UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION

SEMESTER II

SESSION 2012/2013

COURSE NAME	:	INSTRUMENTATION AND CONTROL SYSTEMS
COURSE CODE	:	BEH 22003 / BEX 20703
PROGRAMME	:	BEB/BEC/BED/BEE/BEH/BEU
EXAMINATION DATE	:	JUNE 2013
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS QUESTION PAPER CONSISTS OF **EIGHT** (8) PAGES

Q1 (a) A Permanent Magnet Moving Coil (PMMC) instrument has a three-resistor Ayrton shunt connected across it to make an ammeter, as in Figure Q1(a). The resistance values are $R_1 = 0.05\ \Omega$, $R_2 = 0.45\ \Omega$, and $R_3 = 4.5\ \Omega$. The meter has $R_m = 1\ \text{k}\Omega$ and full scale deflection, FSD = 50 μA. Calculate the three ranges of the ammeter.

(10 marks)

(b) Solar power is one of the main alternative energy sources. It is a solid state device that converts the energy of sunlight directly into electricity by the photovoltaic effect. One of the popular modern solar panels is a *cadmium telluride* solar cell type as shown in Figure Q1(b)(i). The solar energy from the solar cell will charge battery bank with a value of V_m. However, the storage voltage, V_m depends on the sunlight intensity. In order to study the pattern of current at load from the solar panel source, the d'Arsonval meter as shown in Figure Q1(b)(ii) is connected in series with R_{Load}. Calculate the value of shunt resistors, R_a, R_b and R_c. Given that $R_m = 1\ \text{k}\Omega$, $I_m = 100\ \mu\text{A}$, $I_1 = 1$ A, $I_2 = 5$ A, $I_3 = 10$ A.

(10 marks)

Q2 An RC circuitry is shown in Figure Q2.

(a) Find the transfer function, $V_3(s)/V_1(s)$. (Given R = 1 kΩ and C = 1 μF)

(10 marks)

(b) Calculate the output $v_3(t)$ if the input $v_1(t) = 1\text{V}$.

(5 marks)

(c) Sketch the solution of $v_3(t)$ from (b).

(5 marks)

Q3 (a) Define the following:

(i) The root mean square (rms) value of a sinusoidal waveform and its equation with respect to peak voltage V_p.

(ii) The average value of a sinusoidal waveform and its equation for full wave rectifier with respect to peak voltage V_p.

(5 marks)

(b) A half-wave rectifier is shown in Figure Q3(b). D_1 and D_2 have average forward resistances of 50Ω and each is assumed to have an infinite resistance in the reverse direction. Determine the following.

(i) The value of the multiplier resistance R_s

(ii) The AC sensitivity

(iii) The equivalent DC sensitivity

(15 marks)

Q4 (a) A feedback loop is a common and powerful tool when designing a closed-loop control system. Feedback loop takes the system output into consideration, which enables the system to adjust its performance to meet a desired output response. Identify the unknown blocks, A and B, in the block diagram of a closed-loop control system in Figure Q4(a).

(2 marks)

(b) Explain five (5) differences between the open-loop and closed-loop control systems.

(5 marks)

(c) In order to understand and control a complex system, a control and instrument engineer needs to obtain quantitative mathematical models of the control system. It is necessary to analyze the relationships between the system variables and to obtain its mathematical model. Figure Q4(c) shows the schematic of a closed-loop position control for an electro-mechanical system. Construct its block diagram with description of each component and variables.

(5 marks)

(d) Solve the transfer function, $C(s)/R(s)$, from the block diagram in Figure Q4(d) using the block diagram reduction technique.

(8 marks)

Q5 (a) A unit step input is applied to the system in Figure Q5(a). Determine the output response and sketch the resulting time history. [Assume that all initial condition is zero].

(5 marks)

(b) Figure Q5(b) shows a block diagram of servo system with velocity feedback. Determine the overall transfer function of the system.

(4 marks)

(c) If the system in Figure Q5(b) is required to obtain system response with 20% of maximum overshoot and 1 sec of the peak time, determine the following performance specification when the system is subjected to a unit step input. [Assume that $J = 1$ kg-m^2 and $B = 1$ N-m/rad/sec]

(i) Possible value for gain, K and K_h.

