RF Circuit Design

L5

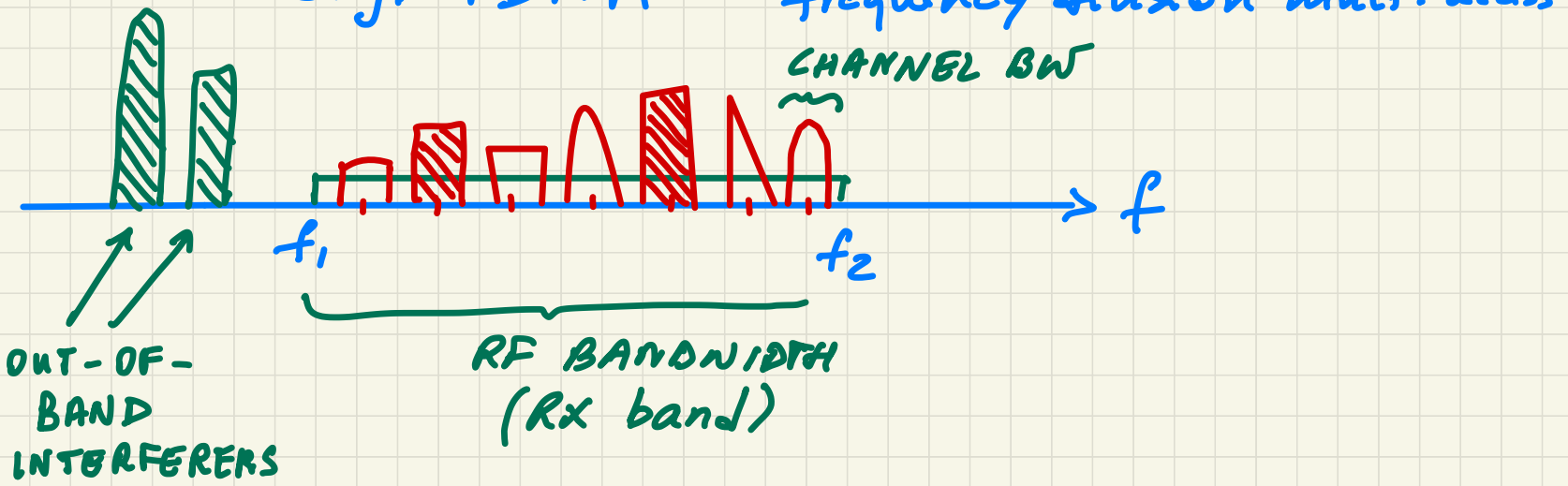
RX Block Diagram

Multi-user communication system

→ MULTIPLE ACCESS to the channel

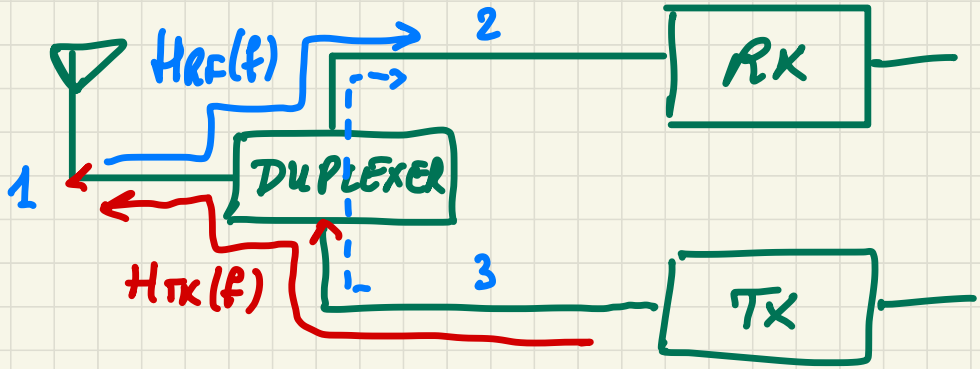
↓

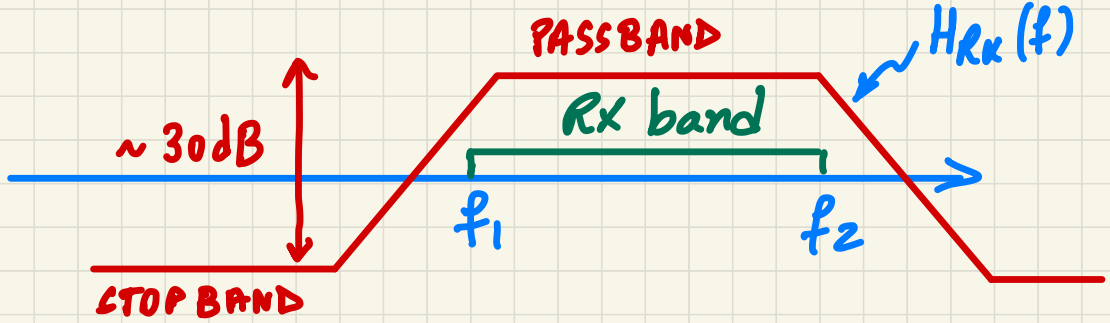
e.g. FDMA frequency division mult. access

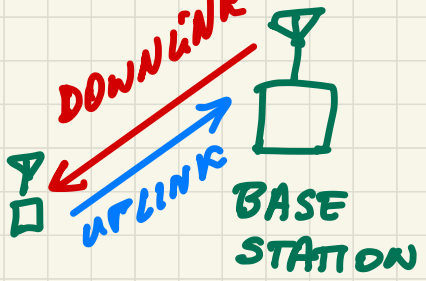


⇒ RX has to perform :

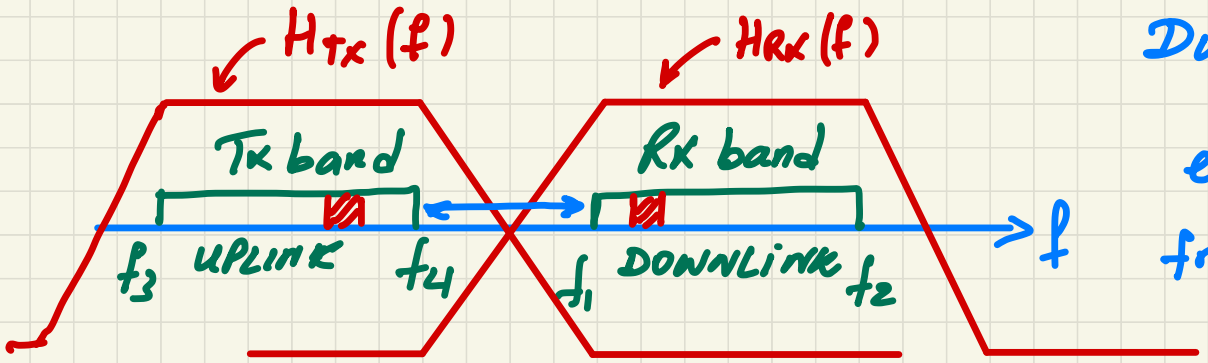
1. BAND selection (Duplexer) : out-of-band rejection
2. CHANNEL selection : • cannot be performed at RF frequency **
   • tunable filters have worse performance than fixed freq. filters







MOBILE DEVICE



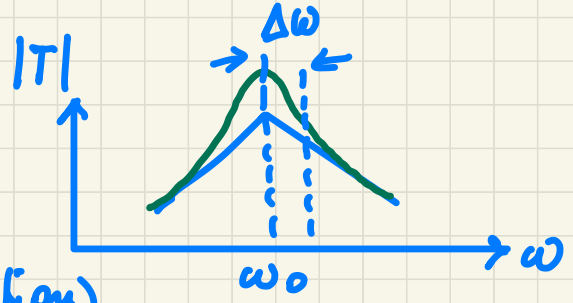
Duplexing

↓

e.g. FDD

freq. division duplexing

** Channel selection : example



f_{RF} = 1GHz (center frequ.)

