May 16, 2020

EEE 202 ELECTRIC CIRCUITS II

SPRING'20 - MIDTERM EXAM

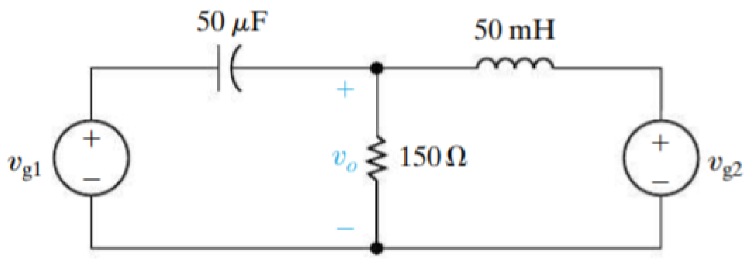
Name: ______________________________________, **Signature:** ____________________________

Show your work clearly in the spaces provided. Otherwise, no credit will be given.

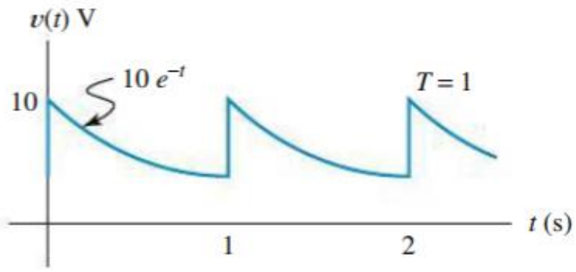
(20 pts) **Q.1** Using the node-voltage method, find the steady-state expression for $v_o(t)$ in the circuit shown in the following figure if

$$v_{g1} = 25\sin(400t + 143.13\,°)\ \text{V},$$

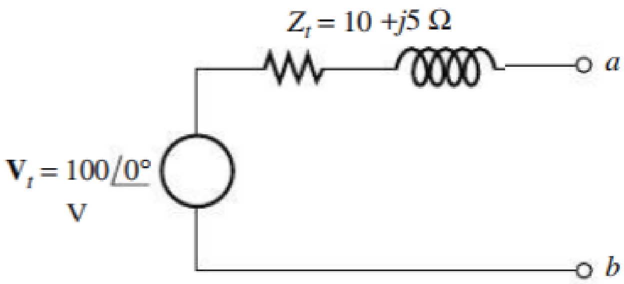
$$v_{g2} = 18.03\cos(400t + 33.69\,°)\ \text{V}.$$



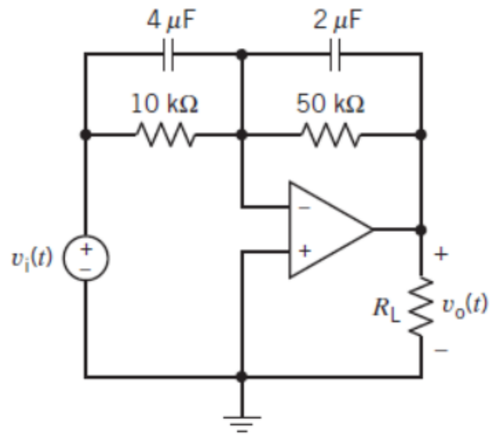
(14 pts) **Q.2** Find the rms value of the voltage waveform shown in the following figure.



(16 pts) **Q.3** The Thévenin equivalent of a two-terminal network is shown in the following figure. The frequency is $f = 50$ Hz. We wish to connect a load across terminals *a*-*b* that consists of a resistance and a capacitance in parallel such that the power delivered to the resistance is maximized. Find the value of the resistance and the value of the capacitance.



(20 pts) **Q.4** The input to the circuit shown in the following figure is the source voltage $v_{\mathrm{i}}(t)$ and the response is the voltage across R_{L}, $v_{\mathrm{o}}(t)$. Express the gain and phase shift as a functions of the radian frequency ω.



(16 pts) **Q.5** Two electrical loads are connected in parallel to a 400-V rms, 50-Hz supply. The first load is 12 kVA at 0.7 lagging power factor; the second load is 10 kVA at 0.8 lagging power factor. Find the average power, the apparent power, and the power factor of the two combined loads.

(14 pts) **Q.6** A balanced wye-connected three-phase source has line-to-neutral voltages of 440 V rms. Find the rms line-to-line voltage magnitude. If this source is applied to a wye-connected load composed of three 30-Ω resistances, find the rms line-current magnitude and the total power delivered.

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}

Reminder:

In answering exam questions, you had better get the print-out of the exam file and solve the problems and fill out the honor pledge in the spaces provided by handwriting. After finishing the exam, you should scan pages and save them as one pdf file. Please, do not forget to use CamScanner-like applications to prepare organized scanned pages as a file. In the meantime, if you are unable to get the print-out, you may write your answers on standard size (A4) paper and get the scanned pages as a pdf file.

Finally, you are to submit the file to me via the place in Blackboard by 5:30 pm today.

HONOR PLEDGE

I pledge on my honor that I have not given or received any unauthorized assistance on this exam, and that all work has been my own.

Name:

Signature:

Student Number: