May 11, 2021

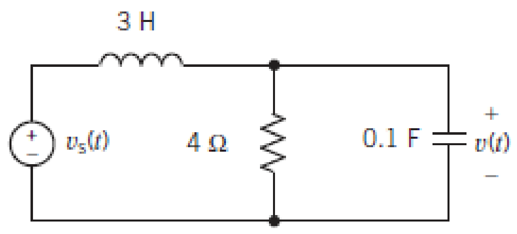
EEE 202 ELECTRIC CIRCUITS II

SPRING'21 - MIDTERM EXAM (ONLINE)

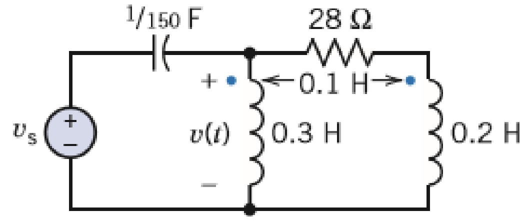
Name: ____, Signature: _______________________________

Closed books and closed notes. Use of mobile phones is considered cheating. Show your work clearly. Otherwise, no credit will be given.

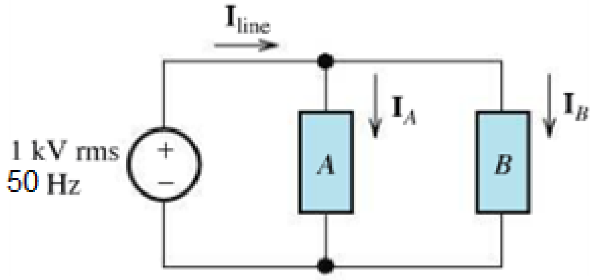
(25 pts) **Q.1** (LO01) The input to the circuit shown in the following figure is the voltage of the voltage source $v_s(t) = 5\cos(2t + 45°)$ V. The output is the capacitor voltage $v(t)$. Determine steady-state output voltage.



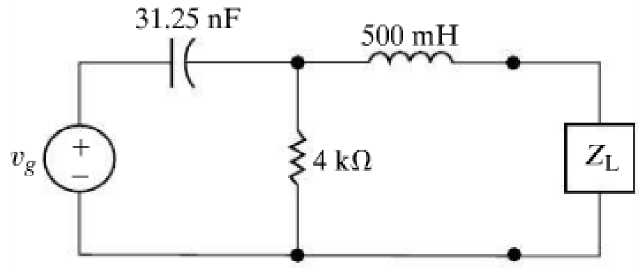
(25 pts) **Q.2** (LO01) Determine $v(t)$ for the circuit shown in the following figure when $v_s = 20\cos 30t$ V.



(25 pts) **Q.3** (LO02) Two loads – *A* and *B* – are connected in parallel across a 1-kV rms 50-Hz line as shown in the following figure. Load *A* consumes 10 kW with a 90-percent-lagging power factor. Load *B* has an apparent power of 15 kVA with an 80-percent-lagging power factor. Find the real power, reactive power, and apparent power delivered by the source. What is the power factor seen by the source?



(25 pts) **Q.4** (LO02) For the circuit shown in the following figure, determine the load impedance that will result in maximum average power being transferred to the load and the corresponding maximum average power if $v_g = 10\cos(4000t)$ V.



Useful Info:

Phasors:

$\mathbf{V}(\omega) = V_m e^{j\theta_v} = V_m \angle \theta_v$ $\mathbf{I}(\omega) = I_m e^{j\theta_i} = I_m \angle \theta_i$ $e^{\pm j\theta} = \cos\theta \pm j \sin\theta$

$\mathbf{V_L}(\omega) = \mathrm{Z_L}\mathbf{I_L}(\omega)$ $\mathbf{V_C}(\omega) = \mathrm{Z_C}\mathbf{I_C}(\omega)$ $\mathbf{V_R}(\omega) = \mathrm{Z_R}\mathbf{I_R}(\omega)$

$\mathrm{Z_L} = j\omega L$ $\mathrm{Z_C} = 1/j\omega C$ $\mathrm{Z_R} = R$

Note that ω is the angular frequency, which is $2\pi f$.

