2.9. Consider the problem of using a low-voltage system to power a small cabin. Suppose a 12-V system powers a pair of 60-W lightbulbs (wired in parallel). The distance between these loads and the battery pack is 50 ft.

a. Since these bulbs are designed to use 60 W at 12 V, what would be the filament resistance of each bulb ?

b. What would be the current drawn by two such bulbs if each receives a full 12 V?

c. Of the gages shown in Table 2.3, what gage wire should be used if it is the minimum size that will carry the current?

d. Find the equivalent resistance of the two bulbs plus the wire resistance to and from the battery. Both lamps are turned on (in this and subsequent parts).

e. Find the current delivered by the battery with both bulbs turned on.

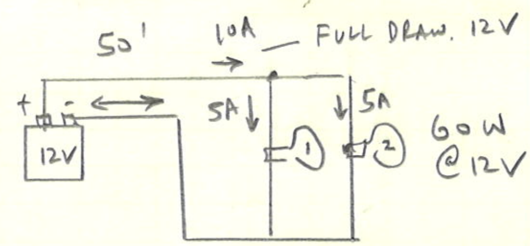
f. Find the power delivered by the battery.

g. Find the power lost in the connecting wires in watts and as a percentage of battery power.

h. Find the power delivered to the bulbs in watts and as a percentage of their rated power.

$P = \frac{V^2}{R} =$

$P = VI =$



(a) $P = VI = \frac{V^2}{R} = \frac{(12)^2}{R}$

$R = \frac{(12^2)}{60} = \frac{144}{60} = \underline{\underline{2.4\,\Omega}}$ ANS.

(b) $P = I^2 R \Rightarrow I^2 = \frac{P}{R} = \frac{60}{2.4} \Rightarrow I = \sqrt{\frac{60}{2.4}} = \underline{\underline{5\,A}}$ ANS

(c) 10 A TO SUPPLY BOTH BULBS @ 5A

$\Rightarrow$ <u>14 GAGE</u> IS MIN SIZE w/ 15 A MAX CURRENT.
ANS.

(d) $R_{WIRE} = 50' \times 2 \times \frac{.2525}{100'}$ $\qquad R_{BULBS} = (2.4\,\Omega \parallel 2.4\,\Omega)$

$= .2525\,\Omega$ $\qquad = 1.2\,\Omega$

$R_{TOT} = R_{WIRE} + R_{BULBS} = .2525 + 1.2$

$= \underline{\underline{1.4525\,\Omega}}$ ANS

(e) $I = \frac{V}{R_{TOT}} = \frac{12}{1.4525} = \underline{\underline{8.26\,A}}$ ANS.

(f) $P_{BAT} = 12\,(8.26) = \underline{\underline{99.14\,W}}$ ANS.

(g) $P_{\substack{WIRE \\ LOSS}} = I^2 R_{WIRE} = (8.26)^2 (.2525) = \underline{\underline{17.22\,W}}$ ANS. $\qquad \% P_{\substack{WIRE \\ LOSS}} = 17.?$

$$\% P_{\substack{WIRE \\ LOSS}} = \frac{17.22\,W}{99.14\,W} = 17.36\%$$

(h) $I_{BULB} = \frac{8.26\,A}{2} = 4.13\,A$

$P_{BULB} = I_{BULB}^2 R_{BULB} = (4.13)^2(2.4) = \underline{\underline{40.94}}\,W$ ANS — 1 BULB

$P_{BULBS} = 2 P_{BULB} = \underline{\underline{81.88\,W}}$ ANS — 2 BULBS

$$\% P_{BULBS} = \frac{81.88}{99.14\,W} = \underline{\underline{82.5\%}}$$ ANS.

2.15. If the photovoltaic (PV) module in Problem 2.14 is connected to a 5-Ω load, find the current, voltage, and power that will be delivered to the load under the following circumstances. Comment on the power lost due to shading.

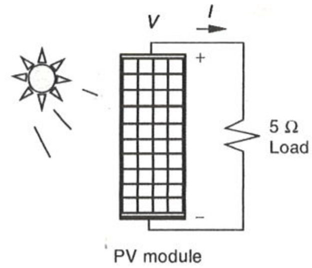
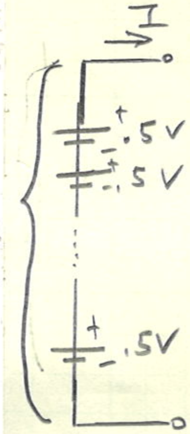


Figure P2.15

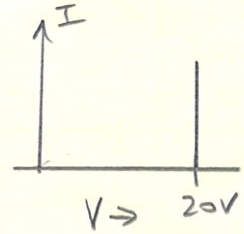
a. Every cell in the PV module is in the sun.
b. One cell is shaded.
c. Two cells are shaded.



