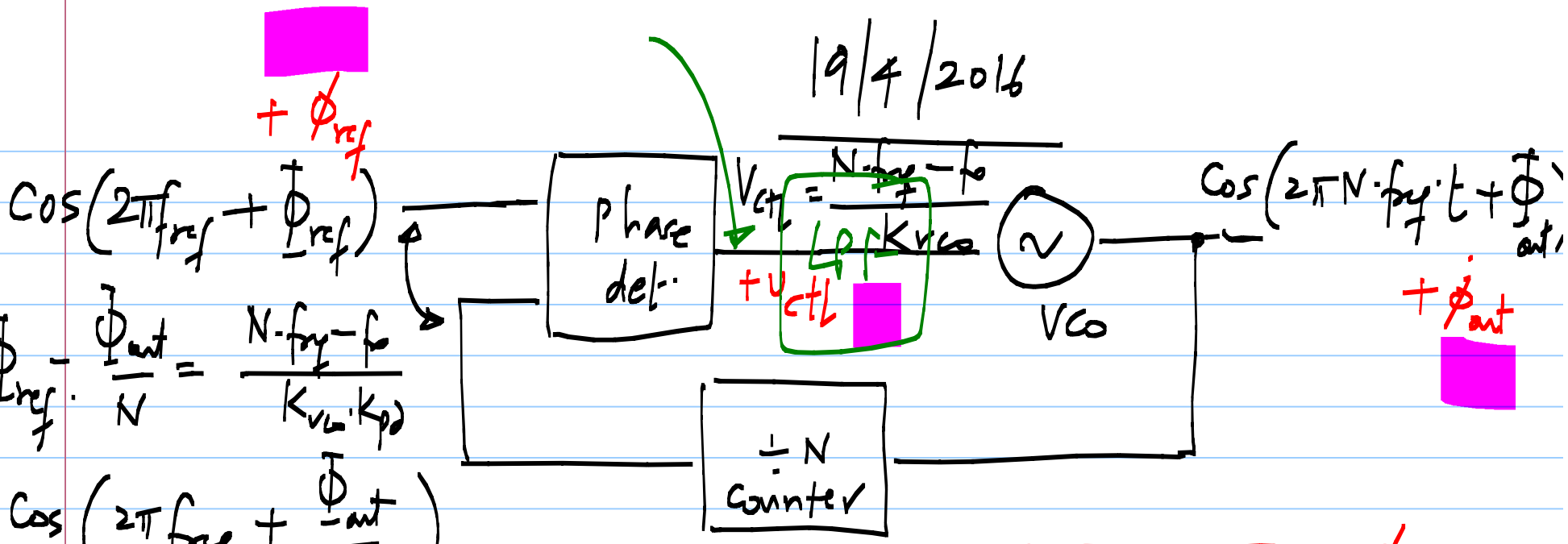
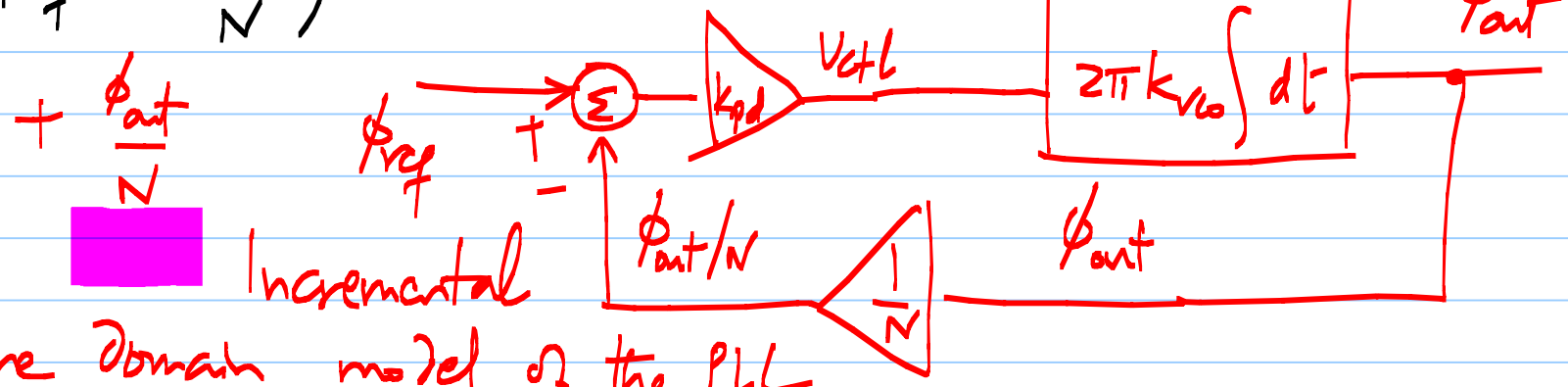
19/4/2016



