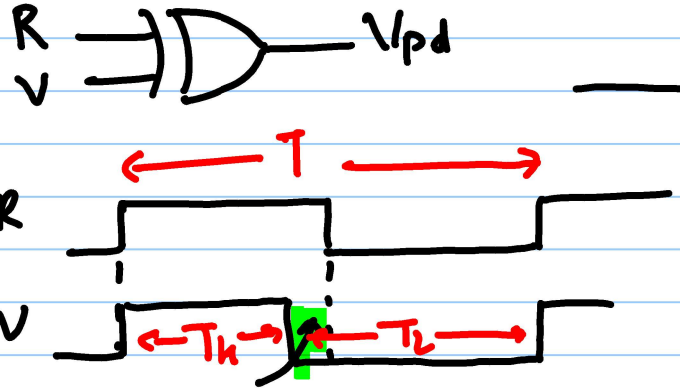
# Lecture #14

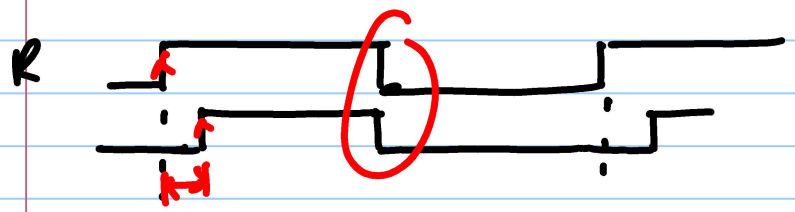
Note Title 23-08-2017

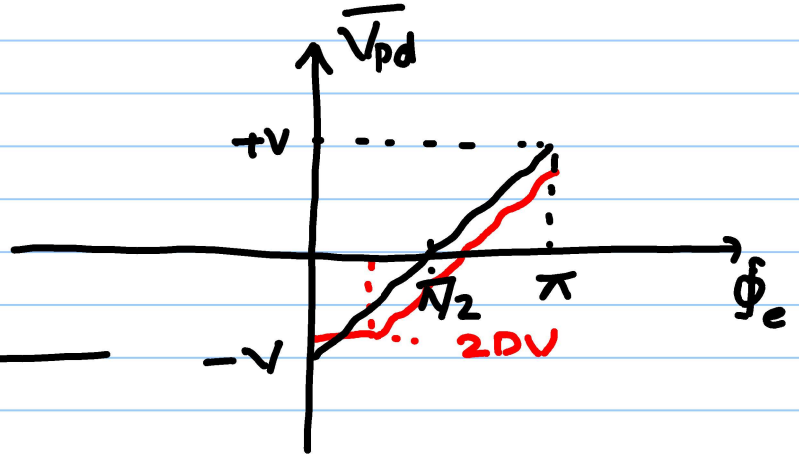
Digital Phase Error Det. — DFF based PD / EXOR based PD

