NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 1 EXAMINATION 2023-2024

EE2101 – CIRCUIT ANALYSIS

November / December 2023 Time Allowed: 2 hours

INSTRUCTIONS

1. This paper contains 4 questions and comprises 7 pages.
2. Answer all 4 questions.
3. All questions carry equal marks.
4. This is a closed book examination.
5. Unless specifically stated, all symbols have their usual meanings.
6. The Laplace Transform Table is provided in Appendix A on pages 6 and 7.

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1. (a) Using Mesh analysis, determine the currents i_1 and i_2 of the circuit in Figure 1.1. Hence, determine the power of the current source.

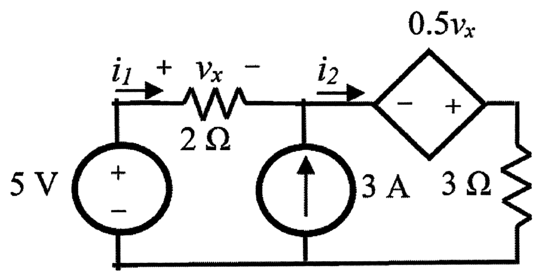

Figure 1.1

(12 Marks)

Note: Question No. 1 continues on page 2.

(b) Find the Thevenin equivalent of the terminal *a, b* of the circuit in Figure 1.2. If a load as shown in Figure 1.3 is connected to the terminals *a, b,* determine the steady-state current of the inductor.

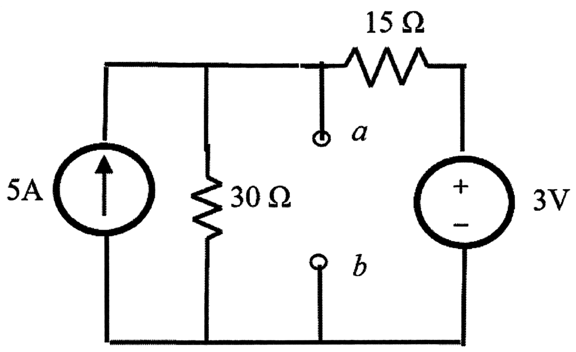

Figure 1.2

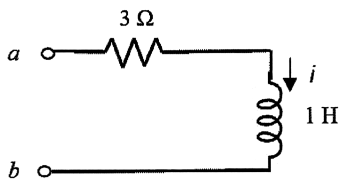

Figure 1.3

(13 Marks)

2. (a) Consider the circuit in Figure 2.1 where the switch *S* has been closed for a very long time. The switch is open at $t = 0$. Using time domain analysis, determine the voltage $v(t)$ for $t > 0$.

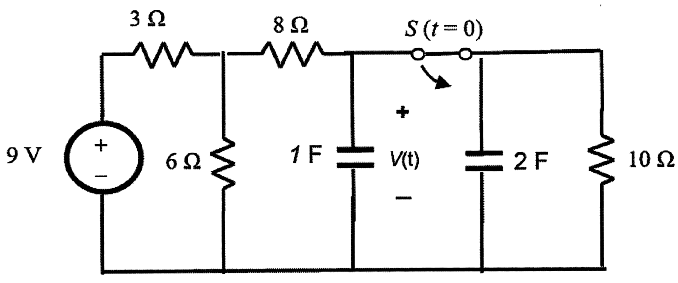

Figure 2.1

(13 Marks)

Note: Question No. 2 continues on page 3.

(b) Given $v(0) = 0$ V, $i(0) = 0$ A and u(t) is a unit step function, determine $i(t)$ of the circuit in Figure 2.2 by using s-domain analysis.

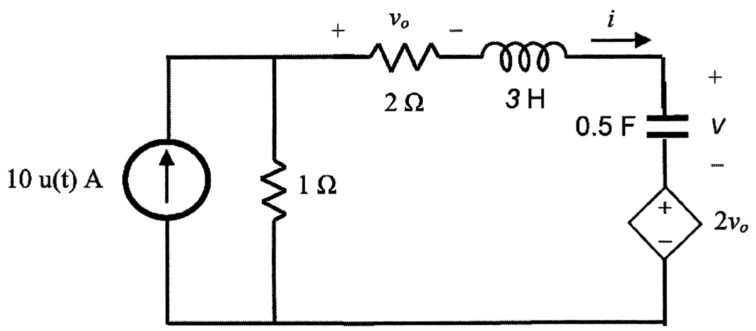

Figure 2.2

(12 Marks)

3. (a) The circuit in Figure 3.1 is designed such that the 50 Hz current source delivers maximum power to the load modeled by the resistor R and inductor L. Find the value of the resistor R and inductor L for maximum power to be delivered to the load. Hence, find the maximum power absorbed by the load.

