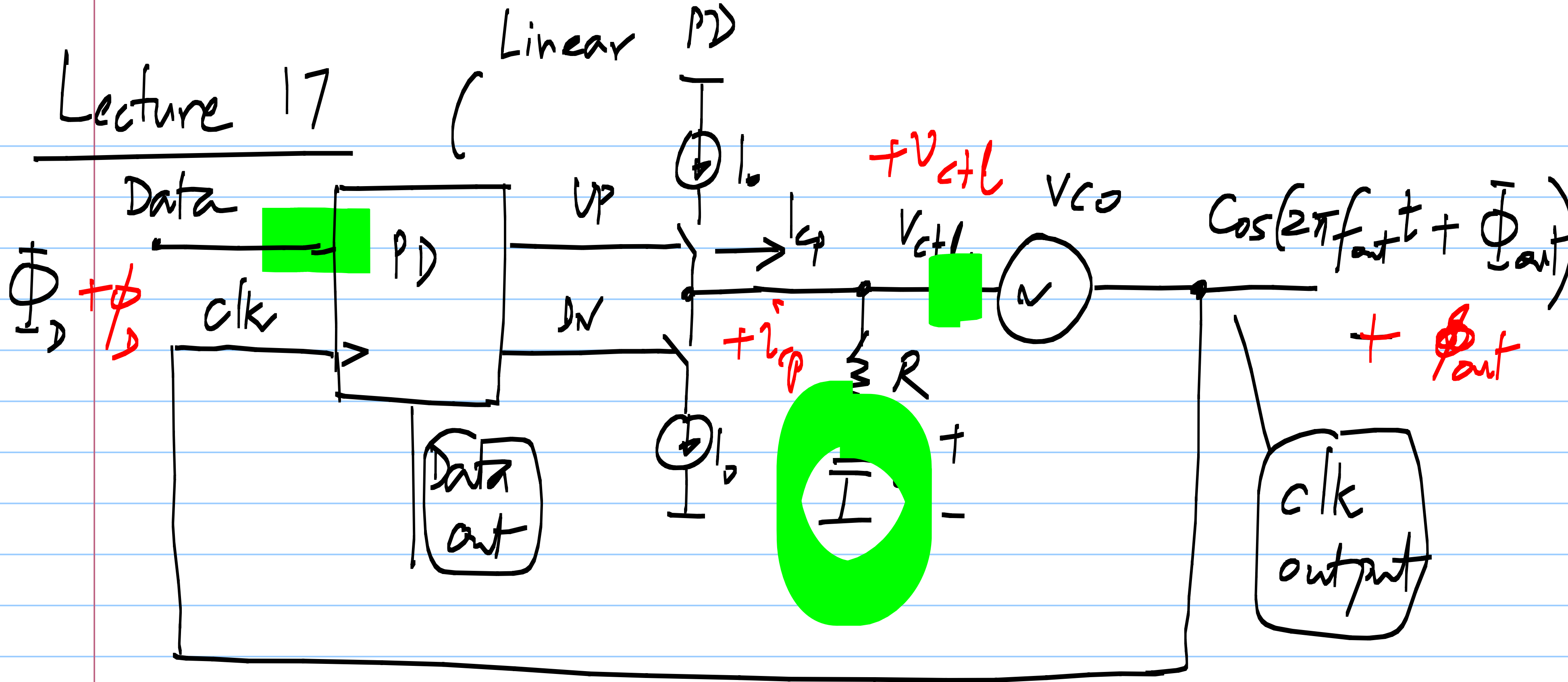
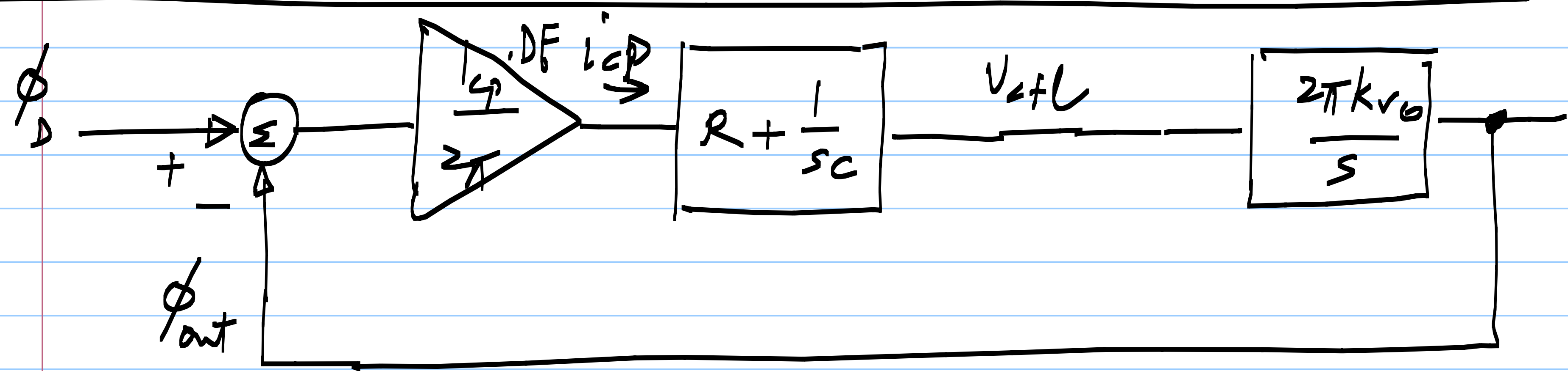
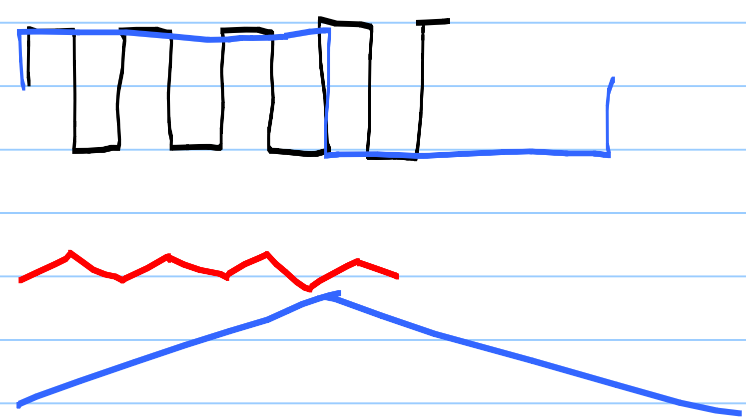
Lecture 17



