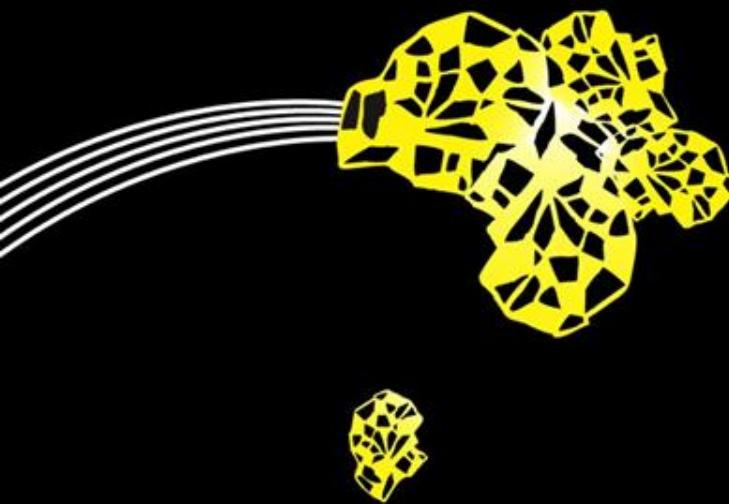


Modern wireless receiver techniques

Bram Nauta

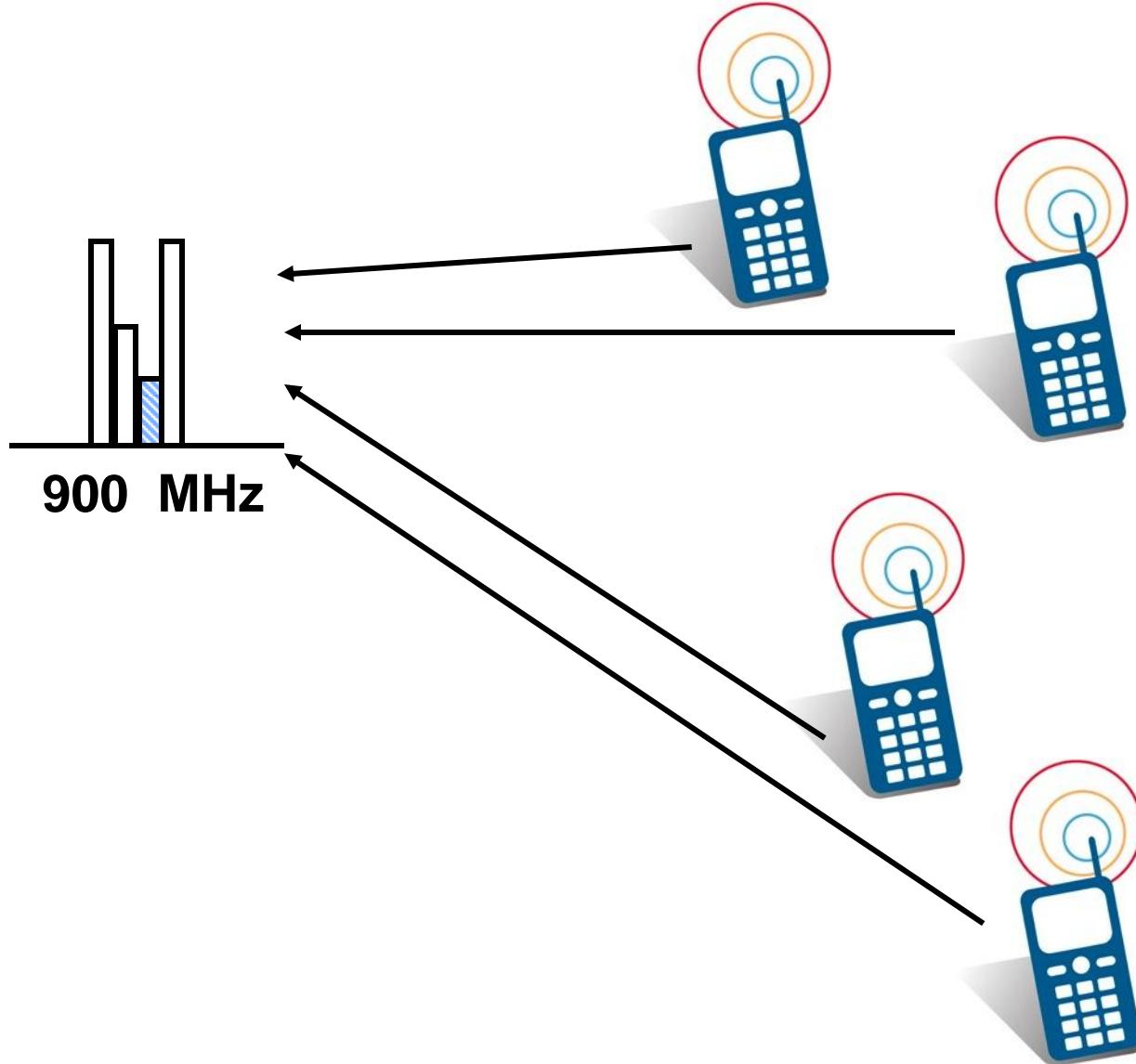




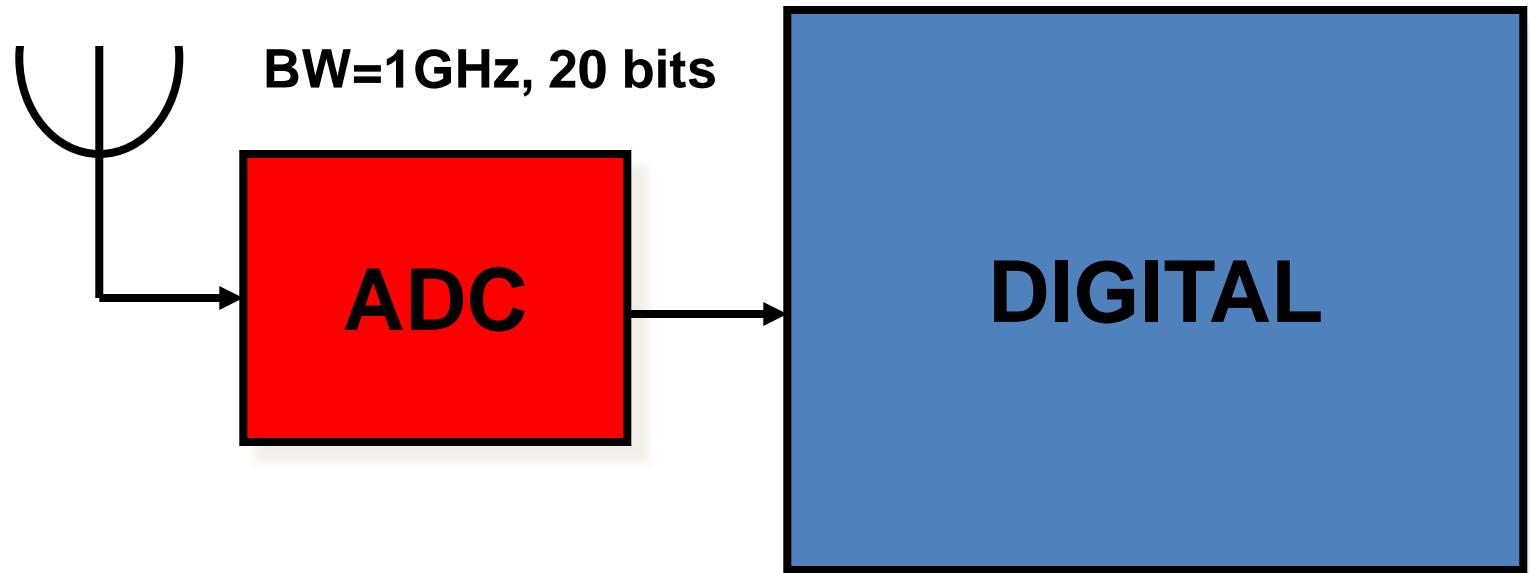




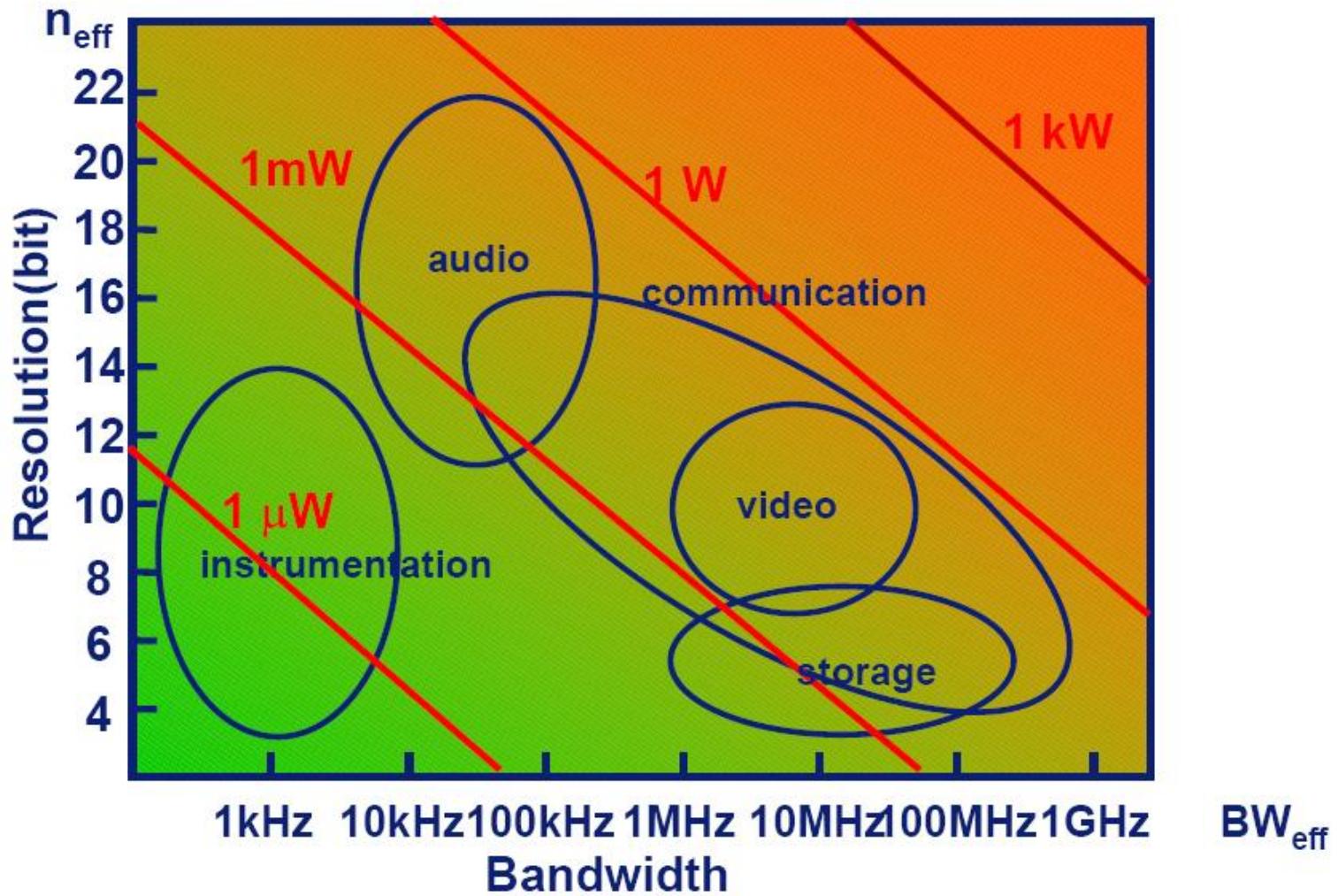
Wireless Receivers



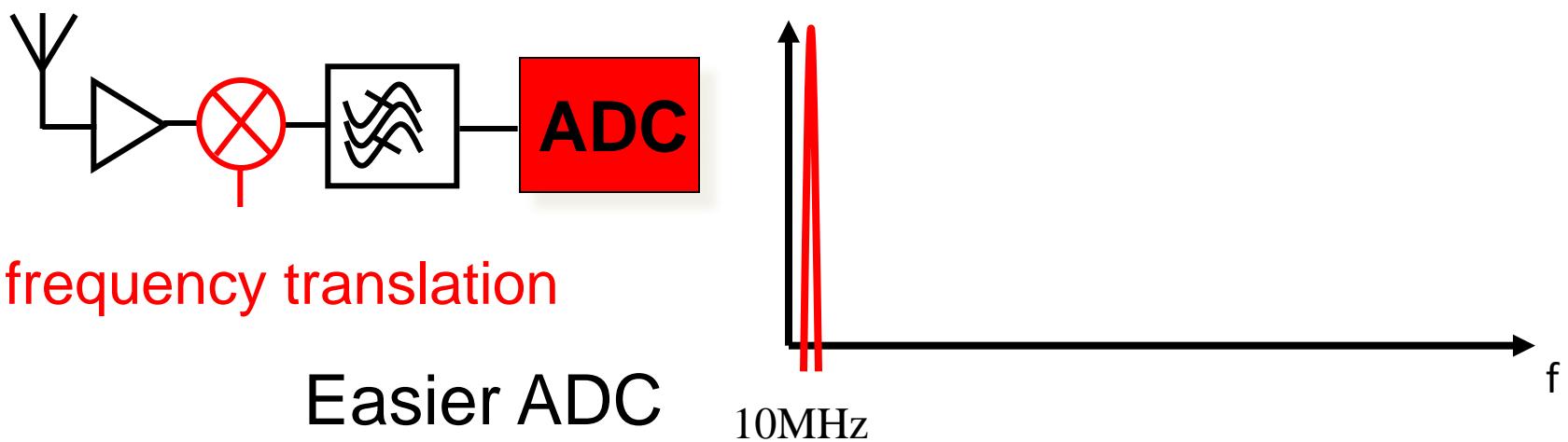
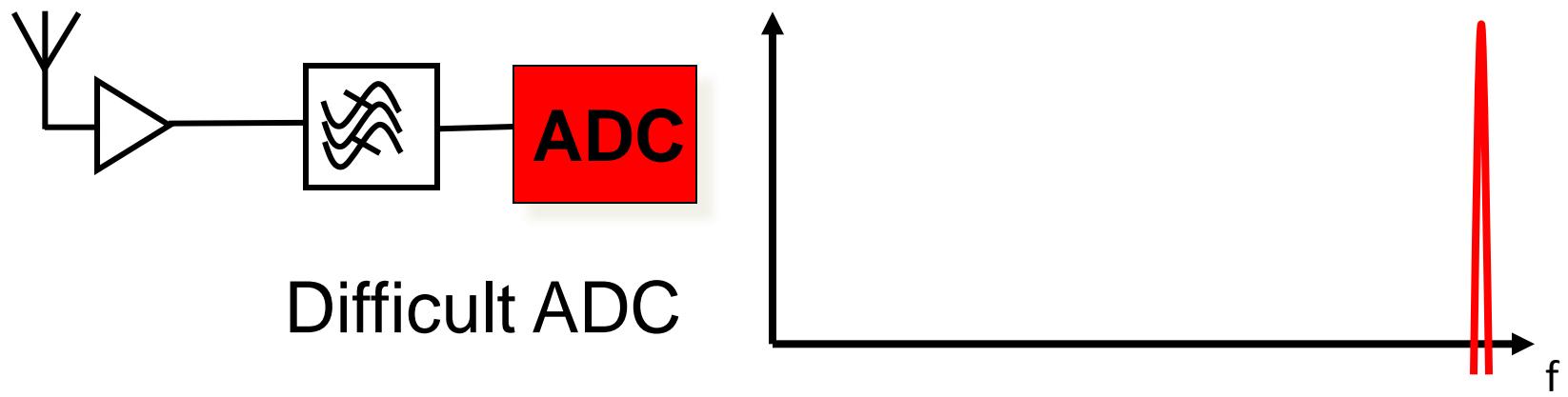
Analog to Digital Converter?



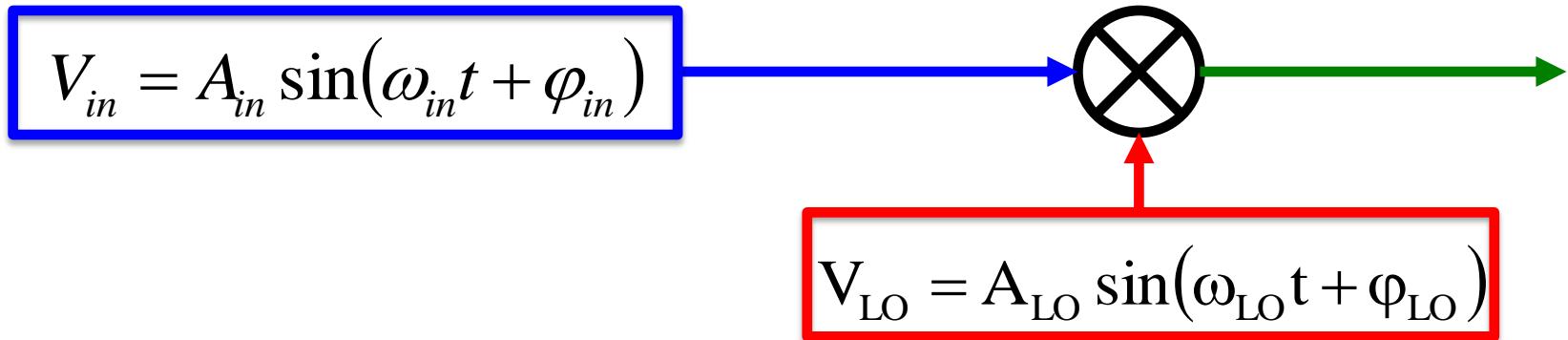
Analog to Digital Converter trade offs



Use Frequency Translation:



