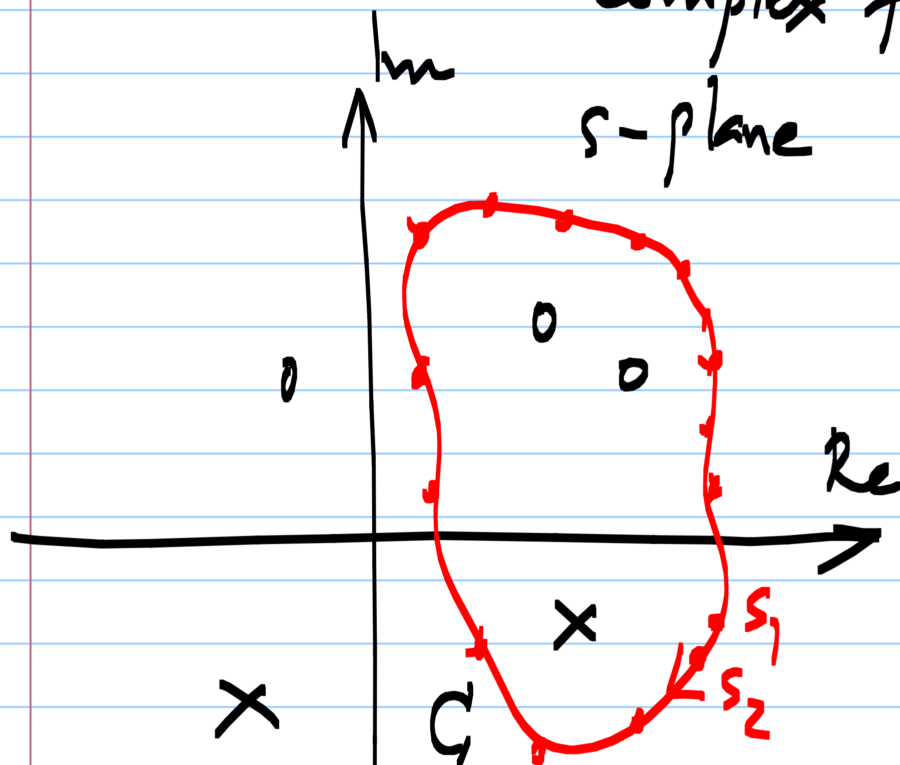
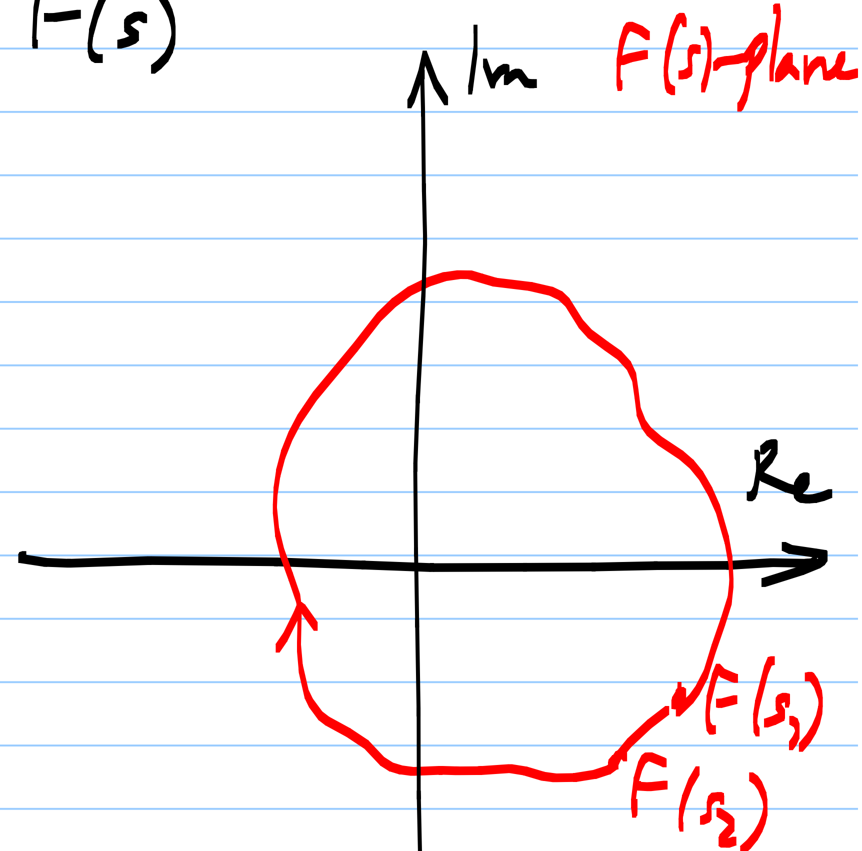
EE 2019 Complex variable s 21/2/2018

