.666x10^{-3})=0.628 ohms

Z= $\sqrt{R^2+Xl^2}=\sqrt{(0.513)^2+(0.628)^2}=0.81\,ohms$

Cos θ = $\frac{R}{Z}=\frac{0.513}{0.81}=0.633$

P= $\frac{E^2 cos\theta}{Z}=\frac{(240)^2(0.633)}{0.81}=45013.33\,W$

P= 45kW

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71. A coil of 40-ohm resistance and of 150 mH inductance is connected in parallel with a 50 µF capacitor. What is the power factor of the circuit?

Solution:

$X_L = \omega L = (377)\ (0.15) = 56.55\ \Omega$

$X_C = 1 / \omega C = 1 / (377)\ (40 \times 10^{-6}) = 66.31\Omega$

$(1 / Z_T) = (1 / Z_1) + (1 / Z_2) = [1 / (40 + j56.55)] + (1 / -j66.31)$

$(1 / Z_T) = [1 / (0.0037\ cjs\ 145.74°)]$

$Z_T = 277.78\ cjs\ –145.74\ \Omega$

Pf = cos -145.74°

Pf = 0.82

72. Find the equivalent admittances and impedance of the three branch parallel circuit shown below.

Given:

Z_1= 10+j2 = 10.19∟11.31°
Z_2= 2Ω = 2∟0°
Z_3= 5+j8 = 9.43∟57.99°

Solution:

$Y_{eq}= (Z_1)^{-1} + (Z_2)^{-1} + (Z_3)^{-1}$
$Y_{eq}= (10.19\angle 11.31°)^{-1} + (2\angle 0°)^{-1} + (9.43\angle 57.99°)^{-1}$
$Y_{eq}= .0052\angle -69.12°$

$Z_{eq}= Y_{eq}^{-1}$
$Z_{eq}=(192.18\angle 69.12°)^{-1}$

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73. Given: $Z_1 = -j2.5\,ohms\,; Z_2 = j4\,ohms\,; Z_3 = 5\,ohms\,; Z_4 = 1 + j5\,ohms.$ If the four impedances are connected n parallel, find the equivalent impedance in ohms.

Solution:

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \frac{1}{Z_4}$$

$$\frac{1}{Z_t} = \frac{1}{-j2.5} + \frac{1}{j4} + \frac{1}{5} + \frac{1}{1 + j5}$$

¿ $j0.4 - j0.25 + 0.2 + \frac{1}{5.1\angle 78.69°}$

¿ $0.2 + j0.15 + 0.196\angle -78.69°$

¿ $0.2 + j0.15 + 0.0384 - j0.1922$

$$\frac{1}{Z_t} = 0.2384 - j0.0422 = 0.2421\angle -10.038°$$

$$Z_t = \frac{1}{0.2421\angle -10.038°} = 4.13\angle 10.038° = 4.066 + j0.719\,\Omega$$

$$Z_t \cong 4.1 + j0.72\,\Omega$$

74. Three impedances Z_a = 3 + j4 ohms, Z_c = 4 – j4 ohms and Z_r = 0 + j3 ohms are connected in parallel. Solve for the power factor of the combination.

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}=\frac{1}{3+j4}+\frac{1}{4-j4}+\frac{1}{j3}$$

$$\frac{1}{5\angle 53.13°}+\frac{1}{5.656\angle -45°}-j0.333$$

$$¿0.2\angle -53.13°+0.1768\angle 45°-j0.333$$

$$¿0.12-j0.16+0.125-j0.125-j0.333$$

$$¿0.245-j0.368=0.442\angle -56.34°$$

$$Z_t=\frac{1}{0.442\angle -56.34°}=2.262\angle 55.34°$$

$$pf=\cos 56.34°$$

$$pf=0.554\,lagging$$

75. A coil of a 50-ohm resistance and of 150 mH inductance is connected in parallel with a 50 μ F capacitor. What is the power factor of the circuit?

Solution:

$$X_L = wL = 377(0.15) = 56.55\,\Omega$$

$$X_c = \frac{1}{wC} = \frac{1}{377(5O\,x\,10^{-6})} = 53.05\,\Omega$$

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{50 + j56.55} + \frac{1}{-j53.05}$$

$$¿\frac{1}{75.484\angle 48.517°} = j0.01885$$

$$¿0.0132\angle -48.517° + j0.01885$$

$$¿0.00874 - j0.00988 + j0.01885$$

$$¿0.00874 + j0.00897 = 0.0125\angle 45.744°$$

$$Z_t = \frac{1}{0.0125\angle 45.744°}$$

$$¿80\angle -45.744°$$

$$pf = \cos(-45.744°)$$

$$pf \cong 0.7$$

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76. A resistor of 50 ohms and an impedance of 100+ j50 ohms are connected in parallel across a 220 volts supply. What is the power factor of the load?

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}=\frac{1}{50}+\frac{1}{100+j50}$$

¿ $0.02+\frac{1}{111.803\angle 26.565°}$

¿ $0.02+0.00894\angle -26.565°$

¿ $0.02+0.008-j0.004$

¿ $0.028\angle -j0.004$

¿ $0.0283\angle 8.13°$

$$Z_t=\frac{1}{0.0283\angle 8.13°}$$

¿ $35.335\angle -8.13°$

$pf=c\,0\,s(-8.13°)=0.9899$

$pf\cong 99$

77. A 250 V, 30 Hz generator supplies power to a parallel circuit consisting of a 20 hp motor whose efficiency is 90% at 0.80 lagging and a second load that draws an apparent power of 7 kVA at unity pf. Determine the system power factor.

Solution:

$$P_1 = \frac{P_{out}}{\eta} = \frac{20(746)}{0.9} = 16.58\,kW$$

$$S_1 = \frac{P_1}{pf} = \frac{16.58}{0.8} = 20.725\,kVA$$

$$\theta_1 = \cos^{-1} 0.8 = 36.869°$$

$$S_t = S_1 + S_2$$

$$¿20.725 \angle -36.869° + 7$$

$$¿23.58 - j12.434$$

$$S_t = 26.657 \angle -27.803°$$

$$pf_t = \cos 27.803°$$

$$pf_t = 0.884\,lagging$$

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78. A circuit consists of X_a = j5 ohms, X_c = -j5 ohms and R= 5 ohms all are connected in parallel. Find the equivalent impedance.

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}$$

$$\frac{1}{Z_t}=\frac{1}{j5}+\frac{1}{-j5}+\frac{1}{5}$$

$$¿-j0.2+j0.2+0.2=0.2$$

$$Z_t=\frac{1}{0.2}=5\Omega$$

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79 A pure capacitance of 530.515 $\times 10^{-6}$ farad and an inductance of 530.515 $\times 10^{-4}$ henry are connected in parallel across an AC power source. Solve for their resultant impedance assuming that the frequency is 30 Hz.