$$\phi_{ref} - \frac{\phi_{out}}{N} = \frac{N \cdot f_{out} - f_0}{K_{VCO} \cdot K_{pd}}$$

$$\cos\left(2\pi f_{ref} + \frac{\phi_{out}}{N}\right)$$



Incremental

Phase domain model of the PLL

$\cos(\theta(t))$: VCO output

$$\theta(t) = 2\pi f_0 t + 2\pi K_{VCO} \int (V_{ctl} + v_{ctl})\, dt$$

Op-point

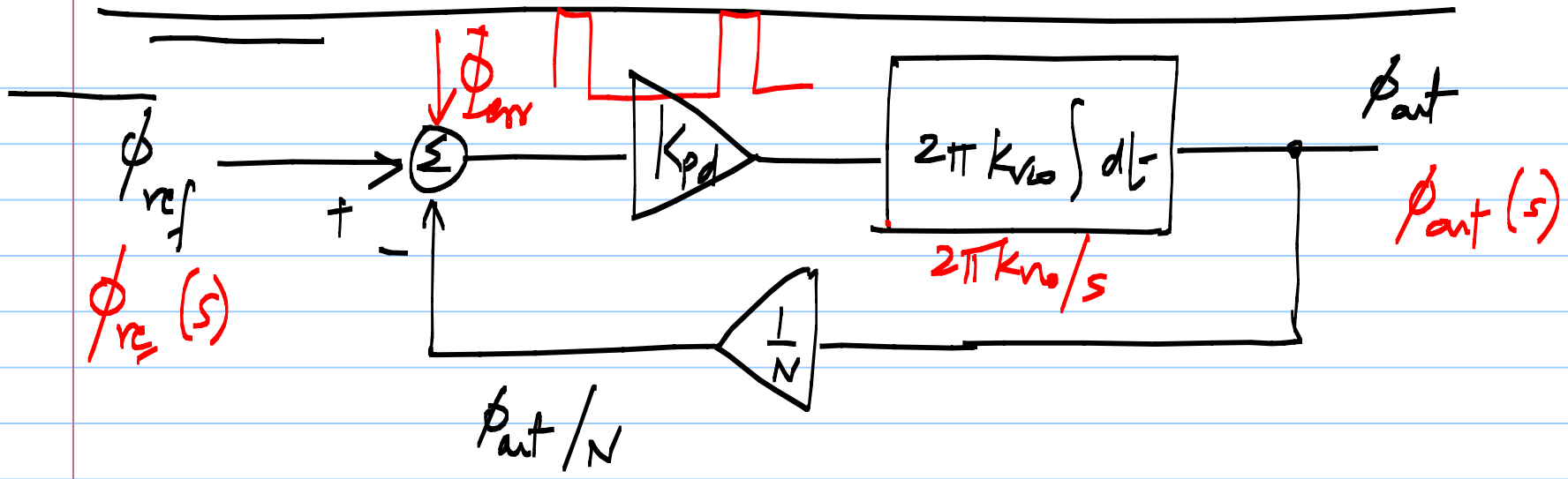
$$2\pi \cdot N f_{ref} \cdot t + \Phi_{int}$$

increment

$+ \phi_{out}$

$$\phi_{out} = 2\pi K_{VCO} \int v_{ctl} \cdot dt$$

Incremental phase domain model of the PLL



$\phi_{ref}(s)$

$\phi_{out}(s)$

$\frac{\phi_{out}(s)}{\phi_{ref}(s)}$, its dc gain, Loop gain $\frac{V_{ctl}(s)}{\phi_{ref}(s)}$