Complex fn. $F(s)$

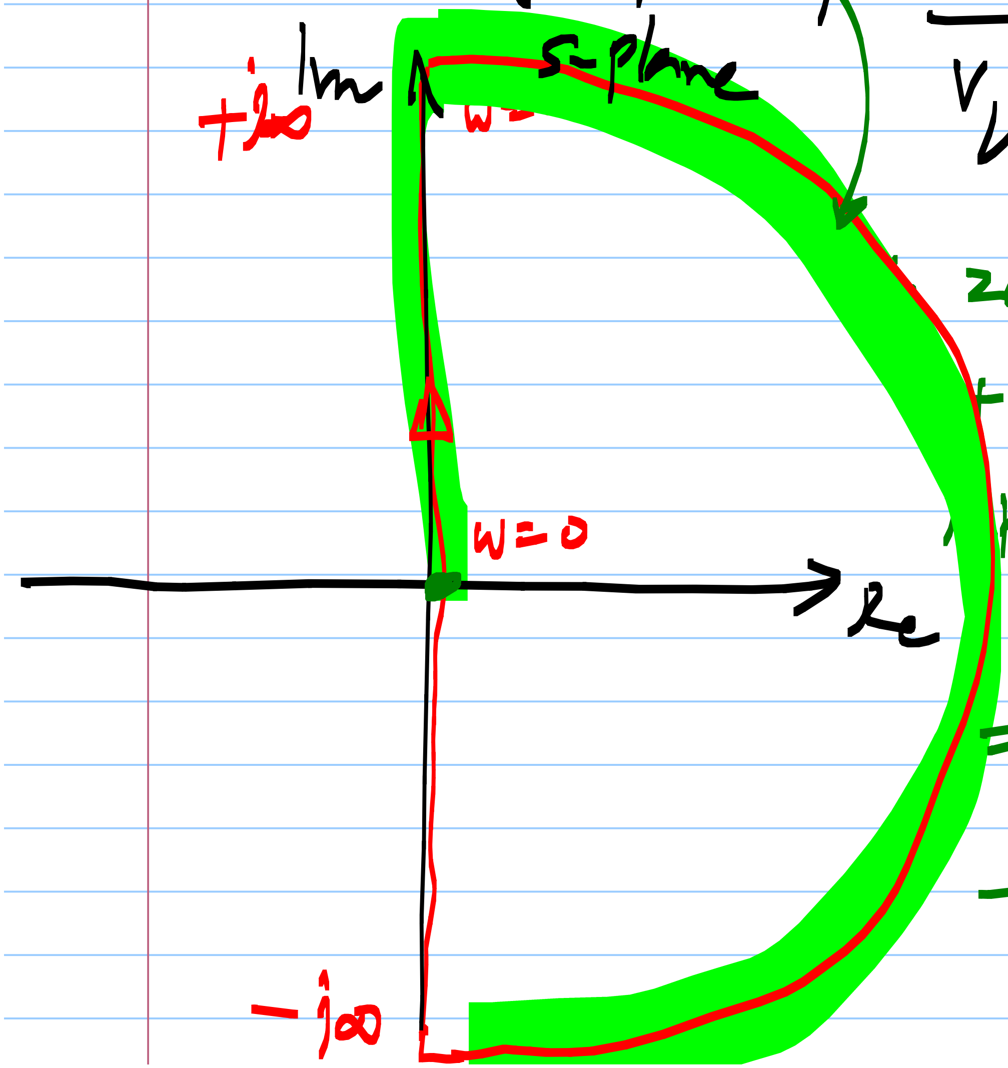




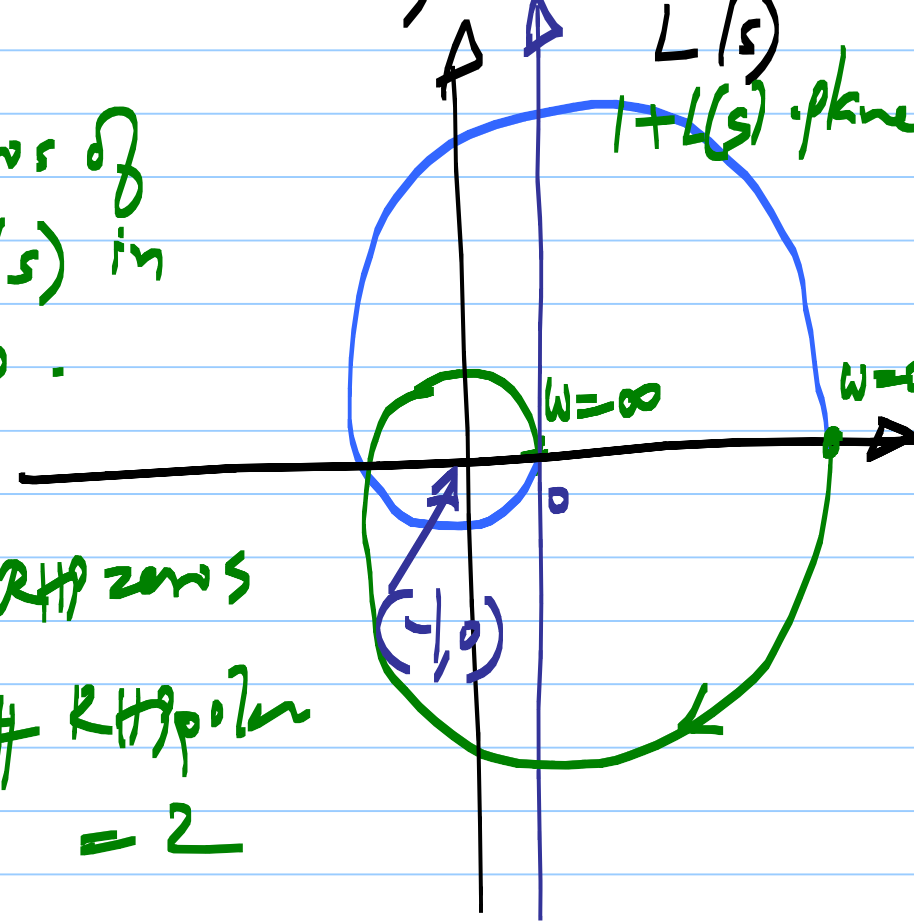
zeros − # poles in C = # encirclement of the origin in CW dir

Stability: No poles of the closed loop TF in RHP (s-plane)

$$\frac{V_o}{V_i} = \frac{k}{1 + k/A(s)} = \frac{k \cdot \overbrace{A(s)/k}^{L(s)}}{1 + \underbrace{A(s)/k}_{L(s)}}$$



zeros of $1+L(s)$ in RHP = # RHP zeros − # RHP poles = 2



$$1 + L(s) = 1 + \underbrace{\frac{N_L(s)}{D_L(s)}}_{L(s)} = \frac{D_L(s) + N_L(s)}{D_L(s)}$$

roots = poles of $1 + L(s)$

= poles of $L(s)$

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s-plane contour: $j\omega$ axis + ∞ large semicircle

enclosing RHP

Evaluate $L(j\omega)$: $\omega = 0 - \infty$

Plot $L(j\omega)$ on $L(j\omega)$ plane; Count CW encirclements of $(-1, 0)$

Nyquist stability criterion

: poles of

s-plane contour: $j\omega$ axis + ∞ large semicircle

enclosing RHP

Evaluate $L(j\omega)$: $\underline{\omega = 1 - \infty}$

Plot $L(j\omega)$ on $L(j\omega)$ plane ; Count CW encirclements of $(-1, 0)$

RHP poles of the closed loop TF.

