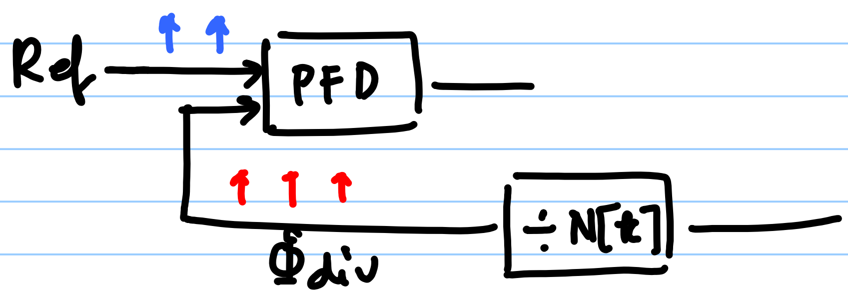
Note Title 06-11-2017

Lecture # 49

Fractional-N PLL

1. t_k: time instant of rising edge on ref.

$t_k + \Delta t_k$: time instant of rising edge on divided clock.



$t_{k+1} - t_k = T$ (ref. time period)

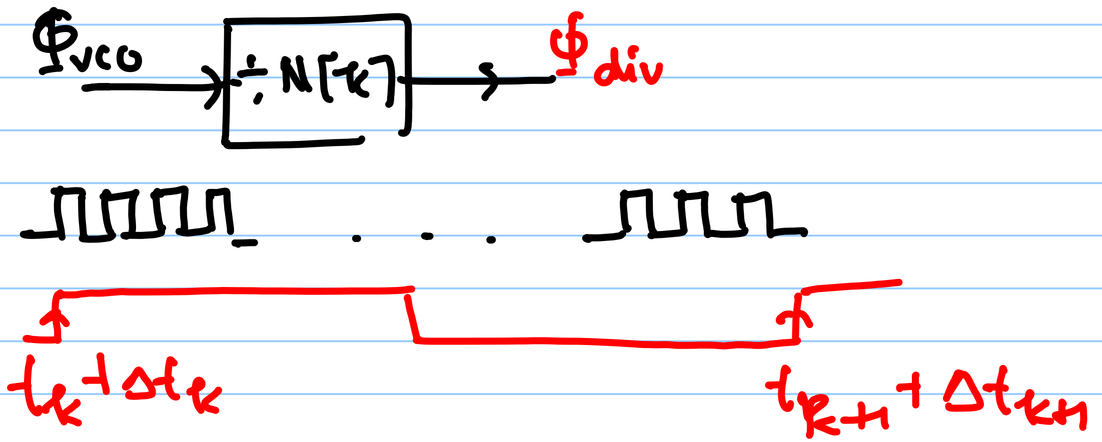
2. $\Phi_{vco} = 2\pi K_{vco} \int V_{ctrl} \cdot dt = 2\pi f_{nom} t + \Phi_{out}(t)$

$f_{nom} = (N+\alpha) f_{ref}$, $0 < \alpha < 1$

3. $t_{k+1} + \Delta t_{k+1}$: time instant for $(k+1)^{th}$ rising edge on Φ_{Div}

$t_k + \Delta t_k$: 〃 k^{th}

$$\Phi_{vco}(t_{k+1} + \Delta t_{k+1}) - \Phi_{vco}(t_k + \Delta t_k) = 2\pi N[k]$$



$$LHS = 2\pi f_{nom}(t_{k+1} + \Delta t_{k+1} - t_k - \Delta t_k) + \Phi_{out}(t_{k+1} + \Delta t_{k+1}) - \Phi_{out}(t_k + \Delta t_k)$$

$$= 2\pi f_{nom}(\underbrace{t_{k+1} - t_k}) + \underbrace{2\pi f_{nom}(\Delta t_{k+1} - \Delta t_k)}$$
$$\underbrace{+ \Phi_{out}(t_{k+1} + \Delta t_{k+1}) - \Phi_{out}(t_k + \Delta t_k)}$$

$$= 2\pi \underline{f_{nom} . T} + \hat{\Phi}. \quad (T \to 1/f_{ref}) \qquad =$$

$$= 2\pi N_{nom} + \qquad = 2\pi N[k]$$

$$2\pi f_{nom} (\underline{\Delta t_{k+1}} - \underline{\Delta t_k}) = 2\pi \underline{(N[k] - N_{nom})} - \left(\hat{\Phi}_{out}(t_{k+1} + \Delta t_{k+1}) - \hat{\Phi}_{out}(t_k + \Delta t_k)\right)$$

Sum k samples.

