$$z^{-1} = e^{-Ts}$$

$$E(z) = Z[e^{*}(t)] = E^{*}(s)\Big|_{z=e^{Ts}} = \sum_{n=0}^{\infty} e(kT) \cdot z^{-k}$$

7.4.2 Methods of z-Transform

By the definition.

Partial fraction expansion.

Properties of z-Transform

1. linear property

$$Z\left[a\cdot e_1^*(t)\pm b\cdot e_2^*(t)\right]=a\cdot E_1(z)\pm b\cdot E_2(z)$$

2. Real shifting theorem

$$\begin{cases}\text{Lag} \quad Z\left[e(t-nT)\right]=z^{-n}E(z)\\ \text{Lead} \quad Z\left[e(t+nT)\right]=z^{n}\left[E(z)-\sum_{k=0}^{n-1}e(kT)\cdot z^{-k}\right]\end{cases}$$

3. Complex shifting theorem

$$Z\left[e(t)\cdot e^{\mp at}\right]=E\left(z\cdot e^{\pm aT}\right)$$

4. Initial-value theorem

$$\lim_{n\to 0}e(nT)=\lim_{z\to\infty}E(z)$$

5. Final-value theorem

$$\lim_{n\to\infty}e(nT)=\lim_{z\to 1}(z-1)\cdot E(z)$$

6. Convolution theorem

$$c^*(t)=e^*(t)*g^*(t) \quad \Rightarrow \quad C(z)=E(z)\cdot G(z)$$

7.4.4 Inverse z-Transform

$$Z^{-1}[X(z)] = x(nT)$$

Tips:

Inverse Z-transform can only provide discrete-time signal $x^{*}(t)$, instead of continuous signal $x(t)$。

- Long Division（长除法）
- Partial-Fraction expansion   Expansion of $\dfrac{E(z)}{z}$
- Residue（留数法） $e(nT) = \sum \mathrm{Res}\left[E(z) \cdot z^{n-1}\right]$

Chapter 7 Analysis and Design of Linear Discrete-Time System （Sampled-data System）

7.1 Introduction

7.2 The Sampling Process and Sampling Theorem

7.3 Signal Recovery and Zero-Order Hold

7.4 Z-Transform and Inverse Z Transform

7.5 Mathematical Models of Discrete-Time Systems

7.6 Performance Analysis of Discrete-Time Systems

7.7 Digital Control Design for Discrete-Time Systems

7.5 Mathematical Models of Discrete-Time Systems

- **Difference Equation**
- **Impulse Transfer function**

7.5.1 Linear Time-Invariant Difference Equations

(1) Definition of difference e(kT) = e(k)

Forward difference

First-order $\Delta e(k) = e(k+1) - e(k)$

Second-order $\Delta^2 e(k) = \Delta e(k+1) - \Delta e(k)$

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

$\vdots$

nth-order $\Delta^n e(k) = \Delta^{n-1} e(k+1) - \Delta^{n-1} e(k)$

$$\dot{e}(t) = \frac{\mathrm{d}e(t)}{\mathrm{d}t} = \lim_{T \to 0} \frac{\Delta e(k)}{T} \approx \frac{\Delta e(k)}{T}$$

$$\text{Backward difference}\begin{cases}\text{First-order} & \nabla e(k)=e(k)-e(k-1)\\ \text{Second-order} & \nabla^2 e(k)=\nabla e(k)-\nabla e(k-1)\\ \vdots & \qquad\qquad =e(k)-2e(k-1)+e(k-2)\\ \text{nth-order} & \nabla^n e(k)=\nabla^{n-1}e(k)-\nabla^{n-1}e(k-1)\end{cases}$$

$$\dot{e}(t)=\frac{\mathrm{d}e(t)}{\mathrm{dt}}=\lim_{T\to 0}\frac{\nabla e(k)}{T}\approx\frac{\nabla e(k)}{T}$$

(2) Difference equation

The equation of the input, output and their higher order differences.

The (forward) difference equation of nth-order linear time-invariant discrete system.

$$c(k+n)+a_1c(k+n-1)+a_2c(k+n-2)+\cdots+a_{n-1}c(k+1)+a_nc(k)$$
$$=b_0r(k+m)+b_1r(k+m-1)+\cdots+b_{m-1}r(k+1)+b_mr(k)$$

or $$c(k+n) = -\sum_{i=1}^{n} a_i c(k+n-i) + \sum_{j=0}^{m} b_j r(k+m-j)$$

The (backward) differential equation of n-order linear time-invariant discrete system.

$$\boldsymbol{c(k) + a_1 c(k-1) + a_2 c(k-2) + \cdots + a_{n-1} c(k-n+1) + a_n c(k-n)}$$
$$\boldsymbol{= b_0 r(k-n+m) + b_1 r(k-n+m-1) +}$$
$$\boldsymbol{\cdots + b_{m-1} r(k-n+1) + b_m r(k-n)}$$

or $$c(k) = -\sum_{i=1}^{n} a_i c(k-i) + \sum_{j=0}^{m} b_j r(k-j)$$

(3) To solve difference equations: $\begin{cases} \text{Iteration method (迭代)} \\ \text{Z-transform method} \end{cases}$

Example 1 The differential equation of a continuous system is:
$$\begin{cases} \ddot{e}(t)-4\dot{e}(t)+3e(t)=r(t)=1(t) \\ e(t)=0 \qquad (t\le 0) \end{cases}$$

Obtain the corresponding forward difference equation and its solution.

Solution.

$$\dot{e}(t)\approx\frac{\Delta e(k)}{T}=\frac{e(k+1)-e(k)}{T}\overset{T=1}{=}e(k+1)-e(k)$$

$$\ddot{e}(t)\approx\frac{\Delta^2 e(k)}{T^2}=\frac{\Delta e(k+1)/T-\Delta e(k)/T}{T}\overset{T=1}{=}e(k+2)-2e(k+1)+e(k)$$

$$\begin{array}{r} e(k+2)-2e(k+1)+e(k) \\ -4\,[\qquad\qquad e(k+1)-e(k)\,] \\ +3\,[\qquad\qquad\qquad\qquad e(k)\,] \\ \hline e(k+2)-6e(k+1)+8e(k)=1(k) \end{array}$$

$$\begin{cases} e(k+2)-6e(k+1)+8e(k)=1(k) \\ e(k)=0 \qquad (k\le 0) \end{cases}$$

Solution I of the difference equation —— Iteration method

$$\begin{cases} e(k+2)-6e(k+1)+8e(k)=1(k) \\ e(k)=0 \qquad (k\le 0) \end{cases}$$

