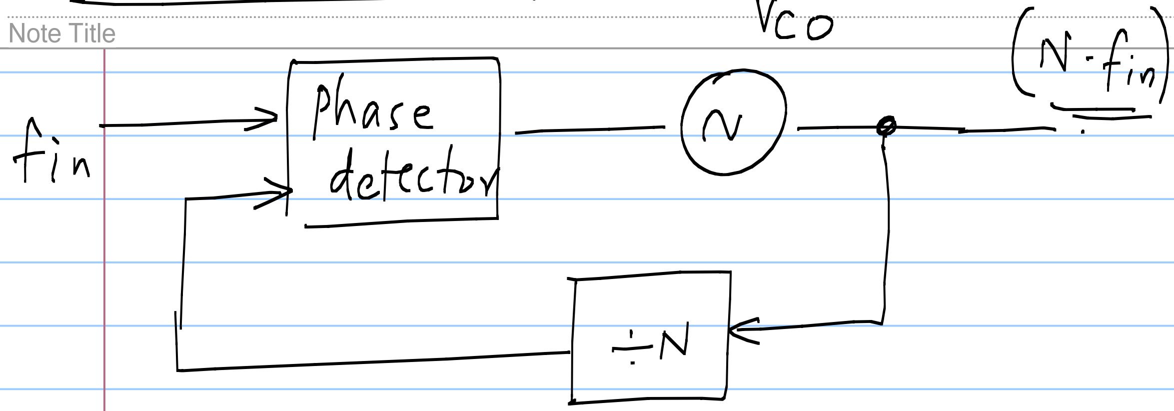
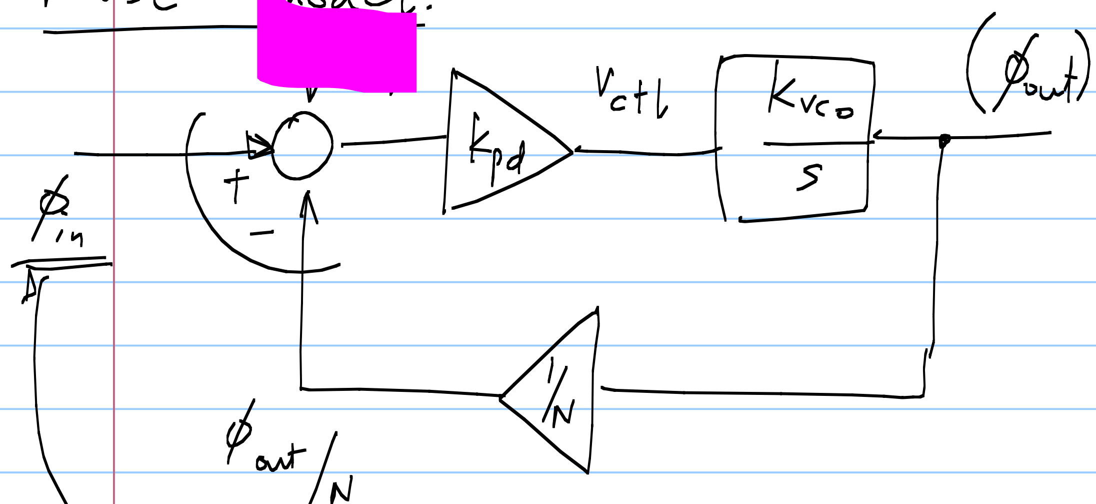
Phase locked loop.

Note Title 15-10-2007

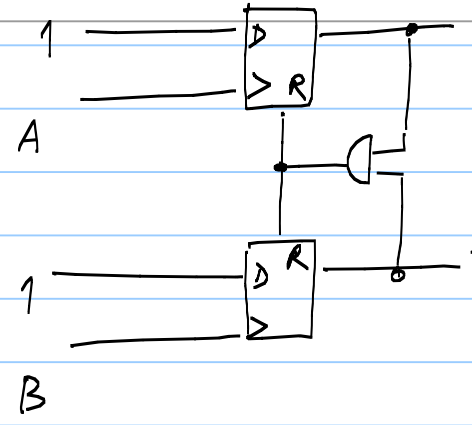


Phase model:



