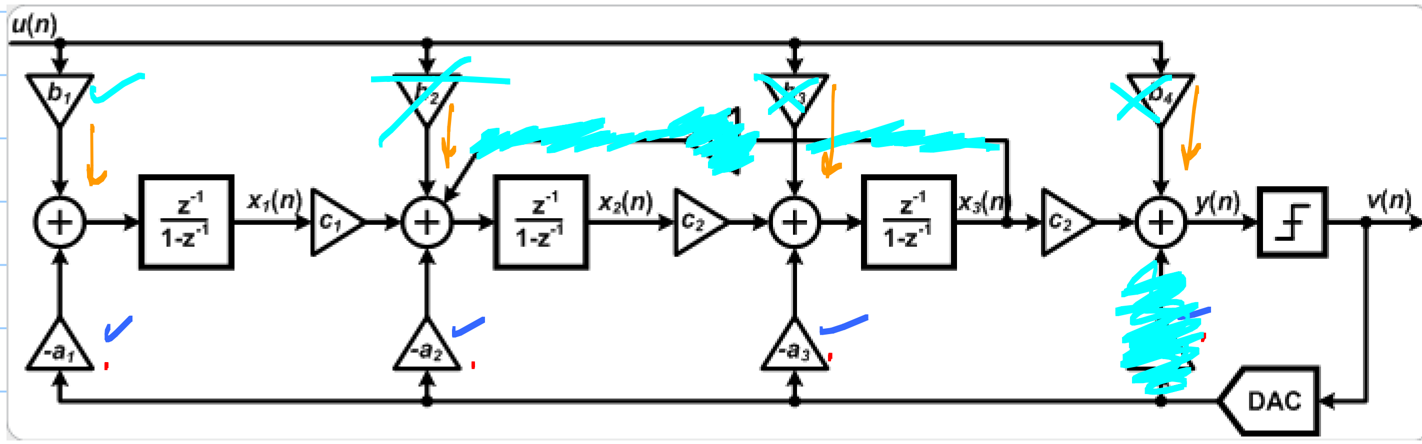
ECE 615 – Lecture 13

Note Title 10/17/2013



CIFB → N integrators

$$L_0(z) = \frac{b_1 + b_2(z-1) + \cdots + b_{N+1}(z-1)^N}{(z-1)^N}$$

$$L_1(z) = \frac{a_1 + a_2(z-1) + \cdots + a_N(z-1)^{N-1}}{(z-1)^N}$$

a's → determine the zeros of $L_1(z)$

$$NTF(z) = \frac{1}{1 - L_1(z)} = \frac{(z-1)^N}{D(z)}$$

NTF zeros ← $(z-1)^N$

NTF pole locations ← $D(z)$

* introduce non-zero poles into the NTF in order to control the OBG.

b's → input feed-in coefficients

$$STF(z) = \frac{L_0(z)}{1 - L_1(z)} = \frac{b_1 + b_2(z-1) + \cdots + b_{N+1}(z-1)^N}{D(z)}$$

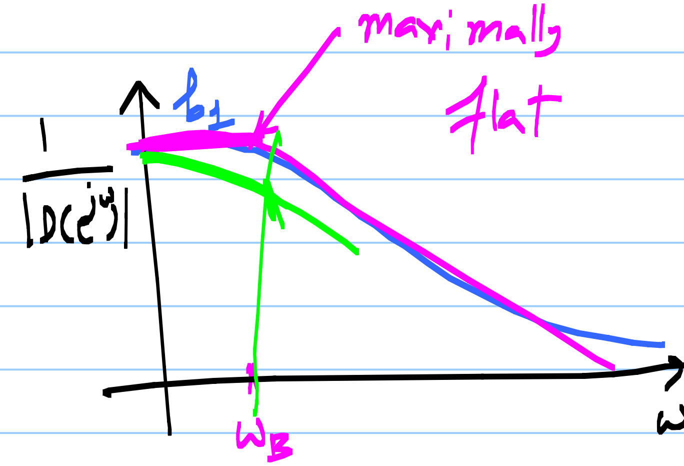
b's determine the zeros of STF while a's determine the poles i.e. D(z)

└→ STF

Ex.