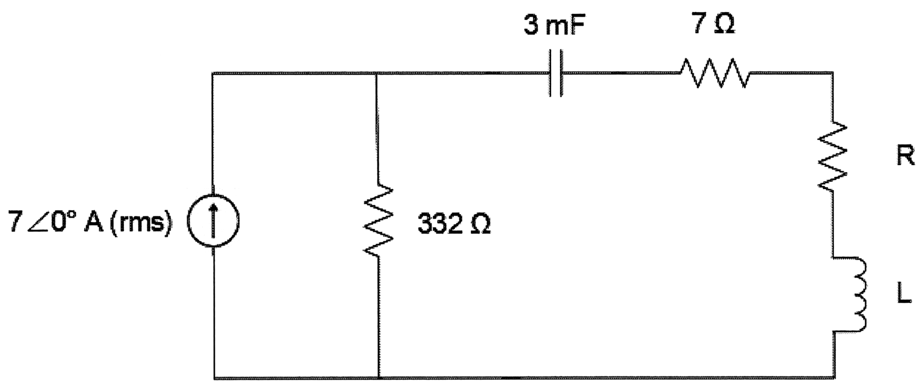

Figure 3.1

(12 Marks)

Note: Question No. 3 continues on page 4.

(b) Electrical power is delivered to a Porcelain Manufacturing Plant as shown in Figure 3.2. The frequency of voltage source is 50 Hz. The Porcelain Manufacturing Plant has the following loads:

- Inductive loads absorbing 23900 kVAR at a power factor of 0.71 lagging.
- Highly resistive loads absorbing 19000 kW at a power factor of 0.9 lagging.
- Capacitive loads absorbing 1380 kVA at a power factor of 0.53 leading.

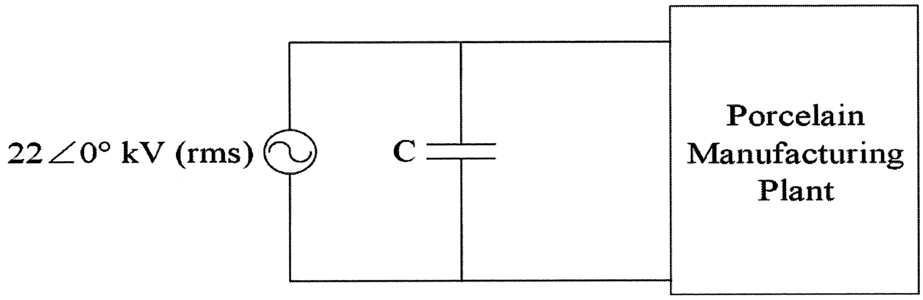

Figure 3.2

(i) Find the total complex power of the Porcelain Manufacturing Plant.
(ii) Find the reactive power supplied by the capacitor C in Figure 3.2 that will correct the power factor to 0.95 lagging as seen by the 22 kV voltage source.

(13 Marks)

4. (a) Find the transfer function $V_o(s)/I_s(s)$ for the circuit shown in Figure 4.1.

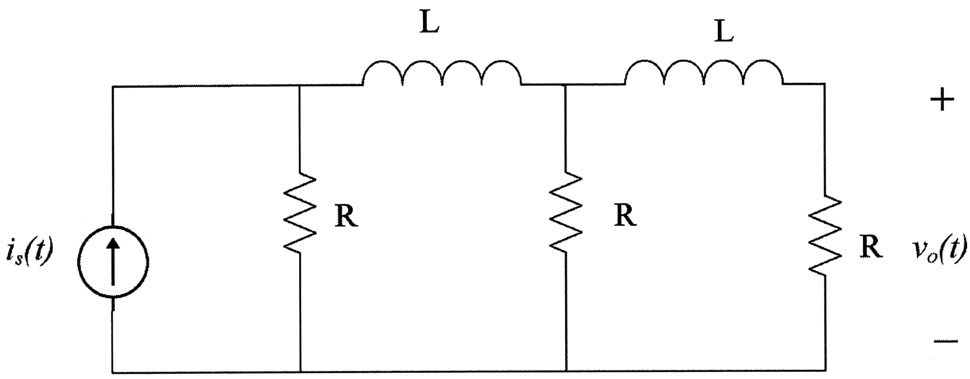

Figure 4.1

Suppose $i_s(t) = 3u(t)$. Find the value of $v_o(t = \infty)$.

(12 Marks)

Note: Question No. 4 continues on page 5.

