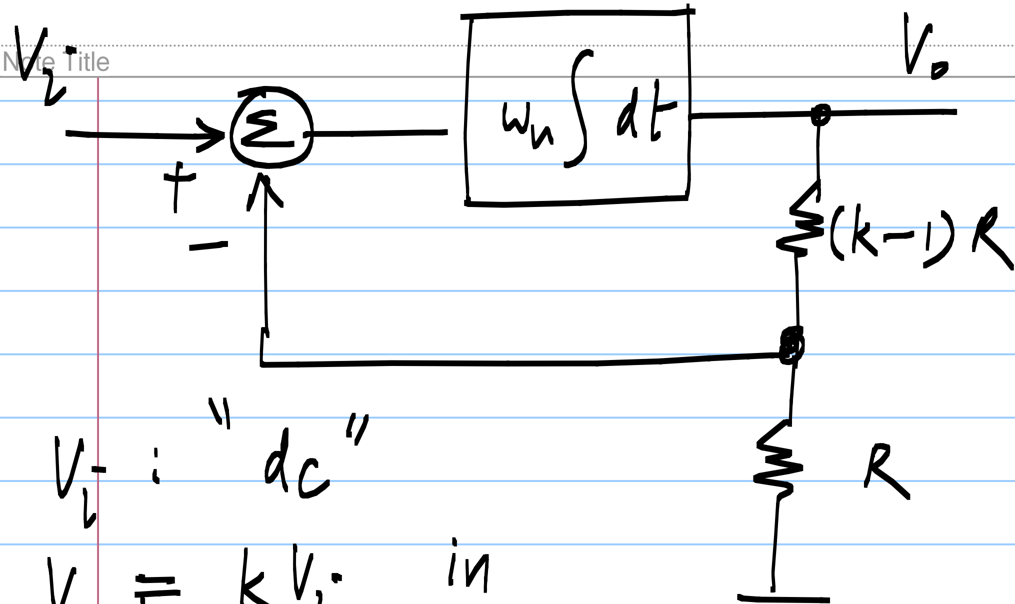
Lecture #3 :

Note Title 12/23/2010

- Sense the difference between desired and actual
- Integrate the error (difference)
- Drive the output such that the error reduces

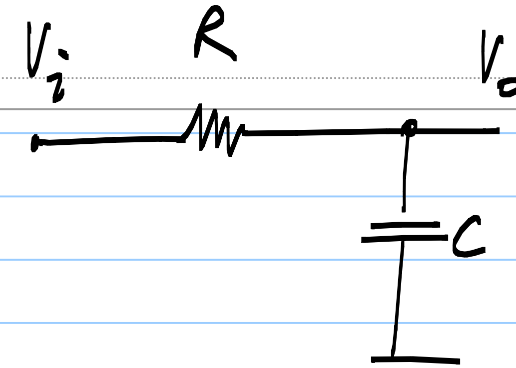
Any error in sensing translates to an error in the output



V_i : "dc"

$V_o = kV_i$ in steady state

$$\frac{1}{\omega_u}\cdot\frac{dV_o}{dt} = V_i - \frac{V_o}{k}$$



$$RC\cdot\frac{dV_o}{dt} = V_i - V_o$$

$$V_o(t) = V_o(0)\exp\left(-\frac{\omega_u}{k}\cdot t\right) + V_i\left[1 - \exp\left(-\frac{\omega_u}{k}t\right)\right]$$

