NANYANG TECHNOLOGICAL UNIVERSITY

SEMESTER 2 EXAMINATION 2022-2023

EE2101 – CIRCUIT ANALYSIS

April / May 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 nodal analysis, determine the voltages v_1 and v_2 of the circuit in Figure 1.1. Hence, determine the power of the current source.

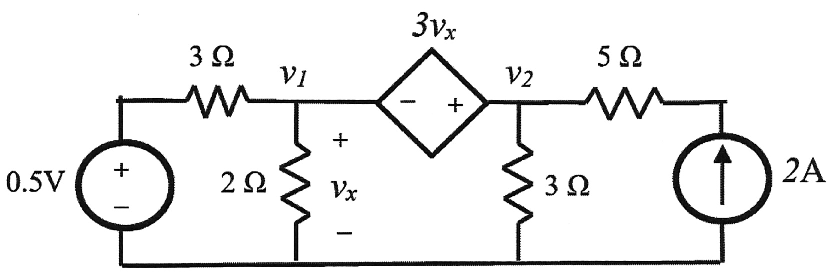

Figure 1.1

(12 Marks)

Note: Question No. 1 continues on page 2

(b) Using Thevenin theorem, find the maximum power that can be delivered to the resistor R of the circuit in Figure 1.2. If the resistor R is replaced by a series combination of a resistor and an inductor as shown in Figure 1.3, determine the steady state current of the inductor.

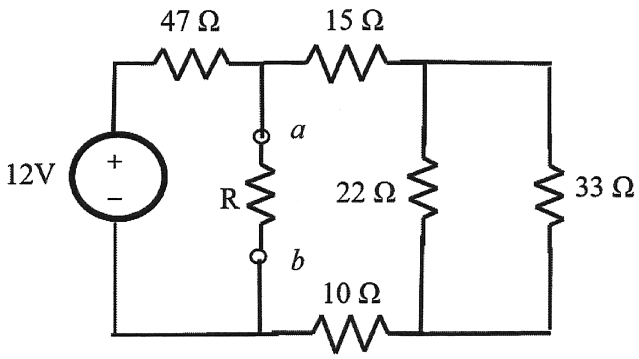

Figure 1.2

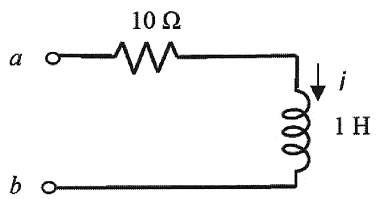

Figure 1.3

(13 Marks)

2. (a) Consider the circuit in Figure 2.1 where the switch S has been at position a for a very long time. The switch is moved to position b at t = 0. Using time domain analysis, determine the current $i(t)$ for $t > 0$.

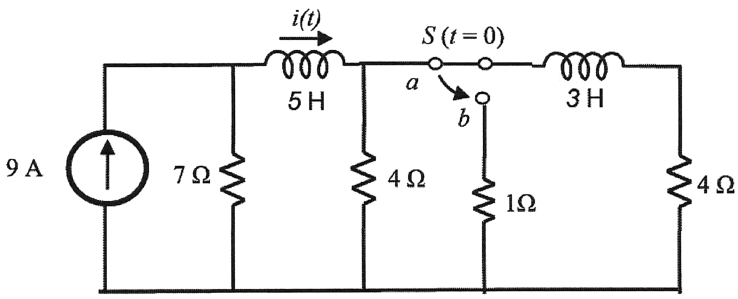

Figure 2.1

(12 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 $v(t)$ of the circuit in Figure 2.2 by using s-domain analysis. Hence, determine $i(t)$.

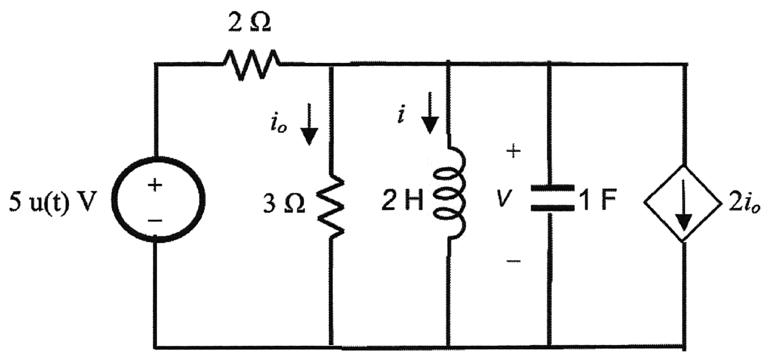

Figure 2.2

(13 Marks)

