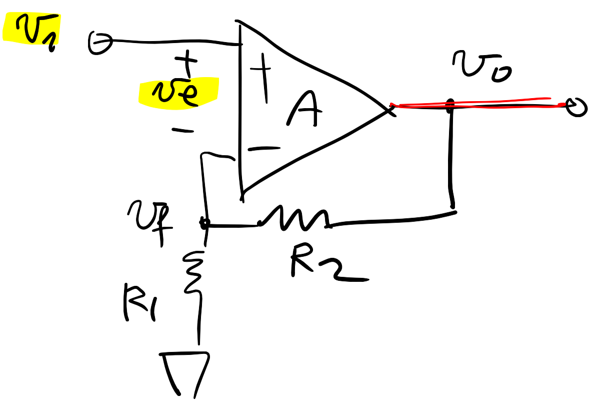
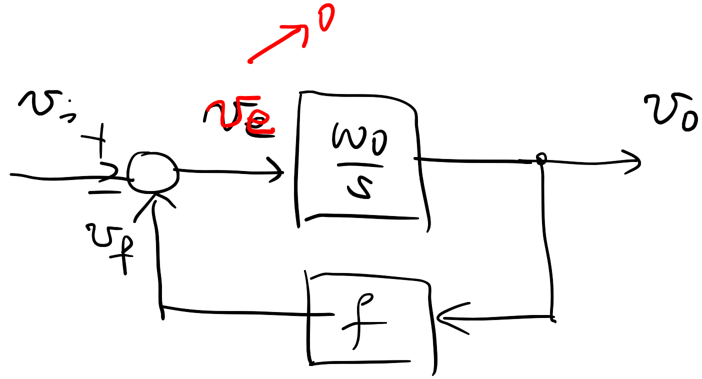
L6 – Op-Amp (Dynamics)





"well-designed"

$$A f \to \infty \Rightarrow v_e \to 0.$$

$$\underline{v_i = v_f} = v_o f$$

$$\boxed{v_o = \frac{1}{f} \cdot v_i}$$

① $A \to \infty$

② $A(s) = \frac{\omega_0}{s}$

$\omega_0 = ?$, op27

• $\omega_0 \doteq 2\pi \times 10^7$ rad/s

① $v_o(t)$.

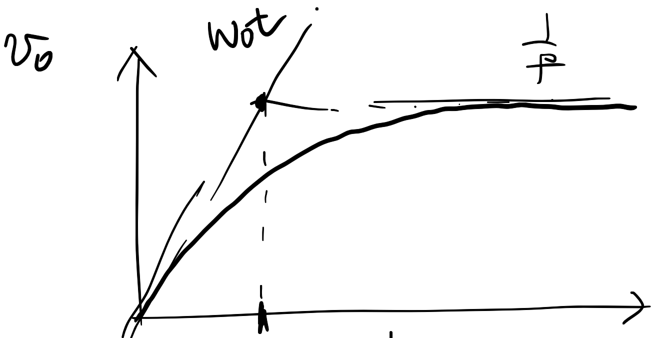
② $v_e(t)$.

$$\frac{v_o}{v_i} = G(s) = \frac{\frac{\omega_0}{s}}{1 + \frac{\omega_0}{s} \cdot f} = \boxed{\frac{\omega_0}{s + \omega_0 f}}$$

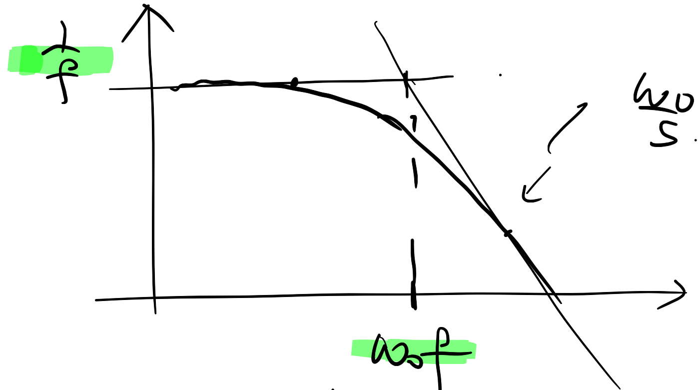
"Evans form"

$$= \frac{1}{f}\left(\frac{1}{\frac{1}{\omega_0 f} s + 1}\right)$$

"Bode"



$\tau = \frac{1}{\omega_{0f}}$



- "time const" $\frac{1}{\omega_{0f}}$
- Initial Resp : $\omega_0 t$
- F.V $= \frac{1}{f}$

"Infer"

- "Bandwidth" $= \omega_{0f}$
- HF resp $= \frac{\omega_0}{s}$
- DC $= \frac{1}{f}$

① Key features :

- Rise time t_r ⟵ ω_h " Bandwidth "
- Overshoot. ⟵ Resonant peak . ⟵ ϕ_m $L(s)$
- Steady state ⟵ DC gain .

