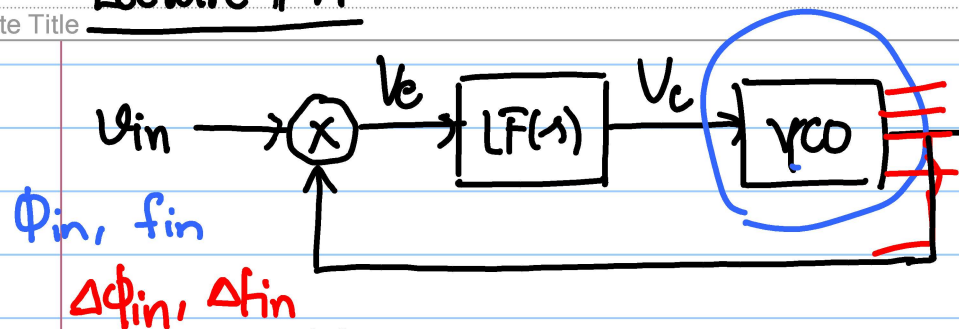
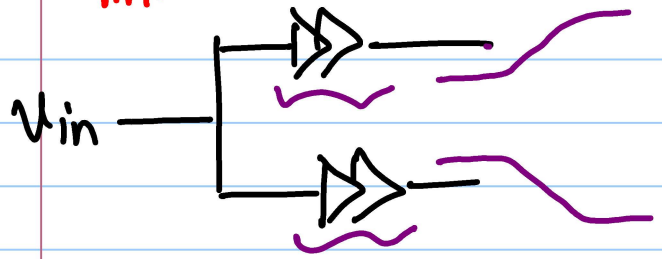
Lecture #11

