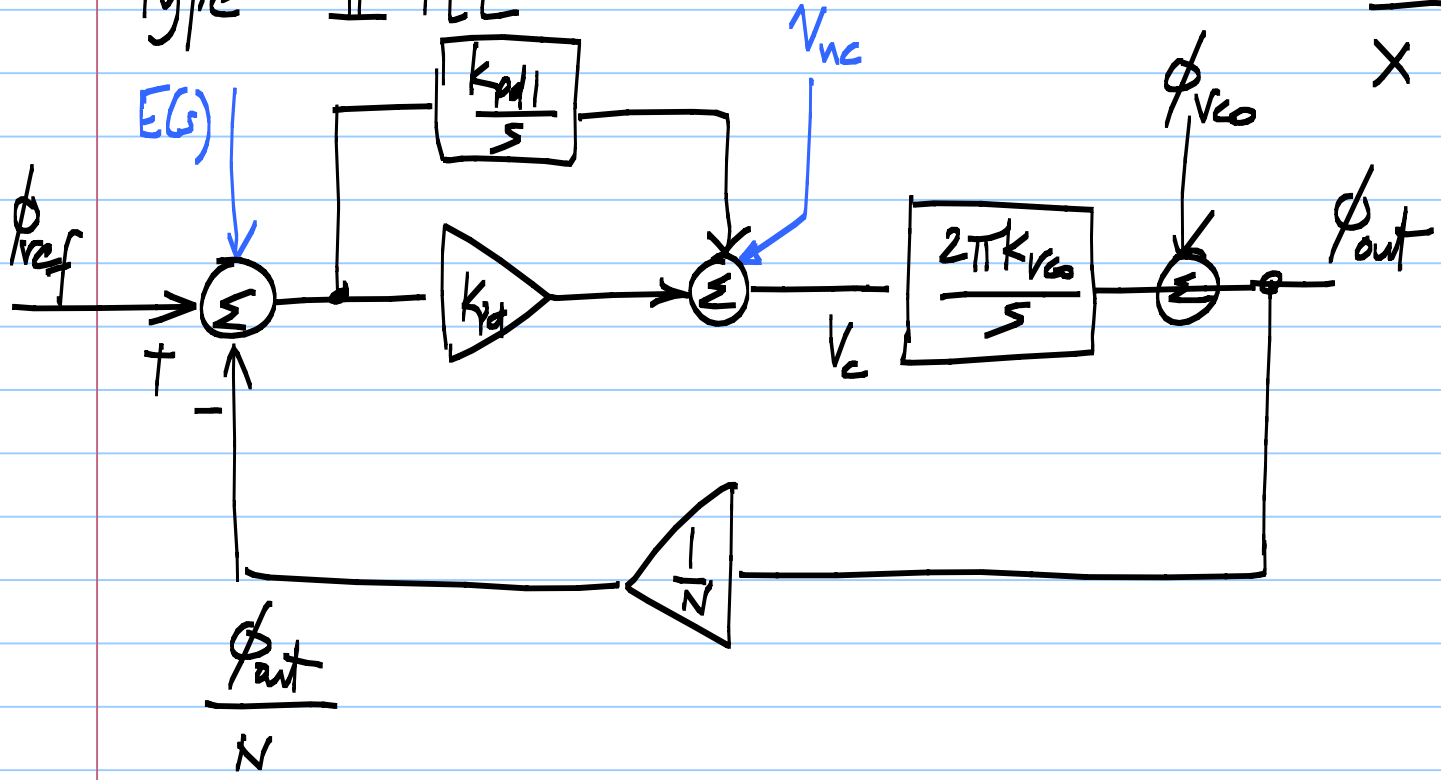
Lecture 49:

Type II PLL



"forward path"

$$\frac{Y}{X} = \frac{G}{1 + \underbrace{GH}_{\text{loop gain}}}$$

Lowpass

$$\frac{\phi_{out}(s)}{\phi_{ref}(s)} = N \cdot \frac{1 + \frac{s}{z_1}}{1 + \frac{s}{z_1} + \frac{s^2}{\omega_{n,loop} \cdot z_1}}$$

