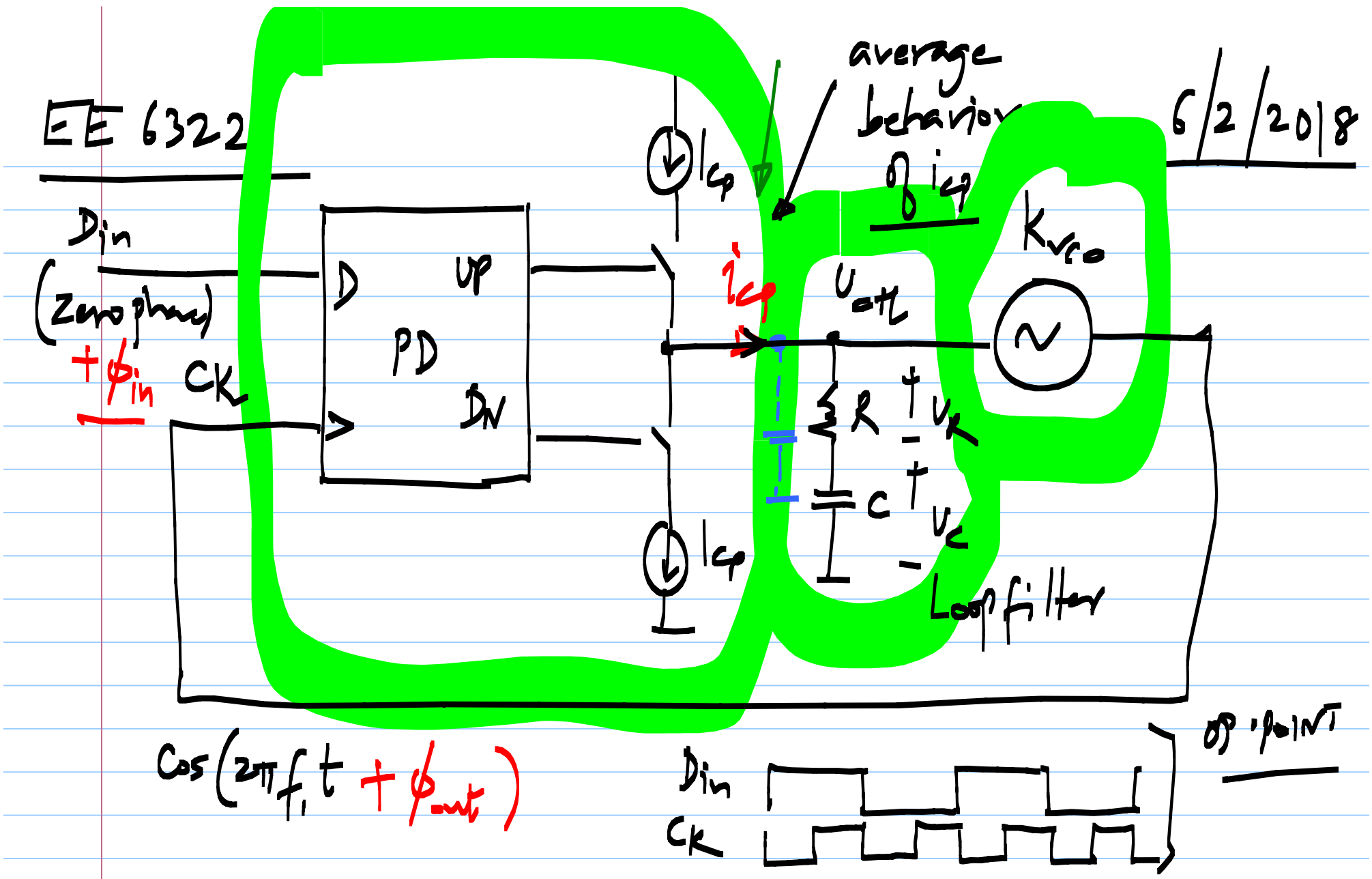