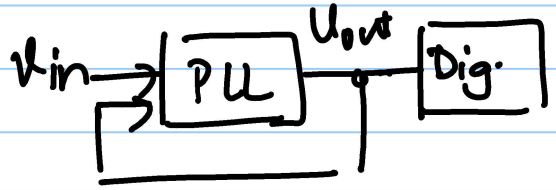
Note Title 25-09-2020



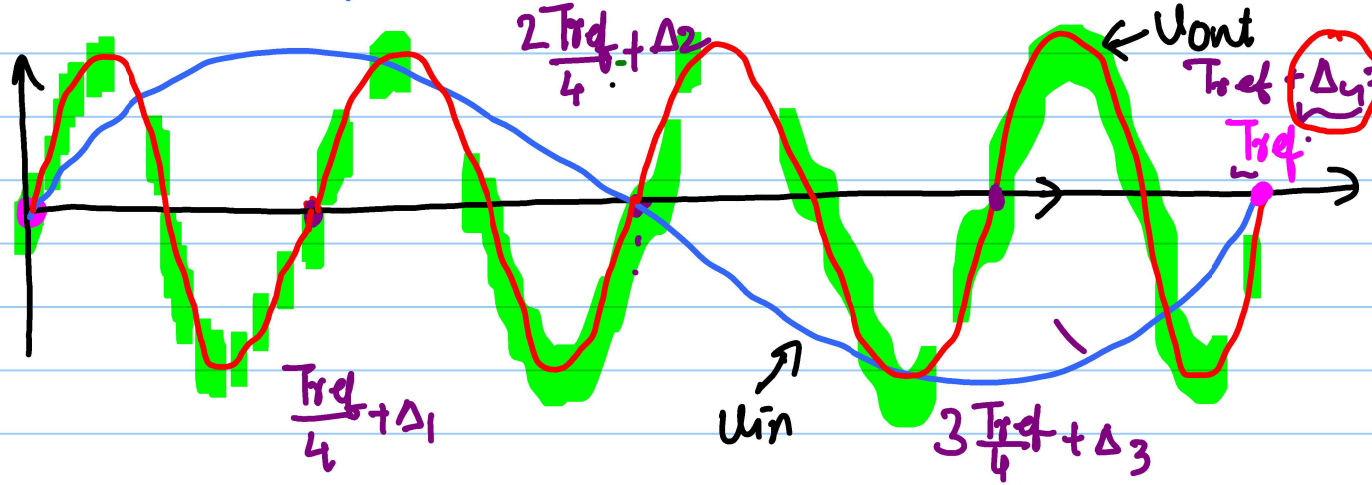
$f_{out} = f_{in}$ ✓

$\frac{d}{dt}(\phi_{in} - \phi_{out}) = 0$

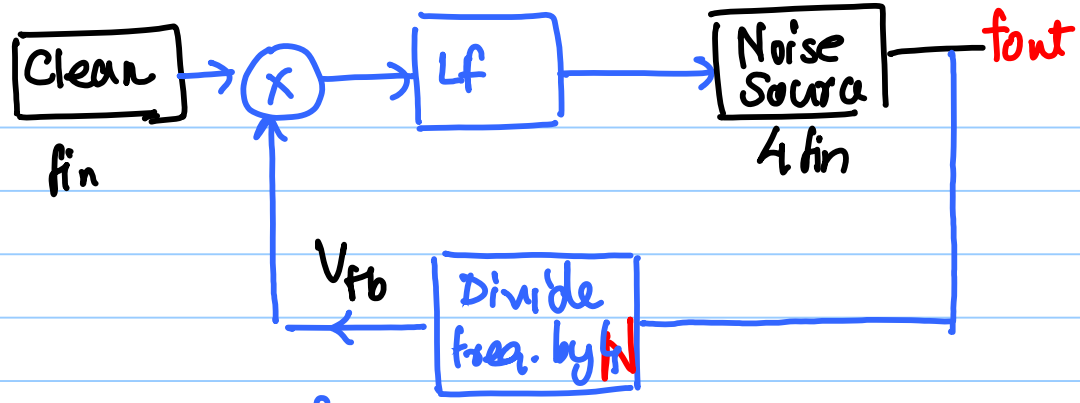




- V_{in} @ fin
- V_{out} @ fin, $0^\circ, 90^\circ, 180^\circ, 270^\circ$



- Clean clock source @ fin.
- Noise clock source (VCO) @ 4 fin



$T_{out} = \frac{T_{ref}}{4} \times 1.05$

$\Delta_y = 0.2 T_{ref}$

$f_{div} = f_{out}/N \approx f_{in}$

$f_{out} = N f_{in}$

$\frac{d}{dt}(\phi_{in} - \phi_{div}) = 0$

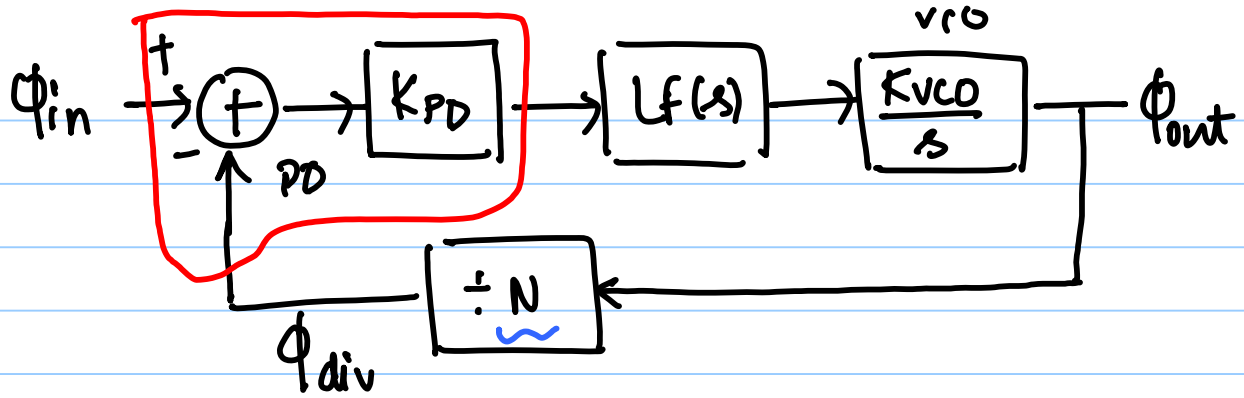
$V_{out} = \sin(2\pi f_{out} \cdot t)$

$\phi_{out} = \int 2\pi f_{out} \cdot dt$ ✓

$V_{fb} = \sin\left(2\pi \frac{f_{out}}{N} \cdot t\right)$

$\phi_{div} = \int 2\pi \frac{f_{out}}{N} \cdot dt$

