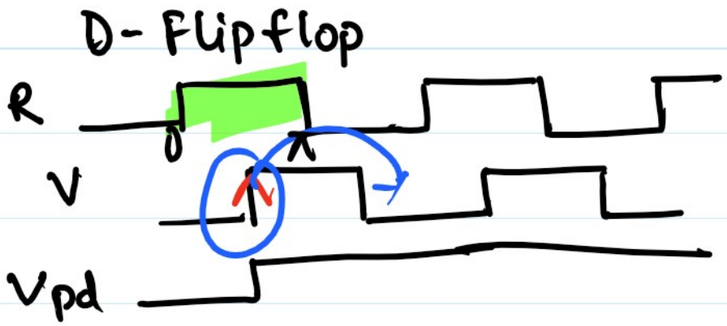
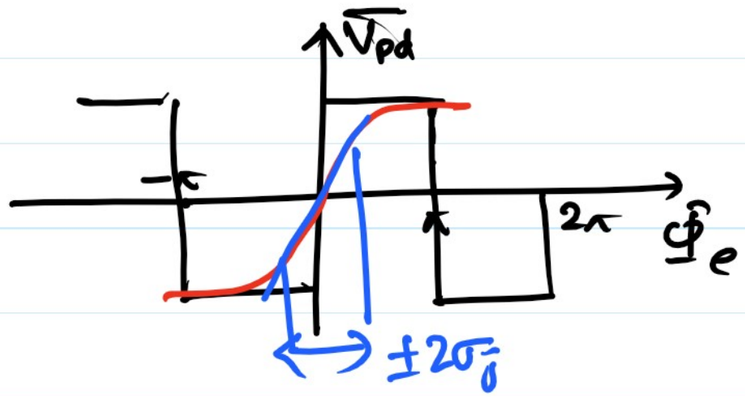
Lecture 07

Monday, January 30, 2017 9:54 AM

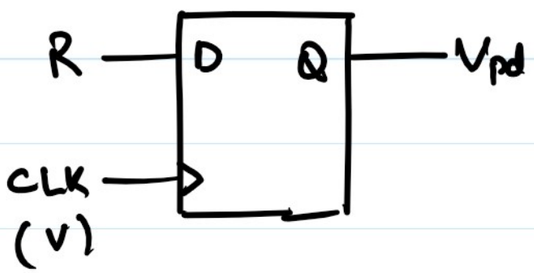
Phase error detector

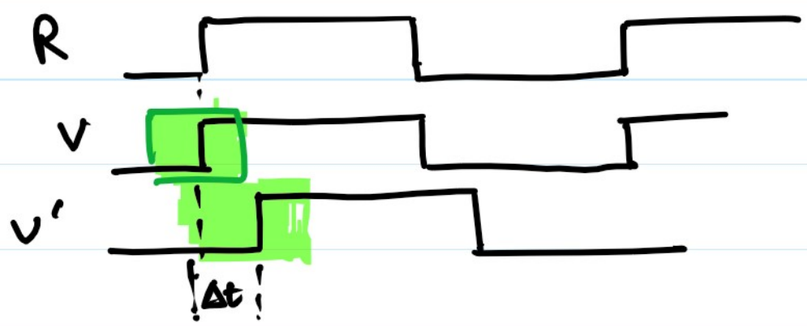




$$\frac{d(\bar{V}_{pd})}{d(\Phi_e)}$$

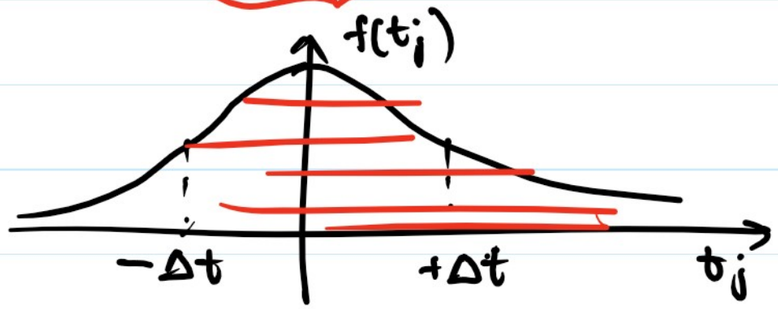
Noise on clock is Gaussian $N(0,\sigma)$