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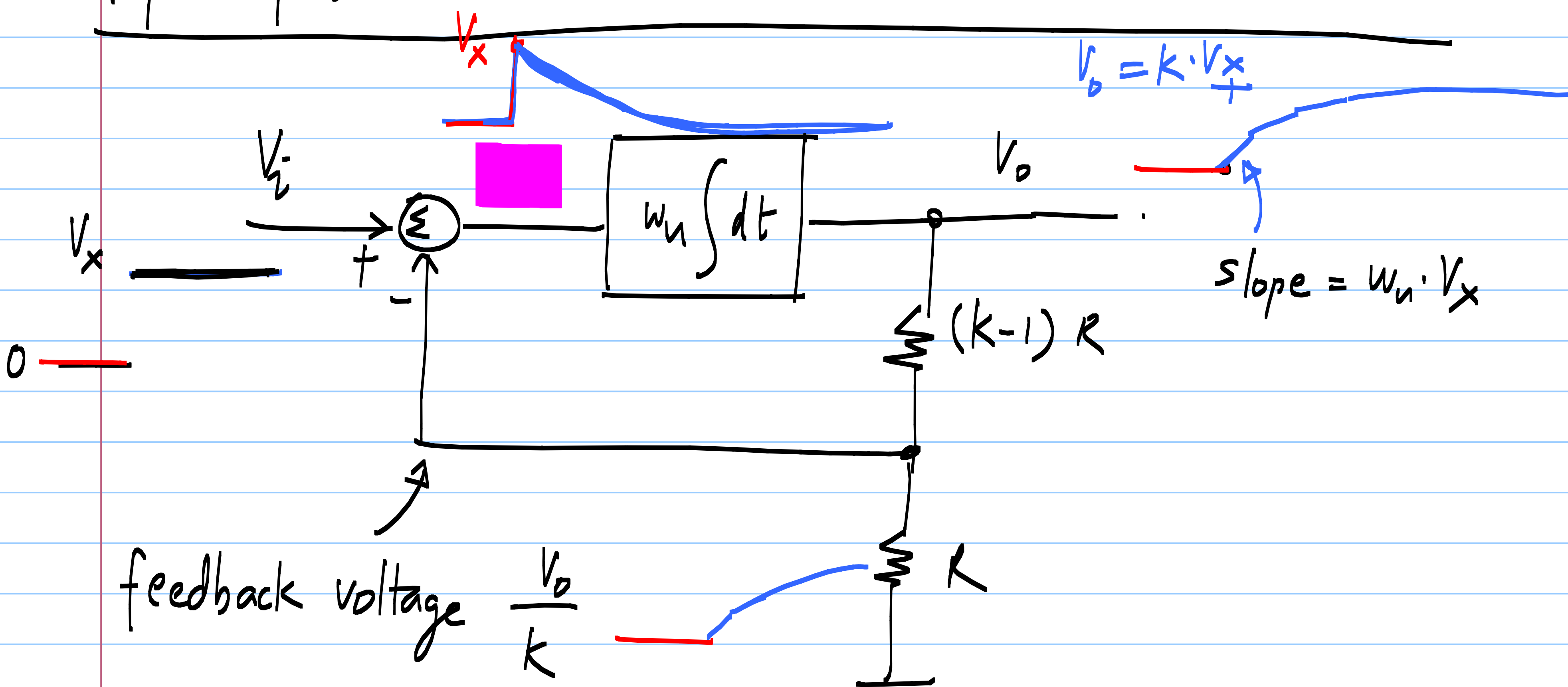
Response of the negative feedback amplifier to a step input.