Solution:

$$X_c = -j\frac{1}{2\pi fC} = \frac{1}{2\pi(30)(530.515\times 10^{-6})} = -J10$$

$$X_L = J2\pi fL = J2\pi(30)(530.515\times 10^{-4}) = J10$$

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$¿\frac{1}{-J10} + \frac{1}{J10} = 0$$

$$Z_t = \frac{1}{0}$$

$$Z_t = undefined$$

.

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80. Three impedances $Z_a, Z_{c,} Z_r$ are connected in parallel. If at 60 Hz, Z_a = 0+j8, Z_C = 0 – j2 and Z_r = 5 + j0 ohms. Solve for the resultant power factor.

Solution:

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$\frac{1}{Z_t} = \frac{1}{j8} + \frac{1}{-j12} + \frac{1}{j5}$$

$$¿ - j0.125 + j0.5 + 0.2$$

$$¿ 0.2 + j0.375$$

$$¿ 0.425 \angle 61.927°$$

$$Z_t = \frac{1}{0.425 \angle 61.927°}$$

$$¿ 2.353 \angle -61.927° \Omega$$

$$pf = \cos(-61.927)$$

$$pf = 0.47\, leading$$

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81. A capacitor ,an electric resistance heater, and an impedance are connected in parallel to a 120 V, 60 Hz system. The capacitor draws 50 VAR, the heater draws 100 W and the impedance coil draws 269 VA at a pf of 0.74 lagging. Determine the system power factor.

Solution:

$$S_1 = J50$$

$$S_2 = 100$$

$$\theta_3 = \cos^{-1} 0.74 = 42.268°$$

$$S_3 = 269 \angle -42.268° = 199.06 - J\,180.93$$

$$S_t = S_1 + S_2 + S_3 = J50 + 100 + 199.06 - J\,180.93$$

$$S_t = 299.06 - j130.93 = 326.46 \angle -23.64°\,VA$$

$$pf_t = \cos(-23.64°)$$

$$pf_t = 0.916\,lagging$$

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82. A resistance of 5 ohms is connected in series with a capacitor of 442.1 μF. The combination is then connected in parallel with an inductance of 21.22 mH. Solve for the resultant current if the circuit is connected across a 120 V, 60 Hz AC source.

Solution:

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi(60)(442.1\times10^{-6})} = 6\,\Omega$$

$$Z_1 = R - jX_C = 5 - J6 = 7.8\angle -50.19°$$

$$Z_2 = j2\pi fL = j(2\pi)(60)(0.02122) = j8$$

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{7.81\angle -50.19°} + \frac{1}{j8}$$

$$¿0.128\angle 5.19° - j0.125$$

$$¿0.08195 + j0.0983 - j0.125$$

$$¿0.08195 - j0.0267$$

$$¿0.08618\angle 18.046°$$

$$Z_t = \frac{1}{0.08618\angle 18.046°} = 11.6\angle -18.046°$$

$$I_t = \frac{E_t}{Z_T} = \frac{120}{11.16} = 10.34\,A$$

83. A circuit consists of X_a = j10 ohms, X_c = -j25 ohms and R= 15 ohms all are connected in parallel. Find the equivalent impedance.

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}$$

$$\frac{1}{Z_t}=\frac{1}{j10}+\frac{1}{-j25}+\frac{1}{15}$$

$$¿-j0.2+j0.2+0.2=0.06$$

$$Z_t=\frac{1}{0..06}=16.67\Omega$$

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84. Calculate the current in this circuit, and also the amount of mechanical power (in units of "horsepower") required to turn this alternator (assume 100% efficiency): given, volts and 4.6 resistance.

Soloution

I = V / R

I = 480/ 4.6

I = 104.35 A

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85. The power factor for the circuit, overall, has been substantially improved. The main current has been decreased from 1.41 amps to 994.7 milliamps, while the power dissipated at the load resistor remains unchanged at 119.365 watts. The power factor
is much closer to being 1:

Solution:

p.f. =true power / apparent power
p.f. = 119.365W / 119.366 VA
p.f. = 0.9999887
impedance (polar) angle = 0.272
cos 0.272 = 0.9999887

86. A 250 V, 30 Hz generator supplies power to a parallel circuit consisting of a 20 hp motor whose efficiency is 80% at 0.70 lagging and a second load that draws an apparent power of 7 kVA at unity pf. Determine the system power factor.

Solution:

$$P_1 = \frac{P_{out}}{\eta} = \frac{20(746)}{0.8} = 18.65\,kW$$

$$S_1 = \frac{P_1}{pf} = \frac{18.65}{0.7} = 26.64\,kVA$$

$$\theta_1 = \cos^{-1} 0.7 = 45.57°$$

$$S_t = S_1 + S_2$$

$$¿ 26.64\angle -45.57° + 7$$

$$¿ 26.64 - j\,19.023$$

$$S_t = 31.93\angle -36.56°$$

$$pf_t = \cos 36.56°$$

$$pf_t = 0.803\,lagging$$

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87. An inductive reactance of 20Ω is connected in parallel with capacitive reactance of 50Ω. If the combination is connected in series with 10 Ω resistance, solve for the total impedance of the circuit.

Solution:

$$z_T = \left[\frac{1}{0+jX_L}+\frac{1}{0-jX_L}\right]^{-1} +10$$

$$Z_T = \left[-j\frac{1}{X_L}+j\frac{1}{X_C}\right]^{-1} +10$$

$$Z_T = \left[-j\frac{1}{20}+j\frac{1}{50}\right]^{-1} +10$$

$$Z_T = 10+j33.33$$

$$Z_T = 34.80\angle 73.30$$

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88. A given load takes 50kVaat 0.8 lagging power factor while another load connected in parallel across the same source takes 70 kVa at 0.65 lagging power factor. Find the total apparent power.

Solution:

S_1 =50 kVa @ 0.8 lagging

S_2 =70 kVa @ 0.65 lagging

S_T = S_1 + S_2

S_T =50 └- $\cos^{-1}$ 0.8 + 70 └- $\cos^{-1}$ 0.65

S_T =50 └-36.87 + 80 └-49.46

S_T =92-90.80j° kVa

89. Given: $V = 50\angle 30°$; $I_T = 27.9\angle 57.8°$ A. Determine the value of Z_1.

Solution:

$Z_{ab} = (Z_2 \times Z_3) / (Z_2 + Z_3)$
$Z_{ab} = (4-j4) \times (20) / (4-j4) + (20)$
$Z_{ab} = 4.65\angle -35.54° \Omega$

$I'' = V / Z_{ab}$
$I'' = (100\angle 90°) / (4.65\angle -35.54° \Omega)$
$I'' = -12.5 + j17.5$ A

$I' = I_T - I''$
$I' = (-10.86 + j49) - (-12.5 + j17.5)$
$I' = 31.54\angle 87.02°$ A

$Z = V / I'$
$Z = (100\angle 90°) / (31.54\angle 87.02°)$
$Z = 3.17\angle 2.98° \Omega$

90. An inductive reactance of 20Ω is connected in parallel with capacitive reasctance of 50Ω. If the combination is connected in series with 20 Ω resistance, solve for the total impedance of the circuit.