The **rms** value of a periodic waveform $w(t)$ is defined as: $W_{rms} = \sqrt{\frac{1}{T}\int_{t_0}^{t_0+T} w^2(t)dt}$

For a **sinusoidal waveform** $v(t) = V_m \cos(\omega t + \theta)$: $V_{rms} = \frac{V_m}{\sqrt{2}}$

Equivalent impedance when the impedances are in series $Z_{eq} = \sum_{i=1}^{k} Z_i = Z_1 + Z_2 + \cdots + Z_k$.

Equivalent impedance when the impedances are in parallel $\frac{1}{Z_{eq}} = \sum_{i=1}^{k} \frac{1}{Z_i} = \frac{1}{Z_1} + \frac{1}{Z_2} + \cdots + \frac{1}{Z_k}$.

The **average power** $P = V_{rms} I_{rms} \cos(\theta_\mathrm{V} - \theta_\mathrm{I})$. The **reactive power** $Q = V_{rms} I_{rms} \sin(\theta_\mathrm{V} - \theta_\mathrm{I})$.

The **complex power** $\mathbf{S} = \frac{\mathbf{VI}^*}{2} = \frac{V_m I_m}{2} \angle(\theta_\mathrm{V} - \theta_\mathrm{I}) = V_{rms} I_{rms} \angle(\theta_\mathrm{V} - \theta_\mathrm{I}) = P + jQ$.

The **apparent power** is $|\mathbf{S}| = \frac{V_m I_m}{2}$. The **power factor** $pf = \cos(\theta_\mathrm{V} - \theta_\mathrm{I})$.

For the **maximum power transfer**, $\mathrm{Z_L} = \mathrm{Z_t^*}$, where $\mathrm{Z_L}$ is the load impedance and $\mathrm{Z_t^*}$ is the complex conjugate of the Thévenin equivalent impedance $\mathrm{Z_t}$ of the circuit.

For **coupled inductors** in the time domain $v_1 = L_1 \frac{di_1}{dt} \pm M \frac{di_2}{dt}$ and $v_2 = L_2 \frac{di_2}{dt} \pm M \frac{di_1}{dt}$

For an **ideal transformer**, $\mathbf{V}_2 = \frac{N_2}{N_1}\mathbf{V}_1$ and $\mathbf{I}_1 = -\frac{N_2}{N_1}\mathbf{I}_2$.

Total complex power in a **balanced three-phase** circuits: $\boldsymbol{S}_\mathbf{T} = 3\boldsymbol{S}_\mathbf{p} = 3\frac{\mathbf{VI}^*}{2}$.

In **balanced three-phase** circuits, $V_{LL} = \sqrt{3}V_p$ and $I_L = I_p$ for Y connection; $V_{LL} = V_p$ and $I_L = \sqrt{3}I_p$ for Δ connection.

Network function: $\mathbf{H}(\omega) = \frac{\mathbf{Y}(\omega)}{\mathbf{X}(\omega)}$, where $\mathbf{X}(\omega)$ is the phasor corresponding to the input to the circuit and $\mathbf{Y}(\omega)$ is the phasor corresponding to the steady-state response of the network.

Gain: $|\mathbf{H}(\omega)| = \left|\frac{\mathbf{Y}(\omega)}{\mathbf{X}(\omega)}\right|$, **phase shift:** $\angle\mathbf{H}(\omega) = \angle\mathbf{Y}(\omega) - \angle\mathbf{X}(\omega)$.

Logarithmic gain: $20\log_{10}|\mathbf{H}(\omega)|$ in decibel (**dB**).

In an **ideal op-amp**: $i_+ = i_- = 0$ $v_+ = v_-$

Nano (**n**) → 10^{-9} Micro (**µ**) → 10^{-6} Milli (**m**) → 10^{-3} Kilo (**k**) → 10^{3} Mega (**M**) → 10^{6}