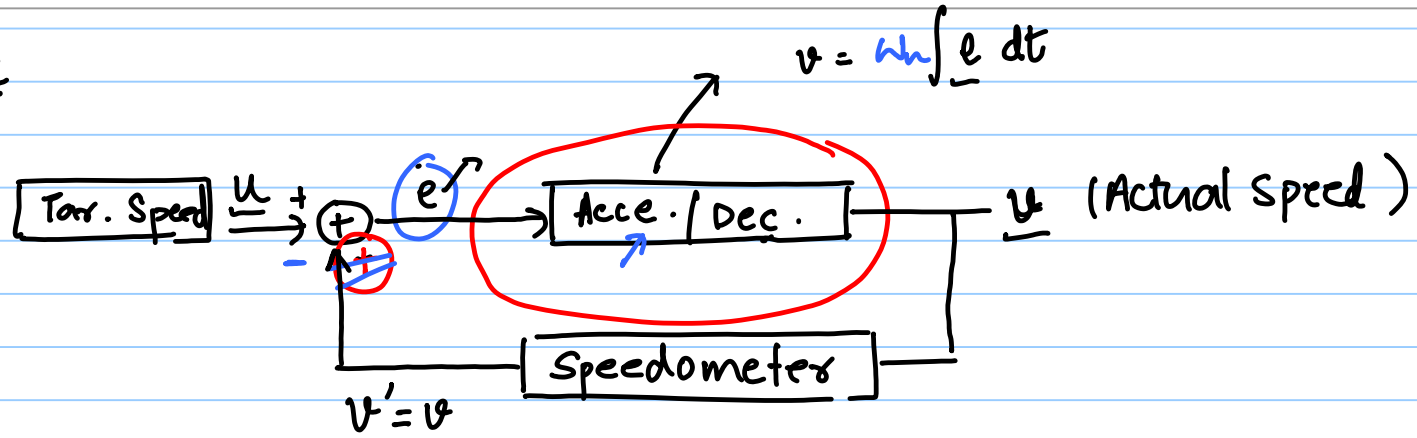
Lecture #5

Note Title 23-01-2020

Example



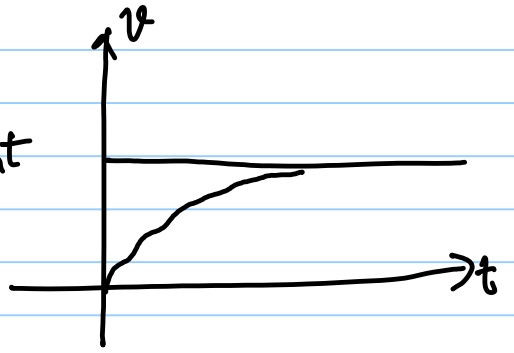
$$\omega_n \int_0^t e \cdot dt = v$$

$$\omega_n \int_0^t (u - v)\, dt = v \Rightarrow \boxed{\omega_n (u - v) = \frac{dv}{dt}}$$

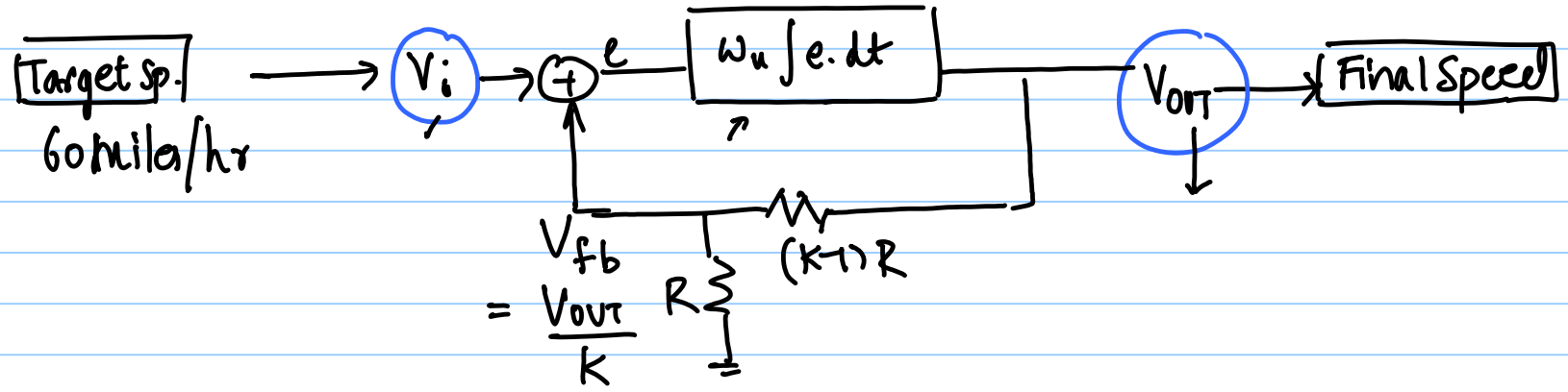
$$\frac{dv}{dt} + \omega_n \cdot v = \omega_n u$$

