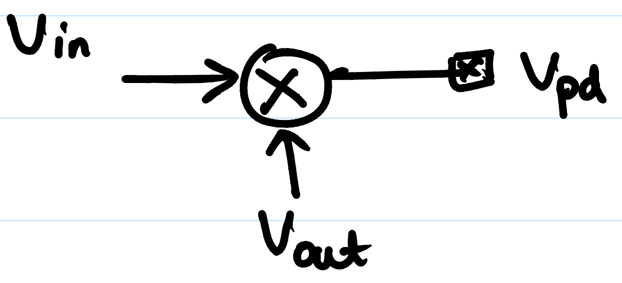
Lecture 05

Tuesday, January 24, 2017 8:54 AM

Phase Error Detectors

- Analog
  - Multiplier
  - Sample & Hold
- Digital
  - ExOR
  - SR flipflop
  - 3-State PFD
  - D-flipflop PD

Multiplier based PD



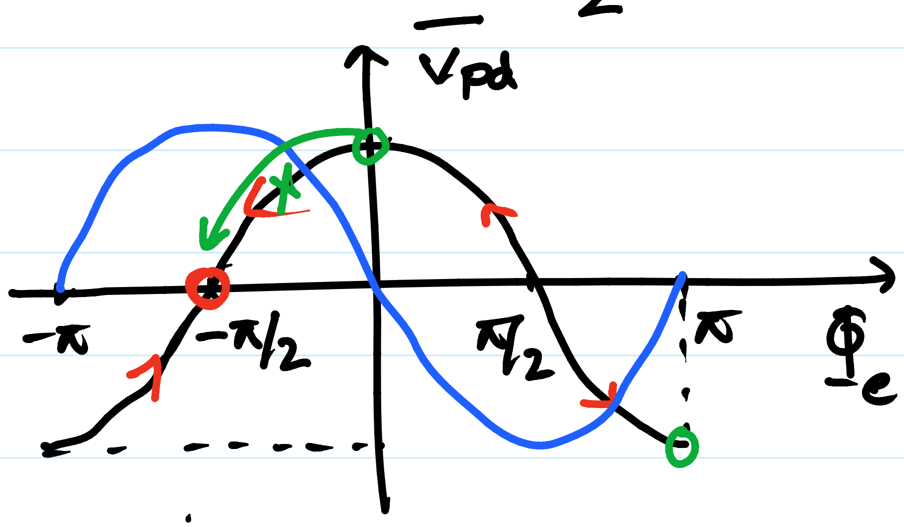
$$V_{in} = A_{in} \sin(\omega t)$$

$$V_{out} = A_{out} \sin(\omega t - \Delta\phi)$$

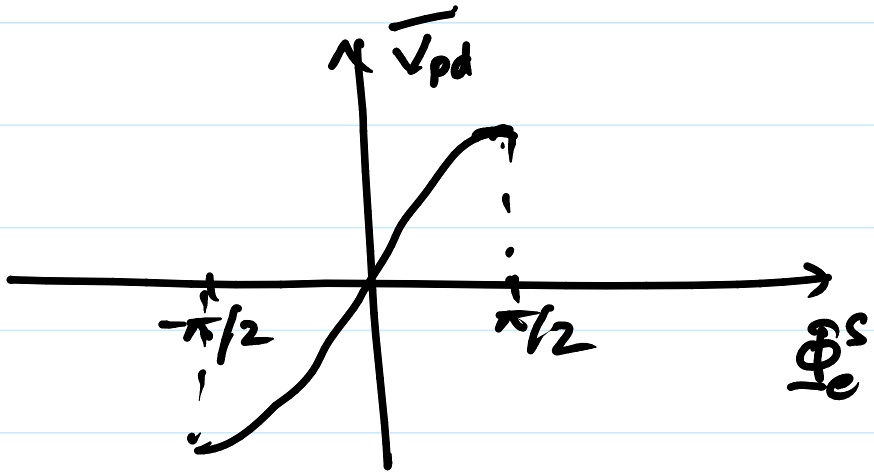
$$V_{pd} = V_{in} V_{out}$$

$$= -\frac{A_{in} A_{out}}{2} \left[\cos(2\omega t - \Delta\phi) - \cos(\Delta\phi) \right]$$