$$\bar{V}_{pd} = +1\, P(\Delta t + t_j \geq 0) - 1\, P(\Delta t + t_j < 0)$$

$$= P(t_j \geq -\Delta t) - P(t_j < -\Delta t)$$



$$\bar{V}_{pd} = 1 - 2P(t_j < -\Delta t)$$

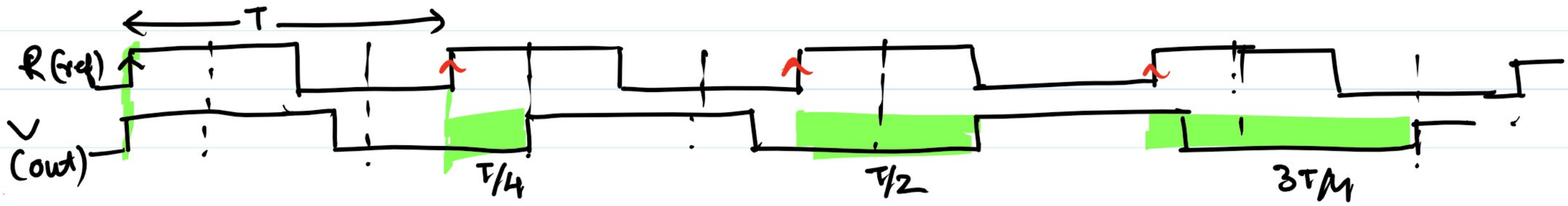
$$V_{pd} = 1 - 2P(t_j < -\Delta t)$$

$$= 1 - 2\int_{-\infty}^{-\Delta t} \frac{1}{\sqrt{2\pi}} \frac{1}{\sigma_j} \exp\left(\frac{-t_j^2}{2\sigma^2}\right) dt_j$$

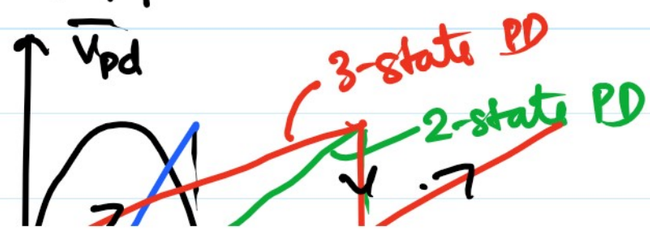
$$\frac{d(\bar{V}_{pd})}{d(\Delta t)} = -\frac{2}{\sqrt{2\pi}} \frac{1}{\sigma_j} (-1) \exp\left(\frac{-\Delta t^2}{2\sigma^2}\right)$$

$$\left.\frac{d(\bar{V}_{pd})}{d(\Delta t)}\right|_{\Delta t = 0} = \sqrt{\frac{2}{\pi}} \frac{1}{\sigma_j}$$

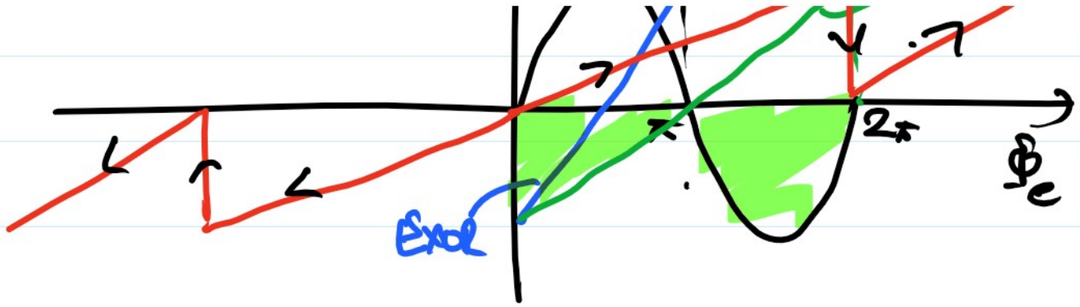
PDs Multiplier, sample & hold, EXOR, 2-State PD, 3-state PFD, D-flip flop.