$$z_1 : \frac{K_{pd,1}}{K_{pd}}$$

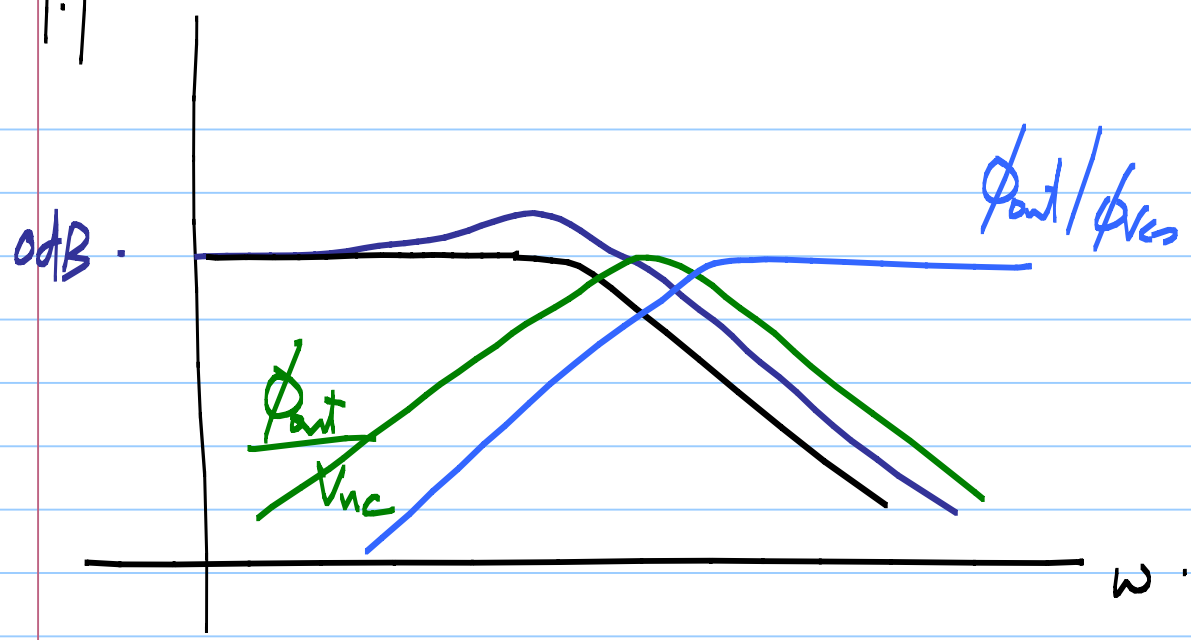
$$\omega_{n,loop} : 2\pi K_{pd} K_{vco}$$

Bandpass

$$\frac{\phi_{out}(s)}{V_{nc}(s)} = \frac{\frac{2\pi K_{vco}}{s}}{1 + \frac{2\pi K_{vco}}{N \cdot s}\left(K_{pd} + \frac{K_{pd,1}}{s}\right)} = \frac{N}{K_{pd}} \cdot \frac{s/z_1}{1 + \frac{s}{z_1} + \frac{s^2}{\omega_{n,loop} z_1}}$$

Highpass

$$\frac{\phi_{out}(s)}{\phi_{vco}(s)} = \frac{1}{1 + \frac{2\pi K_{vco}}{N \cdot s}\left(K_{pd} + \frac{K_{pd,1}}{s}\right)} = \frac{\frac{s^2}{\omega_{n,loop} z_1}}{1 + \frac{s}{z_1} + \frac{s^2}{\omega_{n,loop} \cdot z_1}}$$



$\frac{1}{N} \cdot \frac{\phi_{out}}{\phi_{ref}}$

$\frac{K_{pd}}{N} \cdot \frac{\phi_{out}}{V_{nc}}$

$\frac{\phi_{out}}{\phi_{vco}}$

$\frac{\phi_{out}}{\phi_{ref}}$: Lowpass with dc gain = N ; $\frac{\phi_{out}}{\phi_{vco}}$: Highpass

$\frac{\phi_{out}}{\phi_{vco}}$: Bandpass with a peak gain $\frac{N}{K_{pd}}$

Clean up the jitter of the reference oscillator:

* Low bandwidth PLL; More filtering of ϕ_{ref}

Clean up the jitter of the VCO: (reduce contribution of ϕ_{vco})

