ECE 517 - Lecture 28

Note Title 4/27/2017

ΔΣM NTF Design → Trade offs → inband noise (IBN) vs OBG (stability)

* Maximum stable amplitude (MSA)
↳ max input amplitude for which the ΔΣM is stable

from heuristics!

$N_0 = 1$-bit OBG = 1.5
$N_0 \sim 3$-4 bits OBG < 3.5 or 3

MSA vs OBG
↳ Quantizer resolution (N_0)
$N_0 \uparrow \Rightarrow$ OBG $\uparrow$

Specifications : SQNR of 100dB
BW = 1 MHz , $f_s < 200\,MHz$

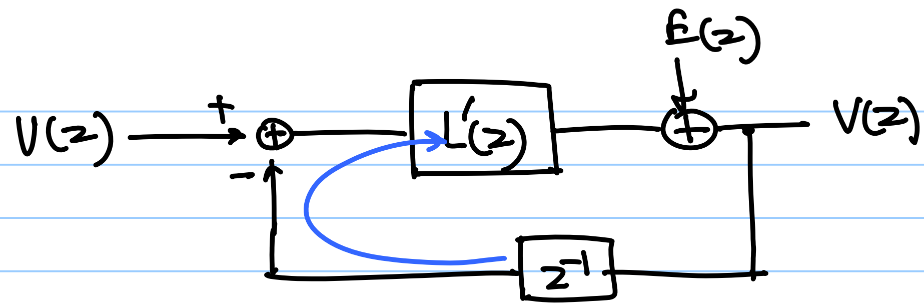
Design parameters!

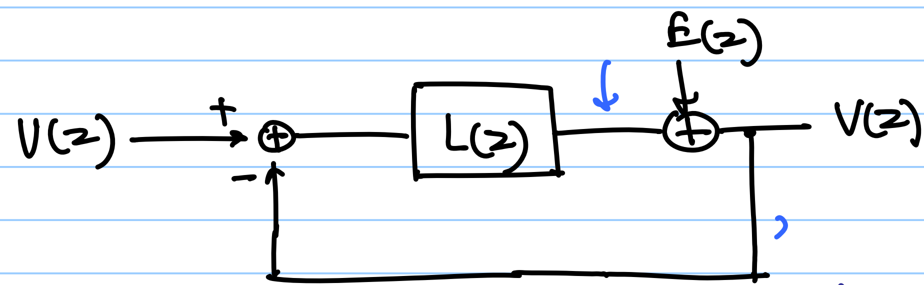
↳ OSR ⟶ $f_s = 2 \cdot BW \cdot OSR$

Order (n) : 2–5 , Quantizer resolution (N_o)

↳ OBW < 3.5

↳ MSA = ? (MSA > 0.8 FS)

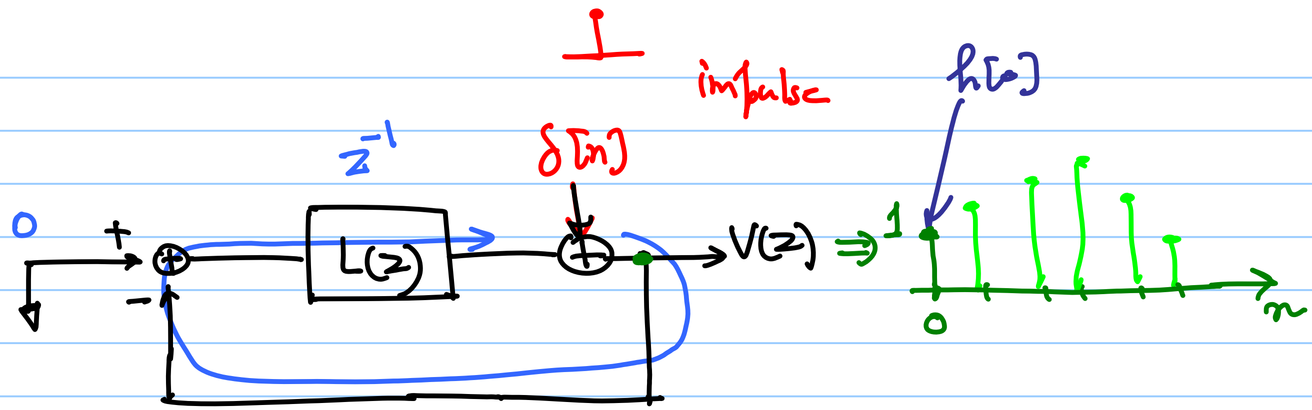




$$L(z) = \frac{z^{-1}}{1-z^{-1}} \leftarrow \text{Delaying integrator}$$

$$L(z) = \frac{1}{1-z^{-1}}$$

* No delay free loops!