## EXOR PD



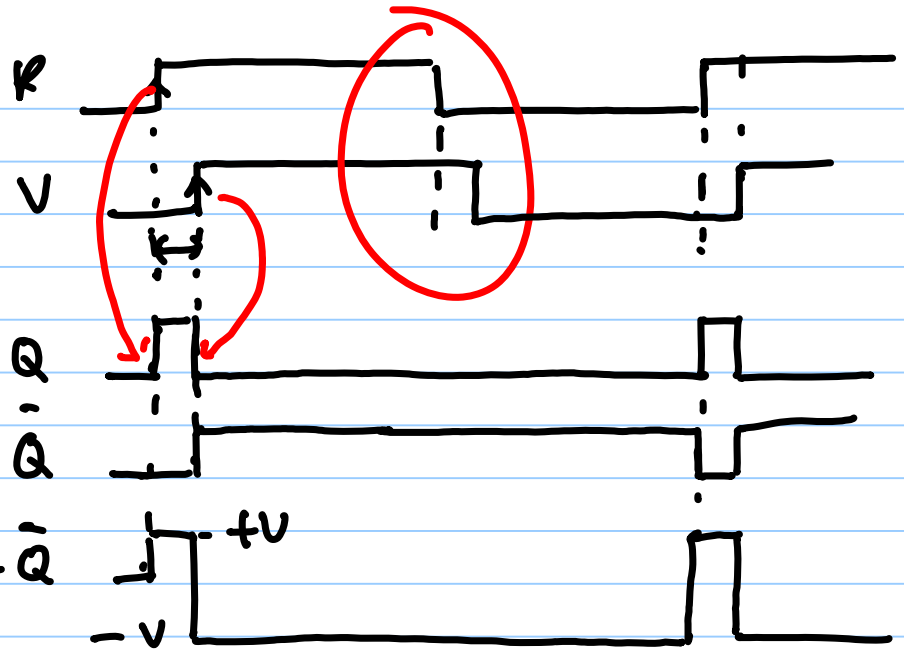

$$D = \frac{T_H}{T_H + T_L}$$

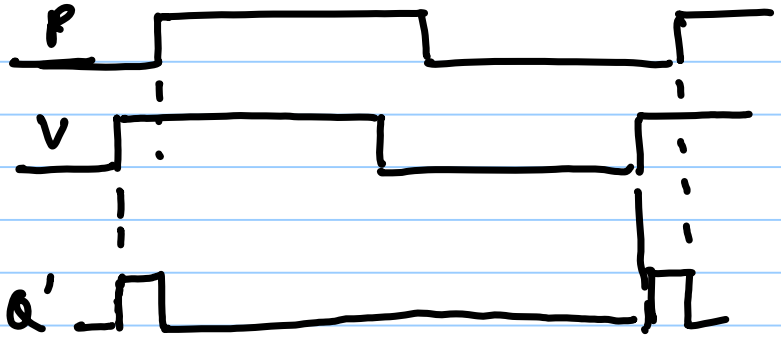



$$K_{pd} = \frac{2V}{\pi} \quad [V/rad]$$

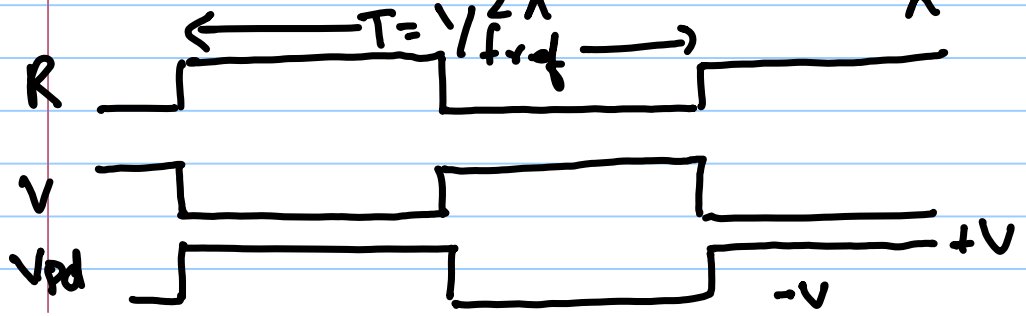
Linear range: 0 to π

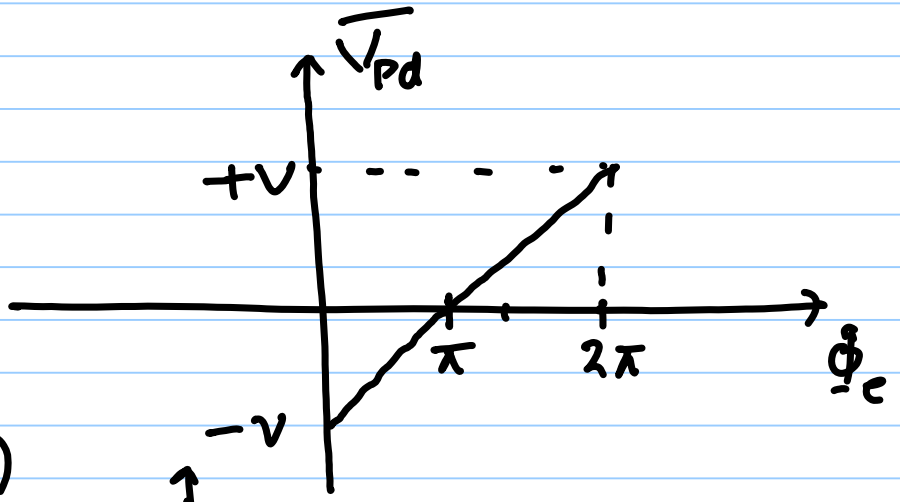


