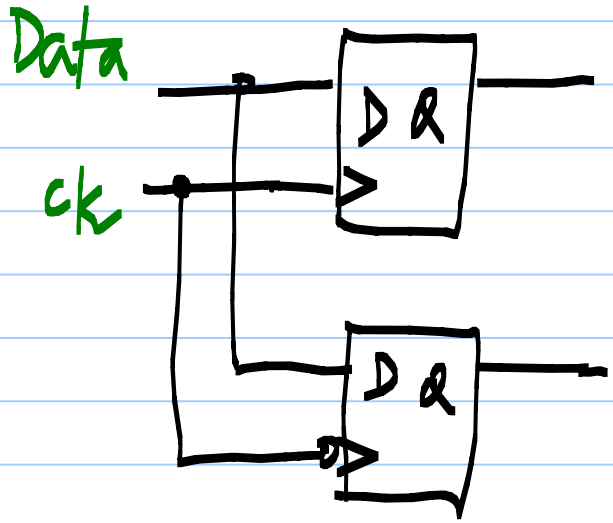
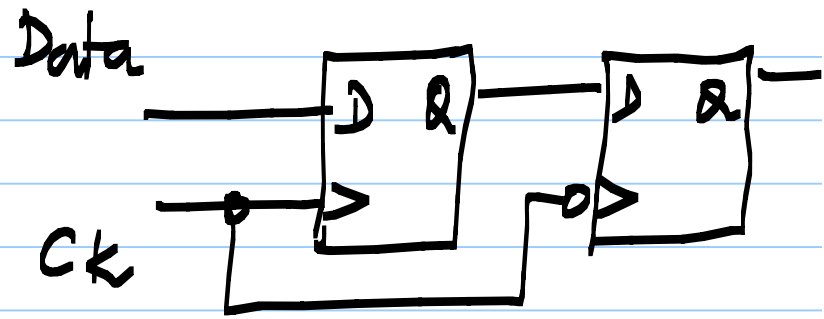
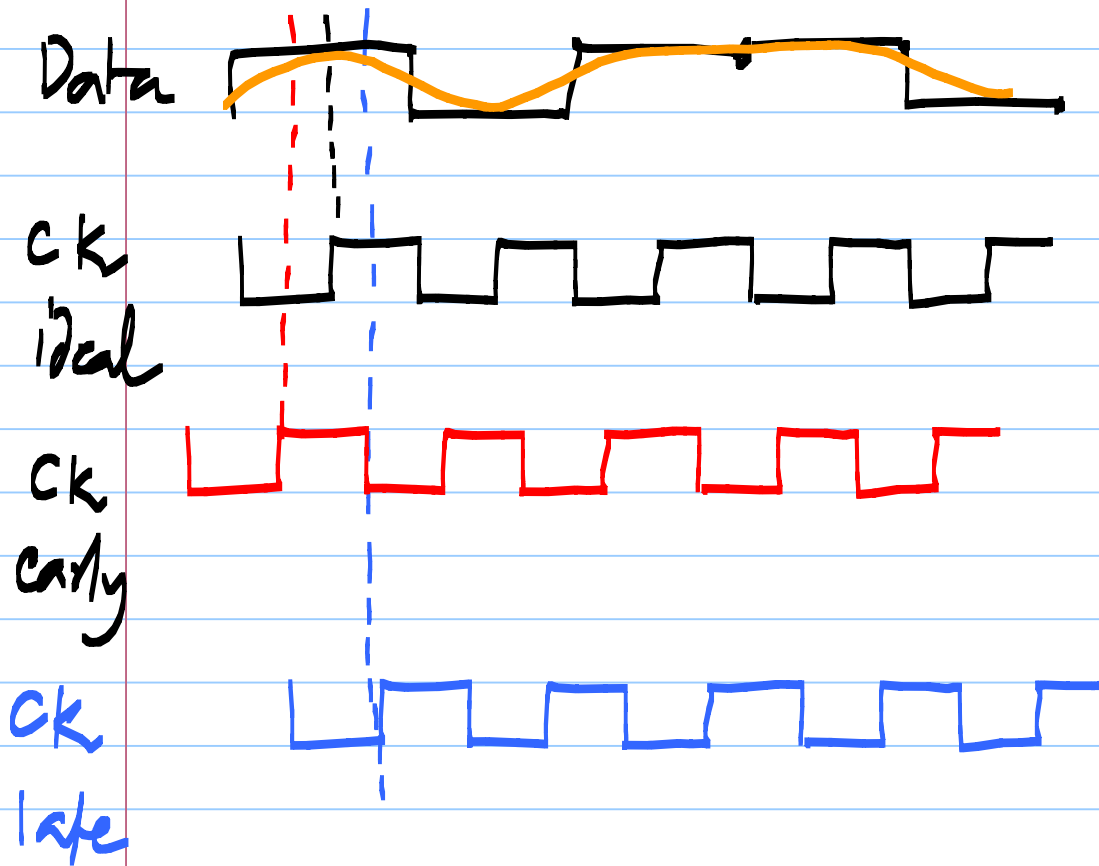
