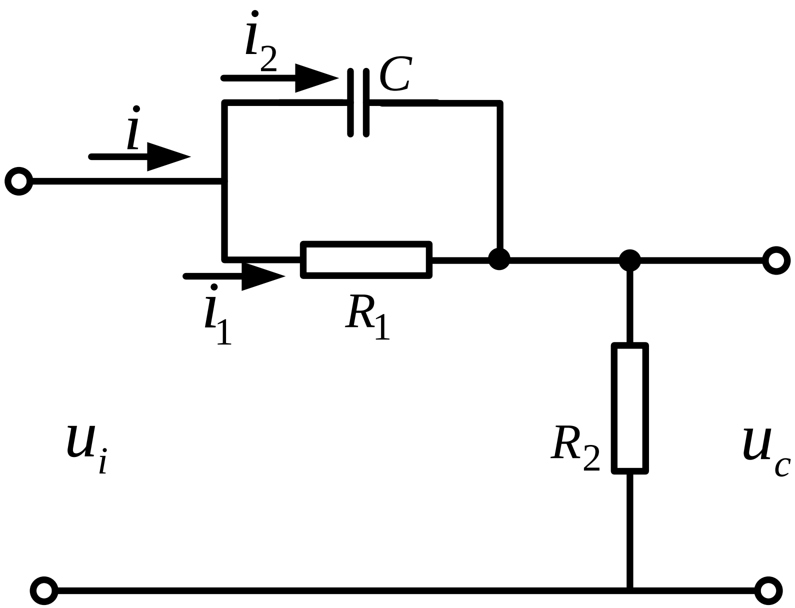
思考题（2.3节）

由微分方程的拉氏变换得到的系统方块图是不是唯一的?



$$i_1 = \frac{u_i - u_C}{R_1}$$

$$\boxed{i_1 R_1 = \frac{1}{C}\int i_2 dt}$$

$$i = i_1 + i_2$$

$$u_C = R_2 i$$

$$i_1 = \frac{u_i - u_C}{R_1}$$

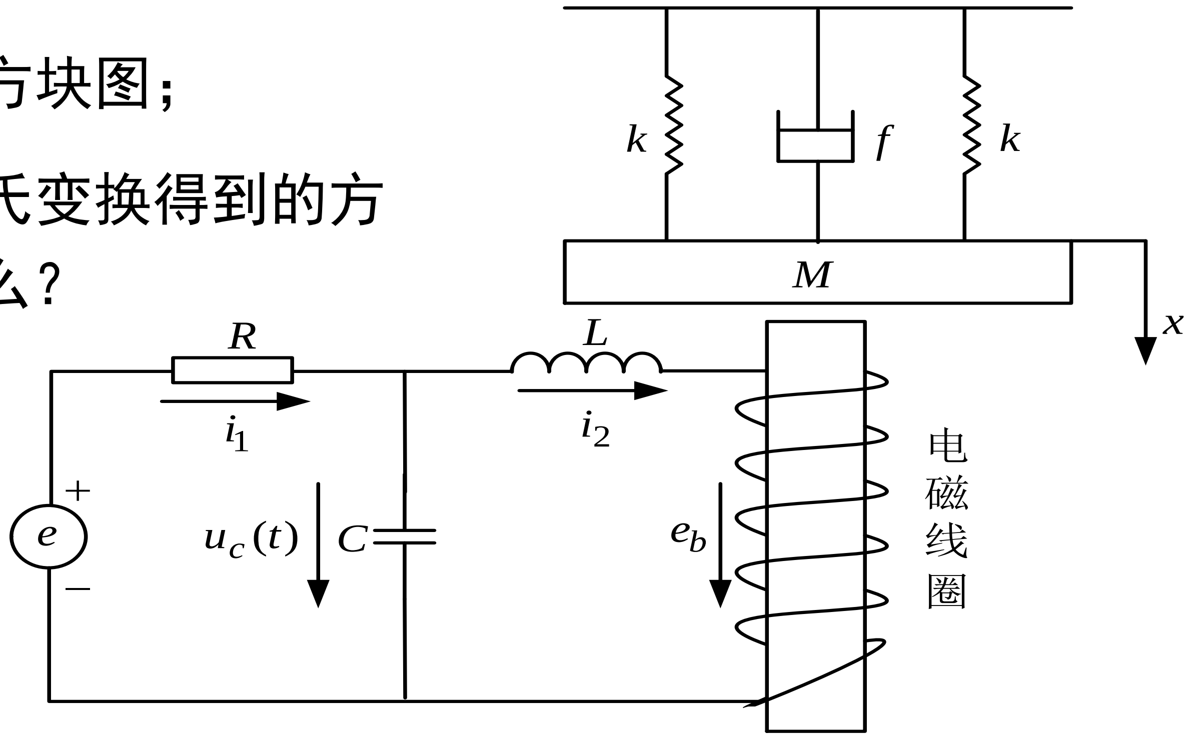
$$\boxed{i_2 = C\frac{d\left(u_i - u_C\right)}{dt}}$$