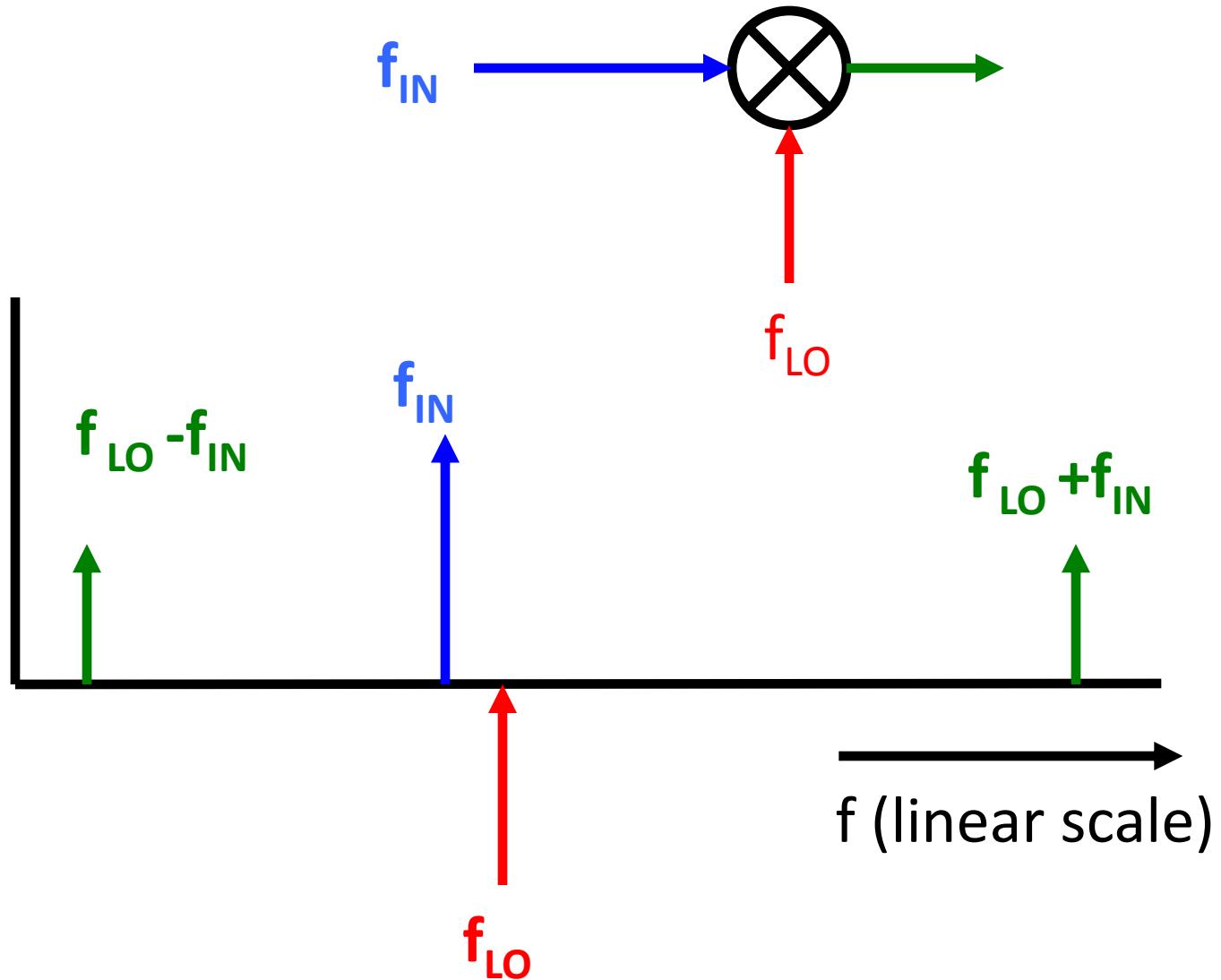
multiply with Local Oscillator signal



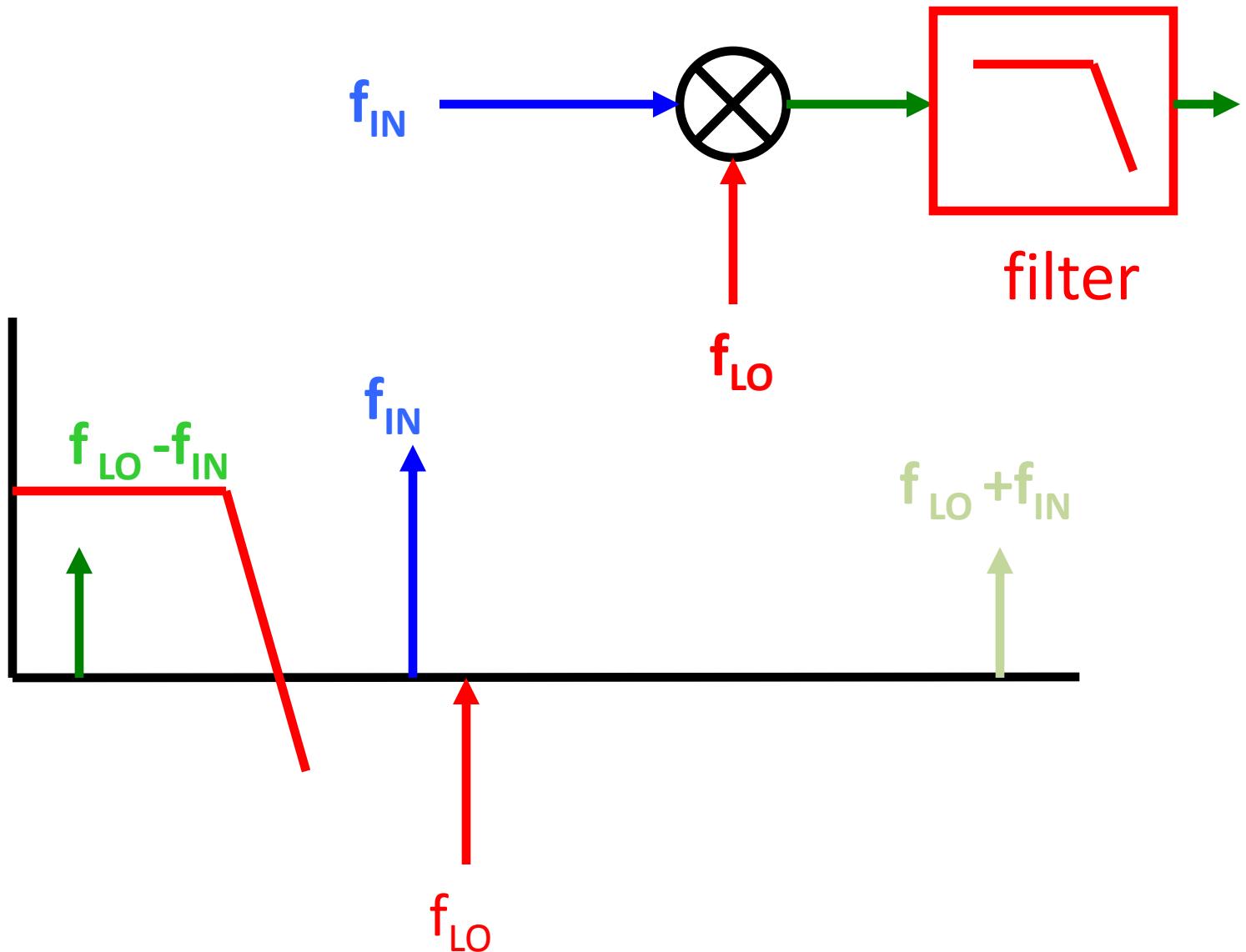
$$V_{out} = [V_{in} \cdot V_{LO}] = \frac{1}{2} A_{in} A_{LO} \sin[(\omega_{LO} - \omega_{in})t + (\varphi_{LO} - \varphi_{in})] + \frac{1}{2} A_{in} A_{LO} \sin[(\omega_{LO} + \omega_{in})t + (\varphi_{LO} + \varphi_{in})]$$

TRANSPARANT for amplitude and phase information!!
Information is available at other Frequency