(b) Figure 4.2 shows a balanced 50 Hz delta-connected source with rms voltages (V_{ab} = 415 ∠ 13° V, V_{bc} = 415 ∠ -107° V, V_{ca} = 415 ∠ -227° V) supplying power to a balanced delta-connected load. The phase load is Z_L = (2199 + j1569) Ω and the transmission line impedance is Z_T = (17 + j23) Ω. Find the line currents and the total real power supplied by the delta-connected source.

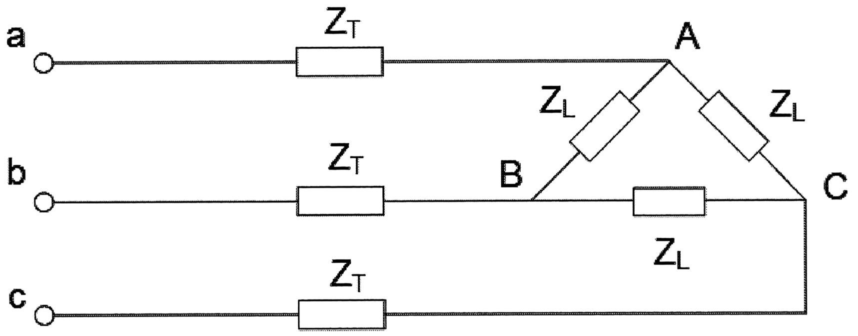

Figure 4.2

(13 Marks)

Appendix A

Laplace Transform Table

	$f(t)$	$F(s)$
1. Unit impulse	$\delta(t)$	1
2. Unit step	$u(t)$	$\frac{1}{s}$
3. Unit ramp	$r(t) = tu(t)$	$\frac{1}{s^2}$
4. Unit parabola	$p(t) = \frac{1}{2}t^2u(t)$	$\frac{1}{s^3}$
5. Exponential	e^{-at}	$\frac{1}{s+a}$
6. t-Multiplication exponential	te^{-at}	$\frac{1}{(s+a)^2}$
7. Sine	$\sin \omega t$	$\frac{\omega}{s^2+\omega^2}$
8. Cosine	$\cos \omega t$	$\frac{s}{s^2+\omega^2}$
9. Damped Sine	$e^{-at}\sin \omega t$	$\frac{\omega}{(s+a)^2+\omega^2}$
10. Damped Cosine	$e^{-at}\cos \omega t$	$\frac{s+a}{(s+a)^2+\omega^2}$
11. Linearity	$c_1 f_1(t) + c_2 f_2(t)$	$c_1 F_1(s) + c_2 F_2(s)$
12. Differentiation	$\frac{d}{dt}f(t)$	$sF(s) - f(0)$
13. n-Fold differentiation	$\frac{d^n}{dt^n}f(t)$	$s^nF(s) - s^{n-1}f(0) - s^{n-2}f'(0)$ $-\cdots\cdots-sf^{(n-2)}(0) - f^{(n-1)}(0)$
14. Integration	$\int_{0-}^{t} f(\tau)d\tau$	$\frac{F(s)}{s}$
15. t-Multiplication	$tf(t)$	$\frac{-d}{ds}F(s)$

Note: Laplace Transform Table continues on page 7.

Appendix A (continued)

Laplace Transform Table (continued)

	$f(t)$	$F(s)$
16. n-Fold t-Multiplication	$t^n f(t)$	$(-1)^n \frac{d^n}{ds^n} F(s)$
17. Time shift	$f(t-t_0)u(t-t_0)$; $t_0 > 0$	$e^{-st_0} F(s)$
18. Frequency shift	$e^{-s_0 t} f(t)$	$F(s+s_0)$
19. Time-frequency scaling	$f(ct)$; $c > 0$	$\frac{1}{c} F\left(\frac{s}{c}\right)$
20. Periodic Function	$f(t) = f_1(t)u(t) + f_1(t-T)u(t-T) + f_1(t-2T)u(t-2T) + \cdots$	$\frac{1}{1-e^{-sT}} F_1(s)$

END OF PAPER

EE2101 CIRCUIT ANALYSIS

Please read the following instructions carefully:

1. **Please do not turn over the question paper until you are told to do so. Disciplinary action may be taken against you if you do so.**

2. You are not allowed to leave the examination hall unless accompanied by an invigilator. You may raise your hand if you need to communicate with the invigilator.

3. Please write your Matriculation Number on the front of the answer book.

4. Please indicate clearly in the answer book (at the appropriate place) if you are continuing the answer to a question elsewhere in the book.