E927500
Circuit Analysis
May 27, 2015

Mid Term II

A. (5x6=30 points) Answer each of the following statements.

(a) Comparison between transform as "isolation device" and "matching device".

(b) Comparison between "120-V connection" and "240-V connection" in household system.

(c) Comparison between "phase current" and "line current" in three-phase system.

(d) Comparison between "single-phase" and "three-phase".

(e) Explain "To mitigate the inductive aspect of the load, a capacitor is added in parallel with the load. The power factor has improved."

(f) Explain "If same power loss is tolerated in single-phase and three-phase systems, the three-phase system should be more economic."

B. (10+5= 15 points) Turns ratio in Ideal Transformer

Derive (a) $\dfrac{\mathbf{V}_2}{\mathbf{V}_1}=\dfrac{N_2}{N_1}=n$ and (b) $\dfrac{\mathbf{I}_2}{\mathbf{I}_1}=\dfrac{N_1}{N_2}=\dfrac{1}{n}$ for the ideal transformer (as Fig. 1(a)) according to a linear transformer as shown in Fig. 1(b), where n is the turns ratio.

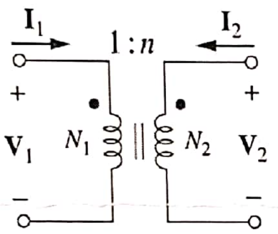


Fig. 1(a)

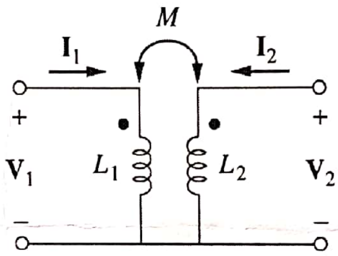


Fig. 1(b)

C. (5+5+10+5=25 points) Equivalent Circuit for Ideal Transformer & Impedance Matching + Maximum Power Transfer with Ideal Transformer

(a) Please derive and draw an equivalent circuit for Fig. 2(a) obtained by reflecting the secondary circuit to the primary side.

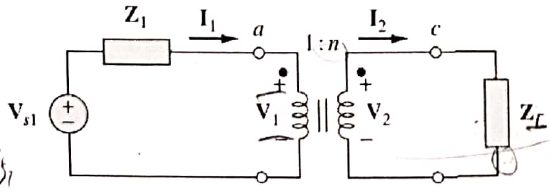
As the circuit of Fig. 2(b), an ideal transformer can be used to match the load, $\mathbf{Z}_L$ = 200 Ω, to the amplifier to achieve maximum power transfer. The Thevenin equivalent of the amplifier is: $\mathbf{V}_{Th}$ = 30 V and $\mathbf{Z}_{Th}$ = 3000 + j4000 Ω. 5W $\frac{200}{n^2}=5000$ $\frac{200}{n^2}=3000$ $n^2=\frac{2}{30}=\frac{1}{15}=0.258$

n (b) Calculate the required turns ratio for maximum power transfer. n^2

(c) Determine the load voltages and the power transfers with the ideal transformer based on $P = V^2/R$ and the equivalent circuit by reflecting the primary circuit to the secondary one. $\frac{30}{3000+j4000+3000}=I_1$

(d) Calculate the complex power supplied by the source.

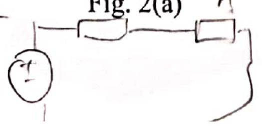
V_{th} $\mathbb{I}_2=\frac{1}{n}\mathbb{I}_1$



$V_{th}=V_1=V_{s1}$

$V_1=\frac{V_2}{n}=\frac{V_{s2}}{n}$ $\frac{Z_L}{n^2}=\frac{200}{n^2}$

Fig. 2(a)



V_{s1}

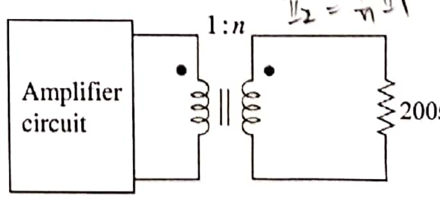


Fig. 2(b)

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D. (8+12+5=25 points) Balanced Three-Phase System with Power Factor Correction

Figure 3 shows a three-phase circuit. The capacitors can be added to improve the power factor of the load. We need to determine the value of the capacitance, C, required to obtain a power factor of 0.9 lagging if three capacitors are connected as a Δ in parallel.