Solution:

$$z_T = \left[\frac{1}{0+jX_L}+\frac{1}{0-jX_L}\right]^{-1} + 25$$

$$Z_T = \left[-j\frac{1}{X_L}+j\frac{1}{X_C}\right]^{-1} + 25$$

$$Z_T = \left[-j\frac{1}{50}+j\frac{1}{20}\right]^{-1} + 25$$

$$Z_T = j30+25$$

$$Z_T = 25-33.333j$$

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91. A two-element series circuit with R = 10 Ω and X_L= 25Ω has an effective voltage of 110 volt across the resistor. Find the complex power and the power factor.

Given:

$R= 10\ \Omega$
$X_L= 25\ \Omega$
$E_R= 110V$

Solution:

$I= V_R / R$
$I= 110/ 10$
$I= 11\ A$

$P_R= I^2 R$
$P_R= (11)^2 (10)$
$P_R= 1210\ W$

$Q_L= I^2 X_L$
$Q_L= (11)^2 (15)$
$Q_L= 1815\ VARS$

Complex Power = 1210 +j1815

Power Factor= P/ S

Power Factor= 1210 / $\sqrt{(1210)^2+(1815)^2}$

Power Factor= 0.56 lagging

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92. A two element series circuit has average power of 760W and a power factor of 0.8 leading. Determine the circuit elements if the applied voltage V = 66.0 cos (6000t + 30°) V.

Given:

P_{ave}= 760 W ; p.f= 0.8

Solution:

$E_{Effective}$ = 66.0 / $\sqrt{2}$ = 46.67

P= V_{eff} x I_{eff} cos θ

I_{eff}= 760 / [(70)(0.8)]

I_{eff}=13.57 A

I_{eff}^2 R= 760

R= $760/19^2$

R= 2.11Ω

For leading power factor ,

θ = $\cos^{-1}$ (0.8)

θ = 36.87°

z= R – jX_C ; X_C = 2.11 tan 36.87°

Therefore,

2.11 = 1 / ω C

C = 1 / [(2.11)(2 π)(60)]

C = 1.25 m F

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93. A two branch parallel circuit has a corresponding phasor diagram as shown below. Find the branch impedances Z_1 and Z_2.

Solution using V_1 as reference phasor

$I_1 = 5.2\angle -75.5°$ A ; $I_2 = 8.21\angle 90°$ A

$Z_1 = V/I_1$

$Z_1 = (100\angle 0°) / (5.2\angle -75.5°)$

$Z_1 = 20.2\angle 82.87°$

$Z_1 = 4.82 + j18.62\ \Omega$

$R_1 = 4.82\Omega$

$X_{L1} = 18.62\Omega$

$Z_2 = V/I_2$

$Z_2 = (100\angle 0°) / (8.21\angle 90°)$

$Z_2 = 15\angle -90°\Omega$

$Z_2 = 0 - j12.18\Omega$

$R_2 = 0\Omega$

$X_{C2} = 12.18\Omega$

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94. A two branch parallel circuit has an applied voltage and resulting currents as given in the phasordigram shown in the figure. Find the branch impedances Z_1 and $Z_{2.}$

Given:

I_1= 15A
I_2= 13 A
V= 220V

Solution:

Using X as reference phasor

V_1= 220∟-30°
I_1= 15 ∟30°
I_2= 13∟-53.1°

Z_1= V/ I_1
Z_1= (220∟-30°)/(15 ∟30°)
Z_1= 14.67∟-60°
Z_1= 7.33-j12.70Ω

Z_2= V/ I_2
Z_2= (220∟-30°)/(13∟-53.1°)
Z_2= 16.92∟23.1°
Z_2= 15.576+j6.64Ω

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95. A resistor of 10 ohms and an impedance of 30+ j6 ohms are connected in parallel across a 220 volts supply. What is the power factor of the load?

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}=\frac{1}{10}+\frac{1}{30+j6}$$

$$¿0.1+\frac{1}{0.033\angle-11.31°}$$

$$¿0.1+0.00894\angle-26.565°$$

$$¿0.02+0.0321-j6.410\,x\,10-3$$

$$¿0.0524\angle-7.014°$$

$$Z_t=\frac{1}{0.0524\angle-7.014°}$$

$$¿19.05\angle7.014°$$

$$pf=c\,0\,s(7.014°)=0.9925$$

$$pf\cong99.25$$

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96. A circuit consists of X_a = j10 ohms, X_c = -j10 ohms and R= 30 ohms all are connected in parallel. Find the equivalent impedance.

Solution:

$$\frac{1}{Z_t}=\frac{1}{Z_1}+\frac{1}{Z_2}+\frac{1}{Z_3}$$

$$\frac{1}{Z_t}=\frac{1}{j10}+\frac{1}{-j10}+\frac{1}{30}$$

¿ $j0.1-j0.1+0.03=0.03$

$$Z_t=\frac{1}{0.03}=33.33\,\Omega$$

97. Given $I_1 = 4\angle -45°$ and $I_T = 5.21\angle 37.4°$ A. Find Z_2

Solution:

$I_2 = I_T - I_1$
$I_2 = (5.21\angle 37.4°) – (4\angle -45°)$
$I_2 = 1.31 + j6.00$
$I_2 = 6.12\angle 77.67°$

$I_1Z_1 = I_2Z_2$
$Z_2 = (I_1Z_1) / I_2$
$Z_2 = [(4\angle -45°)(5)] / (6.12\angle 60°)$
$Z_2 = -1.76 – j2.75Ω$

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98. A coil of a 100-ohm resistance and of 50 mH inductance is connected in parallel with a 4.7 μ F capacitor. What is the power factor of the circuit?

Solution:

$$X_L = wL = 377(0.05) = 18.85\,\Omega$$

$$X_c = \frac{1}{wC} = \frac{1}{377(4.7\,x\,10-6)} = 564.3659\,\Omega$$

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{100 + j18.85} + \frac{1}{-j564.3659}$$

$$¿\frac{1}{101.7611\angle 10.6749°} = j0.00177$$

$$¿0.01030\angle -20.3946°$$

$$Z_t = \frac{1}{0.01030\angle -20.3946°}$$

$$¿97.06197\angle 20.3946°$$

$$pf = \cos(20.3946°)$$

$$pf \cong 0.94$$

99. Three impedances Z_a, Z_c, Z_r are connected in parallel. If at 60 Hz, Z_a =0+ j15, Z_C = 0 – j25 and Z_r = 9 + j0 ohms. Solve for the resultant power factor.

