$$C(s) = k\left(1+\frac{1}{T_I s}\right) = k\left(\frac{T_I s+1}{T_I s}\right)$$

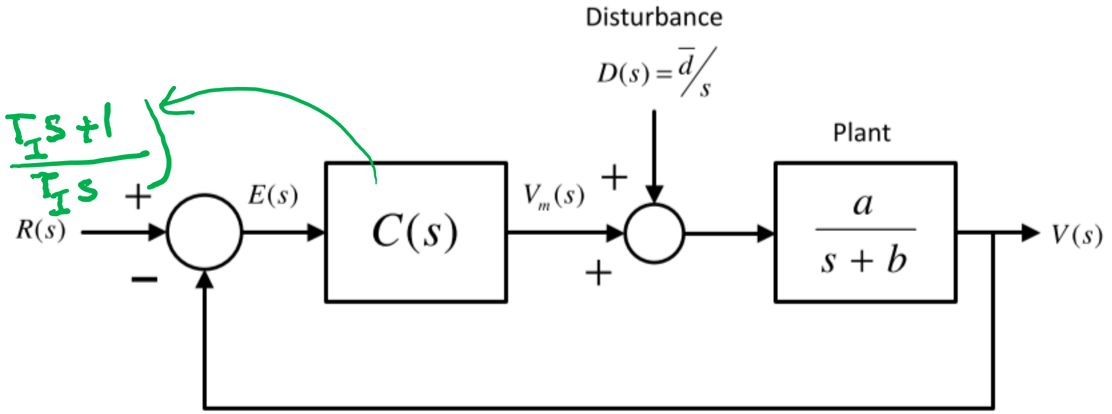

Figure 2: Block diagram of the closed-loop system

1. The transfer function of the plant is $P(s)=\frac{a}{s+b}$, it has one pole at $s=-b$. Since $b \neq 0$. The plant is type zero.

$$\frac{V(s)}{R(s)} = \frac{C(s)P(s)}{1+C(s)P(s)}, \quad E(s) = R(s)-V(s) = R(s)\left[1-\frac{C(s)P(s)}{1+C(s)P(s)}\right]$$

$$\Rightarrow \frac{E(s)}{R(s)} = \frac{1}{1+C(s)P(s)} = \frac{T_I s(s+b)}{T_I s(s+b)+ak(T_I s+1)} = \frac{T_I s(s+b)}{T_I s^2+(bT_I+akT_I)s+ak}$$

$$\frac{V(s)}{D(s)} = \frac{P(s)}{1+C(s)P(s)} \Rightarrow \frac{E(s)}{D(s)} = \frac{-P(s)}{1+C(s)P(s)} = \frac{-aT_I s}{T_I s(s+b)+ak(T_I s+1)} = \frac{-aT_I s}{T_I s^2+(bT_I+akT_I)s+ak}$$

② $R(s) = \dfrac{\bar{V}}{s}$, $D(s) = \dfrac{\bar{d}}{s}$.

using superposition $E(s) = \dfrac{T_I \cancel{s}(s+b)}{T_I s^2 + (bT_I + akT_I)s + ak} \dfrac{\bar{V}}{\cancel{s}} + \dfrac{-aT_I \cancel{s}}{T_I s^2 + (bT_I + akT_I)s + ak} \dfrac{\bar{d}}{\cancel{s}}$

③ Assuming $\lim_{t \to \infty} e(t)$ exists (The closed loop is BIBO stable) .

Then we Can apply F.V.T.

$$\lim_{s \to 0} sE(s) = \lim_{s \to 0} s \left(\frac{T_I \bar{V}(s+b) - aT_I \bar{d}}{T_I s^2 + (bT_I + akT_I)s + ak} \right)$$

$$= 0 .$$