قائمة الاسئلة

نطم تحكم رقمي - كلية الهندسة - قسم -الكهرباء - شعبتي قوى والآت كهربائية-حاسبات وتحكم المستوى الرابع- ثلاث ساعات - درجة هذا الاختبار (0)

أ.د. فيصل عبدالفتاح إبراهيم

1)

مـــرفقـــات

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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0.010	699.96114	56.90148	-90.79
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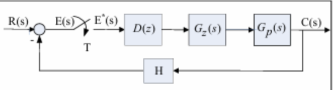

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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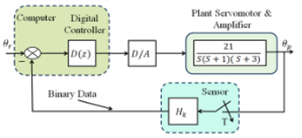

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$		$\mathrm{D(z)} = \frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$
$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$	$z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1 = \frac{1-a_0\lvert G(j\omega_{w1})\rvert\cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert\sin(\theta)}$		$b_1 = \frac{\cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}\sin(\theta)}$
$\mathrm{D(w)} = \mathrm{K_p} + \frac{\mathrm{K_I}}{\mathrm{w}} + \mathrm{K_D}w$		$\mathrm{D(z)} = \mathrm{K_p} + \mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + \mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$
$k_p = \frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}, \quad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$		

Choose the corret answer

Reduction in high-frequency gain

□□□

1) - reduces the closed-loop system bandwidth, resulting a faster system response.
2) - increases the closed-loop system bandwidth, resulting a slower system response.
3) - increases the closed-loop system bandwidth, resulting a faster system response.
4) + reduces the closed-loop system bandwidth, resulting a slower system response.

2)

مـــرفقـــات

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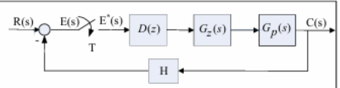

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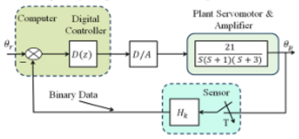

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	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-akT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

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$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the corret answer
The dynamic system is:

1)	+	a system with memory, a system whose input-output behavior can be modeled either by differential equations or difference equations.
2)	-	a system without memory, a system whose input-output behavior can be modeled either by differential equations or difference equations.
3)	-	a system with memory, a system whose input-output behavior can be modeled by differential equations only.
4)	-	a system with memory, a system whose input-output behavior can be modeled by difference equations only.

3)

مـــرفقـــــات

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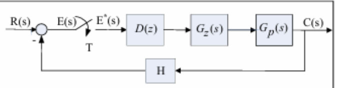

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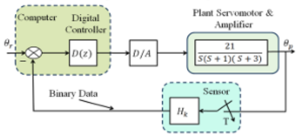

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Choose the corret answer
The digital signals are:

1) - the signals which are continuous in time and amplitude.
2) + represented in terms of zeros and ones with typically 12 bits or more to represent a single number.
3) - defined only at certain instants of time and can change value only at those instants.
4) - defined only at certain instants of time and continuous in amplitude.

4)

مـــرفقـــات

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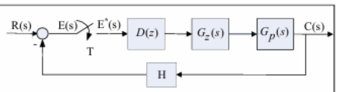

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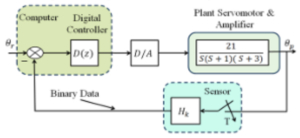

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Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1=\frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the corret answer
A digital controller is:

1) - implemented in firmware or software, and its modification is impossible without a complete replacement of the original controller.
2) - implemented in hardware, and its modification is impossible without a complete replacement of the original controller.
3) + implemented in firmware or software, and its modification is possible without a complete replacement of the original controller.

4) - implemented in hardware, and its modification is possible without a complete replacement of the original controller.

5)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
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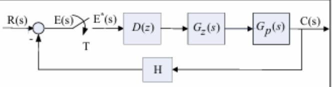

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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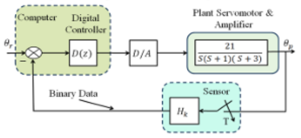

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

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$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the corret answer

A sampler converts

1) - a discrete-signal into a train of pulses accruing at the sampling instant 0, T, 2T, ….. where T is the sampling period.

2) - a continuous and discrete-signal into a train of pulses accruing at the sampling instant 0, T, 2T, ….. where T is the sampling period.

3) - None of these.

4) + a continuous-signal into a train of pulses accruing at the sampling instant 0, T, 2T, ….. where T is the sampling period.

6)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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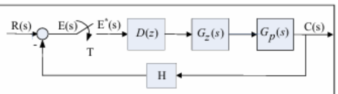

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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The frequency response for G(z) is given in Table (1).

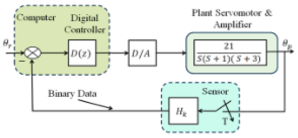

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-akT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-akT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$	
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$	$z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$	$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$	
$D(w)=K_p+\frac{K_I}{w}+K_Dw$	$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$	
$k_p=\frac{cos\,\theta}{a_0\lvert G(j\omega_{w1})\rvert},\quad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0\lvert G(j\omega_{w1})\rvert}$		

Choose the corret answer

The output signal of the ideal sampler (the input of zero-order order hold device) is

1) + continuous amplitude discrete time signal.

2) - discrete amplitude discrete time signal.

3) - discrete amplitude continuous time signal.

4) - continuous amplitude continuous time signal.

7)

Table (1): Frequency response of $G(z)=\dfrac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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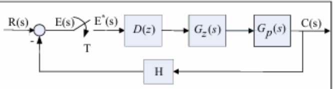

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

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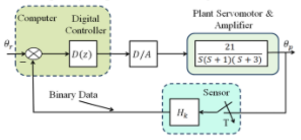

Figure (2)

Table of Laplace and Z-transforms

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	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad \mathrm{D(z)}=\frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$\mathrm{D(w)}=\mathrm{K_p}+\frac{\mathrm{K_I}}{\mathrm{w}}+\mathrm{K_D}w \qquad \mathrm{D(z)}=\mathrm{K_p}+\mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+\mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the corret answer
We will require a hold device to create

1) - a digital input to the discrete controller.
2) + an analog input to the continuous time plant.
3) - an analog input to the discrete controller.
4) - a digital input to the continuous time plant.