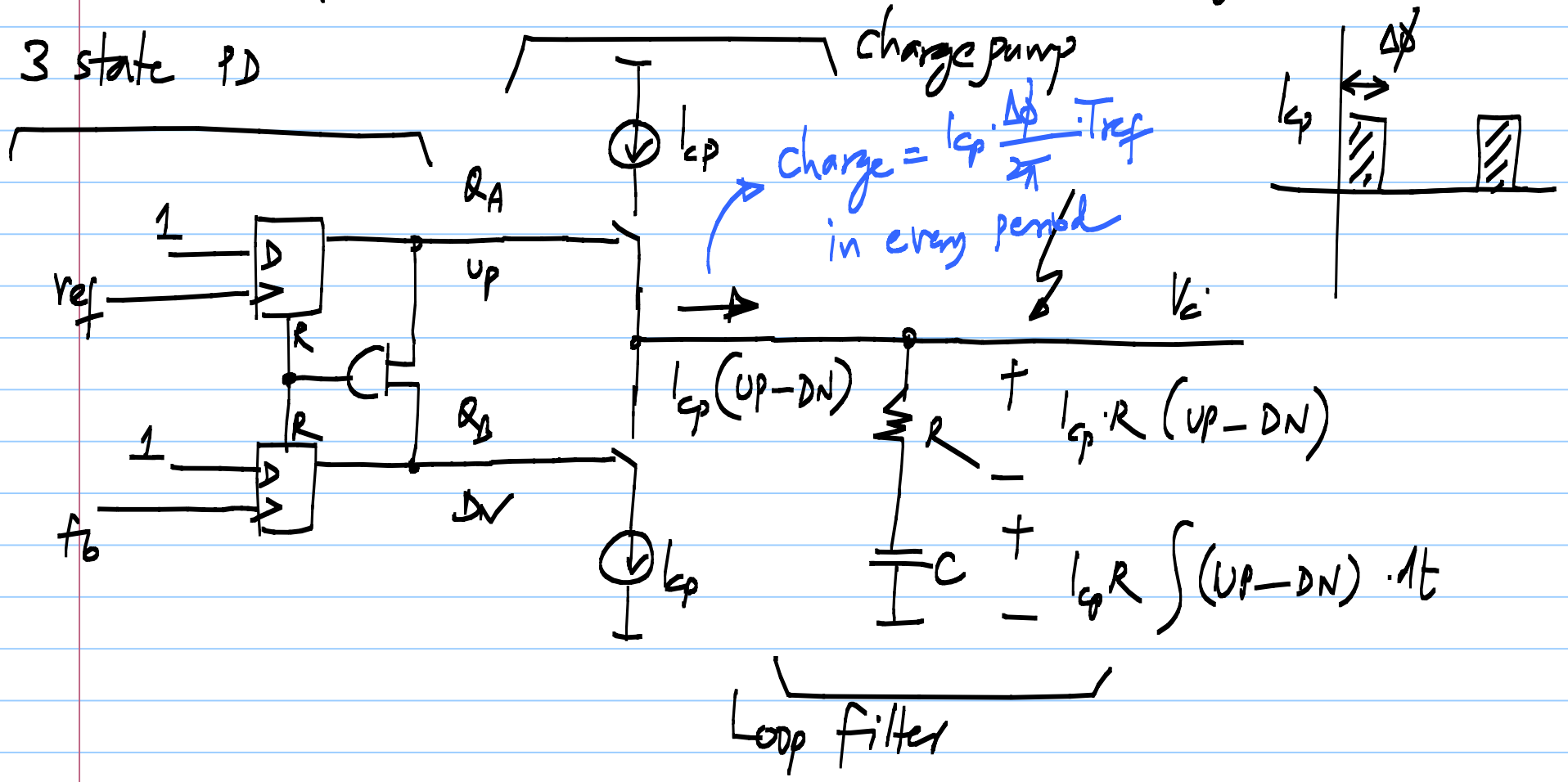
* High bandwidth PLL

Follow the jitter of the reference oscillator:

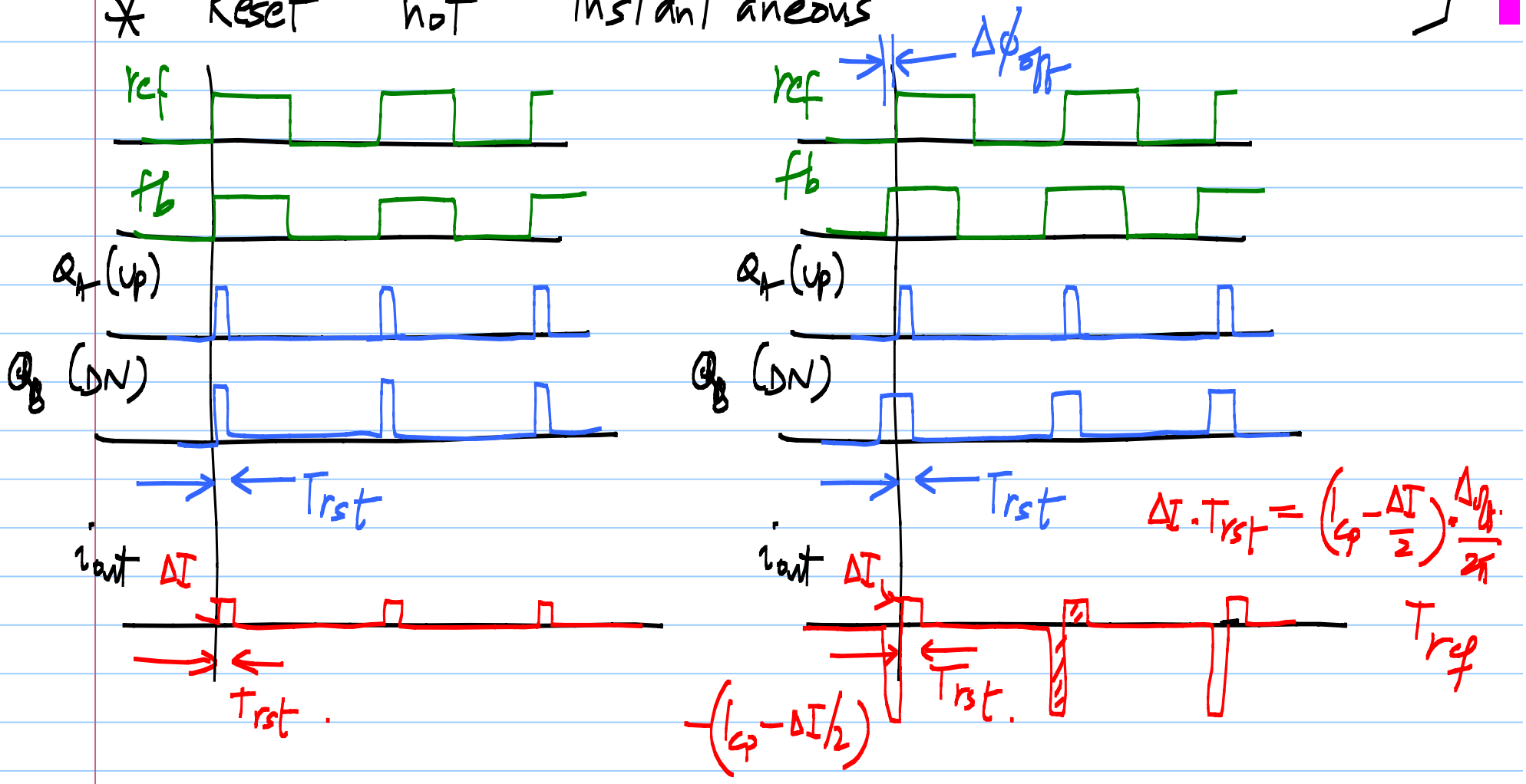
* High bandwidth PLL.

Reference feedthrough in a type II PLL

3 state phase detector < proportional & integral paths.



* upper and lower currents not equal to each other
* Reset not instantaneous



Type II PLL locked with a phase offset $\Delta\phi_{off}$

$$\Delta I \cdot T_{rst} = +\left(I_{cp} - \frac{\Delta I}{2}\right) \cdot \frac{\Delta\phi_{off}}{2\pi} \cdot T_{ref}$$

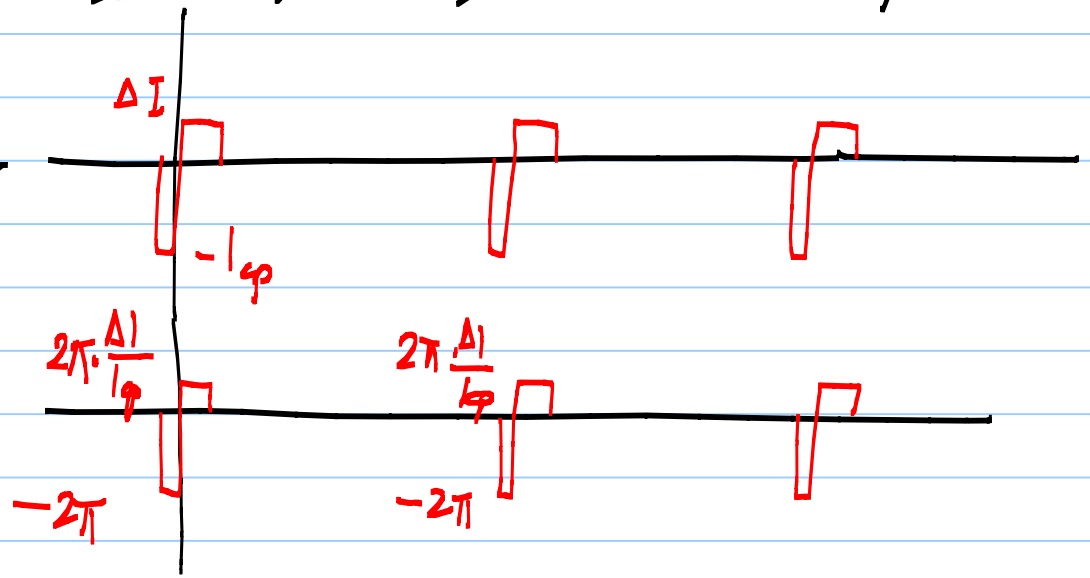
$$\Delta\phi_{off} = 2\pi \cdot \frac{T_{rst}}{T_{ref}} \cdot \frac{\Delta I}{\left(I_{cp} - \frac{\Delta I}{2}\right)} \approx 2\pi \cdot \left(\frac{T_{rst}}{T_{ref}}\right) \cdot \left(\frac{\Delta I}{I_{cp}}\right)$$

