International Institute of Information Technology, Hyderabad

(Deemed to be University)

Networks Signals and Systems

End Semester

Max. Time: 3 hr **Max. Marks: 70**

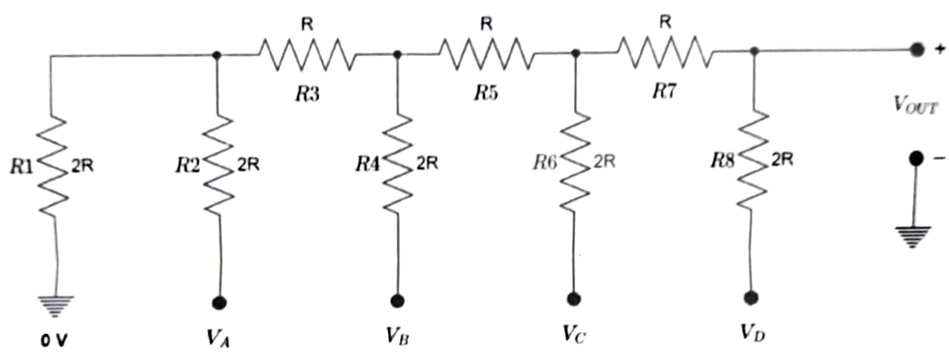
Instructions:

Clearly state the assumptions (if any) made that are not specified in the questions.
Throughout each question, we follow the same notation and terminology, in all parts.

Q1. A new type of device appears to accumulate charge according to the expression $q(t) = 10t^2 - 22t$ mC (t in s). (a) In the interval $0 \le t < 5$ s, at what time does the current flowing into the device equal zero? (b) Plot $q(t)$ and $i(t)$ over the interval $0 \le t < 5$ s. Label the plot well.

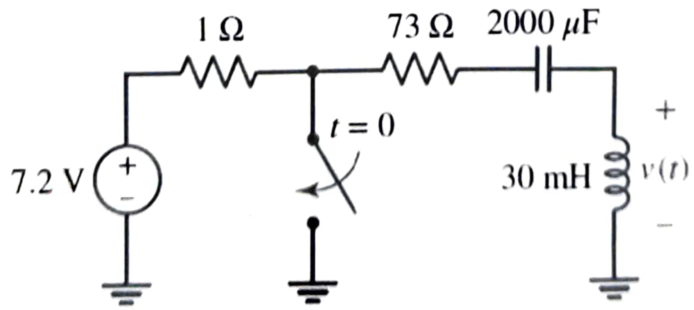
[5+5 = 10 marks]

Q2. Determine the Thevenin Equivalent circuit of the following R-2R ladder network:



[12 marks]

Q3. Analyse the given circuit in time-domain for $t \geq 0$, and calculate the value of $v(t)$. Assume steady state for $t < 0$.

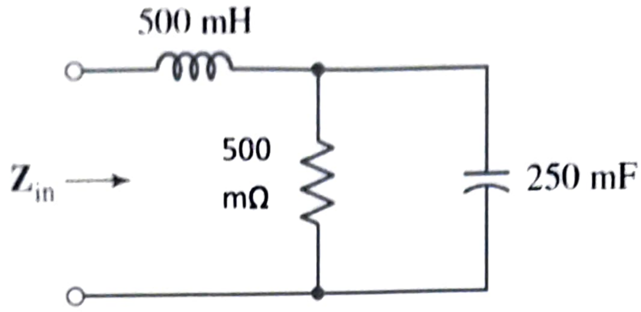


[10 marks]

Q4. Prove that if $x(t)$ is periodic, so is $x^2(t)$. Find the Fourier series (FS) coefficients of $x^2(t)$ in terms of those of $x(t)$ (note: derive from first principles, do not use FS properties directly). Check your answer for $x(t) = \sin(t)$.

[2+4+1 = 7 marks]

Q5. Determine the input impedance $Z_{in}(s)$ seen looking into the terminals of the network depicted in the figure. If $Y_{in}(s) = 1/Z_{in}(s)$, find the value of $Y_{in}(t)$. Plot $Y_{in}(t)$ as a function of time for $t \geq 0$ and comment on its form.



[3+5+5=13 marks]

Q6. Prove that $f(0^+) = \lim_{s\to\infty}[sF(s)]$, for the region of convergence of $t > 0^-$.

[10 marks]

Q7. Prove or disprove the following claims. (Note: To disprove a claim, you may need to give a 'counterexample', i.e., any example for which you should then prove that the claim is not true. For example, if 'all even numbers are positive' is the claim, then you can show the example 0, which is even, but not positive.)

(a) The input $x(t)$ and output $y(t)$ of an LTI system satisfies the equation (in the s-domain)

$$Y(s) = X(s)H(s),$$

where $H(s)$ is the system transfer function. (You are free to assume that the time-domain relationship between $x(t)$ and $y(t)$ via the impulse response).

(b) The ROC of a causal LTI system does not contain any $s \in \mathbb{C}$ such that $Re(s) < 0$.

(c) Let $x_1(t)$ and $x_2(t)$ be the inputs to an LTI system and the respective outputs be $y_1(t)$ and $y_2(t)$. Then, corresponding to the output of the same system being $y_1(t - t_1) + y_2(t - t_0)$, the input is unique and must be $x_1(t - t_1) + x_2(t - t_0)$ only. Here, t_0 and t_1 are constants.

[2+2+3 = 8 marks]