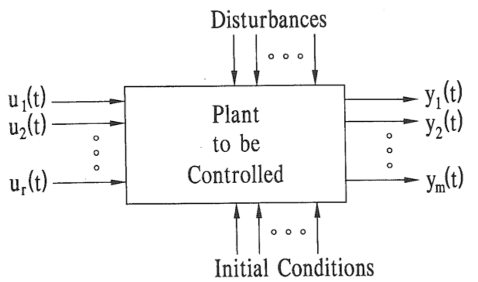
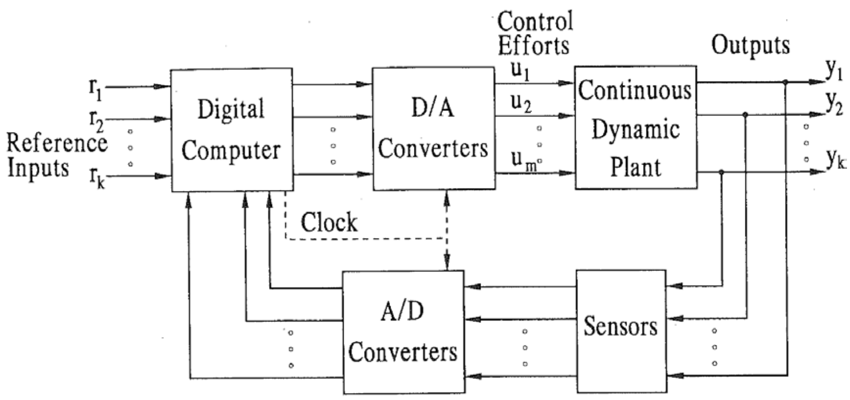
DEPARTMENT OF ELECTRICAL ENGINEERING

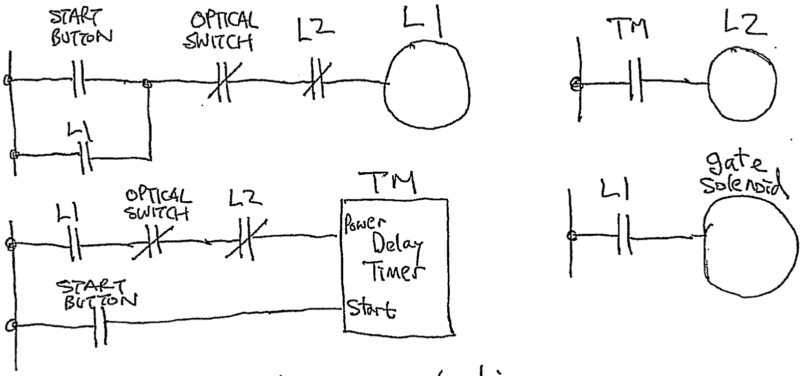
SOLUTION & MARKING SCHEME

(Semester 2, 2021/22)

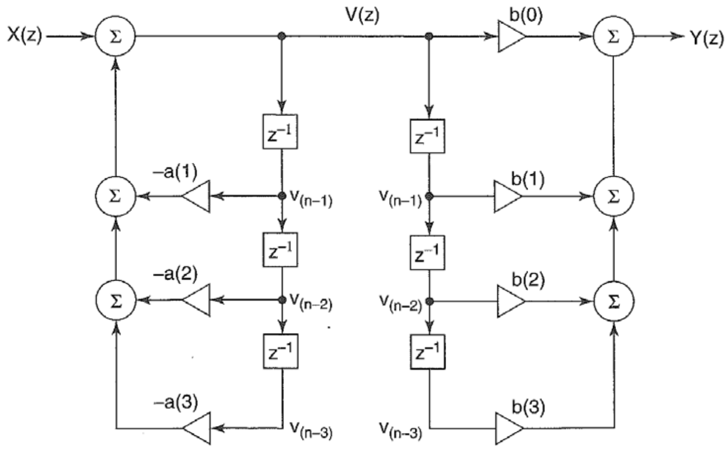
SUBJECT (Code & Title)	EE4008A Applied Digital Control

SUBJECT EXAMINER	Dr N.C. Cheung
SUBJECT MODERATOR	Prof P.T. Lau

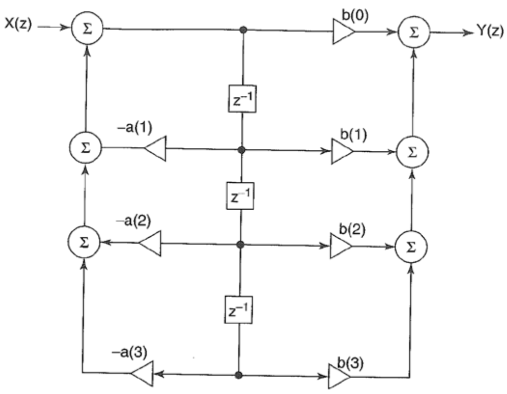
QUESTION NO.	SOLUTION	MARKS
Q1 (a)	A multivariable system: • A multivariable plant is a dynamic system. • It is a "target to be controlled" in a feedback system • It is described by differential equations. • Contains a multiple number of internal variables. 	3
(b)	Example: A robotic arm feedback servo system	2
(c)		5