$b_2, b_3 \ldots b_{r+1} = 0$

$b_1 > 0$



$$STF(z) = \frac{b_1}{D(z)}$$

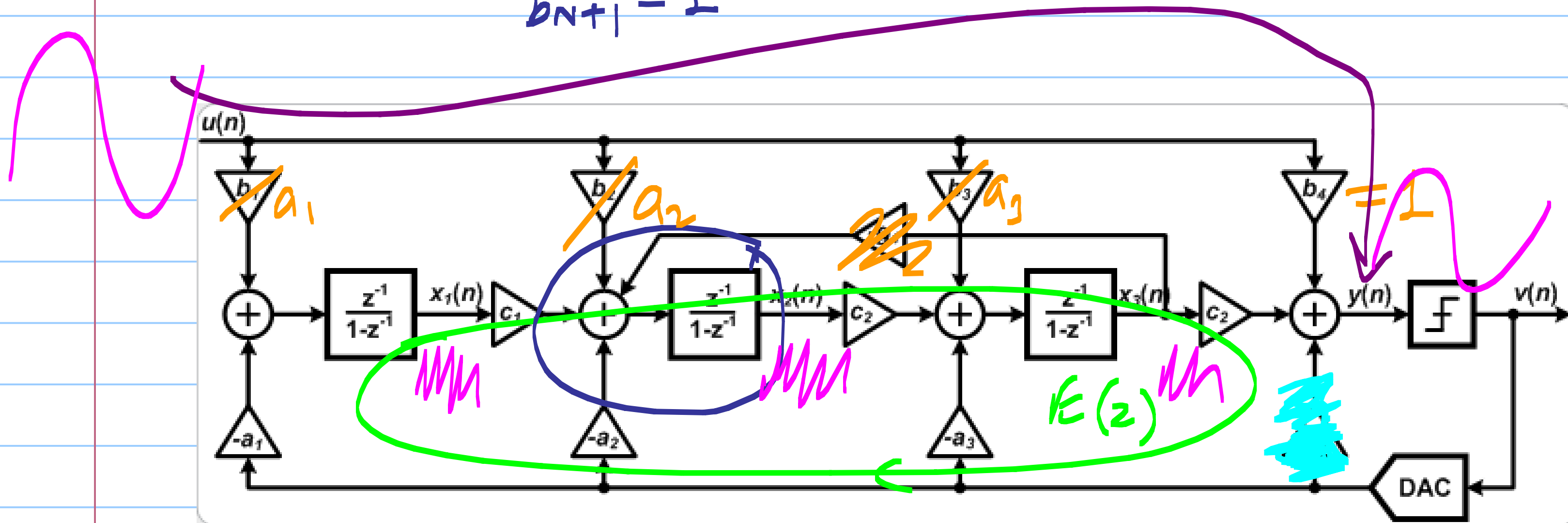
$|STF| = 1$ only for low frequencies

for $|STF| = 1$, set $b_1 = D(0)$

Low-Distortion CIFB :

$b_i = a_i$ for $i \le N$

$b_{N+1} = 1$



STF = 1 for all $0 \le \omega \le \pi$

$STF(z) = 1$

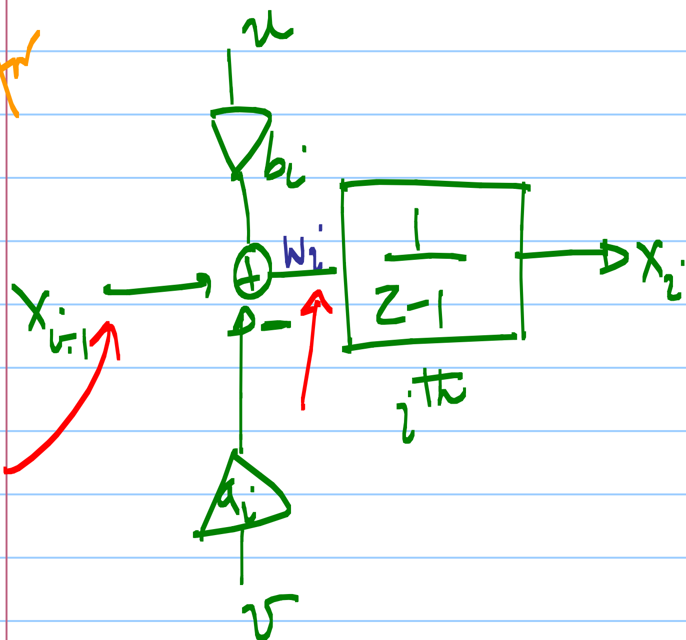
States of the loop filter = Integrator outputs