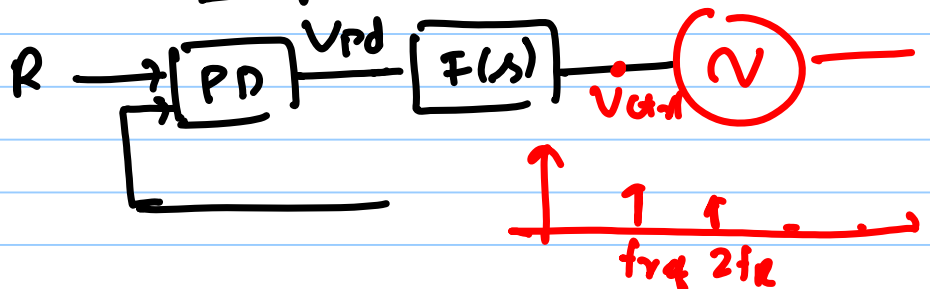




$$\overline{V_{pd}} = \overline{Q - \bar{Q}} = \frac{V \cdot \phi_e - V(2\pi - \phi_e)}{2\pi}$$

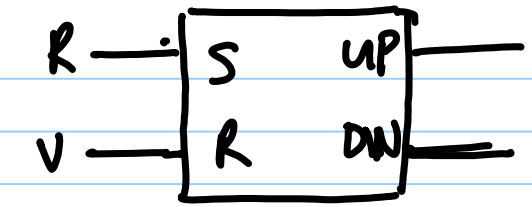
$$= \frac{2V}{2\pi}(\phi_e - \pi) = \frac{V}{\pi}(\phi_e - \pi)$$