$$i = i_1 + i_2$$

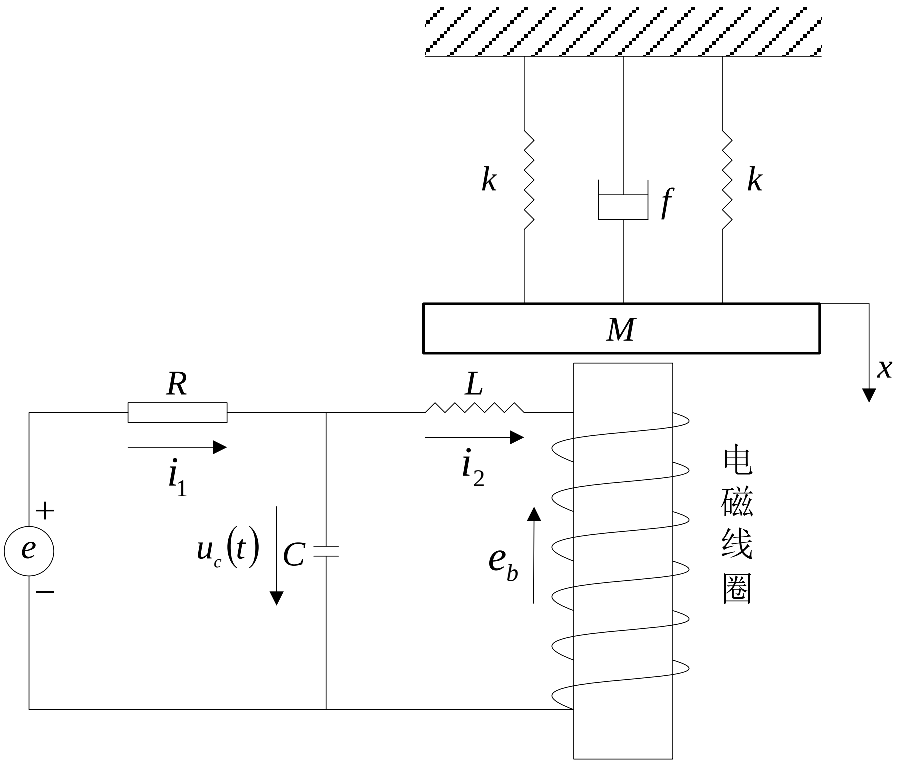
$$u_C = R_2 i$$

已知机电系统如图所示，假定电磁线圈的反电势$e_b = k_1 \dfrac{dx}{dt}$，线圈电流i_2对衔铁M产生的力是$F_0=k_2 i_2$，衔铁M产生的位移x为系统输出，e为系统输入。

1. 列写系统微分方程并求其拉氏变换；
2. 画出对应系统方程的方块图；
3. 说明由微分方程的拉氏变换得到的方块图是否唯一？为什么？
4. 用方块图等效变换求传递函数。并说明传递函数是否唯一？为什么？



已知机电系统如图所示，试求该系统的传递函数。假定电磁线圈的反电势，$e_b = k_1 \dfrac{dx}{dt}$ ，线圈电流 i_2 对衔铁M产生的力是 $F_0 = k_2 i_2$ ，衔铁M产生的位移X为系统输出。



$$e(t) - u_c(t) = Ri_1(t)$$

$$i_1(t) - i_2(t) = c\frac{du_c(t)}{dt}$$

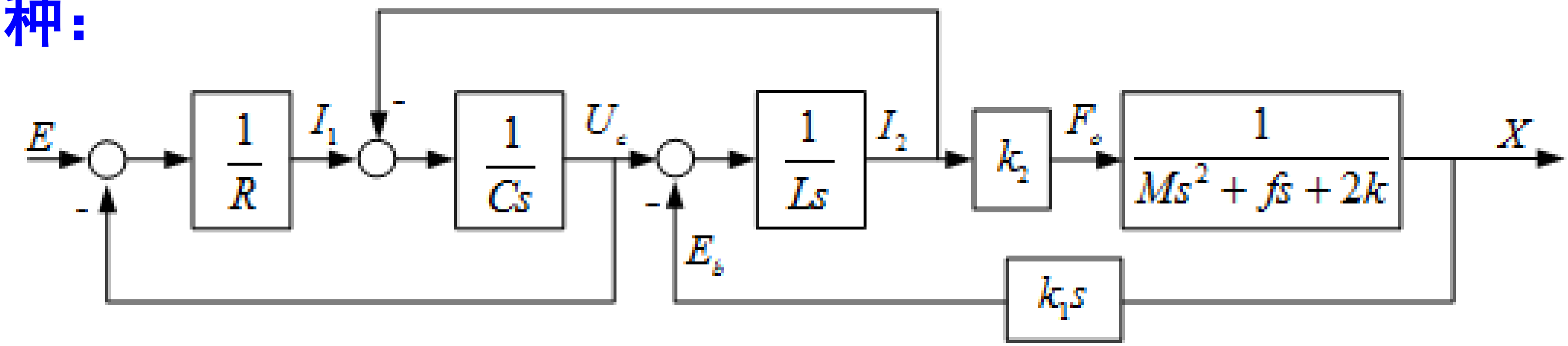
$$u_c(t) + e_b(t) = L\frac{di_2(t)}{dt}$$