(ii) The rise-time, T_r.

(iii) The settling-time, T_s for ±2%.

(iv) Sketch the system transient response in time domain.

(11 marks)

-END OF QUESTIONS-

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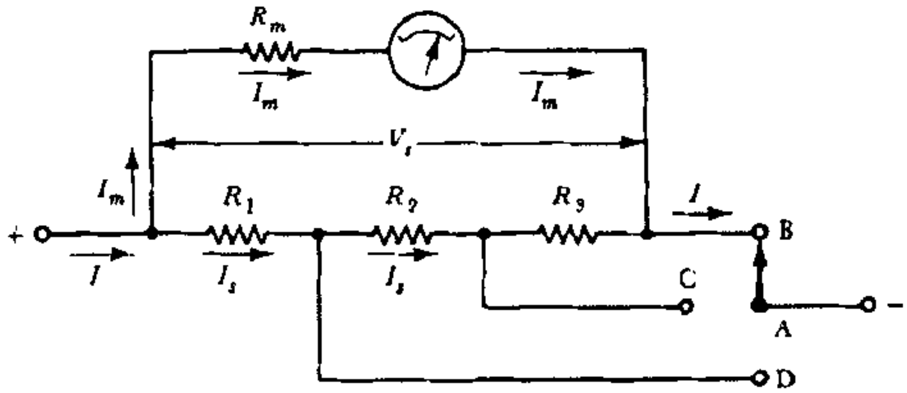

FIGURE Q1(a)

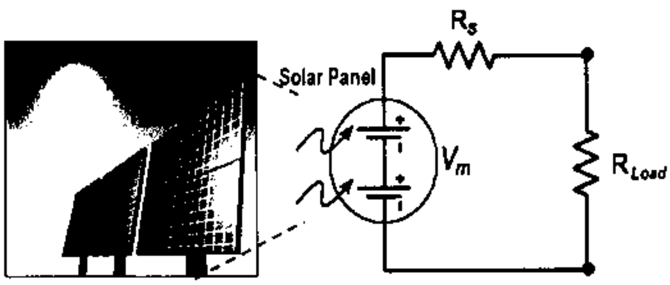

FIGURE Q1(b) (i)

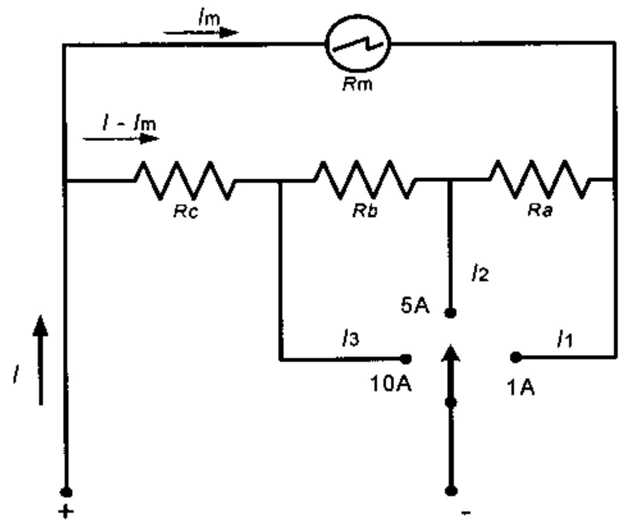

FIGURE Q1(b) (ii)

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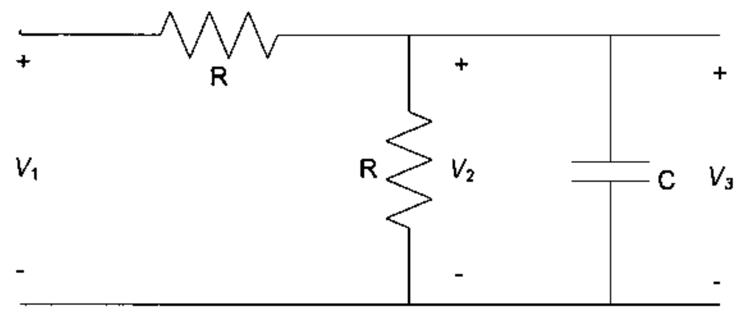