QUESTION NO.	SOLUTION	MARKS
Q2	 Add some explanations	10
Q3	Find the inverse Z – transform of $\dfrac{8z^2}{(2z-1)\ (4z-1)}$ Let $F(z) = \dfrac{8z^2}{(2z-1)\ (4z-1)} = \dfrac{z^2}{(z-\frac{1}{2})(z-\frac{1}{4})}$ Then $\dfrac{F(z)}{z} = \dfrac{z}{(z-\frac{1}{2})(z-\frac{1}{4})}$ Now, $\dfrac{z}{(z-\frac{1}{2})(z-\frac{1}{4})} = \dfrac{A}{z-\frac{1}{2}} + \dfrac{B}{z-\frac{1}{4}}$ We get, $\dfrac{F(z)}{z} = \dfrac{2}{z-\frac{1}{2}} - \dfrac{1}{z-\frac{1}{4}}$ Therefore, $F(z) = 2\dfrac{z}{z-\frac{1}{2}} - \dfrac{z}{z-\frac{1}{4}}$ Inverting, we get $f_n = Z^{-1}\{F(z)\} = 2\,Z^{-1}\left\{\dfrac{z}{z-\frac{1}{2}}\right\} - Z^{-1}\left\{\dfrac{z}{z-\frac{1}{4}}\right\}$ i.e, $f_n = 2\,(1/2)^n - (1/4)^n, \quad n = 0, 1, 2, \ldots\ldots$	15

<table>
<tr><th>QUESTION NO.</th><th>SOLUTION</th><th>MARKS</th></tr>
<tr><td>Q4</td><td>Example: H(z)= $\frac{b(0)+b(1)z^{-1}+b(2)z^{-2}+b(3)z^{-3}}{1+a(1)z^{-1}+a(2)z^{-2}+a(3)z^{-3}}$</td><td>5</td></tr>
<tr><td>(a)</td><td>



Direct form I



Direct Form 2 saves 3x 1/z functional blocks

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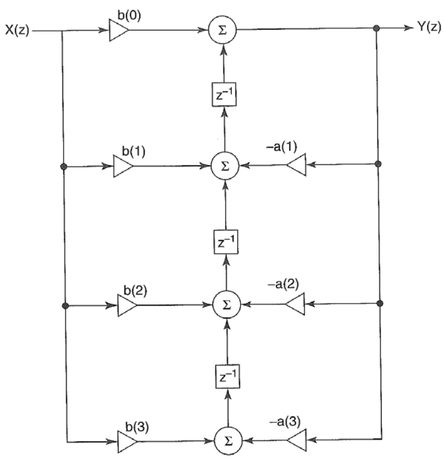
<tr><td>(b)</td><td>



Direct form 2 transposed further saves 3x adders

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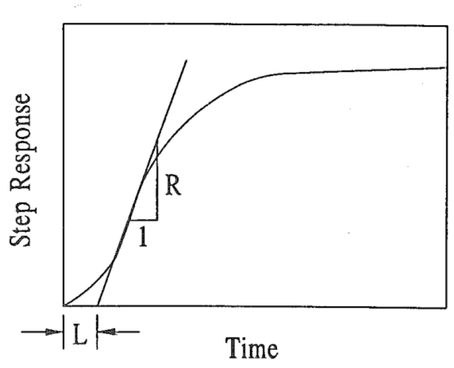
<tr><th>QUESTION NO.</th><th>SOLUTION</th><th>MARKS</th></tr>
<tr><td>Q5</td><td>Step 1: Find the open loop step response of the plant

Step 2: record L and R

Step 3: use the tuning equations
$$K_p = \frac{1.2}{RL}$$
$$K_i = \frac{1}{2L} K_p = \frac{0.6}{RL^2}$$
$$K_d = 0.5LK_p = \frac{0.6}{R}$$</td><td>10</td></tr>
<tr><td>Q6</td><td>$$\begin{aligned} H(z) &= H_c(s)\big|_{s=\frac{2}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right)} \\ &= \frac{1}{\frac{2}{T_d}\left(\frac{1-z^{-1}}{1+z^{-1}}\right) - a} \\ &= \frac{T_d(1+z^{-1})}{2(1-z^{-1}) - aT_d(1+z^{-1})} \\ &= \frac{T_d(1+z^{-1})}{(2-aT_d)-(2+aT_d)z^{-1}} \\ &= \frac{\beta(1+z^{-1})}{1-\alpha z^{-1}} \text{ (bilinar transform)} \end{aligned}$$
Calculate alpha and beta, by putting Td=0.1, and a=7</td><td>10</td></tr>
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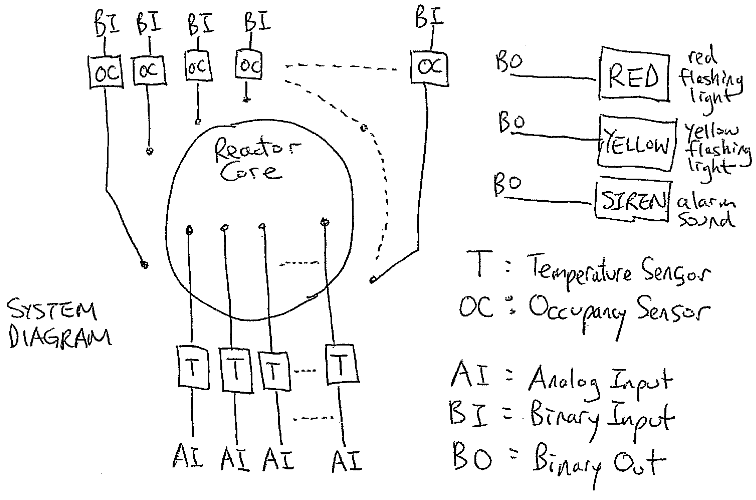
QUESTION NO.	SOLUTION	MARKS