(a) $V = 40(.5) = 20$

$I = \frac{20V}{5\Omega} = 4A$

$P = VI = \underline{\underline{80\,W}}$ ANS.



FULL SUN I-V CURVE

(b) WHEN AN INDIVIDUAL CELL IS SHADED IT ACTS AS A $\underline{\underline{5\Omega}}$ RESISTOR INSTEAD OF A .5V SOURCE.

$$I = \frac{V_{39\ cells}}{R_{LOAD} + R_{SHADED\ CELL}} = \frac{(39)(.5)}{5+5} = 1.95A$$

$P_{LOAD} = VI = (19.5)(1.95) = \underline{\underline{38.02\,W}}$ ANS.

$P_{LOSS} = (1.95)^2(5) = \underline{\underline{19.01\ W}}$ ANS.

(c) $$I = \frac{V_{38\ cells}}{R_{LOAD} + R_{SHADED\ CELLS}} = \frac{(38)(.5)}{15} = \underline{\underline{1.26\bar{6}\,A}}\ \text{ANS}$$

$V = 19V$

$P_{LOAD} = VI = (19)(1.266) = 24.066\ W$

$P_{LOSS} = (1.266)^2(10) = \underline{\underline{16.027}}\ W$ ANS

THE POWER LOST INCREASES NON-LINEARLY AS CELLS ARE SHADED.

3.6. A 120-V, 60-Hz source supplies current to a 1 μF capacitor, a 7.036-*H* inductor and a 1-Ω resistor, all wired in parallel.

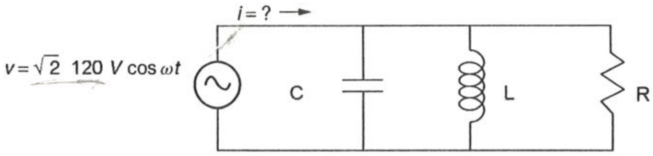


Figure P3.6

a. Find the reactances (Ω) for the capacitor and inductor.

b. Find the rms current throug each load component.

c. Express the impedance of each in polar form **Z** = Z ∠ϕ and rectangular form **Z** = a + jb.

d. Write the currents through each of the three components in the form of phasors $I = I_{rms} \angle\phi$ and in complex notation **Z** = a + jb.

e. Find the total current delivered by the source, expressed in phasor notation I_{tot} notation. What is the rms value of total current?

f. What is the power factor?

g. Write the total current in the time domain $i = \sqrt{2}\, I \cos(\omega t + \phi)$

a) $\bar{Z}_L = j\omega L = j2\pi(60)(7.036) = \underline{j2652.4\ \Omega}$ ANS.

$Z_c = \dfrac{1}{j\omega C} = \dfrac{-j}{2\pi(60)\,10^{-6}} = \underline{-j2652.58\ \Omega}$ ANS

b)

$\bar{V} = 120\angle 0$

$I = \dfrac{V}{Z}$

$I_L = \dfrac{120\angle 0^\circ}{2652\angle 90^\circ} = .0452\angle -90^\circ$ $I_{RMS} = \underline{.0452\ A}$ ANS. FOR BOTH

$I_c = \dfrac{120\angle 0^\circ}{2652\angle -90^\circ} = .0452\angle 90^\circ$

c) $\bar{Z}_L = \underline{2652.4\angle 90^\circ}$; $\bar{Z}_L = \underline{0 + j2652.4\ \Omega}$ ANS

$Z_c = \underline{2652.4\angle -90^\circ}$ ANS. ; $Z_c = \underline{0 - j2652.4\ \Omega}$ ANS.

d) $I_c = \underline{.0452\angle 90^\circ}$ ANS. ; $I_c = \underline{0 + j.0452}$ ANS

$I_L = \underline{.0452\angle -90}$ ANS ; $I_L = \underline{0 - j.0452}$ ANS.

$$\bar{I}_R = \frac{\bar{V}}{R} = \frac{120\angle 0}{1} = \underline{\underline{120\angle 0}} = \underline{\underline{120 + j0}}\ A$$
ANS.

e) $I_{TOT} = \bar{I}_C + \bar{I}_L + \bar{I}_R$

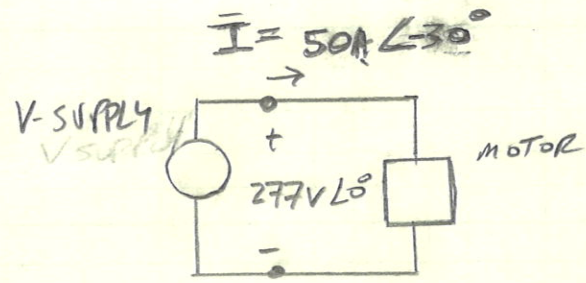
$= .0452\angle 90 + .0452\angle -90 + 120$

$I_{TOT} = \underline{\underline{120\ A\ RMS}}$ ANS.

f) $p.f. = \underline{\underline{1.0}}$ ANS ($\bar{V}$ & I_{TOT} ARE IN PHASE.)

g) $\underline{\underline{i(t) = \sqrt{2}\, 120 \cos(\omega t)}}\ A$ ANS.