Solution:

$$\frac{1}{Z_t} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$\frac{1}{Z_t} = \frac{1}{j15} + \frac{1}{-j25} + \frac{1}{9}$$

$$¿ -j0.0667 + j0.04 + 0.11$$

$$¿ 0.11 - j0.02667$$

$$¿ 0.2885 \angle -67.5864°$$

$$Z_t = \frac{1}{0.2885 \angle -67.5864°}$$

$$¿ 3.4662 \angle 67.8564° \Omega$$

$$pf = \cos(67.8564)$$

$$pf = 0.3769\, leading$$

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100. A voltmeter placed across the 3 ohms resistor shown, if the voltmeter reads 30 volts. What is the ammeter reading?

Solution:

$I_{3\Omega}$ = 30 / 3 = 10A

R_{bc} = (5x2)/(5+2) = 1.43Ω

Z_1= R_{ab}+10
Z_1= 1.43 + 10
Z_1= 11.43Ω

Z_{eq}= (Z_1Z_2)/(Z_1 + Z_2)
Z_{eq}= (1.43)(3+j3)/(1.43)+ (3+j3)
Z_{eq}=3.28∟-33.25°

I_{ac}= (15)(3+j3)/ 11.43
I_{ac}= 3.92 +j3.92

Ammeter Reading

I_{am}= $I_{3\Omega}$ + I_{ac}
I_{am}= 10 +(3.92+j3.92)
I_{am}= 14.46∟15.73°

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101. A series combination of R and C is in parallel with a 20Ω resistor. A 60 Hz source resulting in a total current of 7.21A, a current through the 20Ω resistor is 5A and the current in the RC branch is 3.3A. Determine the R and C.

Solution:

$\theta = \cos^{-1}[(I_T^2 - I_R^2 – I_Z^2)] /(2I_R\ I_z)$

$\theta = \cos^{-1}[(7.21^2 - 5^2 – 3.3^2)] /(5)(7.1)\ (3.3)$

$\theta = 82.10°$

$V_T = (20Ω)(5A)$
V= 100V

$Z = V_T / I_z$
Z=100V/ 3.3A
$Z = 30.30\ ∟\ \theta\ Ω$
$Z = 30.30\ ∟82.10°\ Ω$
Z=4.16 + j 30.01

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102. A load of 300kW with a power factor of 0.7 lagging has the power factor improved to 0.80 lagging by the addition of parallel capacitors. What kVAR of capacitors does require to improved the power factor?

Given:
P= 300kW
Pf_i = 0.70 lagging
Pf_f= 0.80 lagging

Solution:

$\theta_i = \cos^{-1} 0.70$

$\theta_i = 45.57°$

$\theta_f = \cos^{-1} 0.80$

$\theta_f = 36.87°$

$Q_{req} = P [\tan\theta_I - \tan\theta_f]$

Q_{req} 300kW (tan45.57° - tan36.87°)

Q_{req}= 810.28kVAR (leading)

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103. A 30 ohm resistor is connected in series with a parallel combination of a capacitance C and 15mH pure inductance. At angular frequency ω = 1000rad/s, find C such that the line current is 45° out of phase with the line voltage.

Given:

R= 30Ω
L = 15mH
ω = 1000rad/s
C =?

Solution:

$Z = R \pm jX$
$Z_T = 30 + [(j15)(-jX_C)] / (15 - X_C) j$

$Z_{T} = \infty$

$0 = 30 + [(j15)(-jX_C)] / (15 - X_C) j$
$X_C = 60\Omega$

$C = 1 / (2 \pi f X_C)$
$C = 1 / [(1000)(60)]$
$C = 16.6667\ \mu F$

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104. An inductive coil consumes 600W of power at 11A and 110V and 60Hz. Determine the resistance and the inductance of the coil.

Given:
P= 600W
I = 11A

Solution:

$P_T = V_T I_T \cos \theta$

$\theta = Cos^{-1}$ [(110 x 11)/ 600]

$\theta = 60.27°$

$z_T = V_T / I_T$
z_T= 110/11
z_T= 10Ω

Z_T= 10∟60.27 °
Z_T= 32.5 + j.9.53

X_L= 9.53

$X_L = 2 \pi fL$

X_L= 9.53

L = 9.53 / (2 π)(60)

L = 25. 2700mH

R = 5Ω

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105. An inductive coil having a 20 ohm resistance and unknown reactance is connected in parallel with 120 ohm resistor. The combination is connected across a 110V 50/ π Hz source. If the power delivered by the source is 400W, find the value of the inductance.

Solution;

$P_T = P_1 + P_2$
$P_T = (I_1^2 R) + (V^2/R)$
$400 = (I_1^2 (20) + (110^2/120)$
$I_1 = 3.8676$ A

$Z = V_2 / I_2$
$Z = 110 / 3.8676$
$Z = 28.44\ \Omega$

$Z^2 = R^2 + X^2$
$(28.44)^2 = 20^2 + X^2$
$X_L = 20.22$

$X_L = 2\pi fL$

$L = 20.22 / (2\pi)(50/\pi)$

L = 0.2022H

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106. A given load takes 40kVa at 0.6 lagging power factor while another load connected in parallel across the same source takes 80 kVa at 0.7 lagging power factor. Find the total apparent power.

Solution:

S_1 =40 kVa @ 0.5 lagging

S_2 =80 kVa @ 0.88 lagging

S_T = S_1 + S_2

S_T =40 └- $\cos^{-1}$ 0.6 + 80 └- $\cos^{-1}$ 0.7

S_T =40 └-53.13 + 80 └45.57

S_T =80.00-j89.13° kVa

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107. A parallel circuit consists of a resistor having a conductance of 5 mhos, an inductive reactor having a susceptance of 9 mhos and a capacitive reactor having a susceptance of 7 mhos. What is the impedance of the circuit?

Solution:

G_T =5Ω

β_{TL} =9Ω

β_{TC} =7Ω

Y_T =5-j9+j7

Y_T =4-j2

$Z_T = \frac{1}{4-j2}$

Z_T =0.2236 └26.57°

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108. Two parallel branches have admittances of 5+j2 and 3-j4 respectively. If the current in the first branch is 12 A, determine the total current supplied to the combination.

Solution:

$Y_T = Y_1 + Y_2$

$Y_T = 5 + j2 + 3 - j4$

$Y_T = 8 - j2$

$Z_1 = 8.25 \angle -14.04°$

E=IZ

E=(12)($8.25 \angle -14.04°$)

E= $98.95 \angle -14.04°$

$Y_T = 8.25 \angle -14.04°$

$I_T = E X_T$

$98.95 \angle -14.04°$
$I_T = ¿$][$8.25 \angle -14.04° ¿$

$I_T = 11.2178 \angle = 64.44°$

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109. An inductive coil with a resistance R and inductance L is connected in parallel with a 30 Ω resistor. The combination is then connected across a 60 Hz source. If the currents in the coil, resistor and total are 7,4 and 5 A respectively. Determine the inductance of the coil.