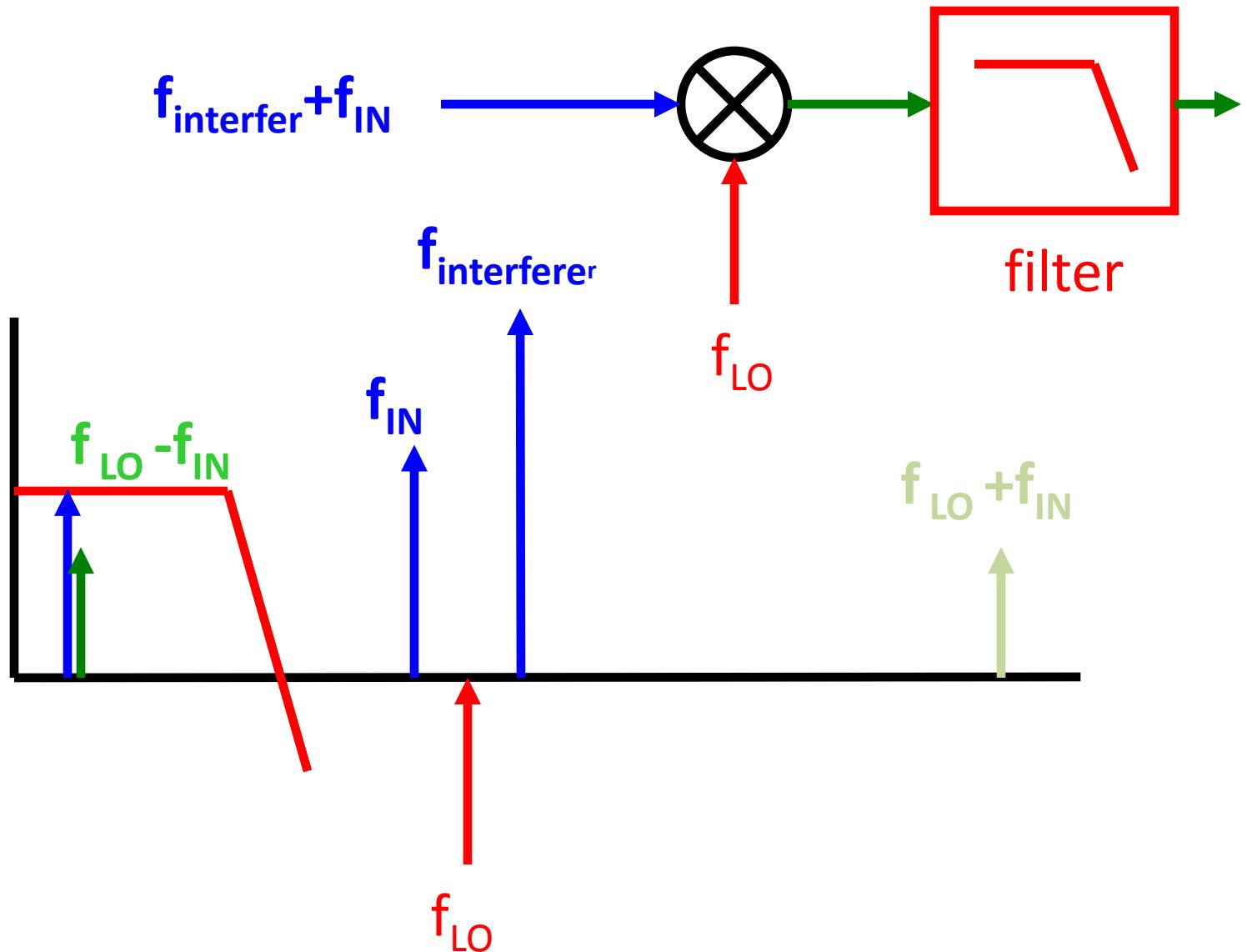
multiply with Local Oscillator signal



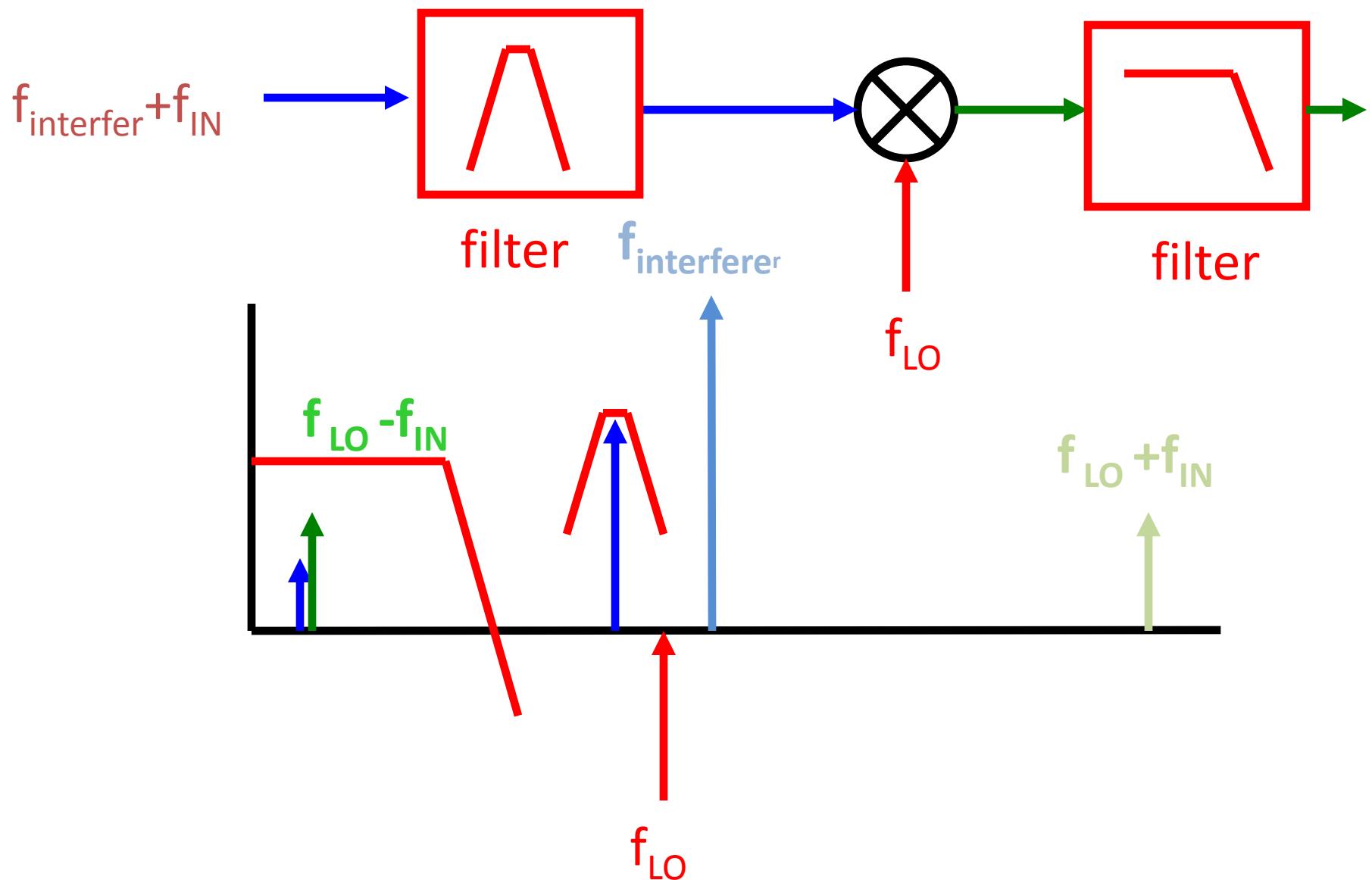
..and filter junk away



Problem: interferers

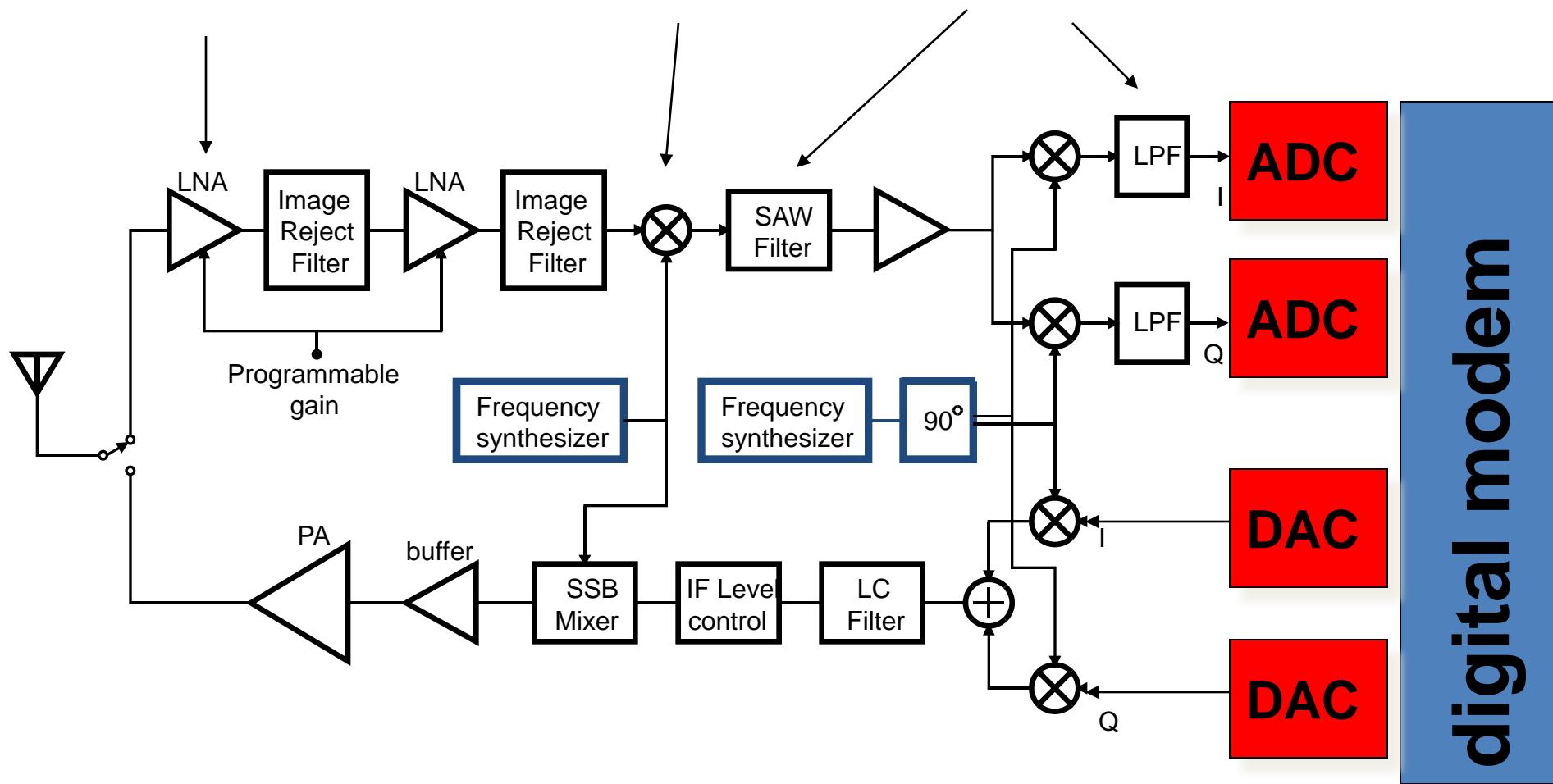


..so filter interferer too!



so that's why RF frontend can be complex

amplification, frequency translation, selectivity

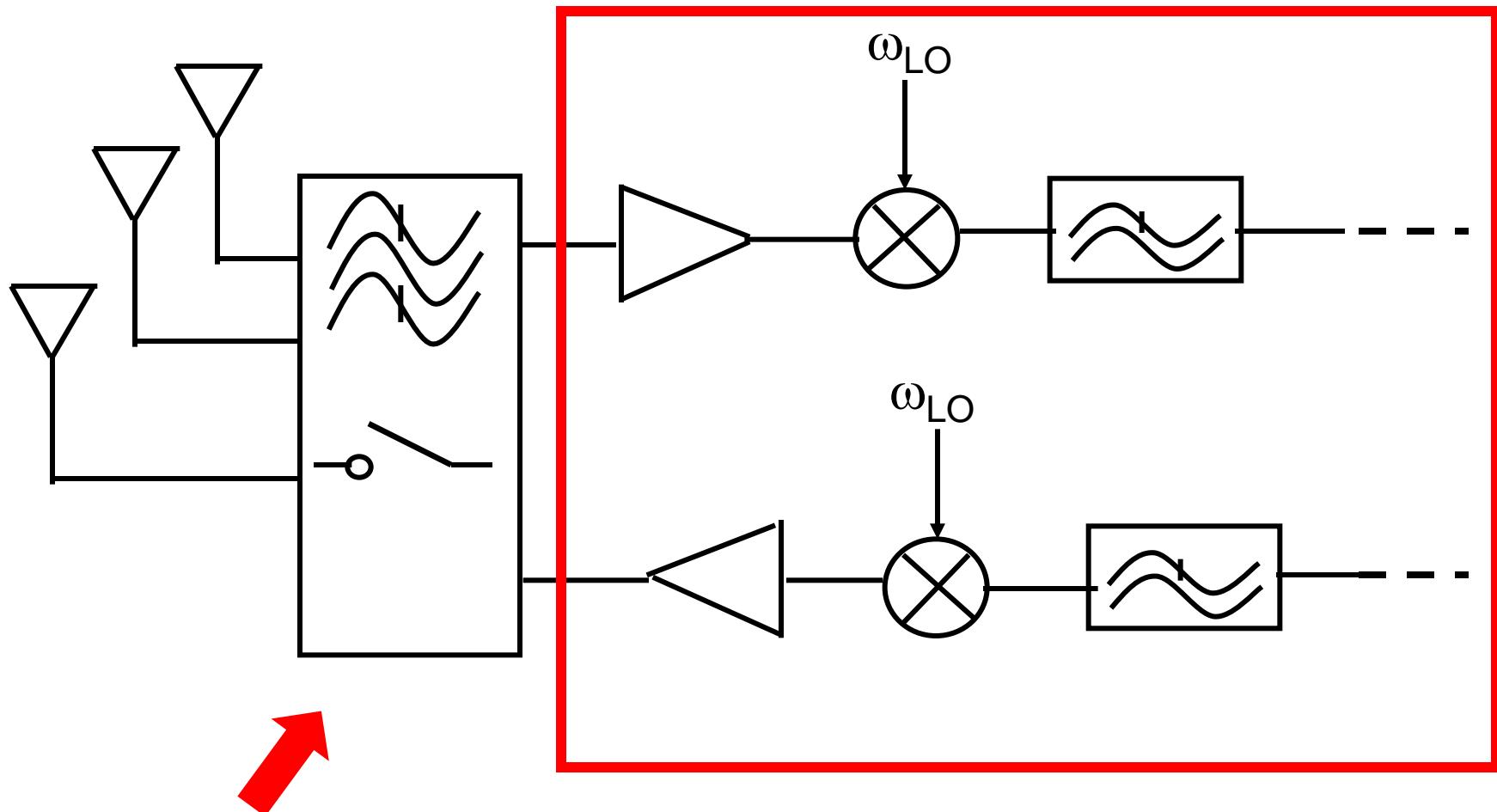


DECT became “1 chip” solution



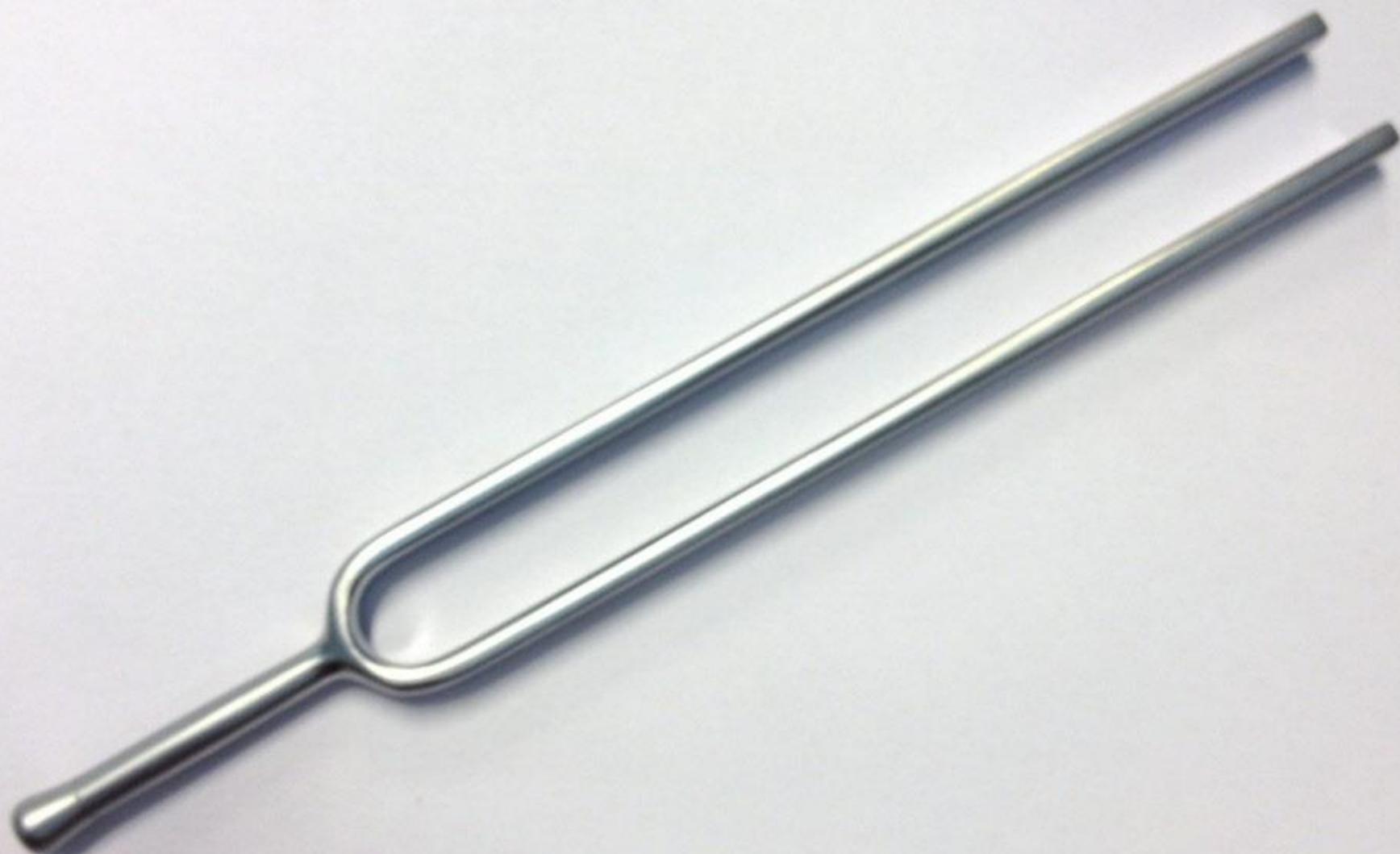
Dream: one wide band frontend IC:

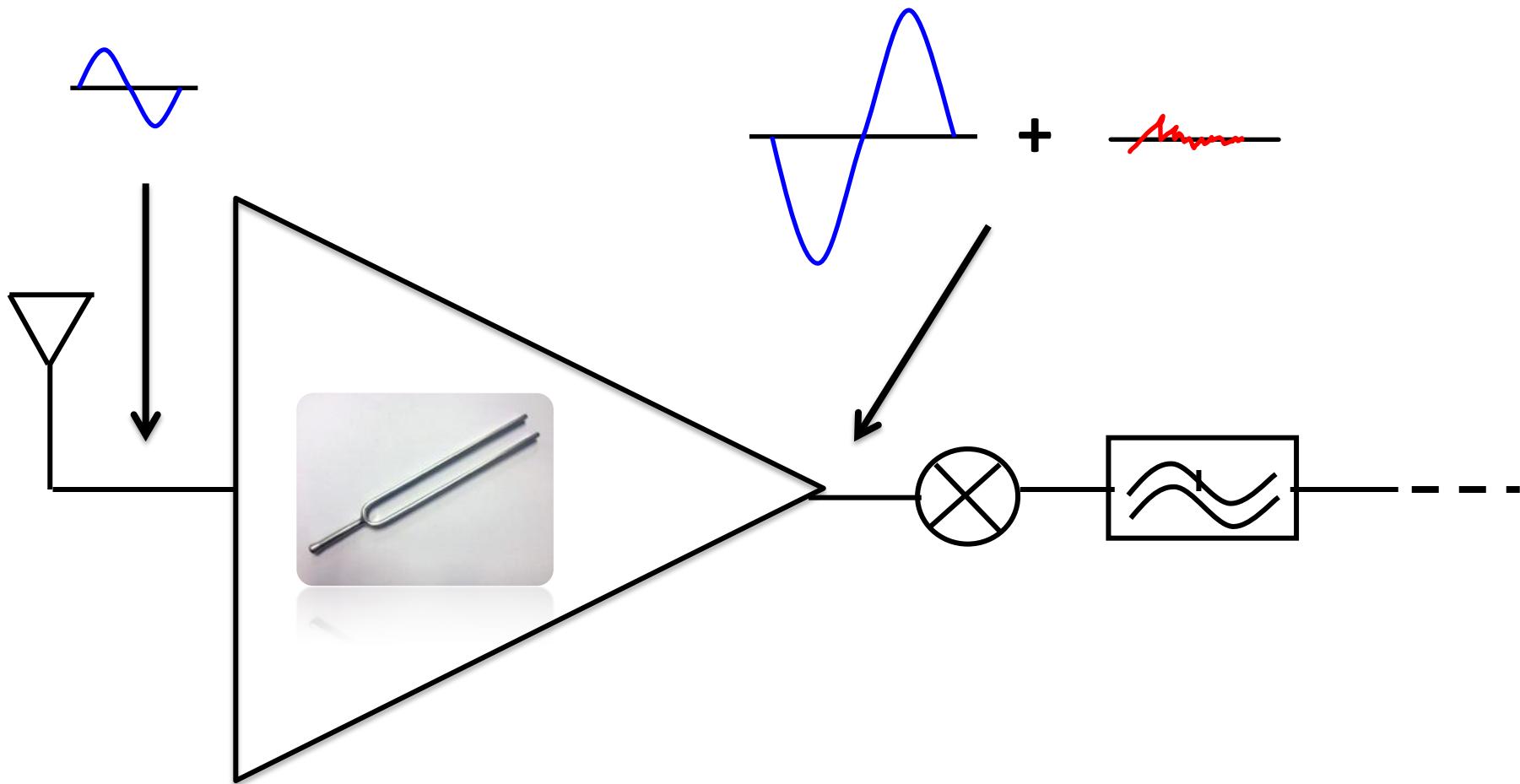
Software Defined

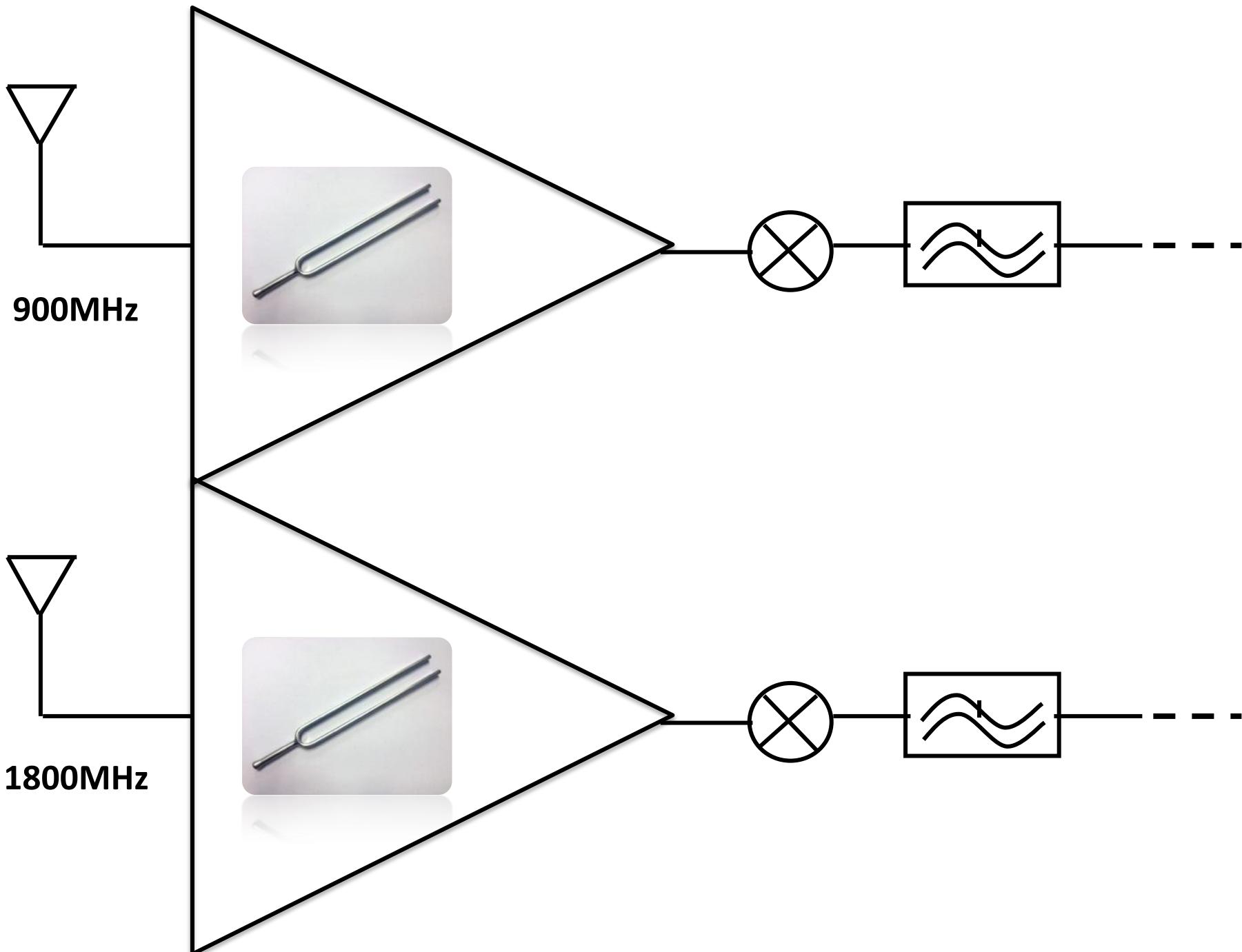


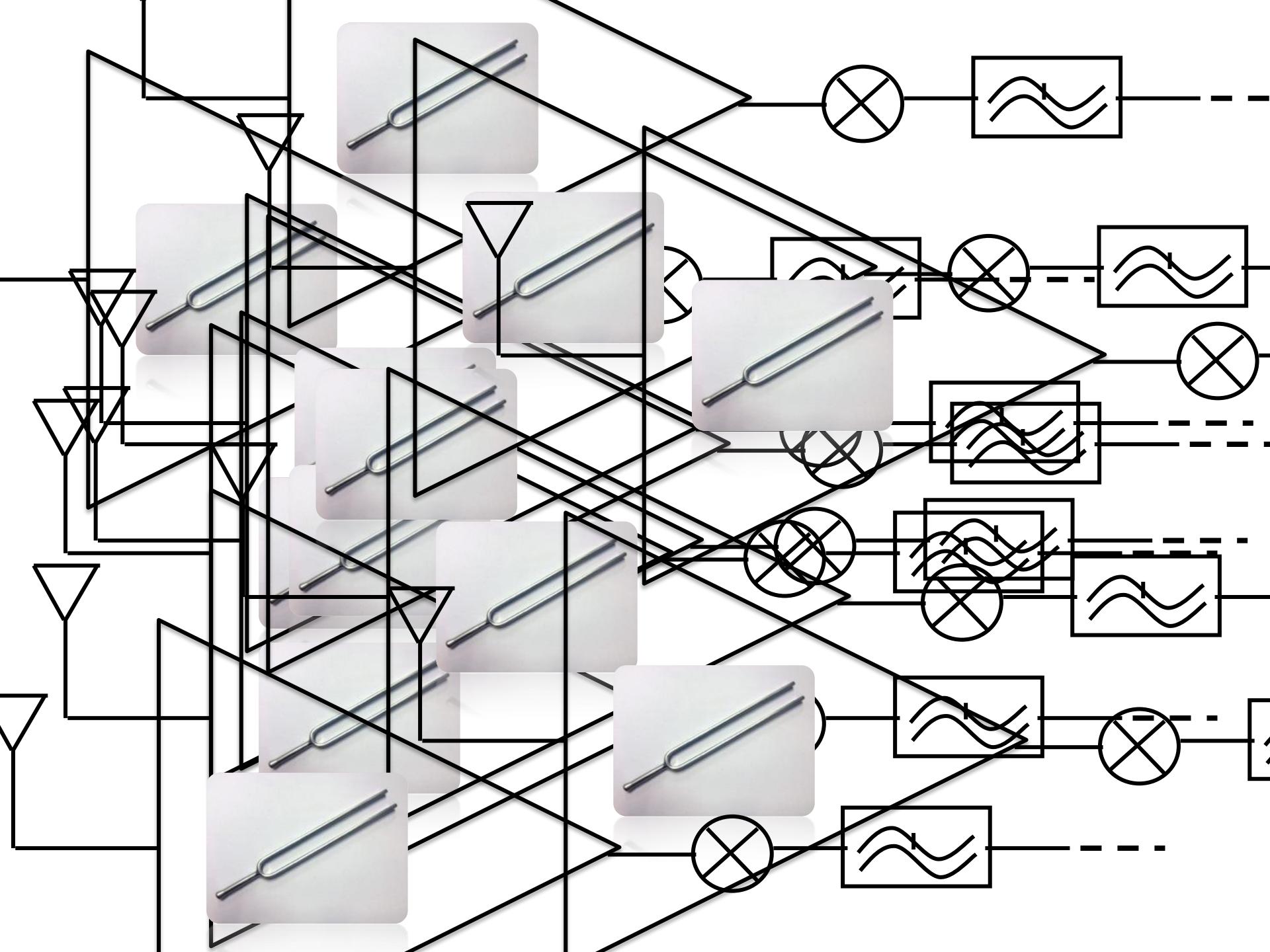
Keep minimal

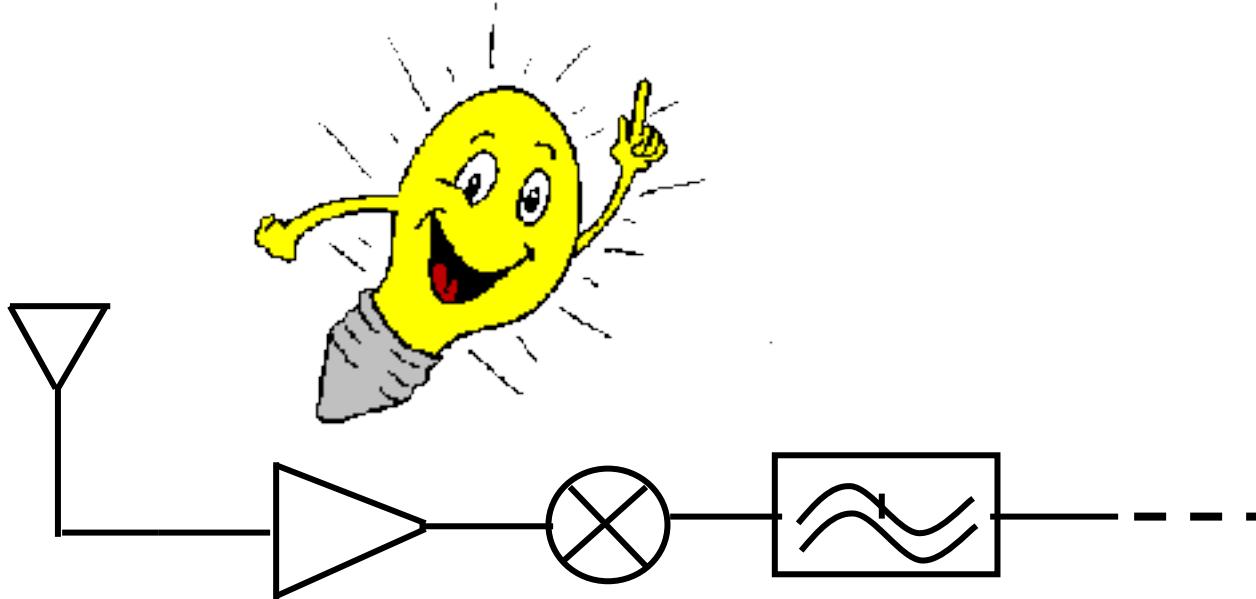
**Thermal
Noise
Cancelling**



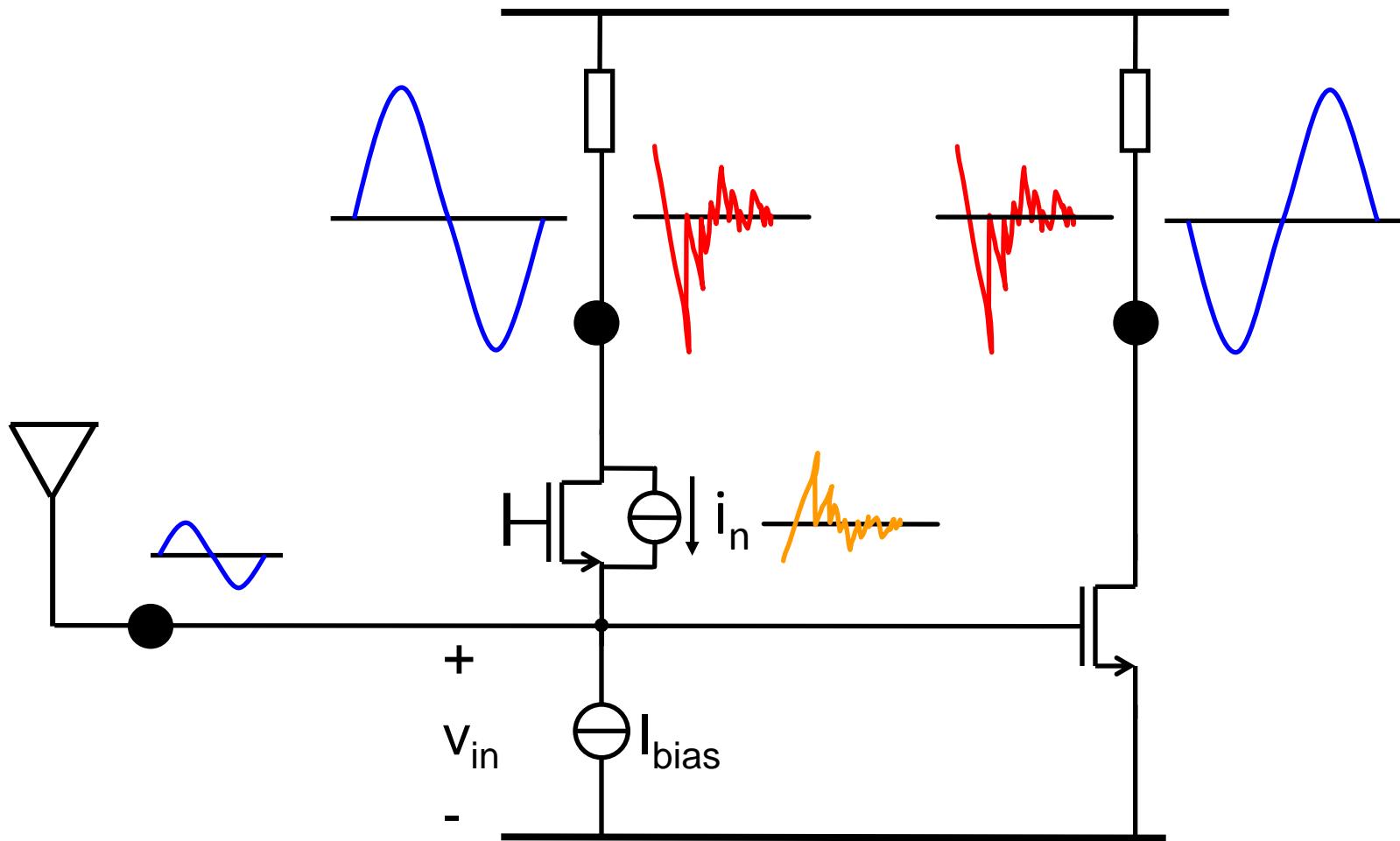








Noise Canceling



N-path Filters

Idea from 1947: Band Pass Filters

NARROW BAND-PASS FILTER USING MODULATION*

By N. F. Barber, M.Sc.

(Admiralty Research Laboratory, Teddington)

IT is not easy to build a band-pass filter whose pass-band is very narrow. Filters of this kind usually employ a mechanical resonating system, such as a crystal when the pass band is at a high frequency, or a reed for a low frequency. The mid-frequency of the pass-band is fixed by the mechanical properties of the crystal or reed, and once the filter is built this frequency f_0 cannot be changed. If a very exact specification is needed the construction of a suitable crystal is expensive.

The following method of filtering by modulation seems to offer many advantages. The mid-frequency of the pass-band is fixed by the frequency f_0 of a modulating signal supplied to the filter. It follows that if we provide one source of this frequency we can construct as many filters as we please whose

pass-bands will all have exactly the same mid-frequency f_0 . This frequency is not a characteristic of the individual filters, and we may adjust their pass-bands to centre upon some new frequency f_1 merely by supplying them with this frequency as a modulating signal. The width of the pass-band is a characteristic of each individual filter and is determined by a low-pass network of electrical components.