② $\left(\underbrace{\text{DC gain}}_{\boxed{\frac{1}{f}}} \times \text{Bandwidth}\right) = \frac{1}{f} \times \omega_0 f = \boxed{\omega_0} = \underline{\text{constant}}$

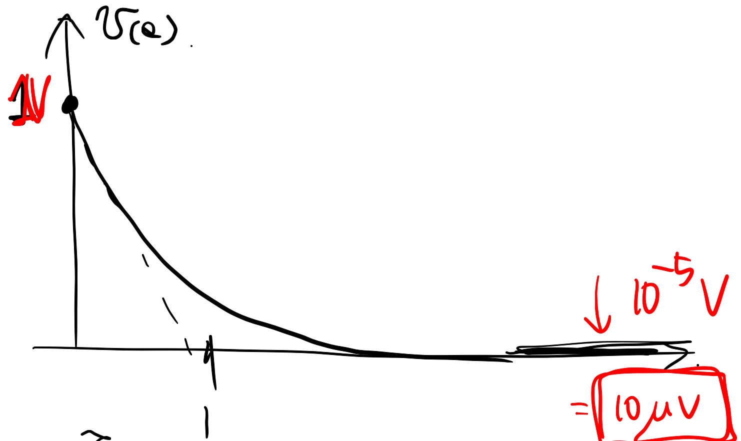
*

Error dynamics $v_e(t)$.

$$\frac{v_e}{v_i} = \frac{1}{1+L(s)} \triangleq S(s) = \frac{1}{1+\frac{\omega_0}{s}\cdot f} = \frac{s}{s+\omega_0 f}.$$

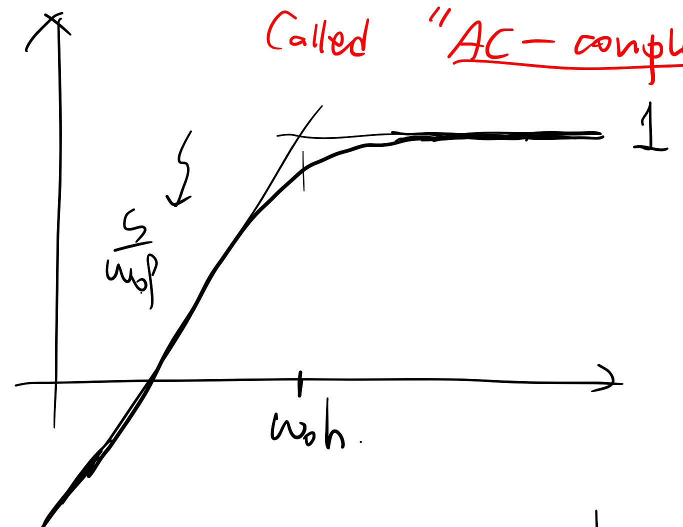
zero at the origin.

Called "AC-coupled" syst.



$\tau = \frac{1}{\omega_0 f}$.

transient. $v_e \neq 0$.

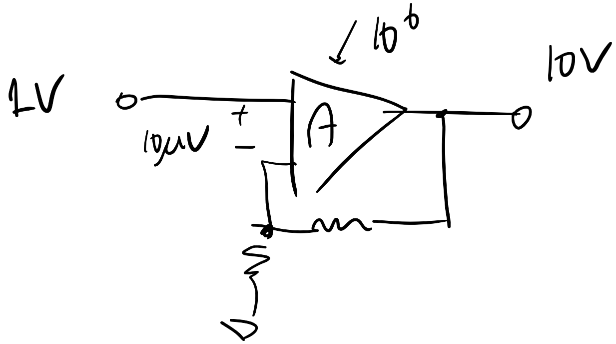


$A(s) = \frac{\omega_0}{s}$

$|A(j\omega)|_{\omega\to 0} \to$ "∞"