$= \boxed{\# \text{ RHP zeros of } 1+L(s)}$ − ~~# RHP poles of $1+L(s)$~~

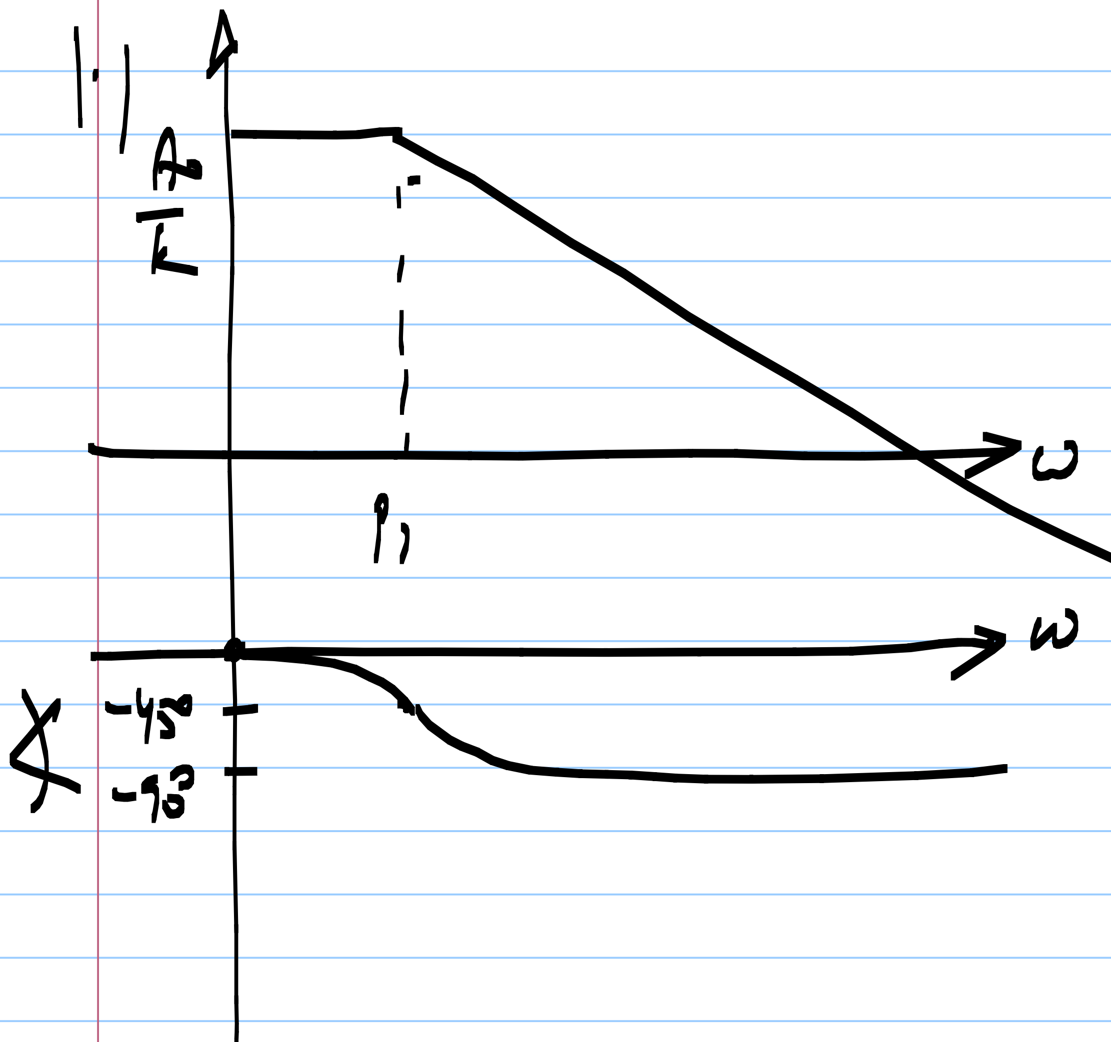