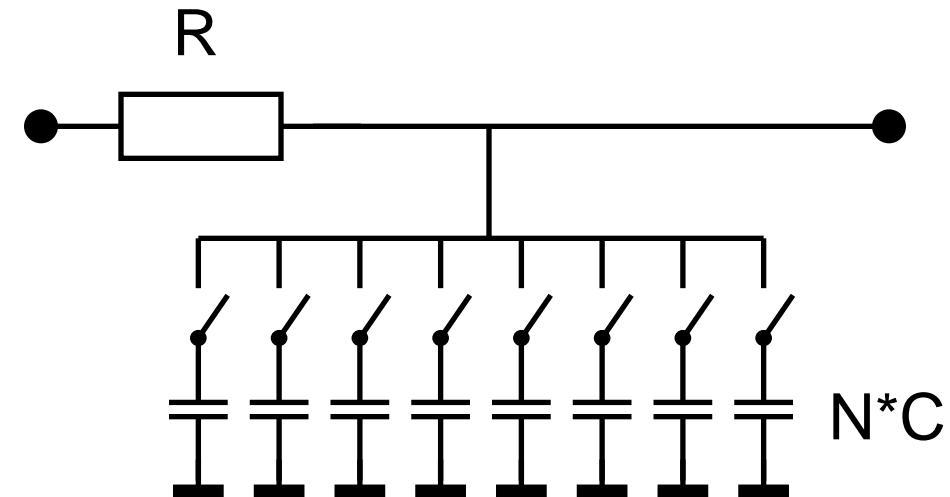
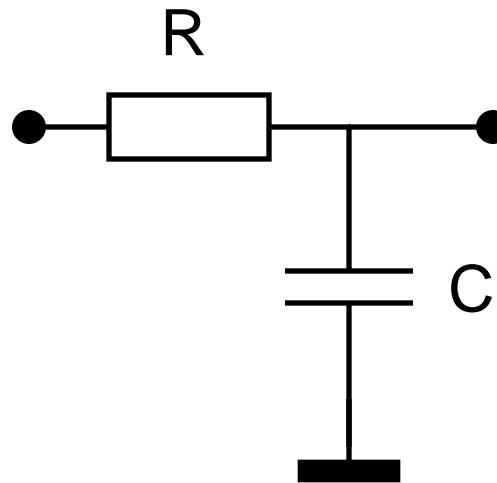
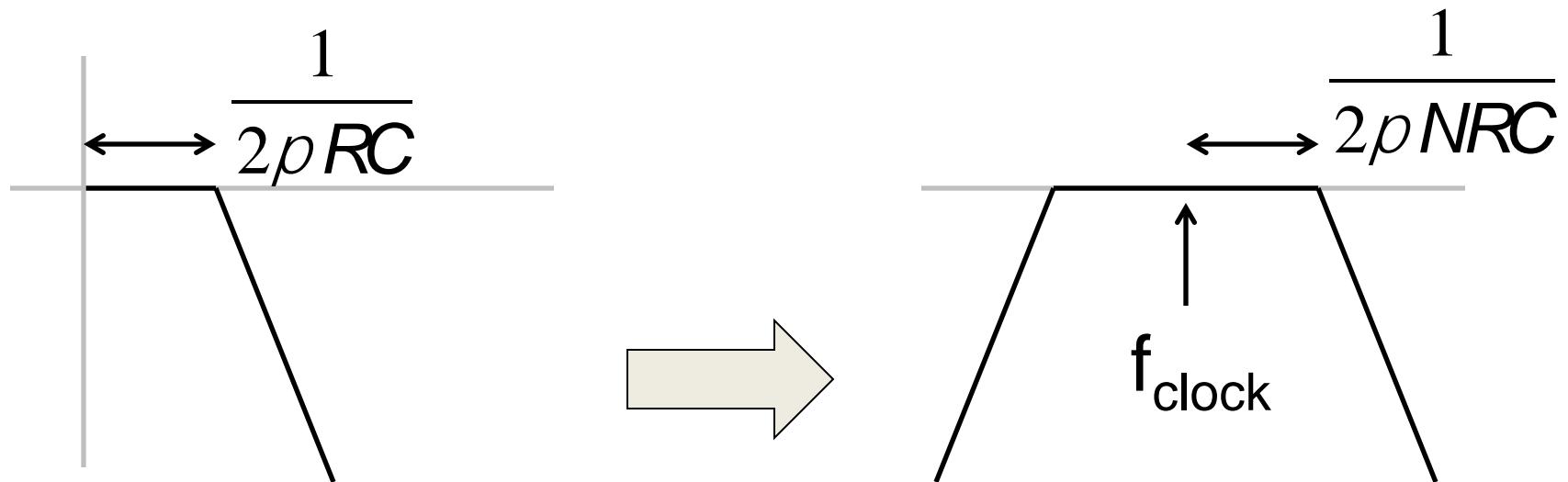
The simplest process of filtering by modulation is to multiply the input signal $A \sin(2\pi ft + \alpha)$ by a modulating signal $A_0 \sin 2\pi f_0 t$ to give amongst other tones a difference tone equal to $\frac{1}{2}A A_0 \cos [2\pi(f - f_0)t + \alpha]$. When f is nearly equal to f_0 this difference tone will have a lower frequency than any others present and we may extract it from the rest by means of a low-pass filter. This transmits only tones whose frequency $(f - f_0)$

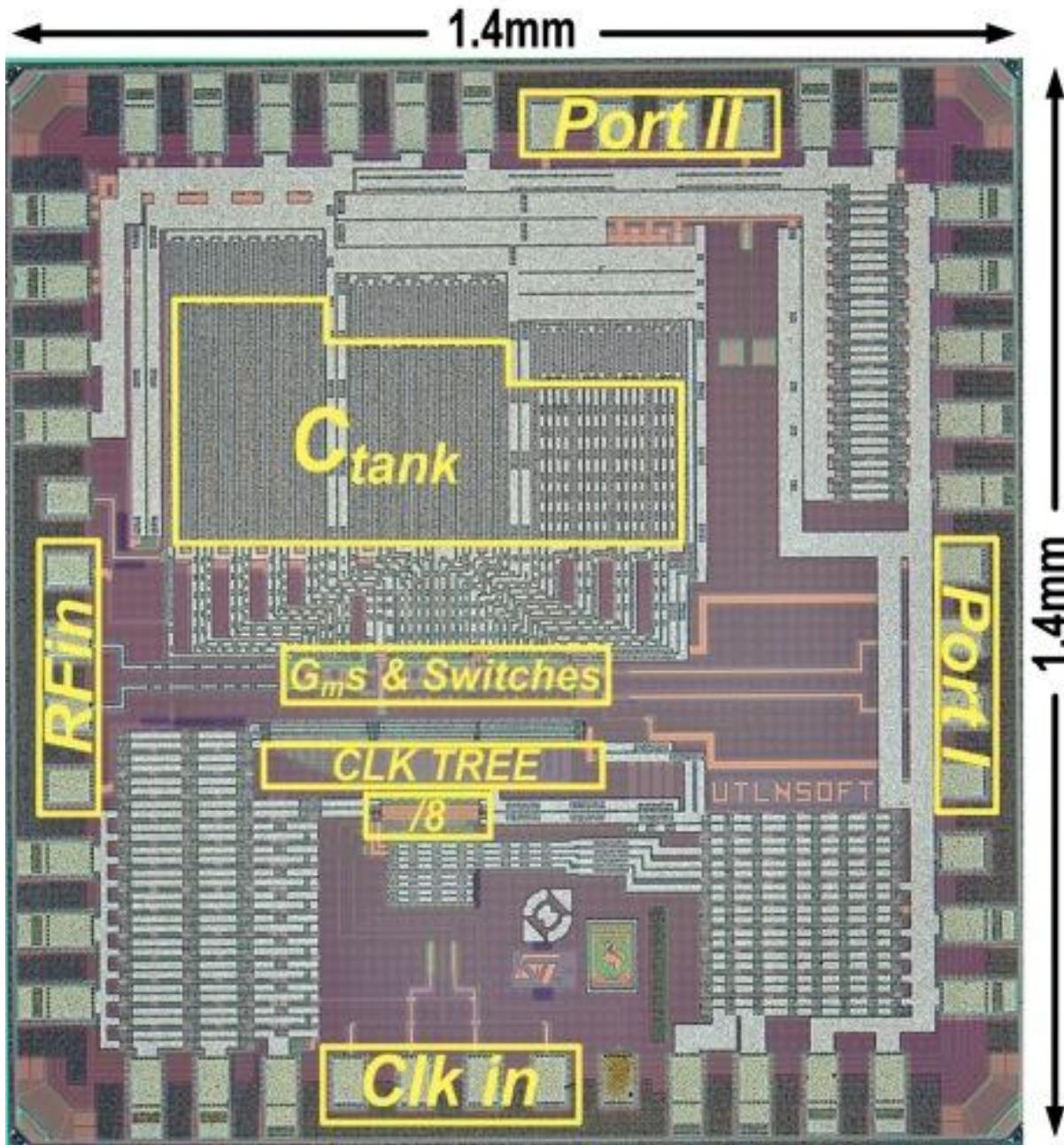
* MS accepted by the Editor, October 1946.

[Barber, Wireless Engineer, May 1947]

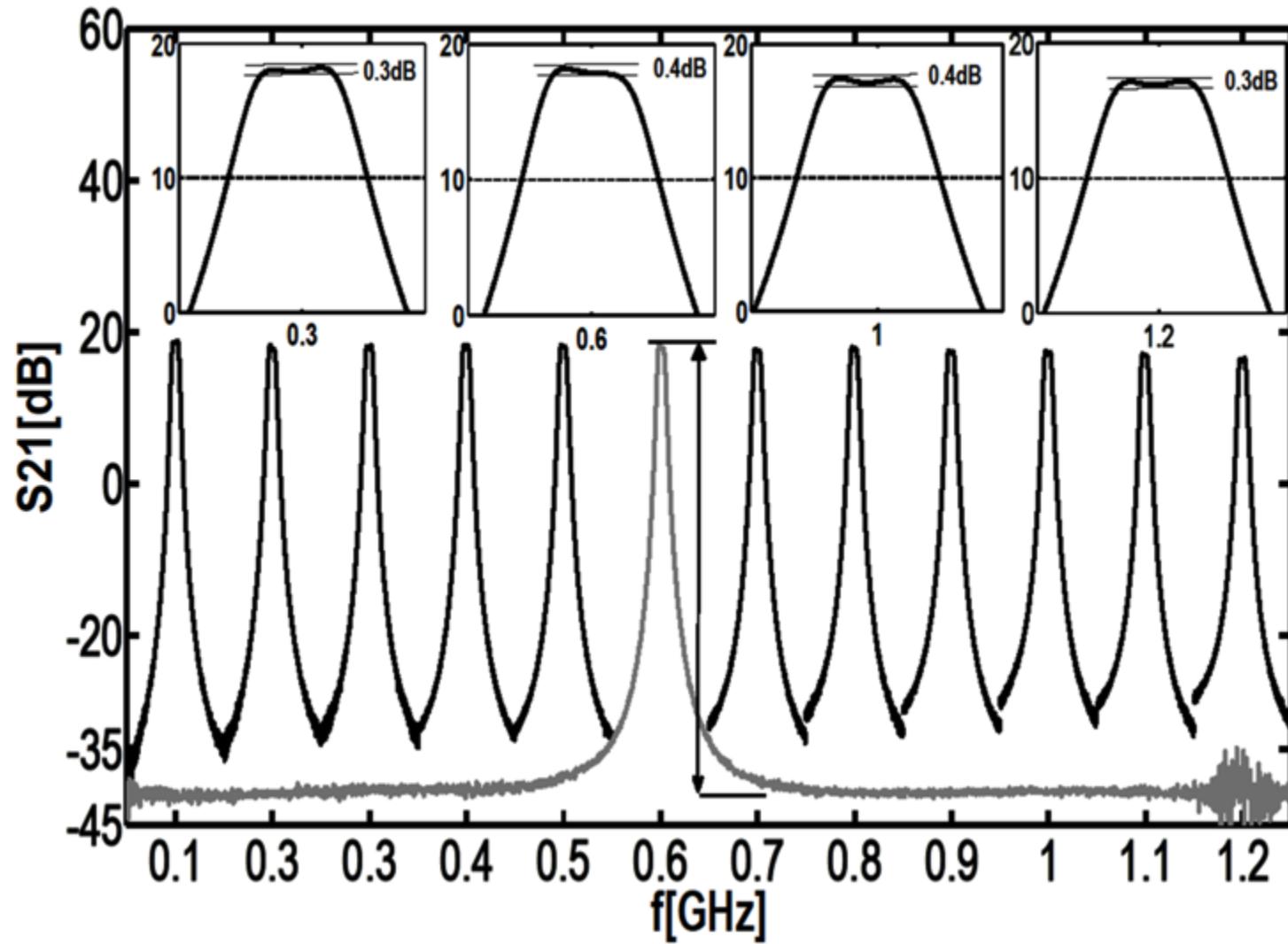
[Franks, ISSCC 1960]