Δf = 200KHz (channel separation)

LC filter : $|T(\Delta\omega)| \simeq \frac{\omega_0/2Q}{\Delta\omega}$ } -3dB BW of LC filter

$\frac{\Delta\omega}{\omega_0} \ll \frac{1}{4Q^2}$

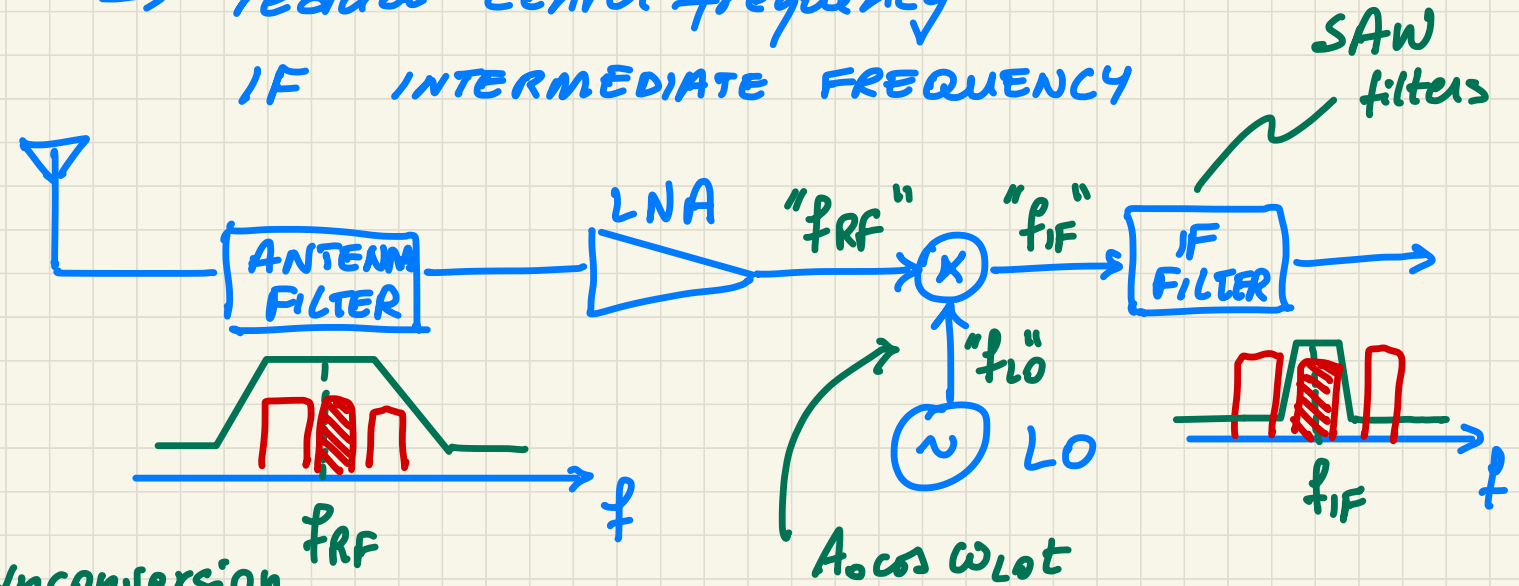
$|T(\Delta\omega)| = 10^{-3} \Rightarrow Q = 2.5 \cdot 10^6$

(60 dB)