Solution:

$$E=(30)(4)$$

$$E=120\,V$$

$$\beta=\cos^{-1}[\frac{7^2+4^2-5^2}{(7)(5)(4)}]$$

$$\beta=74.40°$$

$$\theta=180-\beta$$

$$\theta=106.60°$$

$$I=\frac{E}{Z};Z=\frac{120}{5}=24\,\Omega$$

$$Z=24\,\angle 74.40°$$

$$Z=6.45+j\,23.12$$

$$R=6.45\,\Omega$$

$$X_L=23.12\,\Omega$$

$$L=\frac{23.12}{(2\pi)(60)}$$

$$L=0.06\,H$$

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110. The power factor for the circuit, overall, has been substantially improved. The main current has been decreased from 1.41 amps to 994.7 milliamps, while the power dissipated at the load resistor remains unchanged at 111.782 watts. The power factor
is much closer to being 1:

Solution:

P.f. =true power / apparent power
P.f. = 111.782W / 111.982 VA
P.f. = 0.99821

impedance (polar) angle = 3.4286
cos 3.4286 = 0.99821

111. Calculate the current in this circuit, and also the amount of mechanical power (in units of "horsepower") required to turn this alternator (assume 100% efficiency): given, volts and 5.6 resistance.

Solution:

$I = V / R$
$I = 480 / 5.6$
$I = 85.71\ A$

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112. A load of 10 + j15 is connected across a 220 volts source. Determine the power factor and the VARS.

Solution:

$Z = 10 + j15 = 18.03 < 56.31^\circ$
pf = cos Ɵ = cos 56.31° = 0.55

pf = 55 %

$$Q = EI \sin \Theta = \frac{E^2}{Z} \sin \Theta = \frac{220^2}{18.03} \sin 56.31^\circ$$

Q = 2233.57 VARS

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113. The network is part of the schematic describing an industrial electronic sensing device. What is the total impedance of the circuit at 5 kHz?

Solution:

$Z_1 = 50 + 1/j\omega C = 50 + 1/(2\pi)(2x10^3)(5x10^{-6})$
$\quad = 50 – j15.92$
$Z_2 = 80 + j\omega L = j(2\pi)(2x10^3)(5x10^{-6})$
$\quad = 80 + j.06$
$Z_3 = 100$

$1/Z = 1/Z_1 + 1/Z_2 + 1/Z_3$
$1/Z= 10^{-3} (10 + j15.92+ j9.745 +3.605- j.06)$
$Z= (13.605 + j25.605) \times 10^{-3}$
$\quad = 26.17\times 10^{-3}\angle 8.97°$

$Z = 28.995\angle 62.02°\Omega$

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114. Two electric units are connected across a source whose frequency is 50 cps. If the voltage drop across the units are 120 and 95 volts and they are out of phase by 90°, what is the equation of the voltage across the source?

Solution:

$E_T = \sqrt{E_1^{\,2} + E_2^{\,2}}$

$= \sqrt{120^2 + 95^2}$

$E_T = 5 \sqrt{937} = 153.05$

$\Theta = \tan^{-}\left(\frac{95}{120}\right)$

$\Theta = 38.37^\circ$

$E_{Mt} = E_T \sqrt{2}$

$= 153.05\ (\sqrt{2})$

$E_{Mt} = 216.45$ V

$\omega = 2\pi f$

$= 2\pi\ (50)$

$\omega = 314$

$E_t = 216.45 \sin(314t + 38.37^\circ)$ V

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115. An impedance draws a current of 12 A at 0.8 lagging power factor from a source voltage of 240V, 60 Hz. What is the current when resistance is reduced by 50%?

Solution:

Z = $\frac{e}{i}$ = $\frac{240}{12}$ = 20Ω

Pf = $\frac{R}{Z}$

R = Z (Pf) = (20) (0.8) = 16Ω

X_L = $\sqrt{Z^2 - R^2}$

= $\sqrt{20^2 - 16^2}$

X_L = 12Ω

When R = 8Ω

Z = $\sqrt{R - X_L{}^2}$

= $\sqrt{4^2 - 6^2}$

Z = 2 $\sqrt{7}$ Ω

I = $\frac{e}{z}$ = Z = $\frac{240\,V}{2\sqrt{7}\,\Omega}$

I = 45.36 A

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116. A current of 20 A and a power factor of 0.7 lagging is taken from a single phase 240 volt supply. The reactive power of the system is?

Solution:

$$\theta = \cos^{-1} 0.7 = 45.58°$$

$Q = EI\sin\theta$

$Q = (240)(20)\sin 45.58°$

Q = 3428.29 VARS

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117. A coil of 50-ohm resistance and of 150 mH inductance is connected in parallel with a 60 µF capacitor. What is the power factor of the circuit?

Solution:

$X_L = \omega L = (377)(0.15) = 56.55\ \Omega$

$X_C = 1 / \omega C = 1 / (377)(60 \times 10^{-6}) = 44.21\Omega$

$(1 / Z_T) = (1 / Z_1) + (1 / Z_2) = [1 / (50 + j56.55)] + (1 / -j44.21)$

$(1 / Z_T) = [1 / (0.0125\ cjs\ 45.744°)]$

$Z_T = 36.85 cjs - 53.30°\ \Omega$

Pf = cos -53.30
°

Pf = 0.6

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118. A current of 10 A and a power factor of 0.7 lagging is taken from a single phase 110 volt supply. The reactive power of the system is?

Solution:

$$\theta = \cos^{-1} 0.8 = 45.53°$$

Q=E sin θ

Q= (110)(10)sin45.53 $°$

Q=784.98 VARS

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119. A capacitor of 3.19 microfarad is connected in parallel with a resistance of 2,000 ohms. The combination inductance 795 mH and a resistance of 100 ohms across a supply given by e= 400sin (3wt + 60^o)
Determine he instantaneous equation for the current and its 314 rms value.

X_L = ω L = 314 (795 mH) = 250 ohms

X_C = $\frac{1}{\omega C} = \frac{1}{314(3.18\, micro\, farad)}$

Z_T =100 +j250 + $\frac{2{,}000(-j1{,}000)}{2{,}000-j1{,}000}$ = 500- j550

For the third harmonics:

X_L = 3 ωL = 3x 314 (795 mH) = 750 ohms

Z_T = 100 + j750 + $\frac{2000(-J333.333)}{2000-J333.333}$ = 452 .695 $\angle 7$ 0.105 ohms

I = 0.53814 sin (314 + 47.726) + 0.029053 sin (942t – 0.105) amperes

120. A single phase load on 220 V takes a 35kW at 0.60 lagging .Find the kVAR size ofcapacitor , which maybe connected in parallel with this motor to bring the resultant power factor to 1.0.

$$\theta = \frac{1}{\cos}(0.60) = 53.13^{o}$$

$$Q_L = P_L \tan \theta_L = 35\tan 53.13$$

$$= 47\text{kVAR}$$

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121. An inductive reactance of 10 ohms is connected in parallel with a capacitive reactance of 30 ohms. If the combination is connected in series with a 10 ohms resistance. Solve for the equivalent power factor of the combination.