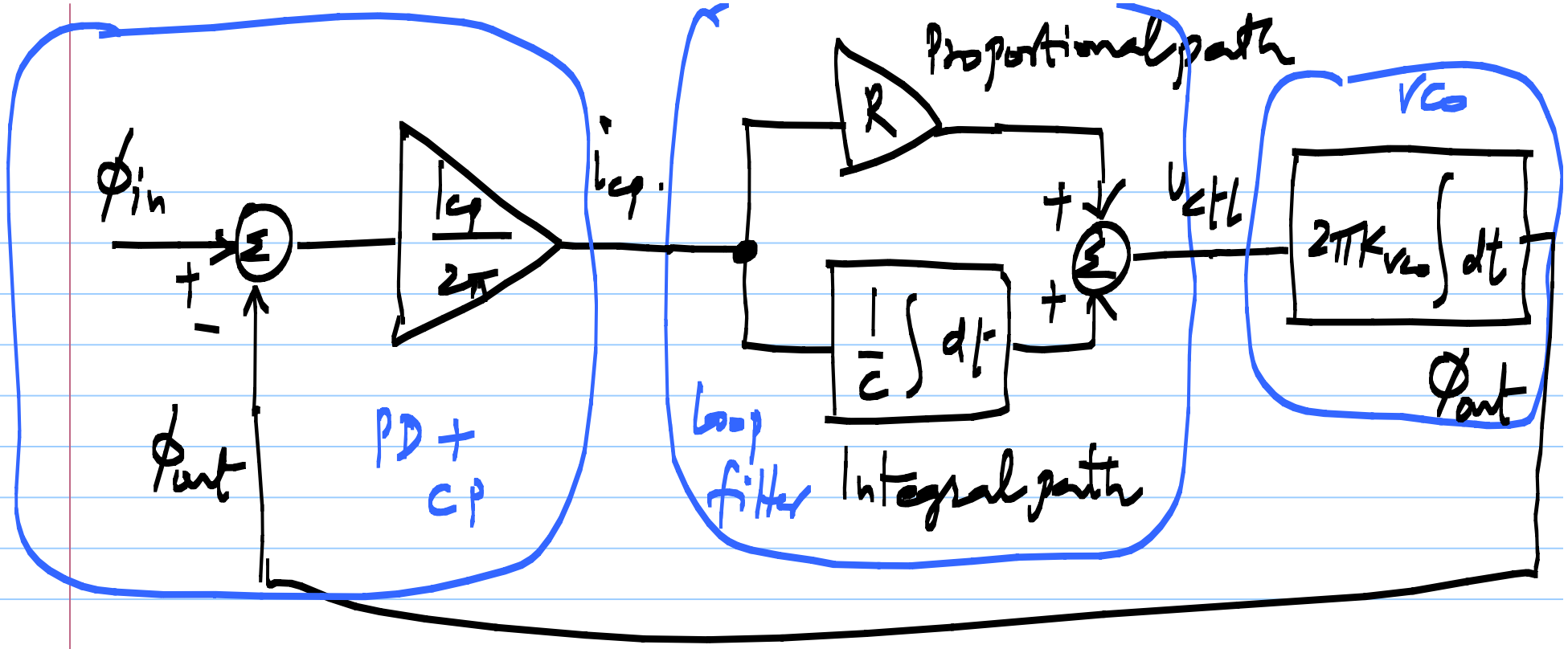
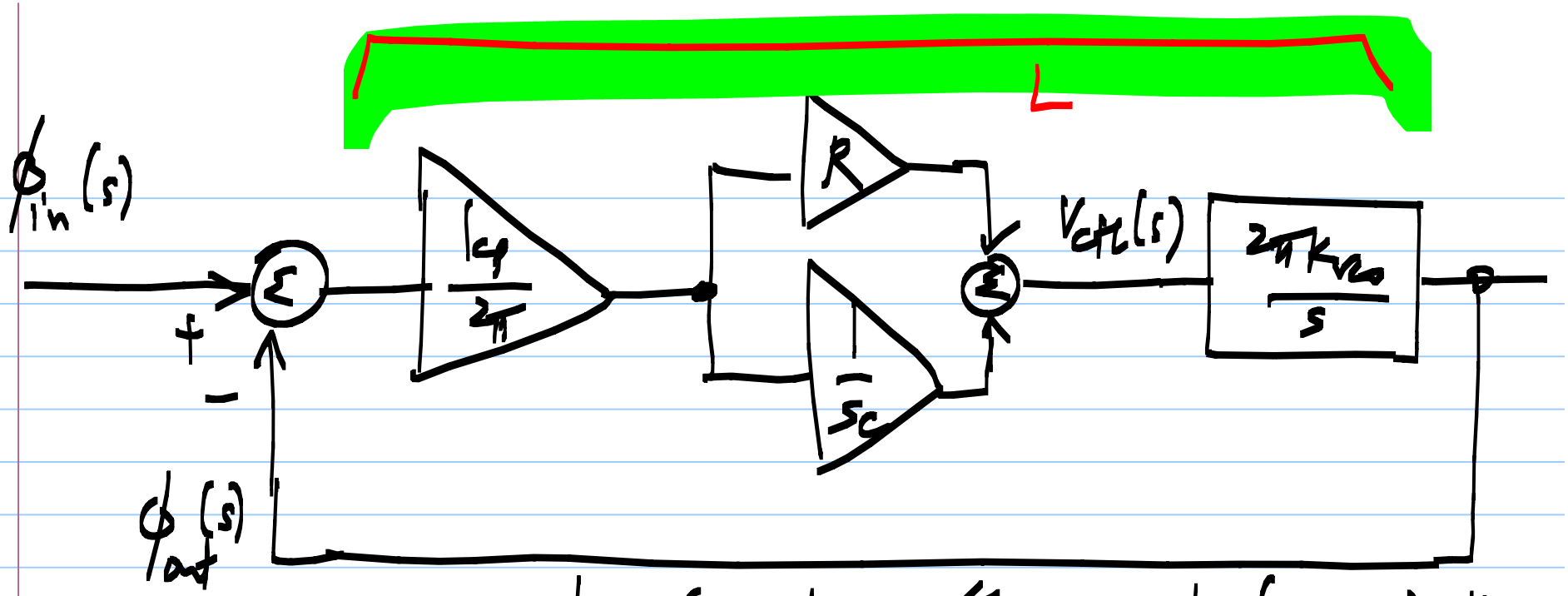