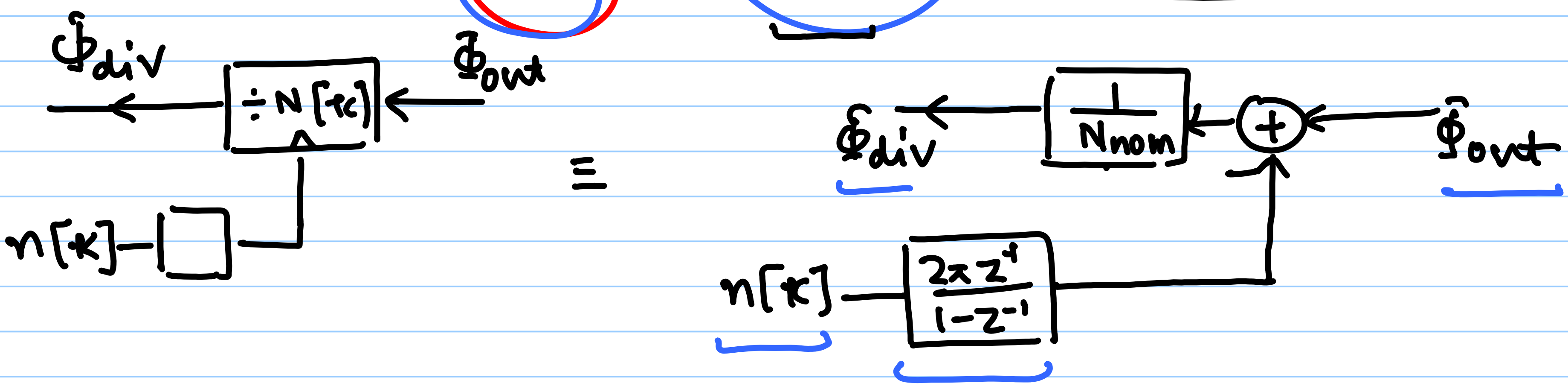
$$2\pi f_{nom} (\Delta t_{k+1} - \Delta t_0) = 2\pi \sum_{i=1}^{K} n[i] - \left(\hat{\Phi}_{out}(t_{k+1} + \Delta t_{k+1}) - \hat{\Phi}_{out}(t_0 + \Delta t_0)\right)$$

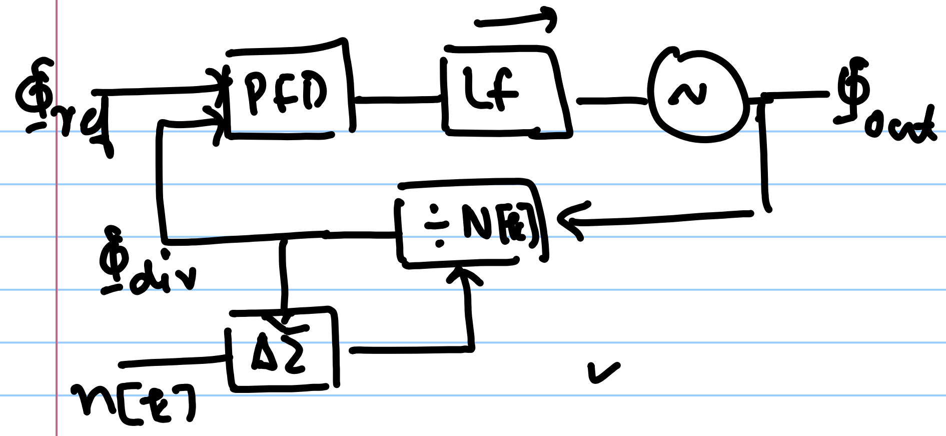
$\Delta t_0 = 0$, $\hat{\Phi}_{out}(t_0 + \Delta t_0) = 0$

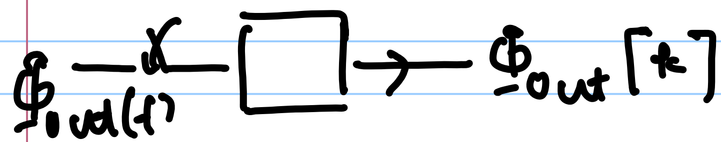
$$\Rightarrow \quad 2\pi f_{nom} (\Delta t_{k+1}) = 2\pi \sum_{i=1}^{K} n[k] - \hat{\Phi}_{out}(t_{k+1} + \Delta t_{k+1})$$

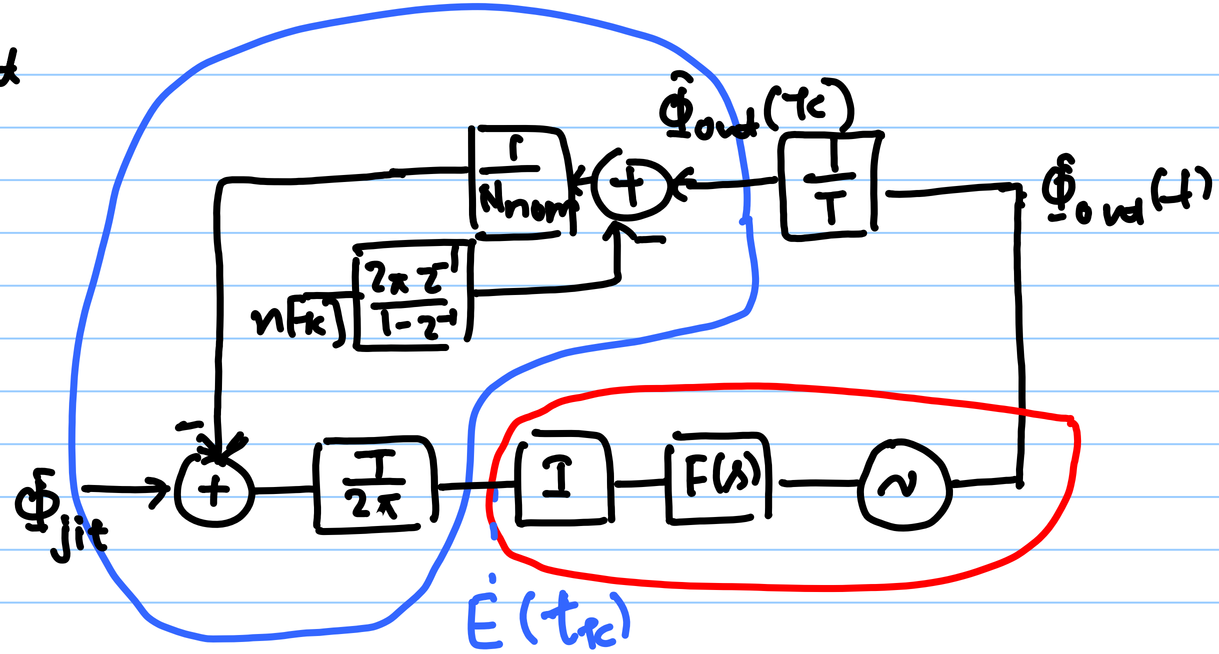
$$\Delta t_{\tau_k} = \frac{T}{2\pi} \frac{1}{N_{nom}} \left[2\pi \sum_{i=1}^{\tau_k} n[i] - \Phi_{out}(\tau_k) \right]$$

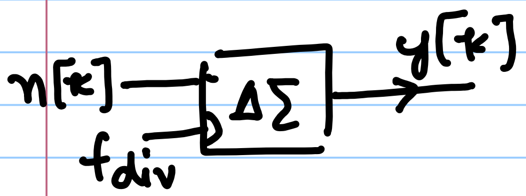
$$\Phi_{div}(\tau_k) = -\frac{1}{N_{nom}} \left[2\pi \sum_{i=1}^{k} n[i] - \Phi_{out}(\tau_k) \right]$$





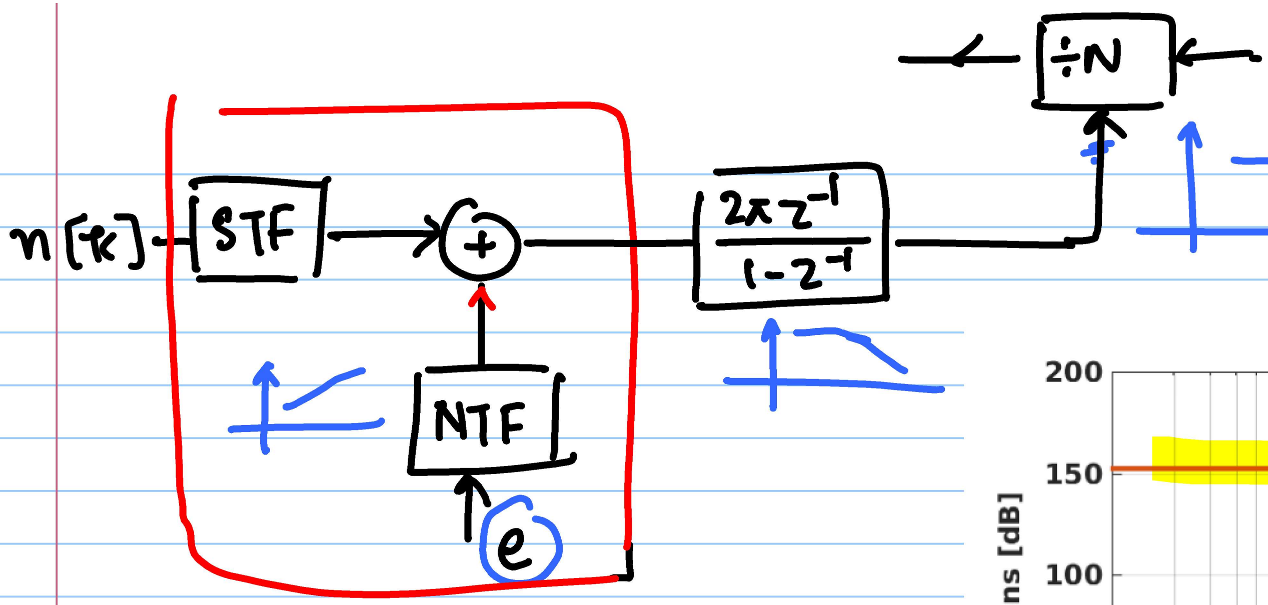






$$Y(z) = STF(z)\, n(z) + NTF(z)\, E(z)$$

$$NTF(z) = (1-z^{-1})^m$$



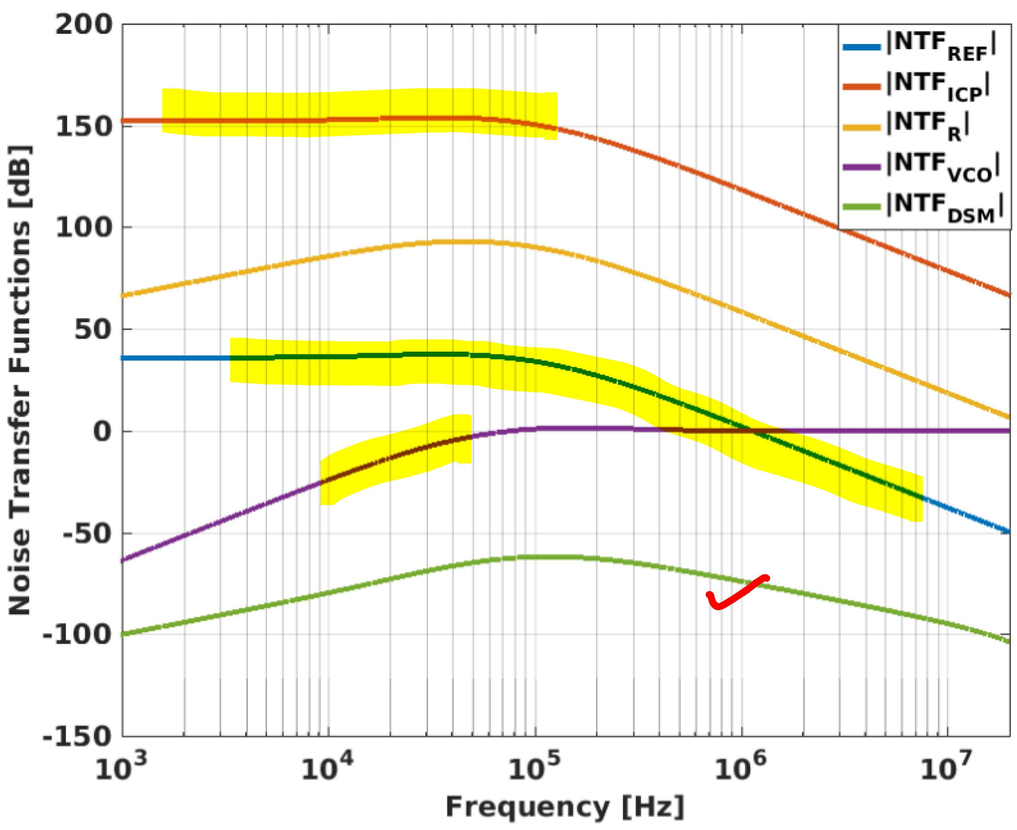
$f_{ref} = 40$ MHz.

