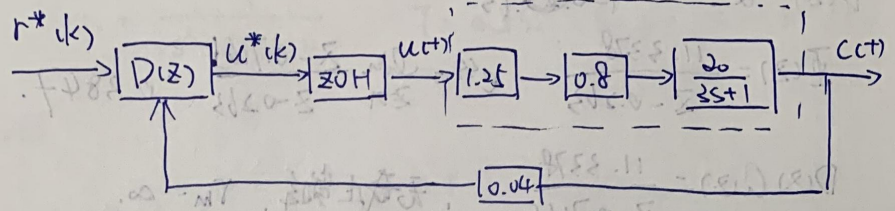
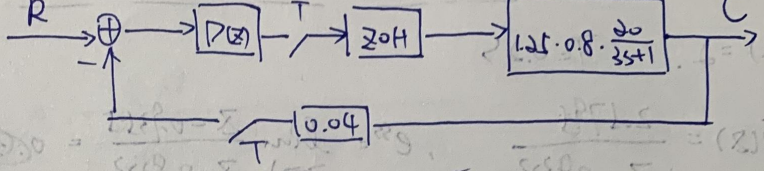
(B3-9) 3.



$D(z)=kd=1,10$

$T=0.2,1$

求闭环. 稳定.



$$D(z)G(z)=\frac{20kd(1-e^{-\frac{1}{3}T})}{z-e^{-\frac{1}{3}T}}$$

$$G(z)=Z\left[\frac{1-e^{-Ts}}{s}\cdot 1.25\cdot 0.8\cdot\frac{20}{3s+1}\right]=Z(1-z^{-1})\cdot Z\left[\frac{20}{s(3s+1)}\right]$$

$$G(z)=\frac{z-1}{z}\cdot\frac{z(1-e^{-\frac{1}{3}T})\cdot 20}{z-1(z-e^{-\frac{1}{3}T})}=\frac{20(1-e^{-\frac{1}{3}T})}{z-e^{-\frac{1}{3}T}}$$

$$e^{ss}=\lim_{z\to 1}\frac{1}{1+D(z)G(z)}$$

$$\Phi(z)=\frac{G(z)D(z)}{1+0.04G(z)D(z)}=\frac{kd\cdot G(z)}{1+0.04kdG(z)}=\frac{20kd(1-e^{-\frac{1}{3}T})}{(z-e^{-\frac{1}{3}T})+0.04kd(1-e^{-\frac{1}{3}T})}$$

$$e^{ss}=\lim_{z\to 1}\frac{z-e^{-\frac{1}{3}T}}{z-e^{-\frac{1}{3}T}+20kd(1-e^{-\frac{1}{3}T})}$$

① $D(z)=1$. $T=0.2s$.

$$G(z)=\frac{1.29}{z-0.936}\ ,\quad \Phi(z)=\frac{1.29}{z-0.884}$$

$$e_{ss}=\lim_{z\to 1}\frac{z-0.935}{z-0.8839}=0.556.$$

$$G(z)D(z)=\frac{1.29}{z-0.936}\ ,\quad \omega_c=7.287\ rad/s\ ,\ \gamma_m=50.3^\circ.$$

$$\omega_h=15.71\ rad/s\quad L_h=20\lg_{10}(1.508)=3.53dB$$

② $D(z)=1$ $T=1s$.

$$\Phi(z)=\frac{1.669}{z-0.4898}.$$

$$e_{ss}=\lim_{z\to 1}\frac{z-0.7165}{z-0.4898}=0.556.$$

$$D(z)G(z)=\frac{1.669}{z-0.7165}\ ,\quad \gamma_m=\infty,\ \omega_h=3.1416\ rad/s$$

无穷止频率 $L_h=\infty 10.378\ dB.$

③ $D(z)=2$. $T=0.15$

$$\Phi(z)=\frac{11.3378}{z-0.263}\qquad e^{ss}=\lim_{z\to 1}\frac{z-0.7165}{z-0.263}=0.3847.$$

$$D(z)G(z)=\frac{11.3378}{z-0.7165}$$，无穿越频率，$\gamma_m=\infty$.