$$e_b(t) = k_1\frac{dx}{dt}$$

$$F_0 = k_2 i_2(t)$$

$$F_0 - 2kx(t) - f\frac{dx(t)}{dt} = M\frac{d^2x(t)}{dt^2}$$

第1种：



$$i_1 = \frac{e - u_c}{R} \qquad I_1 = \frac{E - U_c}{R}$$

$$u_c = \frac{1}{C}\int (i_1 - i_2)dt \qquad U_c = \frac{I_1 - I_2}{Cs}$$

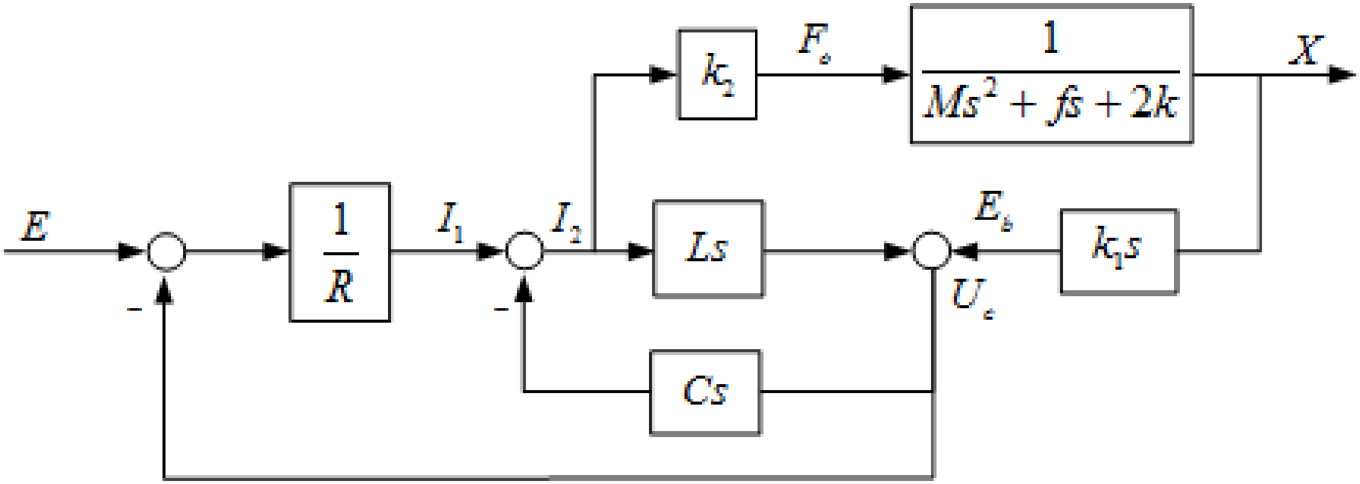
$$i_2 = \frac{1}{L}\int (u_c - e_b)dt \qquad I_2 = \frac{U_c - E_b}{Ls}$$

$$e_b = k_1 \frac{dx}{dt} \qquad E_b = k_1 sX$$

$$F_0 = k_2 i_2 \qquad F_0 = k_2 I_2$$

$$M\frac{d^2x}{dt^2} = F_0 - f\frac{dx}{dt} - 2kx \qquad X = \frac{1}{Ms^2 + fs + 2k}F_0$$

第2种：



$$I_1 = \frac{E - U_c}{R}$$

$$U_c = \frac{I_1 - I_2}{Cs} \qquad I_2 = I_1 - CsU_c$$

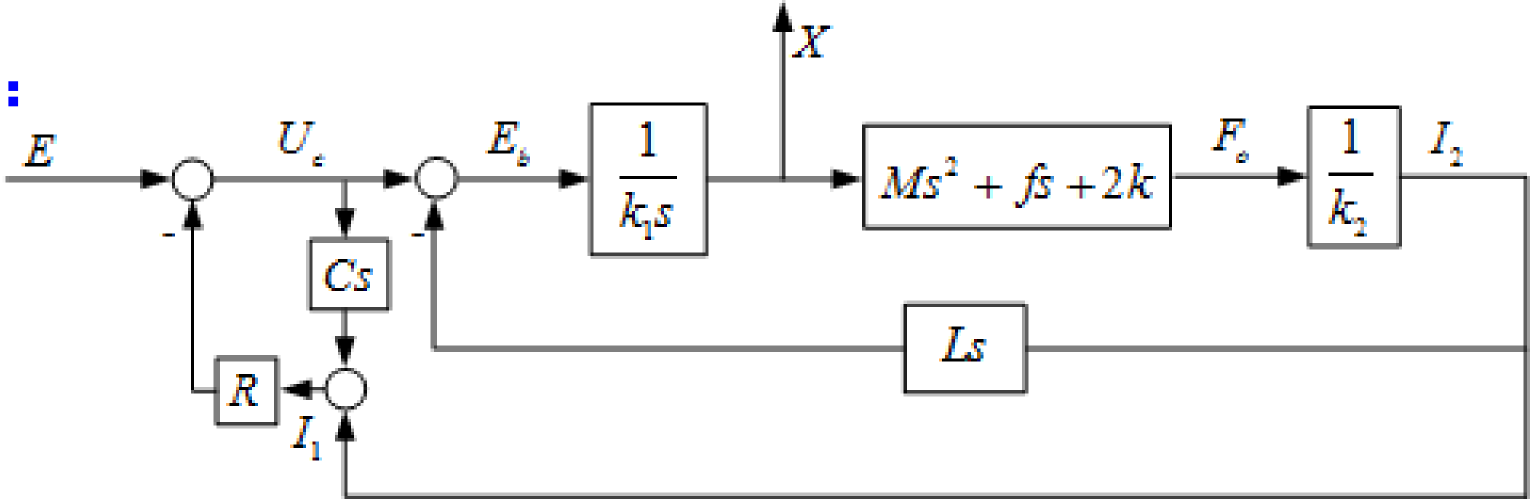
$$I_2 = \frac{U_c - E_b}{Ls} \qquad U_c = LsI_2 - E_b$$

