CDR
- Lin. PD : $\frac{1}{2\pi}$
- BB PD : Gain depends on $\phi_D - \phi_{CK}$

JTOL, JGEN, JTRAN : K_{PD}

R, I_{CP}, V_{CO}

Two-sided

$$S_{v_n}(f) = \frac{A}{K_{VCO}^2}$$

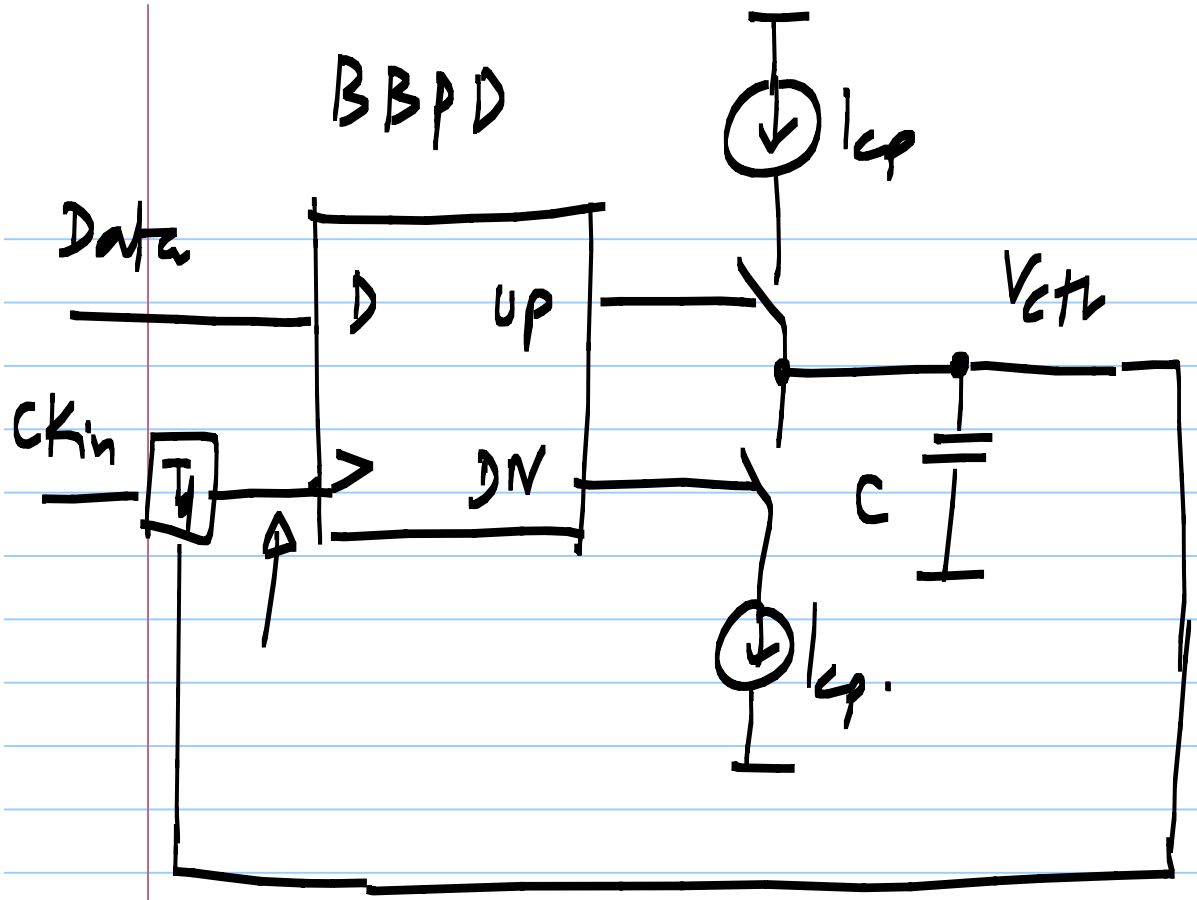
$$S_{v_n}(f) \cdot \left(\frac{K_{VCO}}{f}\right)^2 = S_{\phi}(f)$$