Linear
PD
(Linear PD
$\Phi_D + \phi_D$
Data
clk
PD
UP
DN
I_0
I_0
I_{cp}
$+i_{cp}$
R
C
+
-
V_{ctl}
$+v_{ctl}$
VCO
$\cos(2\pi f_{out} t + \Phi_{out})$
$+ \phi_{out}$
Data out
clk output

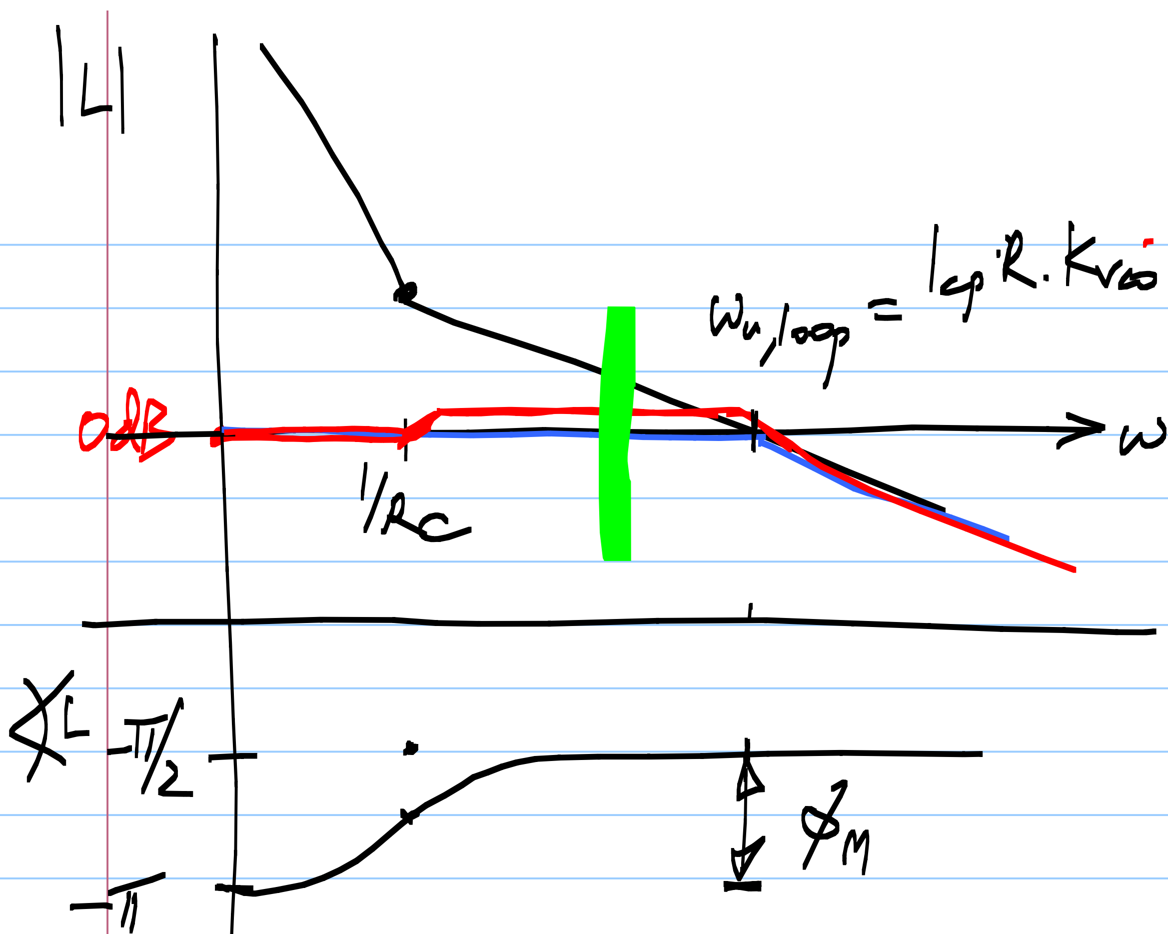
Linear model of the clock and data recovery (CDR) loop





$$L(s) = I_{cp}\left(R + \right)\cdot\frac{K_{vco}}{s}$$

ΔF: additional multiplying factor



$$\omega_{u,loop} = I_{cp}\cdot R\cdot K_{vco}\cdot \Delta F$$

$$\frac{\phi_{out}}{\phi_i} = \boxed{\frac{1}{1+\frac{1}{L}}} = \frac{1 + sCR}{1 + s\cdot CR + s^2\cdot\frac{C}{I_0 K_{vco}}}$$

$$Q = \frac{1}{R\sqrt{I_0 K_{vco}\cdot C}}$$

$N(s) = 1 + sCR$: Zero @ $-\frac{1}{RC}$ rad/s

$D(s) = 1 + sCR + s^2 \frac{C}{I_1 K_{VCO}}$ Poles $-\frac{1}{RC}$, @ $-I_0 R K_{VCO}$ rad/s

