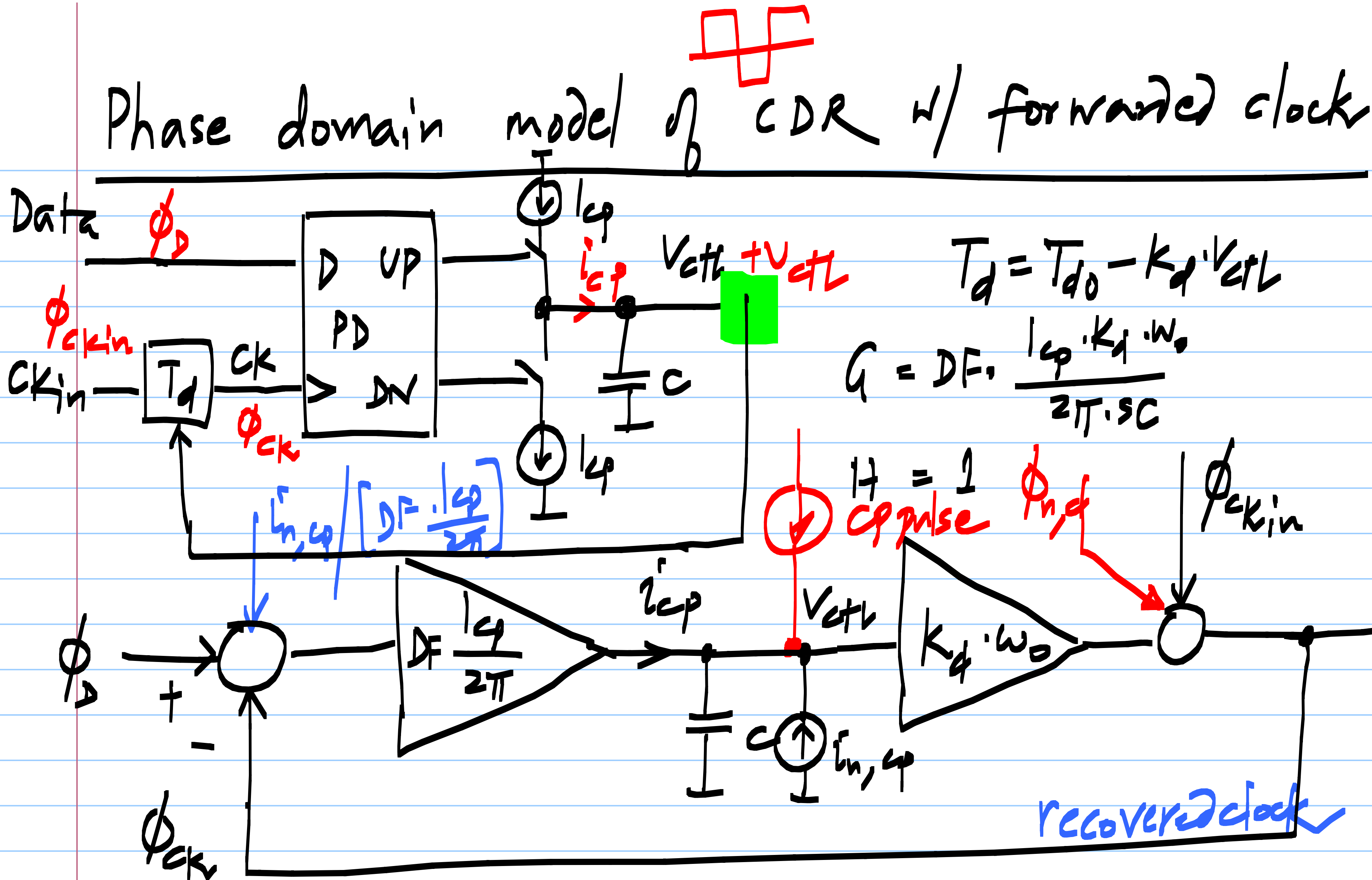
Phase domain model of CDR w/ forwarded clock



$$T_d = T_{d0} - K_d \cdot V_{ctl}$$

$$G = DF \cdot \frac{I_{cp} \cdot K_d \cdot \omega_0}{2\pi \cdot sC}$$

$$H = 1$$

$$\omega_{BW} = \left[\frac{DF \cdot I_{cp} \cdot K_d \cdot \omega_o}{2\pi C}\right]$$

