Circuit Theory and Electronics Fundamentals

Special Season Exam – July/28/2021. Duration: 3h00m

Only calculator e and scratch paper are allowed. Closed-book exam.

1. Consider the circuit in Figure 1, where I_S=6*mA* and V_B=12*V*.

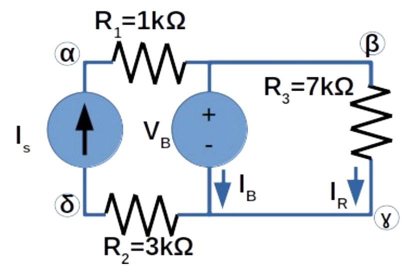

Figure 1

a) Consider the o <u>Superposition Theorem</u> for calculating V_α-V_γ and I_B. Present the results, symbolically and numerically, in matrix **A** (2x2).

$$\begin{bmatrix} V_\alpha - V_\gamma \\ I_B \end{bmatrix} = A \begin{bmatrix} I_S \\ V_B \end{bmatrix}$$

b) Compute the power in sources I_S e V_B, and indicate, justifying, if each source is receiving or supplying energy.

c) Compute the parameters of the <u>Thévenin's and Norton's Equivalents</u>, R_{eq}, V_{eq} and I_{eq} , seen from node β to node α. Consider two terminals connected to these nodes.

2. Consider the circuit in Figure 2, where I_S=6*mA* and V_K=k(V_β- V_α), k=-2 V/V

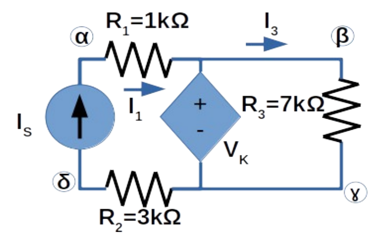

Figure 2

a) Using the <u>Mesh Method</u>, compute, symbolically and numerically, matrix **A** (2x2) and vector **B** (2x1).

$$A \begin{bmatrix} I_1 \\ I_3 \end{bmatrix} = B$$

b) Using the <u>Node Method</u>, and assuming that ɣ is ground, compute, symbolically and numerically, matrix **A** (3x3), and vector **B** (3x1).

$$A \begin{bmatrix} V_\alpha \\ V_\beta \\ V_\delta \end{bmatrix} = B$$

3. Consider the circuit in Figure 3, where $i_S(t)$ = -20 cos(ωt-π/4) *mA* and f=10Hz.

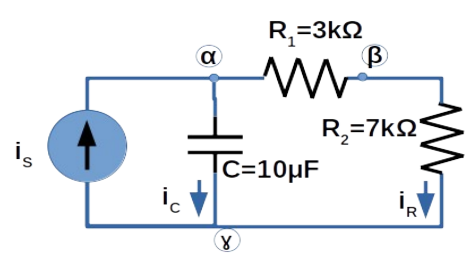

Figure 3

a) Determine the <u>forced solution</u> $v_1(t)=v_\beta(t)–v_\alpha(t)$.

b) Compute the <u>active and reactive power</u> associated with the current source.

e) Compute the <u>Transfer Function</u> $T(s)=V_1(s)/I_s(s)$ symbolically, where $V_1(s)=V_\beta(s)–V_\alpha(s)$, and indicate the implemented <u>filter type</u>, justifying your answer.

4. Consider again the circuit in Figure 3, where $i_S(t)$ = 10 sign(sin(ωt)) *mA*, for

f=10Hz and $sign(x) = \begin{cases} 1, & x \geq 0 \\ -1, & x < 0 \end{cases}$

a) Assuming the capacitor is discharged at instant t=0*s*, plot the voltage $v_2(t)=v_\beta(t)–v_\gamma(t)$ during the first period T, numerically calculating its values at instants 0, T/2 and T.

b) Determine the <u>maximum instantaneous power</u> associated with the energy dissipated by R_2 in the time interval [0,T], and the instant when that happens.

5. Consider the circuit in Figure 4 where the diode is ideal.

a) For $v_S(t)$ = 10 V and $v_\alpha(0)$ = 9.5 V, compute $i_D(t)$ for t≥0 s.

b) For $v_S(t)$ = 10 cos(ωt) *V*, f=1 *kHz*, plot $v_s(t)$, $v_\beta(t)$ and $i_D(t)$ during 2 periods.

c) For $v_S(t)$ = 10 cos(ωt) *V* and f=1 *kHz*, answer only one of the following two questions: **(i)** Compute the time instants t_{OFF} when the diode goes from being ON to being OFF. **(ii)** Compute V_{ripple}, the voltage ripple peak-to-peak value in node β (difference between the maximum and minimum voltages), using a linear approximation for the capacitor's voltage variation during one period. Assume t_{OFF}=250ns.