its 3dB BW

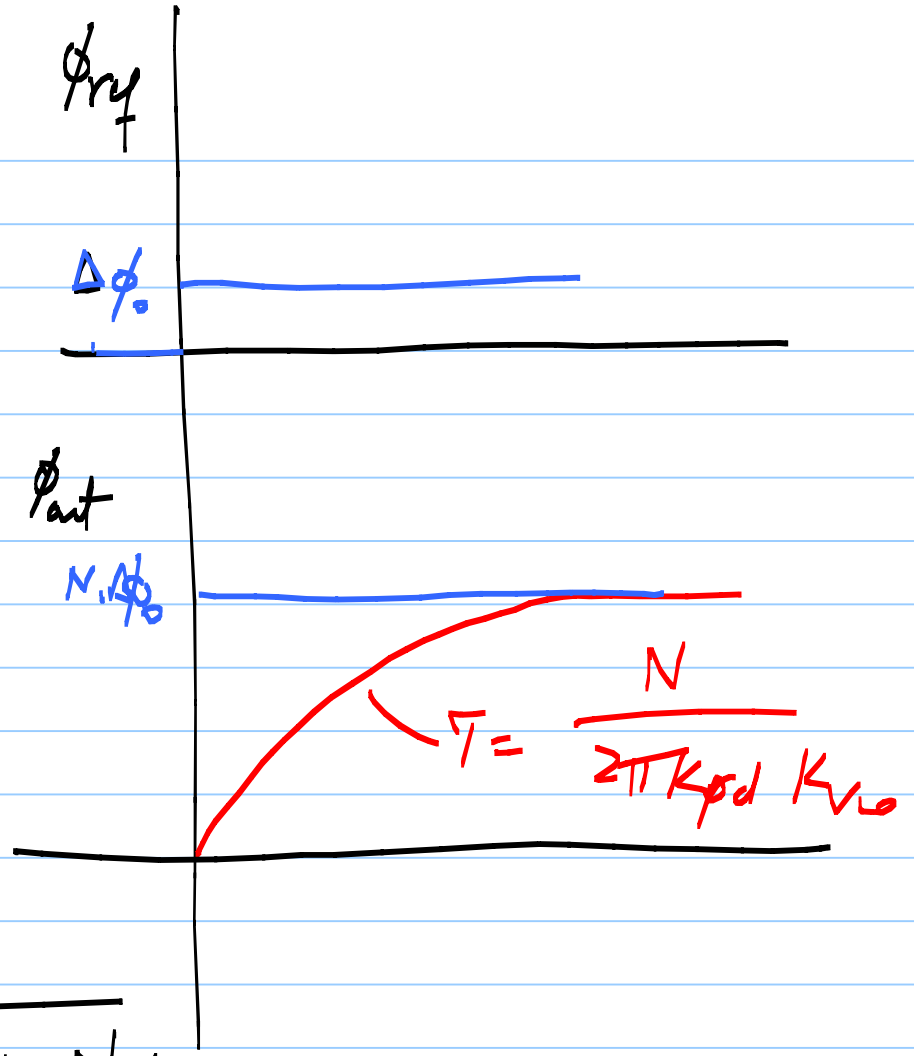
$$\frac{\phi_{out}(s)}{\phi_{ref}(s)} = \frac{N}{1 + \frac{s}{(2\pi K_{pd} K_{vco}/N)}}$$