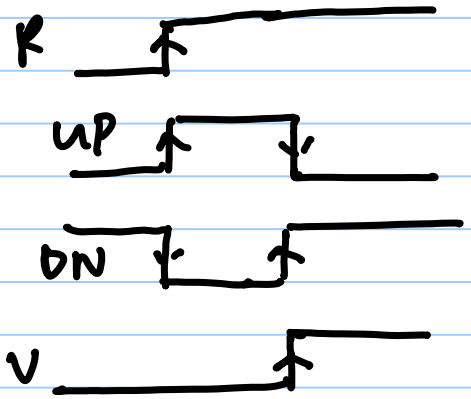


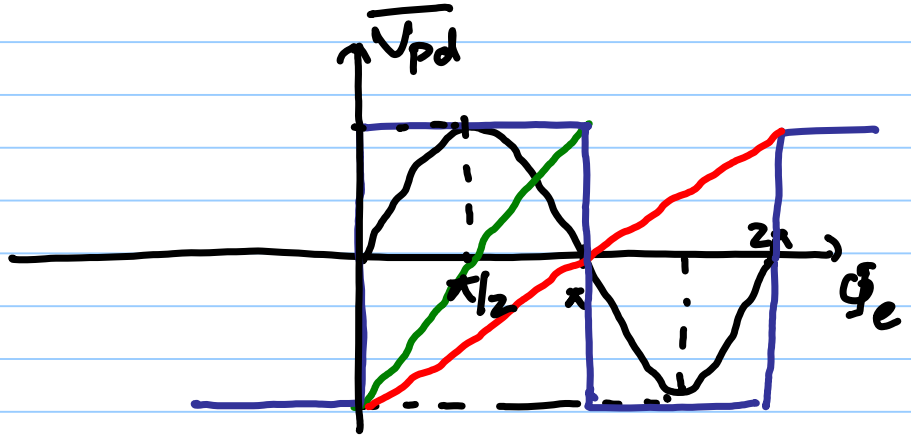



# SR latch-based PD

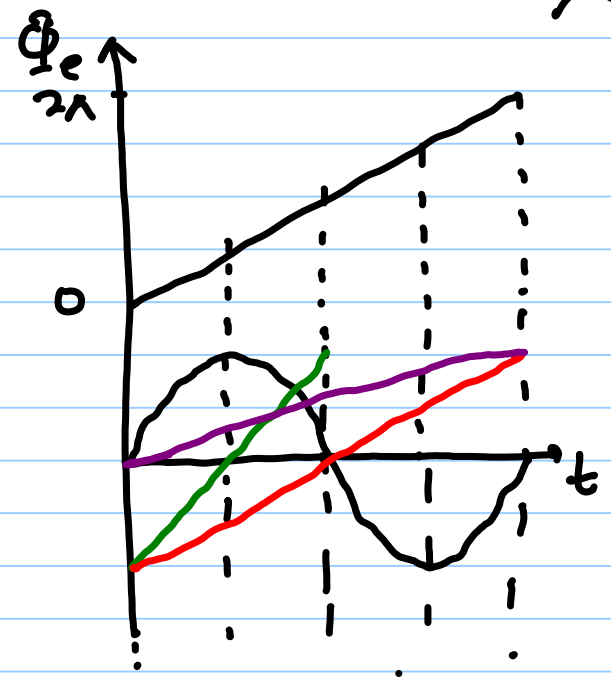


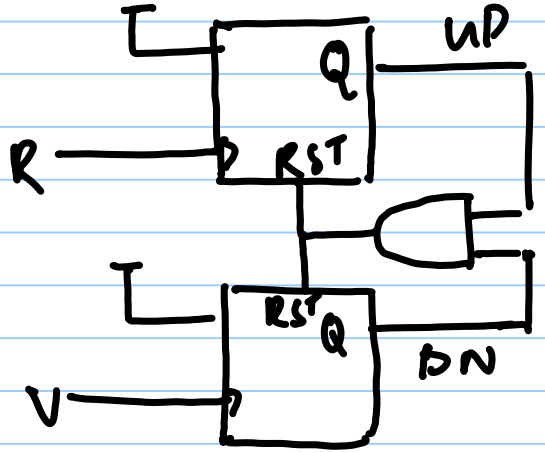

$\Delta\omega = \omega_{in} - \omega_{out} \neq 0$

$> 0$

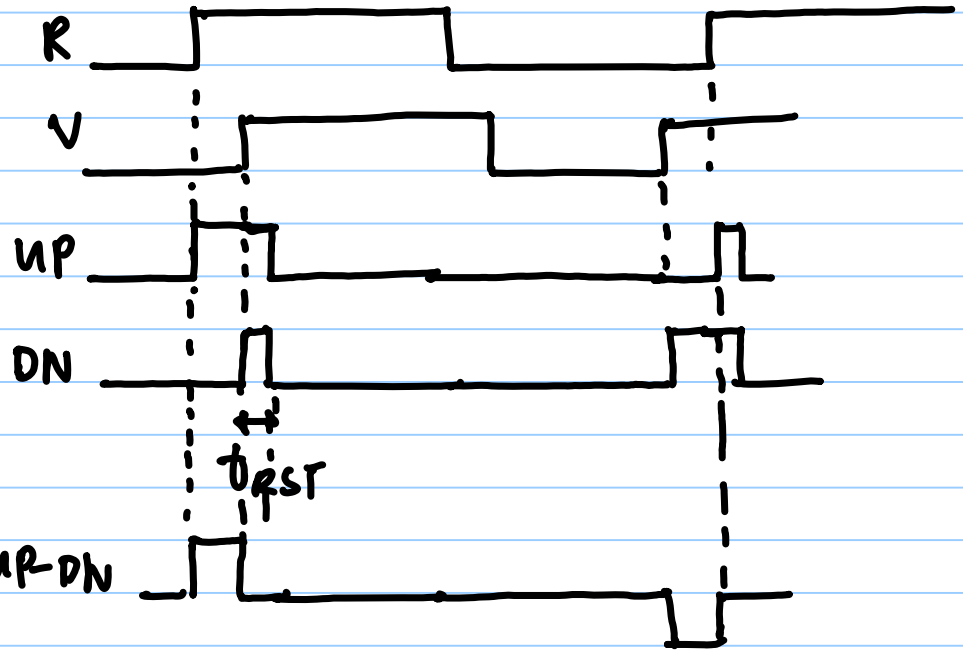


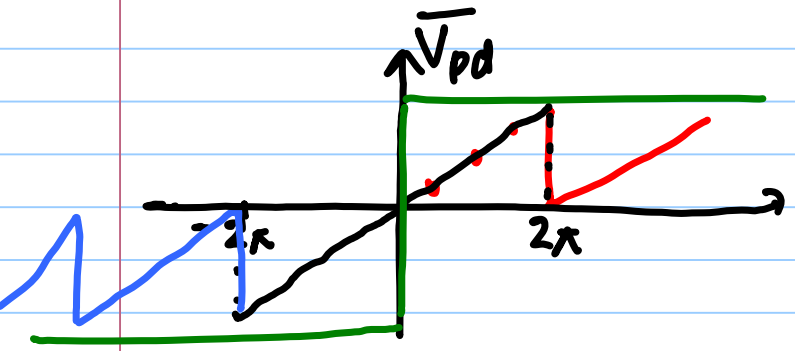