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

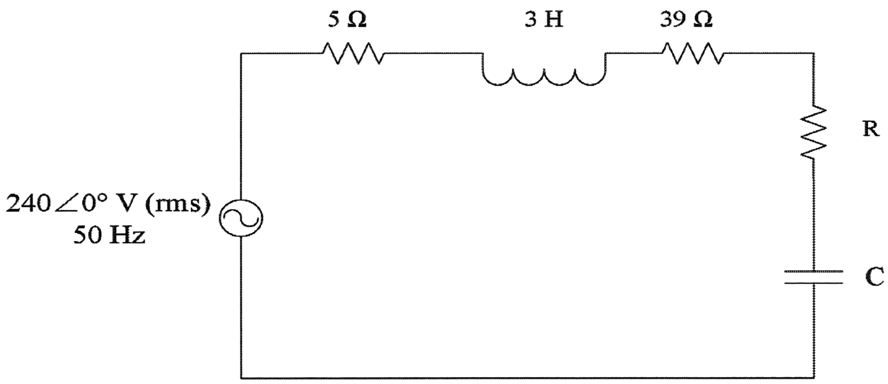

Figure 3.1

(12 Marks)

Note: Question No. 3 continues on page 4.

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

- Inductive loads absorbing 19700 kVAR at a power factor of 0.73 lagging.
- Highly resistive loads absorbing 11000 kW at a power factor of 0.92 lagging.
- Capacitive loads absorbing 970 kVA at a power factor of 0.57 leading.

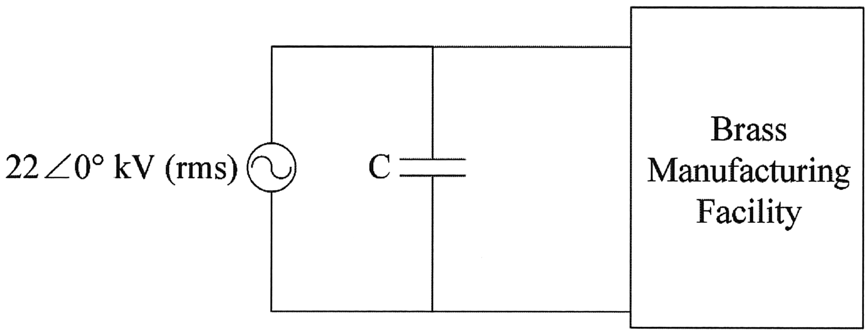

Figure 3.2

(i) Find the total complex power of the Brass Manufacturing Facility.
(ii) Find the reactive power supplied by the capacitor C in Figure 3.2 that will correct the power factor to 0.93 lagging as seen by the 22 kV voltage source.

(13 Marks)

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

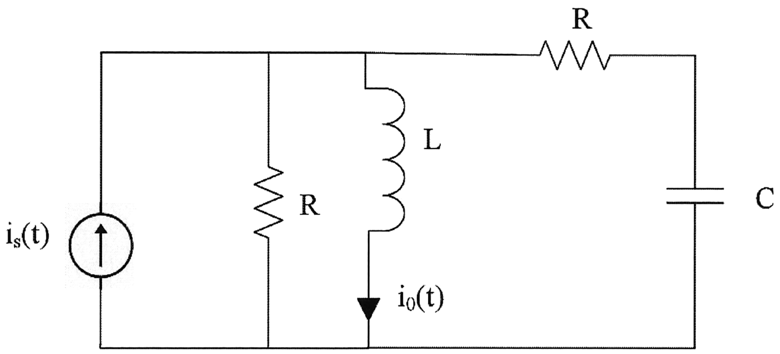

Figure 4.1

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

(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_{ac} = 415 ∠ 17° V, V_{cb} = 415 ∠ -103° V, V_{ba} = 415 ∠ -223° V) supplying power to a balanced wye-connected load. The phase load is Z_L = (790 + j537) Ω and the transmission line impedance is Z_T = (7 + j9) Ω. Find the line currents and the total real power absorbed by the three-phase load.

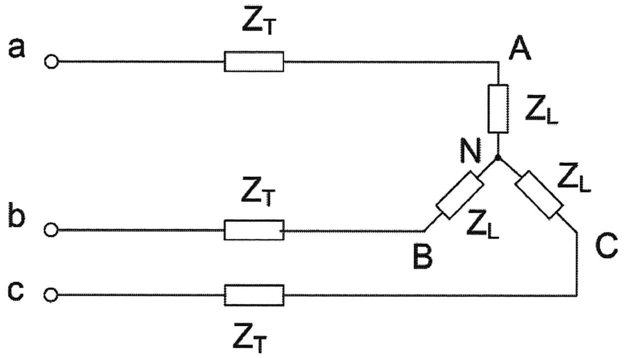

Figure 4.2

(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	$p(t) = \frac{1}{2}t^2 u(t)$	$\frac{1}{s^3}$
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	$\frac{d^n}{dt^n} f(t)$	$s^n F(s) - s^{n-1} f(0) - s^{n-2} f'(0)$ $- \cdots\cdots - sf^{(n-2)}(0) - f^{(n-1)}(0)$
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.