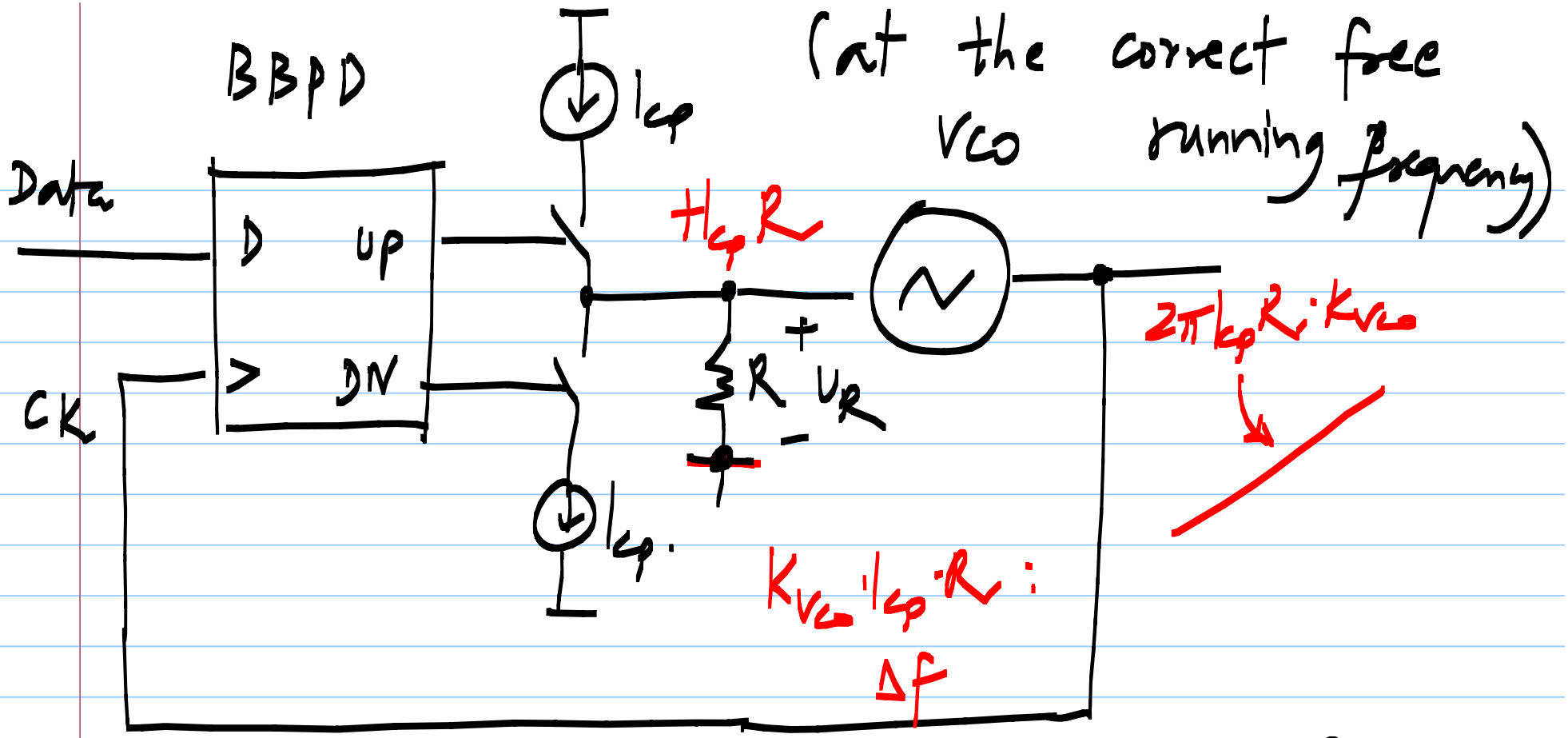
$$L(f) = \frac{A}{f^2}$$

$S_{\phi}(f)$ $L(f)$ * noise term

v_n

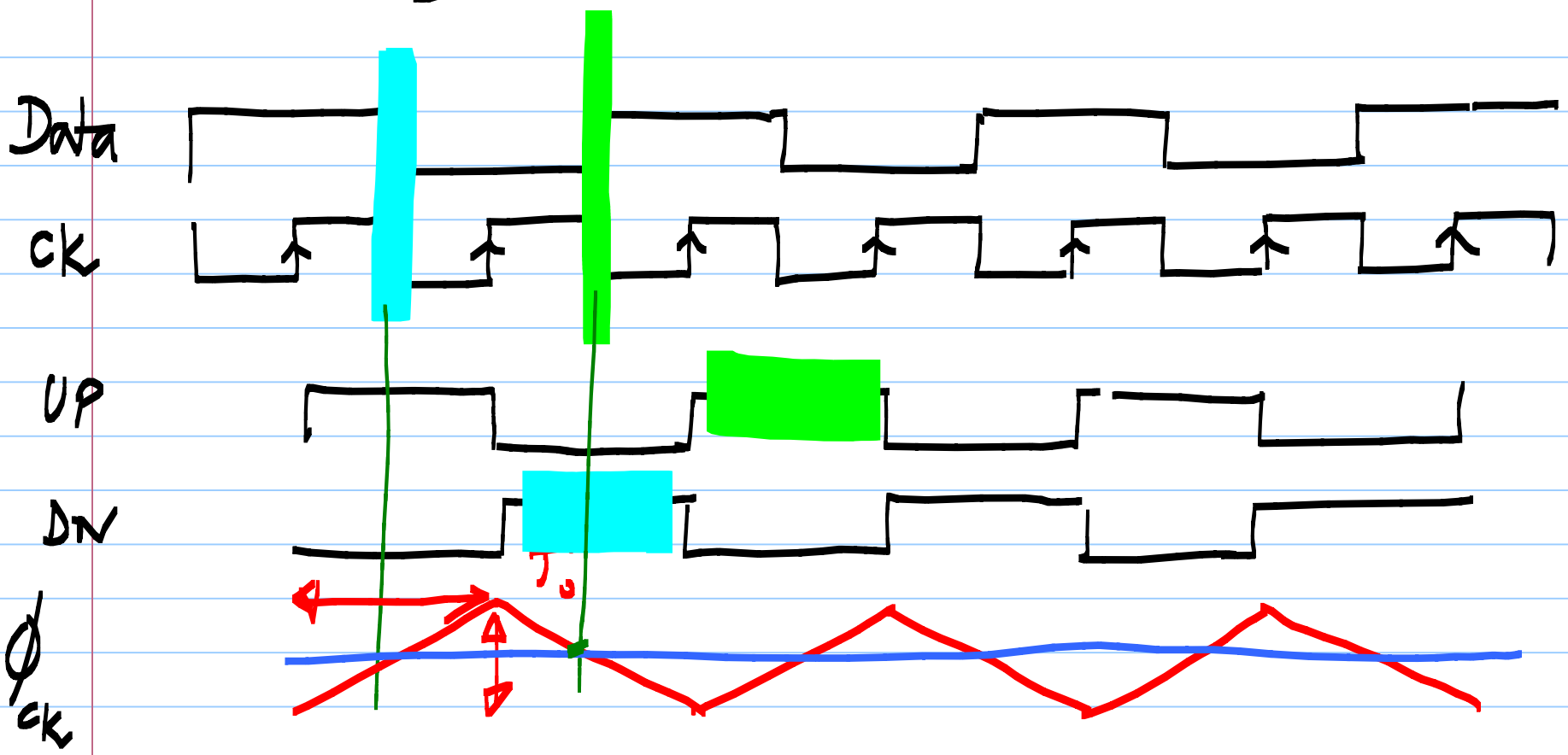
$$\frac{\phi_{VCO}(s)}{V_{ctl}(s)} = \frac{2\pi K_{VCO}}{s}$$