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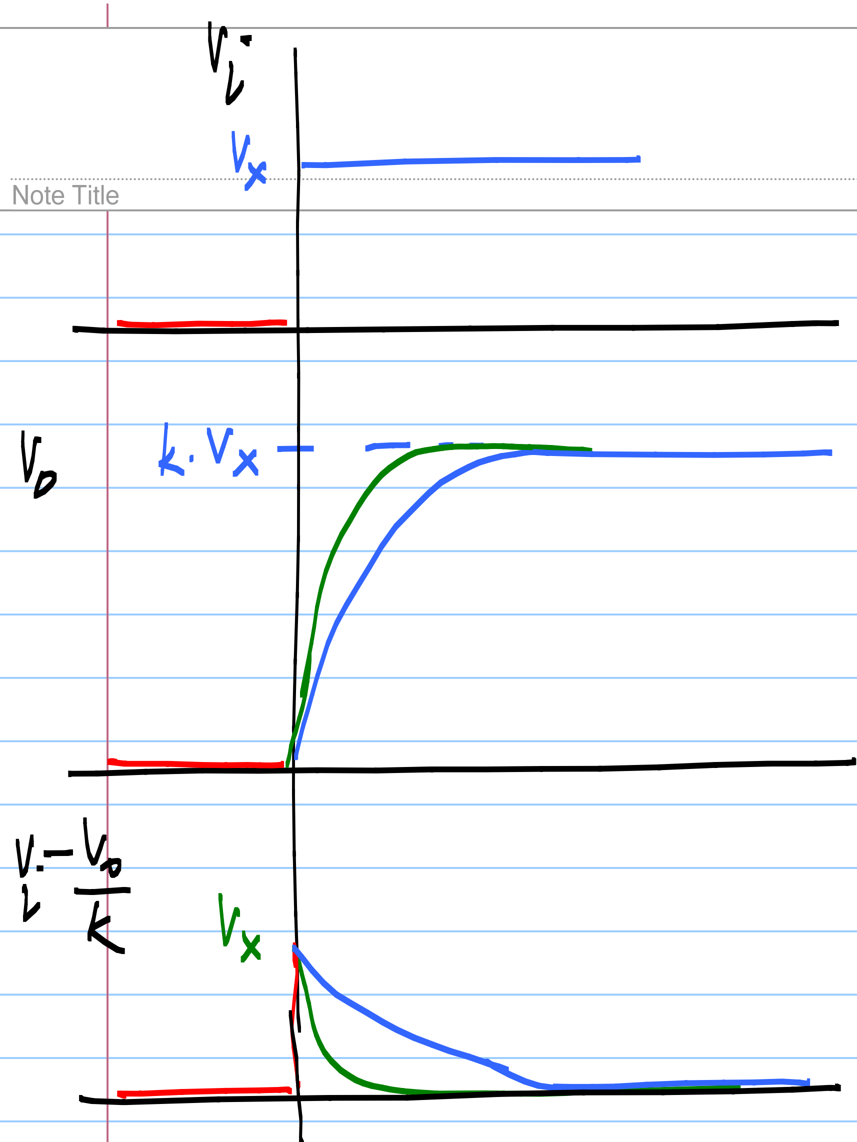

$4.6\left(\frac{k}{\omega_u}\right)$ to reach 99% of steady state

Higher ω_u:

- faster approach to steady state
- Smaller energy ("area") of the error $\underbrace{V_i - \frac{V_o}{k}}$