$\omega_h=3.1416\ rad/s$. $L_h=16.39\ dB$

④. $D(z)=2$. $T=0.25$

$$\Phi(z)=\frac{2.5795}{z-0.8323}\qquad e^{ss}=\lim_{z\to 1}\frac{z-0.9355}{z-0.8323}=0.3846$$

$$D(z)G(z)=\frac{2.5795}{z-0.9355}$$：无穿越频率：$\gamma_m=\infty$

$\omega_h=15.708\ rad/s$. $L_h=-3.588\ dB$

(A4-1) 1. $D(s)=\frac{1}{s^2+0.2s+1}$, $T=0.5s$. $s_{1,2}=-0.1\pm 0.995i$. 稳定

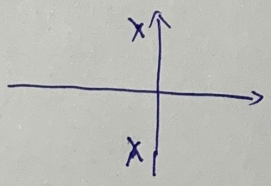
① 向前差分法:

$$D(z)=D(s)\Big|_{s=\frac{z-1}{T}}=\frac{1}{(\frac{z-1}{T})^2+0.2(\frac{z-1}{T})+1}=\frac{T^2}{z^2+(0.2T-2)z+T^2-0.2T+1}$$

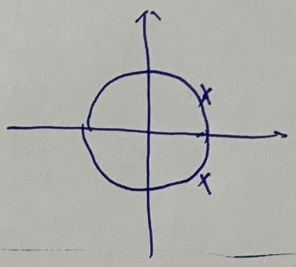
$$D(z)=\frac{0.25}{z^2+(0.1-2)z+0.25-0.1+1}=\frac{0.25}{z^2-1.9z+1.15}$$

$z_{1,2}=0.95\pm 0.497i$, 不稳定.

s域:



⇒ z域

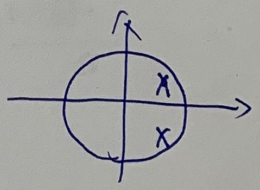


② 向后差分法:

$$D(z)=D(s)\Big|_{s=\frac{z-1}{Tz}}=\frac{1}{(\frac{z-1}{Tz})^2+0.2(\frac{z-1}{Tz})+1}=\frac{(Tz)^2}{(1+1.2T)z^2-(2+0.2T)z+1}$$

$$D(z)=\frac{0.25z^2}{1.6z^2-2.1z+1}$$

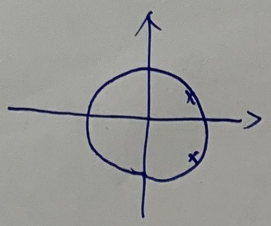
$z_{1,2}=0.6562\pm 0.44i$



③. Tustin 法.

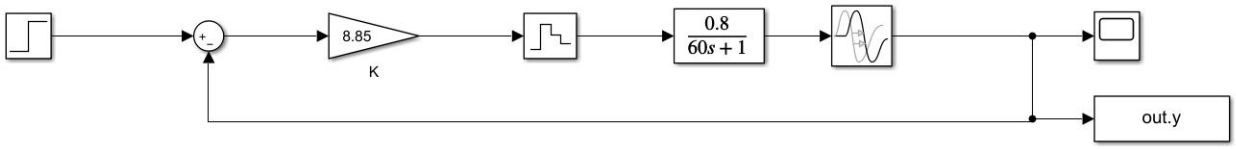
$$D(z)=D(s)\Big|_{s=\frac{2}{T}\frac{z-1}{z+1}}=\frac{1}{(\frac{4(z-1)}{z+1})^2+0.2\times\frac{4(z-1)}{z+1}+1}=\frac{(z+1)^2}{17.8z^2-30z+16.2}$$