Transfer functions:

$$\frac{\phi_{ck}}{\phi_D} = \frac{DF \cdot \frac{I_{cp} \cdot K_d \omega_o}{2\pi \cdot sC}}{1 + DF \cdot \frac{I_{cp} K_d \omega_o}{2\pi sC}} = \frac{1}{1 + \frac{s}{(DF \cdot I_{cp} K_d \omega_o)/2\pi C}} = \frac{1}{1 + s/\omega_{BW}}$$

$$\frac{\phi_{ck}}{\phi_{ck,in}} = \frac{1}{1 + DF \cdot \frac{I_{cp} K_d \omega_o}{2\pi sC}} = \frac{s/[(DF \cdot I_{cp} \cdot K_d \omega_o)/2\pi C]}{1 + s/[(DF \cdot I_{cp} K_d \omega_o)/2\pi C]} = \frac{s/\omega_o}{1 + s/\omega_{BW}}$$

$$\frac{\phi_{ck}}{i_{n,cp}} = \frac{1}{(DF \cdot I_{cp}/2\pi)} \cdot \frac{1}{1 + \left[\frac{s}{(DF \cdot I_{cp} K_d \omega_o)/2\pi C}\right]} = \frac{1}{DF \cdot I_{cp}/2\pi} \cdot \frac{1}{1 + s/\omega_{BW}}$$