$$V(z) = U(z) + NTF(z) \cdot E(z) \rightarrow (1)$$

$b_i = a_i$

$i \le N$

for

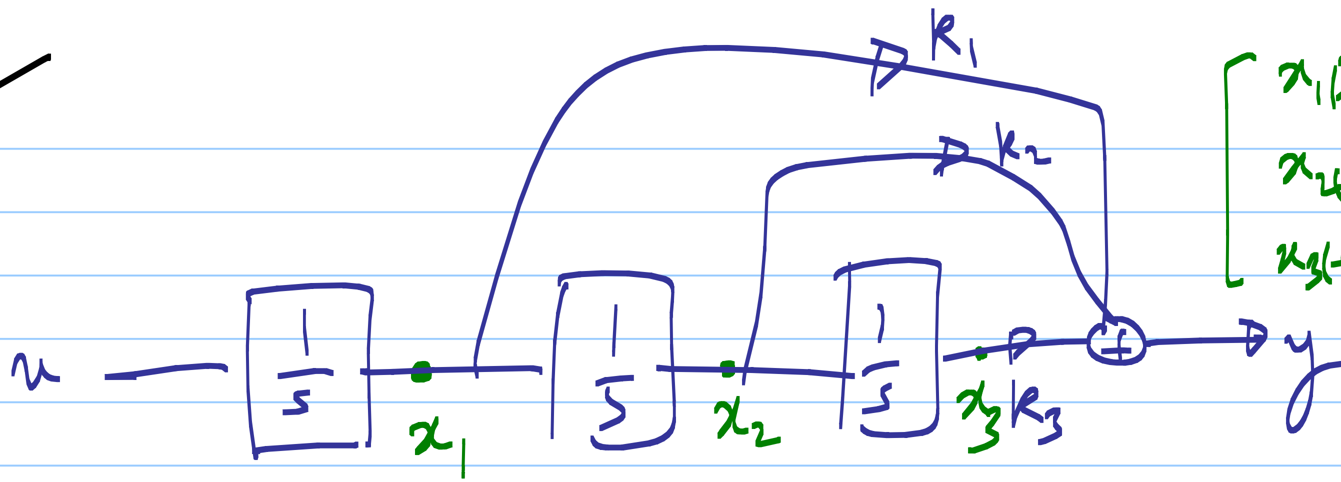


$$W_i(z) = X_{i-1} - a_i V + b_i u \qquad \because b_i = a_i$$

$$= X_{i-1} + a_i \left(U(z) - V(z) \right)$$

$$= X_{i-1} - a_i \cdot NTF(z) \cdot E(z) \longleftrightarrow (1)$$

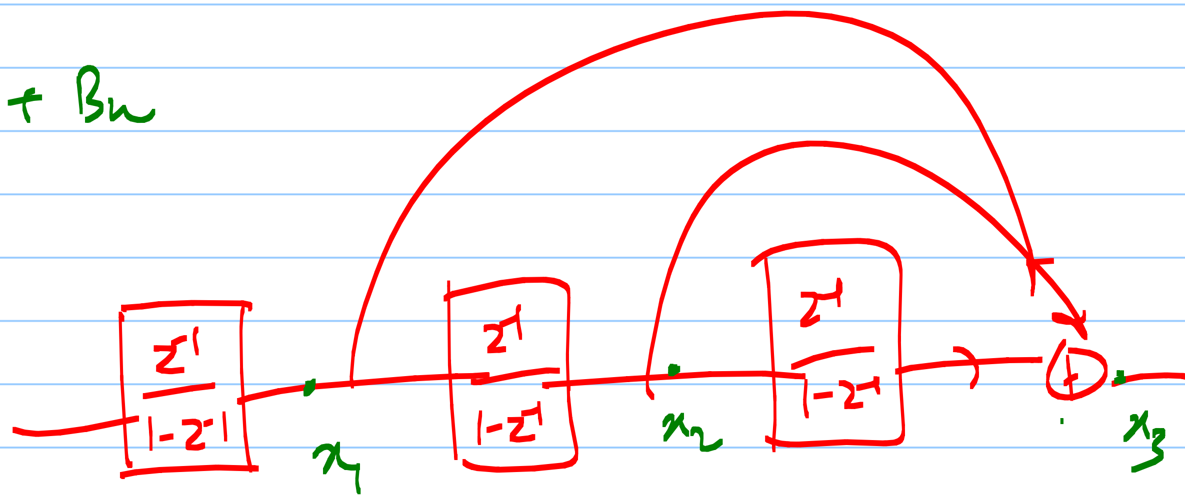
ASIDE



$$\begin{bmatrix} x_1(t) \\ x_2(t) \\ x_3(t) \end{bmatrix}$$ "State"

$$\dot{x} = Ax + Bu$$

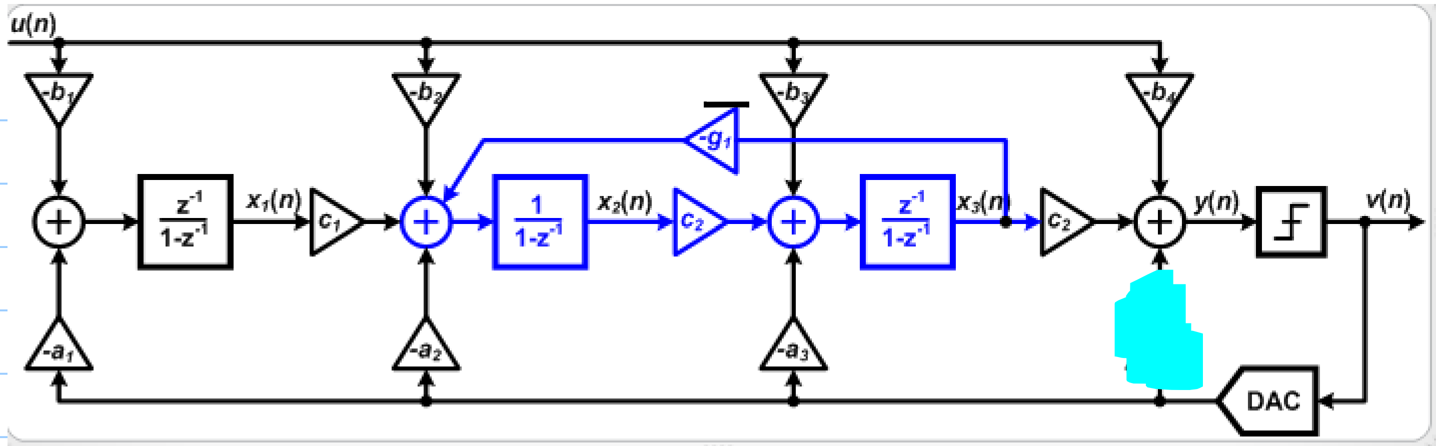
$$\begin{bmatrix} x_1[n] \\ x_2[n] \\ x_3[n] \end{bmatrix}$$



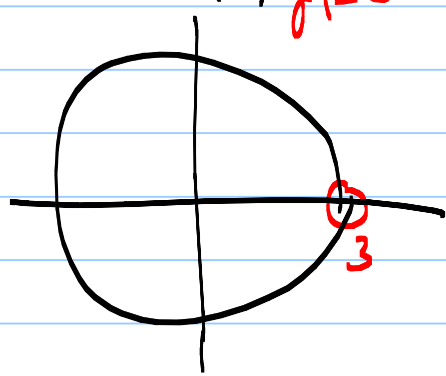
* The loop-filter only processes the quantization noise

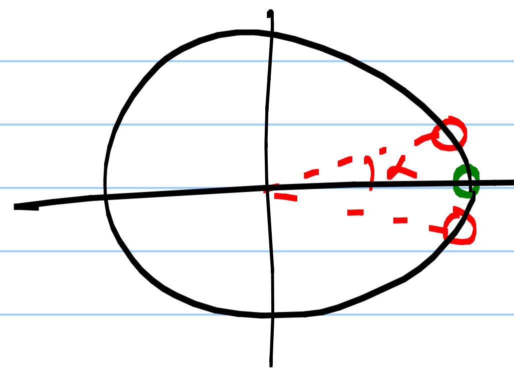
↳ reduced opamp output swings, e.g. for multibit quantizers.