$$\overline{V}_{pd} = \frac{A_{in} A_{out}}{2} \cos(\Delta\phi) = \frac{A_{in} A_{out}}{2} \cos(\Phi_e) \; ; \; \Phi_e = \Delta\phi$$



$$\Phi_e^s = \Phi_e + \pi/2$$



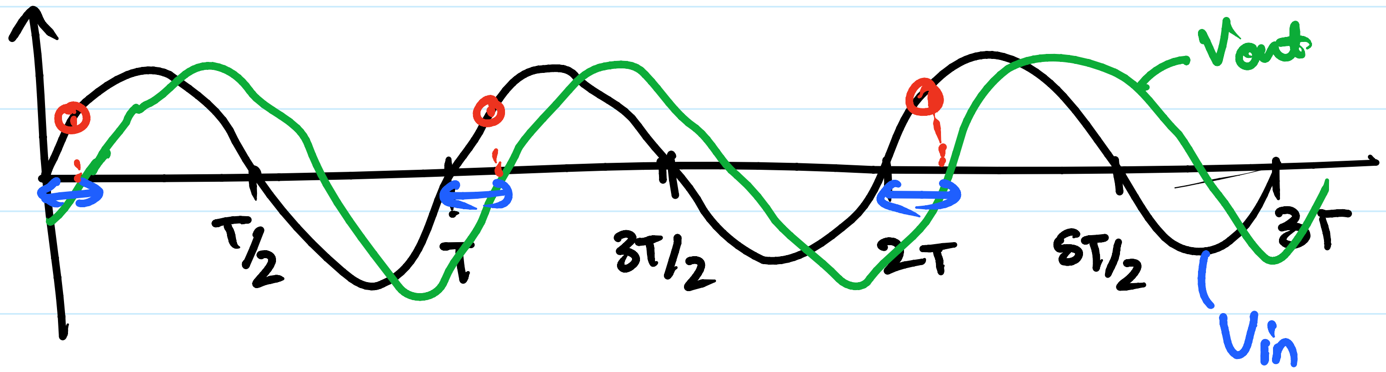
Montonous Range for $\hat{\Phi}_e^S = \pm\pi/2$

$$K_{pd} = \frac{d(\overline{V}_{pd})}{d(\hat{\Phi}_e)} = -\frac{A_{in} A_{out}}{2} \sin(\hat{\Phi}_e)$$

PD : Non-linear gain at locking phase error $\hat{\Phi}_e = -\pi/2$

Range of $\hat{\Phi}_e^S$ $[-\pi/2, \pi/2]$

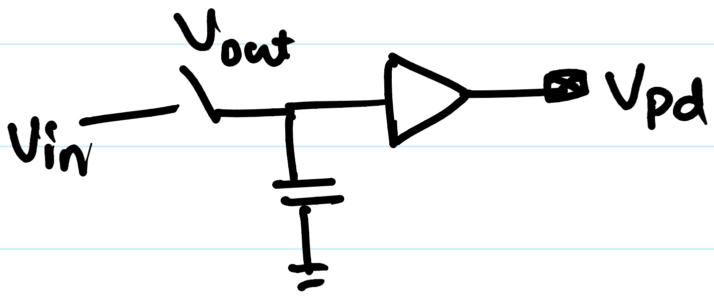
2) Sample & Hold PD



a) $\hat{\Phi}_e$ is constant ✓

b) $\hat{\Phi}_e + v_n$

c) freq. error



f_{out} = 8 GHz.

f_{ref} = 1 GHz.