$$E_b = k_1 sX$$

$$F_0 = k_2 I_2$$

$$X = \frac{1}{Ms^2 + fs + 2k} F_0$$

第3种：



$$I_1 = \frac{E - U_c}{R}$$

$$U_c = E - RI_1$$

$$U_c = \frac{I_1 - I_2}{Cs}$$

$$I_1 = CsU_c + I_2$$

$$E_b = k_1 sX$$

$$X = \frac{E_b}{k_1 s}$$

$$X = \frac{1}{Ms^2 + fs + 2k} F_0$$

$$F_0 = (Ms^2 + fs + 2k)X$$

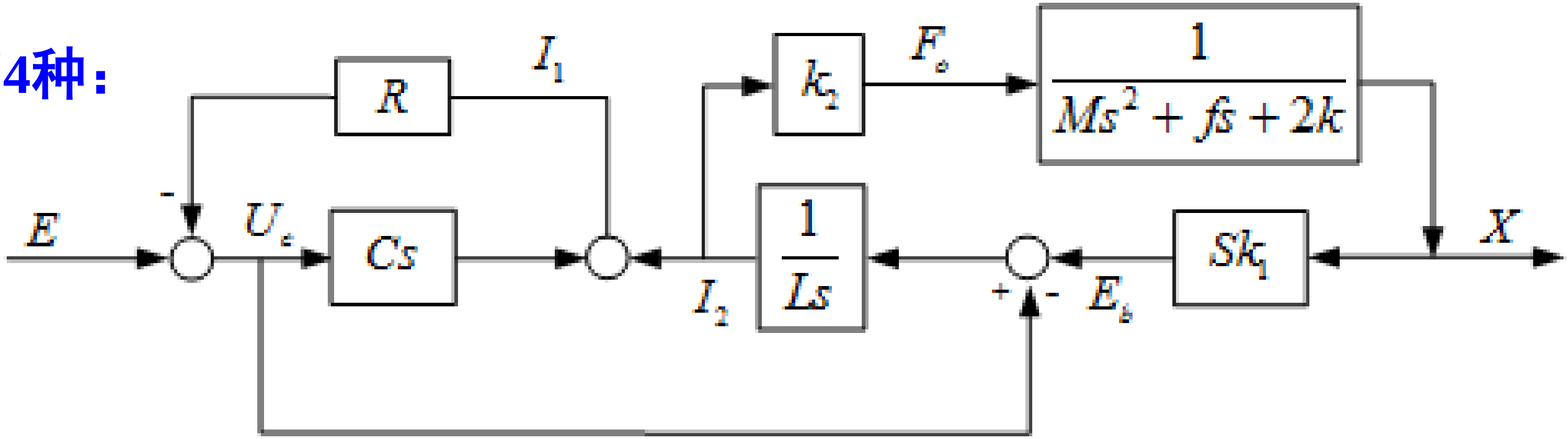
$$F_0 = k_2 I_2$$

$$I_2 = \frac{F_0}{k_2}$$

$$I_2 = \frac{U_c - E_b}{Ls}$$

$$E_b = U_c - LsI_2$$

第4种：



$$I_1 = \frac{E - U_c}{R} \qquad U_c = E - RI_1$$

$$U_c = \frac{I_1 - I_2}{Cs} \qquad I_1 = CsU_c + I_2$$

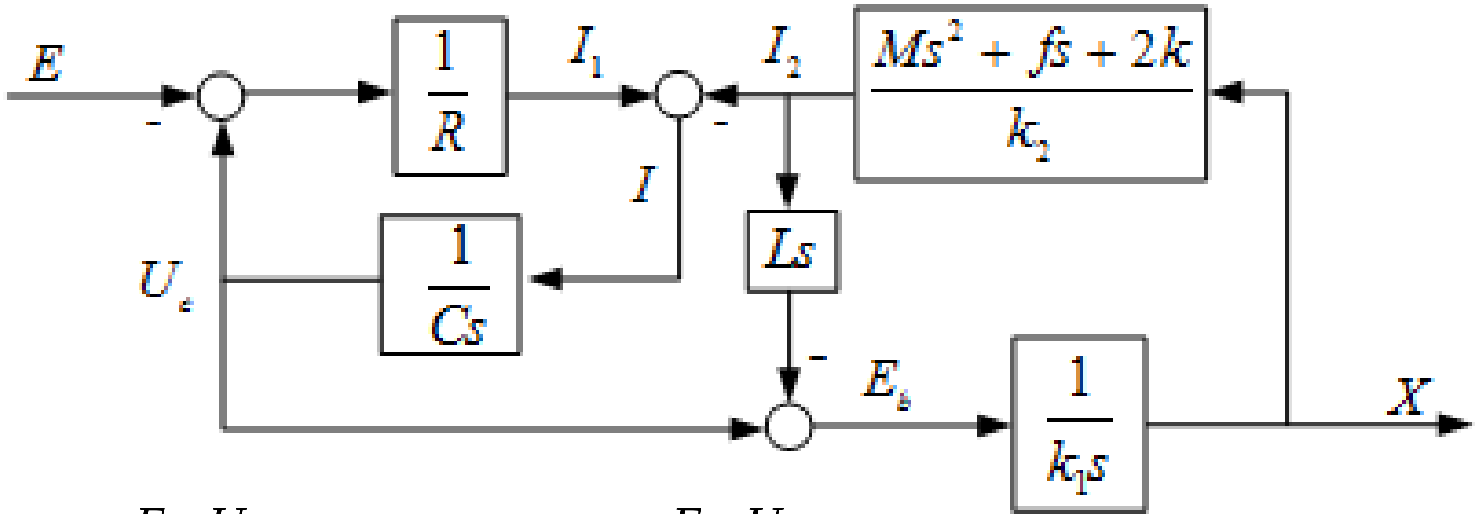
$$I_2 = \frac{U_c - E_b}{Ls} \qquad I_2 = \frac{U_c - E_b}{Ls}$$