$$\boxed{\phi_{div} = \frac{\phi_{out}}{N}}$$



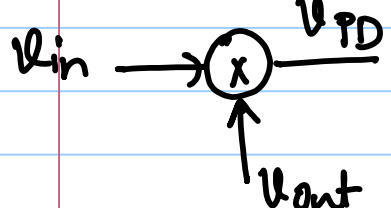
Integer-N clock multiplier

Phase / Frequency Detector

Analog
- Multipliers
- Sample & Hold.

Digital
- EXOR
- S-R latch.
- Phase/freq.
- Flip-flop.

Multiplier based PD



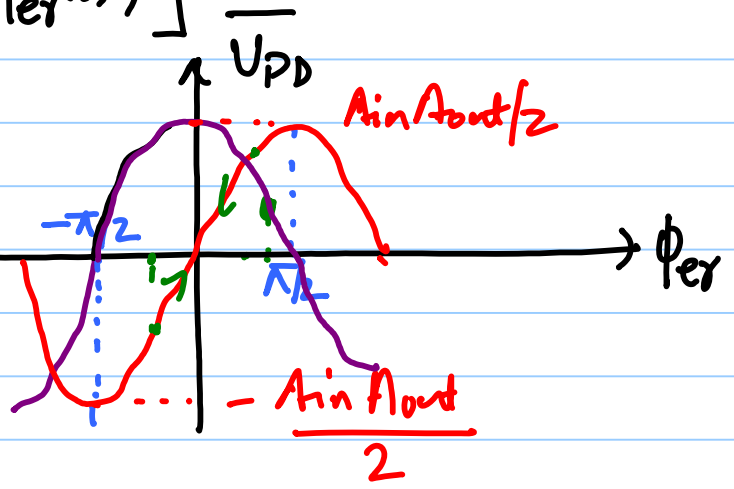
$$v_{PD} = v_{in} \times v_{out}$$

$$= A_{in} \sin(\omega_{in} t + \phi_{in}(0)) \times A_{out} \cos(\omega_{out} t + \phi_{out}(0))$$

$$= \frac{A_{in} \cdot A_{out}}{2} \left[\sin(\omega_{in} + \omega_{out} t + \phi_{in}(0) + \phi_{out}(0)) + \sin(\Delta\omega \cdot t + \phi_{in}(0) - \phi_{out}(0)) \right]$$

$$v_{PD}\Big|_{\omega_{in} = \omega_{out}} = \frac{A_{in} \cdot A_{out}}{2} \left[\sin(2\omega_{in} \cdot t + \phi_{in}(0) + \phi_{out}(0)) + \sin(\phi_{er}(0)) \right]$$