CRFB → Cascade of resonators with distributed feedback

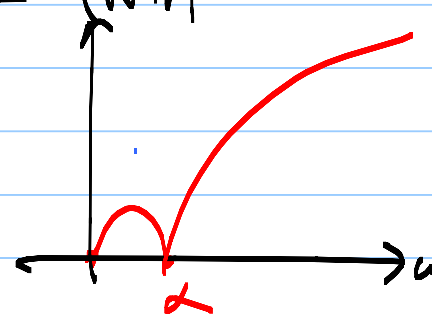


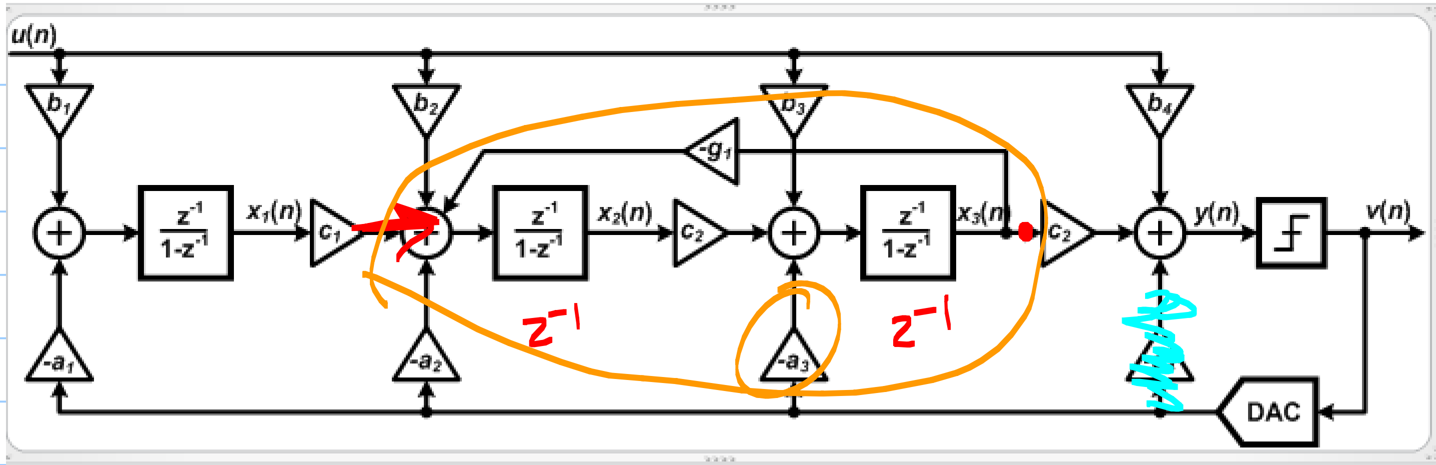
NTF(z) $g_1 = 0$



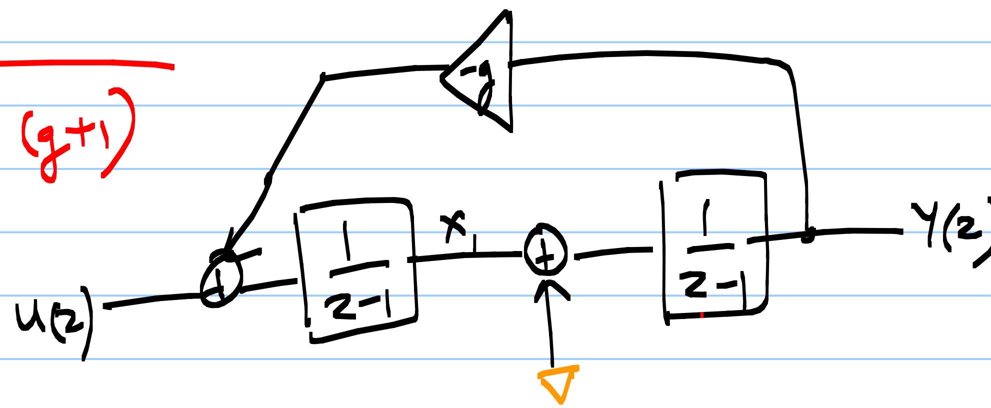


$\alpha = \pm\sqrt{g_1}$