o

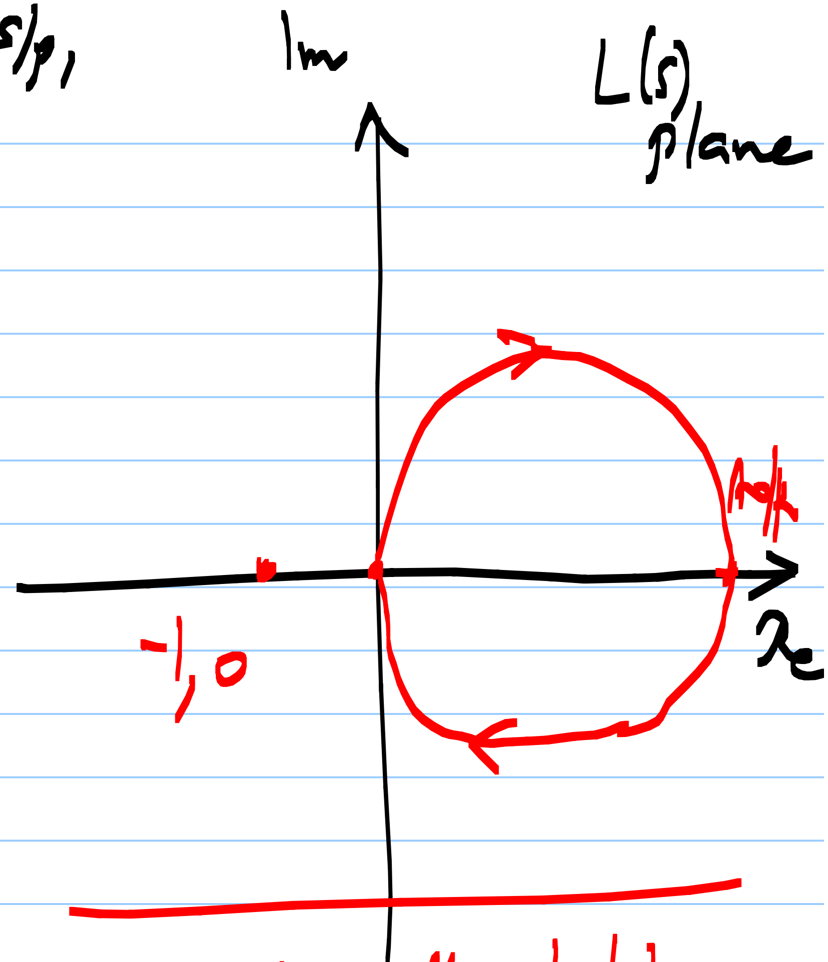
Single-stage opamp: $L(s) = \frac{A(s)}{k} = \frac{A_0/k}{1 + s/p_1}$