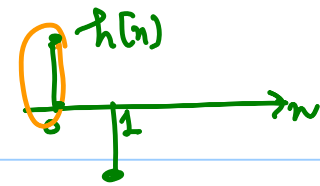
The first sample of the impulse response of the loop

$h[0] = 1$ "NTF realizability condition"

$$h(n) \xrightarrow{Z} NTF(z)$$

$NTF(z) = 1 - z^{-1}$

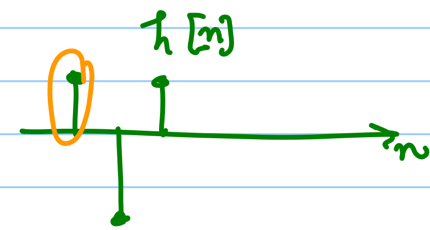
$h[n] = \{1, -1\}$



$$NTF(z) = \sum_{n=0}^{\infty} h[n] z^{-n} = 1 - z^{-1}$$

$$NTF(z) = (1 - z^{-1})^2$$
$$= 1 - 2z^{-1} + z^{-2}$$

$h[n] = \{1, -2, 1\}$

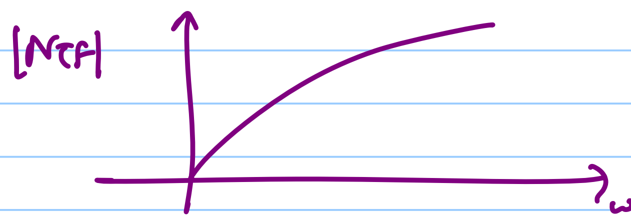


$$h[0] = \lim_{z \to \infty} NTF(z) = \lim_{z^{-1} \to 0} NTF(z) = 1$$

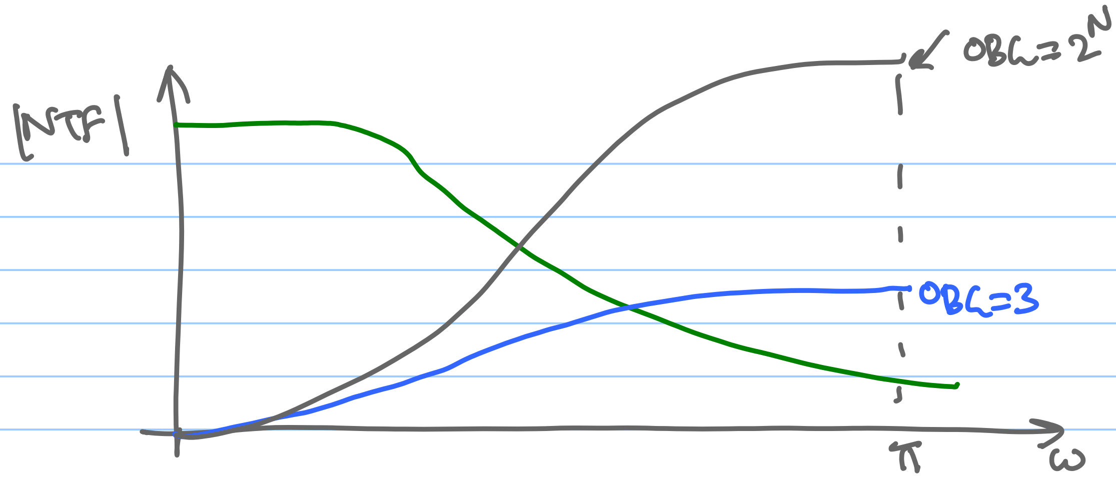
$$\sum_{n=-\infty}^{\infty} h[n] \rightarrow \text{gain at DC}$$

$$e^{-j\pi} \Rightarrow -1$$

$$\sum_{n=0}^{\infty} |h[n]| \simeq \text{gain at } \omega = \pi$$



High pass filter



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

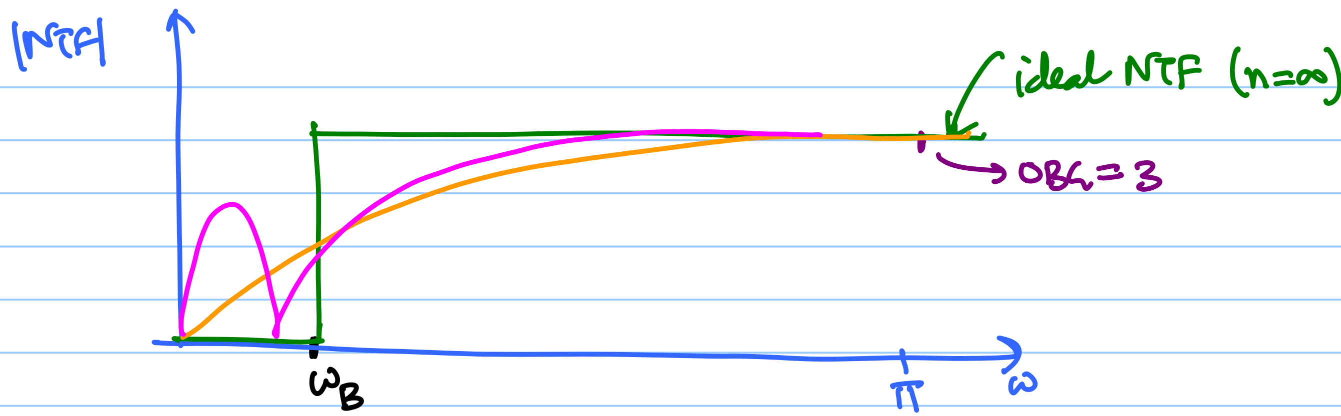
$$NTF(z) = \frac{(1-z^{-1})^4}{a_0 + a_1 z^{-1} + \cdots + a_4 z^{-4}} = \frac{N(z)}{D(z)}$$