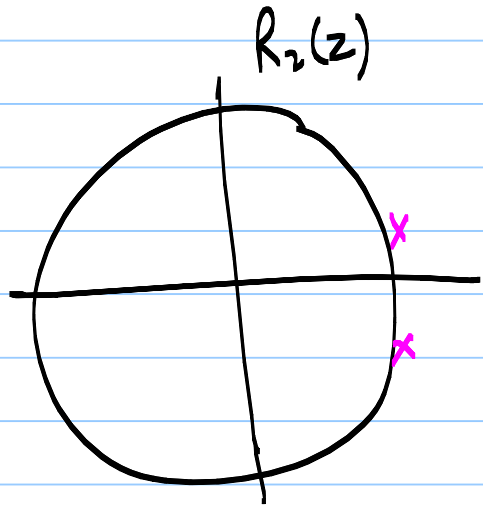


$$R_1(z) = \frac{1}{z^2 - 2z + (g+1)}$$



for this modified resonator

poles are at $p_i = 1 \pm j\sqrt{g}$

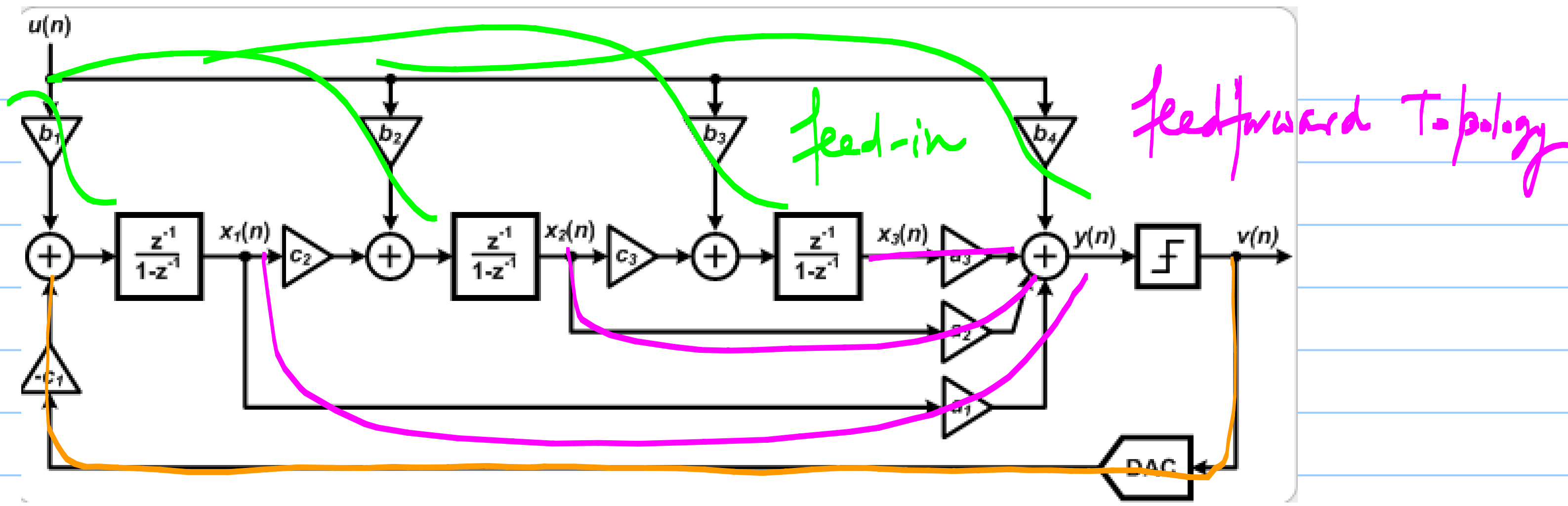


$|p_i| = \sqrt{1+g} > 1$

"CIFB with resonators"