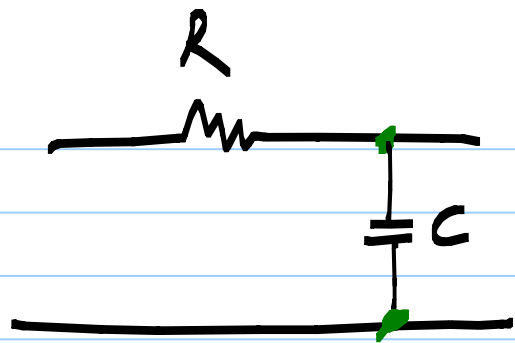
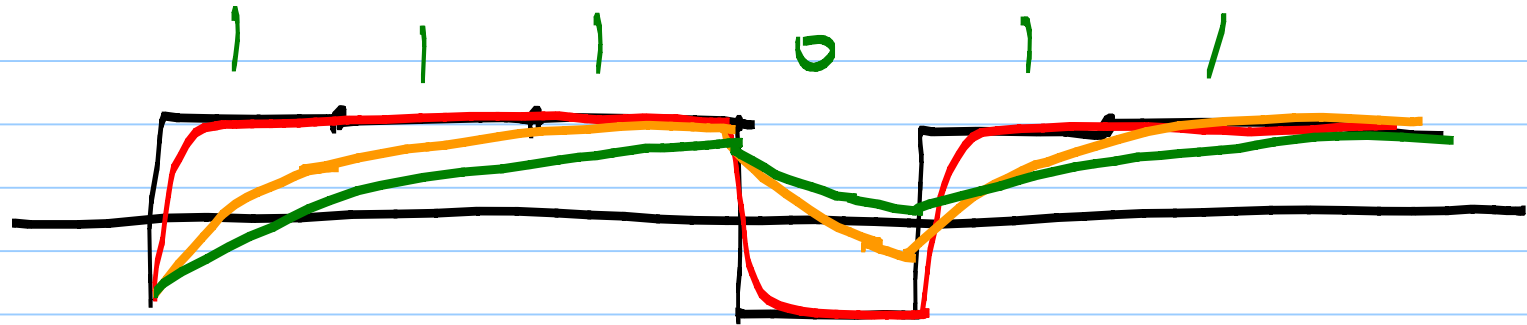