$1 \leftarrow a_0$

$h[0] = NTF(\infty) = 1$

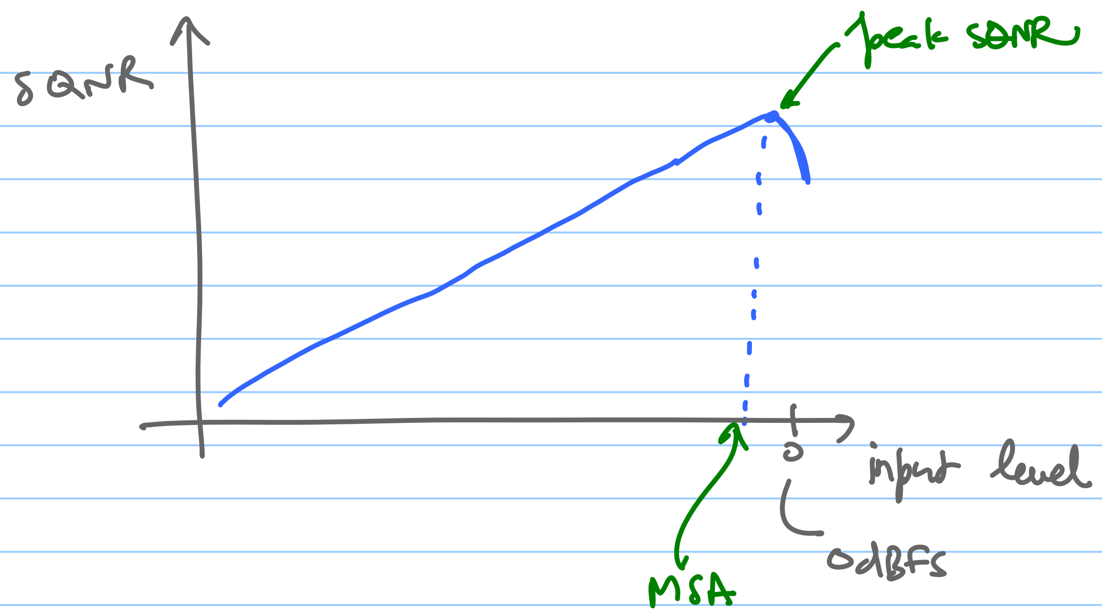
$a_0 = 1$

Approximation Problem

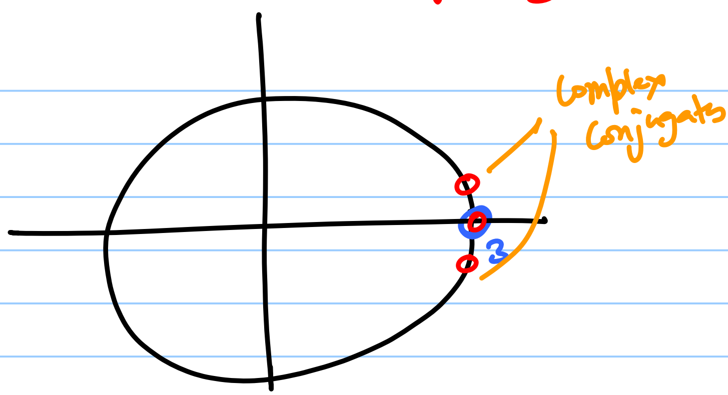


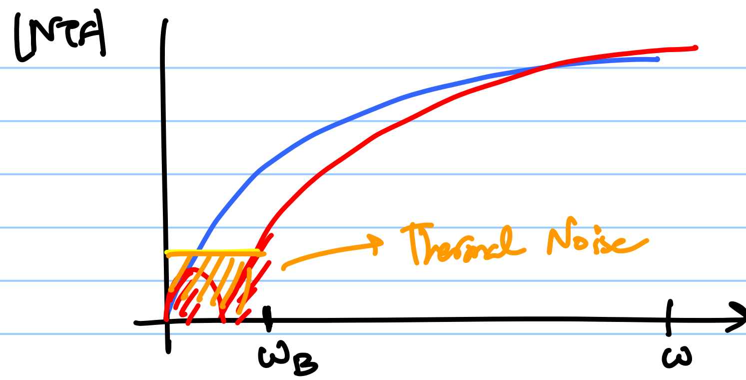
1. Butterworth
2. Inverse Chebyshev
3. Maximally flat all poles

2' Elliptical


peak SQNR
SQNR
input level
0
0dBFS
MSA

NTF-Zero Optimization

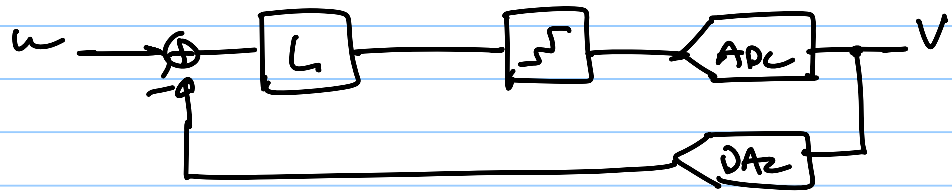




$$NTF(z) = \underline{\underline{(1-z^{-1})}}^3$$

Spread the zero around in the BW.

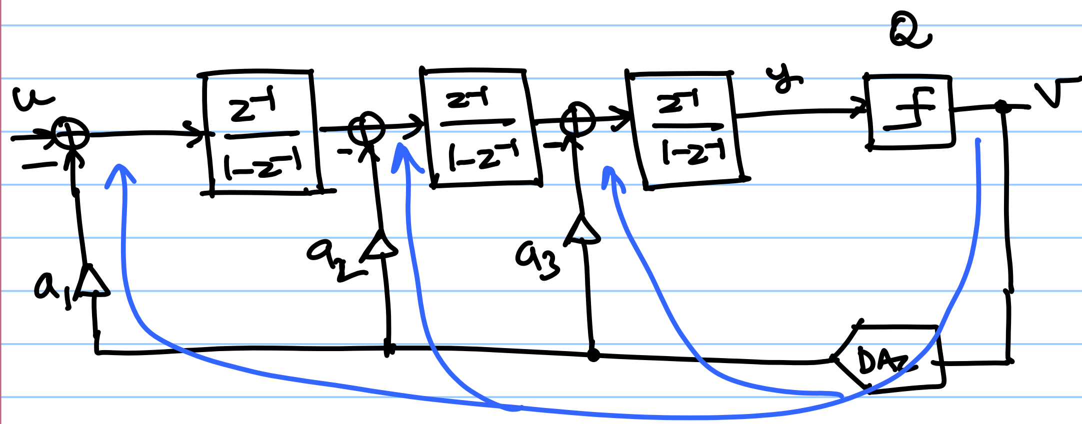
How to find MSA ?