8)

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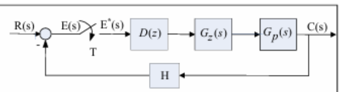

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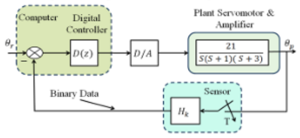

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	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the corret answer
A pole of E(s) in the left half-plane transforms into a pole of E(z)

1) - outside the unit circle.
2) - on the unit circle.
3) + inside the unit circle.
4) - on the real axis only.

9)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
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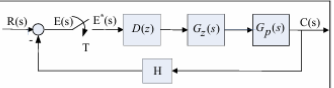

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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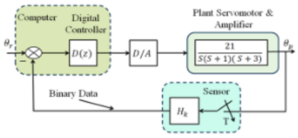

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
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Notes

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$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

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Choose the corret answer
There is no transfer function can be written for a system in which:

1)	-	the input is sampled.
2)	-	the output is sampled.
3)	-	the output is not sampled.
4)	+	the input is not sampled.

10)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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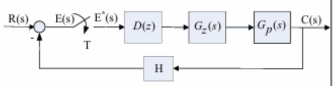

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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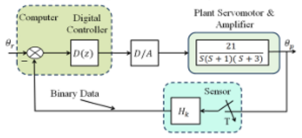

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
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	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-akT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$; $z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
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Choose the corret answer

The conditions on a transfer function G(z) such that its dc gain is unbounded is:

1) + G(z) has a pole at z=1.
2) - G(z) has a pole at z=-1.
3) - G(z) has a zero at z=-1.
4) - G(z) has a zero at z=1.

11)

مــرفقـــات

Table (1): Frequency response of $G(z)=\dfrac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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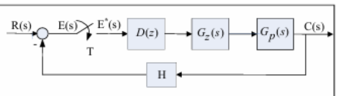

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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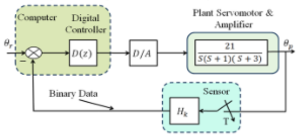

Figure (2)

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Choose the corret answer
If the sampling frequency is increased:

1) - the digital response will not approach the analog case.
2) + the digital response will approach the analog case.
3) - the sampling period is increased.
4) - None of these.

12)

مـــرفـقـــات

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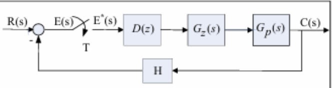

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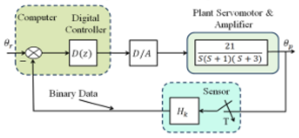

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	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1 = \frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1 = \frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w) = K_p + \frac{K_I}{w} + K_D w \qquad D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$$

$$k_p = \frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Rules of Thumb (1st order systems) the sample rate:

1) - $(1/T) > 5/t_s$ or $T < t_s/5$

2) - $(1/T) > 10/\tau$ or $T < \tau/10$

3) + $(1/T) > 5/\tau$ or $T < \tau/5$

4) - $(1/T) > 10/t_s$ or $T < t_s/10$

13)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
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0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
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5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
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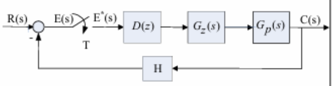

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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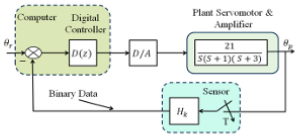

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$	
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$	$z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$	$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$	
$D(w)=K_p+\frac{K_I}{w}+K_Dw$	$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$	
$k_p=\frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}$, $\quad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$		

Choose the correct answer:

Given the following difference equation:

$$x(k)+2x(k-1)=e(k)-e(k-1)$$

Where

$$x(-1)=0, \qquad E(z)=\frac{z}{z-1}$$

Then, x(k) is equal to:

1) - $x(k)=-2+(2)^k$

2) - $x(k)=(2)^k$

3) - $x(k)=2k$

4) +

$$x(k) = (-2)^{k}$$

14)

مــرفقــات

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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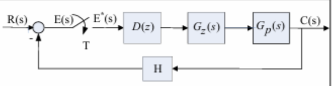

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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The frequency response for G(z) is given in Table (1).

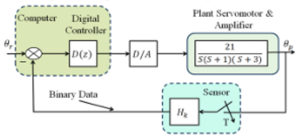

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1$ $+e^{-at}$	$akT-1$ $+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$\mathrm{D(z)} = \frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$
$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$ $z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1 = \frac{1-a_0\lvert G(j\omega_{w1})\rvert\cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert\sin(\theta)}$	$b_1 = \frac{\cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}\sin(\theta)}$
$\mathrm{D(w)} = \mathrm{K_p} + \frac{\mathrm{K_I}}{\mathrm{w}} + \mathrm{K_D}w$	$\mathrm{D(z)} = \mathrm{K_p} + \mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + \mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$
$k_p = \frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}$,	$k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$

Choose the correct answer:

E(z) of the following function is:

$$E(s) = \frac{1-e^{-0.25S}}{S(S+0.25)}, \qquad T = 0.25\ s$$

1) +

$$E(z) = \frac{0.24235}{z-0.9394)}$$

2) -

$$E(z) = \frac{z-0.24235}{z-0.9394}$$

3) -

$$E(z) = \frac{0.3935}{z - 0.6065}$$

4) -

$$E(z) = \frac{z - 0.3935}{2(z + 0.6065)}$$

15)

مــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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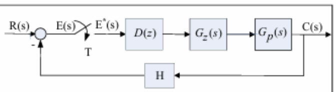

Figure (1)

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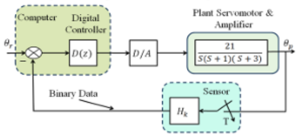

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	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

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$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

$E^*(s)$ of the following function is equal to:

$$E(s)=\frac{S-2}{S(S-1)}$$

1) -
$$E^*(s)=\frac{2}{(1-e^{-TS})}-\frac{1}{(1-e^{-T(S+1)})}$$

2) +
$$E^*(s)=\frac{2}{(1-e^{-TS})}-\frac{1}{(1-e^{-T(S-1)})}$$

3) -
$$E^*(s)=\frac{1}{(1-e^{-TS})}+\frac{2}{(1-e^{-T(S+1)})}$$

4) -
$$E^*(s)=\frac{1}{(1-e^{-TS})}-\frac{2}{(1-e^{-T(S-1)})}$$

16)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

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2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