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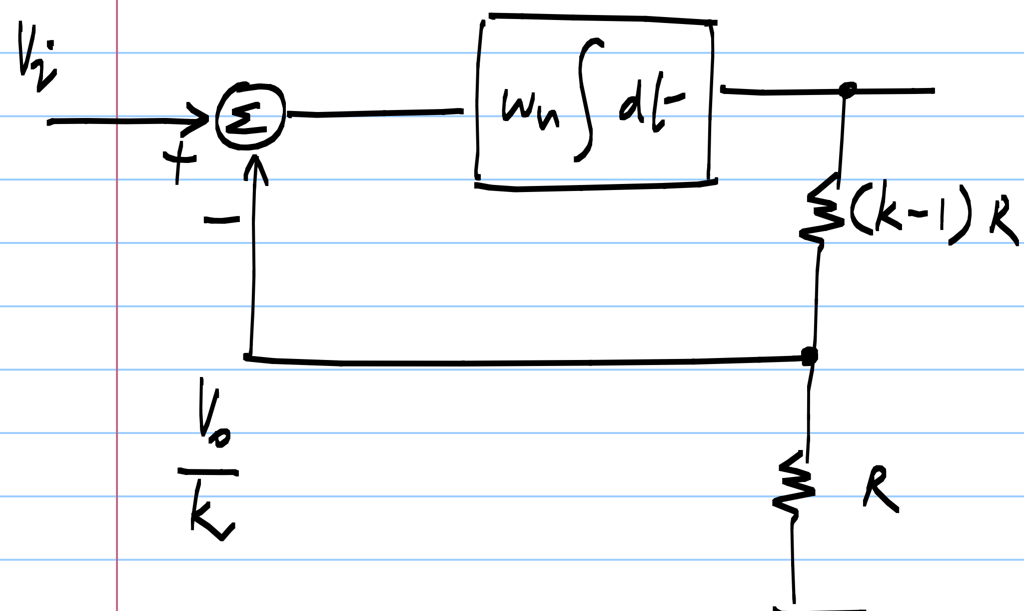
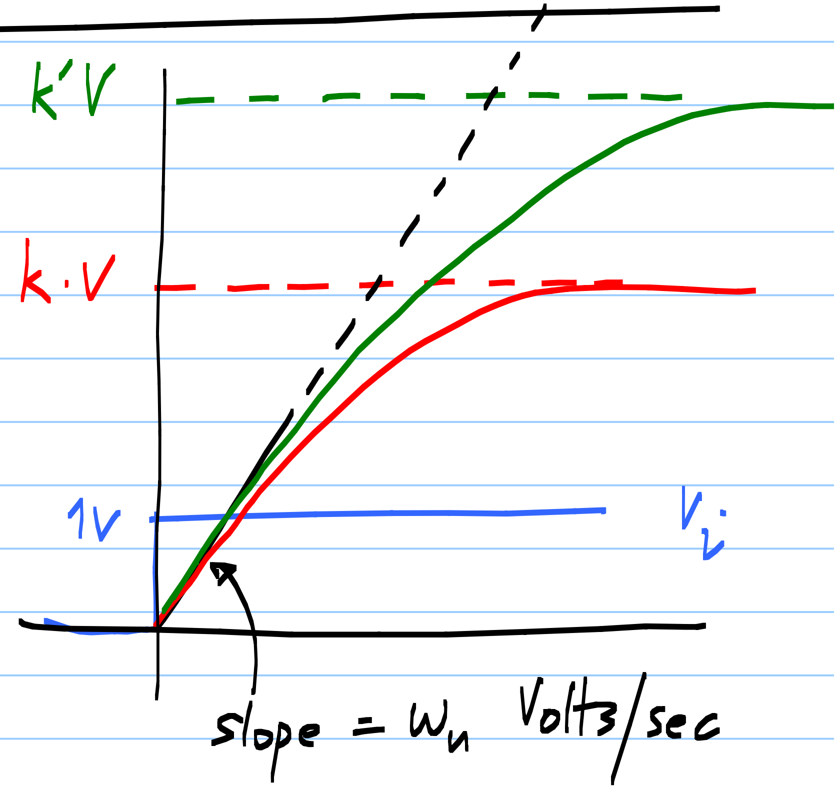
$$V_o(t) = V_o(0)\, \exp\left(-\frac{w_u t}{k}\right) + k V_i \cdot \left[1 - \exp\left(-\frac{w_u t}{k}\right)\right]$$

$$\left(\text{for constant } V_i\right)$$

time constant $= \dfrac{k}{w_u}$





Response of the amplifier to sinusiodal inputs

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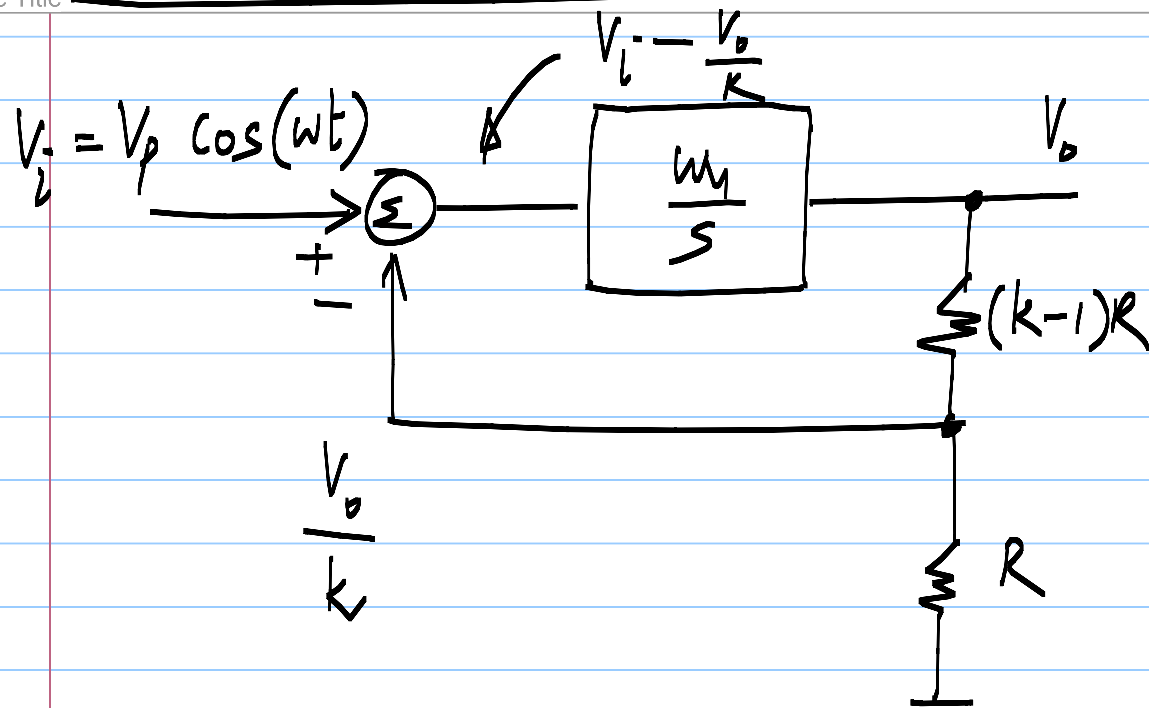