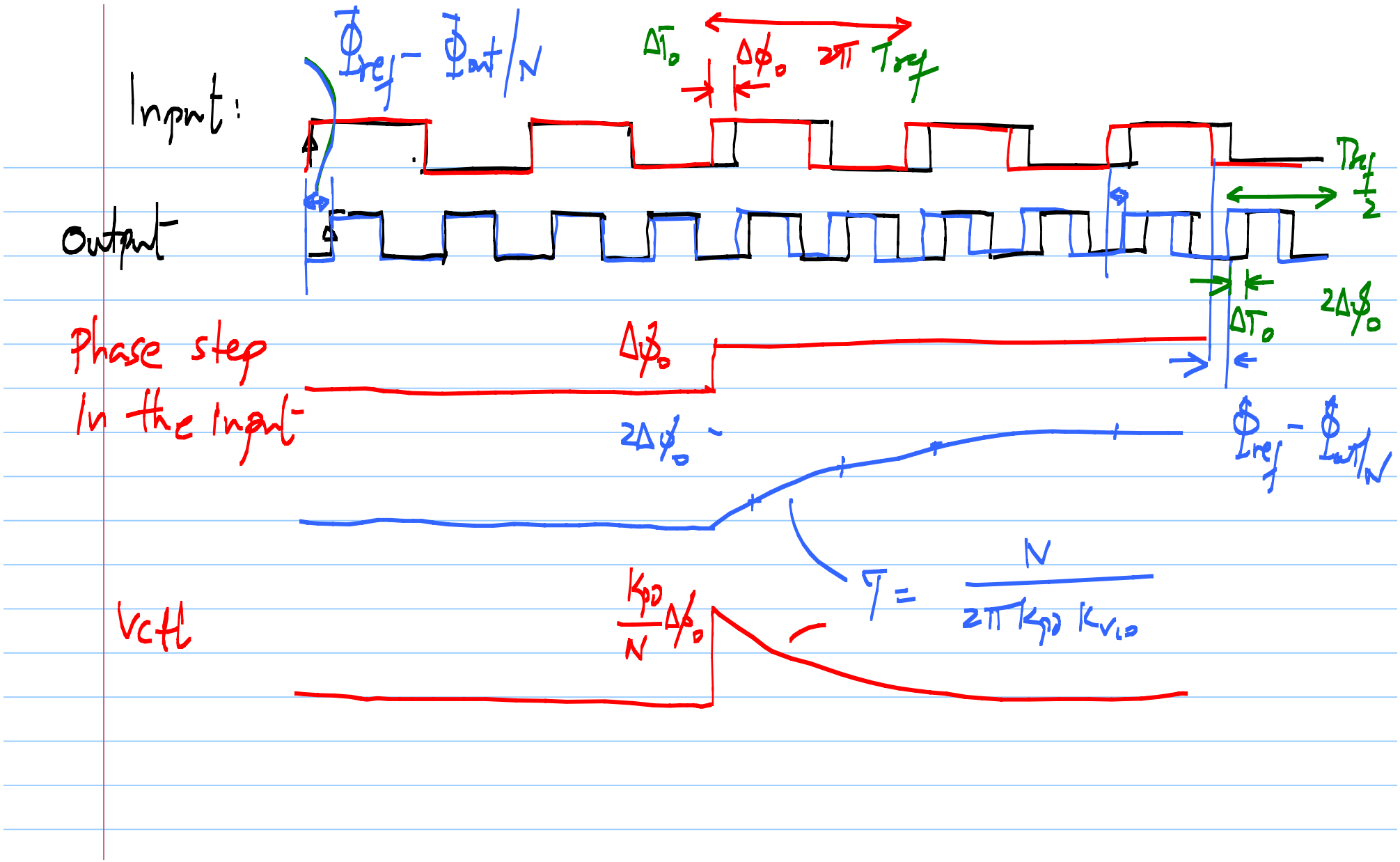
dc gain: N

BW (rad/s): $2\pi K_{pd} K_{vco}/N$

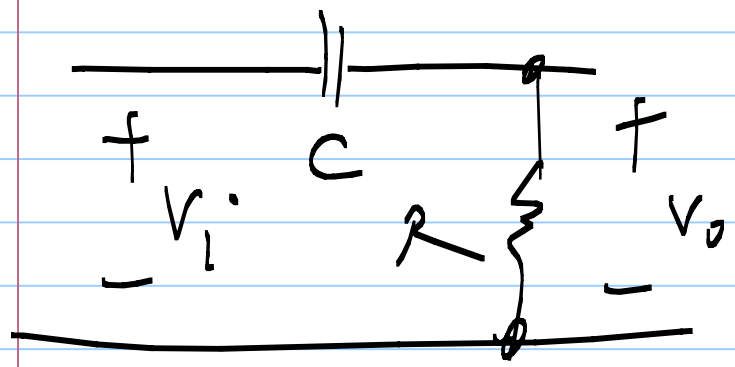
$$L(s) = \frac{2\pi K_{pd} K_{vco}}{N \cdot s}$$