FIGURE Q2

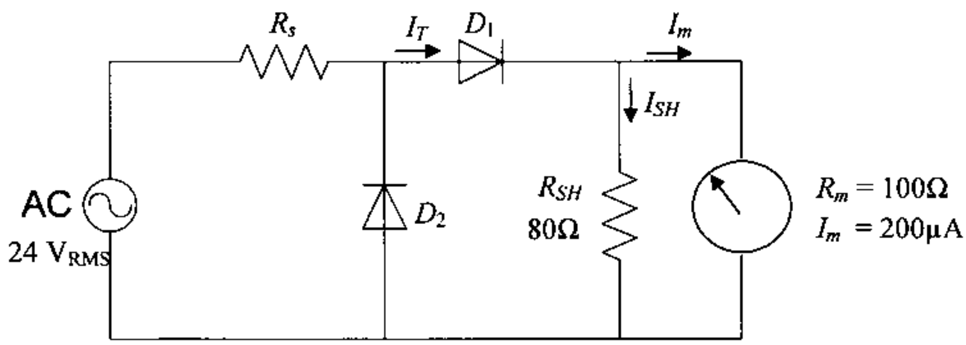

FIGURE Q3(b)

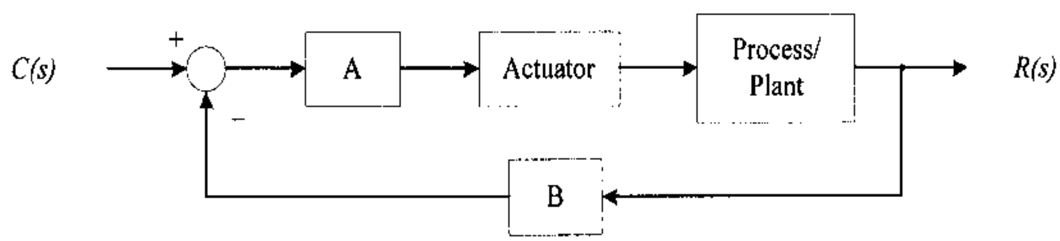

FIGURE Q4(a)

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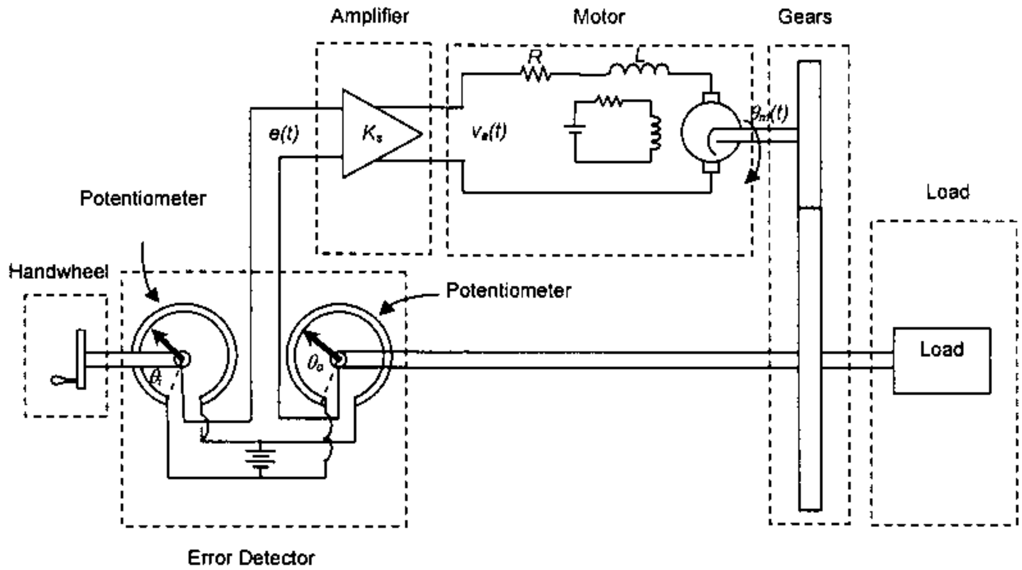

FIGURE Q4(c)

