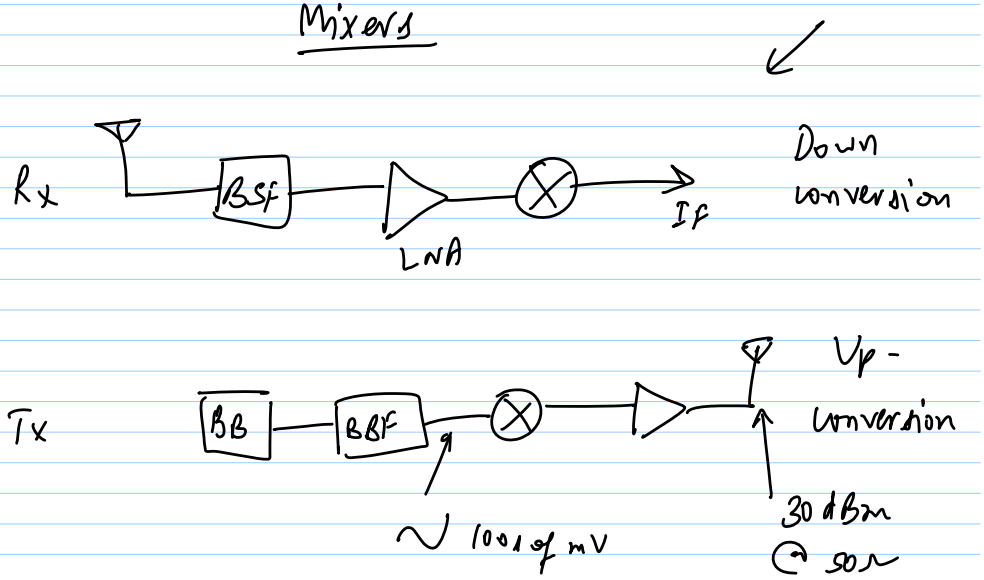
16-9-13

Lec 19

Mixers



* Multiplication

$x_{RF}(t) = A_{RF} \cos \omega_{RF} t \quad ; x_{LO}(t) = A_{LO} \cos \omega_{LO} t$

$x_{IF}(t) = x_{RF}(t) \times x_{LO}(t)$

$= \frac{A_{RF} A_{LO}}{2} \left[\cos(\omega_{LO} - \omega_{RF})t + \cos(\omega_{LO} + \omega_{RF})t \right]$

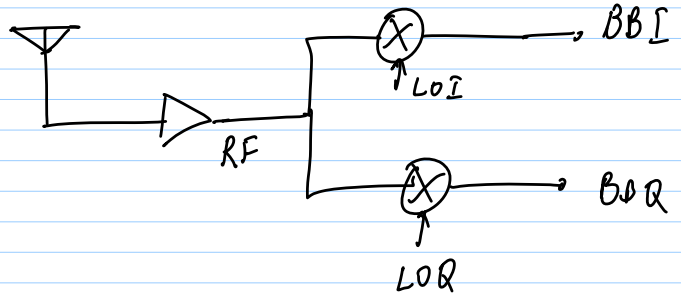
Metrics

1) Conversion gain G_c → Power conv. gain / Voltage conv. gain

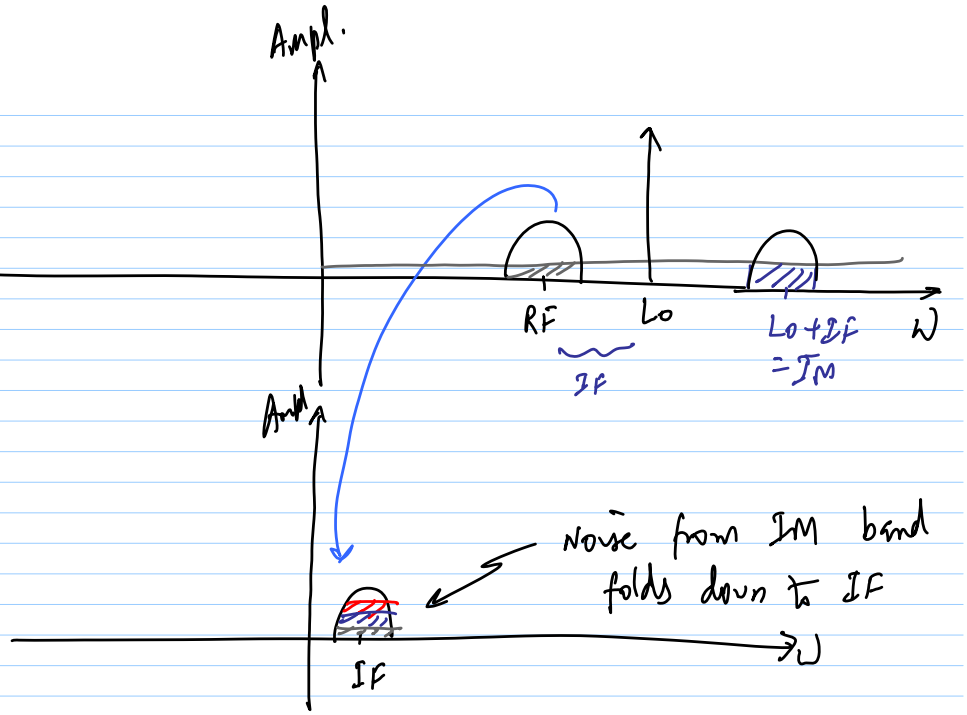
$G_c = \frac{A_{LO} A_{RF}/2}{A_{RF}} = \frac{A_{LO}}{2}$; $G_c < 1$ is possible

2) NF

$NF = \frac{SNR @ RF\ Port}{SNR @ IF\ port}$ (diff. freq.)