Solution $$e(k+2)=6e(k+1)-8e(k)+1(k)$$

$$k=-1: \quad e(1)=6e(0)-8e(-1)+1(-1)=0$$

$$k=0: \quad e(2)=6e(1)-8e(0)+1(0)=0-0+1=1$$

$$k=1: \quad e(3)=6e(2)-8e(1)+1(1)=6-0+1=7$$

$$k=2: \quad e(4)=6e(3)-8e(2)+1(2)=6\times 7-8\times 1+1=35$$

$$\vdots \qquad\qquad \vdots$$

$$e^*(t)=\delta(t-2)+7\delta(t-3)+35\delta(t-4)+\cdots$$

Solution II of difference equation — Z-transform method

$$e(k+2)-6e(k+1)+8e(k)=1(k)$$

$$\begin{cases} e(k+2)-6e(k+1)+8e(k)=1(k) \\ e(k)=0 \qquad (k\le 0) \end{cases}$$

$$Z: \quad z^2\,[E(z)-e(0)z^0-e(1)z^{-1}]$$

$$-6\cdot z\,[E(z)-e(0)z^0]$$

$$+\quad 8\,[E(z)]$$

$$(z^2-6z+8)E(z)=Z[1(k)]=\frac{z}{z-1}$$

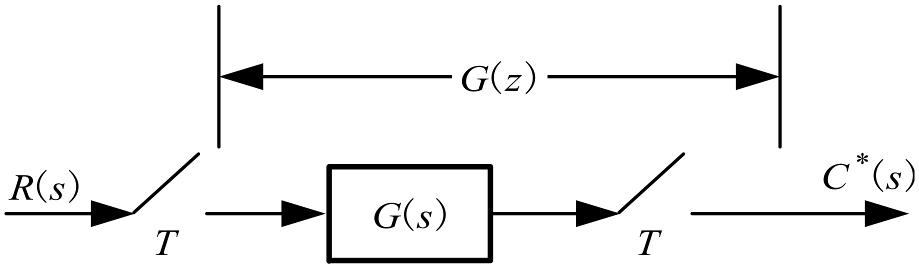
$$E(z)=\frac{z}{(z-1)(z-2)(z-4)}$$

$$Z^{-1}: e(n)=\sum \mathrm{Res}\left[E(z)\cdot z^{n-1}\right]$$

$$=\lim_{z\to 1}\frac{z\cdot z^{n-1}}{(z-2)(z-4)}+\lim_{z\to 2}\frac{z\cdot z^{n-1}}{(z-1)(z-4)}+\lim_{z\to 4}\frac{z\cdot z^{n-1}}{(z-1)(z-2)}=\frac{1}{3}-\frac{2^n}{2}+\frac{4^n}{6}$$

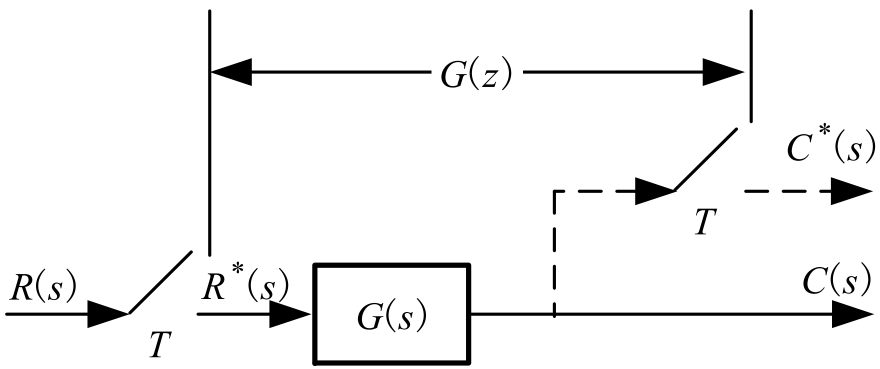
$$e^*(t)=\sum_{n=0}^{\infty}e(nT)\cdot\delta(t-nT)=\sum_{n=0}^{\infty}\left(\frac{1}{3}-\frac{2^n}{2}+\frac{4^n}{6}\right)\cdot\delta(t-nT)$$

7.5.2 Mathematical Models in Complex Domain — Impulse Transfer Function（脉冲传递函数）

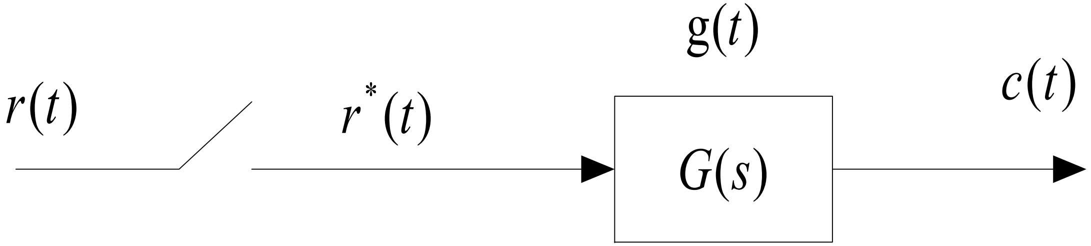


1. Definition

The ratio of the z-T. of the output to the z-T. of the input under zero initial condition.



$$G(z)=\frac{C(z)}{R(z)}=\frac{\sum_{k=0}^{\infty}c(kT)z^{-k}}{\sum_{k=0}^{\infty}r(kT)z^{-k}}$$



for a LTI system:

$$\left.\begin{array}{l} if: r(nT)=\delta(nT), \quad then: c(nT)=g(nT) \\ if: r(nT)=\delta[(n-k)T], \quad then: c(nT)=g[(n-k)T] \end{array}\right\} \textbf{Weighted sequence}$$