Phase detector for random data

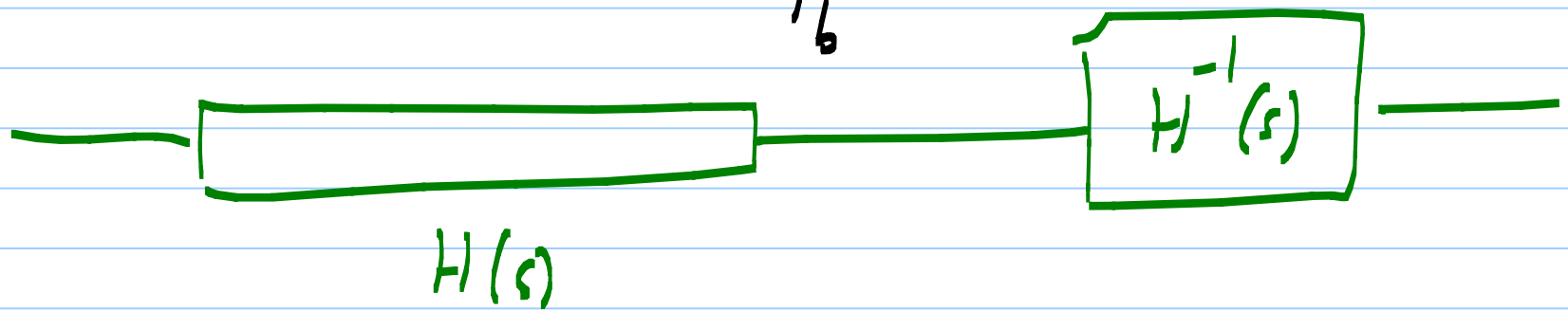


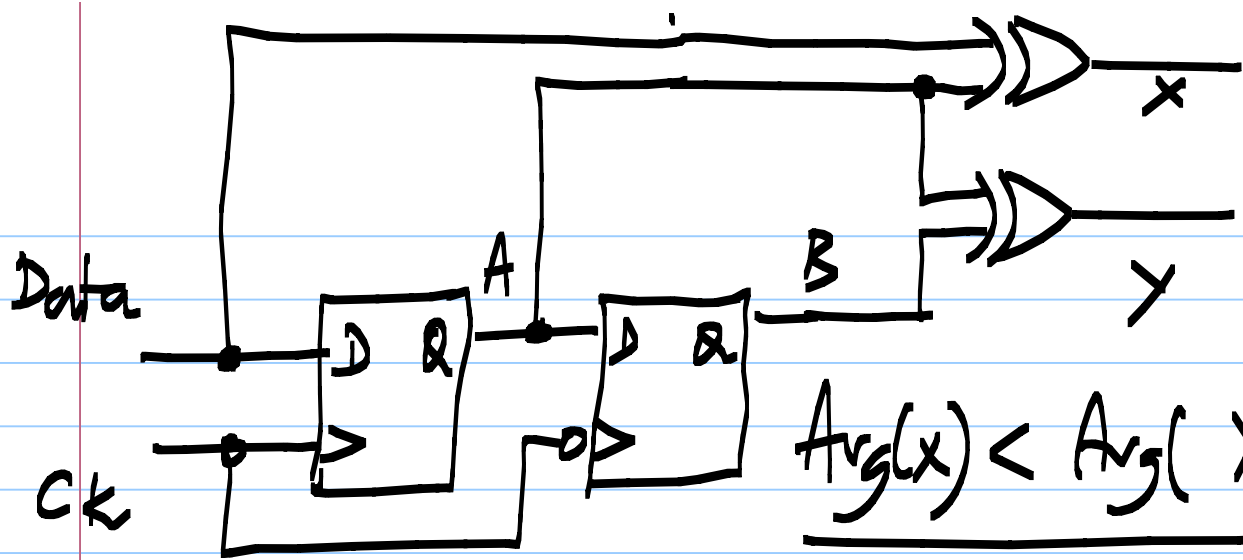