Low pass – Bandpass transformation



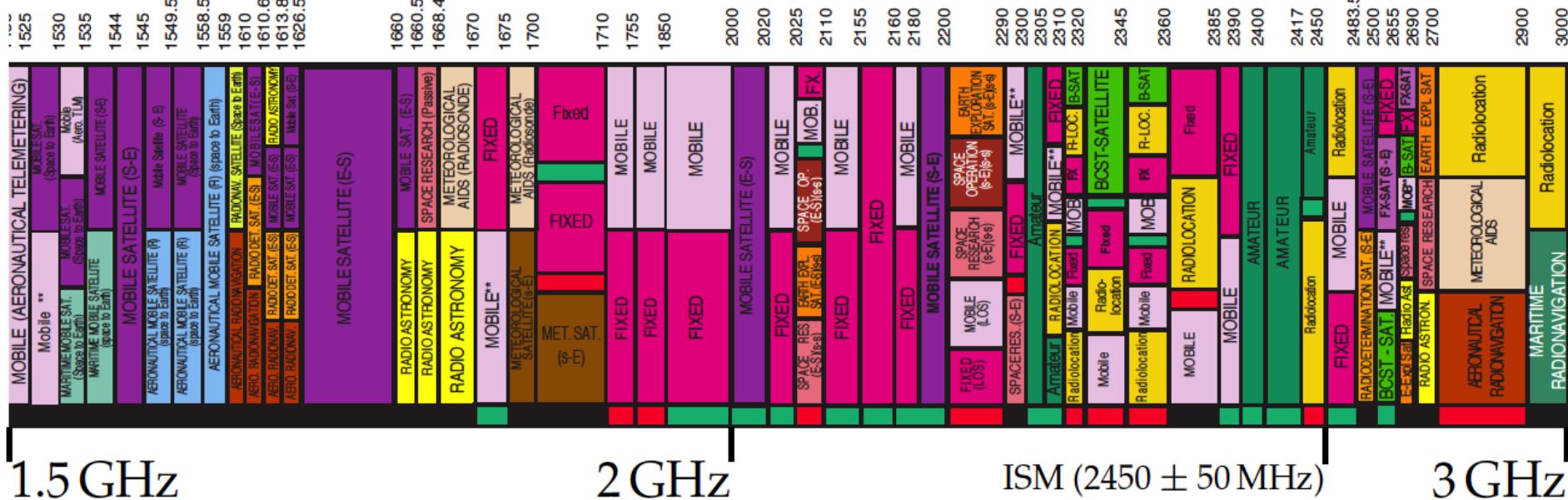


Filter Transfer Function

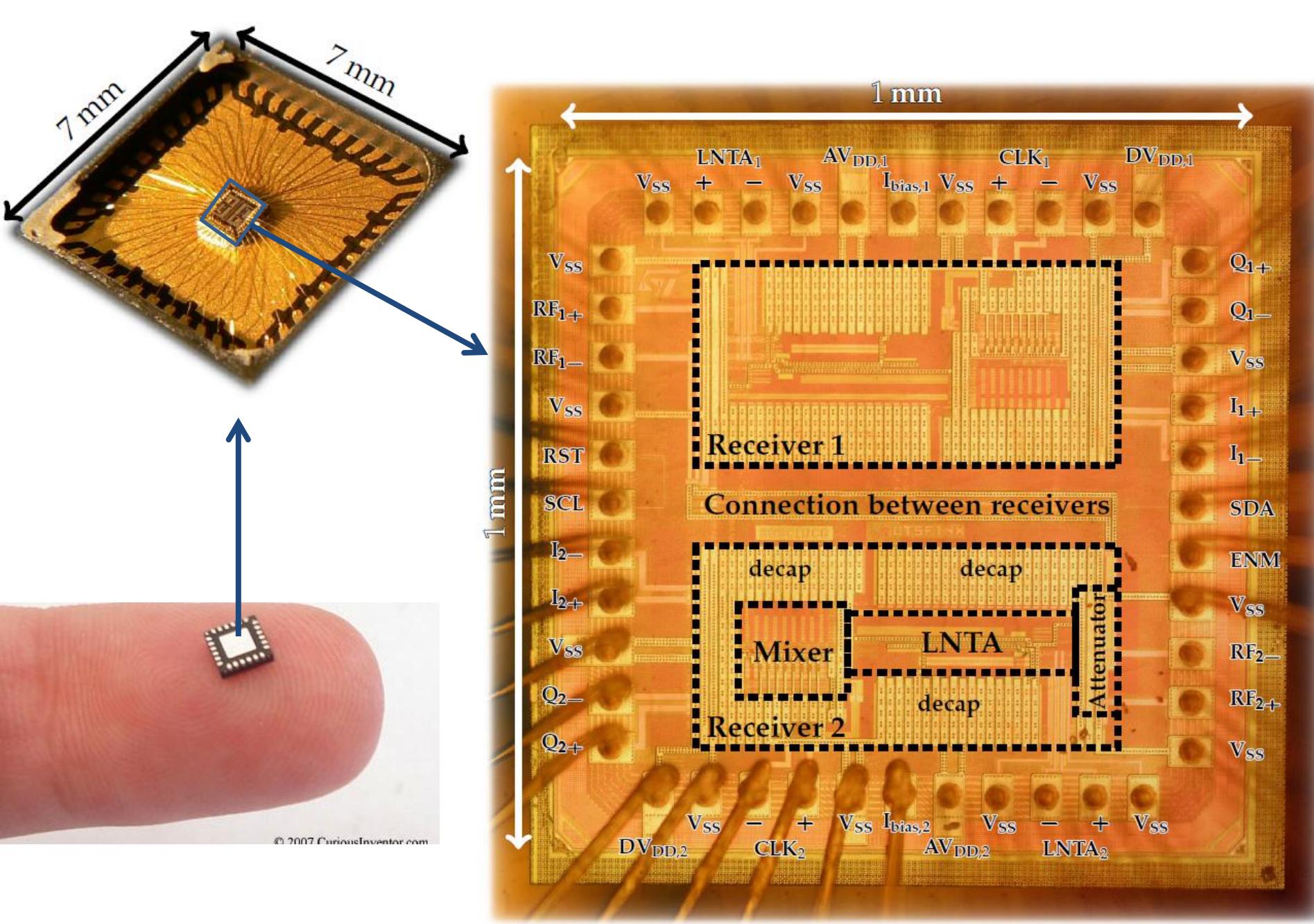


Cognitive Radio

Radio spectrum is “full”