Thus:

$$r^*(t)=\sum_{n=0}^{\infty} r(nT)\delta(t-nT)$$

$$=r(0)\delta(t)+r(T)\delta(t-T)+\cdots+r(nT)\delta(t-nT)+\cdots$$

$$c(t)=r(0)g(t)+r(T)g[t-T]+\cdots+r(nT)g[t-nT]+\cdots$$

$$c(kT)=r(0)g(kT)+r(T)g[(k-1)T]+\cdots+r(nT)g[(k-n)T]+\cdots$$

$$=\sum_{n=0}^{\infty} r(nT)g[(k-n)T]$$

$$c(kT)=\sum_{n=0}^{\infty} r(nT)g[(k-n)T]$$

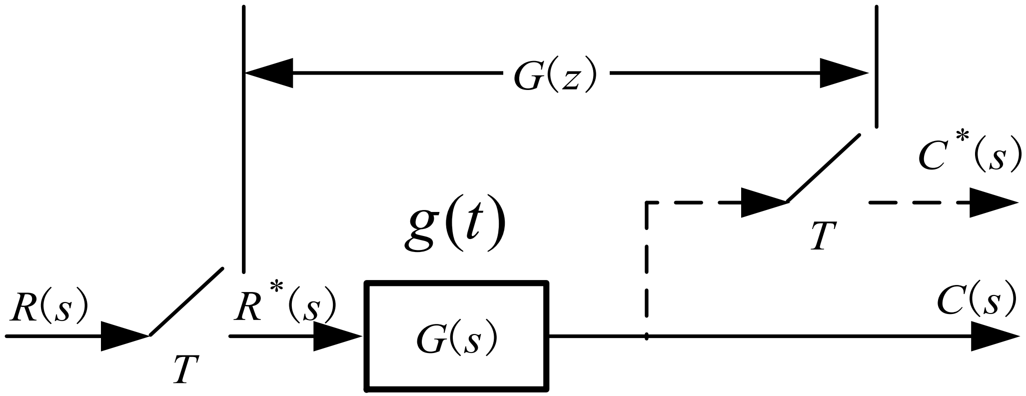
$$C(z)=\sum_{k=0}^{\infty} c(kT)z^{-k} \quad =\sum_{k=0}^{\infty}\sum_{n=0}^{\infty} r(nT)g[(k-n)T]z^{-k}$$

$$=\sum_{n=0}^{\infty} r(nT)z^{-n}\sum_{k=0}^{\infty} g[(k-n)T]z^{-(k-n)}$$

The z-transform of unity impulse response sequence

$$\therefore G(z)=\frac{C(z)}{R(z)}=\sum_{k=n}^{\infty} g[(k-n)T]z^{-(k-n)} =\sum_{j=0}^{\infty} g(jT)z^{-j}$$

G(Z)=Z[g(t)]=Z[G(s)]



For a difference equation:

$$c(kT)+a_1c(kT-T)+\cdots+a_{n-1}c(kT-(n-1)T)+a_nc(kT-nT)$$
$$=b_0r(kT-(n-m)T)+\cdots+b_{m-1}r(kT-(n-1)T)+b_mr(kT-nT)$$

$$\Longleftrightarrow \quad c(kT)=-\sum_{i=1}^{n}a_ic[(k-i)T]+\sum_{j=0}^{m}b_jr[(k-j)T]$$

$$\xLeftrightarrow{\text{z-T.}} \quad C(z)=-\sum_{i=1}^{n}a_iC(z)z^{-i}+\sum_{j=0}^{m}b_jR(z)z^{-j}$$

$$\Longleftrightarrow \quad G(z)=\frac{C(z)}{R(z)}=\frac{\sum_{j=0}^{m}b_jz^{-j}}{1+\sum_{i=1}^{n}a_iz^{-i}}$$

Example 1 **Consider the discrete system shown in the figure with**

$$G(s)=\frac{1}{s(0.1s+1)}$$

Obtain the impulse-transfer function $G(z)$。

Solution: General Ideas: G(s) $\Rightarrow$ g(kT) $\Rightarrow$ G(z)

Method I. The impulse response is:

$$G(s) = \frac{1}{s(0.1s+1)} \Rightarrow \begin{array}{l} g(t) = (1 - e^{-10t}) \qquad (t > 0) \\ g(kT) = 1 - e^{-10kT} \end{array}$$

Then the impulse tranfer function is:

$$G(z) = \sum_{k=0}^{+\infty} g(kT) z^{-k} = \sum_{k=0}^{+\infty} \left(1 - e^{-10kT}\right) z^{-k}$$

$$= \frac{z}{z-1} - \frac{z}{z-e^{-10T}} = \frac{z(1-e^{-10T})}{(z-1)(z-e^{-10T})}$$

Method II. Because $G(s) = \frac{1}{s} - \frac{1}{s+10}$

Then by G(Z)=Z[g(t)]=Z[G(s)], it derives

$$G(z) = \frac{z}{z-1} - \frac{z}{z-e^{-10T}} = \frac{z(1-e^{-10T})}{(z-1)(z-e^{-10T})}$$

The properties of impulse transfer function:

(1) G(z) is a complex function of complex variable z；

(2) G(z) depends only on the structure and parameters of the system；

(3) G(z) has a relation with the difference equation of the system；

(4) G(z) is equal to Z[$k^*(t)$]；

(5) G(z) ~ zero-pole location in z plane.

The limitation of impulse-transfer functions

(1) It can not reflect the full information of the system response under non-zero initial conditions;

(2) It is only for SISO discrete systems;

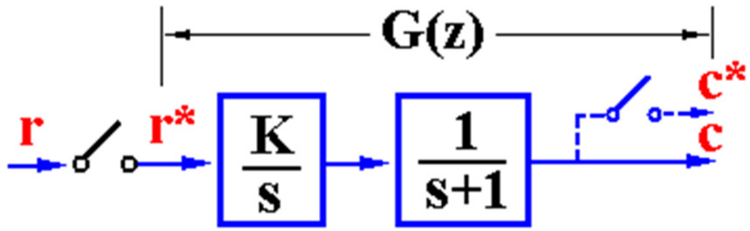
(3) It is only for LTI (linear time-invariant) difference equations;

Example 2 Consider the discrete system shown in the figure (T=1). Obtain

(1) Impulse-transfer function of the system

(2) Zero-poles location in z plane;

(3) Difference equation of the system.