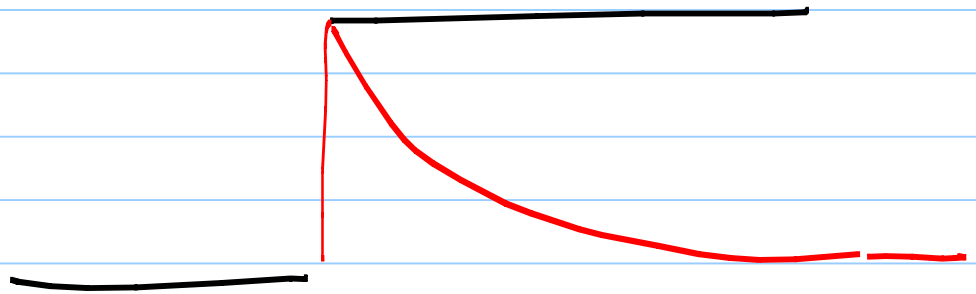
$$\frac{V_{ctl}(s)}{\phi_{ref}(s)} = \frac{\frac{s}{2\pi K_{vco}}}{1 + s/(2\pi K_{pd} K_{vco})/N}$$

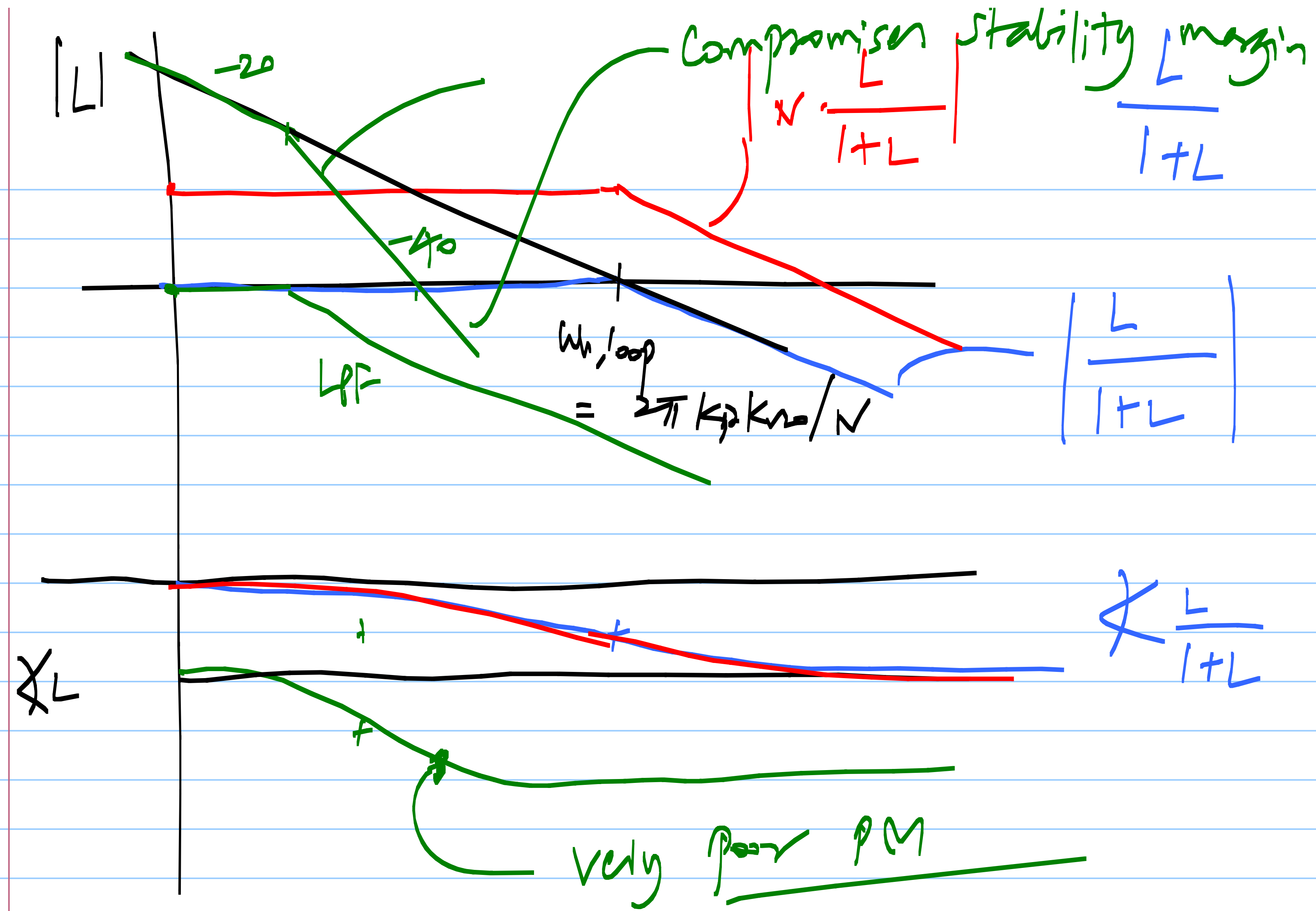



Input:
Output
Phase step
In the Input
Vctl
$\Phi_{ref} - \Phi_{out}/N$
ΔT_0
$\Delta\phi_0$
2π
T_{ref}
$T_{ref}/2$
$2\Delta\phi_0$
$\Delta\phi_0$
$2\Delta\phi_0$