BBPD
Data
D
up
DN
CKin
Vctl
C
Icp
Icp



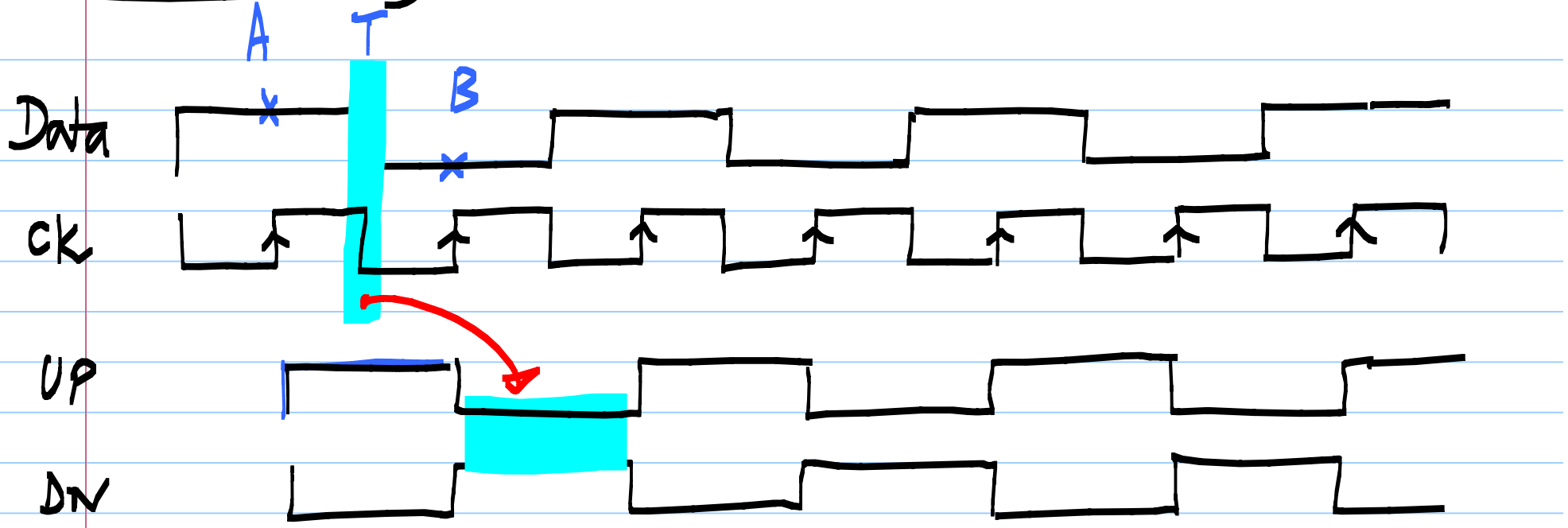
* Consider only the proportional path (for instantaneous changes)

Alternating data:

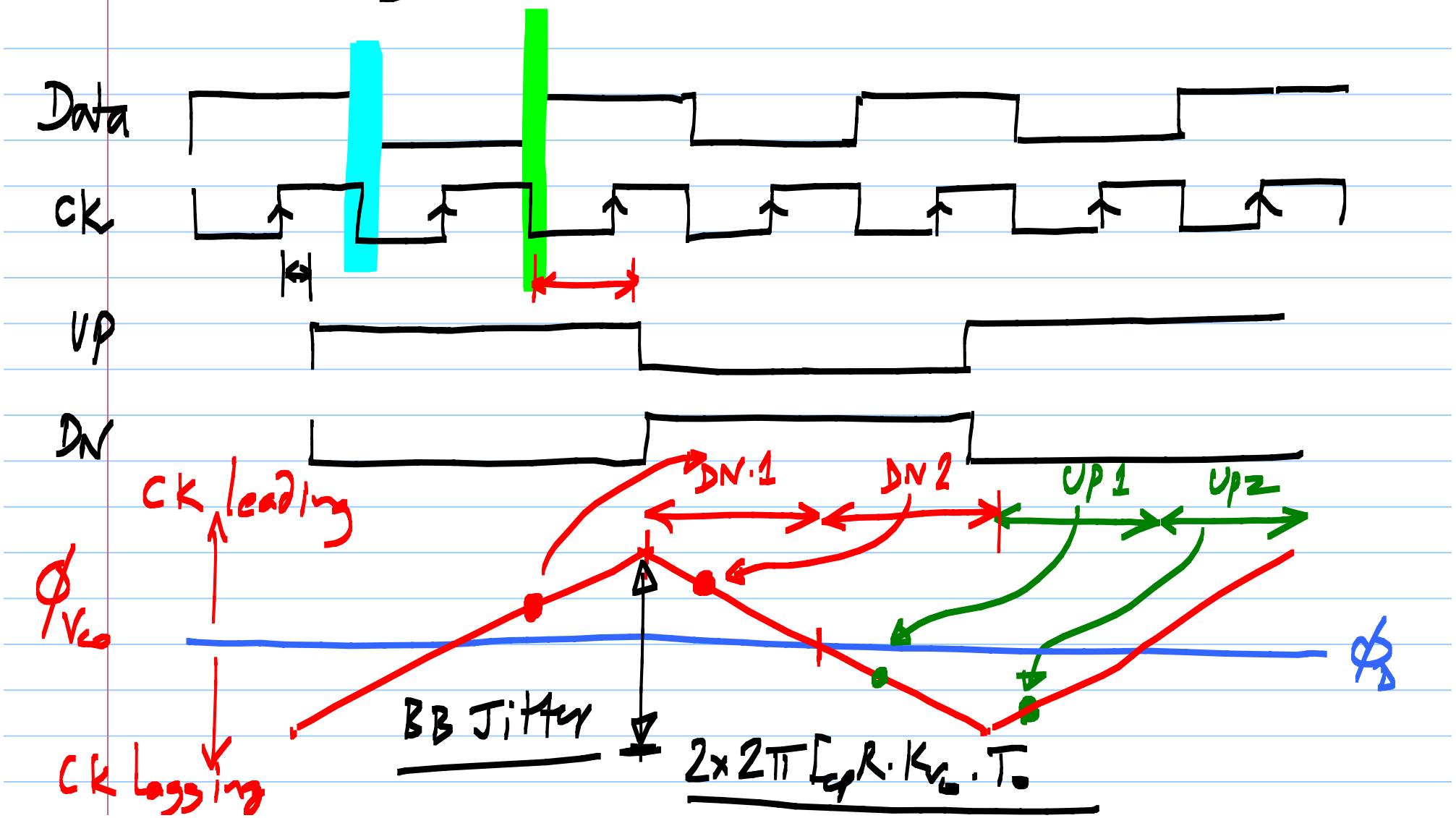


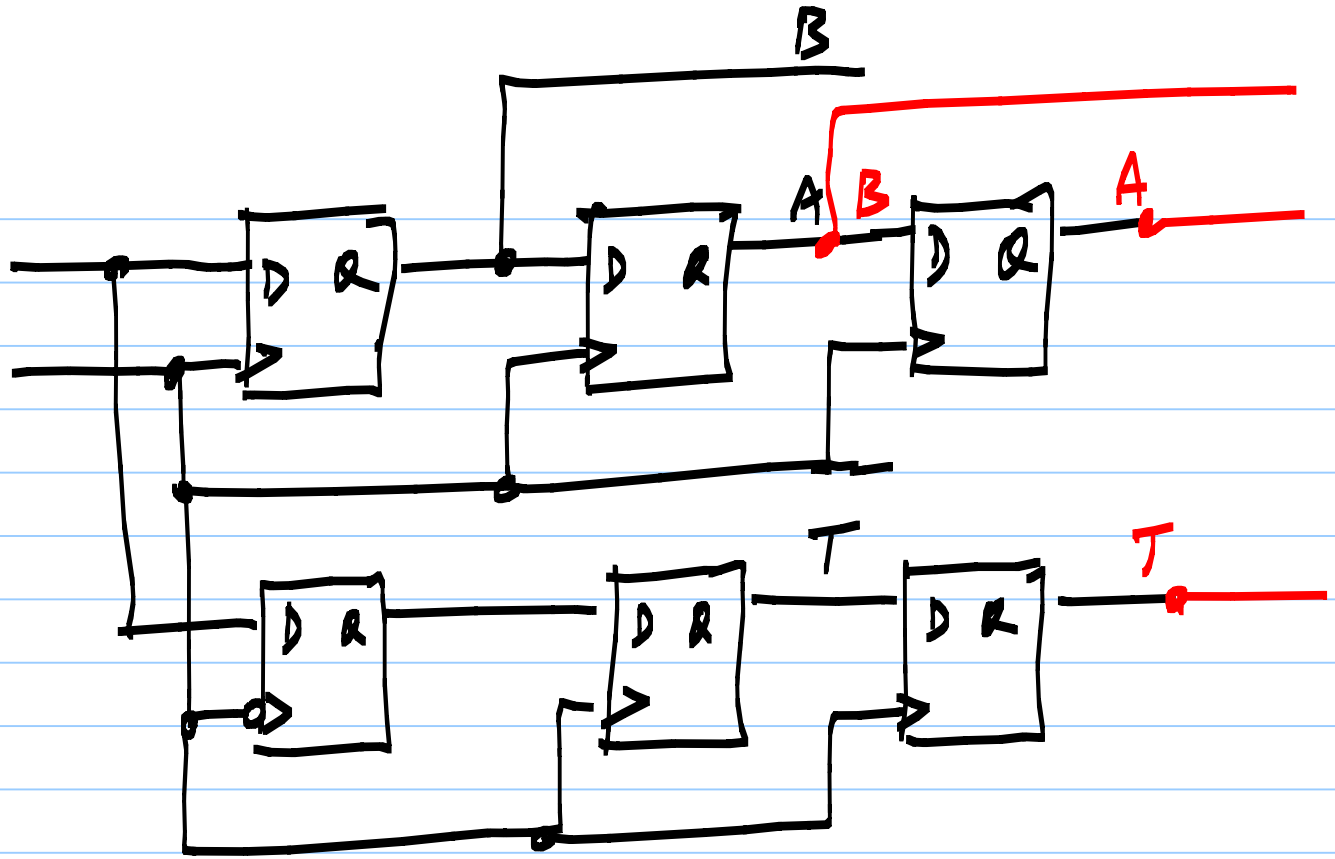
$$2\pi / K_\varphi R K_{VCO} \cdot T_0$$