$$E_b = k_1 sX \qquad E_b = k_1 sX$$

$$F_0 = k_2 I_2 \qquad F_0 = k_2 I_2$$

$$X = \frac{1}{Ms^2 + fs + 2k} F_0 \qquad X = \frac{1}{Ms^2 + fs + 2k} F_0$$

第5种：



$$I_1 = \frac{E - U_c}{R}$$

$$U_c = \frac{I_1 - I_2}{Cs}$$

$$I_2 = \frac{U_c - E_b}{Ls}$$

$$E_b = k_1 s X$$

$$F_0 = k_2 I_2$$

$$X = \frac{1}{Ms^2 + fs + 2k} F_0$$

$$I_1 = \frac{E - U_c}{R}$$

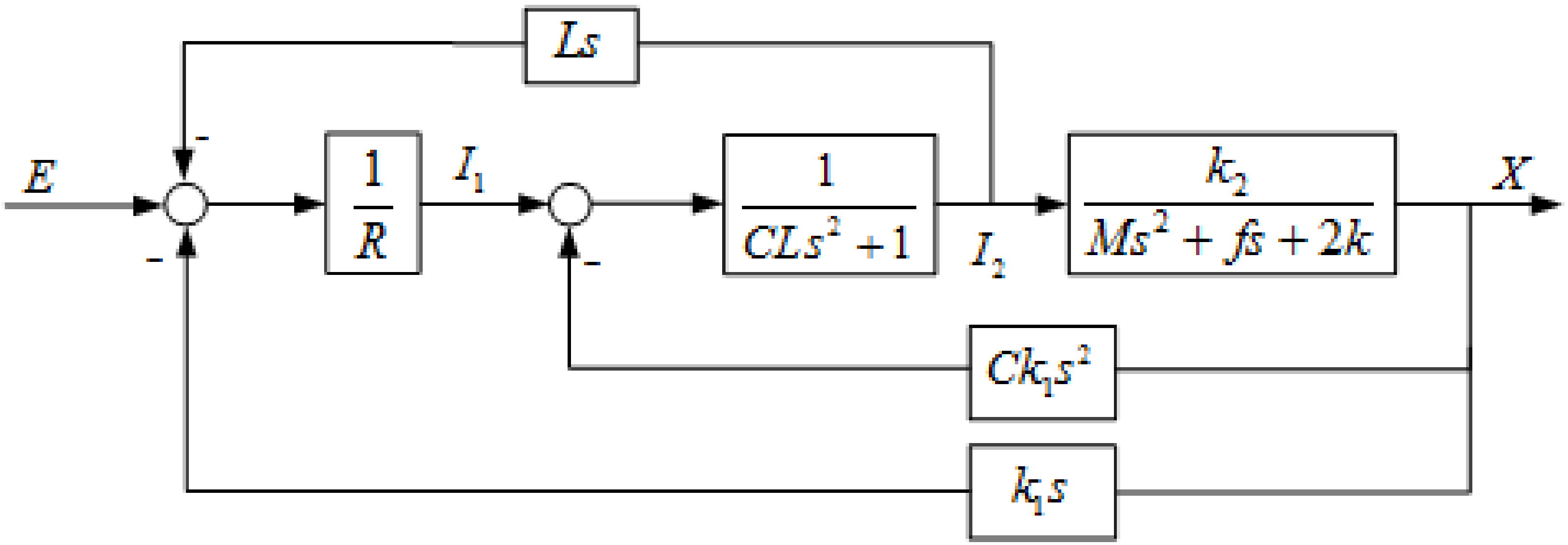
$$U_c = \frac{I_1 - I_2}{Cs}$$

$$E_b = U_c - LsI_2$$

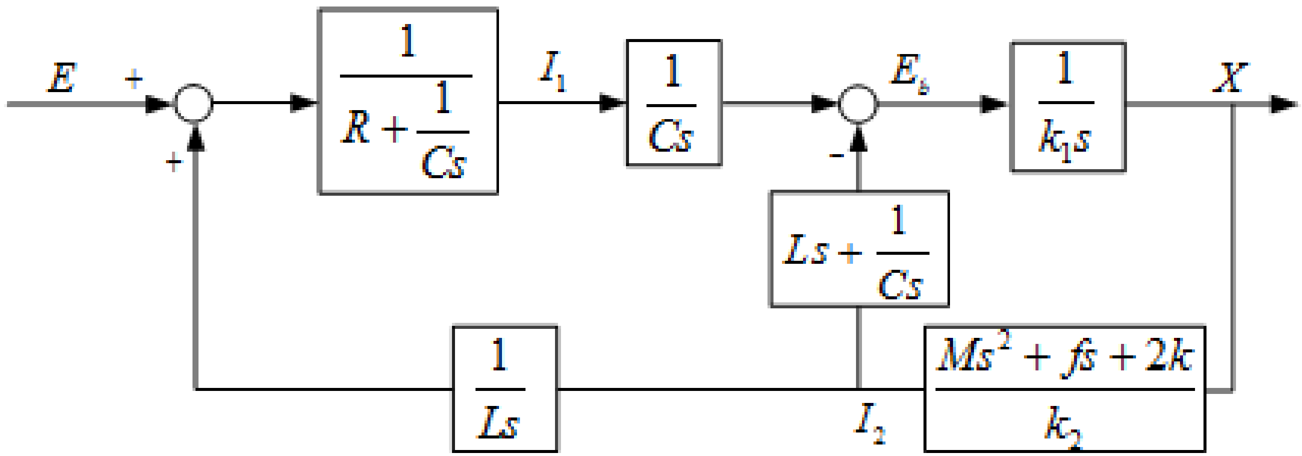
$$X = \frac{E_b}{k_1 s}$$