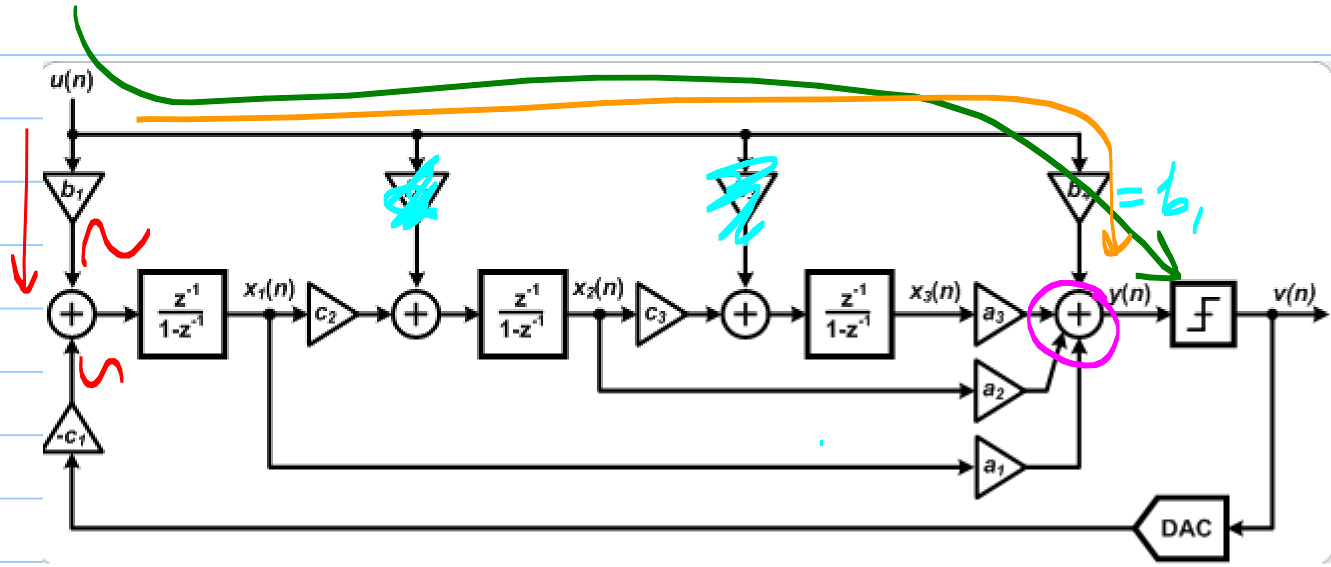
* Overall loop "can be" stable

CIFF → cascade of integrators with ff summation



Special Case => $b_1 = b_{N+1} = 1$

$b_2 = b_3 \cdots = b_N = 0$



for $b_{N+1} = 1$ (full input feedforward)