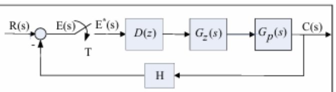

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

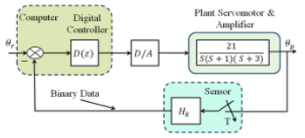

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

Let T = 0.1s and

$$E(s)=\frac{S+4}{(S+2)(S-2)}$$

Without calculating E(z), its poles are:

1) - $z_1 = 0.8187$ and $z_2 = 1.0202$

2) - $z_1 = 1.1221$ and $z_2 = 0.9802$

3) + $z_1 = 0.8187$ and $z_2 = 1.1221$

4) - $z_1 = 1.0202$ and $z_2 = 0.9802$

17)

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Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

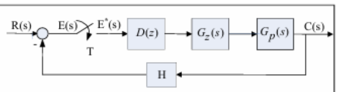


Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

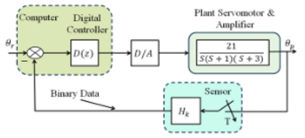


Figure (2)

Table of Laplace and Z-transforms

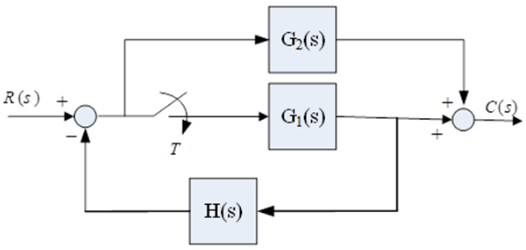
Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$		$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$	$z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$		$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$
$D(w)=K_p+\frac{K_I}{w}+K_Dw$		$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$
$k_p=\frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert},\quad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$		

Choose the correct answer:

Consider the system of the following Figure



The system output $C(z)$ is equal to:

1) -
$$C(z)=\overline{G_2R}(z)+\frac{\overline{G_1H}(z)-\overline{G_1G_2H}(z)}{1+\overline{G_1H}(z)}R(z)$$

2) -
$$C(z)=\overline{G_2R}(z)+\frac{G_1(z)+\overline{G_1G_2H}(z)}{1+\overline{G_1H}(z)}R(z)$$

3) -
$$C(z)=\overline{G_2R}(z)-\frac{G_1(z)-\overline{G_1G_2H}(z)}{1+\overline{G_1H}(z)}R(z)$$

4) +
$$C(z)=\overline{G_2R}(z)+\frac{G_1(z)-\overline{G_1G_2H}(z)}{1+\overline{G_1H}(z)}R(z)$$

18)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
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1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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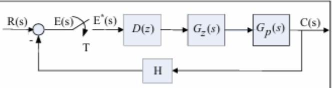

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

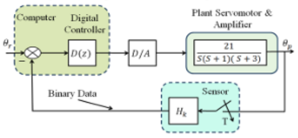

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$	
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$	$z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$	$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$	
$D(w)=K_p+\frac{K_I}{w}+K_Dw$	$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$	
$k_p=\frac{cos\,\theta}{a_0\lvert G(j\omega_{w1})\rvert}$, $\quad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0\lvert G(j\omega_{w1})\rvert}$		

Choose the correct answer:

Consider the system of the Figure(1). With $D(z)=1,\ T=0.1\ s,\ H=1$ and

$$G_p(s)=\frac{1}{S(S+1)}$$

The transfer function $C(z)/R(z)$ is:

1) + $\frac{C(z)}{R(z)}=\frac{0.00484\,z+0.00468}{z^2-1.9\,z+0.9095}$

2) - $\frac{C(z)}{R(z)}=\frac{0.0484\,z+0.00468}{z^2-1.9\,z+0.9095}$

3) - $\frac{C(z)}{R(z)}=\frac{0.00484\,z+0.0468}{z^2-1.9\,z+0.9095}$

4) -

$$\frac{C(z)}{R(z)} = \frac{0.00484\,z + 0.00468}{z^2 + 1.9\,z + 0.9095}$$

19)

Table (1): Frequency response of $G(z) = \dfrac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
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0.700	7.98088	18.04102	-140.11
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0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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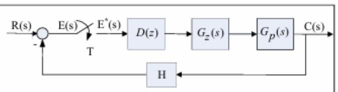

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

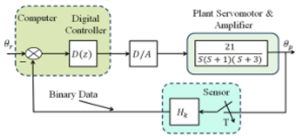

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$
$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$; $z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1 = \frac{1-a_0\lvert G(j\omega_{w1})\rvert\cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert\sin(\theta)}$	$b_1 = \frac{\cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}\sin(\theta)}$
$D(w) = K_p + \frac{K_I}{w} + K_D w$	$D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$
$k_p = \frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}$,	$k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$

Choose the correct answer:

For the system shown in the Figure (1). With D(z)=1, T=0.4 s, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z) = \frac{0.1813}{z-\ 0.8187},$$
$$where\ \ G(s) = G_p(s)G_z(s)$$

The unit-step response for the closed-loop system $(c(kT))$ is:

1) - $c(kT) = 1 - (0.8187)^k$

2) + $c(kT) = 0.5\left[1 - (0.6374)^k\right]$

3) - $c(kT) = 0.5\left[1 - (-0.2642)^k\right]$

4) - $c(kT) = 1 - (-0.8187)^k$

20)

Table (1): Frequency response of $G(z) = \dfrac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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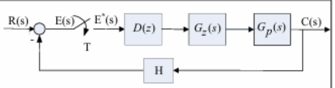

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

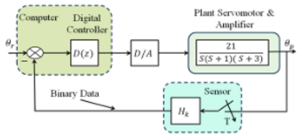

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1 = \frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1 = \frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w) = K_p + \frac{K_I}{w} + K_D w \qquad D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$$

$$k_p = \frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T = 0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z) = \frac{0.00484\ z + 0.00468}{z^2 - 1.905\ z + 0.905}$$

The time constant τ of the closed-loop system is:

1) - The time constant $\tau = 9$ s

2) - The time constant $\tau = 0.211$ s

3) + The time constant $\tau = 2.11$ s

4) - The time constant $\tau = \infty$ s

21)