$$V_i(s) \longrightarrow \boxed{H(s)} \longrightarrow V_o(s)$$

$$v_i(t) \qquad\qquad v_o(t)$$

$$\delta(t) \longrightarrow h(t)$$

$$H(s) \xrightarrow{\text{Inv. L.T.}} h(t)$$

$$u(t) \longrightarrow y_u(t)$$

$$u(t) \longrightarrow \frac{1}{s}$$

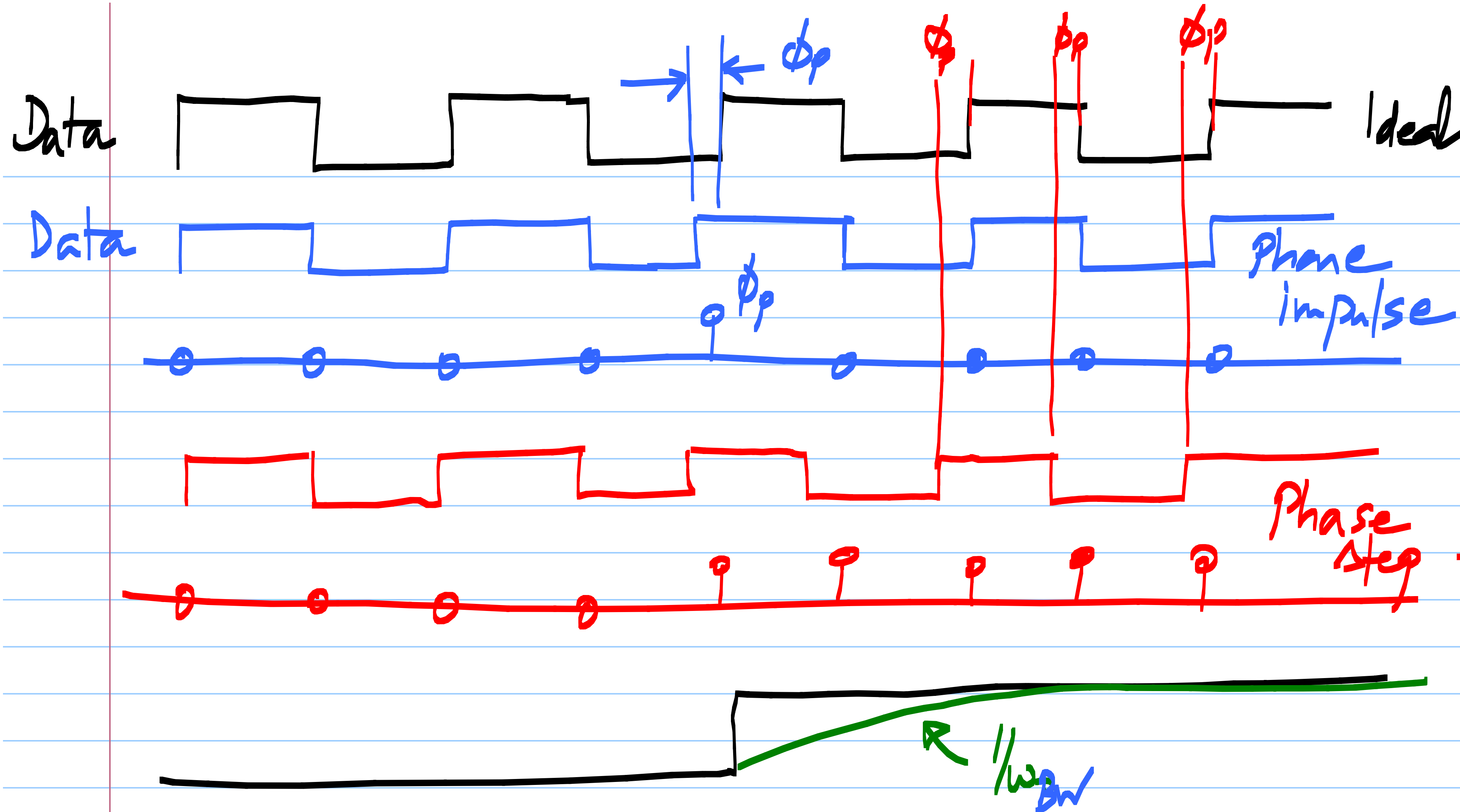
$$\frac{H(s)}{s} \xrightarrow{\text{Inv. L.T.}} y_u(t)$$