Pole-zero Doublet

Pole freq. higher than $\left(+\frac{1}{RC}\right)$

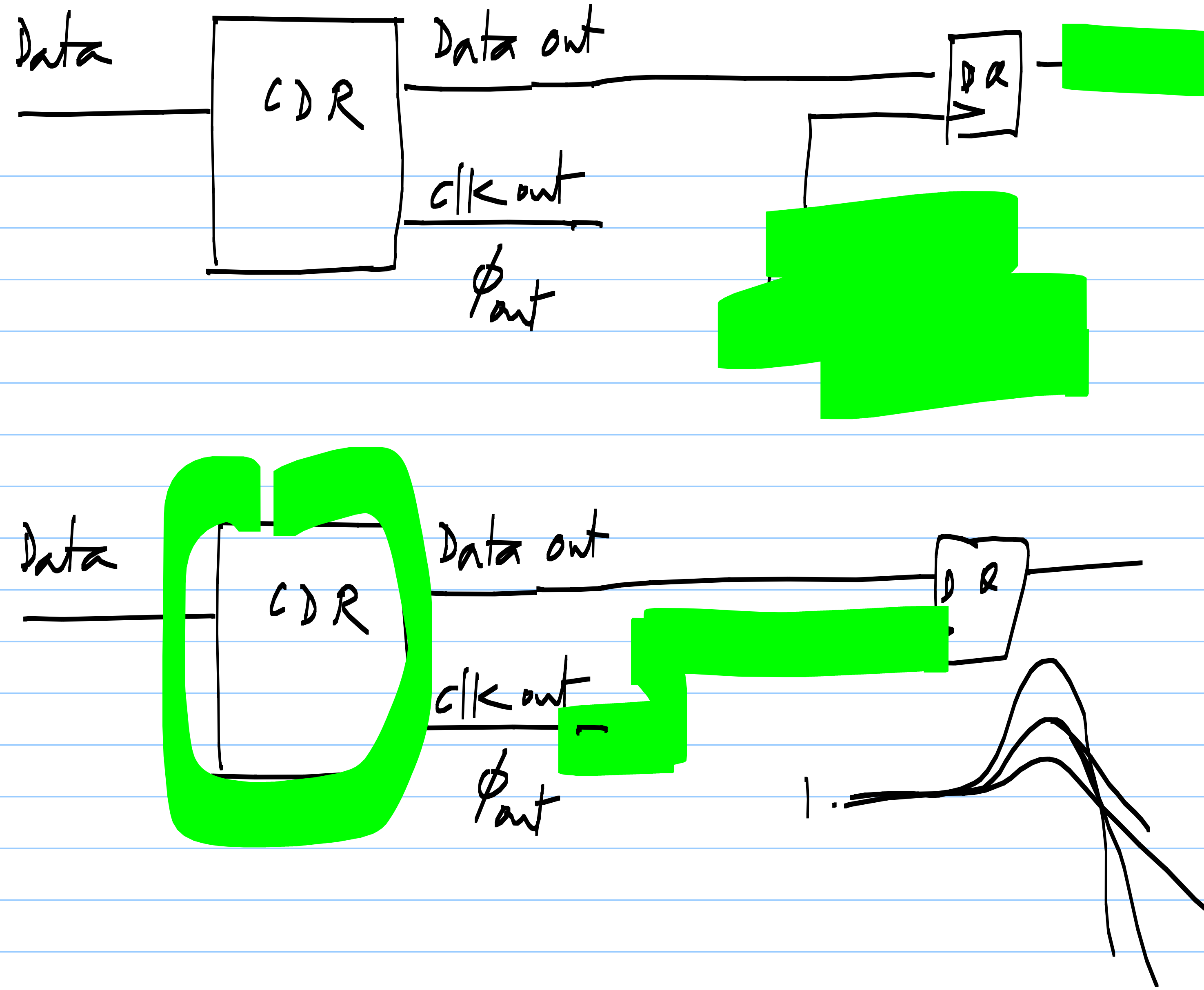
Peaking in the transfer function $\frac{\phi_{out}}{\phi_D}$ (rise above 0dB)

Gets worse as the zero moves closer to $\omega_{u,loop}$

2nd order polynomial $as^2 + bs + c$

$$\omega_n = \sqrt{\frac{c}{a}}$$

$$Q = \frac{\sqrt{ac}}{b}$$


Data
CDR
Data out
clk out
ϕ_{out}
D Q
Data
CDR
Data out
clk out
ϕ_{out}
D Q

$\left[\frac{\phi_{out}}{\phi_D}\right]$:

* Low pass transfer fn.
* pole-zero doublet $\left(\approx \frac{1}{RC}\right)$
* 20dB/dec rolloff @ HF

How the output clock edge follows the data

[Jitter transfer
JTRAN]

Jitter tolerance (JTOL)