$$f_R = \frac{1}{T}, \quad f_V = \frac{1}{T + T/4} = \frac{4}{5T}$$



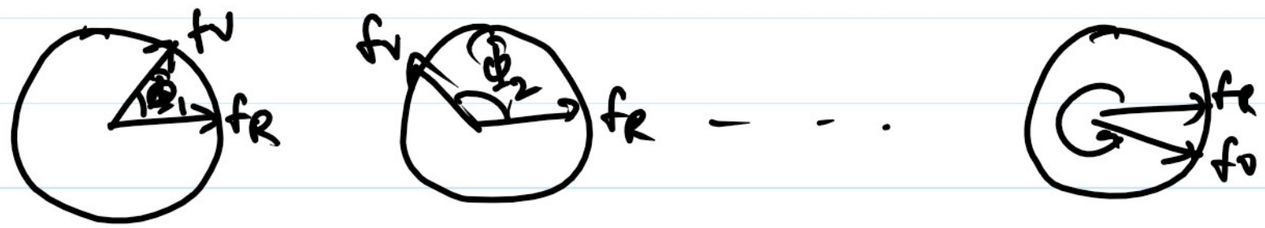
$\bar{V}_{pd}$
Sine
EXOR



EXOR

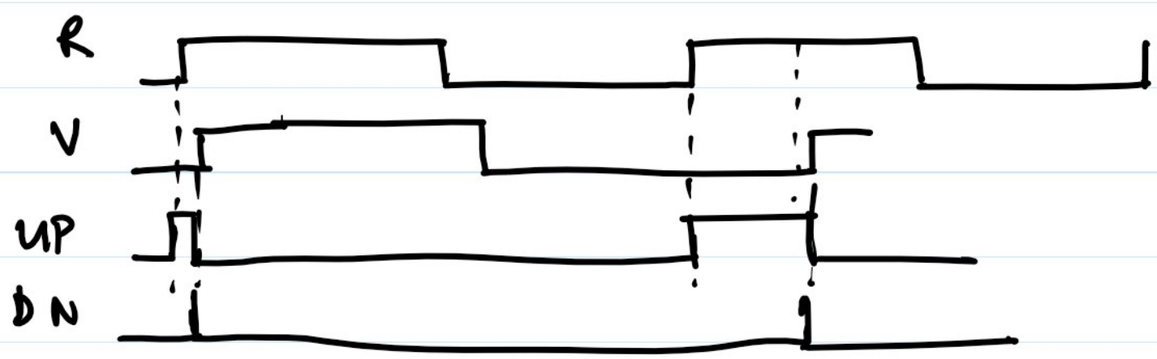
2-state PD

$$\phi_e = \int 2\pi (f_{in} - f_{out})\, dt$$



$$\frac{\Delta\phi}{\text{cycle}} = \frac{2\pi (T_R - T_V)}{\max.(T_R, T_V)}$$

Gain of FD (frequency detector) using PFD



In one ref. period

$$\frac{\Delta t}{T} = \frac{V_{up} - V_{DN}}{}$$

$$\overline{V_{FD}} = \left[\frac{\Delta t}{T} + \frac{2\cdot\Delta t}{T} + \cdots + \frac{N\cdot\Delta t}{T}\right] \times \frac{1}{N}$$

$$= \frac{\Delta t}{NT}(1+2+\cdots N)$$

$$= \frac{\Delta t}{NT}\,\frac{N(N+1)}{2}$$

$$= 0.5\left(\frac{1}{N}+1\right)$$

$$= 0.5\left(1+\frac{\Delta t}{T}\right)$$

$$= 0.5\left(1+\frac{T_R - T_V}{T_R}\right)$$

$$= 1 - \frac{0.5\,T_V}{T_R}$$

$N(\Delta t) = T$

T_R refrence period

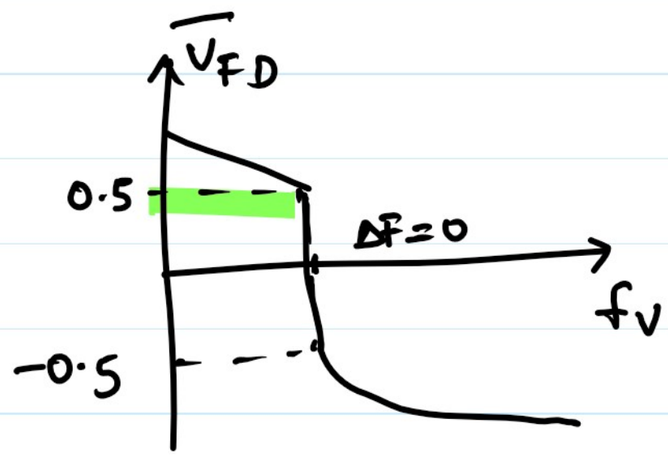
T_V o/p period

$\Delta t = T_R - T_V$; $T_R > R_V$

$$\overline{V_{FD}} = \overline{V_{UP} - V_{DN}} = -\left[1 - \frac{0.5\,f_R}{f_V}\right]$$

$$= \frac{0.5\,f_R}{f_V} - 1 \quad ; \quad f_V > f_R$$

$$\overline{V_{FD}} = \overline{V_{UP} - V_{DN}} = 1 - \frac{0.5\,f_V}{f_R} \quad ; \quad f_V < f_R$$



$$\overline{V_{FD}} = \frac{f_v}{V_{UP} - V_{DN}} = 1 - \frac{0.5 f_v}{f_R} \; ; \; f_v < f_R$$