$$V_p \cos(\omega t + \Phi_o)$$

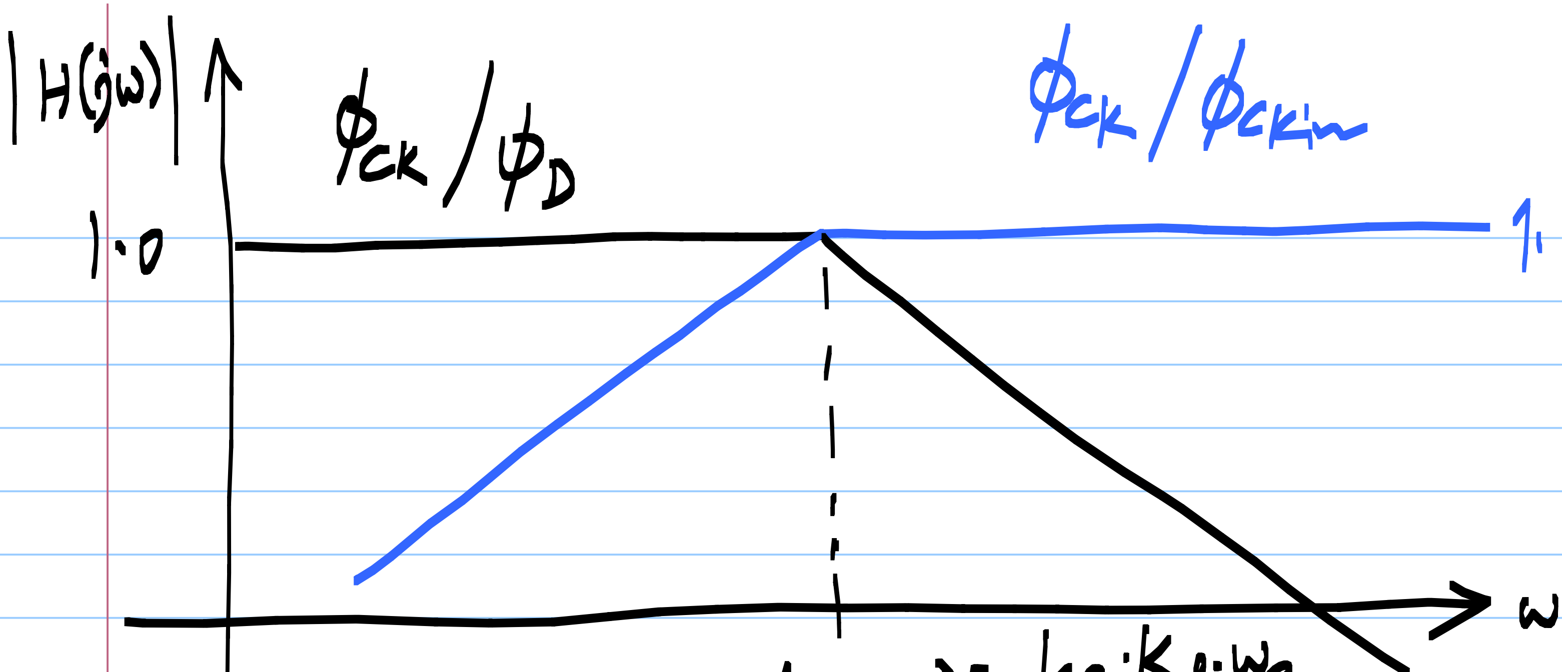
$$\Big\downarrow$$

$$\underline{\text{steady state}}$$

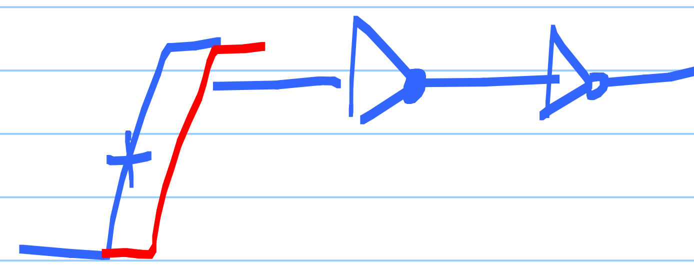
$$V_p \left| H(j\omega) \right| \cdot \cos\left(\omega t + \Phi_o + \angle H(j\omega)\right)$$

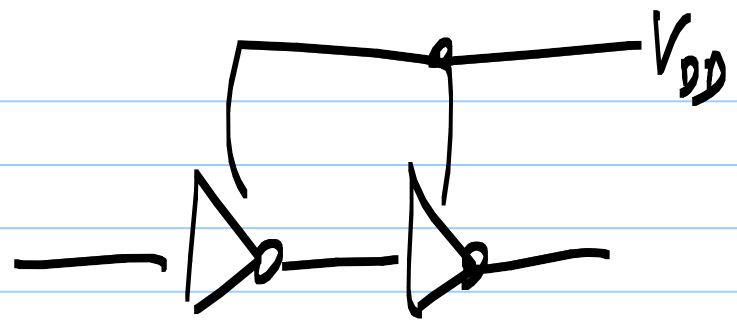


Data
Ideal
Data
ϕ_p
ϕ_p
ϕ_p
ϕ_p
ϕ_p
Phase impulse
Phase step
$1/\omega_{BW}$



$$\omega_{BW} = DF \cdot \frac{I_{cp} \cdot K_\phi \cdot \omega_0}{2\pi C}$$




V_{DD}