$NF = \frac{SNR_{RF}}{SNR_I} = \frac{SNR_{RF}}{SNR_Q}$



NF of ideal wireless mixer is already 3dB!

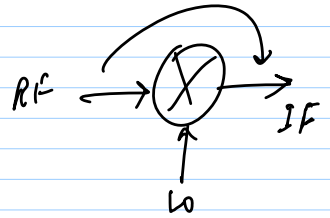
$NF_{SSB} = NF_{DSB} + 3dB$

↑ RF sig only in RF band

↑ Sig in RF & Im bands

3) Linearity

IIP3, IIP2, P1-dB



* AM radio

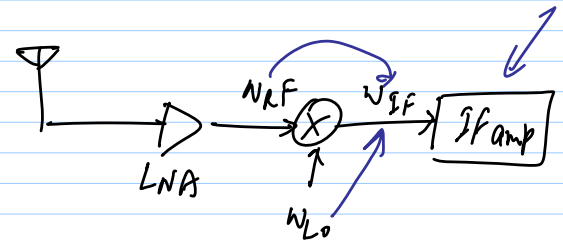
IF = 455kHz ; f_{RF} = 910kHz

$\Rightarrow f_{LO}$ = 1365kHz

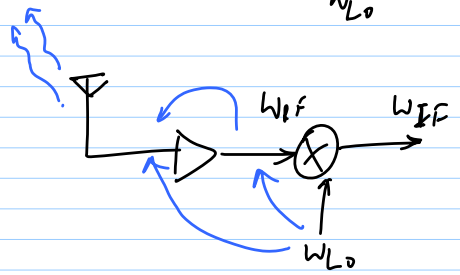
Cubic NL — $(2\omega_{RF} - \omega_{LO}) = \omega_{IF}$

4) Isolation

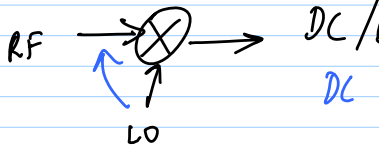
a)

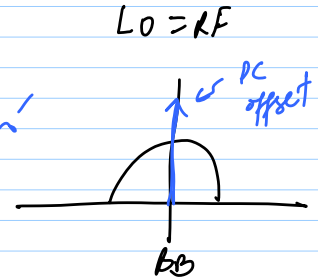


b)



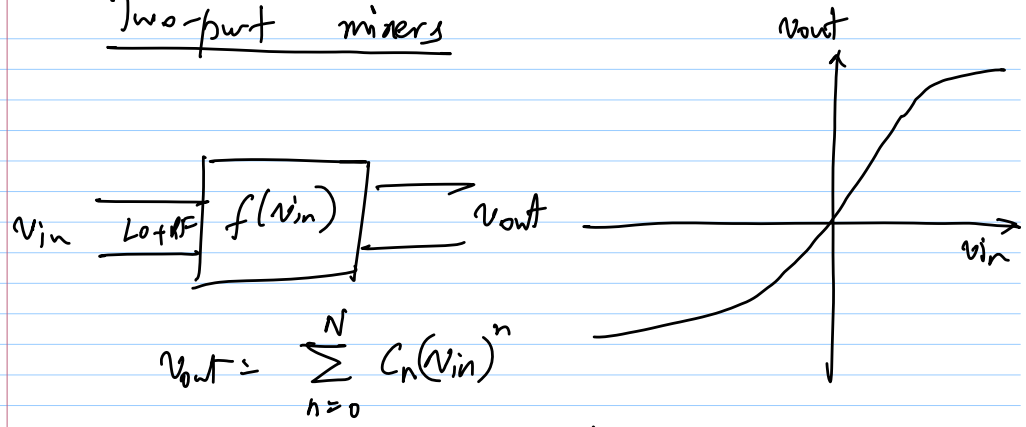
c) DCR





5) Spurs - spurious tones
undesired freq. components @ mixer o/p

Two-port mixers



$$v_{out} = \sum_{n=0}^{N} C_n (v_{in})^n$$

* DC terms — even order NL
* harmonics of inputs $m\omega_{LO}$ & $m\omega_{RF}$
  — filter out

* IM terms
  - $\omega_{RF} \pm \omega_{LO}$ → desired terms for mixing
* $p\omega_{RF} \pm q\omega_{LO}$ — undesired IM terms

Square-law Mixer

$C_i = 0$ for $i \neq 1, 2$

$$v_{out} = C_1 v_{in} + C_2 v_{in}^2$$

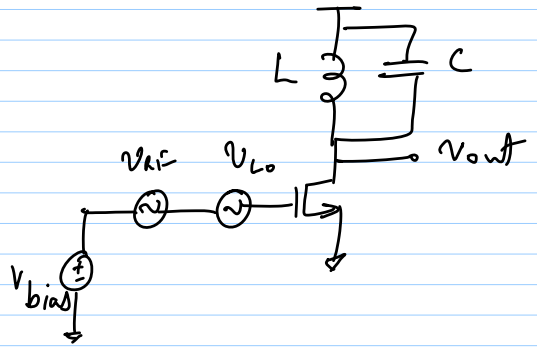
$$v_{in} = v_{RF}\cos\omega_{RF}t + v_{LO}\cos\omega_{LO}t$$

cross term in square term:

$$= 2C_2 v_{RF} v_{LO} \cos\omega_{RF}t \cos\omega_{LO}t$$

$$= C_2 v_{RF} v_{LO} \left[\cos(\omega_{LO}-\omega_{RF})t + \cos(\omega_{LO}+\omega_{RF})t\right]$$

example 1



example 2