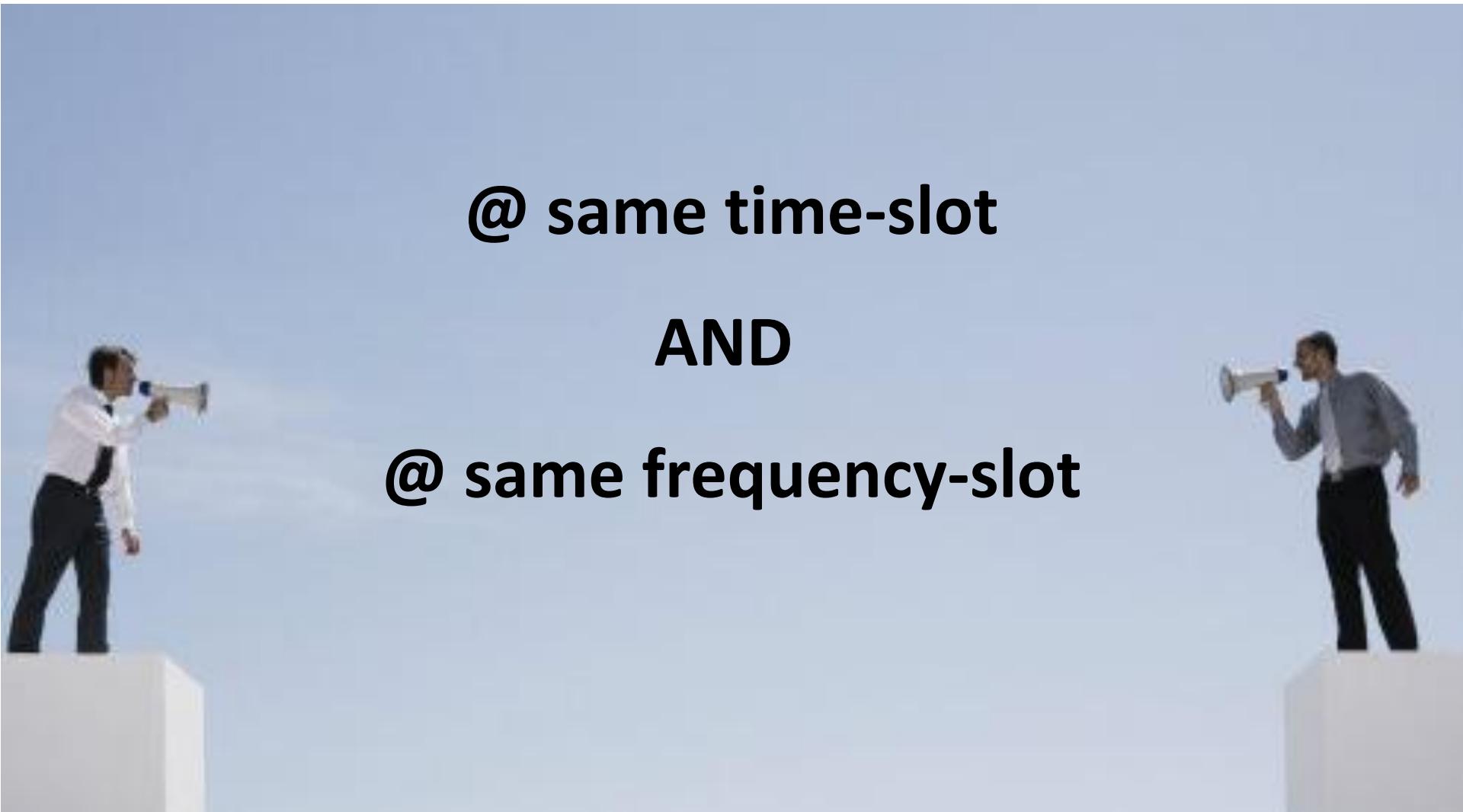


FULL DUPLEX

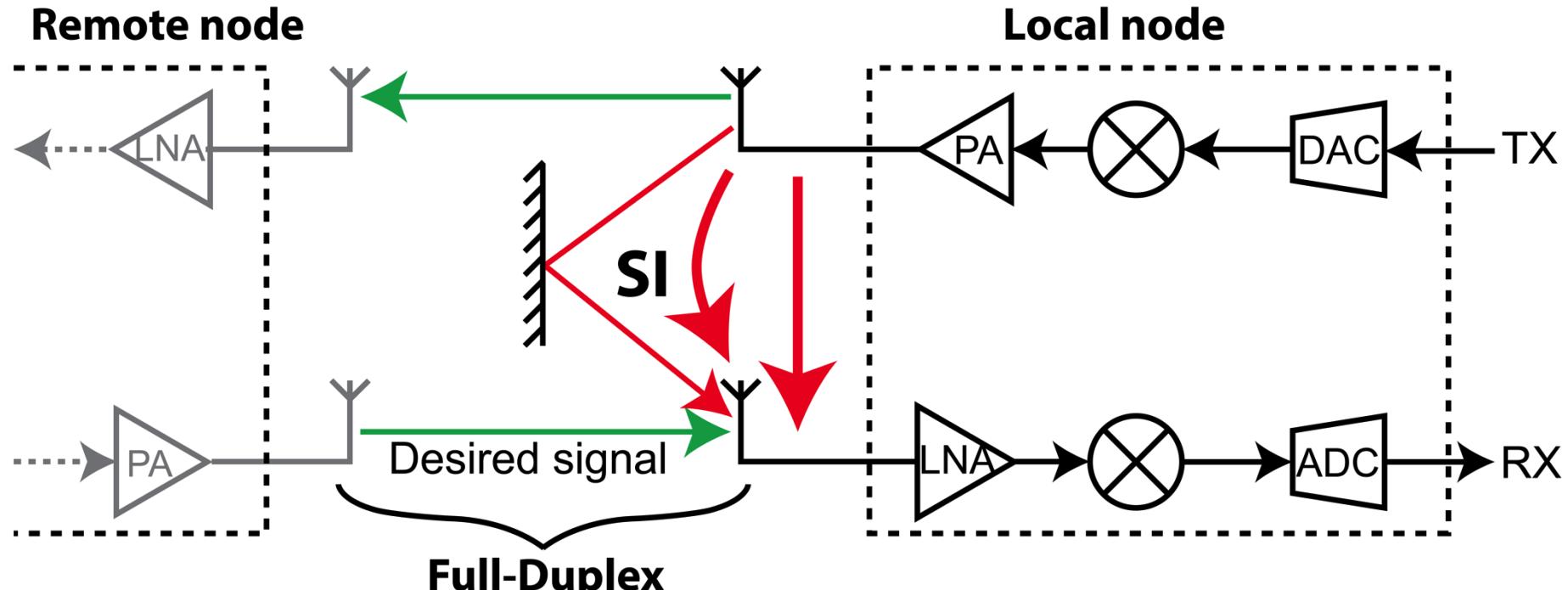
@ same time-slot

AND

@ same frequency-slot



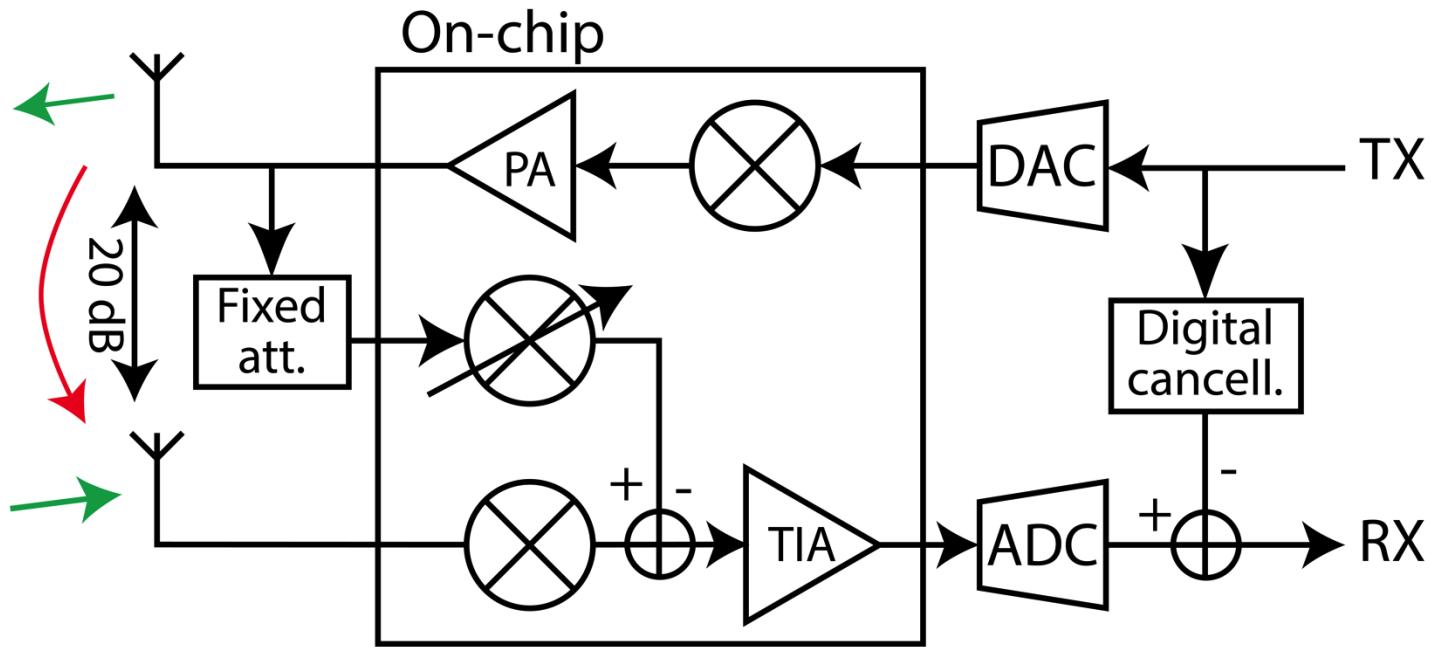
Challenge: Self-interference (SI)



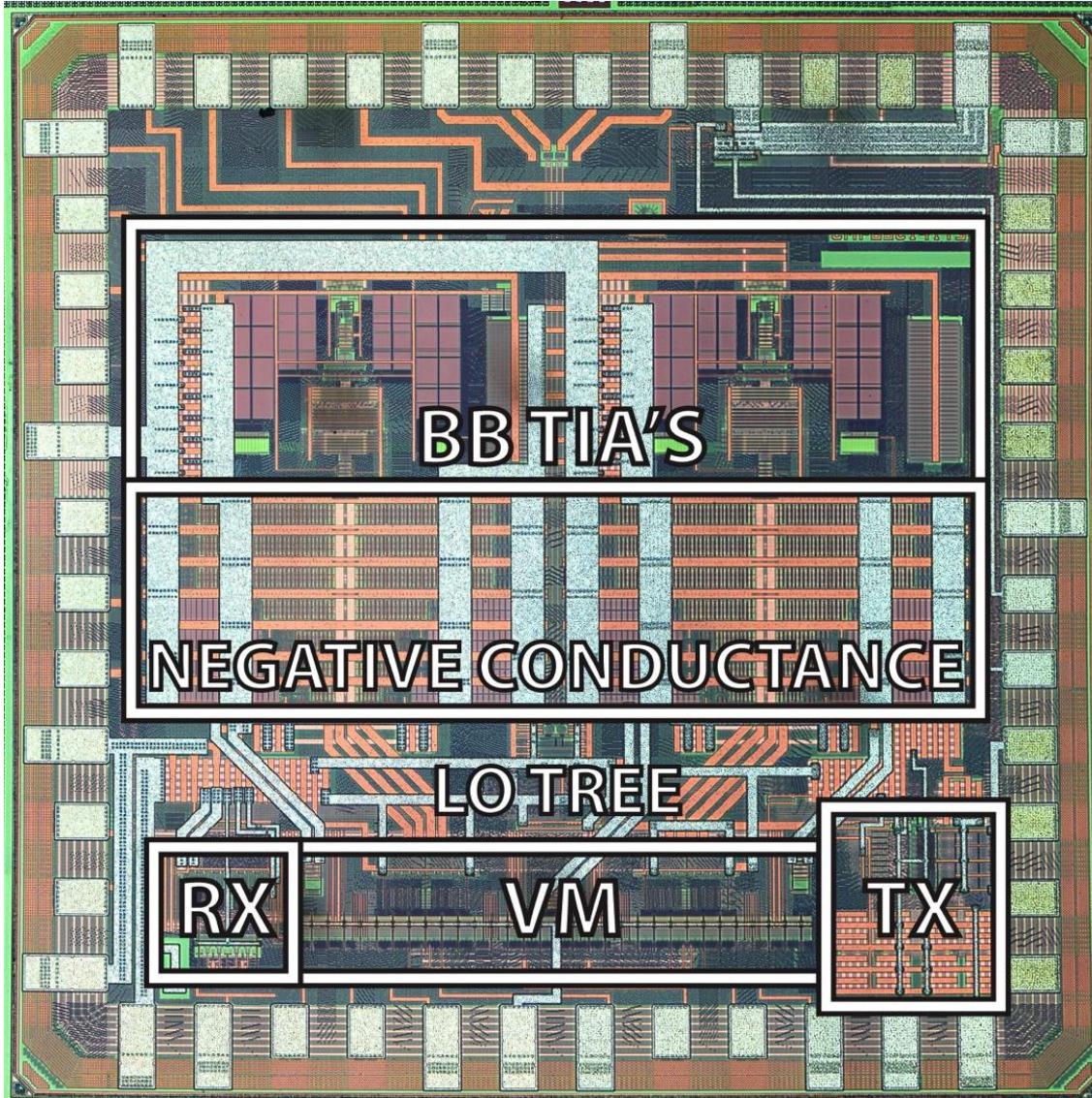
Short-range link:

10^9 (90 dB) SI rejection desired

Prototype front-end

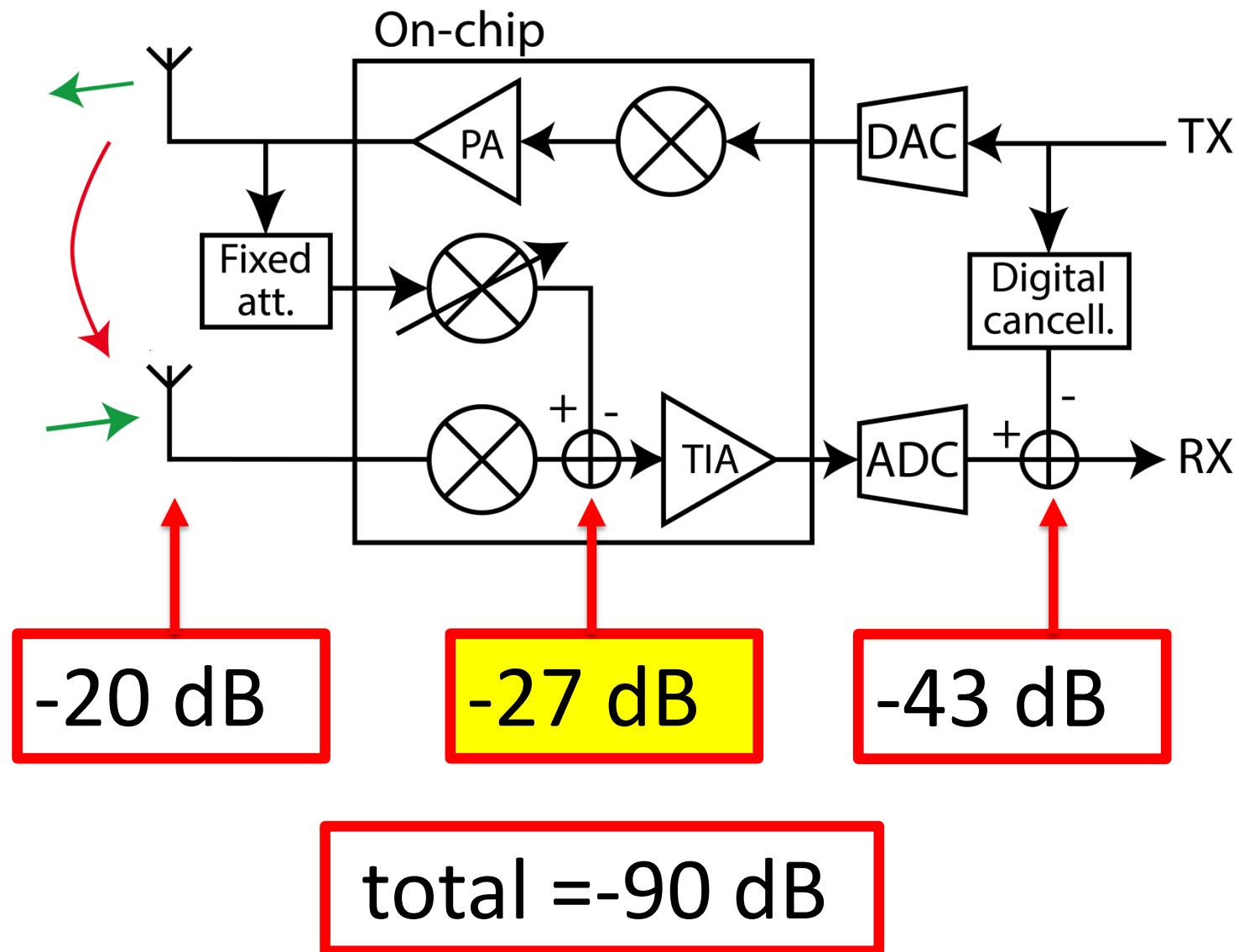


Short-range, low-power full-duplex
High integration potential

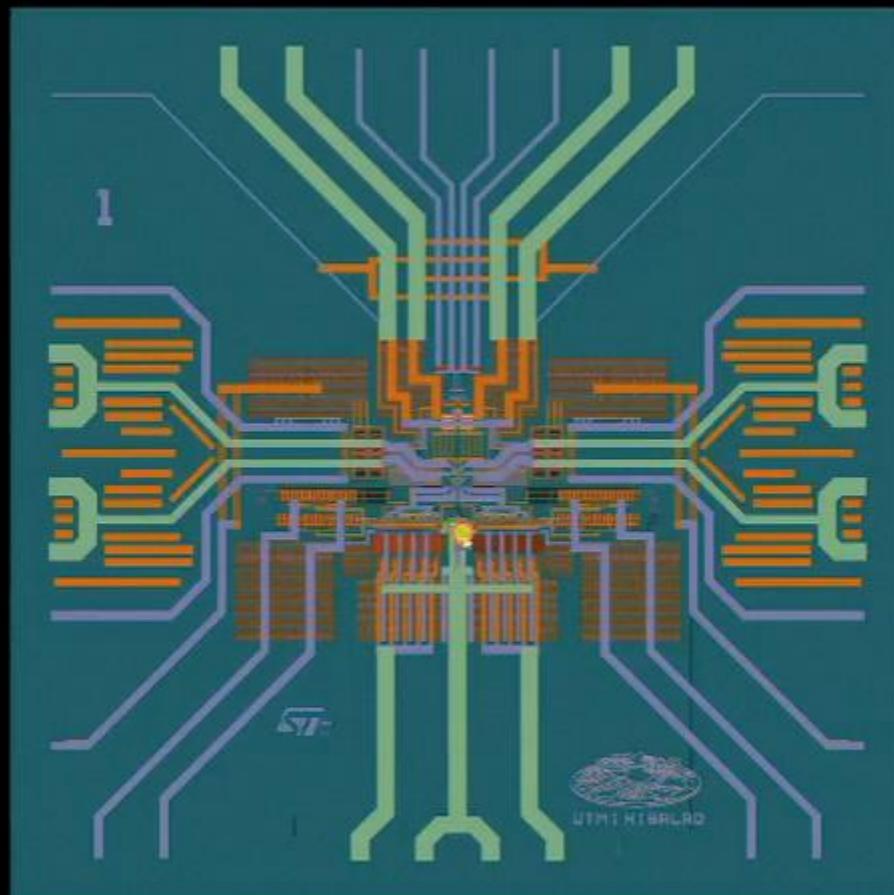


65nm CMOS
1.4x1.4mm
[DJ, ISSCC'15]

Prototype front-end



It's a 3D world



UTMAD



W.T.F





UTSFINH



SC121P3

TWENTE



UTBEEF





UTSALAO

Thank you!