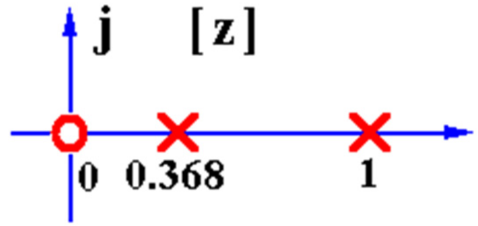


Solution. (1) $$G(z)=\frac{C(z)}{R(z)}=Z\left[\frac{K}{s(s+1)}\right]=K\cdot Z\left[\frac{1}{s}-\frac{1}{s+1}\right]$$

$$=K\left[\frac{z}{z-1}-\frac{z}{z-e^{-T}}\right]=\frac{(1-e^{-T})Kz}{(z-1)(z-e^{-T})}=\frac{(1-e^{-T})Kz}{z^2-(1+e^{-T})z+e^{-T}}$$

$$=\frac{0.632Kz^{-1}}{1-1.368z^{-1}+0.368z^{-2}}$$

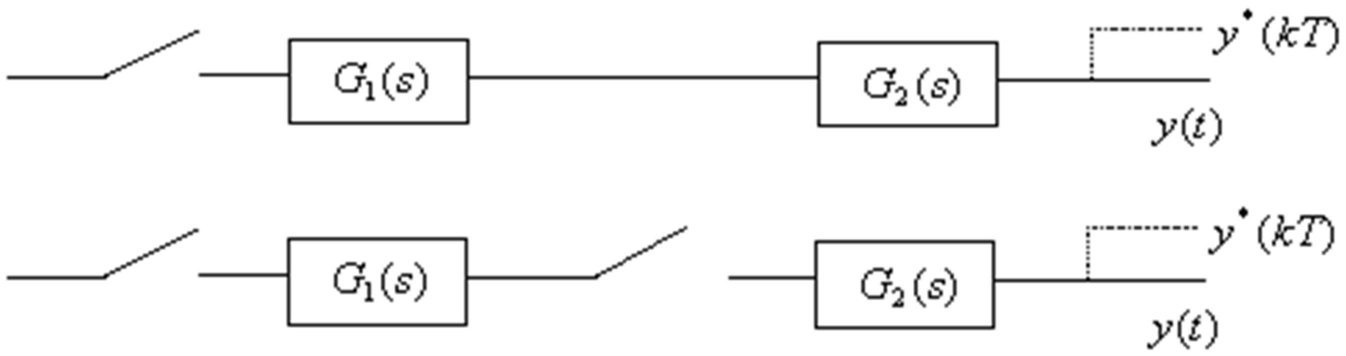
(2) Zero-poles location in z plane



(3) $$\left(1-1.368z^{-1}+0.368z^{-2}\right)C(z)=0.632Kz^{-1}R(z)$$

$$c(k)-1.368c(k-1)+0.368c(k-2)=0.632Kr(k-1)$$

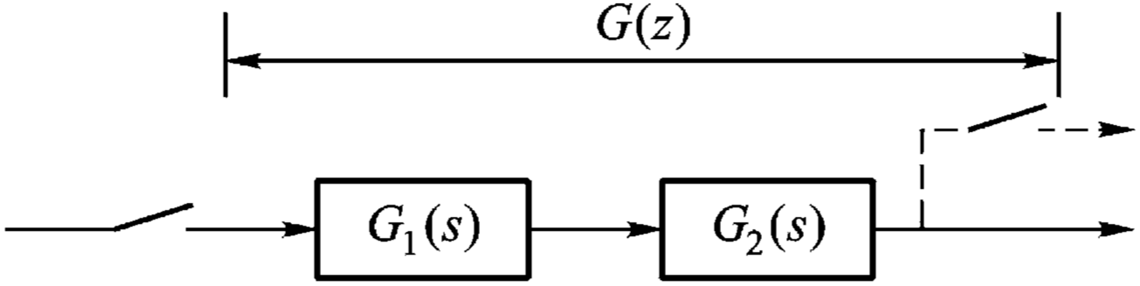
7.5.3 Impulse transfer function of Open-Loop Systems



(1) There is no sampler/switch between two components

$$G(s) = G_1(s)G_2(s)$$

$$G(z) = Z[G_1(s)G_2(s)] = G_1G_2(z)$$



图

Example 3 Consider the discrete system shown in the above figure， where

$$G_1(s) = \frac{1}{s+a} \qquad G_2(s) = \frac{1}{s+b}$$

Obtain the open-loop impulse transfer function。

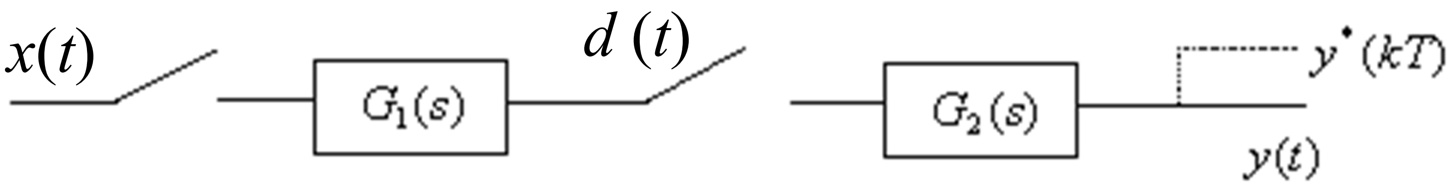
solution：

$$G_1(s)G_2(s)=\frac{1}{b-a}\left[\frac{1}{s+a}-\frac{1}{s+b}\right]$$

$$G(z)=G_1G_2(z)$$

$$=\frac{1}{b-a}\left[\frac{z(e^{-aT}-e^{-bT})}{(z-e^{-aT})(z-e^{-bT})}\right]$$

（2）There is a sampler/switch between two components



$$D(z) = G_1(z)X(z)$$

$$Y(z) = G_2(z)D(z) = G_1(z)G_2(z)R(z)$$

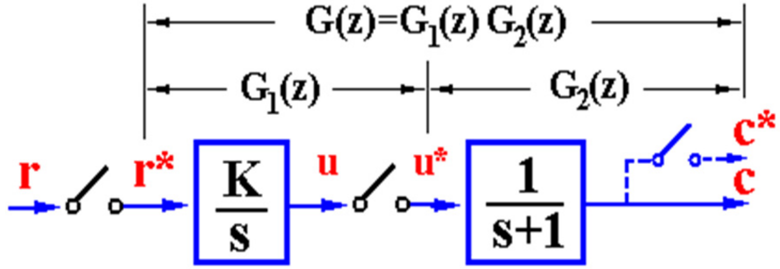
$$\therefore G(z) = G_1(z)G_2(z)$$

注 $G_1(z)G_2(z) \neq G_1G_2(z)$

(1) Switch between factors

$$G(z) = G_1(z)G_2(z) = Z\left[\frac{K}{s}\right] \cdot Z\left[\frac{1}{s+1}\right]$$

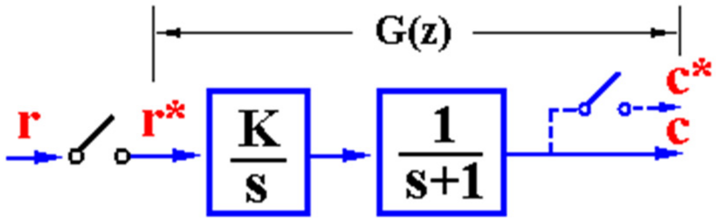
$$= \frac{Kz}{z-1} \cdot \frac{z}{z-e^{-T}} = \frac{Kz^2}{(z-1)(z-e^{-T})}$$



(2) No switch between factors

$$G(z) = Z[G_1(s) \cdot G_2(s)] = G_1G_2(z)$$

$$= K\left[\frac{z}{z-1} - \frac{z}{z-e^{-T}}\right] = \frac{(1-e^{-T})Kz}{(z-1)(z-e^{-T})}$$



Note: the zeros of G(z), the poles of G(z).