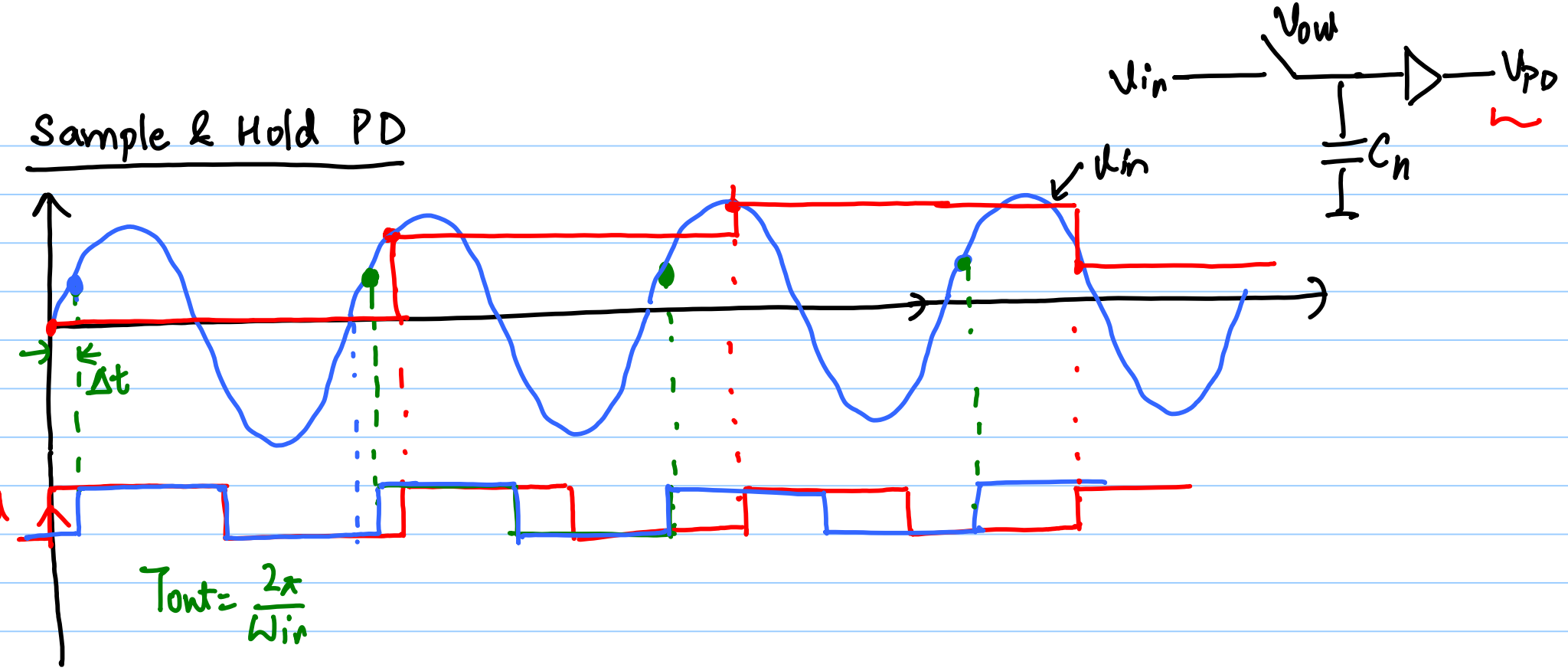
$$\overline{v_{PD}} = \frac{A_{in} \cdot A_{out}}{2} \sin(\phi_{er})$$



Non-linear monotonous range $[-\pi/2, \pi/2]$

$$K_{PD} = \frac{d(\overline{V_{PD}})}{d\phi_{er}} = \frac{A_{in} A_{out}}{2} \cos(\phi_{er})$$

Sample & Hold PD



$V_{in} = \sin(\omega_{in} \cdot t)$

V_{out} : square wave w/ time period T_{out}.

$$V_{PD} = \sin(\omega_{in} \cdot (nT_{out} + \Delta t))$$

$$= \sin\left(n \cdot \frac{2\pi}{T} \cdot T_{out} + \frac{2\pi}{T} \cdot \Delta t\right)$$

$$= \sin\left(n 2\pi + \frac{2\pi}{T} \cdot \Delta t\right) = \sin\left(\frac{2\pi \cdot \Delta t}{T}\right) = \sin(\phi_{err})$$

$\overline{V_{PD}} = \sin(\phi_{er})$: non-linear PD

$K_{PD} = \frac{d(\overline{V_{PD}})}{d\phi_{er}} = \cos(\phi_{er})$

Non-linear monotonous range $[-\pi/2 \text{ to } \pi/2]$