$$\left(V_i - \frac{V_o}{k}\right)\cdot\frac{\omega_u}{s} = V_o$$

$$V_i \frac{\omega_u}{s} = V_o\left[\frac{\omega_u}{k\cdot s} + 1\right]$$

$$\frac{V_o}{V_i} = \left[\frac{\omega_u/s}{\frac{\omega_u}{k\cdot s} + 1}\right] \times \frac{k\cdot s}{\omega_u}$$

$$H(s) = \frac{V_o}{V_i} = \frac{k}{1 + k\cdot\frac{s}{\omega_u}}$$

$$\boxed{H(0) = k}$$

Integrator:

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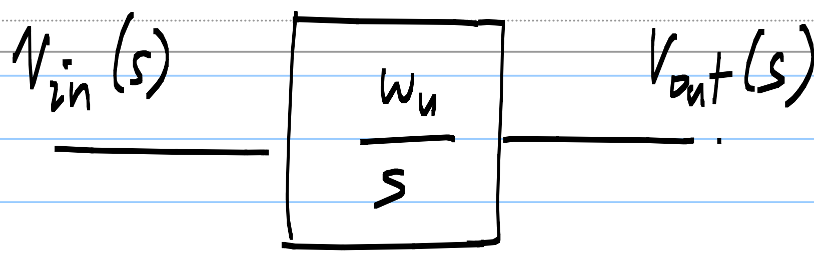