$\cos(2\pi f_{in} t + \Phi + \phi_{in}(t))$

Tri-state P.D



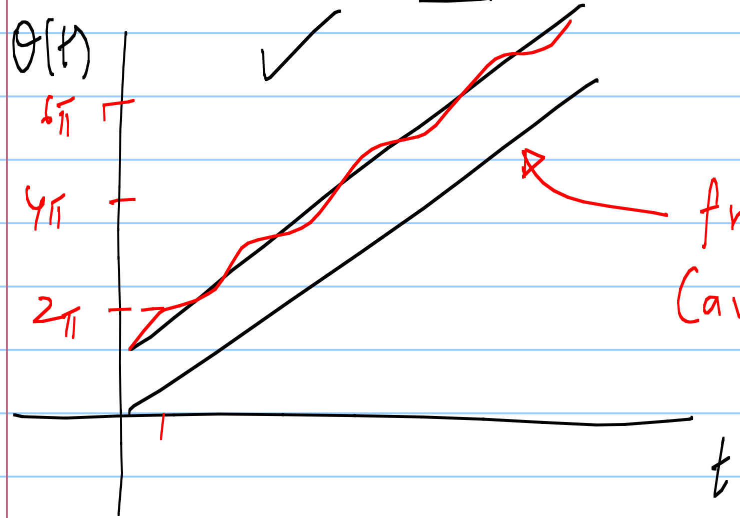
UP − DN:

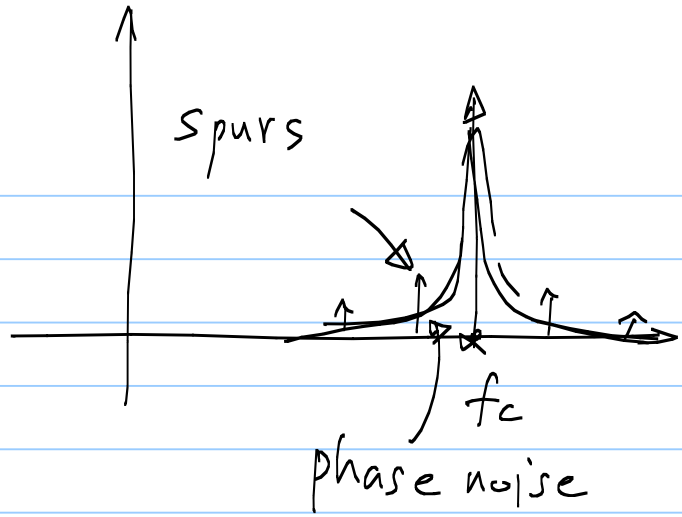
$$\text{output} = \frac{1}{2\pi}(\Delta\phi + E(t))$$

$\cos(\theta(t))$ $\qquad$ $p(\theta(t))$

$\theta(t) = 2\pi f_c t + \Phi + \phi(t)$

$2\pi f_1 t$



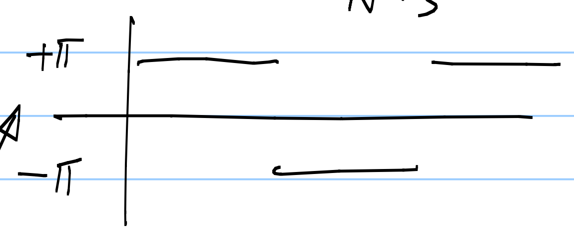


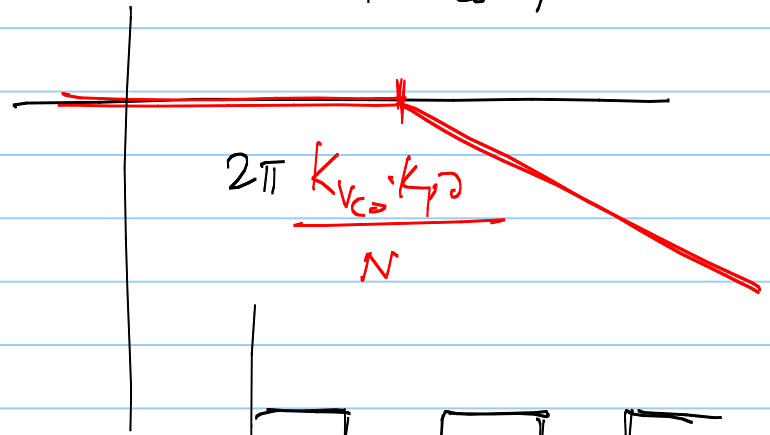
* $E(t)$: periodic error of the phase detector
  $avg(E(t)) = 0$