SOLUTION :

$$Z_1 = 10 + \frac{(J\,10)(-J\,20)}{(J\,10 + J\,30)}$$

$$Z_1 = 10 + \frac{-j^2(200)}{-j\,20} = 10+j15$$

$$Z_1 = 9.999+14.99i$$

Pf = cos56.31
Pf = 0.555 lagging

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122. Given three impedances: Z_1 = 10+j0, Z_2 = 3+j4, Z_3 = 8-j6. Impedance Z_2 and Z_3 are connected in parallel and the combination is connected in series with impedance Z_1 ,across 120 V single phase 60 Hz source. Find the total power drawn by the impedances.

SOLUTION :

Z_1 = 10+j0

Z_2 = 3+j4

Z_3 =8-j6

Z_T = 10 + $\frac{3+4j(8-j6)}{(3+j4)+(8-j6)}$

= 10+4+j2

P = $\frac{120^2}{14.142}$ cos (8.13 degree)

P = 1008 watts

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123. Has a power of 180 Watts and a power factor of 0.8 lagging. Find the circuit constants.

Given:

i = 3.52 sin (5000t + 45°) A

P= 180 W

Cos θ = 0.8

Solution:

The effective value of current = (3.52) / $\sqrt{2}$ = 2.5A

P= I^2R

R=(180) / $(3)^2$

Impedance angle θ = cos $^{-1}$ 0.8 = 36.87 °

Number 2 element is an inductor, using power triangle,

(Q / P) = Tan 36.87° = $[(I_{eff})^2 (X_L)]$ / 180

X_L = (180 tan 36.87°) / 2.5^2

X_L = 21.6 Ω

Since $X_L = 2\pi fL$

$\omega = 2\pi f = 5000$

21.6 = 5000L

L = 21.6 / 5000

L = 4.32 mH

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1. 124. A 3phase feeder carries two balanced loads . The power observed by each is m easured by two wattmeter method giving the following readings:

First load : W= 96kN ; W_2 =160 kW

Second load : W = 90 kN ; W_2 =48 kW

What is the combined load on the feeder and the power factor ?

Solution:

$P_T = P_1 + P_2 = (w_1 + w_2) (w_{1+w_2})$

= (96 + 160) + (90 + 48)

= 394 K w

Power factor of each load:

First Load: w_1 = 96ta KN; W_2 = 160 KW

Q_1 n= $(w_1 + w_2)_1$ tan θ

= (96 + 160) (0.433)

= 110.85kVar

When both loads are lagging p.f.= cos (arctan $\frac{110.85+72.7}{394}$)

= 0.906 lagging

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125. A current of 10A and a power factor of 0.8 lagging is taken from a single phase 250 V supply. The reactive power of the system is :

SOLUTION :

0 = $\cos^{-1}$ 0.8 = 36.869 degree

Q = EIsin θ

Q = (250X10)SIN 36.869 degree
Q = 1500 VARS

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126. A total current of 10 A flows through the parallel combination of three impedance : (2-j5)ohms, (6+j3) ohms and (3+j4) ohms. Calculate the current flowing through each branch. Find also the power factor of the combination.

SOLUTION :

Let Z_1 = (2-j5), Z_2 = (6+3j), Z_3 = (3+J4)

$Z_1 Z_2$ = (2-J5) (6+J3) = 27-j24, $Z_2 Z_3$ =(6+j3)(3+j4)=6+j33

$Z_3 Z_1$ = (3+j4)(2-j5)= 26-j7 : $Z_1 Z_2$ + $Z_2 Z_3$ + $Z_3 Z_1$ = 59+j2

Now,

I_1 = (10+j0) x $\frac{6+j33}{59+j2}$ = 1.21+j5.55

I_2 = (10+j0) x $\frac{26+j7}{59+j2}$ = 4.36-j1.33

I_3 = (10+j0) x $\frac{27-j24}{59+j2}$ = 4.43 –j4.22

Z = $\frac{(2-J5)(6+J33)}{59+j2}$ = 3.01 + j 0.51

V = 10 X (3.007+0.5086i) = 30.07+5.08i

Combination power factor :

Cos 9.6 = 0.986 (lagging)

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127. A single phase inductive load takes 70kVA at 0.60 p.f. lagging . Solve for the kVAR of a capacitor required to improve the power factor to 1.0.

$$\theta = \frac{1}{\cos} (0.60) = 53.13$$

$$Q_L = s_L \sin \theta_L = 70 \sin 45^0$$

$$= 50kVAR$$

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128. A single phase load on 220 V takes a 5kW at 0.60 lagging .Find the kVAR size ofcapacitor , which maybe connected in parallel with this motor to bring the resultant power factor to 1.0.

$$\theta = \frac{1}{\cos}(0.60) = 53.13^{o}$$

$$Q_L = P_L \tan \theta_L = 5\tan 53.13$$

$$= 6.67 kVAR$$

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129. A single phase inductive load takes 50 kVA at 0.60 p.f. lagging . Solve for the kVAR of a capacitor required to improve the power factor to 1.0.

$$\theta = \frac{1}{\cos}(0.60) = 53.13^0$$

$$Q_L = s_L \sin \theta_L = 50 \sin 45^0$$

$$= 40 kVAR$$

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130. A 140 Kva transformer bank will serve a load expected to draw 120 KW At 0.70 lagging power factor. Solve for the size of the capacitor bank with needed to be acted in order to prevent overloading of the transformer bank

SOLUTION:

θ_1 = $\cos^{-1}$ 0.7 = 45. 58degree

Q_T = $\sqrt{S^2-P^2}$ = $\sqrt{140^2-120^2}$

= 72.11 Kvar

Q_C = Q_L - Q_C

= P_L tan θ - Q_T = 120tan45.58 degree – 72.11

Q_c = 50.34 kVAR

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131. A short, 3 phase, 3 wire transmission line has a receiving end voltage of 4160 V phase neutral and serving a balanced 3 phase load of 876, 400 volt-amperes at 0.75 p.f lagging . At the receiving endthe voltage is 4600V, phase to Neutral and the p.f is 0.9 . solve for the size in kVAR of a capacitor needed to improve tne receiving end pf to 0.9 lagging maintaining 4160V.