$z_{1,2}=0.8427\pm 0.4472i$

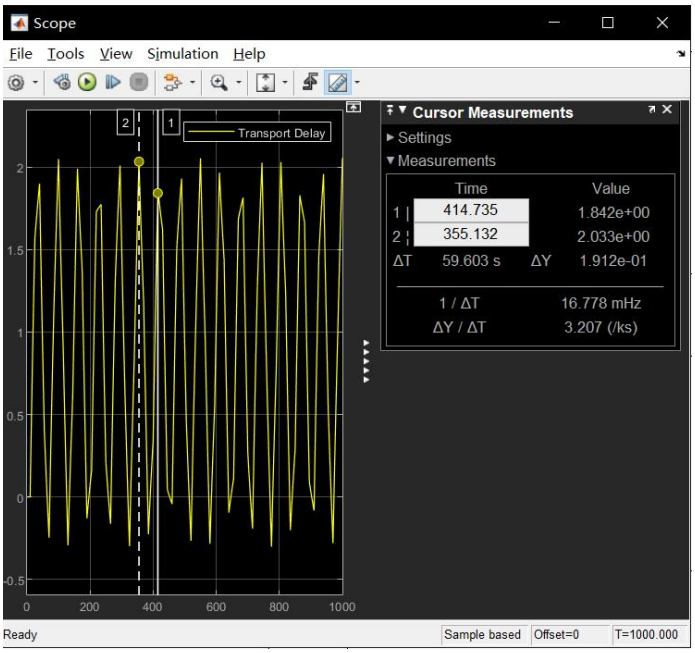


2、

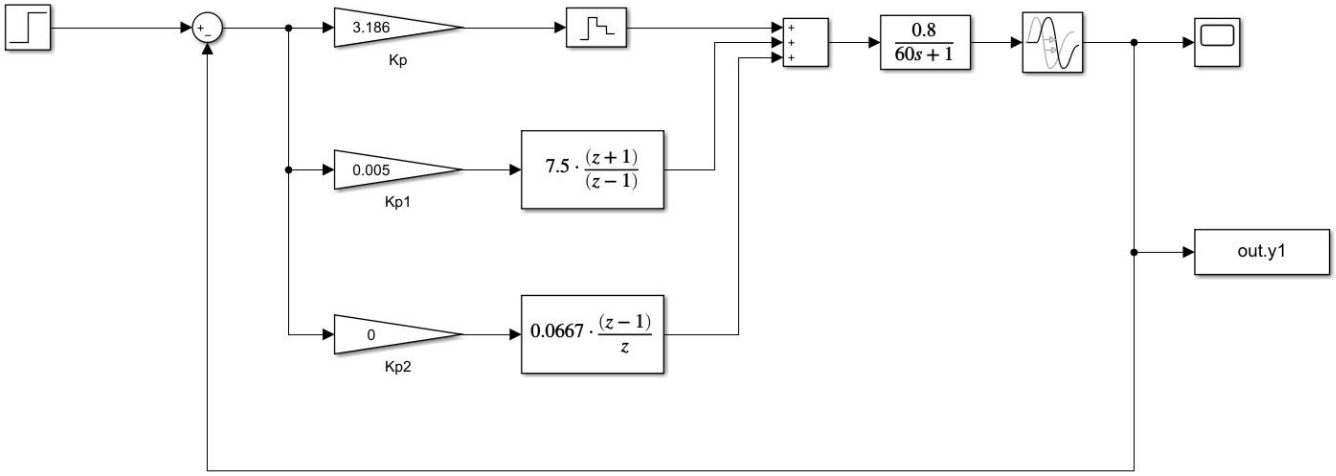