Exercise: **Consider** $G_1(s) = \frac{1}{s}$, $G_2(s) = \frac{10}{s+10}$, **obtain G(z).**

Solution:

If there is no switch between the components,

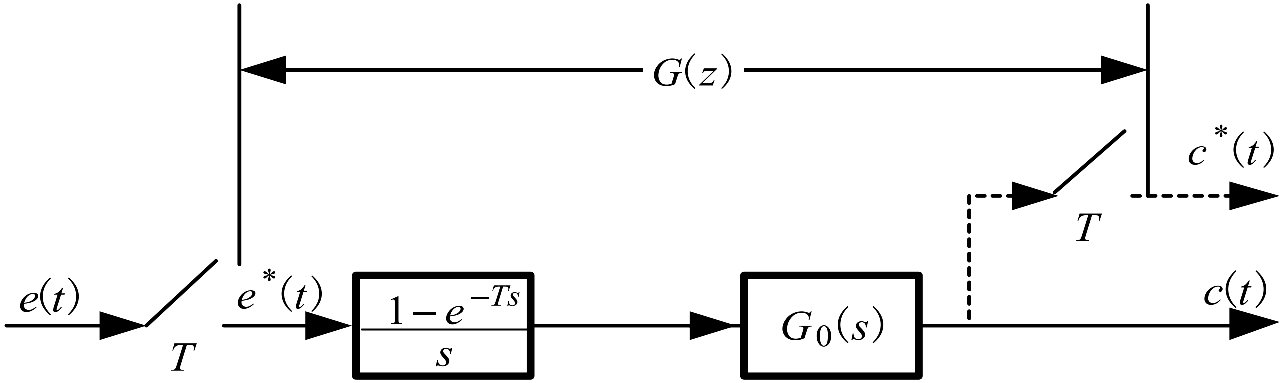
$$G(z) = G_1G_2(z) = Z[\frac{10}{s(s+10)}] = \frac{z(1-e^{-10T})}{(z-1)(z-e^{-10T})}$$

If there is a sampler between the components,,

$$G(z) = G_1(z)G_2(z) = Z[\frac{1}{s}]Z[\frac{10}{s+10}]$$

$$= \frac{z}{z-1}\frac{10z}{z-e^{10T}} = \frac{10z^2}{(z-1)(z-e^{-10T})}$$

(3) ZOH in the system

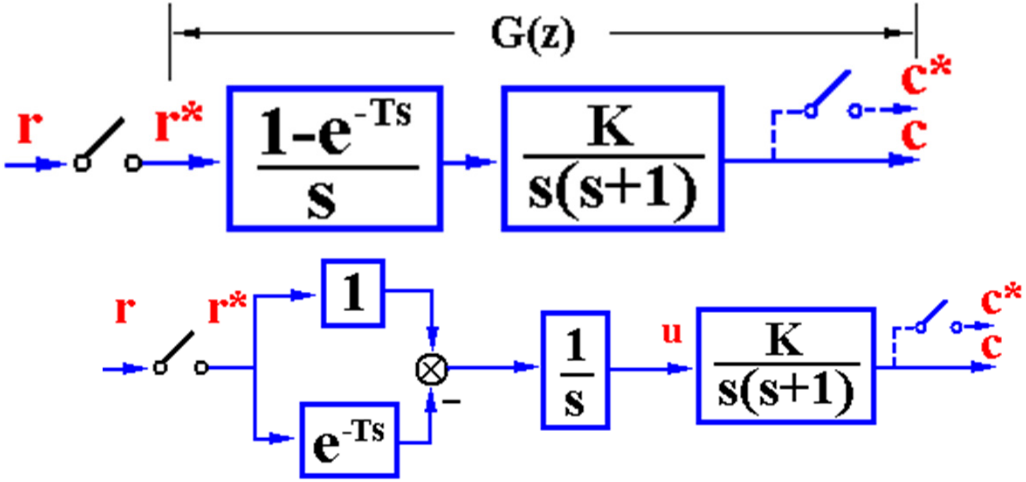


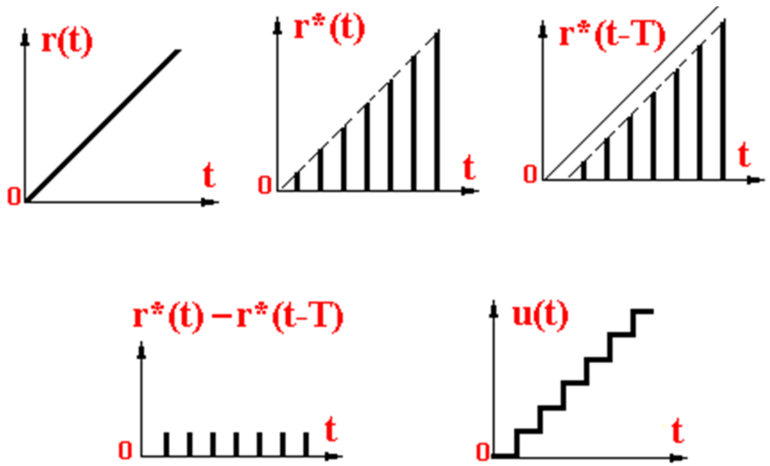
$$C(z)=Z\left[\frac{1-e^{-Ts}}{s}G_0(s)\right]R(z)=Z\left[\frac{1}{s}G_0(s)-\frac{e^{-Ts}}{s}G_0(s)\right]R(z)$$

$$Z\left[\frac{e^{-Ts}}{s}G_0(s)\right]=z^{-1}Z\left[\frac{G_0(s)}{s}\right] \qquad C(z)=(1-z^{-1})Z\left[\frac{G_0(s)}{s}\right]R(z)$$

$$G(z)=\frac{C(z)}{R(z)}=(1-z^{-1})Z\left[\frac{G_0(s)}{s}\right]$$

Example 4 Consider the discrete system shown in the following figure, obtain its impulse transfer function.