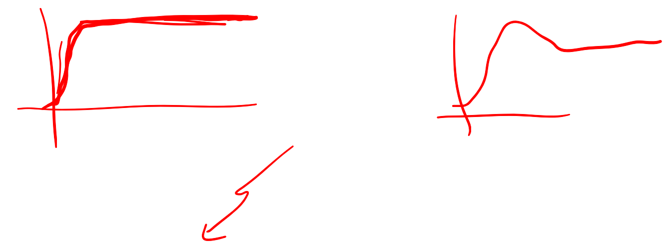
op27. 10^6 $\frac{1}{1+Af}$ 10^5

$f = \frac{1}{10}$ $S \simeq \frac{1}{10^5} = 10^{-5}$

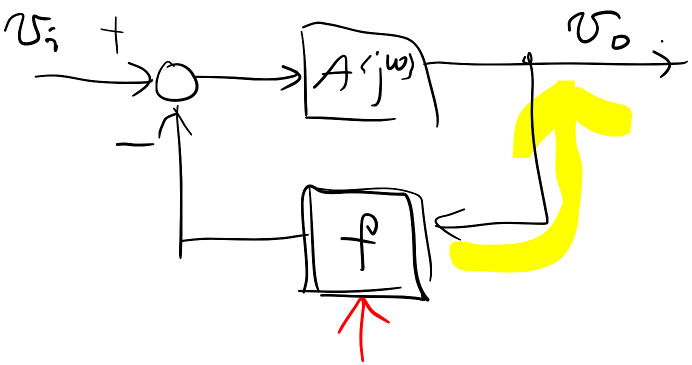


$A \to \infty$

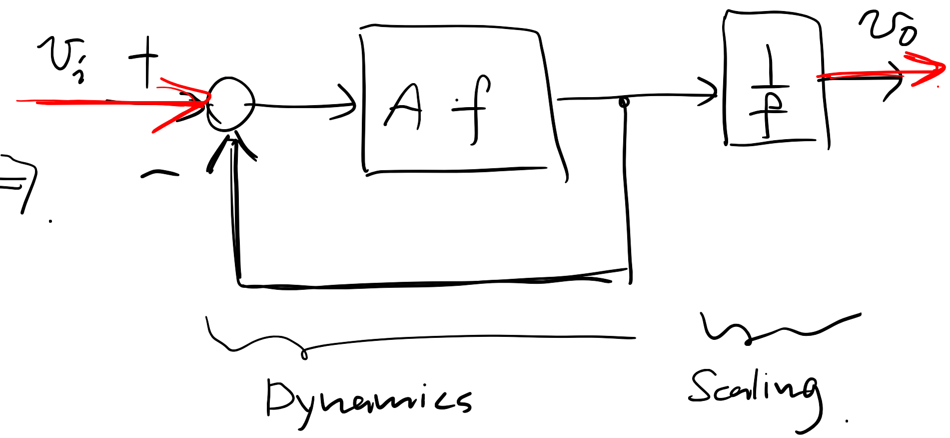
$A = \frac{\omega_0}{s}$



<General Model>.



$\Longrightarrow$



$\triangleq T(s)$

"Complementary Sensitivity"

"Tracking"

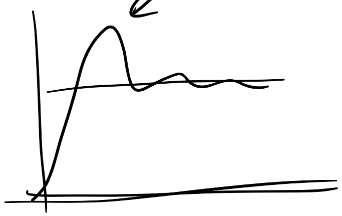
$$S(s) = \frac{1}{1+L(s)}.$$

$$T(s) = \frac{L}{1+L(s)}$$

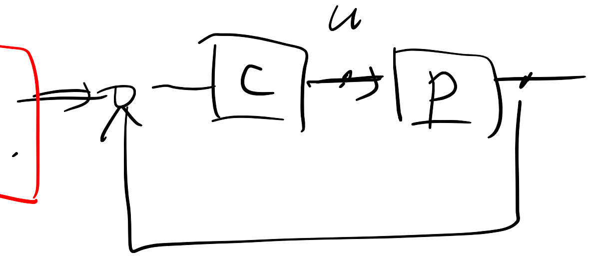
$S(s) + T(s) = 1$.