搭建如下系统：



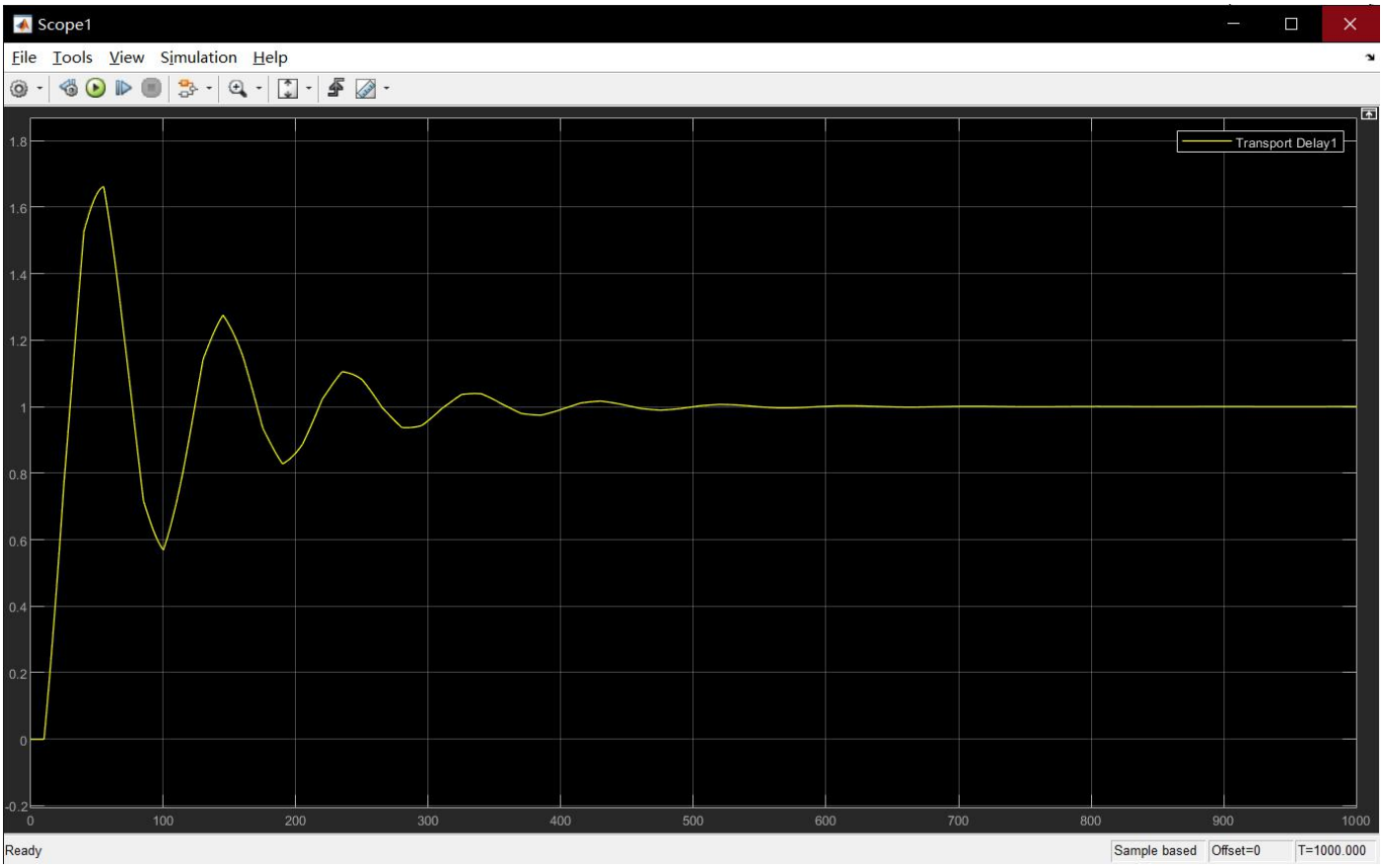
系统等幅震荡时，得到 K_k=8.85；T_k=60s:



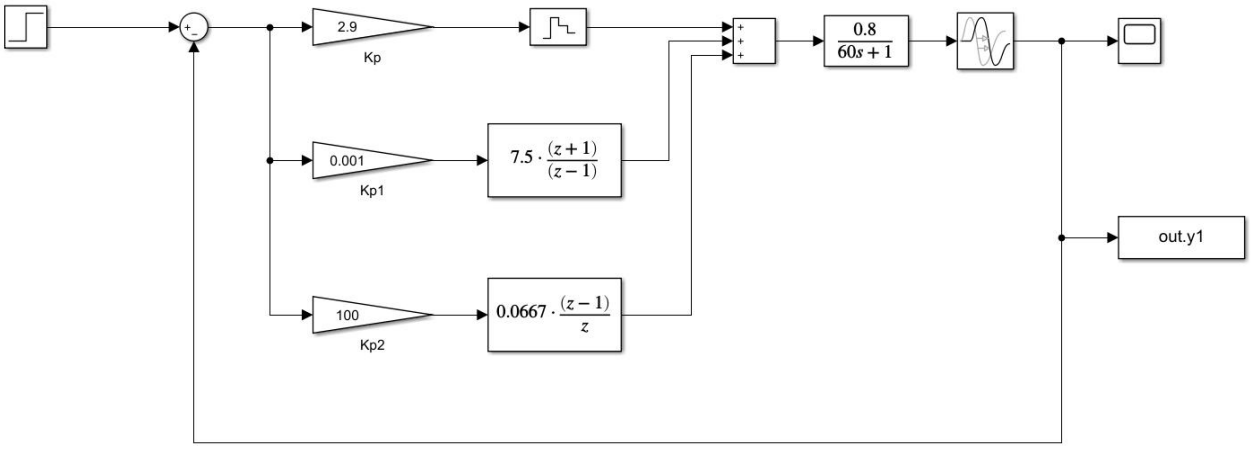
根据表 4-1，计算出 Kp=3.186；Ti=63；搭建相应系统：



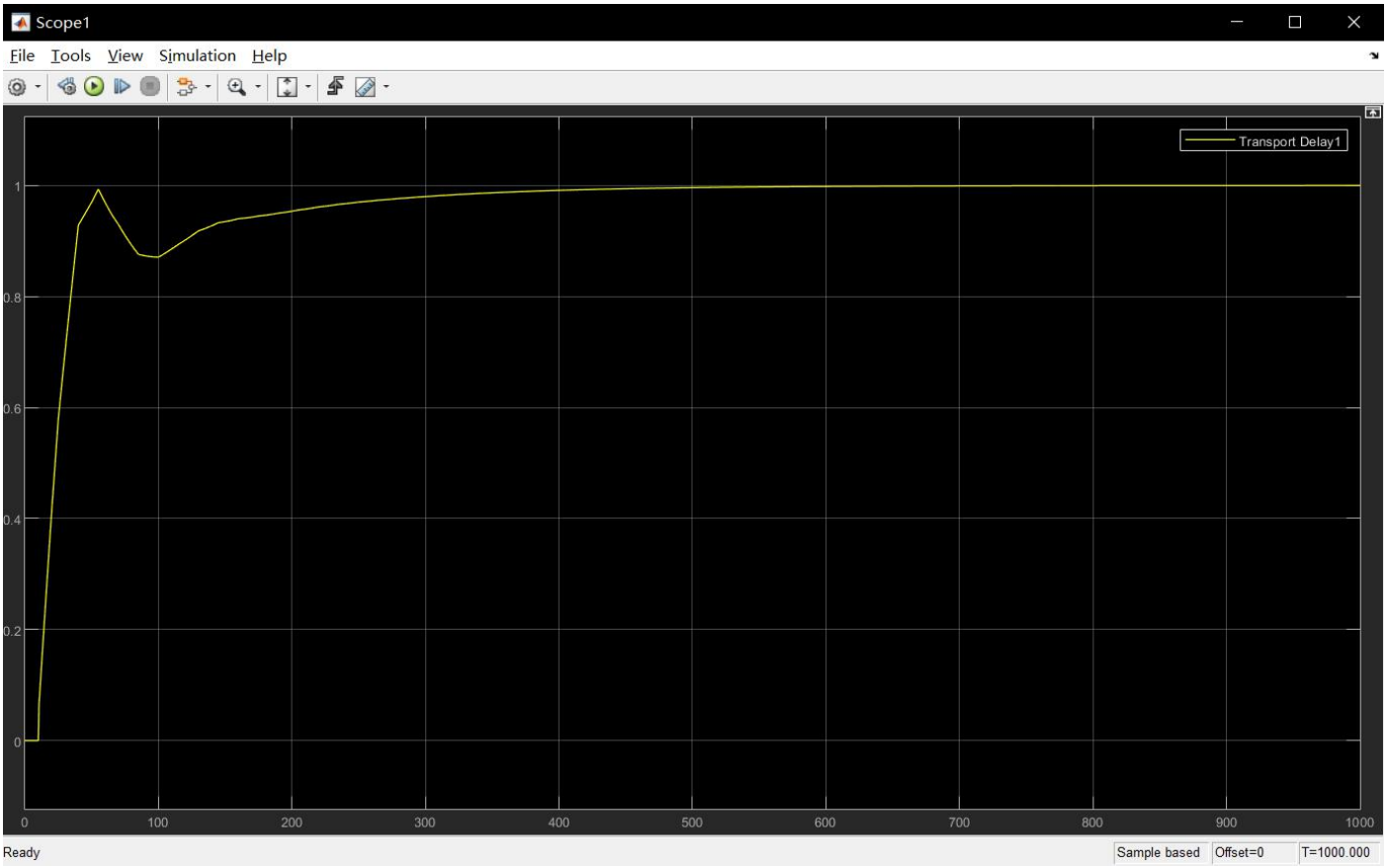
系统阶跃响应如下，不符合题目要求，需要进一步调参。



调参得到如下系统参数：



系统阶跃响应如下，符合题目要求



此时 PID 函数为：

$$D(z) = 2.9 + 0.0075\frac{z+1}{z-1} + 6.67\frac{z-1}{z}$$

当延迟增大到 15/30/60/90 时，此 PID 系统**不能**继续完成预定的指标。
可重新进行 PID 设计环节，也可在变化不大的前提下进行微调。如将延迟增大到 15，系统的 ts 符合题目要求，但系统出现超调量，可手动调整 Kp，并微调 Ti/Td，使得系统重新满足要求。