EEEN313 and ECEN405 **Assignment 1**

Total marks: 115 (Contribution: 15%)

Below are the problems for this assignment. Do your calculation as needed and then put <u>your final answers as well any discussion or plots in the spaces required.</u> Submit this document with a filename: ECEN405_Assmt_2021_"your surname"-"your initial" on the Wiki submission system no later than 13 August by 11.59 pm. You are welcome to discuss and find best ways to solve the problem/s. Please make sure you DON'T copy-paste the solution.

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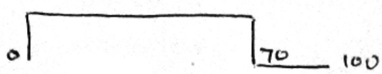
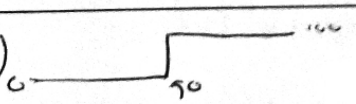
Q1. The voltage and current for a device are periodic functions with T= 100ms is described as the following. Determine (a) the instantaneous power (b) average power and (c) energy absorbed by the device in one time period.

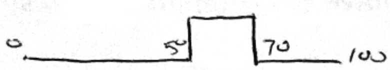
$$v(t) = \begin{cases} 10\text{ V} & 0 < t < 70\text{ ms} \\ 0 & 70\text{ ms} < t < 100\text{ ms} \end{cases}$$

$$i(t) = \begin{cases} 0 & 0 < t < 50\text{ ms} \\ 4\text{ A} & 50\text{ ms} < t < 100\text{ ms} \end{cases}$$

Answer (15)

a) $v(t)$ 

$i(t)$ 

$p(t)$ 

$$= \begin{cases} 0 & 0 < t < 50\text{ms} \\ 40W & 50 \le t \le 70 \\ 0 & 70 < t < 100 \end{cases}$$

~~p(t)~~

b) $P_{av} = \frac{1}{T}\int_0^T p(t)\,dt = \frac{1}{100}\int_{50\times10^{-3}}^{70\times10^{-3}} 40 = \frac{1}{100}\left[40(70\times10^{-3}) - 40(50\times10^{-3})\right]$

$= 8W$

c) $w = \frac{W}{T}$, $W = wT = 0.8J$

Q2. Induction cooking based on power electronics is estimated to be 80% efficient compared to 55% for conventional electrical cooking. If the average home consumes 2kW-hrs of daily using conventional electric heating and one million households switch to induction cooking, calculate the annual savings in electricity usage.

Answer (15)

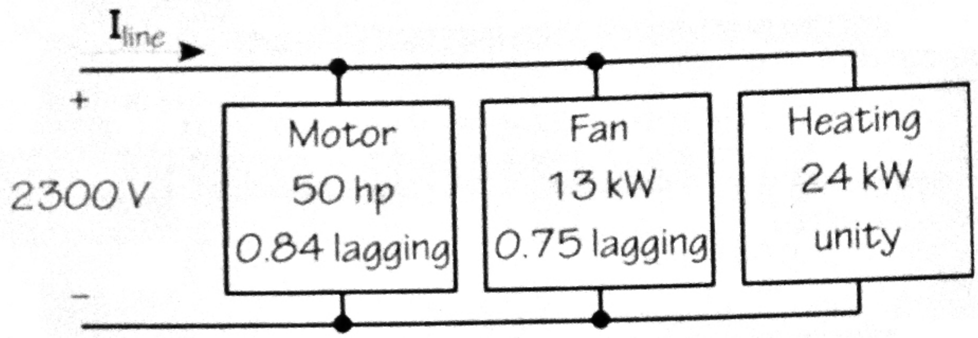
$$\mathcal{E}_{useful} = 0.55 \circ 2kW = 1k1 Whr$$

$$\mathcal{E}_{new\ total} = \frac{1k1}{0.8} = 1k375\ kWhr$$

$$\mathcal{E}_{savings} = (2k - 1.375k)365 = 228{,}125 = 228.125\ kWhrs$$

$$\ldots \times 1000{,}000 = 228.125\ GWhrs$$

Q3. Find Real, Reactive and Apparent power for following load configuration.



$P_m = 37.285$ kW

Answer: (15)

$Q_m = 37.285 \tan(\cos^{-1}(0.84)) = 24.0837$ kVAR

$Q_f = 20 \tan(\cos^{-1}(0.75)) = 11.4649$ kVAR

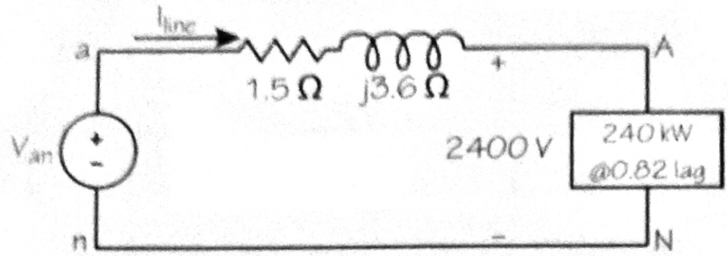
$P_{TOT} = 74.285$ kW

$Q_{TOT} = 35.549$ kVAR

$S_{TOT} = 74.285 - 35.549j = 82.353 \angle -25.57^\circ$ kVA

$pf = \cos(-25.57) = 0.92$ lag.