$\frac{K_{PD}}{N}\Delta\phi_0$
$\tau = \frac{N}{2\pi K_{PD} K_{VCO}}$

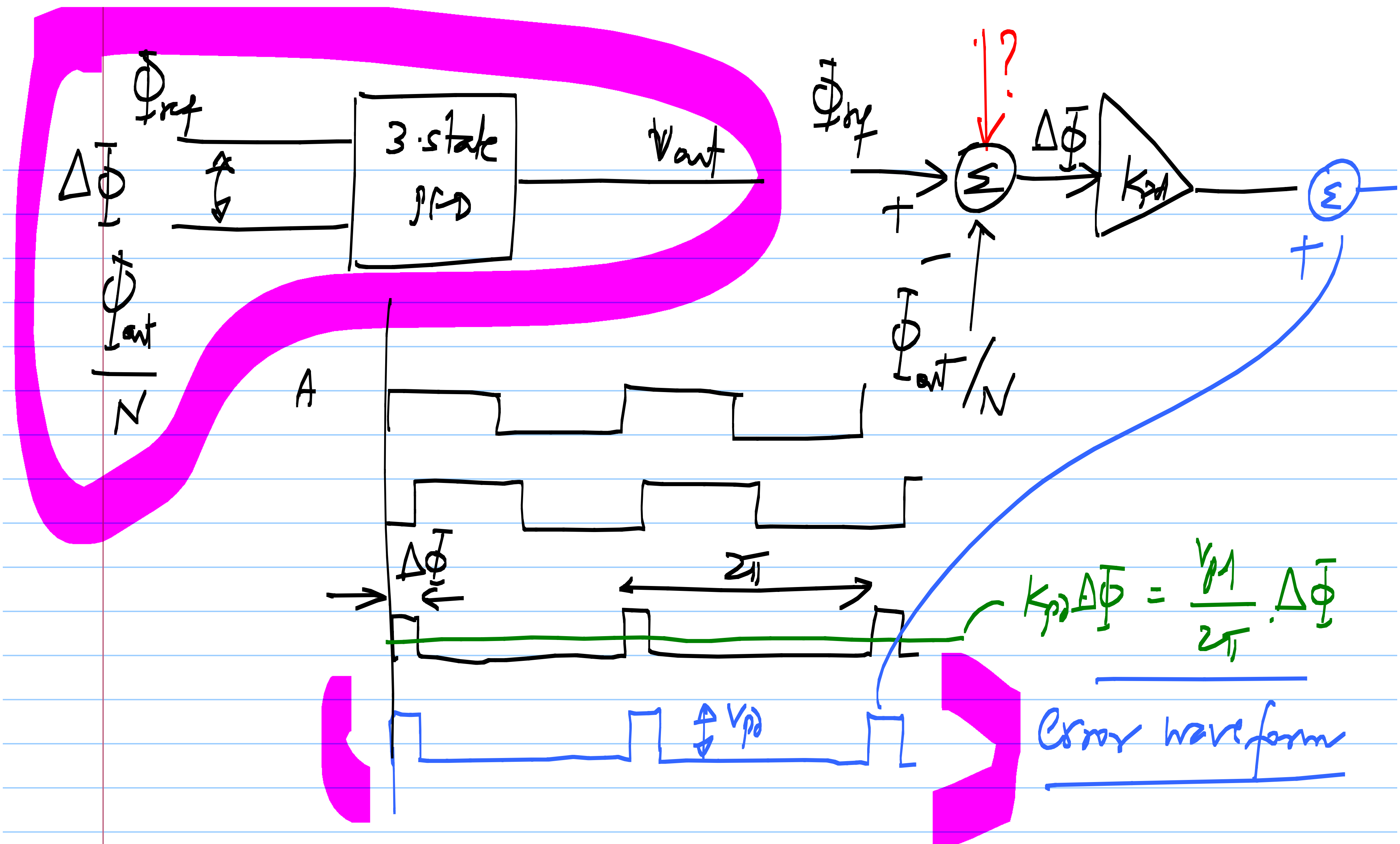
$$\frac{V_{ctl}}{\phi_{ref}} = \frac{\frac{s}{2\pi K_{vco}}}{1 + \frac{s}{(2\pi K_{pd} K_{vco})/N}} = \frac{K_{pd}}{N} \cdot \left[\frac{\frac{s}{(2\pi K_{vco} K_{pd}/N)}}{1 + \frac{s}{(2\pi K_{vco} K_{pd}/N)}} \right]$$