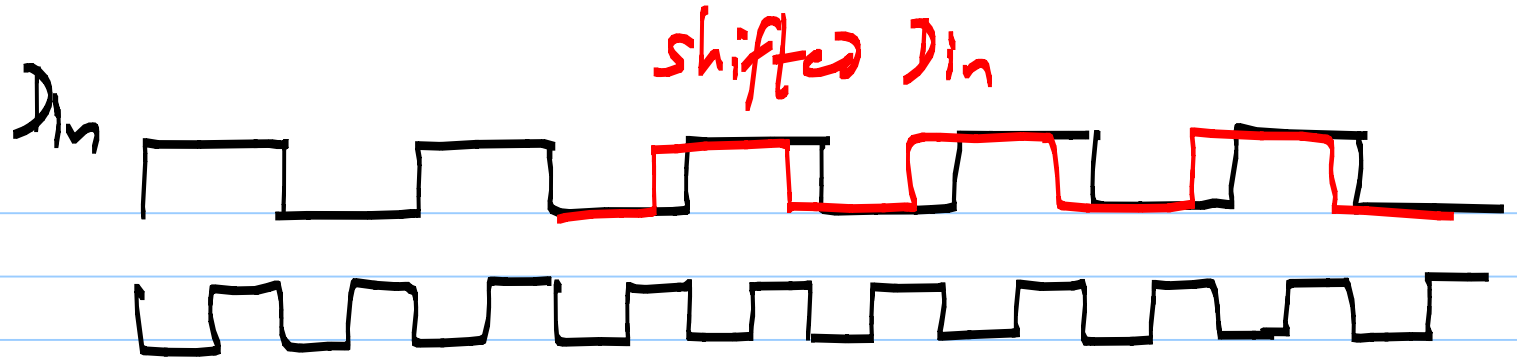