$$G(z)=Z\left[\frac{1-e^{-Ts}}{s}\cdot\frac{K}{s(s+1)}\right]$$

$$=K(1-z^{-1})Z\left[\frac{1}{s^2(s+1)}\right]$$

$$=K\frac{z-1}{z}Z\left[\frac{1}{s^2}-\frac{1}{s}+\frac{1}{s+1}\right]$$

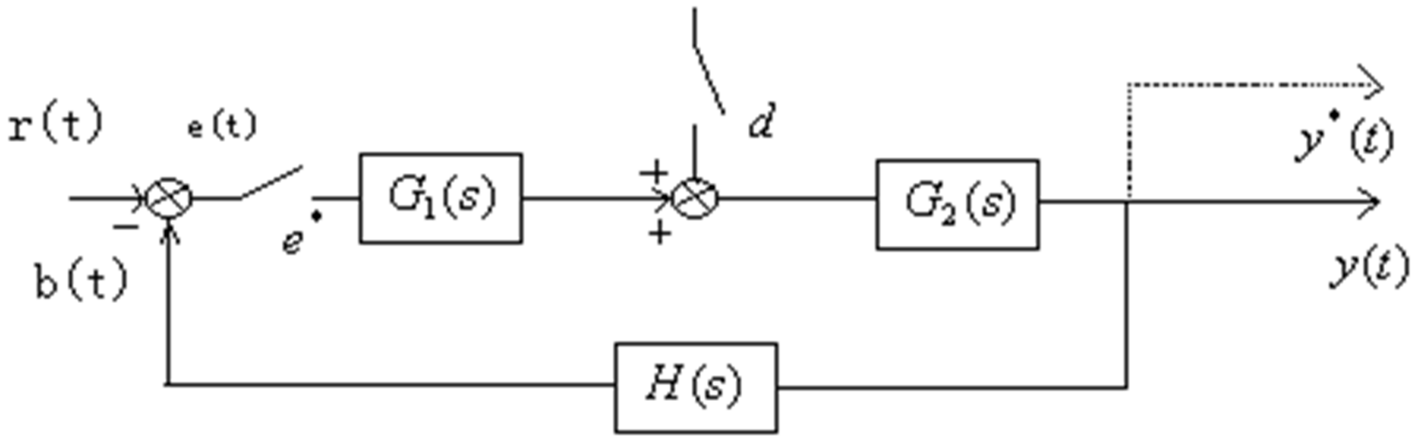
$$=K\frac{z-1}{z}\left[\frac{Tz}{(z-1)^2}-\frac{z}{z-1}+\frac{z}{z-e^{-T}}\right]$$

$$=K\left[\frac{T}{z-1}-1+\frac{z-1}{z-e^{-T}}\right]$$

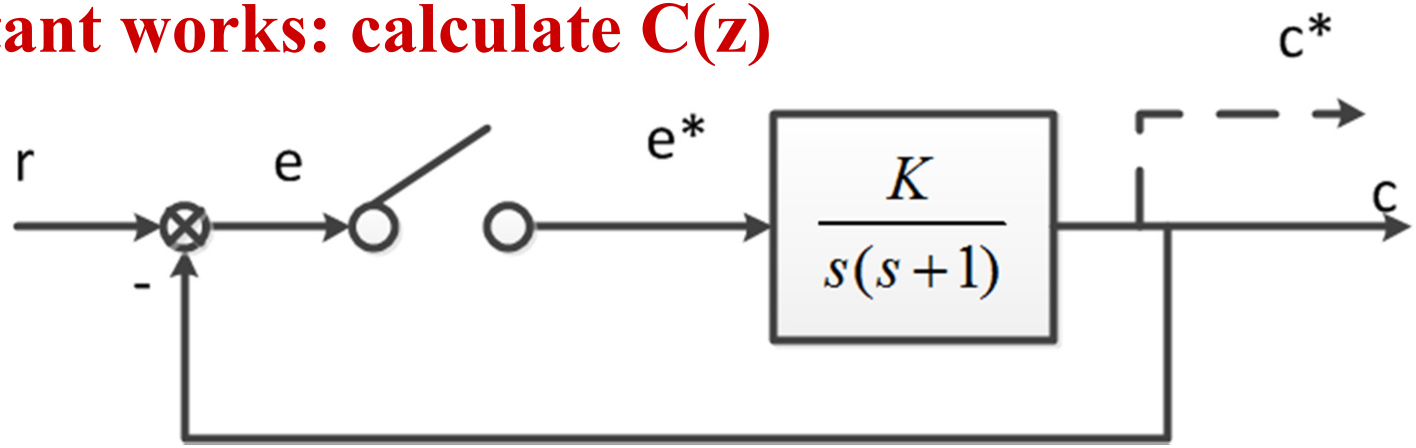
$$=K\frac{(T-1+e^{-T})z+(1-Te^{-T}-e^{-T})}{(z-1)(z-e^{-T})}$$

ZOH does not change the system order and O.-L. poles but changes the O.-L. zeros.

7.5.4、 Impulse transfer function of Closed-Loop Systems

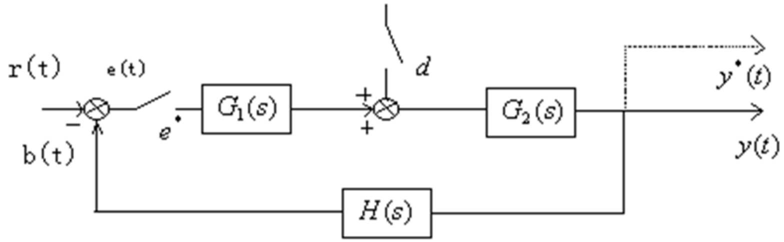


Instant works: calculate C(z)



（1）Impulse Transfer Function for input to output

$$d = 0$$



$$Y(z) = G_1G_2(z)E(z)$$

$$\left.\begin{aligned} &e(t) = r(t) - b(t) \\ &\Rightarrow E(z) = R(z) - B(z) \\ &B(z) = G_1G_2H(z)E(z) \end{aligned}\right\} \Rightarrow E(z) = \frac{R(z)}{1 + G_1G_2H(z)}$$

Error impulse transfer function (误差脉冲传递函数):