$$\underline{V_{out}(s) = \frac{\omega_n}{s} \cdot V_{in}(s)}$$

$$\underline{V_{out}(t) = \omega_n \int v_{in}(t)\, dt}$$

$s = j\omega$

$$V_{out}(j\omega) = \frac{\omega_n}{j\omega} V_{in}(j\omega)$$

$$\frac{V_{out}}{V_{in}} = \frac{\omega_n}{j\omega}.$$

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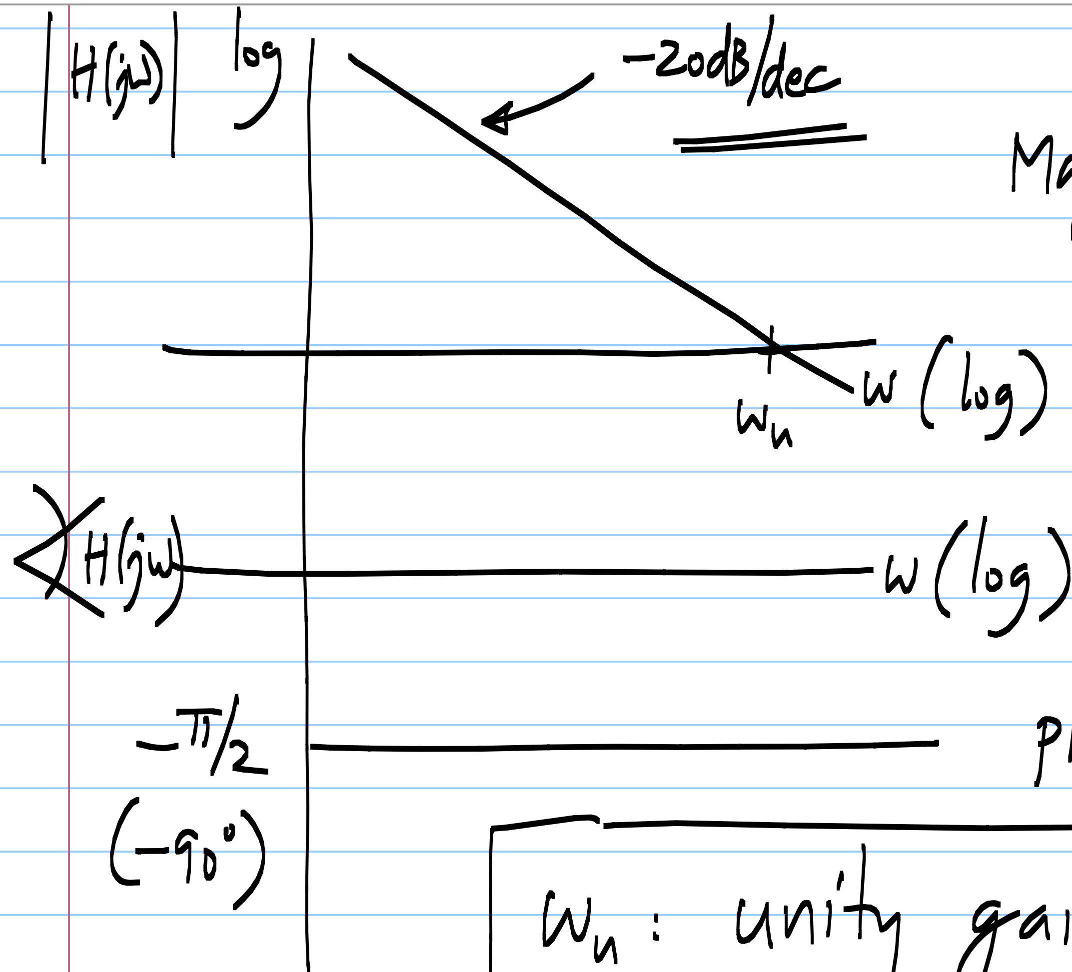
Transfer function of the integrator: $H(j\omega) = \dfrac{\omega_u}{j\omega}$

$$\left|\frac{\omega_u}{j\omega}\right| = \frac{\omega_u}{\omega}$$



Magnitude plot

Bode plot

phase plot

$\boxed{\omega_u\text{: unity gain frequency of the int.}}$

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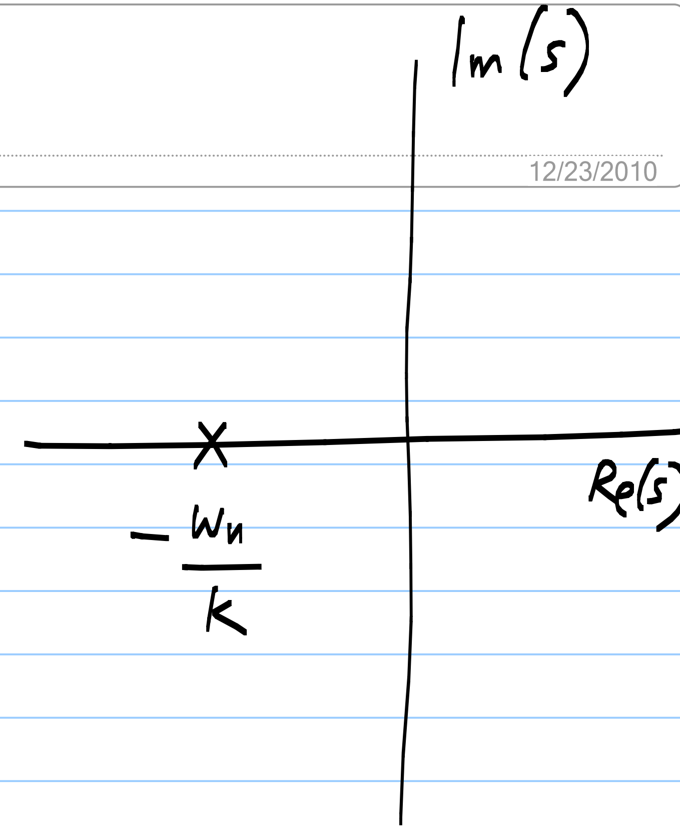
$$H(s) = \frac{V_o}{V_i} = \frac{k}{1 + s \cdot \frac{k}{\omega_u}}$$