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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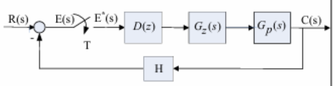

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

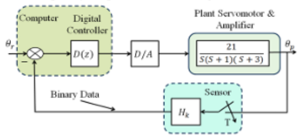

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{kT}e^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1 = \frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1 = \frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w) = K_p + \frac{K_I}{w} + K_D w \qquad D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p = \frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T = 0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z) = \frac{0.00484\,z + 0.00468}{z^2 - 1.905\,z + 0.905}$$

The damping ratio ζ of the closed-loop system is:

1) - The damping ratio $\zeta = 9.0072$

2) - The damping ratio $\zeta = 0.3437$

3) - The damping ratio $\zeta = 0.7000$

4) + The damping ratio $\zeta = 0.4737$

22)

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Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
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0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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2.100	1.18113	1.44597	-195.34
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2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

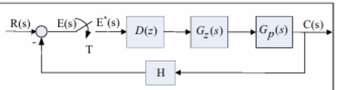

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

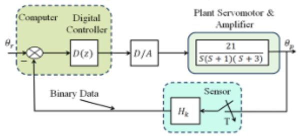

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-akT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-akT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T = 0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z)=\frac{0.00484\,z+0.00468}{z^2-1.905\,z+0.905}$$

The natural frequency ω_n of the closed-loop system is:

1) + The natural frequency $\omega_n = 0.9991$

2) - The natural frequency $\omega_n = 0.9686$

3) - The natural frequency $\omega_n = 0.6173$

4) -

The natural frequency $\omega_n = 0.5932$

23)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
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2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
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10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
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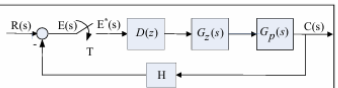

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

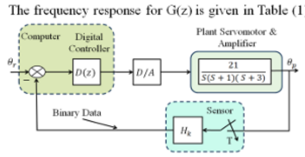

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$; $z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$	$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$
$D(w)=K_p+\frac{K_I}{w}+K_Dw$	$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$
$k_p=\frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}$,	$k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T = 0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z)=\frac{0.00484\ z+0.00468}{z^2-1.905\ z+0.905}$$

The percent overshoot of the closed-loop system is:

1) - The percent overshoot =28.47

2) + The percent overshoot = 18.47

3) - The percent overshoot = ∞

4) -

The percent overshoot $= 0$

24)

مــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

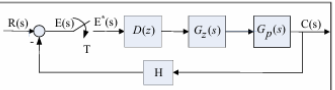

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

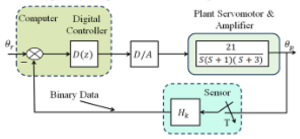

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad \mathrm{D(z)}=\frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$\mathrm{D(w)}=\mathrm{K_p}+\frac{\mathrm{K_I}}{\mathrm{w}}+\mathrm{K_D}w \qquad \mathrm{D(z)}=\mathrm{K_p}+\mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+\mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T=0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z)=\frac{0.00484\,z+0.00468}{z^2-1.905\,z+0.905}$$

The Settling time of the closed-loop system is:

1) - The settling time $\mathrm{T_s}=36$

2) - The settling time $\mathrm{T_s}=0.844$

3) + The settling time $\mathrm{T_s}=8.44\ \mathrm{s}$

4) - The settling time $T_s = 11.17852$

25)

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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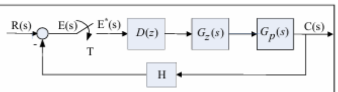

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

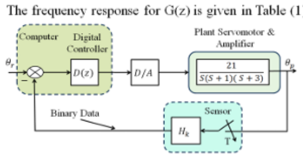

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1 = \frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1 = \frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w) = K_p + \frac{K_I}{w} + K_D w \qquad D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$$

$$k_p = \frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure (1). With $D(z) = \frac{z-0.9}{z-0.8}$, $T = 0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z) = \frac{0.00484\ z + 0.00468}{z^2 - 1.905\ z + 0.905}$$

The type of system is equal to:

1) - The type of system $= 2$

2) - The type of system = 0

3) -

The type of system = ∞

4) +

The type of system = 1

26)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
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0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
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1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

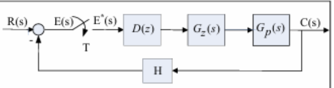

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

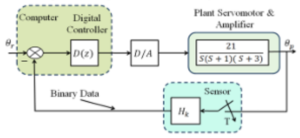

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad \mathrm{D(z)}=\frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$\mathrm{D(w)}=\mathrm{K_p}+\frac{\mathrm{K_I}}{\mathrm{w}}+\mathrm{K_D}w \qquad \mathrm{D(z)}=\mathrm{K_p}+\mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+\mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For the system shown in Figure(1). With D(z)=1, $T = 0.1$ s, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z)=\frac{0.00484\,z+0.00468}{z^2-1.905\,z+0.905}$$

The steady-state error for a unit step input is:

1) + The steady-state error $e_{ss}=0$

2) - The steady-state error $e_{ss}=0.5$

3) - The steady-state error $e_{ss}=\infty$

4) - The steady-state error $e_{ss}=0.1295$

27)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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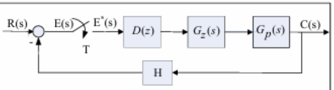


Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

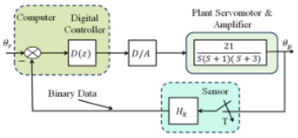


Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$
$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$; $z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1=\frac{1-a_0\lvert G(j\omega_{w1})\rvert cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert sin(\theta)}$	$b_1=\frac{cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}sin(\theta)}$
$D(w)=K_p+\frac{K_I}{w}+K_Dw$	$D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$
$k_p=\frac{cos\,\theta}{a_0\lvert G(j\omega_{w1})\rvert}$,	$k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0\lvert G(j\omega_{w1})\rvert}$

Choose the correct answer:

For the system shown in Figure (1). With D(z)=1, $T=0.1\ s$, and H=1 the pulse transfer function $G(z)$ is given by.

$$G(z)=\frac{0.00484\ z+0.00468}{(z-1)(z-0.905)}$$

The dc gain of the closed-loop system is:

1) - The dc gain = 0.8

2) + The dc gain = 1.0

3) - The dc gain = ∞

4) -

The dc gain = 0.5

28)

مــرفــقــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

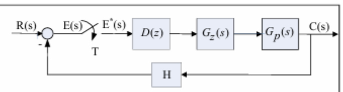


Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

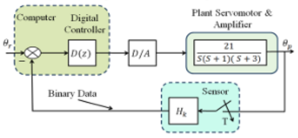


Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

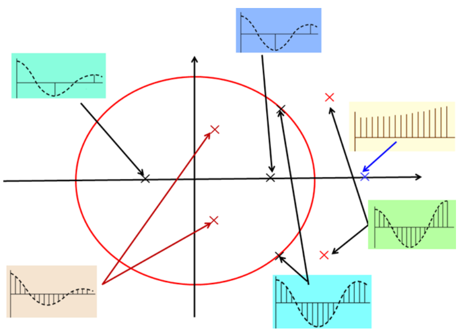
$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

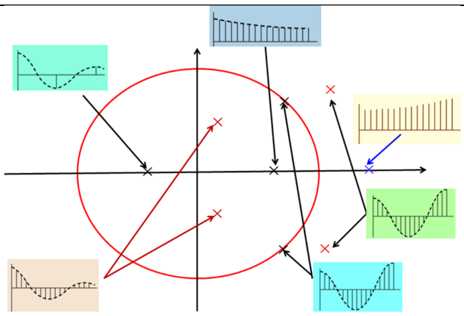
$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:
The following Figure represent the transient response characteristics of the z-plane pole locations

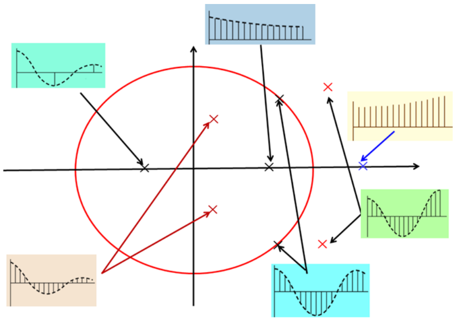
1) -



2) -



3) +



4) -

None of These

29)

مـــرفـقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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0.300	22.23935	26.94244	-113.27
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0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
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1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
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2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
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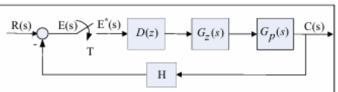

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

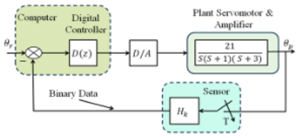

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad \mathrm{D(z)}=\frac{\mathrm{k_d}\,(\mathrm{z}-\mathrm{z_0})}{(\mathrm{z}-\mathrm{z_p})}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

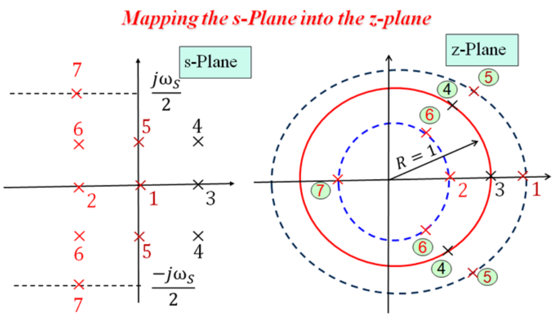
$$\mathrm{D(w)}=\mathrm{K_p}+\frac{\mathrm{K_I}}{\mathrm{w}}+\mathrm{K_D}w \qquad \mathrm{D(z)}=\mathrm{K_p}+\mathrm{K_I}\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+\mathrm{K_D}\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

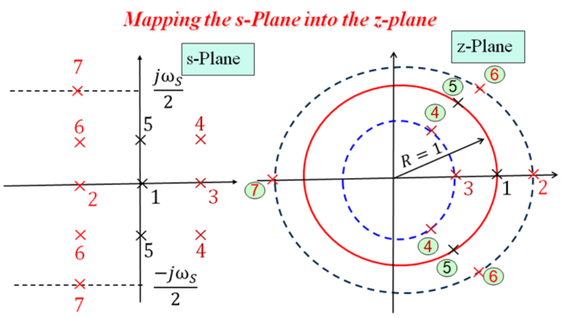
Choose the correct answer:

The following Figure represent mapping the s-plane into z-plane

1) -



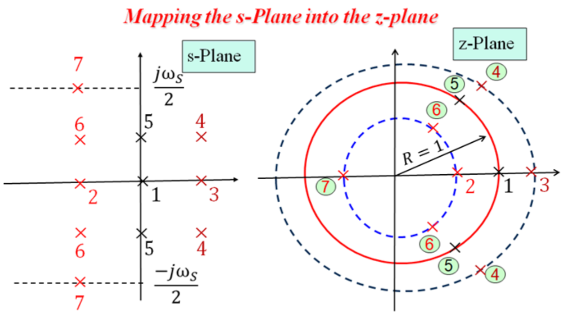
2) -



3) -

None of These

4) +



30)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

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0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
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1.600	2.05223	6.24452	-180.54
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1.900	1.45646	3.26600	-189.87
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2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

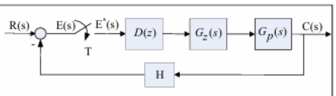

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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The frequency response for G(z) is given in Table (1).

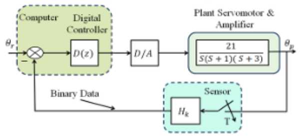


Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1=\frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

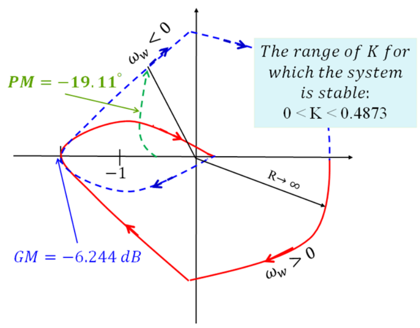
$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

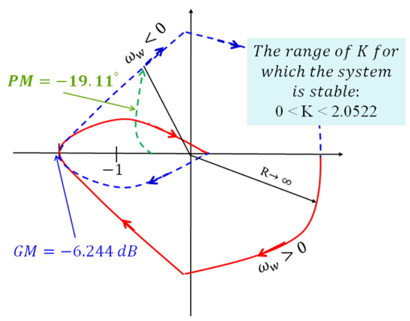
For Figure (2). Let D(z)=1, the sensor gain be unity $H_k=1$.