* $\phi_{out} \neq 0$ even with $\phi_{in} = 0$

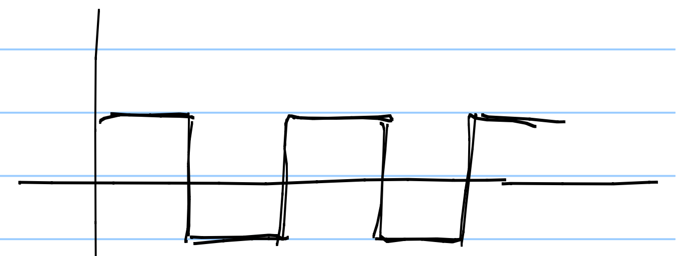
$$\left[\left(\frac{\phi_{out}(s)}{E(s)}\right)\right] = \frac{2\pi\, K_{vco} \cdot K_{pd}/s}{1 + \frac{2\pi K_{vco} \cdot K_{pd}}{N \cdot s}} = N \cdot \left(\frac{1}{1 + s \cdot \frac{N}{2\pi K_{vco} \cdot K_{pd}}} \right)$$

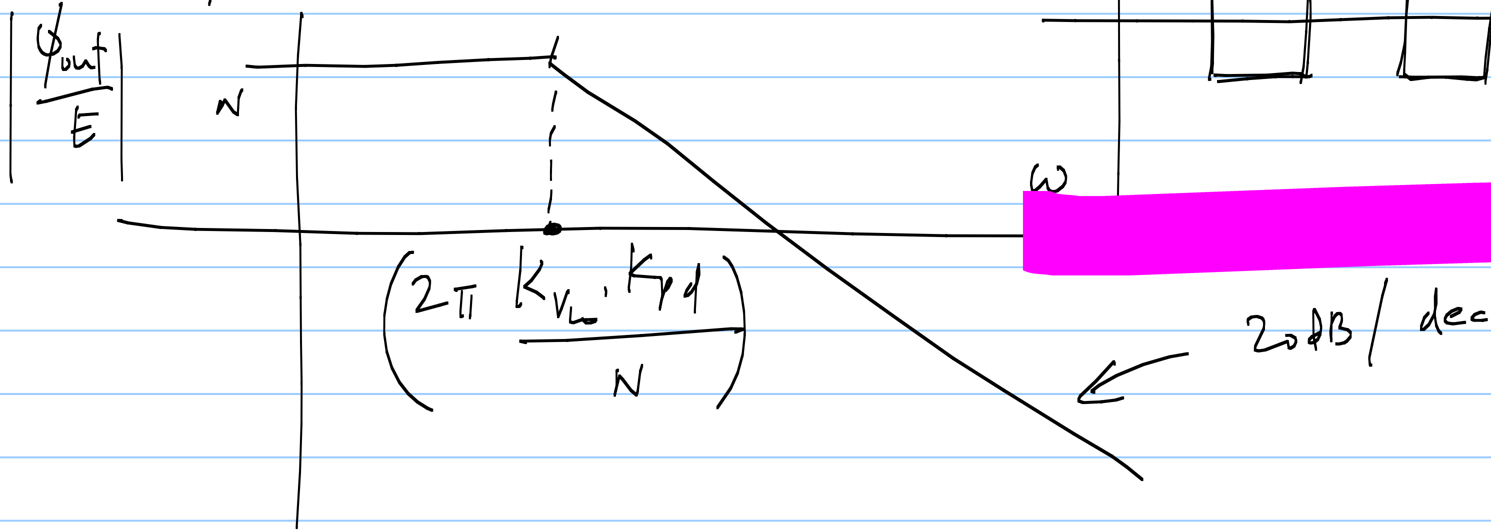
$$\frac{\phi_{out}(s)}{\phi_{in}(s)}$$

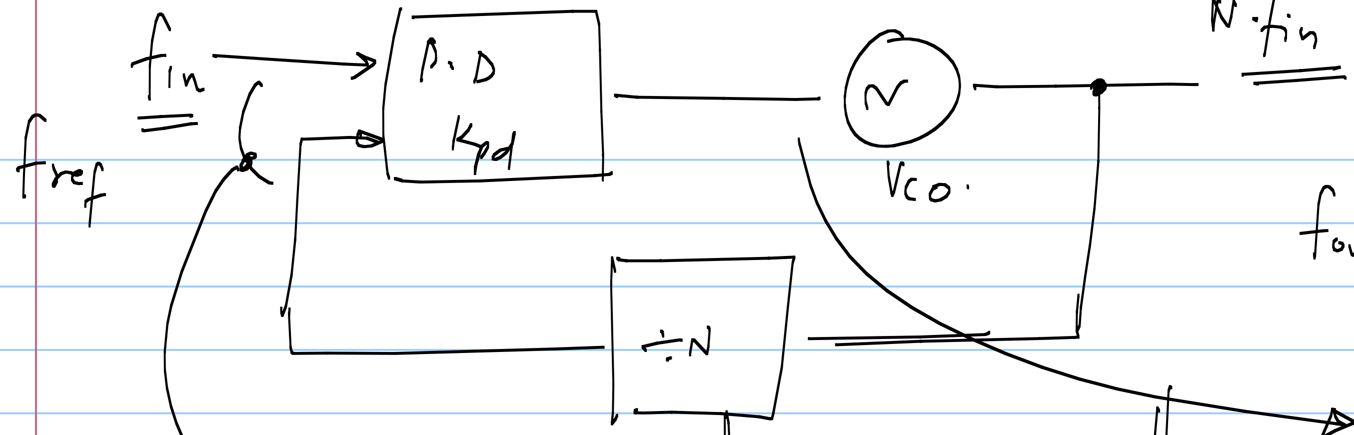




$$E(t) \approx \sum_{n=1}^{\infty} a_n \cos(2\pi \cdot n f_{ref} t + \alpha_n)$$







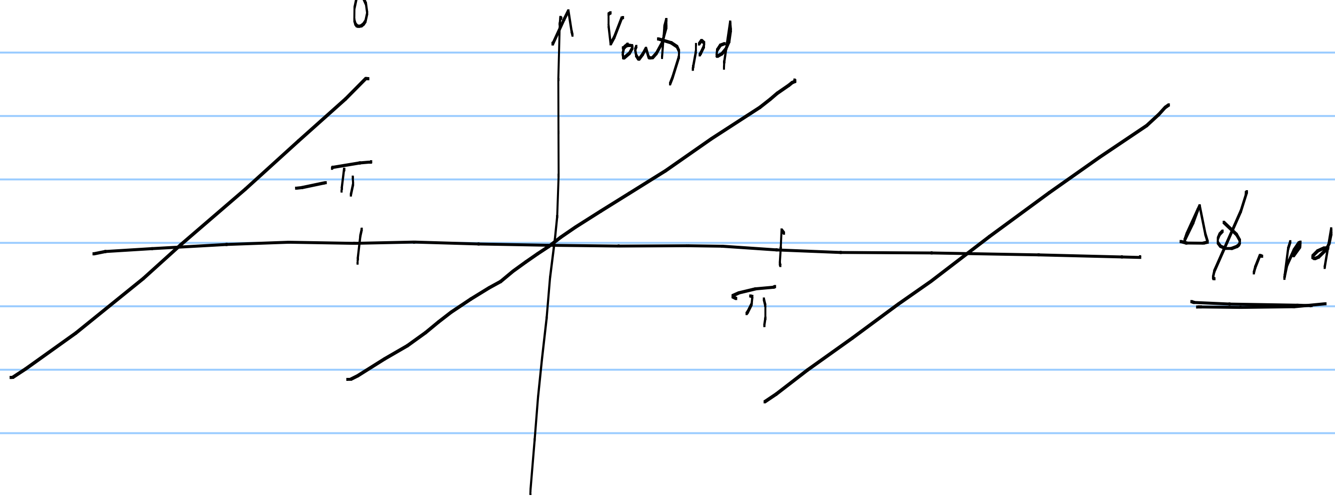
$f_{out} = K_{vco} \cdot V_{ctl} + f_o$