ΔΣ Loop filter Architectures

* feedback type
* feedforward type

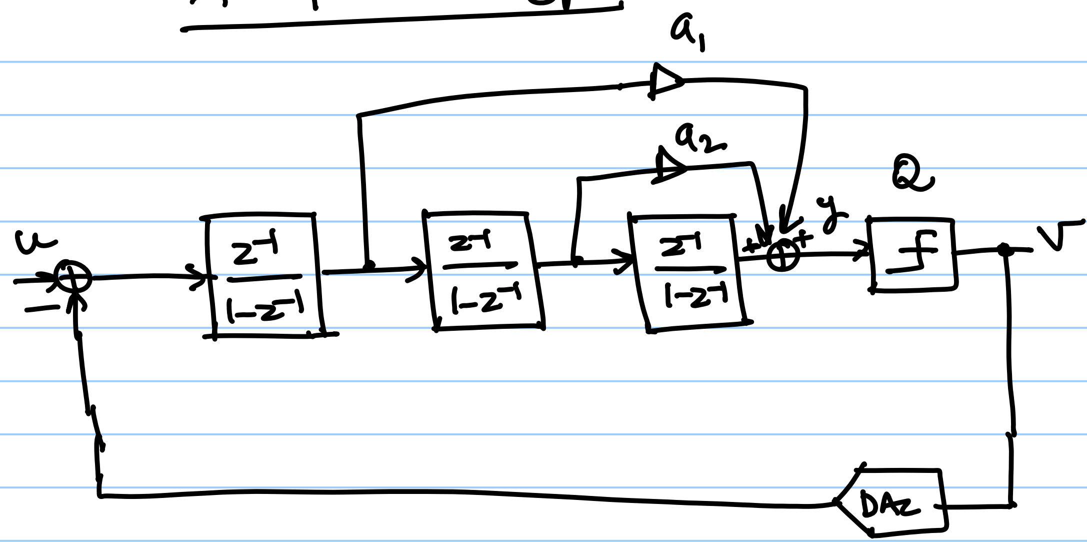
feedback.