The Nyquist diagram of this system is:

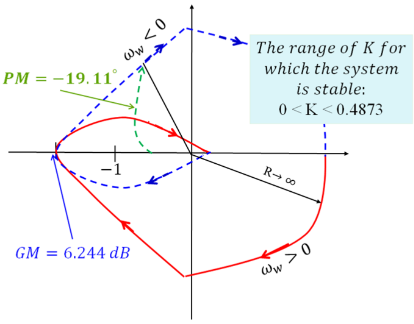
1) +



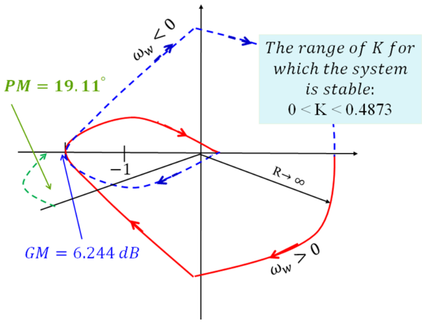
2) -



3) -


$\omega_w < 0$
$PM = -19.11^{\circ}$
The range of K for which the system is stable: 0 < K < 0.4873
−1
$R \to \infty$
GM = 6.244 dB
$\omega_w > 0$

4) -


$\omega_w < 0$
$PM = 19.11^{\circ}$
The range of K for which the system is stable: 0 < K < 0.4873
−1
$R \to \infty$
GM = 6.244 dB
$\omega_w > 0$

31)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
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2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
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2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

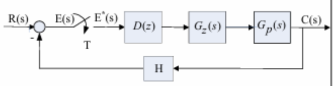

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

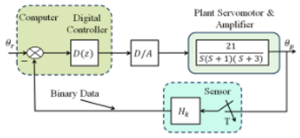

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

Given below the characteristic equation of the discrete system:

$$(3.2-0.2\,k)w^2+(0.8-1.6\,k)\,w+1.8\,k=0$$

With T=1 s, the s-plane frequency (ω) and the w-plane frequency (ω_w) at which the system will oscillate when marginally stable are:

1) - $\omega_w=1.56\ rad/s\ and\ \omega=1.3248\,rad/s$

2) + $\omega_w=0.5388\ rad/s\ and\ \omega=0.5263\,rad/s$

3) - $\omega_w=1.56\,rad/s\ and\ \omega=0.2108\,rad/s$

4) - $\omega_w=0.5263\,rad/s\ and\ \omega=0.5388\,rad/s$

32)

مــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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1.800	1.62615	4.22319	-186.92
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5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

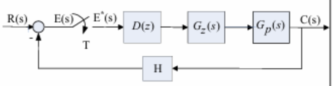

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

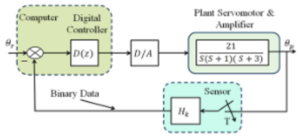

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

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$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

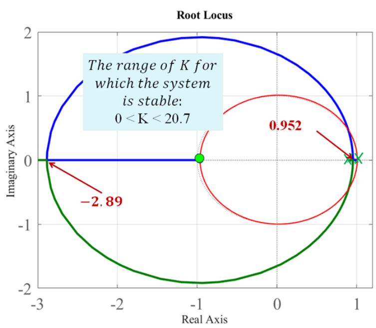
Choose the correct answer:

Consider the system of Figure (1), with $T = 0.1$ s. Let the digital controller be a variable gain K such that $D(z) = K = 1$, $H_k = 0.5$, and

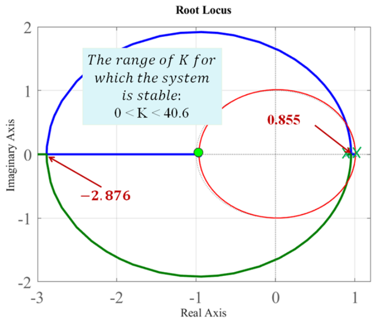
$$G(z)=\frac{0.00484\,z+0.00468}{z^2-1.905\,z+0.905}$$

The z-plane root locus of this system is:

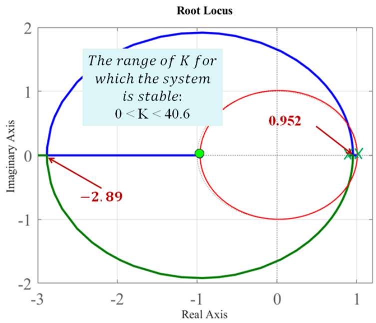
1) -



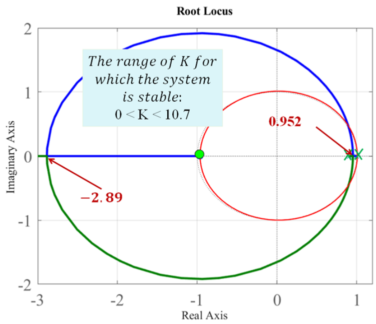
2) -


Root Locus
The range of K for which the system is stable: 0 < K < 40.6
0.855
−2.876
Imaginary Axis
Real Axis

3) +


Root Locus
The range of K for which the system is stable: 0 < K < 40.6
0.952
−2.89
Imaginary Axis
Real Axis

4) -


Root Locus
The range of K for which the system is stable: 0 < K < 10.7
0.952
−2.89
Imaginary Axis
Real Axis

33)

مــرفــقــات

Table (1): Frequency response of $G(z)=\dfrac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
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0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
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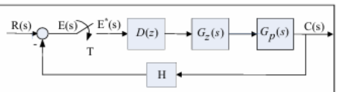

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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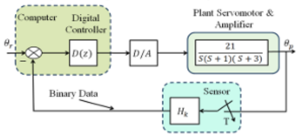

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Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1=\frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

Consider the sampled-data systems with the following characteristic equations :

$$z-e^{-T}+(1-e^{-T})K=0$$

For the case that $T=0.01$, the range of K for which the system is stable is:

1) - $-1.0 < K < 2.16$

2) - $-1.0 < K < 20.0$

3) - $1.0 < K < 200$

4) + $-1.0 < K < 200.0$

34)

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

مـــرفقـــات

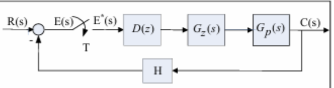

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

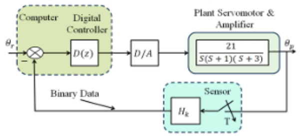

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]$	$D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$
$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}$ $z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}$	$k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$
$a_1 = \frac{1-a_0\lvert G(j\omega_{w1})\rvert\cos(\theta)}{\omega_{w1}\lvert G(j\omega_{w1})\rvert\sin(\theta)}$	$b_1 = \frac{\cos(\theta)-a_0\lvert G(j\omega_{w1})\rvert}{\omega_{w1}\sin(\theta)}$
$D(w) = K_p + \frac{K_I}{w} + K_D w$	$D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$
$k_p = \frac{\cos\theta}{a_0\lvert G(j\omega_{w1})\rvert}$, $k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0\lvert G(j\omega_{w1})\rvert}$	

Choose the correct answer:

For the number sequence $\{e(kT)\}$:

$$E(z) = \frac{Tz}{(z-1)^2}$$

$e(\infty)$ is equal to

1) + $e(\infty) = \infty$

2) - $e(\infty) = 0$

3) - $e(\infty) = T$

4) -

$$e(\infty) = k$$

35)

مـرفـقــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

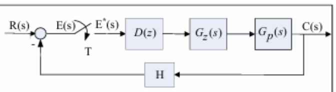

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

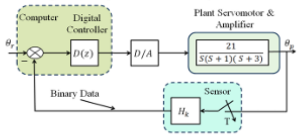

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

Consider the sampled-data systems with the following characteristic equations :

$$(z-0.9)(z-0.8)(z^2+1.1\,z-0.1)=0$$

The natural-response terms for this system are:

1) - $k_1(0.9)^k, k_2(0.8)^k, k_3(-1.1844)^k,$ $and\, k_4(-0.0844)^k$

2) + $k_1(0.9)^k, k_2(0.8)^k, k_3(-1.1844)^k,$ $and\, k_4(0.0844)^k$

3) -

$k_1(-0.9)^k, k_2(-0.8)^k, k_3(-1.1844)^k,$
$and\, k_4(0.0844)^k$

4) - $k_1(0.9)^k, k_2(0.8)^k, k_3(1.1844)^k,$
$and\, k_4(0.0844)^k$

36)

مــرفقــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

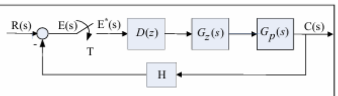

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

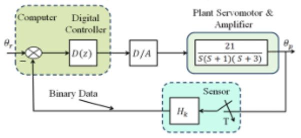

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT=kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right]\qquad D(z)=\frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}\qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)}\qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)}\qquad b_1=\frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw\qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|},\qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Figure (2). Let D(z)=1, the sensor gain be unity $H_k=1$.

The gain margin of this system is:

1) - GM= 6.244 dB

2) - GM=7.3148 dB

3) + GM = -6.244 dB

4) - GM= $-$ 5.215 dB

37)

مـــرفقـــات

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
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2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
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100.000	0.00099	-60.11209	-344.36
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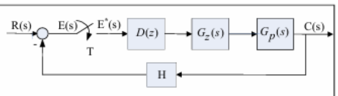

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

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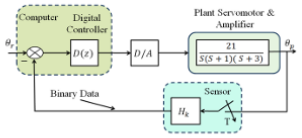

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1=\frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Figure (2). Let D(z)=1, the sensor gain be unity $H_k = 0.1124$.

The sensor gain $H_k = 0.1124$ is not included in Table (1). The phase margin of this system is:

1) - $PM = -43^{\circ}$

2) - $PM = 46^{\circ}$

3) - $PM = -46^{\circ}$

4) + $PM = 43^{\circ}$

38)

مــرفقـــات

ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
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0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
1.600	2.05223	6.24452	-180.54
1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

Table (1): Frequency response of $G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$

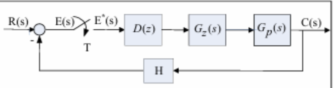

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z) = \frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

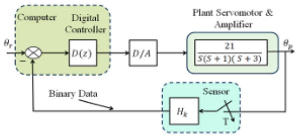

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2} = \frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT} = d^k$	$\frac{z}{z-e^{-aT}} = \frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w) = \frac{a_1 w + a_0}{b_1 w + 1} = a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right] = a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z) = \frac{k_d(z-z_0)}{(z-z_p)}$$

$$z_p = \frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0 = \frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d = \left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} = a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1 = \frac{1-a_0|G(j\omega_{w1})|\cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|\sin(\theta)} \qquad b_1 = \frac{\cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}\sin(\theta)}$$

$$D(w) = K_p + \frac{K_I}{w} + K_D w \qquad D(z) = K_p + K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right] + K_D\left(\frac{z-1}{zT}\right)$$

$$k_p = \frac{\cos\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1} - \frac{k_I}{\omega_{w1}} = \frac{\sin\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Figure (2). Let the sensor gain be unity $H_k = 1$.

Consider the digital controller realize a gain K, that is, $D(z) = K$. The value of K which realize phase margin 40° is.