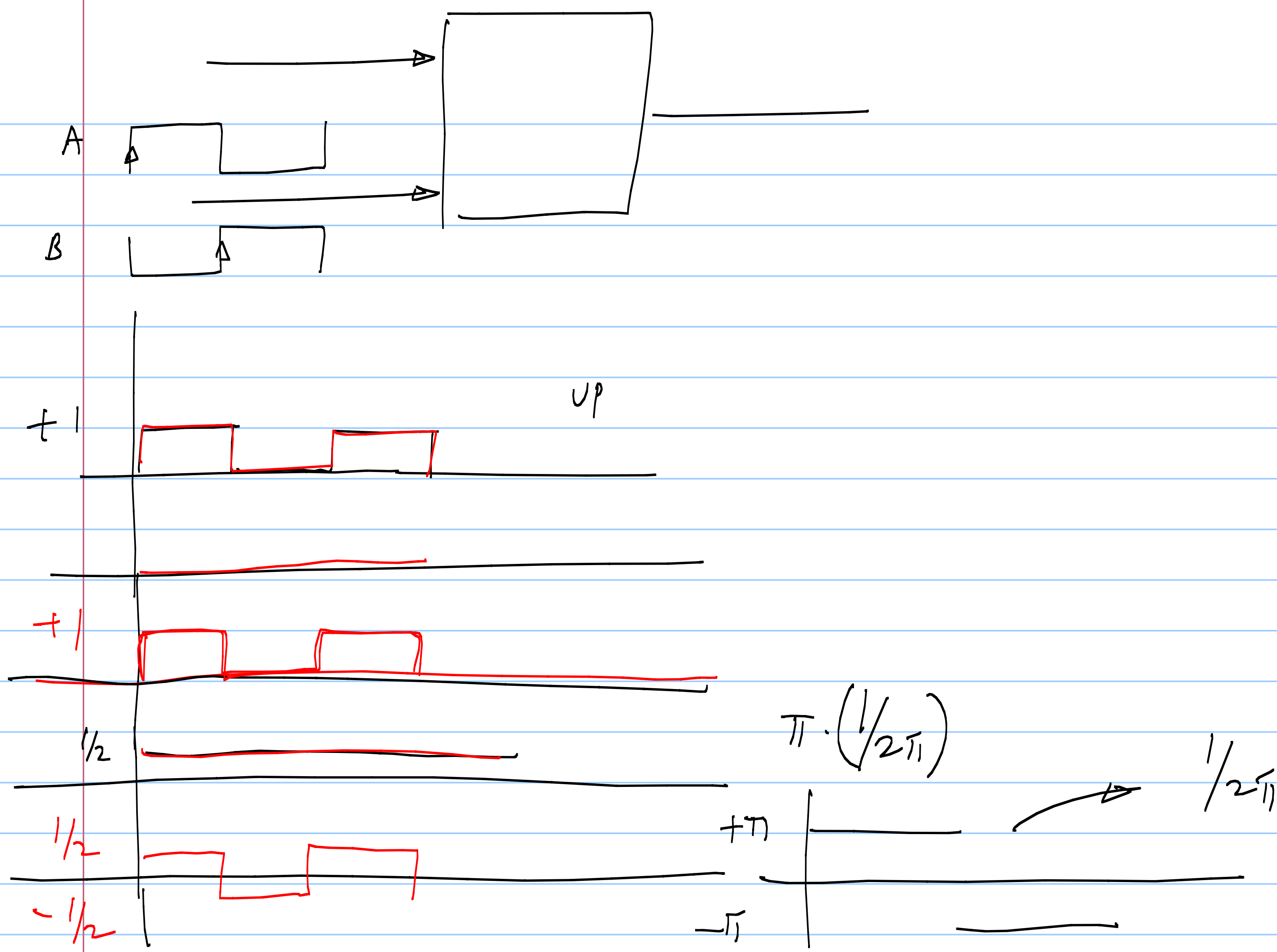
$\left(\frac{N \cdot f_{in} - f_o}{K_{vco}} \right)$

phase diff $= \left\| \left[\frac{(N \cdot f_{in}) - f_o}{K_{vco} \cdot K_{pd}} \right] \right\| < \pi$

$-\pi \cdot K_{vco} \cdot K_{pd} < (N_{f_{in}} - f_o) < \pi \cdot K_{vco} \cdot K_{pd}$