EE 6322
6/2/2018
average behavior of i_{cp}
D_{in}
(zero phase)
$+\phi_{in}$
CK
D
UP
PD
DN
I_{cp}
I_{cp}
i_{cp}
U_{ctl}
K_{VCO}
R
C
U_R
U_C
Loop filter
$\cos(2\pi f_1 t + \phi_{out})$
D_{in}
CK
op point


Proportional path
VCO
ϕ_{in}
i_{cp}
R
$\frac{I_{cp}}{2\pi}$
$\frac{1}{C}\int dt$
V_{ctl}
$2\pi K_{vco}\int dt$
ϕ_{out}
PD + CP
Loop filter
Integral path



$$\frac{I_{cp}}{2\pi}\left(R+\frac{1}{sC}\right)\cdot\frac{2\pi K_{VCO}}{s}=\frac{I_{cp}(1+sCR)\cdot K_{VCO}}{s^2C}$$

$$\frac{\phi_{out}(s)}{\phi_{in}(s)}=\frac{1+sCR}{sCR+1+\frac{s^2C}{I_{cp}K_{VCO}}}=\frac{1+sCR}{1+sCR+\frac{s^2C}{I_{cp}\cdot K_{VCO}}}$$



"dc gain = 1" $\Rightarrow$ Eventually, CK catches up to shifted D_{in}

$$s^2 + 2\zeta\omega_n s + \omega_n^2$$

$$s^2 + \frac{\omega_n s}{Q} + \omega_n^2$$

$Q = 1/2\zeta$

ω_n : natural freq.