$\theta_L = \frac{1}{\cos}$ (0.75) = 41.41°

$\theta_T = \frac{1}{\cos}$ (0.9) = 25.84°

P_L = (876) (0.75) = 657 kW

$Q_T = Q_L - Q_C$

= (657) (tan 41.41 – tan 25.84)

= 569.63 kVAR

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132. A three phase, 3 wire transmission line has an impedance per wire of 3+j7 ohms, the receiving end load is 1950 KW, 0.65 pf lagging with the line voltage of 13,200 V. Determine the kVAR of the capacitor to be connected at the receiving end to make the pf at that end to 0.8 lagging.

SOLUTION :

θ_l = $\cos^{-1}$ 0.65= 49.458 degree

θ_t = $\cos^{-1}$ 0.8 = 36.869 degree

Q_L = P_L tan θ = 1950tan49.458 degree = 2279.77 KVAR

Q_T = 1950TAN 36.869 degree = 1462.45 kVAR

Q_C =2279.77-1462.45

Q_C = 817.32 KVAR

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133. A 3-phase , 3 wire, short transmission line has a resistance of 3 ohms and a reactance of 8 ohms per wire. At the receiving end, a balanced 3-phase load draws a line current of 60 A, at 13500 V line to line, 0.90 power factor lagging. Assuming the receiving end voltage is maintained at 13,500 V, solve the size in kVAR of capacitors needed to raise the power factor at the receiving end to 0.95 leading.

SOLUTION :

P_R = $\sqrt{3}$ EIpf

P_R = $\sqrt{3}$ (13,500)(60)(0.9)

= 1262.655 kW

θ = $\cos^{-1}$ 0.9 = 25.84 lagging

θ_t = $\cos^{-1}$ 0.95=18.195 degree

Q_C = Q_R + Q_T

= 1262.655tan25.84degree+1262.655tan18.195degree

Q_C = 1026.505kVAR

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134. A 1600 watt 230 volt single phase drill with a 45.7 degrees lagging (0.6984) current of 14 amps where given. Find firstly impedance triangle values from these values and then power triangle values.

Find values for improved power factor of 18.2 degrees lagging (0.95) and capacitor required for improved var.

$Z= \frac{V}{I}$ z= 230/14= 16.43Ω

R= 16.43*0.6984= 11.475Ω
XL= √ (16.43^2-11.475^2) = 11.759Ω
z95= 11.475/0.95= 12.079Ω
x= √(12.079^2-11.475^2)= 3.772Ω
xc= 11.759-3.772= 7.987Ω
C=1/ωxc = 1/2*3.14*50*7.987= 0.0003985= 398.5μF
Frequency was calculated as 50 Hz.

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135. A 100 Ω resistor, a 0.0200 H inductor and a 1.20 μF capacitor are connected in parallel with a circuit made up of a 110 Ω resistor in series with a 2.40 μF capacitor. A supply of 150 V, 60 Hz is connected to the circuit. Calculate the total current taken from the supply and its phase angle.

For Z_1 (the upper part of the circuit), we have:

$X_L = 2\pi f L = 2\pi\ (60)(0.0200) = 7.540\ \Omega$

XC=12π(60)(1.20×10−6)=2210.485 Ω

$Z_1 = R_1 + j(X_L - X_C)$

$= 100 + j(7.540 - 2210.485)$

$= 100 - 2202.9j$

$=2205.21\angle -87.40\circ\ \Omega$

For Z_2 (the lower part of the circuit), we have:

XC=12π(60)(2.40×10−6)=1105.243 Ω

$Z_2 = R_2 + j(X_L - X_C)$

$= 110 + j(-1105.243)$

$=1110.7\angle -84.32\circ\ \Omega$

So the **total impedance**, Z_T, is given by:

ZT=*Z*1*Z*2*Z*1+*Z*2

=2449326.75∠−171.72o210−3308.188*j*

=2449326.75∠−171.72o3314.85∠−86.37o

=738.9∠−85.35o

This last line in rectangular form is $Z_T = 59.9 - 736.5j\ \Omega$

Now:

IT=*VTZT*=150∠0o738.9∠−85.35o=0.203∠85.35o

136. Three single phase 167 KVA, 14400/24940, Y-240/480 Volts transformers are connected delta-delta to supply an assorted load of 400 KW at 0.80 p.f lagging . If one transformer is taken out for repair:

a. Determine by how much kvA each of the remaining transformer will be overloaded.

Solution:

a. $$\frac{500\,KVA}{\sqrt{3}} = 288.675\,KVA$$

$$288.675 - 167 = 121.675\,KVA$$

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137. A three phase, 3 wire transmission line has an impedance per wire of 3+j7 ohms, the receiving end load is 215 KW, 0.65 pf lagging with the line voltage of 11,200 V. Determine the kVAR of the capacitor to be connected at the receiving end to make the pf at that end to 0.8 lagging.

SOLUTION :

θ_l = $\cos^{-1}$ 0.65= 49.458 degree

θ_t = $\cos^{-1}$ 0.8 = 36.869 degree

Q_L = P_L tan θ = 215tan49.458 degree = 251.359 KVAR

Q_T = 215tan36.869 degree = 161.245 kVAR

Q_C =251.359-161.245

Q_C = 90.114 KVAR

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138. The input to an induction motor from a13 kV, 60 Hz line is 1000kVA,at 0.8 pf lagging . A capacitor is placed in parallel with the motor to improve the pf. Calculate the capacitance required raising the power factor to 0.9 leading.

SOLUTION:

$\theta_L = \cos^{-1}$ (0.8) = 36.869

$\theta_T = \cos^{-1}$ (0.9) = 25.84

P_L = 1000 (0.8) = 800 W

$Q_C = Q_L + Q_T$

= 987.4 VAR

$X_C = \frac{230^2}{987.4}$ = 53.575 ohms

C = $\frac{1}{2\pi(60)(53.575)}$

= 49.5 μF

$C \approx 50$

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139. A load of 10,000 kVA, 80 percent pf lagging is connected to a 13,200 V line. How much capacitive reactive power is needed to correct the power factor to 0.97 lagging?

SOLUTION:

θ_l = $\cos^{-1}$ 0.82 = 34.915 degree

θ_t = $\cos^{-1}$ 0.9 = 25.84 degree

P_L = S_L pf= (998.4)(0.82)= 818.688 kW

Q_T = (818.688)(tan34.915degree-tan25.84degree)

Q_T = 175 kVAR

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140. An induction motor load of 1500 kW consists of of several units in parallel, operating at an average power factor of 0.80 lagging. In order to improve the power factor, a portion of the induction motor loads is to be replaced by a synchronous motor, operating at rhe same efficiency as the induction motors and at a power factor of 0.7 leading. Find the kVA rating of the synchronous motor required bringing the power factor of the total load of0.9 lagging. Assume the induction motor load, which has to be replaced, operates the same pf as the induction motor group.