- DC gain $\left(H(0)\right) = k$
- pole at $-\frac{\omega_u}{k}$



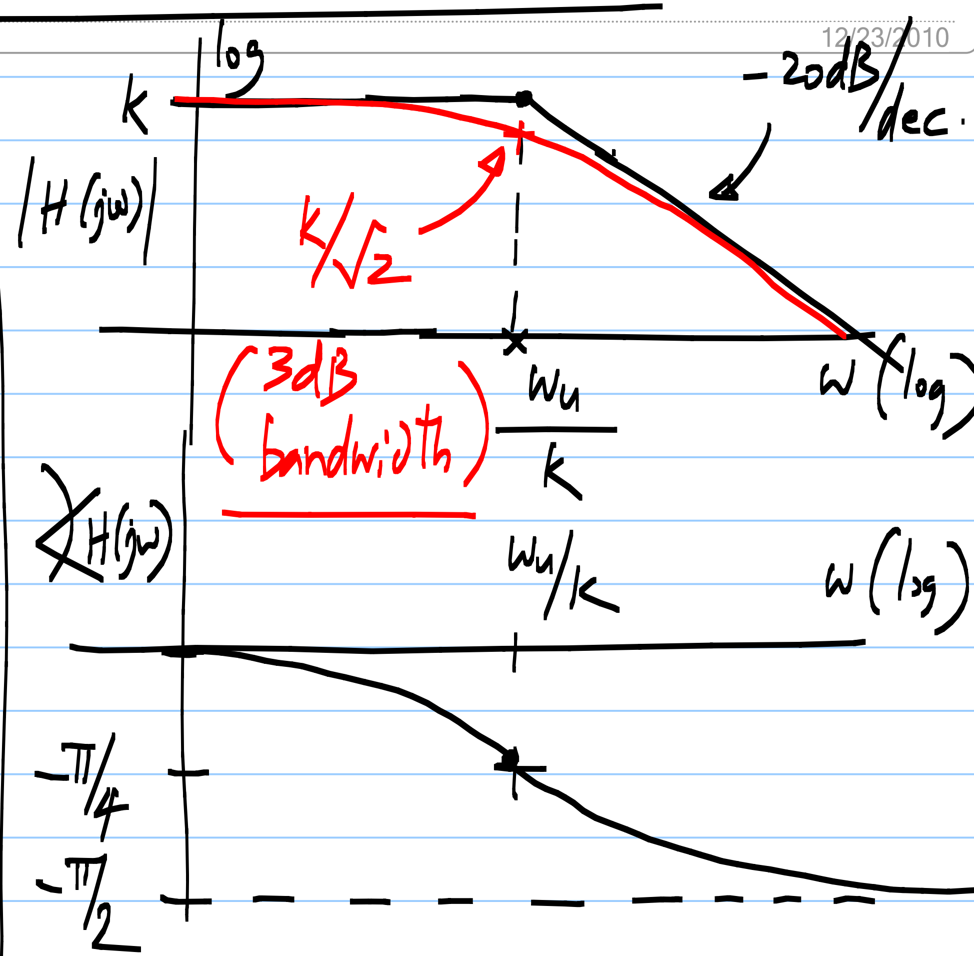
Negative feedback amplifier transfer function :

$$H(s) = \frac{k}{1 + s \cdot \frac{k}{\omega_u}}$$

$$H(j\omega) = \frac{k}{1 + j\omega \cdot \frac{k}{\omega_u}}$$

$$|H(j\omega)| = \frac{k}{\sqrt{1 + \frac{k^2 \omega^2}{\omega_u^2}}}$$

$$\angle H(j\omega) = -\tan^{-1}\left(\frac{\omega \cdot k}{\omega_u}\right)$$



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