$V_{in} = A_{in}\sin(\omega t)$

$V_{pd} = A_{in}\sin(\omega(nT_{out} + \Delta T))$

$= A_{in}\sin(\omega(n\frac{2\pi}{\omega} + \Delta T))$

$= A_{in}\sin(2n\pi + \omega\cdot\Delta T)$

$= A_{in}\sin(\omega\cdot\Delta T) = A_{in}\sin(\Phi_e)$

Range $= \pm\pi/2$, $K_{pd} = A_{in}\cos(\Phi_e)$

PD : Non-linear gain, loop dynamics.

$\overline{V}_{pd}$ has aliased frequency spectrum.

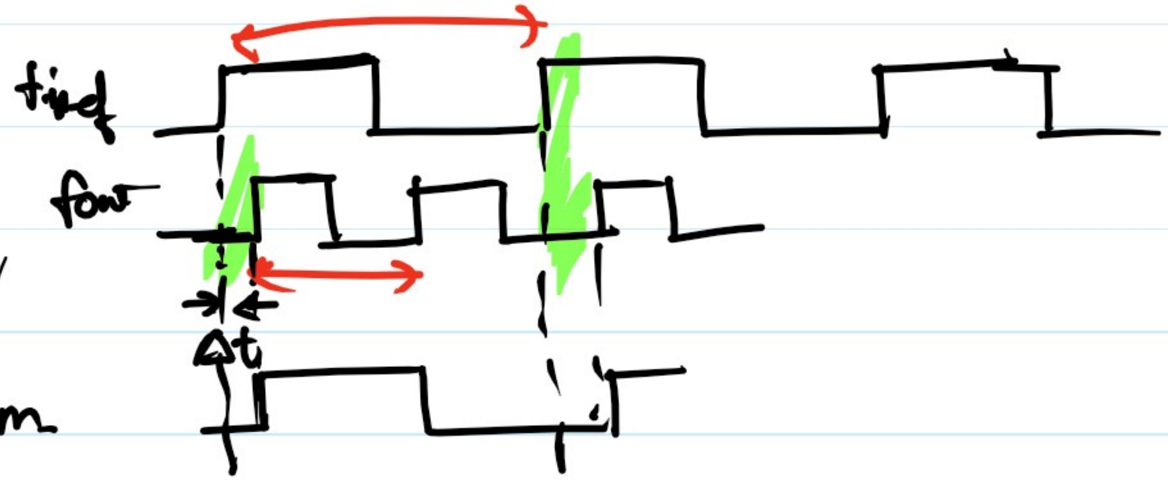
Ex: $f_{free} = 7\,GHz$. $N = 8$

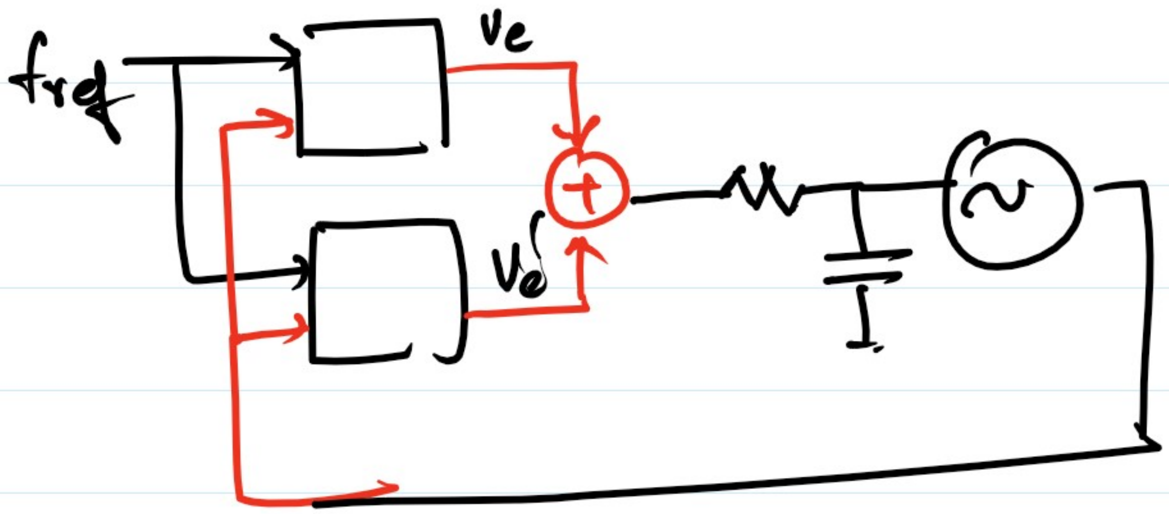
$f_{ref} = 1\,GHz$

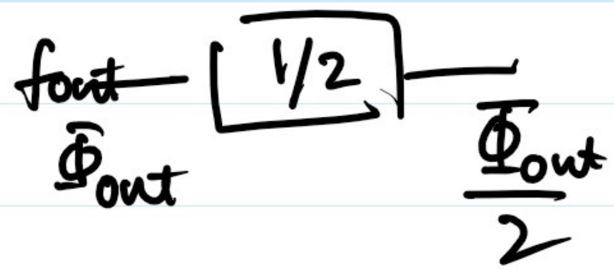
a) $f_{out} = 8\,GHz$.

b) Disable divider.