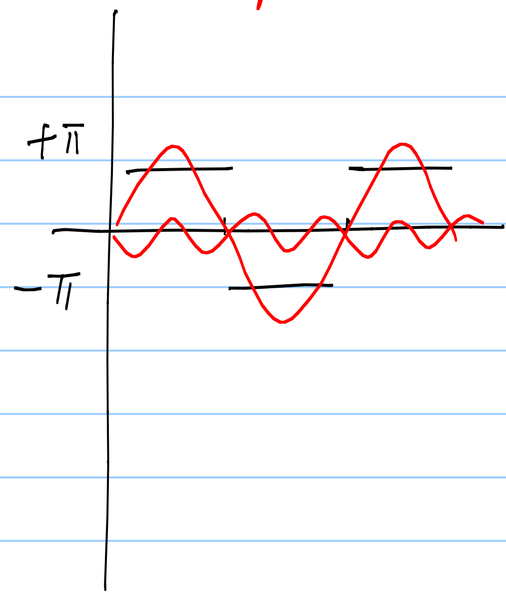
Characteristics of the PD




A
B
up
+1
+1
1/2
1/2
-1/2
π · (1/2π)
+π
-π
1/2π

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

$$|w| \gg \frac{2\pi K_{vco} \cdot K_{pd}}{N}$$



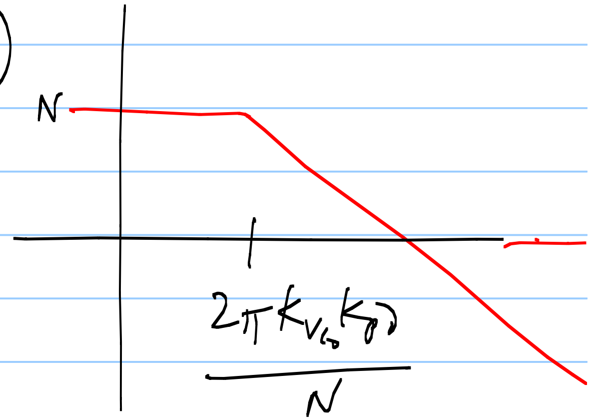
$$E(t) = \sum_{n=1}^{\infty} a_n \cos(2\pi n \cdot f_{ref} t + \alpha_n)$$

$$\simeq 4 \cdot \cos(2\pi f_{ref} t)$$

$$\phi_{out}(t) = \sum_{n=1}^{\infty} \beta_n \cos(2\pi \cdot n f_{ref} t + \beta_n)$$

$$4 \cdot \frac{2\pi \cdot K_{vco} \cdot K_{pd}}{2\pi \cdot f_{ref}} \cos(2\pi f_{ref} t - \pi/2)$$

$$\phi_{int}(t) = \left[4 \cdot \frac{K_{vco} \cdot K_{pd}}{f_{ref}} \cos(2\pi f_{ref} t) \right]$$



$$V_{out}(t) = \cos\left(2\pi \cdot N f_{ref} t + \phi_{out}(t)\right)$$

$$= \cos\left(2\pi N f_{ref} t\right) \cdot \cos\left(\underline{\underline{\phi_{out}(t)}}\right) - \sin\left(2\pi N f_{ref} t\right) \cdot \sin\left(\underline{\underline{\phi_{out}(t)}}\right)$$

$$= \cos\left(2\pi N f_{ref} t\right) - \underline{\underline{\phi_{out}(t)}} \cdot \sin\left(2\pi N f_{ref} t\right)$$

$$\left[4 \cdot \frac{K_{vco} \cdot K_{pd}}{f_{ref}} \cos\left(2\pi f_{ref} t\right)\right]$$

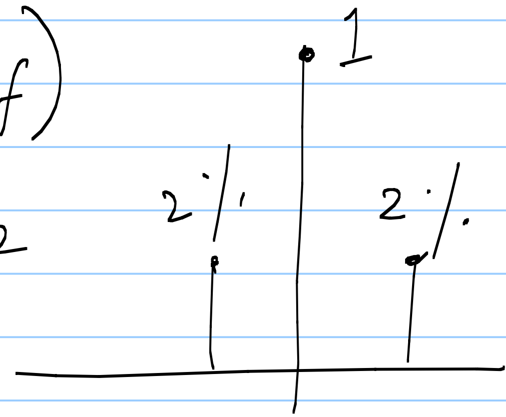
$$= \underbrace{\cos\left(2\pi \cdot N f_{ref} t\right)} - 2 \cdot \left(\frac{K_{vco} \cdot K_{pd}}{f_{ref}}\right) \sin\left(2\pi (N+1) f_{ref} \cdot t\right) - 2 \cdot \left(\frac{(K_{vco} \cdot K_{pd})}{f_{ref}}\right) \sin\left(2\pi (N-1) f_{ref} \cdot t\right)$$

Freq. synthesizer

$f_{ref} = 1\text{MHz}$, $N = 10^3$ (1001), $f_{out} = 1\text{GHz}$ (1.001GHz)

Lock range : > (f_{ref})

$$2 \cdot \left(\frac{K_{vco} \cdot K_{pd}}{f_{ref}} \right) = 2 \cdot 10^{-2}$$



$K_{vco} \cdot K_{pd} = 10\text{ kHz}$

lock range $= \pm \pi \cdot 10\text{ kHz}$