ζ : damping factor

Q : Quality factor

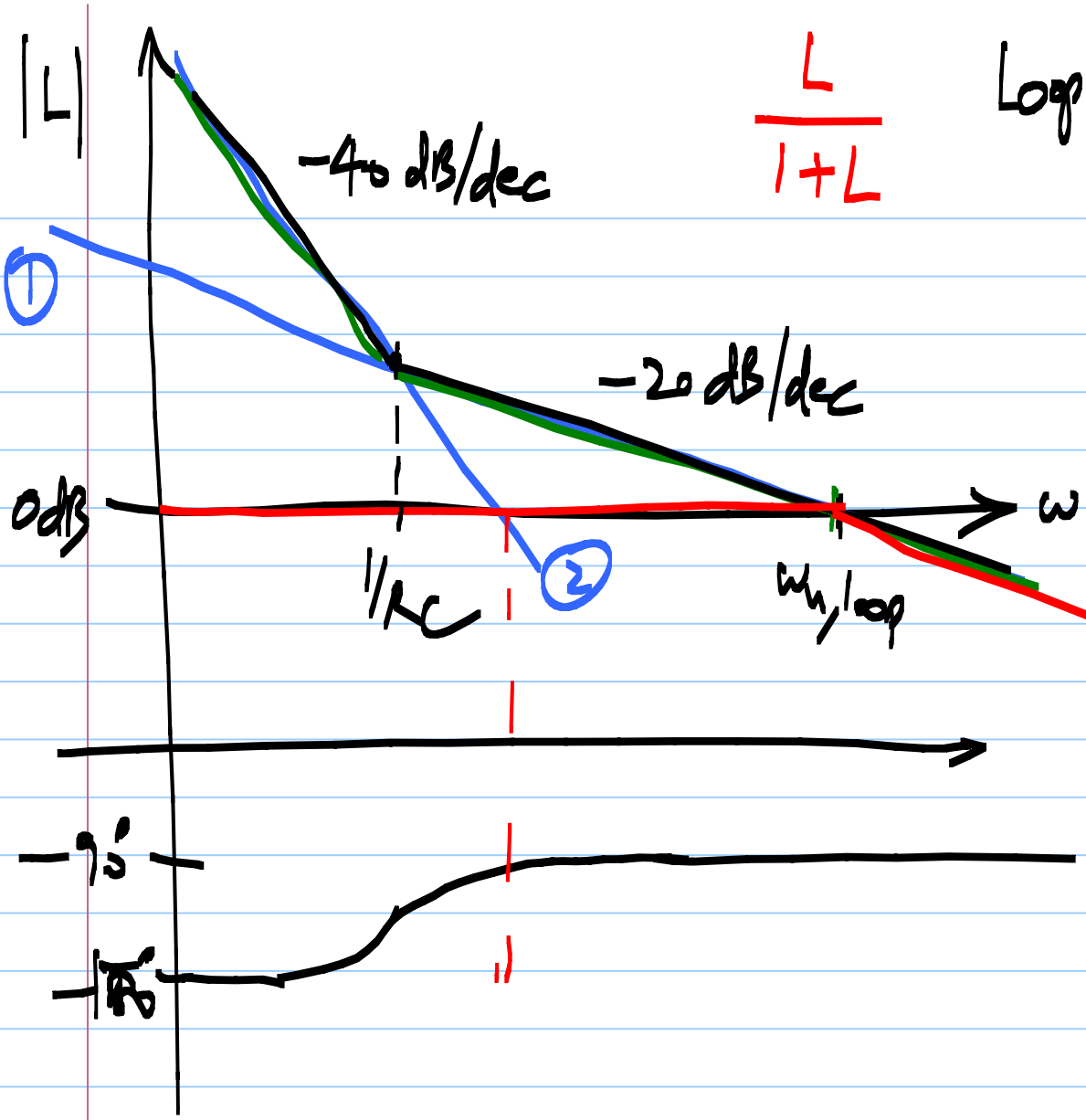
$$\frac{\phi_{out}(s)}{\phi_{in}(s)} = \frac{1+sCR}{1+sCR+\frac{s^2C}{I_{cp}K_{VCO}}}$$

LHP Zero @ $-\frac{1}{CR}$

$$\omega_n = \sqrt{\frac{K_{VCO} \cdot I_{cp}}{C}}$$

$$\zeta = \frac{R}{2}\sqrt{I_{cp}K_{VCO} \cdot C}$$

$$Q = \sqrt{\frac{C}{I_{cp} \cdot K_{VCO}}} \cdot \frac{1}{CR} = \frac{1}{R\sqrt{I_{cp}K_{VCO} \cdot C}}$$



$\frac{L}{1+L}$

Loop gain: $I_{cp}\left(R+\frac{1}{sC}\right)\frac{K_{vco}}{s}$

$L(s)$ $\frac{I_{cp}RK_{vco}}{s}$ ① $+$ $\frac{I_{cp}K_{vco}}{s^2C}$ ②

$\frac{L}{1+L}$ $\frac{1}{RC} < \omega_{n,loop}$

$\underbrace{\omega_{n,loop}}_{rad/s} = I_{cp}\underbrace{RK_{vco}}_{Hz/V}$

$$y \approx$$

$$T \ll |AY|$$

$$\frac{H}{1} \approx \frac{1}{A}$$

$$\frac{\text{unbuffered} + 1}{\text{buffered}}$$

$$\frac{\text{unbuffered}/1 + 1}{1}$$

$$\frac{HY/1 + 1}{1}$$

$$\frac{\frac{HY+1}{HY}}{\frac{H}{1}} =$$

$$\frac{HY+1}{Y} = \frac{1}{A}$$