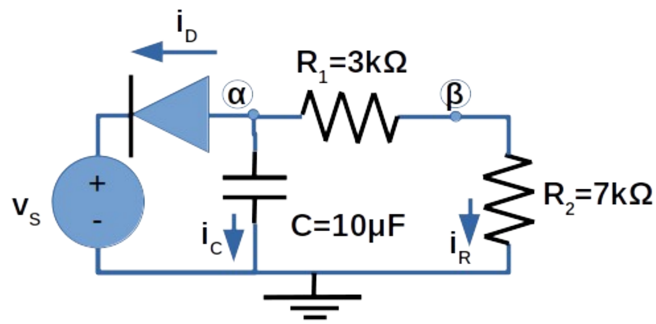

Figure 4

6. Consider the voltage amplifier in Figure 5.

a) Compute the value of R_B so that the collector is at 5V at the quiescent operating point. If you have not answered this question assume for the following questions that R_B=100kΩ.

b) Draw the amplifier's incremental circuit in the pass-band, and determine the voltage gain and the input and output impedances.

c) Determine the circuit's frequency response $V_O(\omega)/V_S(\omega)$, for $C_I=\infty$, C_O=2μF and C_π=2pF.

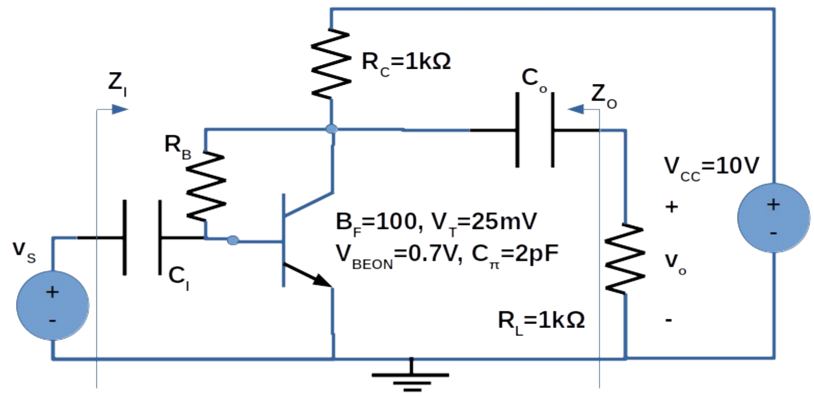

Figure 5

7. Consider the circuit in Figure 6 and assume the OP-AMPs never saturate.

a) Determine $v_Z(v_X, v_W)$, $v_Y(v_Z)$ and $v_W(v_Y)$ and, based on the obtained results, establish the differential equation that relates v_X and v_Y.

b) Compute $v_Y(t)$ in the sinusoidal steady-state (without the initial transient), for $v_X(t)$=2 cos(ωt), R=1kΩ, C=1μF and f=1kHz. Suggestion: establish the algebraic equation that relates $\tilde{V}_X$ and $\tilde{V}_Y$.

c) Determine the Transfer Function $V_Z(s)/V_X(s)$ and indicate, justifying, the implemented filter type.

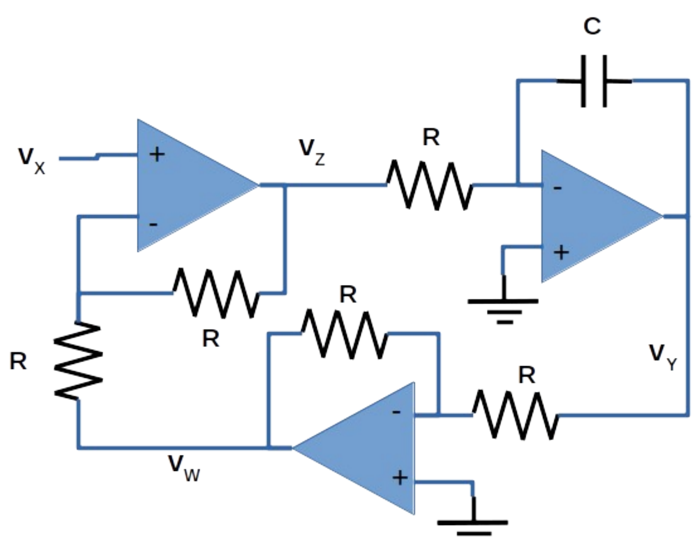

Figure 6

Question grading

1-a)	1-b	1-c)	2-a)	2-b)	3-a)	3-b)	3-c)	4-a)	4-b)	5-a)	5-b)	5-c)	6-a)	6-b)	6-c)	7-a)	7-b)	7-c)
1	1	1	1.5	1.5	1	1	1	1	1	1	1	1	1	1	1	1	1	1