$$I_2 = \frac{Ms^2 + fs + 2k}{k_2} X$$

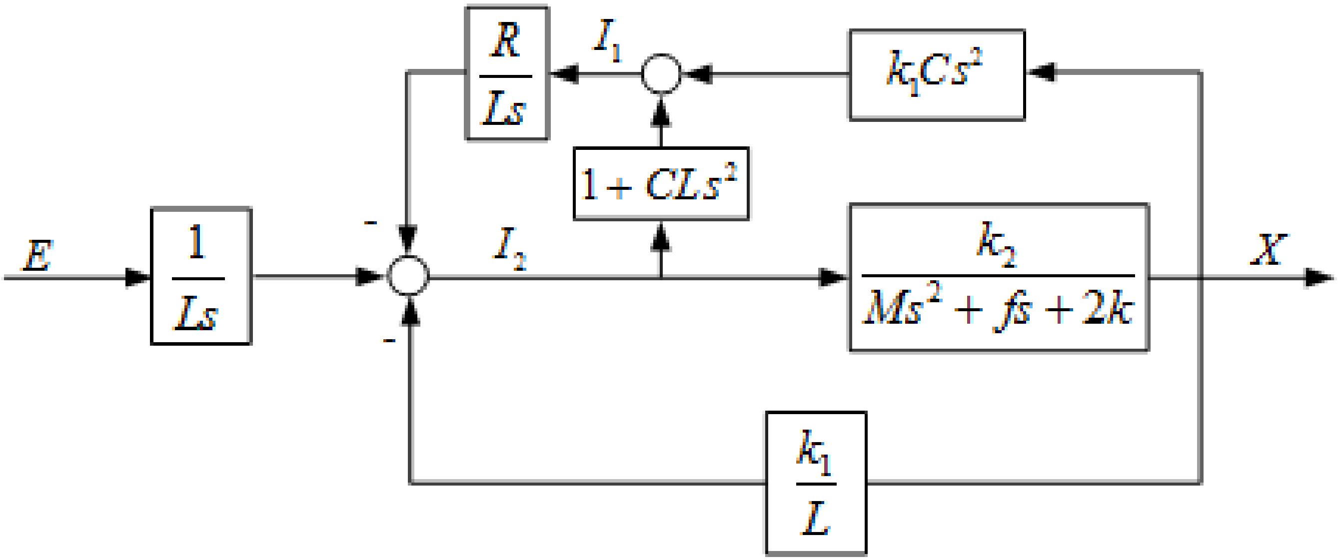
第6种：



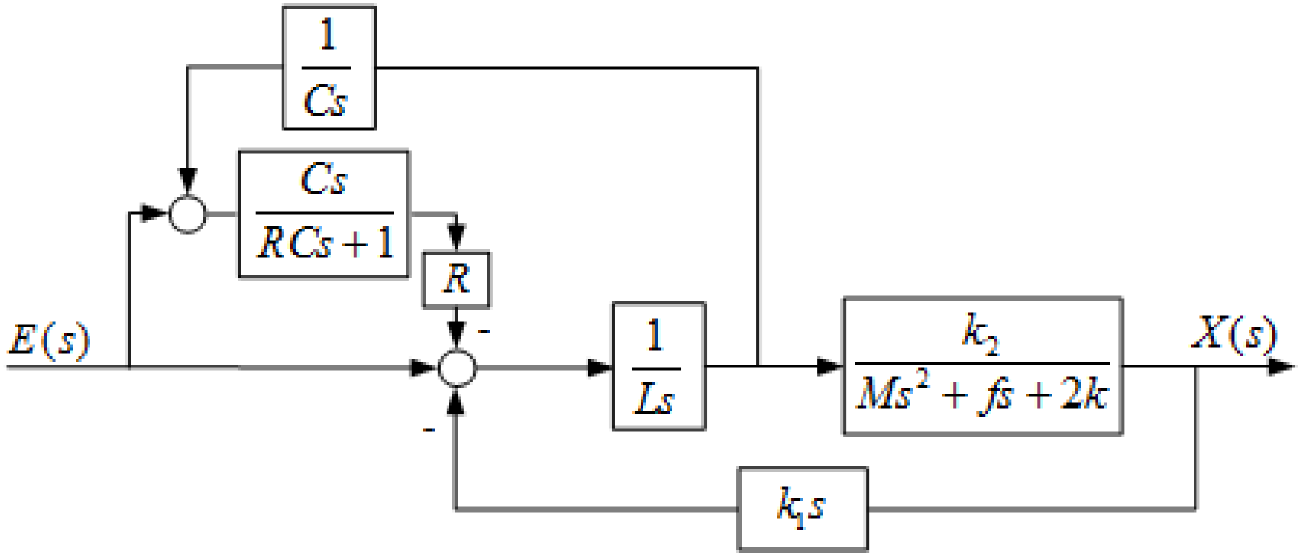
第7种：



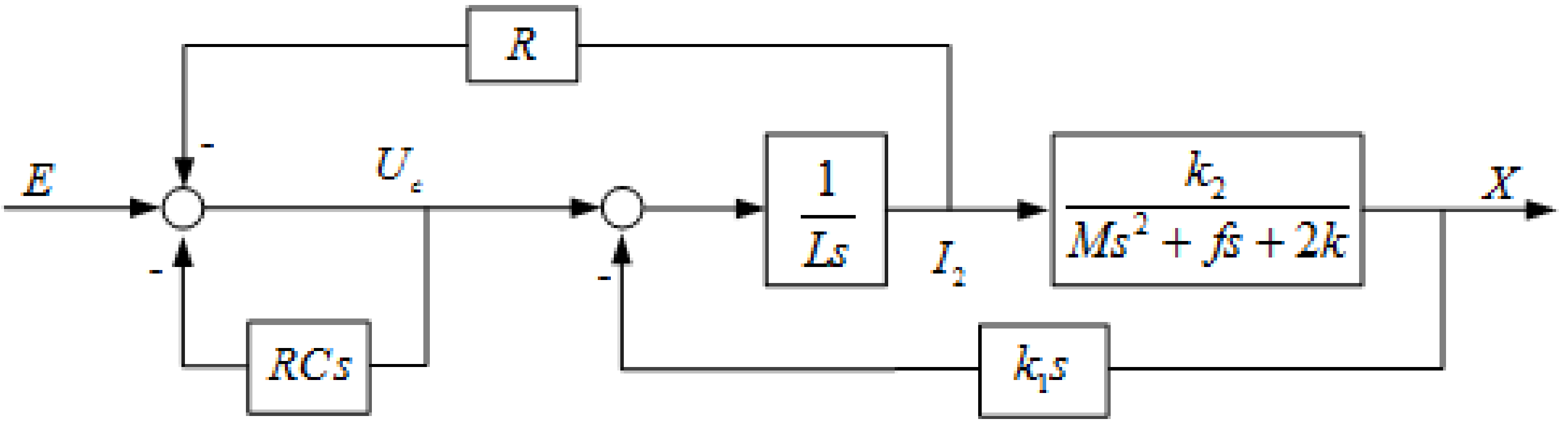
第8种：


E
$\frac{1}{Ls}$
-
-
I_2
$\frac{R}{Ls}$
I_1
$1+CLs^2$
k_1Cs^2
$\frac{k_2}{Ms^2+fs+2k}$
X
$\frac{k_1}{L}$