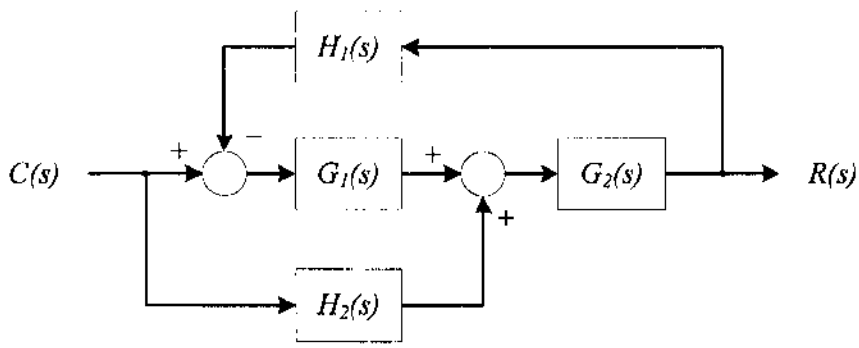

FIGURE Q4(d)

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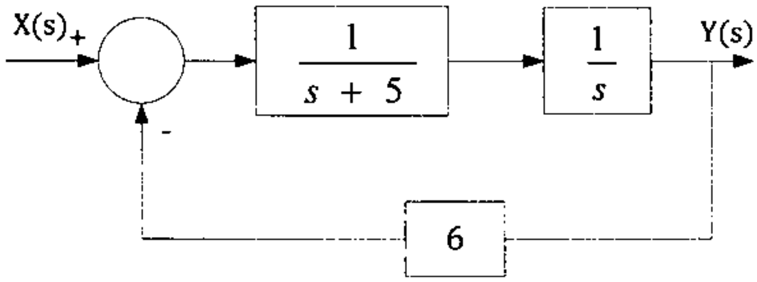

FIGURE Q5(a)

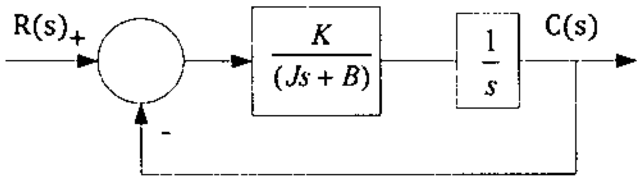

FIGURE Q5(b)

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TABLE 1

Item no.	$f(t)$	$F(s)$
1.	$\delta(t)$	1
2.	$u(t)$	$\frac{1}{s}$
3.	$tu(t)$	$\frac{1}{s^2}$
4.	$t^n u(t)$	$\frac{n!}{s^n+1}$
5.	$e^{-at}u(t)$	$\frac{1}{s+a}$
6.	$\sin \omega t u(t)$	$\frac{\omega}{s^2+\omega^2}$
7.	$\cos \omega t u(t)$	$\frac{s}{s^2+\omega^2}$

TABLE 2

Item no.	Theorem	Name
1.	$\mathscr{L}[f(t)] = F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$	Definition
2.	$\mathscr{L}[kf(t)] = kF(s)$	Linearity theorem
3.	$\mathscr{L}[f_1(t)+f_2(t)] = F_1(s)+F_2(s)$	Linearity theorem
4.	$\mathscr{L}[e^{-at}f(t)] = F(s+a)$	Frequency shift theorem
5.	$\mathscr{L}[f(t-T)] = e^{-sT}F(s)$	Time shift theorem
6.	$\mathscr{L}[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$	Scaling theorem
7.	$\mathscr{L}\left[\frac{df}{dt}\right] = sF(s)-f(0-)$	Differentiation theorem
8.	$\mathscr{L}\left[\frac{d^2f}{dt^2}\right] = s^2F(s)-sf(0-)-f'(0-)$	Differentiation theorem
9.	$\mathscr{L}\left[\frac{d^nf}{dt^n}\right] = s^nF(s)-\sum_{k=1}^{n} s^{n-k}f^{k-1}(0-)$	Differentiation theorem
10.	$\mathscr{L}\left[\int_{0-}^{t} f(\tau)d\tau\right] = \frac{F(s)}{s}$	Integration theorem
11.	$f(\infty) = \lim_{s\to 0} sF(s)$	Final value theorem[1]
12.	$f(0+) = \lim_{s\to\infty} sF(s)$	Initial value theorem[2]