Q7

(a)



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(b)

SEQUENCE OF OPERATION

A - Normal mode – No intruder and no over temperature
B - Intruder mode – Intruder alert, sound siren and yellow flashing lamp
C - Over temperature mode – over temperature alert, sound siren and red flashing lamp

3

(c)

I/O. SUMMARY

	Input Type: Analogue	Input Type: Binary	Mode of Operation: A	Mode of Operation: B	Mode of Operation: C	Output: RED	Output: YELLOW	Output: SIREN
Core Temperature	X		X		X	X		X
Intruder Alert		X	X	X			X	X

3

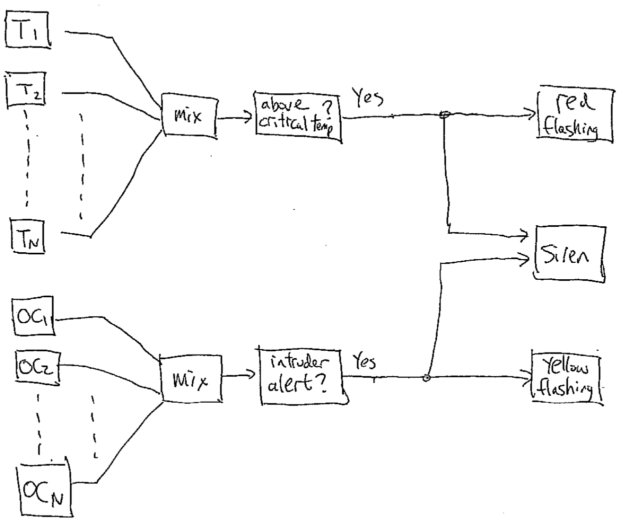
(d)

MODE SUMMARY

	Input Condition: Temperature	Input Condition: Occupancy	Output Action: RED	Output Action: YELLOW	Output Action: SIREN
A	below critical temp	no intruder	no action	no action	no action
B	—	intruder alert	—	flashing	sound
C	above critical temp	—	flashing	—	sound

3

(e)



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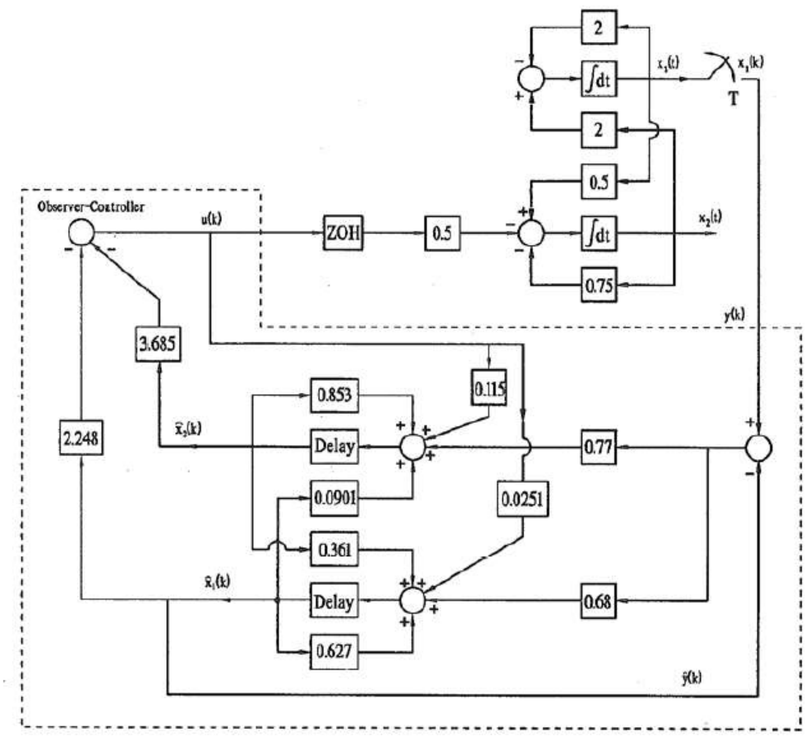
<tr><td>Q8</td><td>


Add explanation
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