$$v(t) = e^{-\omega_n t} \int \omega_n \cdot u \, e^{\omega_n t} \, dt + Q e^{-\omega_n t}$$

$$v(t) = u \left(1 - e^{-\omega_n t}\right)$$



Bike → Automatic

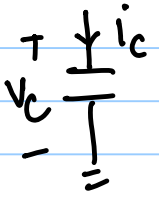


$V_{OUT} = KV_i$

$e = V_i - V_{fb} \to 0$

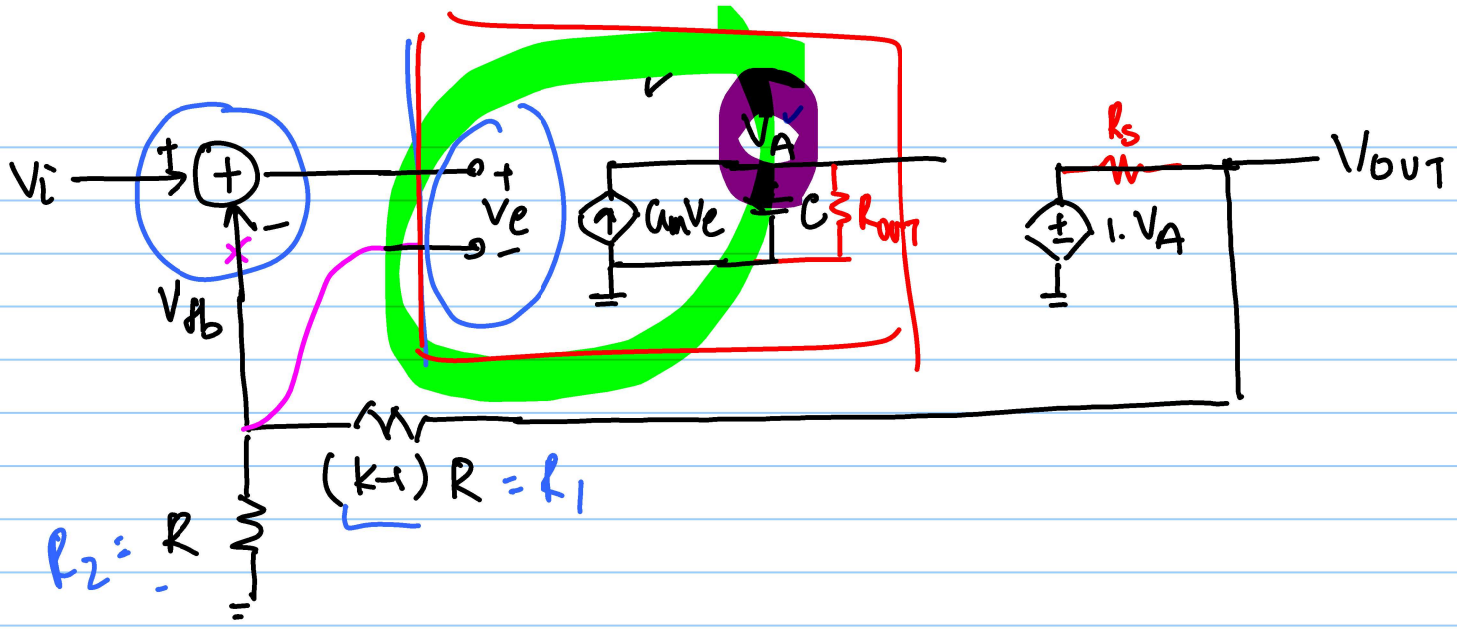
$V_{out} = \omega_n \int e \cdot dt$

$V_{fb} = \frac{V_{OUT}}{K} = \frac{kV_i}{k}$



$V(t) = \frac{1}{C} \int i \, dt$

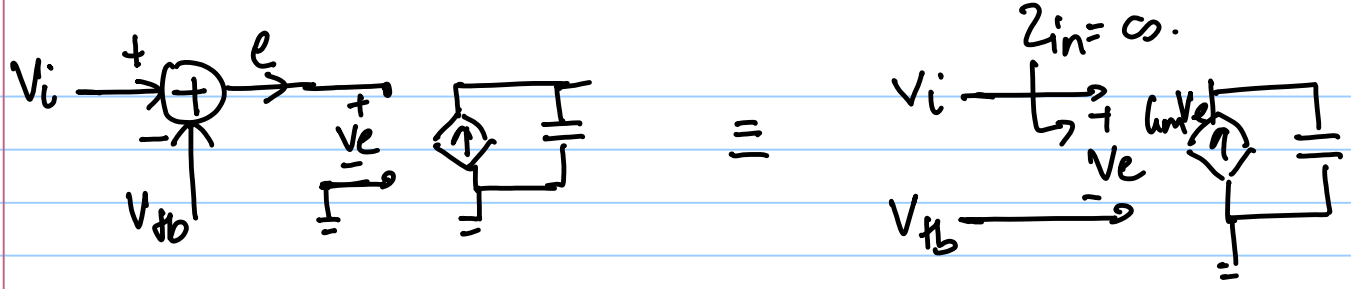
V_i (VCCS)



$$V_A = \frac{1}{C}\int G_m V_e \cdot dt = \frac{1}{C}\int \underbrace{G_m(V_i - V_{fb})}_{i}\, dt = \frac{G_m}{C}\int (V_i - V_{fb})\, dt$$

$$V_{out} = \frac{G_m}{C}\int \left(V_i - \frac{V_{out}}{K}\right) dt$$

$$\frac{dV_{out}}{dt} = \underbrace{\frac{G_m}{C}}_{\omega_n}\left(V_i - \frac{V_{out}}{K}\right) \quad \Rightarrow \quad V_{out} = KV_i\left(1 - e^{-\omega_n t}\right) u(t)$$