2. Channel selection

$Q \div \frac{\omega_0}{\Delta\omega}$ — ω_0: center, $\Delta\omega$: offset

- To reduce Q of filter
  → reduce center frequency
  IF INTERMEDIATE FREQUENCY



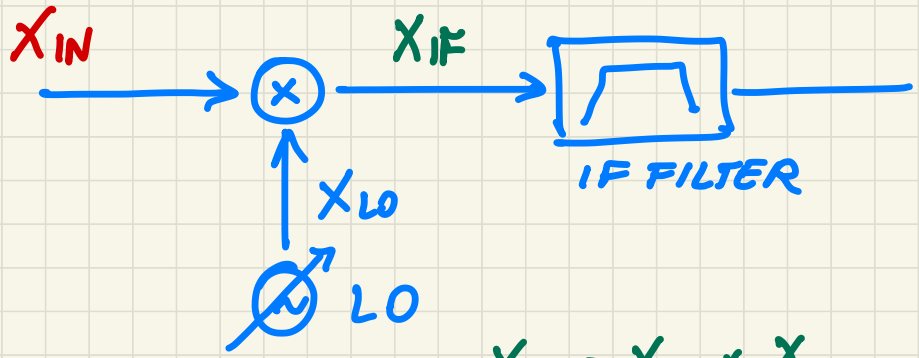
Downconversion

$$f_{IF} = |f_{RF} - f_{LO}|$$

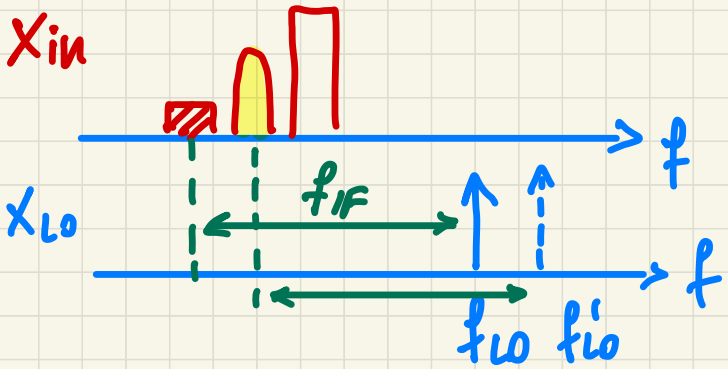
$$\cos \omega_{RF} t \cos \omega_{LO} t =$$
$$= \frac{1}{2} \cos(\omega_{RF} - \omega_{LO})t + \frac{1}{2} \cos(\omega_{RF} + \omega_{LO})t$$