Goal : "shape" $T(s)$ $\begin{cases} \text{Bandwidth.} \Rightarrow \text{rise time.} \\ \text{Resonant peak} \Rightarrow \text{overshoot} \end{cases}$

It's fine . .



Q. How do we shap $T(s) = \boxed{\dfrac{L(s)}{1+L(s)}}$.



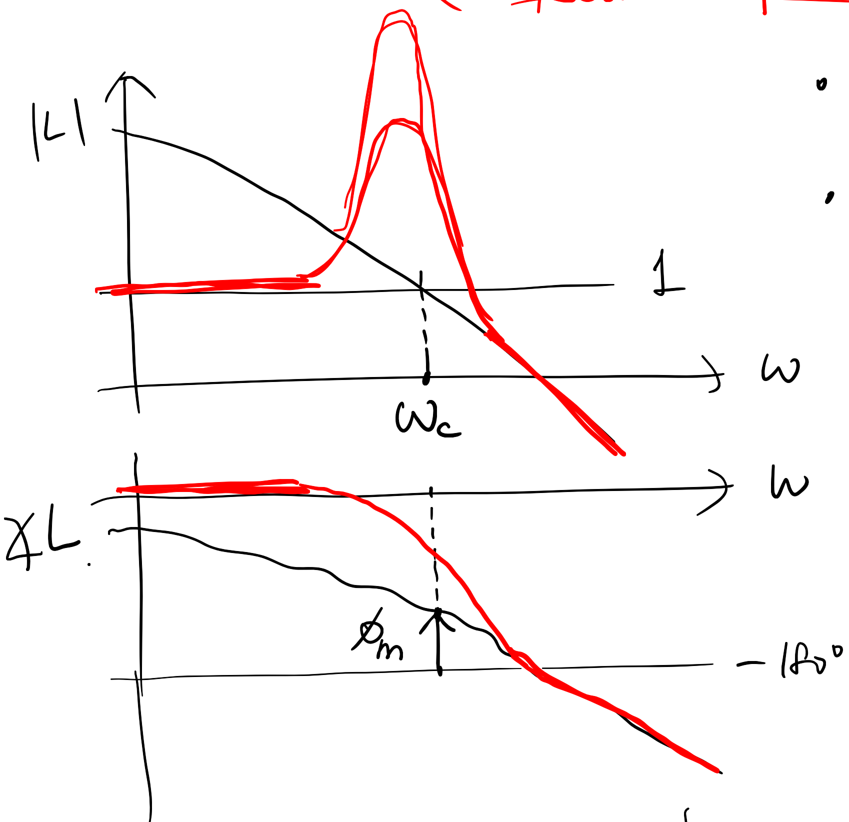
A via shaping $\boxed{\text{"}L(s)\text{"}}$. "Loop

$$\boxed{S(s) = \frac{1}{1+L(s)}}$$

$S(s)$, $\boxed{T(s)}$.

$T(s) = \frac{L}{1+L}$ ← Resonant peaks.

unity-gain.



- ω_c : cross-over freq.
- ϕ_m : phase margen. $\angle L(j\omega_c) - (-180°)$

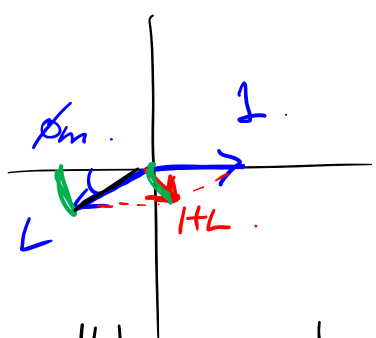
$= \boxed{\angle L(j\omega_c) + \pi}$

$$T = \frac{L}{1+L} = \begin{cases} |L| \gg 1 & T \simeq 1 \quad \begin{cases} |T| = 1 \\ \angle = 0 \end{cases} \\ |L| \ll 1 & T \simeq L \quad \begin{cases} |T| = |L| \\ \angle T = \angle L \end{cases} \\ |L| \simeq 1. & \end{cases}$$

"should consider ϕ"

@ $|L| = 1$.

$T = \frac{L}{1+L}$,,



$|T| = \frac{|L|}{|1+L|} = \frac{1}{|1+L|}$.

when $\phi_m \ll 1$.

$|1+L| \simeq \phi_m \Rightarrow \boxed{|T| \simeq \frac{1}{\phi_m}}$