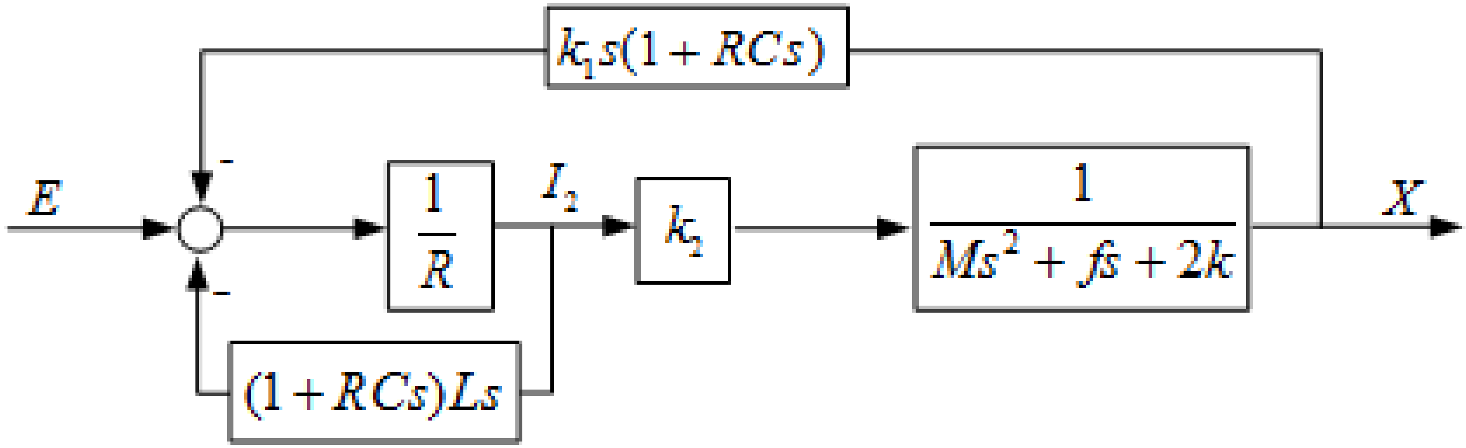
第9种：



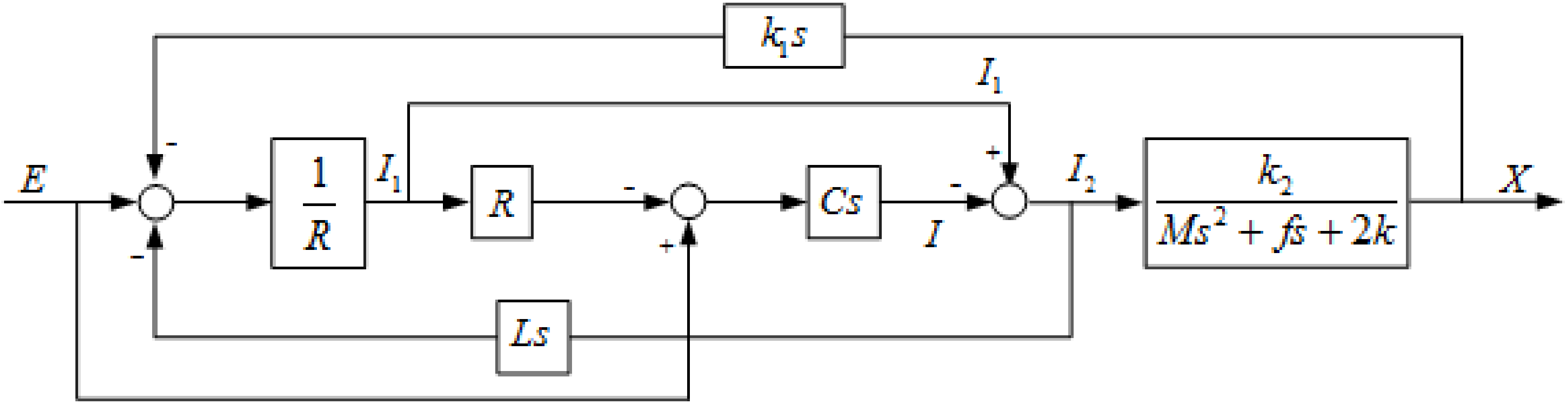
第10种：



第11种：



第12种：



传递函数:

$$I_1(s) = [E(s) - U_c(s)]/R \qquad E_b(s) = K_1 s X(s)$$

$$U_c(s) = [I_1(s) - I_2(s)]/Cs \qquad F_0(s) = K_2 I_2(s)$$

$$I_2(s) = [U_c(s) - E_b(s)]/Ls \qquad X(s) = \frac{1}{Ms^2 + fs + 2K} F_0(s)$$

$$\therefore \frac{X(s)}{E(s)} = \frac{P_1 \Delta_1}{\Delta} = \frac{k_2}{\Delta'}$$

$$\begin{aligned}\Delta' = {} & RCLMS^4 + (RCLf + LM)S^3 \\ & +(2RCLk + Lf + RM + RC)S^2 \\ & +(2Lk + Rf + k_1 k_2)S + 2Rk\end{aligned}$$