P.D + charge pump o/p:

$\frac{2\pi}{I_{cp}}$

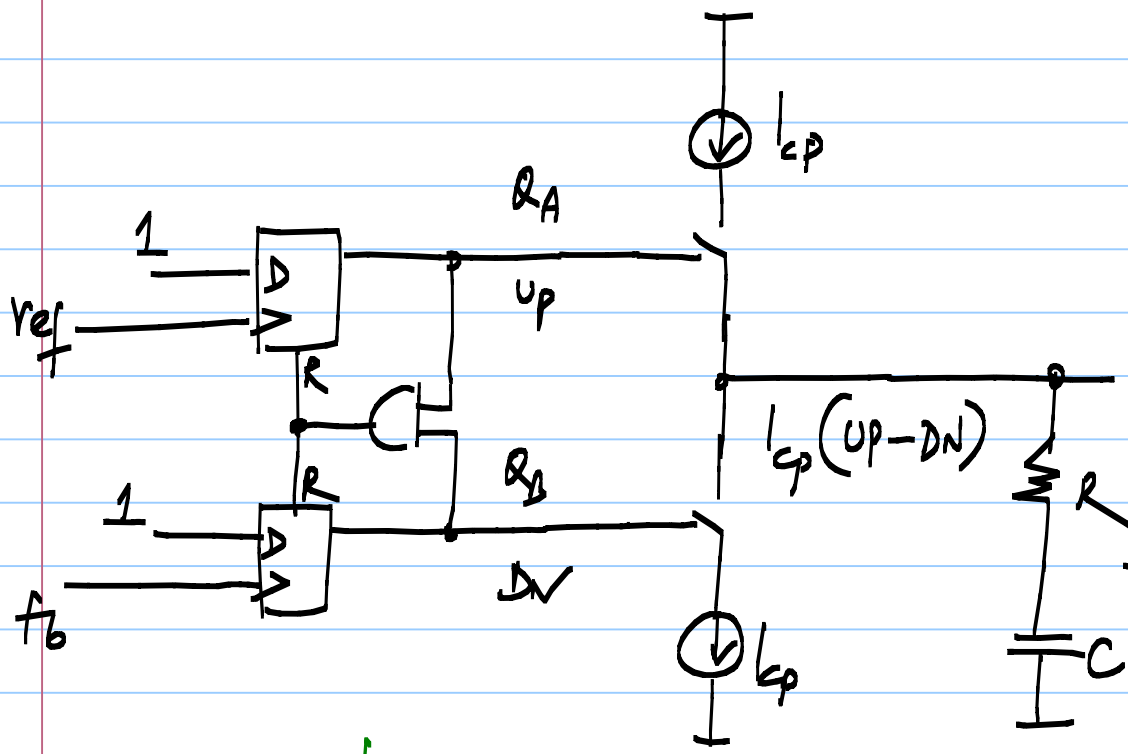
input referred

e(t)