$V_e = e = V_i - V_{fb}$

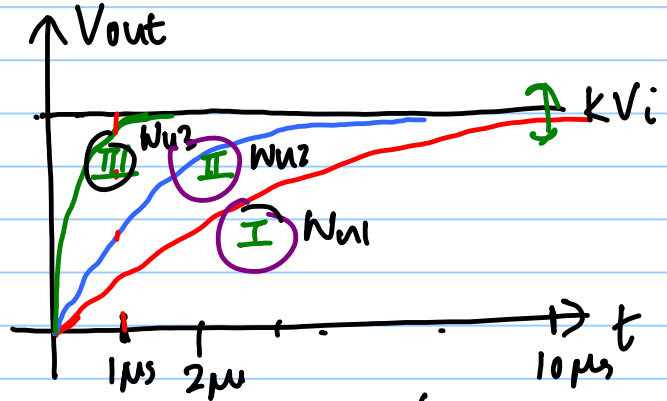
$$V_{out} = K V_i$$

$$V_i = \frac{V_{out}}{K}$$

$$\frac{V_{out}'}{K} = V_{fb}$$

$$V_e = V_i - \frac{V_{out}'}{K}$$

$$V_{out}: K V_i \left(1 - e^{-\omega_n t}\right) u(t)$$

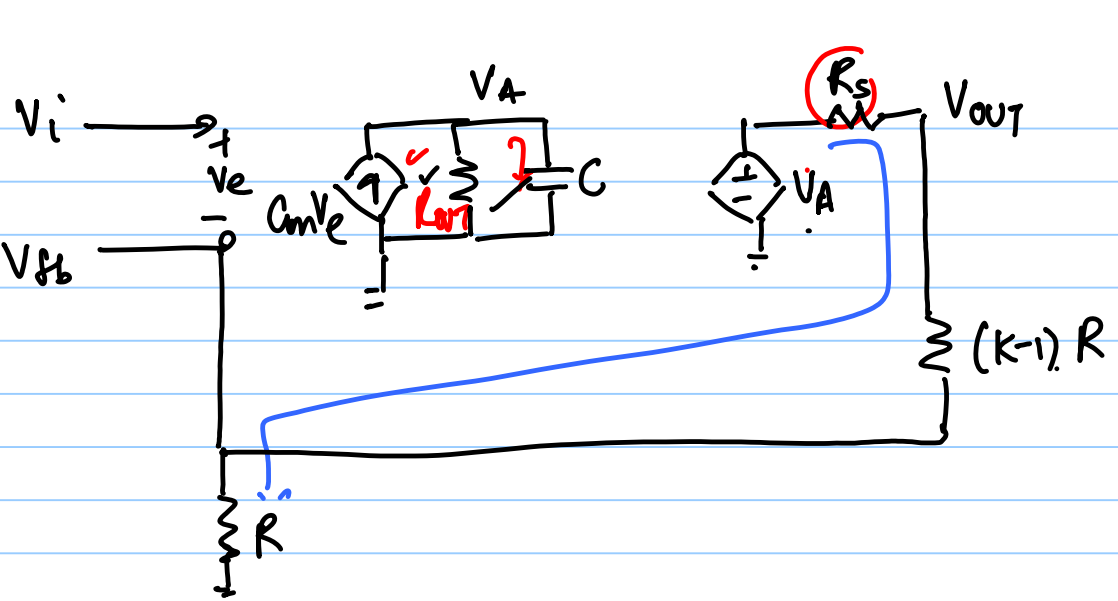


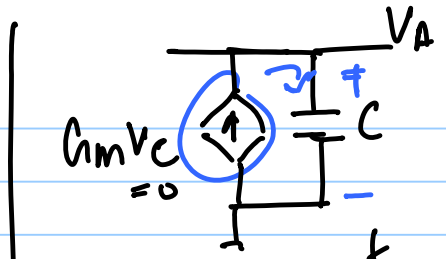
$\omega_{n3} > \omega_{n2} > \omega_{n1}$

$\lim_{t \to \infty} V_e(t) = 0$

$\lim_{t \to \infty} V_{fb}(t) = V_i$

$\frac{dV_{out}}{dt}$





$$V_A = \frac{1}{C}\int_0^t G_m V_e \cdot dt$$

$$\frac{G_m}{C} = \omega_n$$

$C = 0$

$$V_{fb} = \frac{V_{OUT}}{K}$$

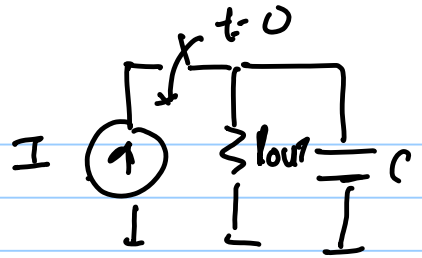
$$V_{OUT} = \frac{KR}{KR+R_S} V_A$$

$R_{out} \to \infty$, R_S finite value.

$$V_i = V_{fb} = \frac{V_{OUT}}{K}$$

$$V_A = \frac{KR+R_S}{KR} \cdot V_{OUT} = \left(1 + \frac{R_S}{KA}\right) V_{OUT}$$

$R_S \to 0$, R_{out} = finite.



$I R_{out}$

$$V_{fb} = \frac{V_{out}}{K} = \frac{V_A}{K}$$

$$V_{out} = V_A = G_m . V_e . R_{out} = G_m R_{out} \left(V_{in} - \frac{V_{out}}{K} \right)$$

$$V_{out} = \underbrace{G_m R_{out}}_{A_{DC}} \left(V_{in} - \frac{V_{out}}{K} \right)$$

$$V_{out} \left(\frac{1}{A_{DC}} + \frac{1}{K} \right) = V_{in} \Rightarrow \underline{V_{out}} = \frac{K V_{in}}{\left(1 + \frac{K}{A_{DC}} \right)}$$

$A_{DC} = G_m R_{out}$

$$V_e = V_{in} - \frac{V_{in}}{\left(1 + \frac{K}{A_{DC}} \right)} = V_{in} \left(\frac{K/A_{DC}}{1 + K/A_{DC}} \right)$$

$$\Delta V_{out} = K V_{in} - \frac{K V_{in}}{1 + \frac{K}{A_{DC}}}$$