Q4. A 4,160-V, 50-Hz, 3Ø system supplies a 720-kW load at 0.82 lagging power factor through lines with a line impedance of 1.5 + j3.6 Ω/Ø. (Ø is often written for "phase.") Find the line current, the percent efficiency, the percent voltage regulation, and the generator power factor, and generator voltage.



Answer: (20)

Assuming Y load

$P_{Load} = |V| |I_{line}| pf_{load} \Rightarrow \frac{P_L}{|V|\, pf} = 121.95\,A$

phase $= \cos^{-1}(0.82) = -34.915°$

$I_{line} = 121.95 \angle -34.915$

$P_{loss} = (1.5)(121.95)^2 = 22.308\,kW$

$\%\eta = 100 \dfrac{240kW}{240kW + 22.308} = 91.495\%$

$V_{line} = I_{line} Z_{line} = 475.605 \angle 32.465°$

$V_s = V_{line} + 2400 = 2.813\,kV \angle 5.21°$ (per phase generator voltage)

$\%VR = \dfrac{|V_s| - |V_{load}|}{|V_{load}|} 100 = 17.21\%$

$S_s = V_s I_{line}^* = 343.045 \angle 40.125\,kVA$

$pf = \cos(40.125) \Rightarrow 0.765$ lagging

Q5. The circuit of the figure on slide 13 (Energy Recovery) of your 'power computations2' notes on energy recovery has Vcc = 90V, L=200mH, R=20Ω, t1=10ms, and T=100ms. Determine (a) the peak current and peak energy storage in the inductor, (b) the average power absorbed by the resistor and (c) the peak and average power supplied by the source.

Answer: (15)

a) peak $I_L = i_L(t=t_1) = \frac{V_{cc} t_1}{L} = 4.5A$

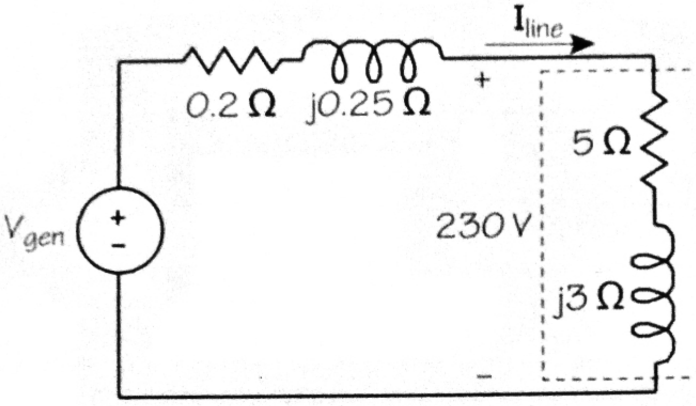
peak $E = \frac{1}{2} 4.5 t_1 V_{cc} = 2.025 J$

b) $P_R = (V_{cc} t_1)^2 / 2LT = 20.25W$

c) $P_S = P_R = 20.25W$

$P_{s\,peak} = V_{cc} I_{pk} = 405W$

Q6. For the following circuit, find P, Q and the power factor.



Answer: (15)

$$I_{line} = \frac{230}{Z_L} = 33.44 \angle -30.96 A$$

$$V_{line} = I_{line} Z_{line} = (33.82 - 20.29j)(0.2 + 0.25j)$$

$$\cancel{11.8} = 12.63 \angle 20.38^{\circ} V$$

$$V_s = 230 + 12.63 \angle 20.38 = 241.88 \angle 1.04 V$$

$$S_s = V_s I_{line}^{*} = (241.88 \angle 1.04)(39.44 \angle -30.46)$$

$$= 8.09 + 5.055j \text{ kVA} = 9.539 \angle 32^{\circ}$$

$P_s = 8.09$ kW $\qquad Q_s = 5.055$ kVAR

pf = cos(32) = 0.848 lead

Q7: In your own words, write the relationship between Apparent, Real and Reactive Powers. How is Power Factor related to them? Describe how would you provide a solution if your house has a Power Factor of 0.3 to improve it to 0.9?

Answer: (20)

Real power is the power consumed / dissipated by the loads in a system, i.e. resistive loads etc.

Reactive power is the that that is temporally ~~stored~~ stored ~~&~~ in reactive components. Ie & in the magnetic fields of inductors & electric fields of & capacitors. This power is not disspated as heat.

The apparent power is the relative power that is drawn from the ~~to~~ supply.

The power factor is the proportion of these 2 powers.

If the pf were 0.3 lag, capacitive loads need to be added, if leading → inductive.