PD o/p is both +ve & -ve for same freq. error

# 3-state PFD (Phase Frequency Detector)

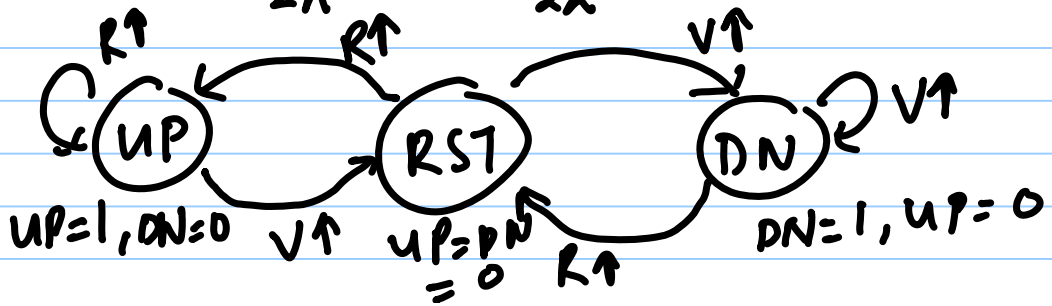


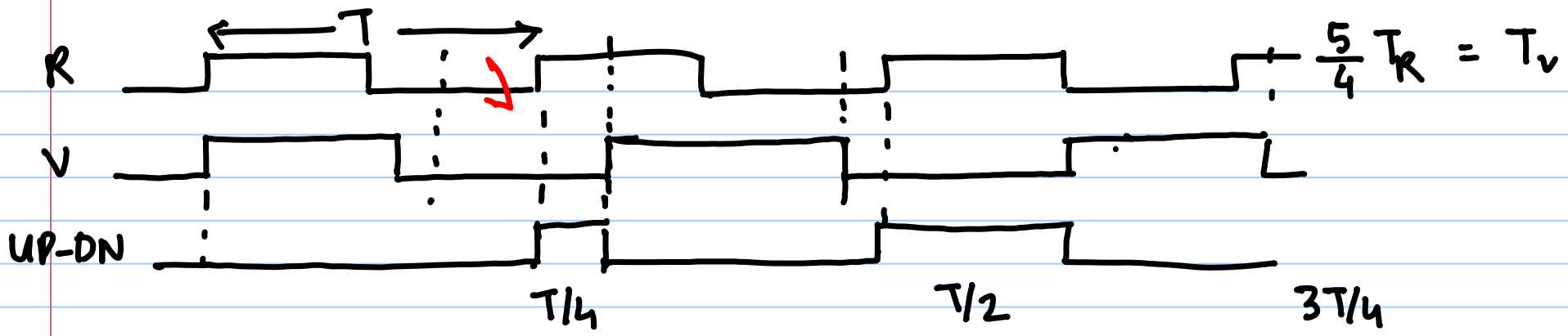


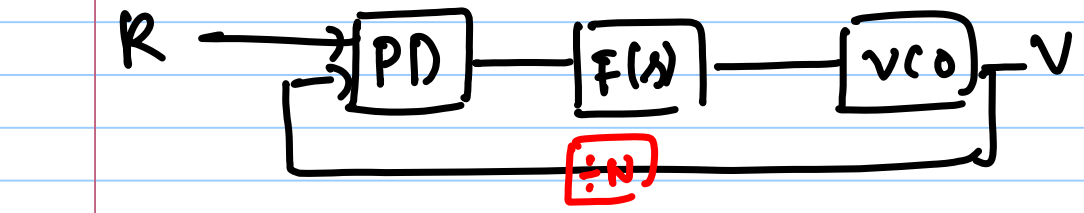


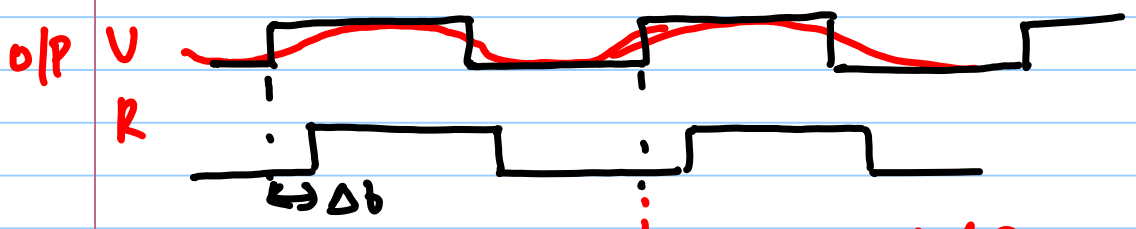



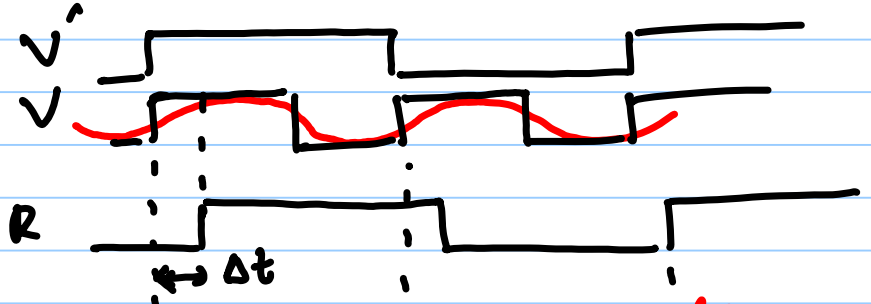

$$\bar{V}_{pd} = +V \times \frac{\phi_e}{2\pi} = \frac{\phi}{2\pi} \cdot V$$





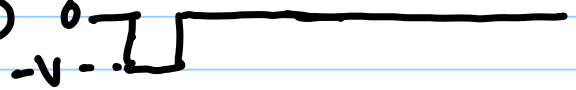




Sampler

$A\sin\left(\frac{2\pi}{T_{out}} \cdot \Delta t\right)$

$A\sin\left(\frac{2\pi}{T_{out}} \cdot 2.\Delta t\right)$

PFD




$$\overline{V_{pd}} = \frac{2\pi}{T} \times \Delta t \times \frac{1}{2\pi}$$