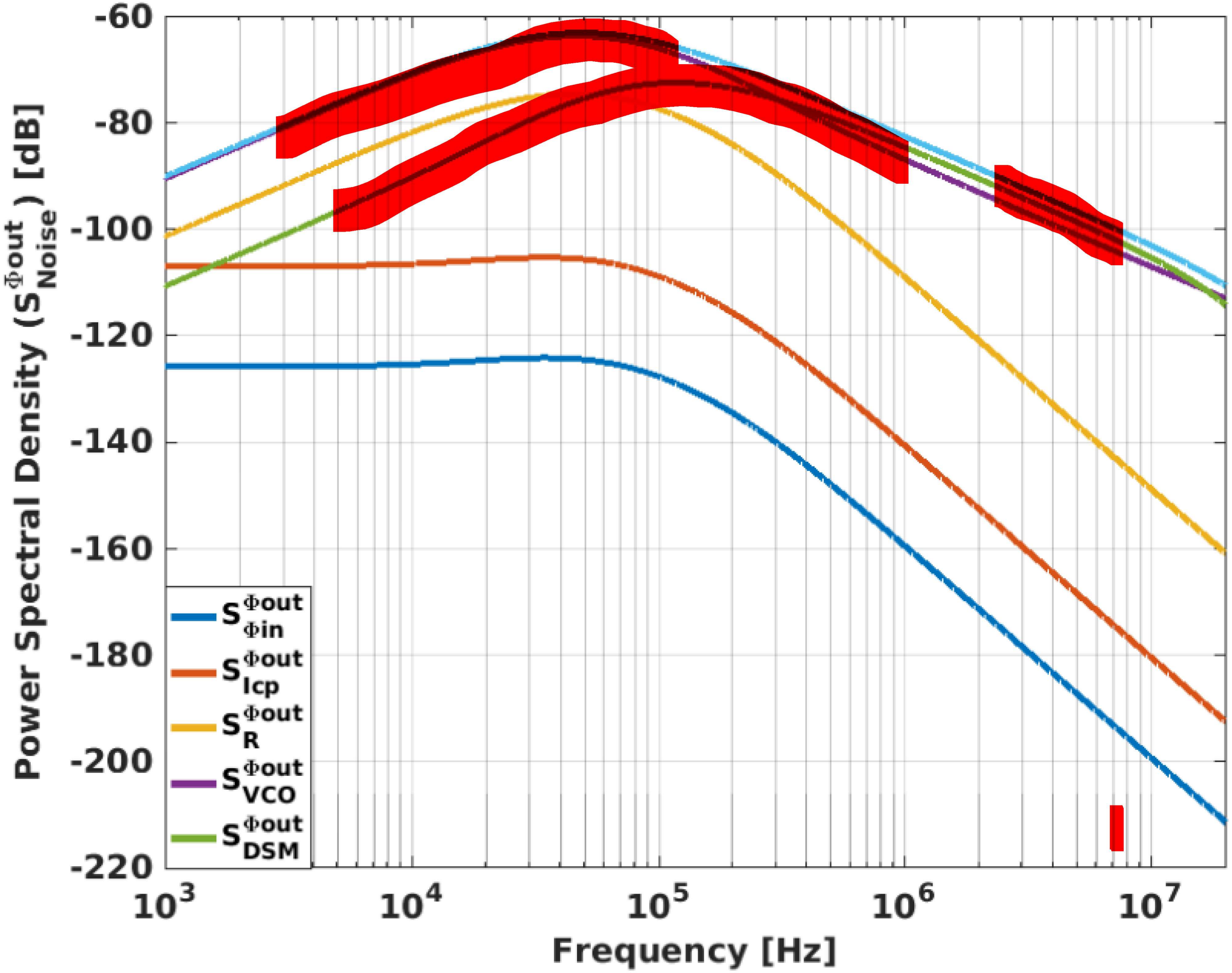
$N = 64$

$f_{out} = 2.56$ GHz.

$|NTF_{DSM}|$

$= (1-z^{-1})^2 \cdot \frac{2\pi z^{-1}}{1-z^{-1}} \times \frac{LG}{1+LG} \times$





Power Spectral Density (S Φout Noise) [dB]
-60
-80
-100
-120
-140
-160
-180
-200
-220
10^3
10^4
10^5
10^6
10^7
Frequency [Hz]
S Φout Φin
S Φout Icp
S Φout R
S Φout VCO
S Φout DSM