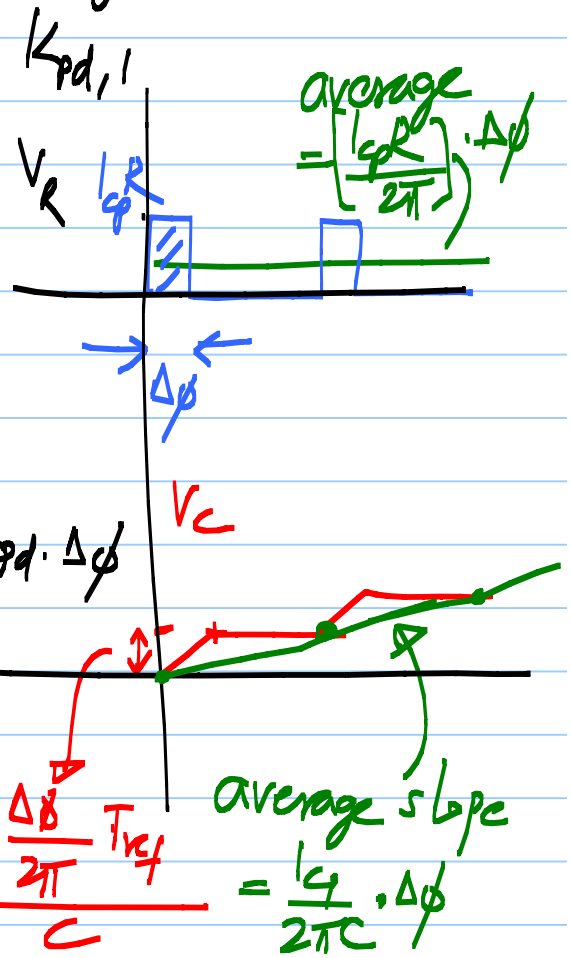


Reference feedthrough in a type II PLL

3 state phase detector < Proportional & integral paths.



$V_R = K_{pd} \cdot \Delta\phi$



$$K_{pd,1} = \frac{I_{cp}}{2\pi C} \; ; \; K_{pd} = \frac{I_{cp}R}{2\pi}$$

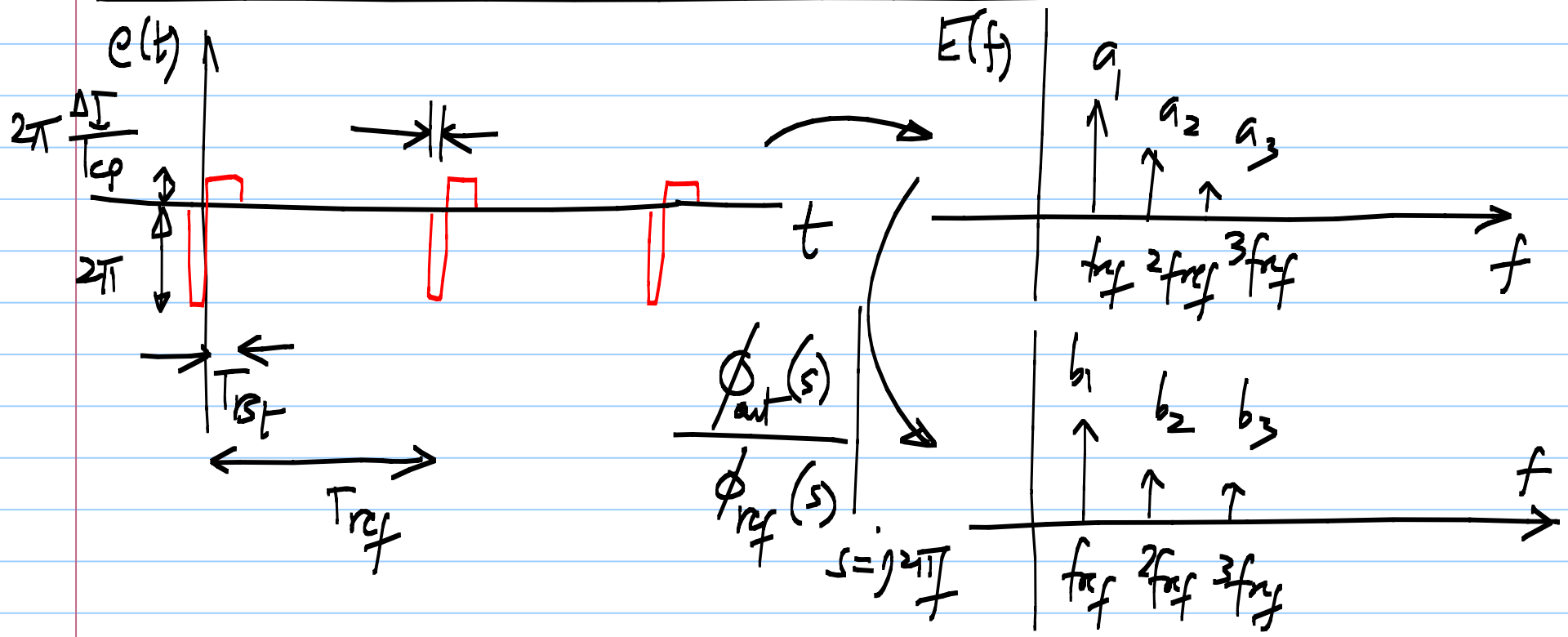
$$\omega_{u,loop} = \frac{2\pi K_{pd} K_{vco}}{N} = \frac{2\pi \cdot \frac{I_{cp} R}{2\pi} \cdot K_{vco}}{N}$$