Two-stage opamp: $L(s) = \frac{A_0/k}{(1 + s/p_1)(1 + s/p_2)}$

3-stage opamp: $L(s) = \frac{A_0/k}{(1 + s/p_1)(1 + s/p_2)(1 + s/p_3)}$

Single-stage opamp: $L(s) = \frac{A_0}{k} \cdot \frac{1}{1+s/p_1}$

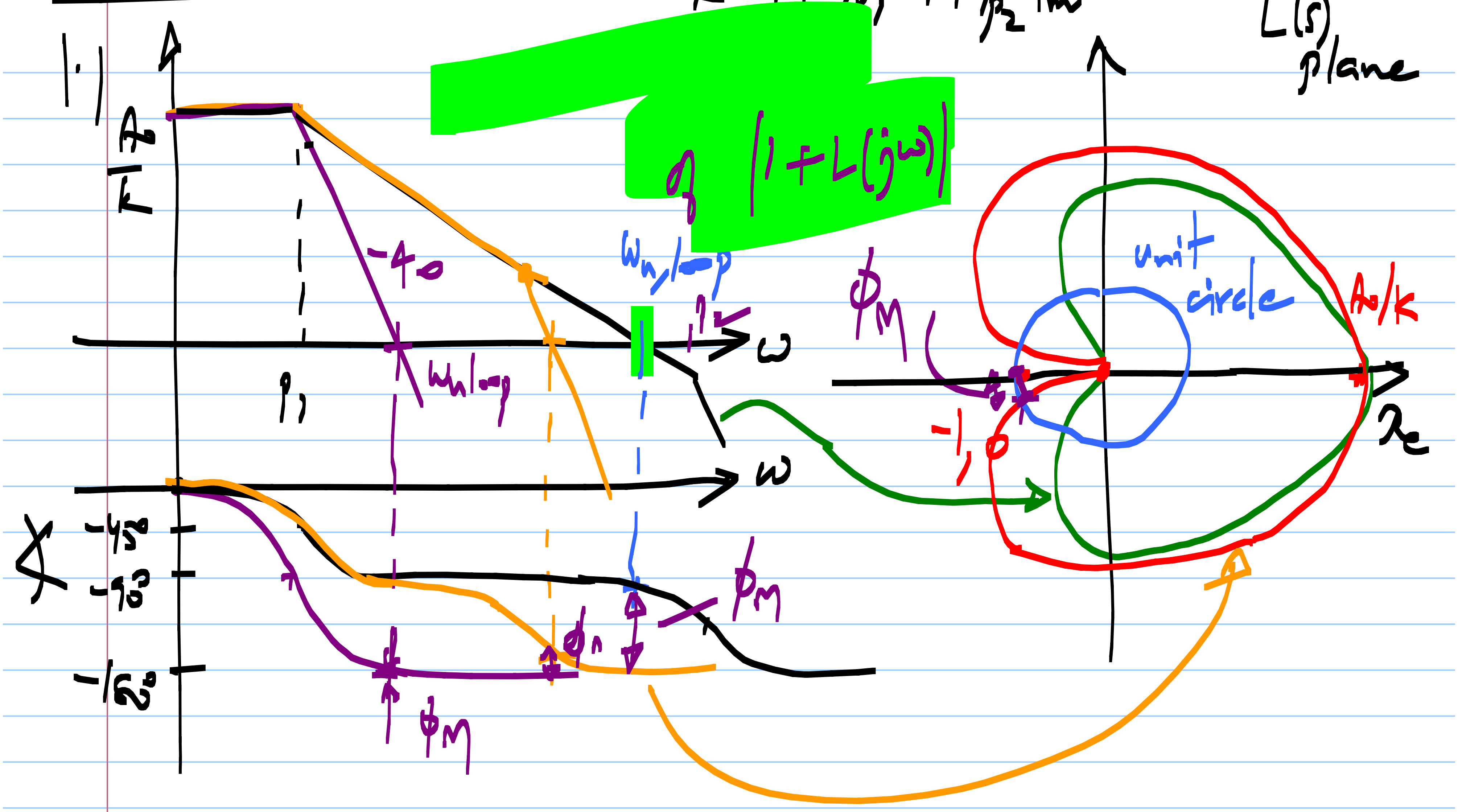




Unconditionally stable system

Two-stage opamp:

$$L(s) = \frac{A_0}{k} \cdot \frac{1}{1+s/p_1} \frac{1}{1+s/p_2}$$



Three-stage opamp: $L(s) = \frac{A_0}{k} \cdot \frac{1}{\left(1+s/p_1\right)\left(1+\frac{s}{p_2}\right)\left(1+s/p_3\right)}$