$RC \ll T_b$
 BW \gg data rate



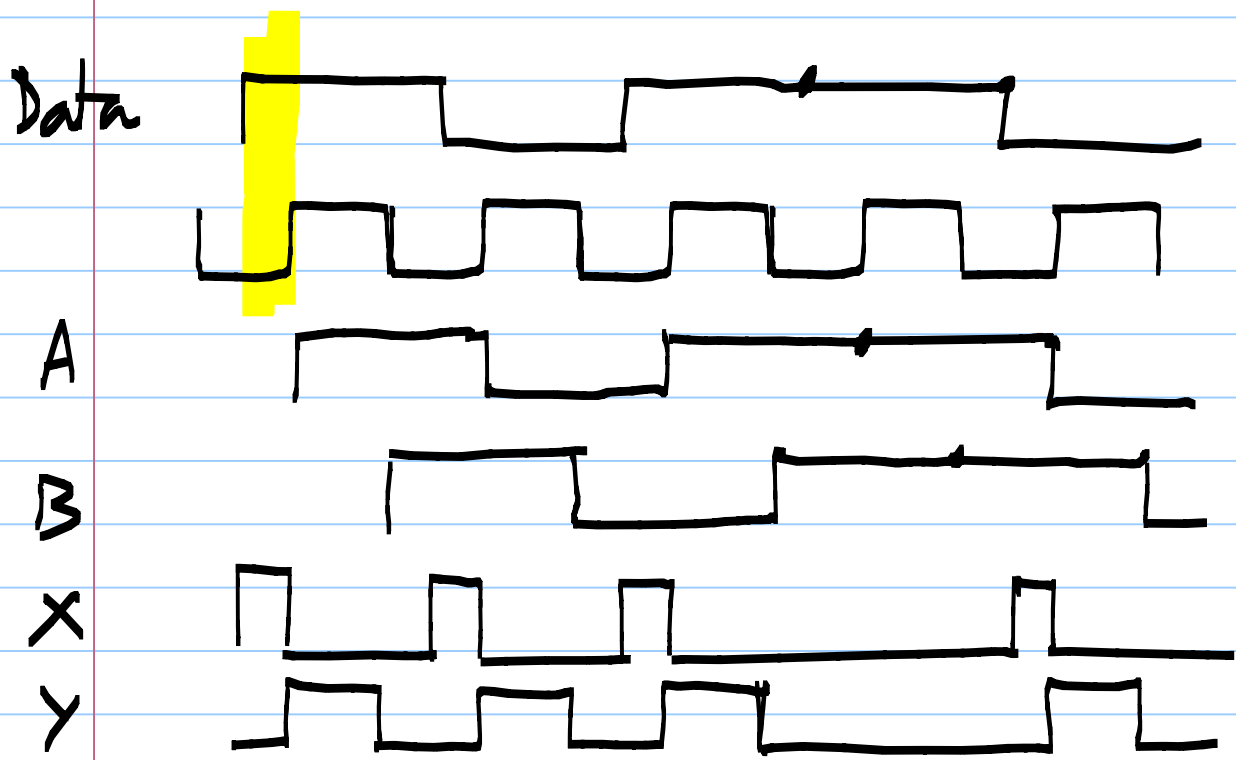
\longleftrightarrow
 T_b





Pulses @ every transition