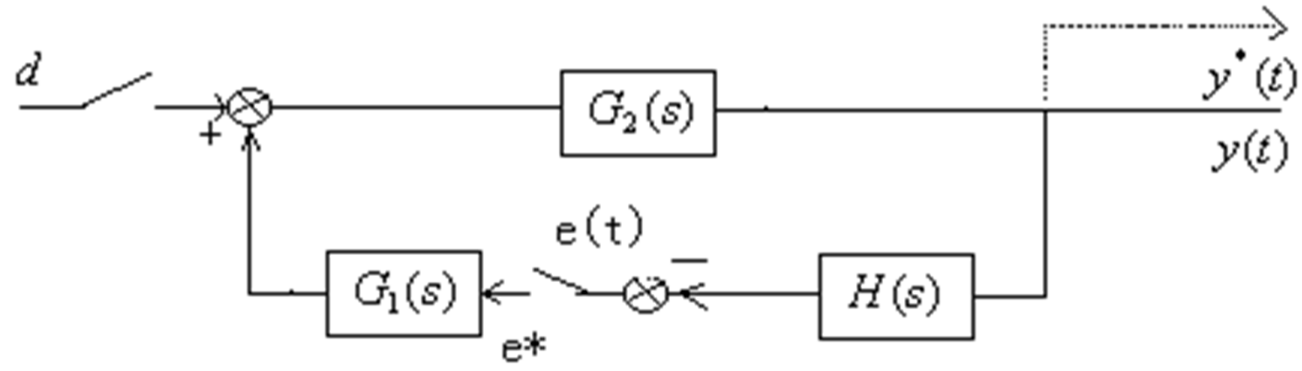
$$G_e(z) = \frac{E(z)}{R(z)} = \frac{1}{1 + G_1G_2H(z)}$$

$$\Rightarrow Y(z) = G_1G_2(z)\frac{R(z)}{1 + G_1G_2H(z)}$$

$$\therefore \Phi(z) = \frac{Y(z)}{R(z)} = \frac{G_1G_2(z)}{1 + G_1G_2H(z)}$$

（2） Impulse Transfer Function for disturbance to output

$$r(t) = 0$$



$$Y(z) = G_2(z)D(z) + G_1G_2(z)E(z)$$

$$E(z) = -[G_2H(z)D(z) + G_1G_2H(z)E(z)]$$

$$\Rightarrow E(z) = -\frac{G_2H(z)}{1+G_1G_2H(z)}D(z)$$

$$\therefore Y(z) = G_2(z)D(z) - \frac{G_1G_2(z)G_2H(z)}{1+G_1G_2H(z)}D(z)$$

E(z) :

D(z) passing through $G_2(z)$;

Loop of E(z)itself。

$$\Rightarrow \Phi_d(z) = \frac{Y(z)}{D(z)} = G_2(z) - \frac{G_1G_2(z)G_2H(z)}{1+G_1G_2H(z)}$$

There is no switch/sampler for the error signal e(t)

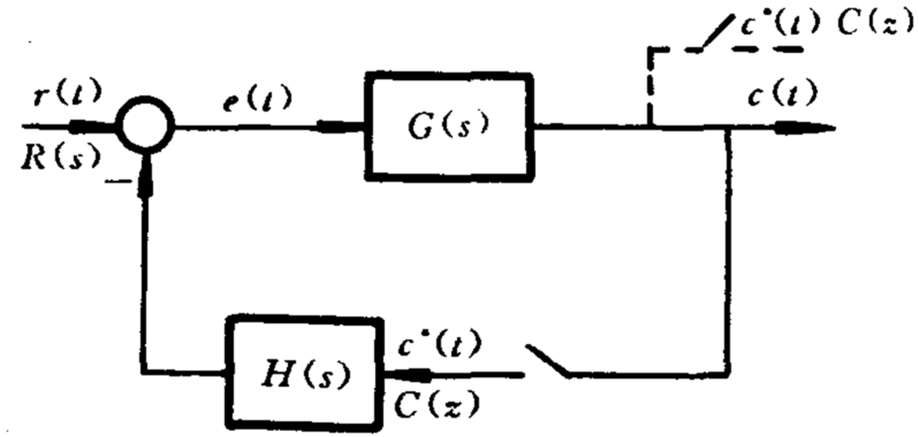


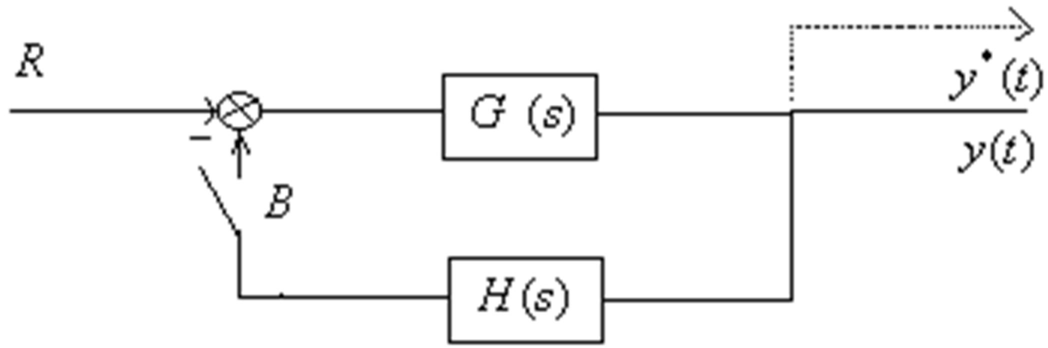
图 7-35　闭环离散系统

$$C(s) = G(s)R(s) - G(s)H(s)C^*(s)$$

$$C(z) = GR(z) - GH(z)C(z) \qquad \Rightarrow C(z) = \frac{GR(z)}{1 + GH(z)}$$

Then, for this system, there exists no impulse transfer function.

Example **Consider the discrete-time system as shown in the figure, find the z-transform of the output y(t).**



Solution:

$$Y(z) = GR(z) - G(z)B(z)$$

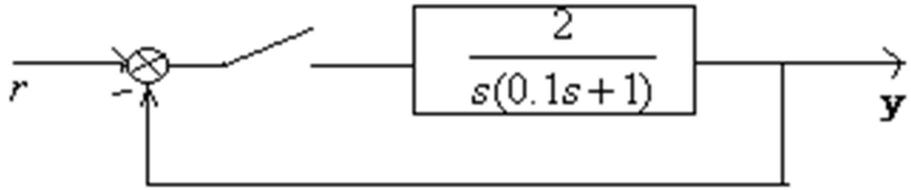
$$B(z) = GHR(z) - GH(z)B(z)$$

$$\therefore B(z) = \frac{GHR(z)}{1+GH(z)}$$

$$\therefore Y(z) = GR(z) - \frac{G(z)GHR(z)}{1+GH(z)}$$

There exists no impulse tranfer function.