HETERODYNE RX ARCHITECTURE

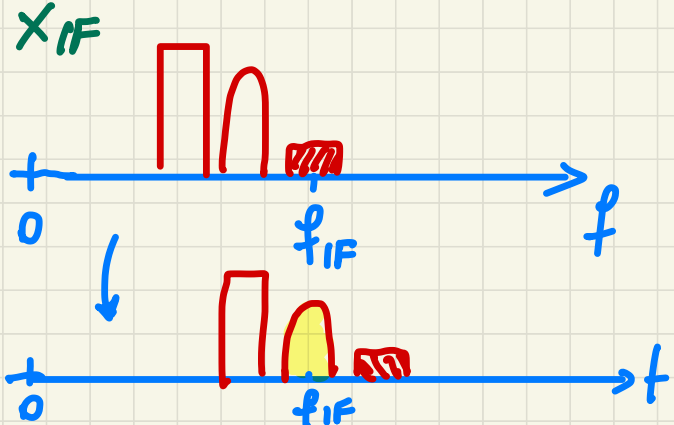
Different frequency



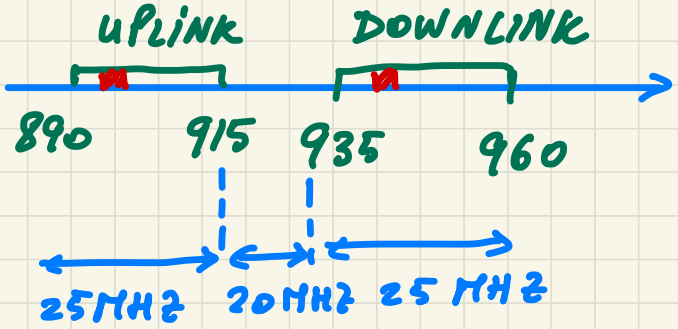
- high-side ←
- low-side injection



$X_{IF} = X_{IN} * X_{LO}$



Example : GSM cellular system "2G"
ETSI standard: Physical layer PHY



FDMA

FDD

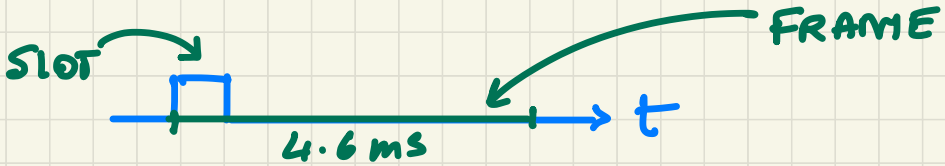
Guard frequency

- Each BAND is divided into 125 carriers :

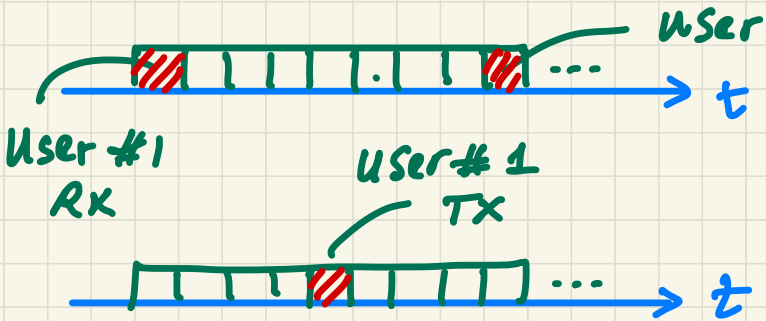
$$\frac{25\,MHz}{125} = 200\,KHz$$

frequency separation of channels

- Each channel is shared by 8 users



Slot time $\frac{4.6\,ms}{8} \simeq 575\,\mu s$



TDMA

time division multiple access

TDD

time division duplexing

Digital modulation

↳ GMSK modulation which is a CPM

continuous-phase mod.

(constant envelope mod.)

↳ non linear PA

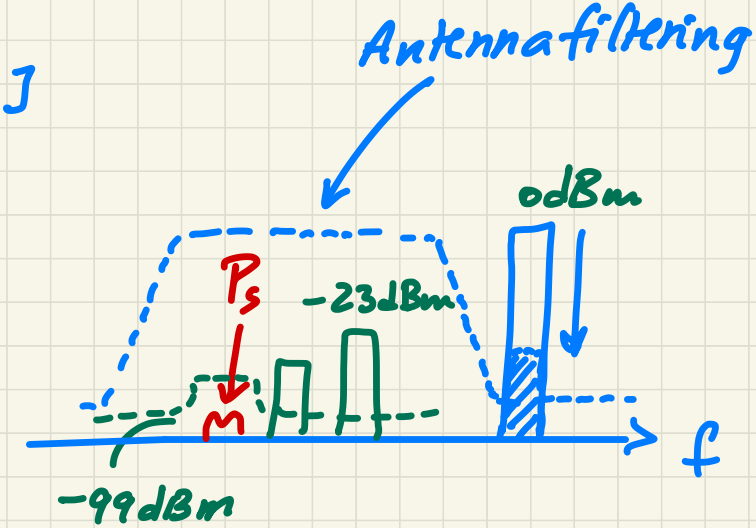
$SNR_{min} \simeq 9\ dB$

$BER = 10^{-3}$

Minimum signal (SENSITIVITY) $P_s = -99\ dBm$

** $dBm = 10 \log_{10} P_{[mW]}$

e.g.
- 0 dBm → 1 mW
- 30 dBm → 1 W
- −20 dBm → 10 μW
- −100 dBm → 10^{-10} mW



99 − 23 = 76 dB!

Sensitivity : $P_S = -99$ dBm

Out-of-band interferers : $P_B = 0$ dBm

In-band interferers : $P_B = -23$ dBm