width = rising edge of CK
EARLY — Data edge

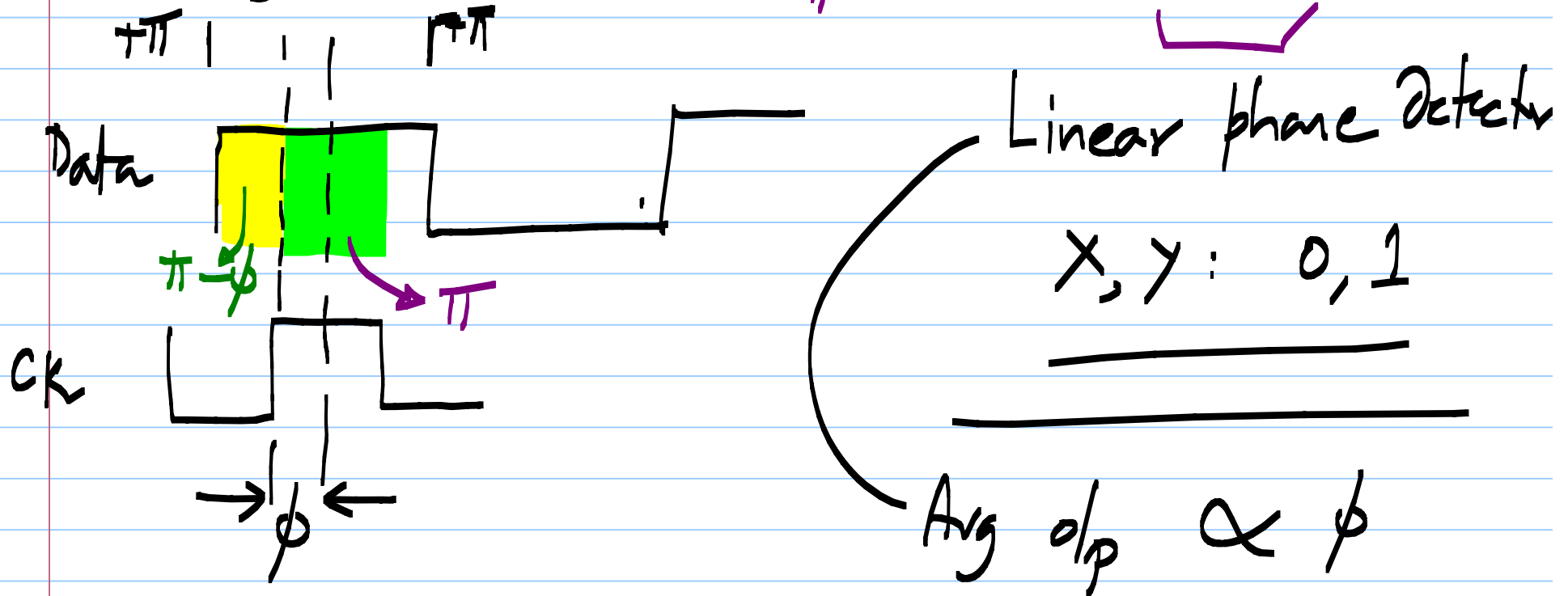
$Arg(x) < Arg(y)$:



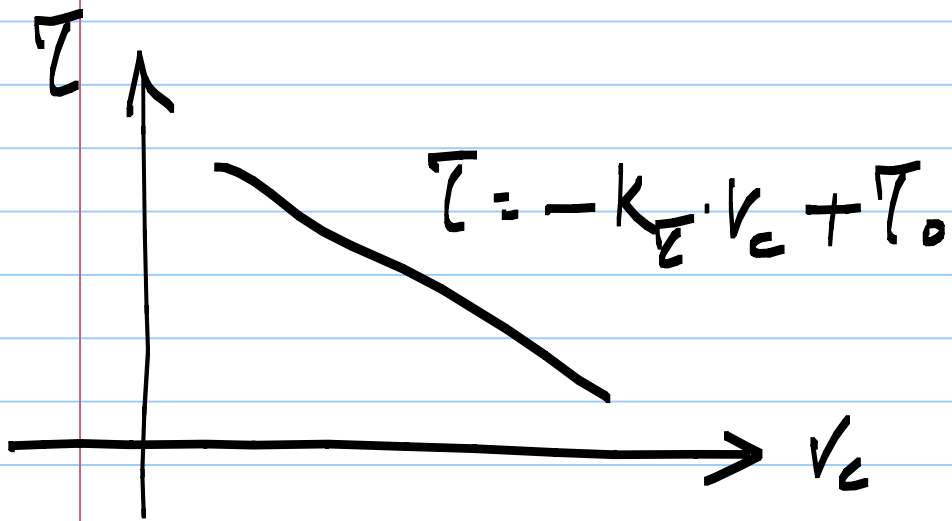
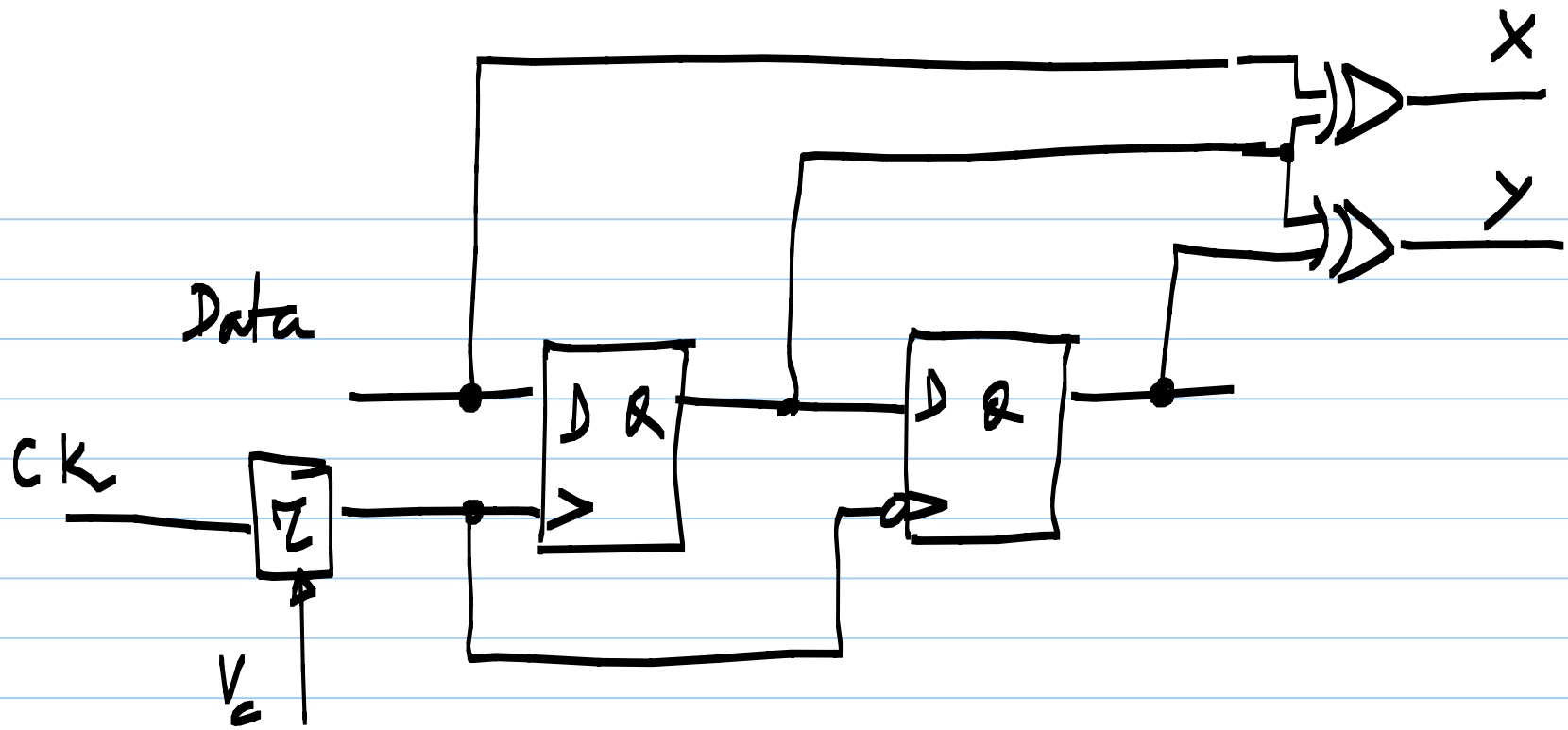
Pulses @ every data transition
width = $T_0/2$

when ^{rising edge of} CK is @
^
the center of Average Data: $X = Y$

$$\text{Arg}(x-y) = \frac{\pi - \phi - \pi}{2\pi} = -\frac{\phi}{2\pi}$$



ϕ : amount by which rising edge of CK is leading the center of data



width of X \leftarrow $>$ width of Y
 (late ck) (early ck)
 T must decrease
 V_c must increase

Clock & Data Recovery ckt:

N/ forwarded clock