$\phi_D < \ ?$ for error-free recovery

BER $< 10^{-12}$

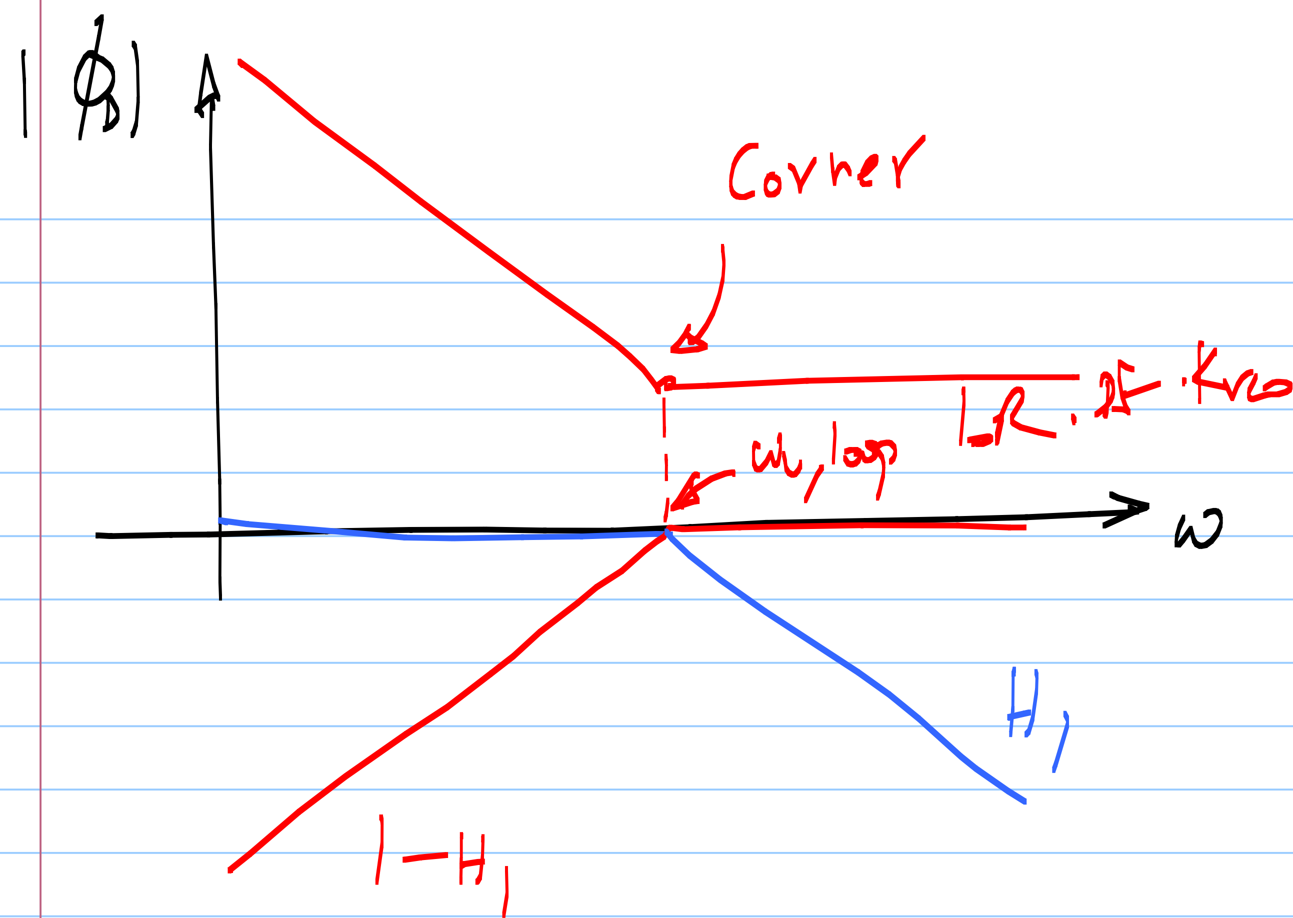
$|\phi_D - \phi_{out}| < \phi_x$

$$\frac{\phi_{out}}{\phi_D} = H_1$$

$$|\phi_D| \, |1 - H_1| < \phi_x$$

$$|\phi_D| < \frac{\phi_x}{|1 - H_1|}$$

Determined by Noise & desired BER level



$$\phi_D \cdot \frac{T_0}{2\pi}$$

$$\frac{\phi_x}{|1-H_1|}$$

$$H_1 = \frac{1}{1+s/p_1}$$

$$1-H_1 = \frac{s/p_1}{1+s/p_1}$$

Jitter tolerance corner : as high as possible

Jitter transfer BW : as low as possible

(for a clean clock)

$= \omega_{u,loop} = \underline{I_{cp} R \cdot DF \cdot K_{VCO}}$ (rad/s)

Jitter generation (J_{GEN})