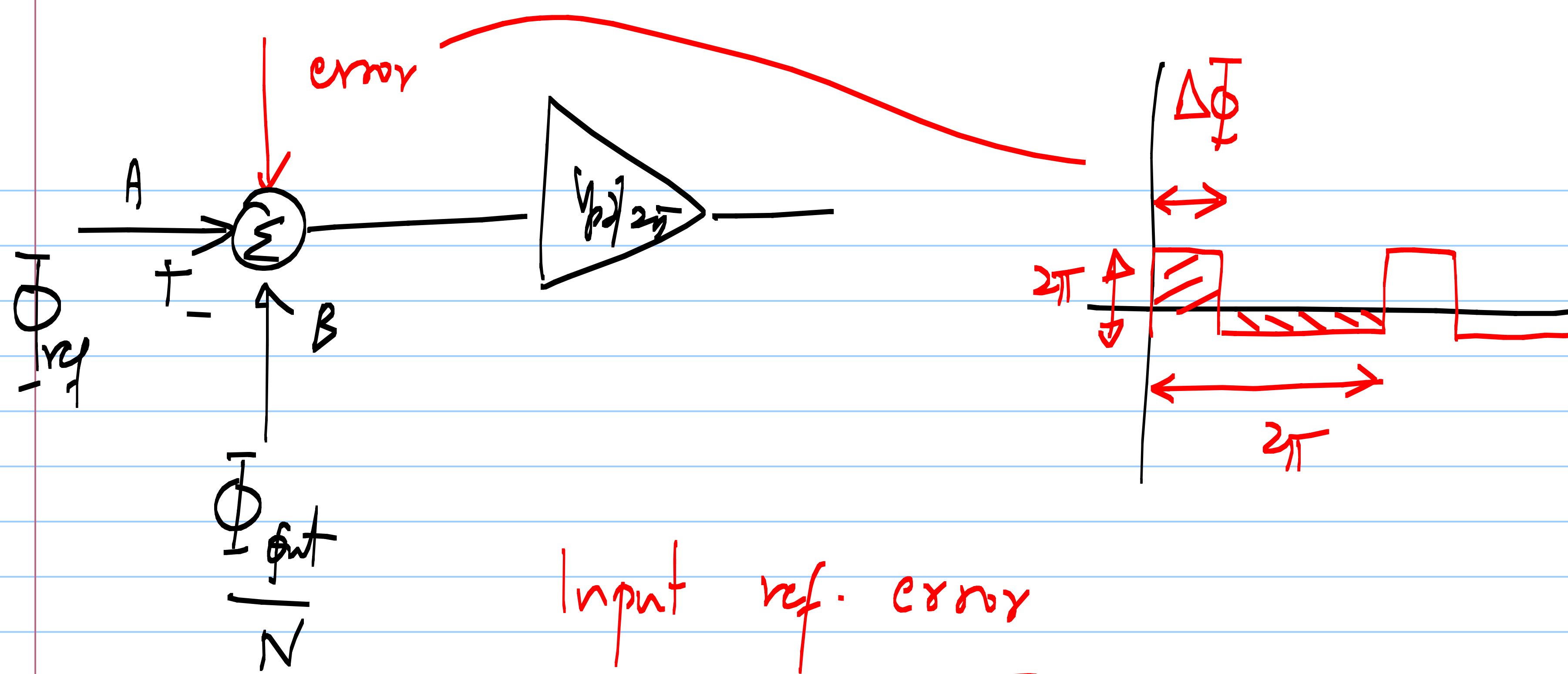


|L|
-20
-40
Compromise stability margin
$\left| N \cdot \frac{L}{1+L} \right|$
$\frac{L}{1+L}$
LPF
$\omega_{n,loop} = 2\pi K_{pd} K_{vco} / N$
$\left| \frac{L}{1+L} \right|$
$\measuredangle L$
$\measuredangle \frac{L}{1+L}$