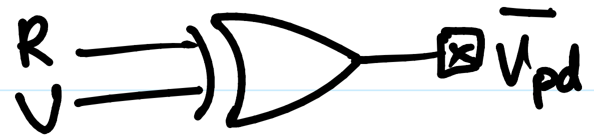
c) Sample f_{out} w/ f_{ref}

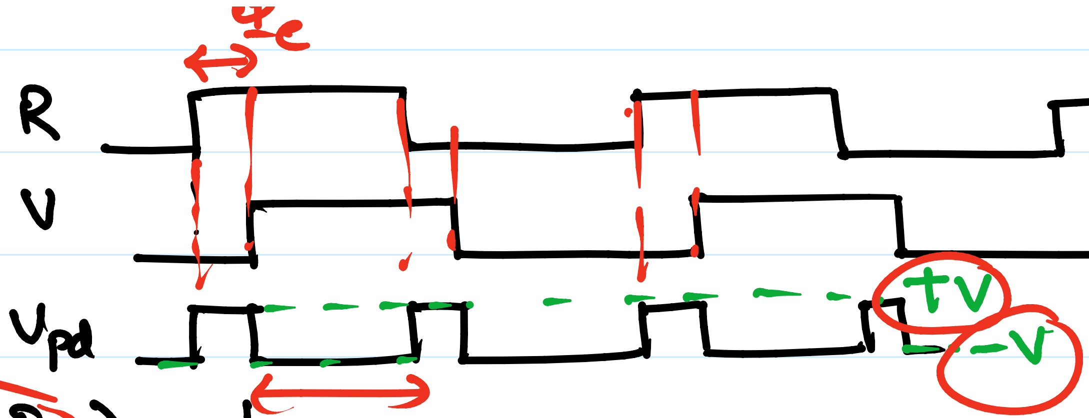






3) Exclusive XOR PD



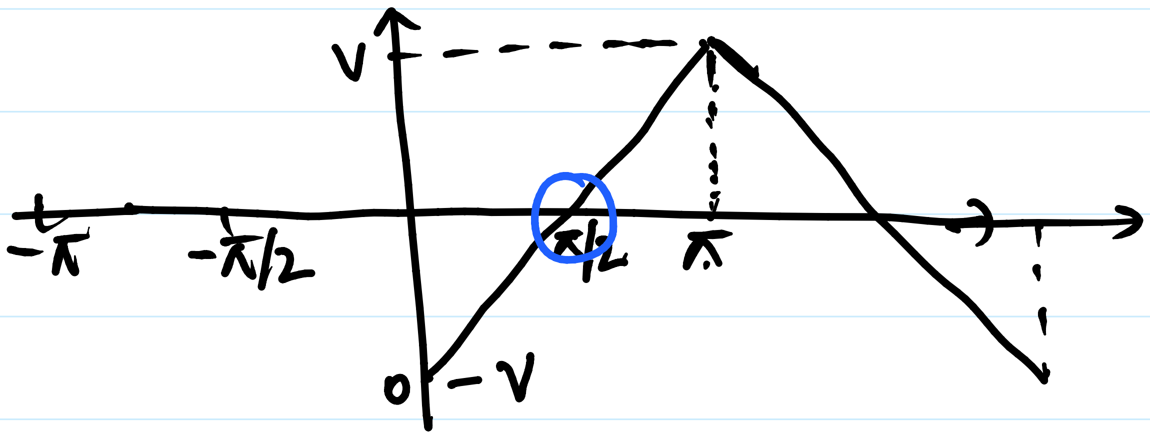


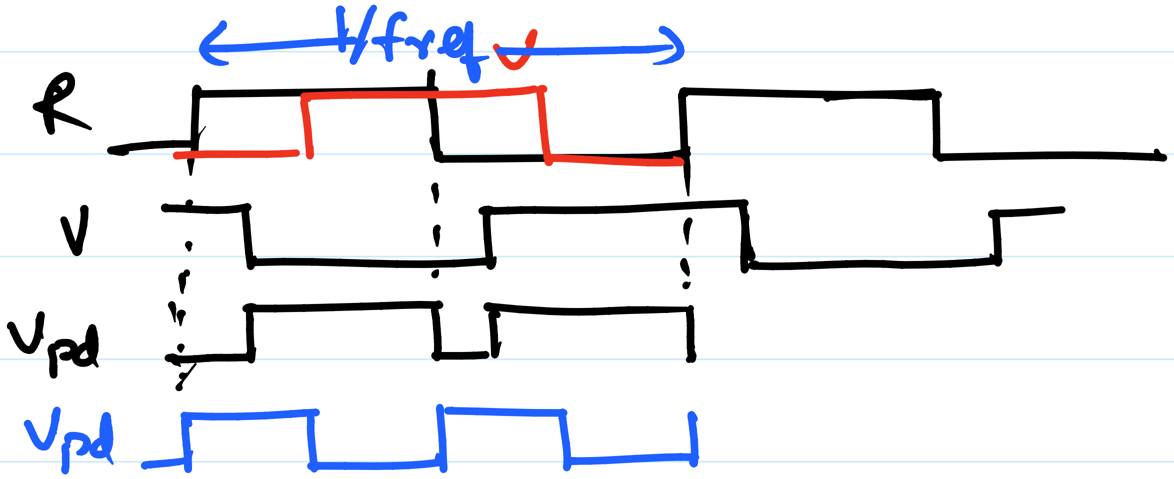