CIFB in ΔΣ Toolbox

Cascade of Integrator with distributed feedback

feedforward Type

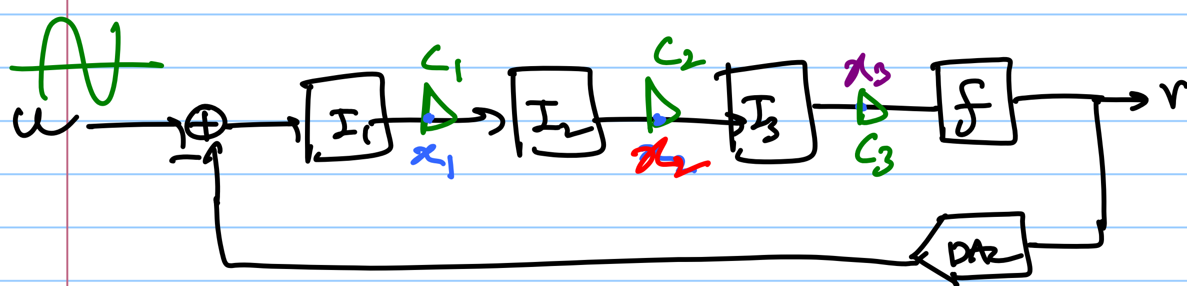


$\Delta\Sigma$ Toolbox → CIFF

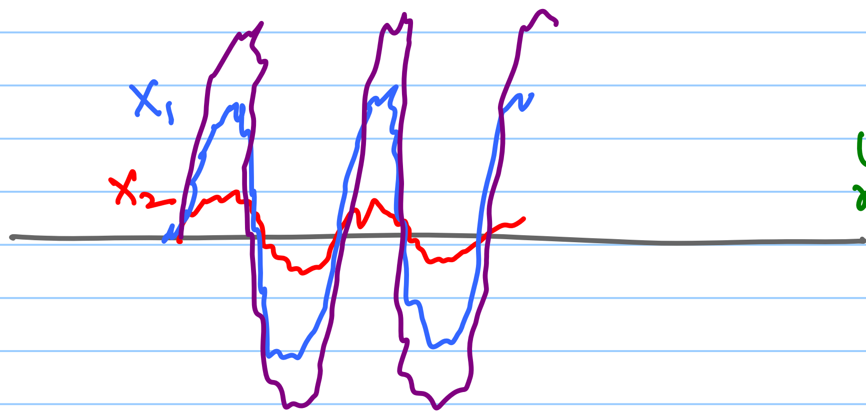
* Hybrid of FB & FF

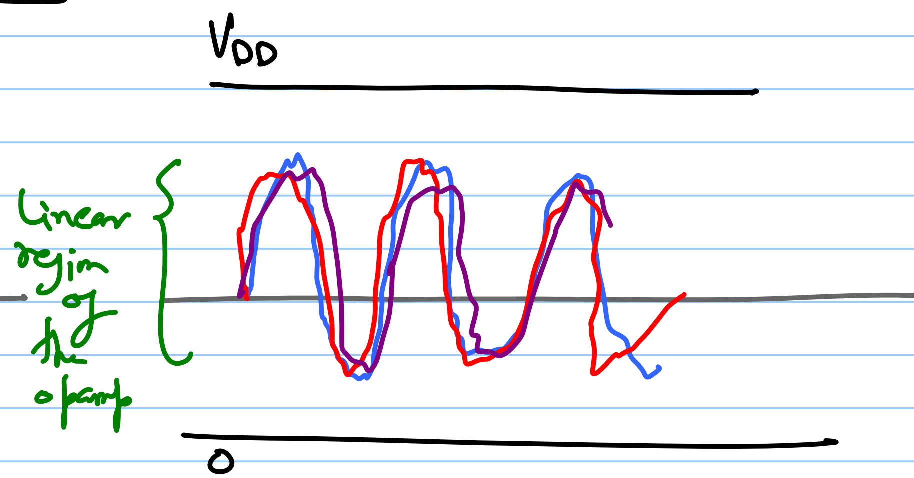
FF vs FB

Dynamic Range Scaling



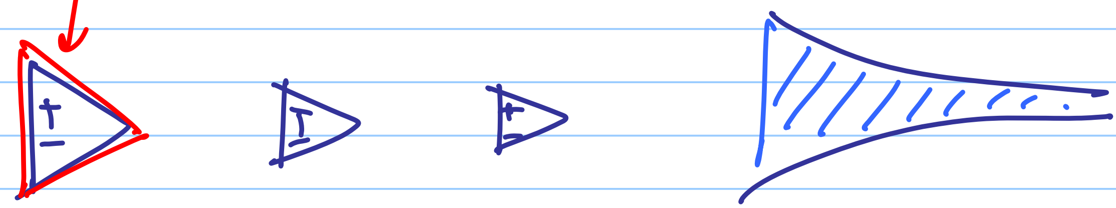
* All integrator output (states) should have similar swings



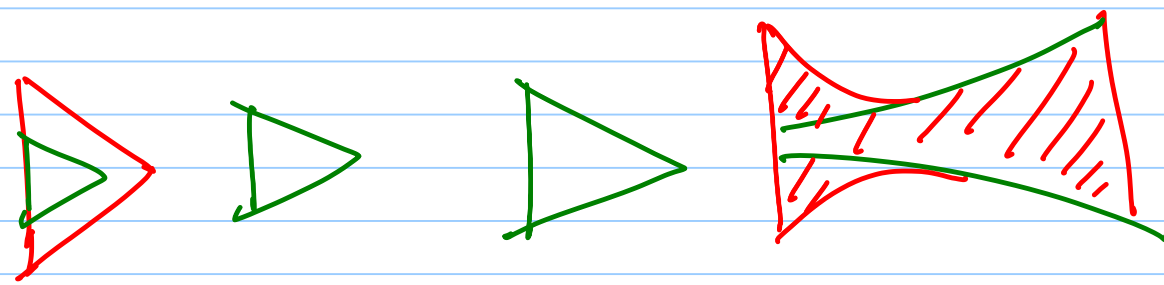


golden opamp for low noise & Distortion

FF



FB



↳ feedforward is better from Power consumption fR → gain peaking ↓