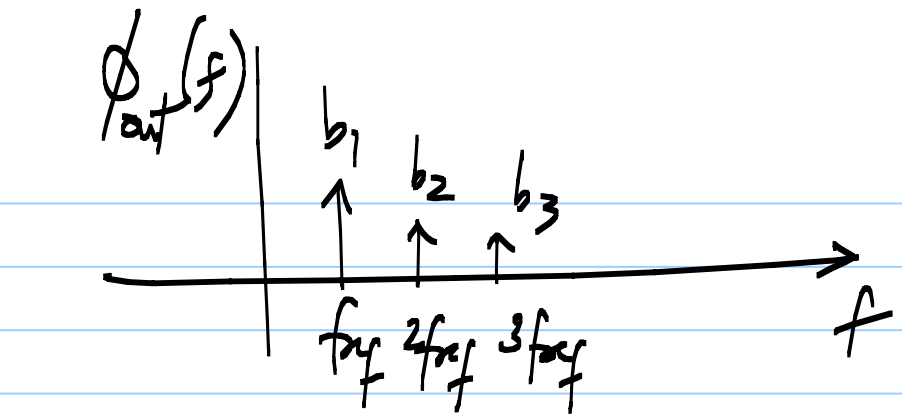
$$\omega_{u,loop} = \frac{I_{cp} R \cdot K_{vco}}{N} \quad (Hz)$$