$$\overline{V_{pd}} = V\left(\Phi_e - (\pi - \Phi_e)\right) \times \frac{1}{\pi}$$

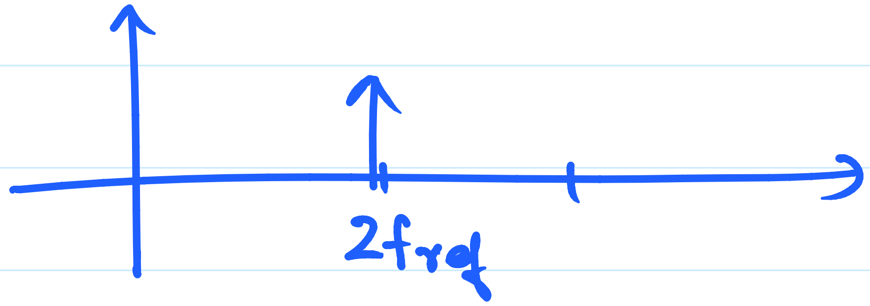
$$= \frac{2V}{\pi}\left(\Phi_e - \pi/2\right)$$

$$K_{pd} = \frac{d(\overline{V_{pd}})}{d\Phi_e}$$

$$= \frac{2V}{\pi}$$







PD: Range = $\pm \pi/2$

Linear gain