1) + $K = 0.1253$

2) - $K = 0.1019$

3) - $K = 0.1514$

4) - $K = 1.38164$

39)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
0.300	22.23935	26.94244	-113.27
0.400	16.10722	24.14041	-120.54
0.500	12.35347	21.83578	-127.45
0.600	9.81217	19.83530	-133.98
0.700	7.98088	18.04102	-140.11
0.800	6.60526	16.39780	-145.86
0.900	5.54121	14.87209	-151.23
1.000	4.70004	13.44204	-156.26
1.100	4.02372	12.09255	-160.96
1.200	3.47242	10.81263	-165.37
1.300	3.01784	9.59392	-169.51
1.400	2.63930	8.42978	-173.40
1.500	2.32135	7.31482	-177.07
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1.700	1.82286	5.21508	-183.81
1.800	1.62615	4.22319	-186.92
1.900	1.45646	3.26600	-189.87
2.000	1.30933	2.34100	-192.67
2.100	1.18113	1.44597	-195.34
2.200	1.06892	0.57894	-197.89
2.300	0.97030	-0.26185	-200.33
2.400	0.88329	-1.07797	-202.65
2.500	0.80623	-1.87086	-204.88
5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
10000.000	0.00086	-61.27231	-359.84

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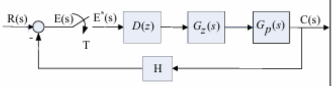

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

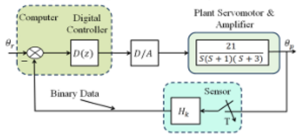

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
unit impulse	1	$\delta(t)$	$\delta(k)$	1
unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	$\mathrm{k}Te^{-aKT}$	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{z\,T}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Figure (2). Let the sensor gain be unity $H_k = 1$.

The PD controller with the dc gain of 5 that yields a system phase margin of 40° is:

1) -
$$D(z)=2.0749\times\frac{(z-0.8344)}{z}$$

2) +
$$D(z)=0.4147\times\frac{(z-0.8343)}{z}$$

3) -
$$D(z)=0.4147\times\frac{(z-0.8343)}{(z-1)}$$

4) -
$$D(z)=2.0749\times\frac{(z-0.8344)}{(z-1)}$$

40)

Table (1): Frequency response of $G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$			
ω_W	$\lvert G(j\omega_W)\rvert$	$\lvert G(j\omega_W)\rvert_{dB}$	$\angle G(j\omega_W$
0.001	6999.99611	76.90196	-90.08
0.010	699.96114	56.90148	-90.79
0.100	69.61424	36.85396	-97.91
0.200	34.24493	30.69193	-105.70
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0.400	16.10722	24.14041	-120.54
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0.600	9.81217	19.83530	-133.98
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2.400	0.88329	-1.07797	-202.65
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5.000	0.14771	-16.61152	-241.03
10.000	0.02406	-32.37441	-272.52
100.000	0.00099	-60.11209	-344.36
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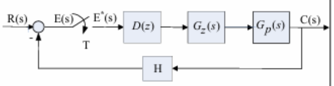

Figure (1)

Shown in Figure (2) is the block diagram of the servo control system for one of the axes of a digital plotter. Let T = 0.1s and the function $G(z)$ is given by:

$$G(z)=\frac{0.0031716(z+3.383)(z+0.242)}{(z-1)(z-0.9048)(z-0.7408)}$$

The frequency response for G(z) is given in Table (1).

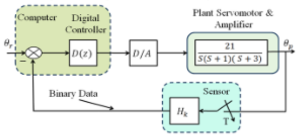

Figure (2)

Table of Laplace and Z-transforms

Entry	Laplace transform $E(s)$	Time function $e(t)$	Time function $e(kT)$ or $e(k)$	z-Transform $E(z)$
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unit step	$\frac{1}{S}$	$u(t)$	1	$\frac{z}{z-1}$
	$\frac{1}{S^2}$	t	$kT = kTd^k$	$\frac{Tz}{(z-1)^2}=\frac{dTz}{(z-d)^2}$
	$\frac{1}{S+a}$	e^{-at}	$e^{-aKT}=d^k$	$\frac{z}{z-e^{-aT}}=\frac{z}{z-d}$
	$\frac{1}{(S+a)^2}$	te^{-at}	kTe^{-aKT}	$\frac{Te^{-aT}z}{(z-e^{-aT})^2}$
	$\frac{a}{S(S+a)}$	$1-e^{-at}$	$1-e^{-akT}$	$\frac{(1-e^{-aT})z}{(z-1)(z-e^{-aT})}$
	$\frac{a^2}{S^2(S+a)}$	$at-1+e^{-at}$	$akT-1+e^{-ak}$	$\frac{z[(aT-1+e^{-aT})z+(1-e^{-aT}-aTe^{-aT})]}{(z-1)^2(z-e^{-aT})}$

Notes

$$D(w)=\frac{a_1w+a_0}{b_1w+1}=a_0\left[\frac{1+w/(a_0/a_1)}{1+w/(b_1)^{-1}}\right]=a_0\left[\frac{1+w/\omega_{w0}}{1+w/\omega_{wp}}\right] \qquad D(z)=\frac{k_d\,(z-z_0)}{(z-z_p)}$$

$$z_p=\frac{\left(\frac{2}{T}-\omega_{wp}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)} \qquad z_0=\frac{\left(\frac{2}{T}-\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{w0}\right)} \qquad k_d=\left(a_0\frac{\omega_{wp}}{\omega_{w0}}\right)\frac{\left(\frac{2}{T}+\omega_{w0}\right)}{\left(\frac{2}{T}+\omega_{wp}\right)}=a_0\frac{(1-z_p)}{(1-z_0)}$$

$$a_1=\frac{1-a_0|G(j\omega_{w1})|cos(\theta)}{\omega_{w1}|G(j\omega_{w1})|sin(\theta)} \qquad b_1=\frac{cos(\theta)-a_0|G(j\omega_{w1})|}{\omega_{w1}sin(\theta)}$$

$$D(w)=K_p+\frac{K_I}{w}+K_Dw \qquad D(z)=K_p+K_I\left[\left(\frac{T}{2}\right)\left(\frac{z+1}{z-1}\right)\right]+K_D\left(\frac{z-1}{zT}\right)$$

$$k_p=\frac{cos\,\theta}{a_0|G(j\omega_{w1})|}, \qquad k_D\omega_{w1}-\frac{k_I}{\omega_{w1}}=\frac{sin\,\theta}{a_0|G(j\omega_{w1})|}$$

Choose the correct answer:

For Figure (2). Let the sensor gain be unity $H_k = 1$.

The unity-dc-gain phase-lag controller that yields a system phase margin of 40° is:

1) -

$$D(z)=0.4262\times\frac{(z-0.9851)}{(z-0.9936)}$$

2) -

$$D(z)=0.081\times\frac{(z-0.8343)}{(z-1)}$$

3) +

$$D(z)=0.1\times\frac{(z-0.994)}{(z-0.9994)}$$

4) -

$$D(z)=0.1\times\frac{(z-0.9994)}{(z-0.994)}$$