Example **Consider the discrete-time system as shown in the figure, for T=0.1, find the unit step response of the system.**



Solution: $G(z) = Z\left[\frac{2}{s(0.1s+1)}\right] = \frac{2z}{z-1} - \frac{2z}{1-e^{-10T}}$

$$= \frac{2z - 0.736z}{(z-1)(z-0.368)} = \frac{1.264z}{z^2 - 1.368z + 0.368}$$

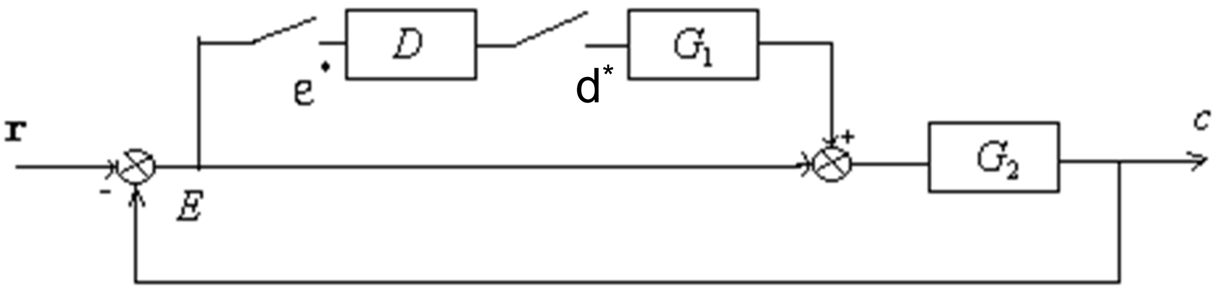
$$\therefore \Phi(z) = \frac{G(z)}{1+G(z)} = \frac{1.264z}{z^2 - 0.104z + 0.368}$$

$$\therefore Y(z) = \Phi(z)R(z) = \Phi(z)\frac{z}{z-1}$$

$$= 1.264z^{-1} + 1.396z^{-2} + 0.945z^{-3} + 0.849z^{-4} + \cdots$$

$$y^*(t) = 1.264\delta(t-0.1) + 1.396\delta(t-0.2) + \cdots$$

Example **Consider the discrete-time system as shown in the figure, find the expression of the output c.**



Solution: There exist both discrete and continuous signals, then employing L-Transform firstly,

$$C = G_1G_2 \cdot D^* \cdot E^* + G_2E = G_1G_2 \cdot D^* \cdot (R-C)^* + G_2(R-C)$$
$$= G_1G_2 \cdot D^* \cdot (R^* - C^*) + G_2(R-C)$$

$$C = \frac{G_2R}{1+G_2} + \frac{G_1G_2}{1+G_2} \cdot D^* \cdot R^* - \frac{G_1G_2}{1+G_2} \cdot D^* \cdot C^*$$

$$\boxed{C = \frac{G_2 R}{1+G_2} + \frac{G_1 G_2}{1+G_2} \cdot D^* \cdot R^* - \frac{G_1 G_2}{1+G_2} \cdot D^* \cdot C^*}$$

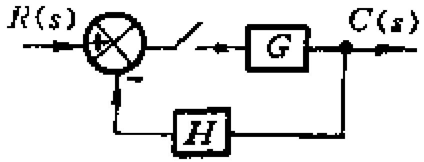
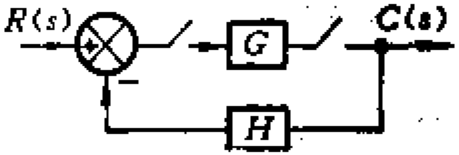
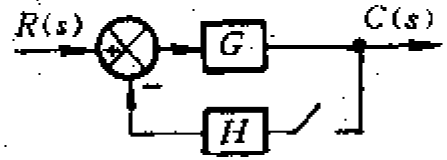
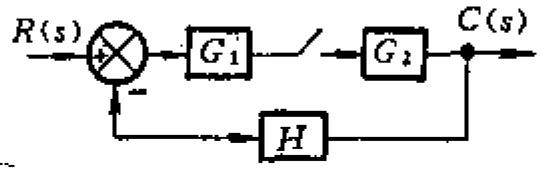
Discretize C to C*， then

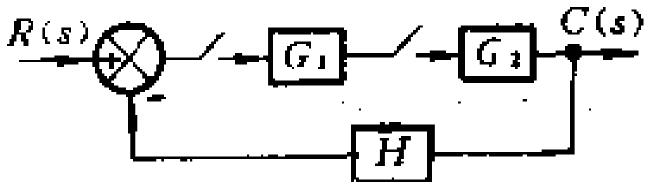
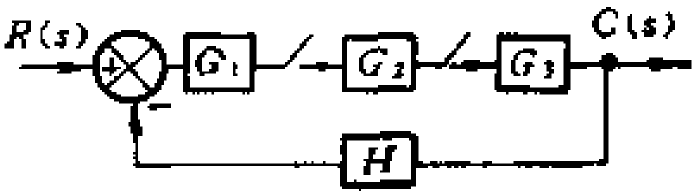
$$C^* = \left[\frac{G_2 R}{1+G_2}\right] + \left[\frac{G_1 G_2}{1+G_2}\right]^* \cdot D^* \cdot R^* - \left[\frac{G_1 G_2}{1+G_2}\right]^* \cdot D^* \cdot C^*$$

PS: $\left[G_1(s) \cdot G_2(s)^*\right]^* = G_1(s)^* \cdot G_2(s)^*$

$$\therefore C^* = \frac{\left[\frac{G_2 R}{1+G_2}\right]^* + \left[\frac{G_1 G_2}{1+G_2}\right]^* D^* R^*}{1 + \left[\frac{G_1 G_2}{1+G_2}\right]^* D^*}$$

Typical diagram of C.L.discrete-time systems

	系 统 方 框 图	$C(z)$
1		$C(z)=\dfrac{G(z)}{1+HG(z)}R(z)$
2		$C(z)=\dfrac{G(z)}{1+G(z)H(z)}R(z)$
3		$C(z)=\dfrac{RG(z)}{1+HG(z)}$
4		$C(z)=\dfrac{RG_1(z)G_2(s)}{1+G_1G_2H(z)}$

5		$C(z)=\frac{G_1(z)G_2(z)}{1+G_1(z)HG_2(z)}R(z)$
6		$C(z)=\frac{G_2(z)G_3(z)RG_1(z)}{1+G_3(z)G_1G_3H(z)}$

作业：p256. 7-5, 7-8