$STF(z) = 1$ & $NTF = \frac{1}{1 - L_1(z)}$

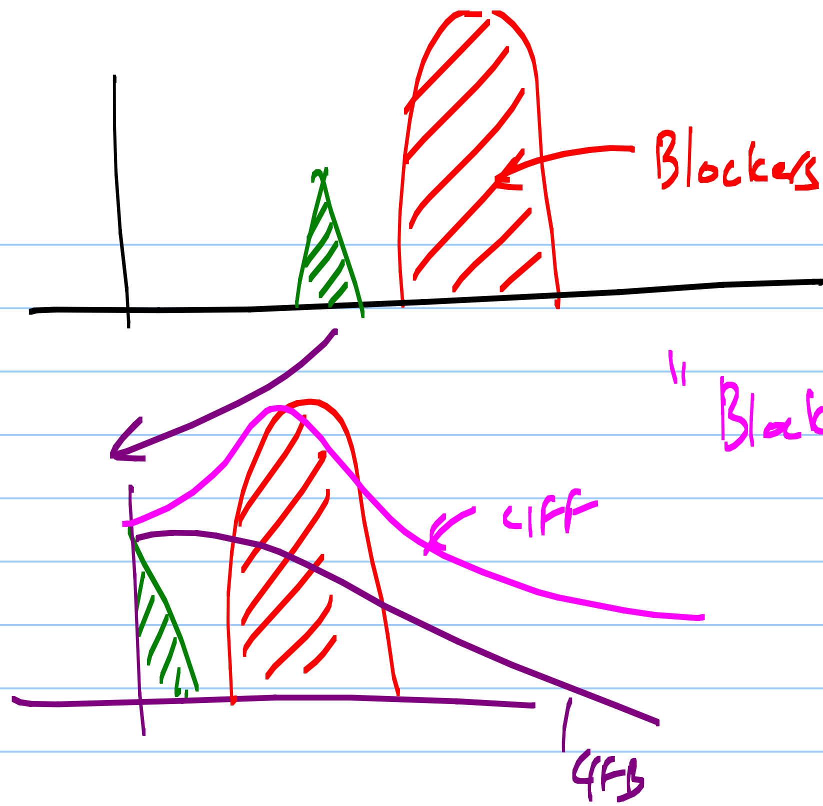
low distortion

when $b_1 = 1$ & $b_{N+1} = 0$ (only input is coupled)

$$STF(z) = 1 - NTF(z)$$

$b_1 = 1$

rest $b_i = 0$



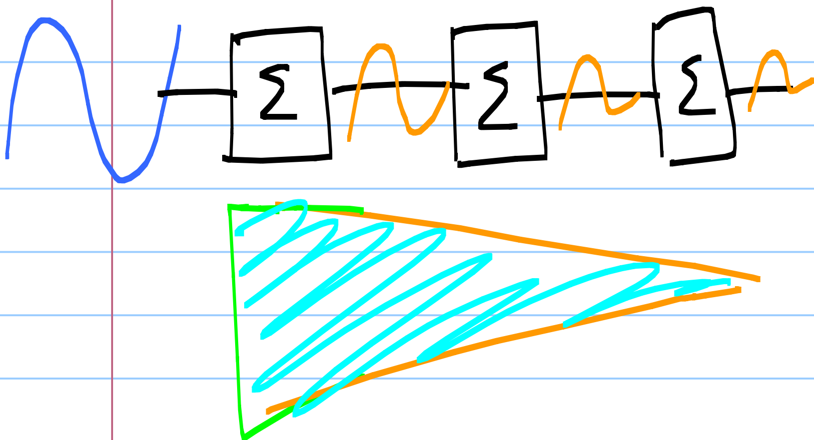
"Blocker Rejection"

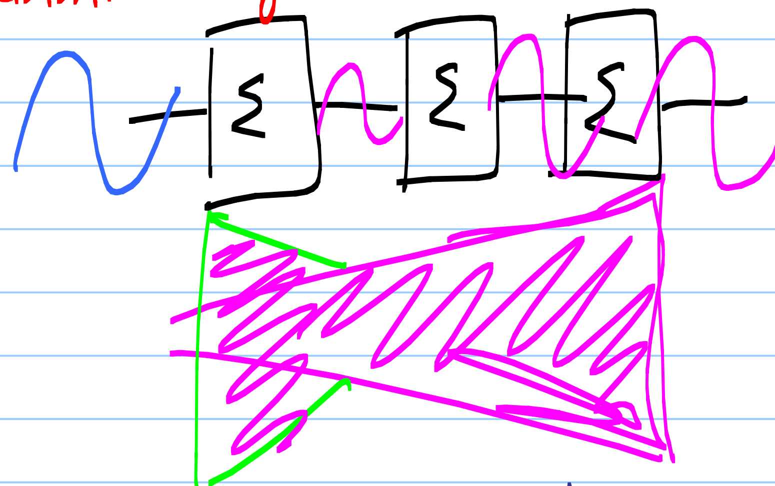
CIFB provides best blocker rejection

FF

FB

The first integrator needs to be low-noise, distortion & golden





In general ⇒ FF modulator are more power efficient compared to the FB type.

FF	FB
(+) only on feedback DAC	(−) #N DACs
(−) Summer block	
Timing can be tricky with S/C	
Small capacitor Area	Large cap Area ↳ more power