(a) Find the per-phase equivalent circuit which can be used to analyze this circuit.

(b) Derive the following formula which can provide for calculating the reactance, X_1, needed to correct the power factor of a load. R and X are the real and imaginary parts of the load impedance before the power factor is corrected and pfc is the corrected power factor. After this equation is used to calculate X_1, the capacitance, C, can be calculated from X_1.

$$X_1 = \frac{R^2 + X^2}{R\tan(\cos^{-1} pfc) - X}$$

(c) Calculate the capacitance of each capacitor according the formula in (b).

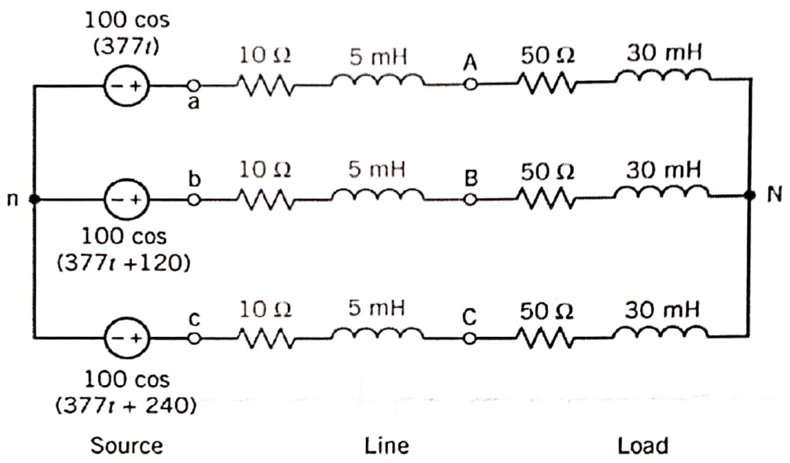

Fig. 3

E. (10+5=15 points) *PSpice*

(a) Fig. 4(a) is an electric circuit of a transformer, and Fig. 4(b) is a *PSpice* simulation figure. Determine whether the design and the parameter settings in Fig. 4(b) are correct. If not, please explain the reason for these mistakes and plot the right *PSpice* simulation figure. If we want to use AC sweep to analysis the electric circuit, how should we set the parameters of the start frequency?

(b) If we use two individual inductances to design a transformer, please plot the *PSpice* simulation figure and explain how to design the parameters in detail.

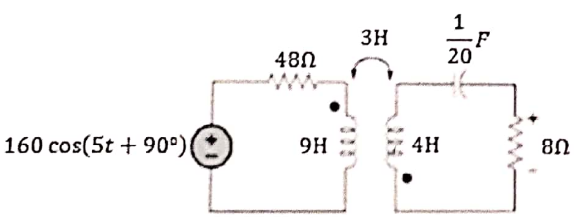

Fig. 4(a)

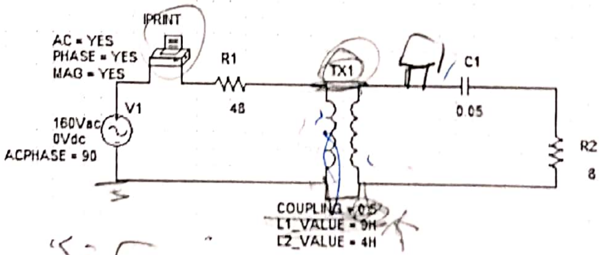

Fig. 4(b)

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