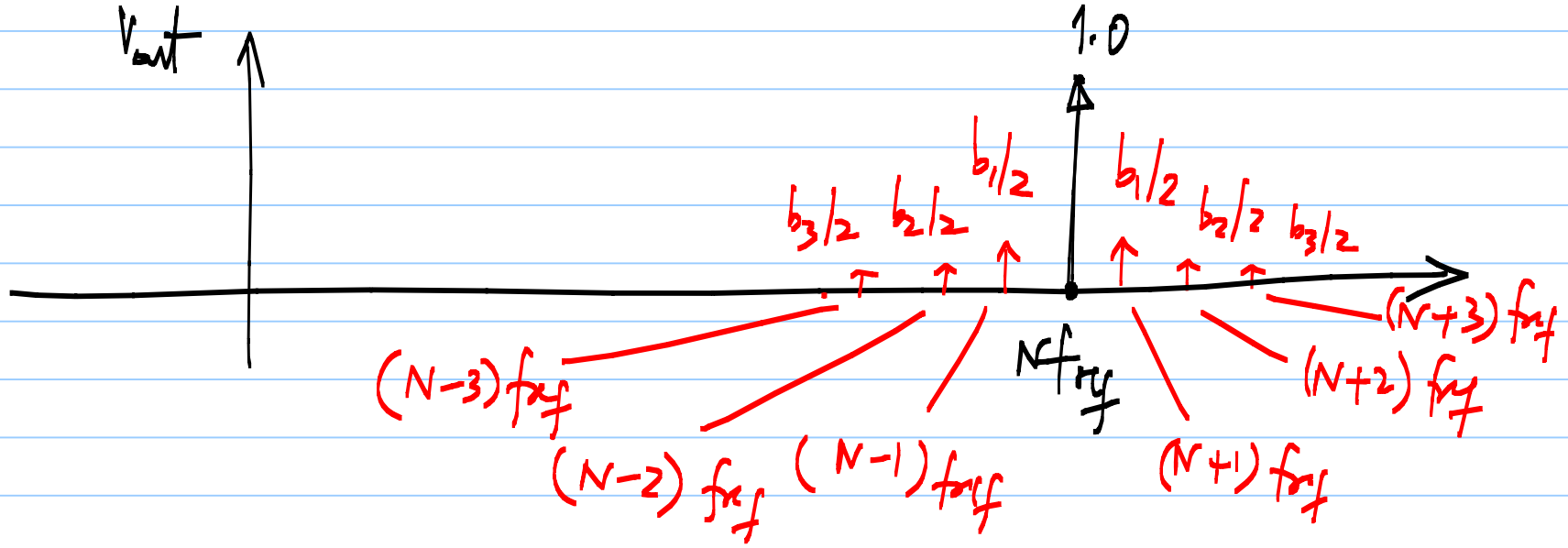
$$\omega_{u,loop} \quad (rad/s)$$

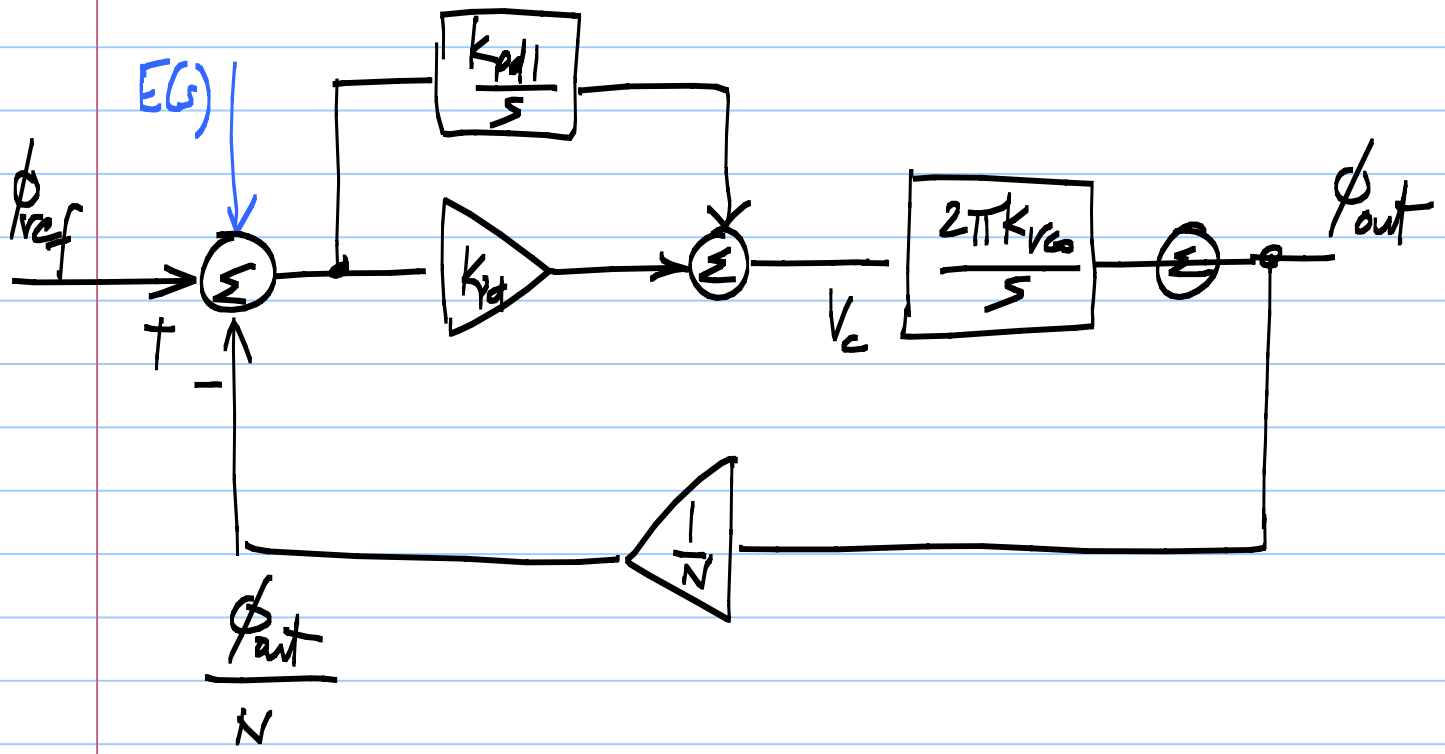
$$z_1 = \frac{K_{pd,1}}{K_{pd}} = \frac{1}{RC}$$

Periodic error e(t) added to the loop:




$\phi_{out}(f)$
b_1
b_2
b_3
f_{ref}
$2f_{ref}$
$3f_{ref}$
f


V_{out}
1.0
$b_1/2$
$b_1/2$
$b_2/2$
$b_2/2$
$b_3/2$
$b_3/2$
$(N-3)f_{ref}$
$(N-2)f_{ref}$
$(N-1)f_{ref}$
Nf_{ref}
$(N+1)f_{ref}$
$(N+2)f_{ref}$
$(N+3)f_{ref}$


E(s)
ϕ_{ref}
$\frac{K_{pll}}{s}$
K_{vd}
V_c
$\frac{2\pi K_{vco}}{s}$
ϕ_{out}
+
−
$\frac{1}{N}$
$\frac{\phi_{out}}{N}$