$\theta_L = \cos^{-1} 0.8 = 36.869°$
SL= 1500-j1500tan 36.869= 1500- j1124.96
$\theta_{syn} = \cos^{-1} 0.7 = 45.573$
S_syn=P + jPtan 45.573= P+j1.02P
S_ind=P- jPtan 36.869=P-j0.75P
$\theta_{new} = \cos^{-1} 0.9 = 25.84$
S_new= 1500- j1500tan 25.84= 1500-j726.42

S_new=SL+SSyn-Sind
1500-j726.42= 1500-j1124.96 +P + j1.02P- (P-j0.75P)

Equate coefficients of j:
-726.42=--1124.94 + 1.02P + 0.75P
P= 225.164kW
Ssyn= P/pf =225/0.7 = 321.66
Ssyn≈322 kVA

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141. A single phase induction motor is rated 5 hp, 75 percent power factor and 220 volts. What approximate size of the capacitor size of the capacitor is necessary to raise the power factor to about 95 percent?

SOLUTION:

θ_l = $\cos^{-1}$ 0.75=41.41 degree

θ_t = $\cos^{-1}$ 0.95 =18.195 degree

P_L =5(0.746)=3.73 kW

Q_L =3.73tan41.41degree=3.289 kVAR

Q_T =3.73tan18.195degree= 1.226kVAR

Q_C =3.289-1.226=2.063

Q_C = 2kVAR

142. A 3-phase , 3 wire, short transmission line has a resistance of 3 ohms and a reactance of 8 ohms per wire. At the receiving end, a balanced 3-phase load draws a line current of 45 A, at 11200 V line to line, 0.90 power factor lagging. Assuming the receiving end voltage is maintained at 11,200 V, solve the size in kVAR of capacitors needed to raise the power factor at the receiving end to 0.8 leading.

SOLUTION :

P_R = $\sqrt{3}$ EIpf

P_R = $\sqrt{3}$ (11,200)(45)(0.8)

= 698.362 KW

θ = $\cos^{-1}$ 0.90 =25.84 lagging

θ_t = $\cos^{-1}$ 0.8=36.869 degree

Q_C = Q_R + Q_T

= 698.362tan25.84degree+698.362tan36.869degree

Q_C = 861.957kVAR

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143. A 300 Kva transformer bank will serve a load expected to draw 122 KW At 0.80 lagging power factor. Solve for the size of the capacitor bank with needed to be acted in order to prevent overloading of the transformer bank

SOLUTION:

θ_1 = $\cos^{-1}$ 0.8 = 36.87 degree

Q_T = $\sqrt{S^2 - P^2}$ = $\sqrt{300^2 - 122^2}$

= 274.07 Kvar

Q_C = Q_L - Q_C

= P_L tan θ - Q_T = 122tan36.869 degree – 274.07

Q_c = 182.57 kVAR

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144. Three single phase 167 KVA, 14400/24940, Y-240/480 Volts transformers are connected delta-delta to supply an assorted load of 400 KW at 0.80 p.f lagging . If one transformer is taken out for repair:

a. If load of 120 HP ,0.746 p.f lagging and 85% efficiency is removed, find the apparent power and power factor of the remaining load system.

a. $P_t = 400\, kw$

$S = 500\, KVA$

$36.87°$
$\sin ¿ = 300\, KVAR$
$R = 500\, KVA ¿$

$P_{¿} = \frac{P_O}{eff}$

$¿ \frac{120\, HP \frac{0.746\, KW}{HP}}{0.85}$

$¿ 105,318\, KW$

$\theta = \cos^{-1} 0.746$

$\theta = 41.755°$

$R = 105,318 \tan 41.755° = 94,016\, ind.\, KVAR$

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145. A short, 3 phase, 3 wire transmission line has a receiving end voltage of 4160 V phase neutral and serving a balanced 3 phase load of 998, 400 volt-amperes at 0.82 p.f lagging . At the receiving endthe voltage is 4600V, phase to Neutral and the p.f is 0.77 . solve for the size in kVAR of a capacitor needed to improve tne receiving end pf to 0.9 lagging maintaining 4160V.

SOLUTION:

$\theta_L = \frac{1}{\cos}$ (0.82) = 34.915^0

$\theta_T = \frac{1}{\cos}$ (0.9) = 25.84^0

P_L = (998.4) (0.82) = 818.688 kW

$Q_T = Q_L - Q_C$

= (818.688) (tan 34.915 – tan 25.84)

= 175 kVAR

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146. A plant has a load of 290kilo watt with an average power factor of 70 %. The owner request you to correct the power factor to reduce its power consumption. How much capacitor kVAR is required to increase the powerfactor to 90%?

SOLUTION:

$\theta_L = \frac{1}{\cos}(0.7) = 45.57^o$

$\theta_t = \frac{1}{\cos}(0.9) = 25.84^o$

$Q_c = Q_L - Q_T$

$= 290 \tan 45.57^o - 290 \tan 25.84$

= 155. 39 kVAR

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147. A 150 Kva transformer bank will serve a load expected to draw 135 KW At 0.80 lagging power factor. Solve for the size of the capacitor bank with needed to be acted in order to prevent overloading of the transformer bank

SOLUTION:

θ_1 = $\cos^{-1}$ 0.8 = 36.87 degree

Q_T = $\sqrt{S^2 - P^2}$ = $\sqrt{150^2 - 135^2}$

= 65.38 Kvar

Q_C = Q_L - Q_C

= P_L tan θ - Q_T = 135tan36.869 degree – 65.38

Q_c = 35.866 kVAR

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148. A current of 12A and a power factor of 0.6 lagging is taken from a single phase 220 V supply. The reactive power of the system is :

SOLUTION :

0 = $\cos^{-1}$ 0.6 = 53.13 degree

Q = EIsin θ

Q = (220X12)SIN 53.13 degree
Q = 2112 VARS

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149. An inductive reactance of 10 ohms is connected in parallel with a capacitive reactance of 20 ohms. If the combination is connected in series with a 10 ohms resistance. Solve for the equivalent power factor of the combination.

SOLUTION :

Z_1 = 10 + $\frac{(J\,10)(-J\,20)}{(J\,10+J\,20)}$

Z_1 = 10 + $\frac{-j^2(200)}{-j\,30}$ = 10+j6.67

Z_1 = 10-6.67i

Pf = cos33.70
Pf = 0.83 lagging

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150. Given three impedances: Z_1 = 10+j2, Z_2 = 2+j5, Z_3 = 3-j2. Impedance Z_2 and Z_3 are connected in parallel and the combination is connected in series with impedance Z_1 ,across 120 V single phase 60 Hz source. Find the total power drawn by the impedances.

SOLUTION:

Z_1 = 10+j2

Z_2 = 2+j5

Z_3 =3-j2

Z_T = 10 + $10+2j(3-j2)$ ¿ ¿ ¿

= 10+2.62-1.08j

P = $\frac{120^2}{12.62}$ cos (4.89 degree)

P = 1136.89 watts

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