3.8 A 277-V supply delivers 50 A to a single-phase electric motor. The motor windings cause the current to lag behind the voltage by 30°. Find the power factor and draw the power triangle showing real power P(kW), reactive power Q(kVAR), and the apparent power S(kVA).

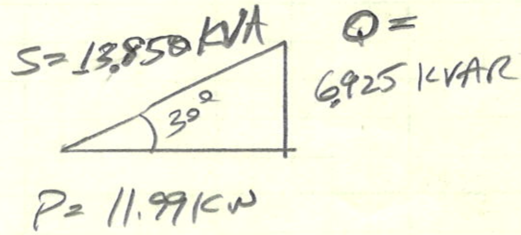


$\bar{S} = \bar{V}\bar{I}^*$

$= (277\angle 0)(50\angle{+30})$

$= 13850\angle 30^\circ$

$= 11{,}994\ W + j\ 6925\ KVAR$



3.9 A 120-V AC supply delivers power to a load modeled as a 5-Ω resistance in series with a 3-Ω inductive reactance. Find the active, reactive, and apparent power consumption of the load along with its power factor. Draw its power triangle.

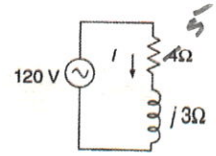


FIGURE P3.9

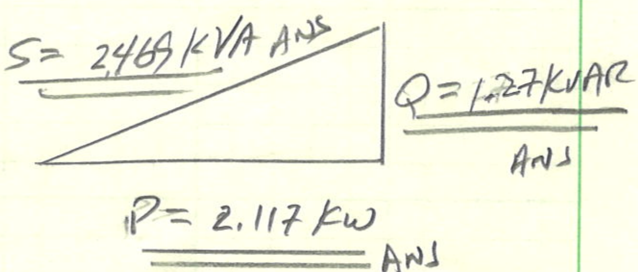
$\bar{V} = 120\angle 0^\circ$

$R = 5\,\Omega$, $X = j3\,\Omega$ $\Big\}$ $Z = 5 + j3$

$\bar{I} = \dfrac{\bar{V}}{Z} = \dfrac{120\angle 0^\circ}{(5+j3)} = 20.57\angle -30.96$

$\bar{S} = \bar{V}\bar{I}^* = (120\angle 0)(20.57\angle +30.96)$

$= 2469\angle 30.96^\circ$



$pf = \cos(\theta_v - \theta_i)$

$= \cos(0 - (-30.96))$

$= .8575$ ANS

ECE 333 HMWK 2 B-1

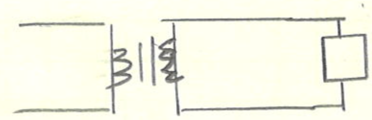
3.10 A transformer rated at 1000 kVA is operating near capacity as it supplies a load that draws 900 kVA with a power factor of 0.70.

a. How many kW of real power is being delivered to the load?

b. How much additional load (in kW of real power) can be added before the transformer reaches its full rated kVA (assume the power factor remains 0.70).

c. How much additional power (above the amount in a) can the load draw from this transformer without exceeding its 1000 kVA rating if the power factor is corrected to 1.0?

RATED 1000kVA



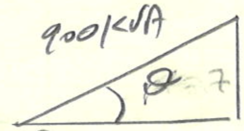
pf=.7

p.f.=.7

a) $P = VI\cos\theta$

$= (900kVA)\,.7$

$= \underline{\underline{630\ KW}}$ ANS.



P= 630 KW

$pf = \cos(\theta)$

$\theta = \cos^{-1}(.7)$

$= 45.57°$

b) $P_{MAX} = (1000\ kVA)(.7)$

$= 700\ kW.$

∴ CAN ADD $(700 - 630) = \underline{\underline{70\ KW}}$ ANS.

BEFORE REACHING RATED KVA

c) p.f. CHANGED TO 1

∴ KW = KVA

SO $1000\,KW - 630\,KW = \underline{\underline{370\,KW}}$ ANS.

ADDITIONAL POWER CAN BE ADDED.