very poor PM



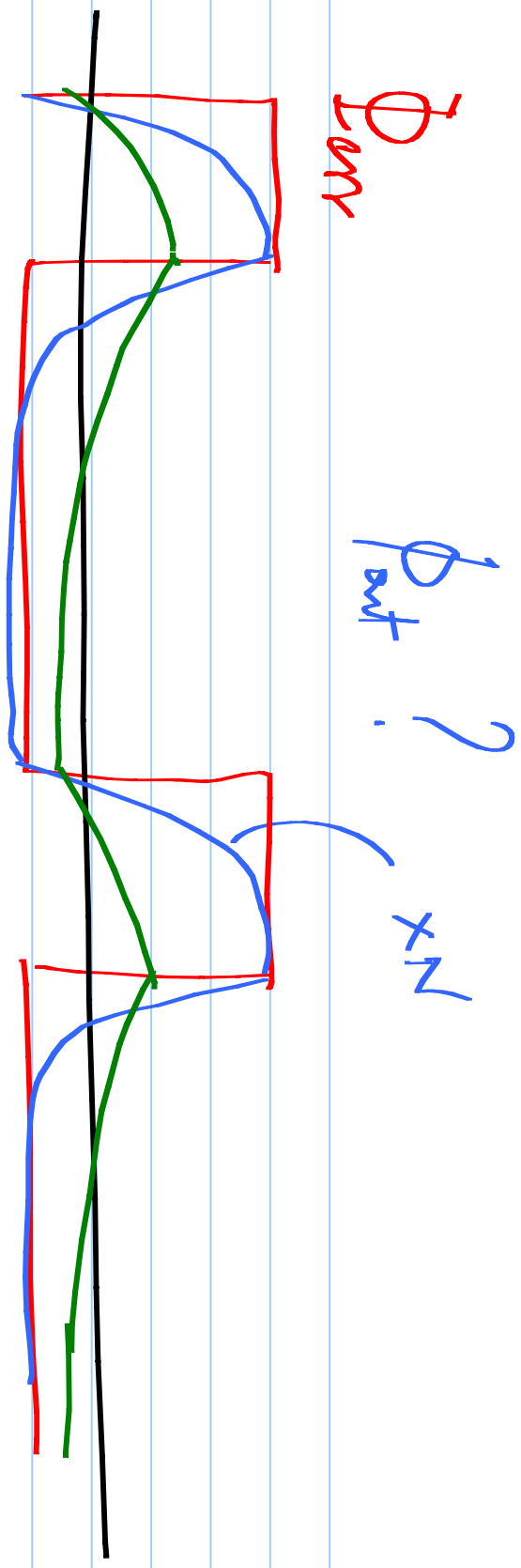
$$K_{pd}\Delta\Phi = \frac{V_{pd}}{2\pi}\cdot\Delta\Phi$$

Error waveform



Input ref. error

* @ f_{ref}
* duty cycle $= \frac{\Delta\Phi}{2\pi}$
* pp value $= 2\pi$


θ_{sat}
θ_{at} ?
x_N