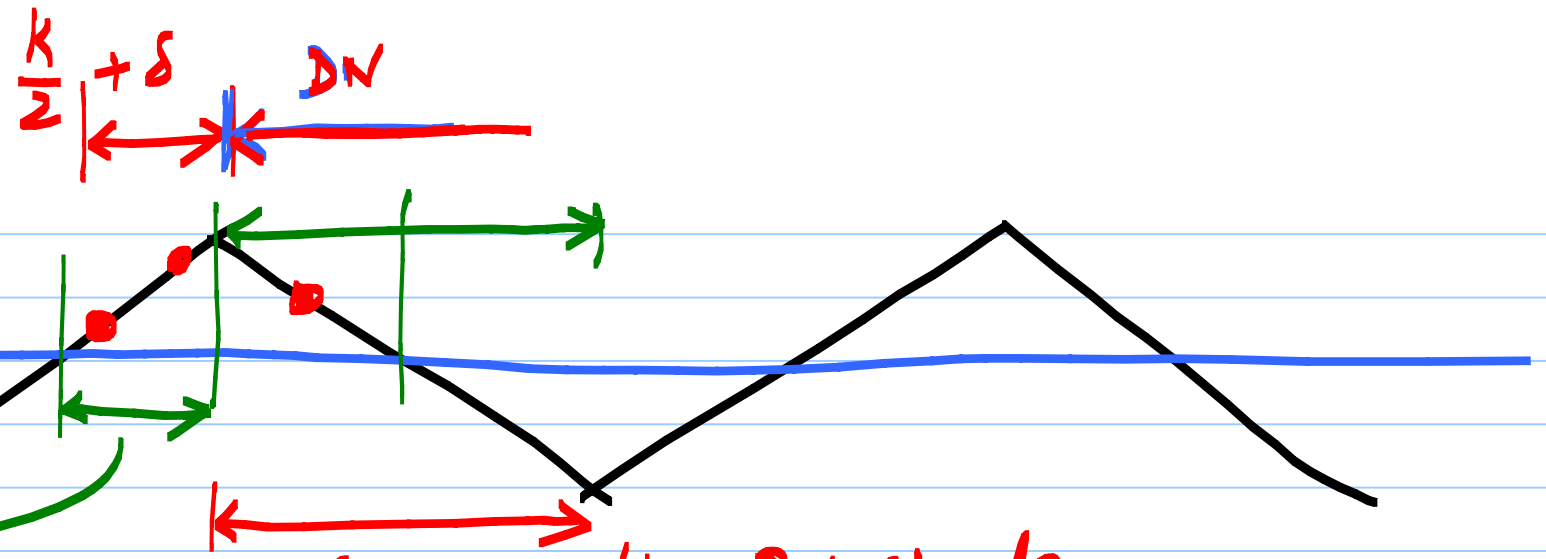
Alternating data:



Alternating data:




B
A
B
A
D
Q
T
T

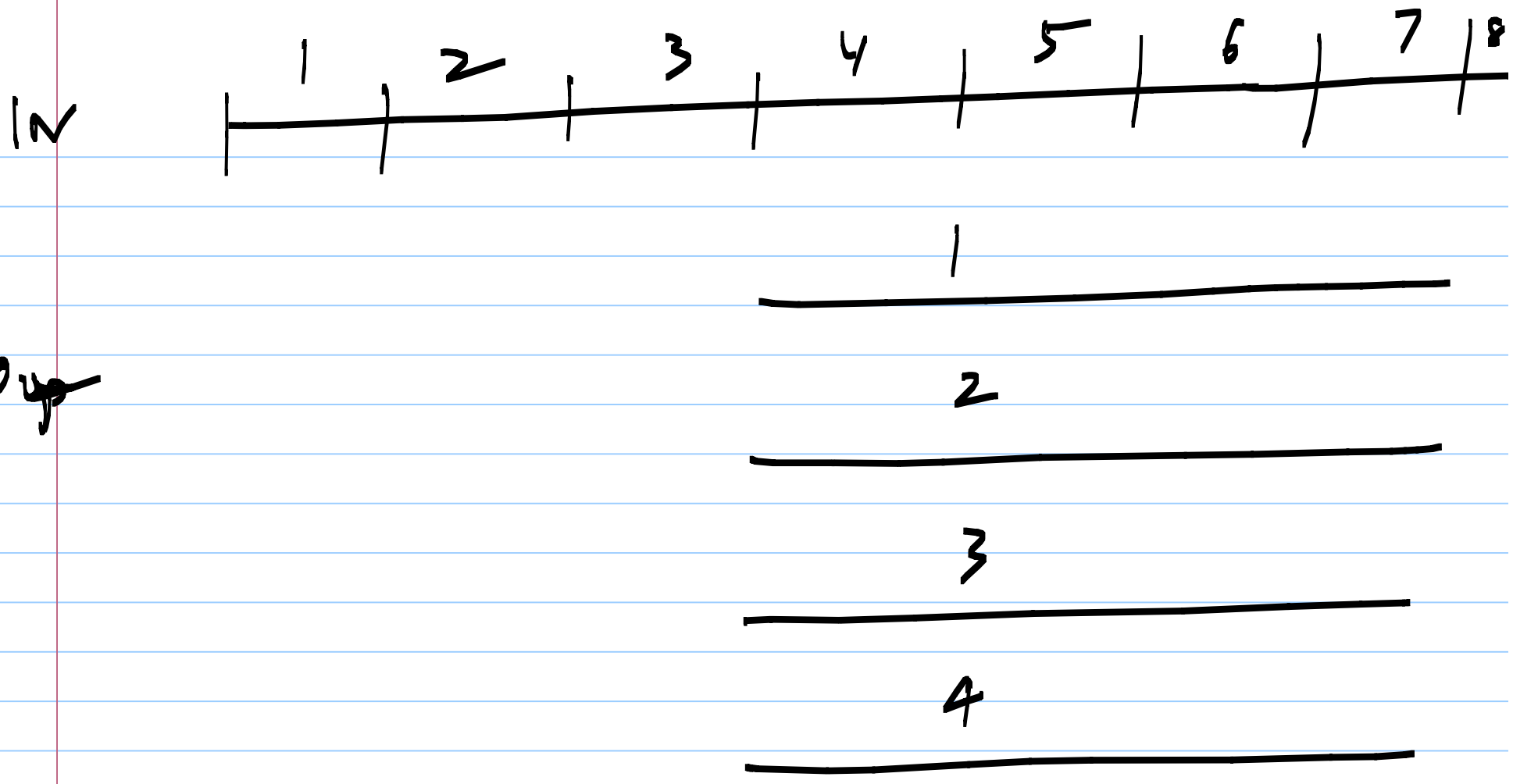


UP, DN: Delayed by $\frac{1}{2}+\delta$ cycles from the relevant transition

$\frac{k+1}{2}$

(k+1) consecutive UP & DN

Delayed by $k/2+\delta$ cycles from the relevant transition


1
2
3
4
5
6
7
8
1
2
3
4

$I_{CP} R K_{VCO}$ $\omega_u = DF \cdot K_{PD} \cdot 2\pi I_{CP} R K_{VCO}$

Bang-bang jitter (with jitter-free alternating data input)

$(2\pi I_{CP} R K_{VCO} T_D)(k+1)$ radians peak-peak p-p

if there is a delay of $(\frac{k}{2} + \delta)$ cycles between a transition and the corresponding UP/DN signals

Depends on the latency.