Department of Communications Engineering

Communication Systems

Third Year Class

Dr. Montadar Abas Taher

montadar@ieee.org

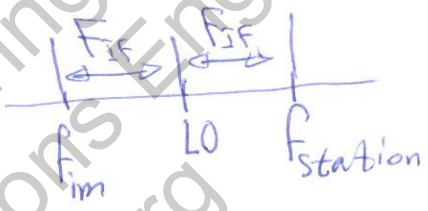
Lecture 14

Super heterodyne Receivers III, Image Problem

Image Problem :-

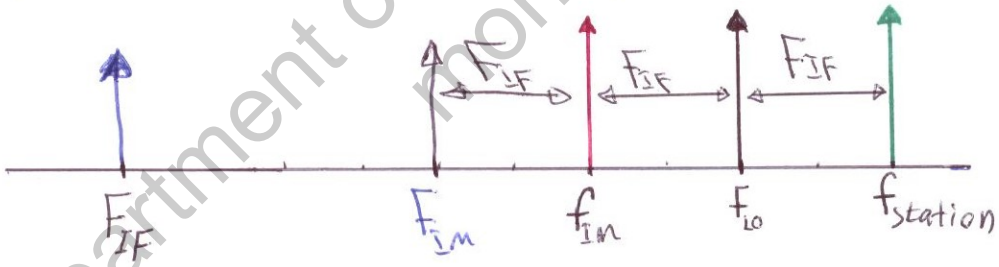
The main disadvantage of superheterodyne receiver is the image problem.

* The heterodyne selects two frequencies not only one
* These two frequencies mirrored about the LO, hence they are image to each other.
* hence the main purpose of the RF BPF is to reject the image signal.
* The IF-filter will also attenuate the image frequency.



There are two cases for the image frequency (F_{Im}) :-

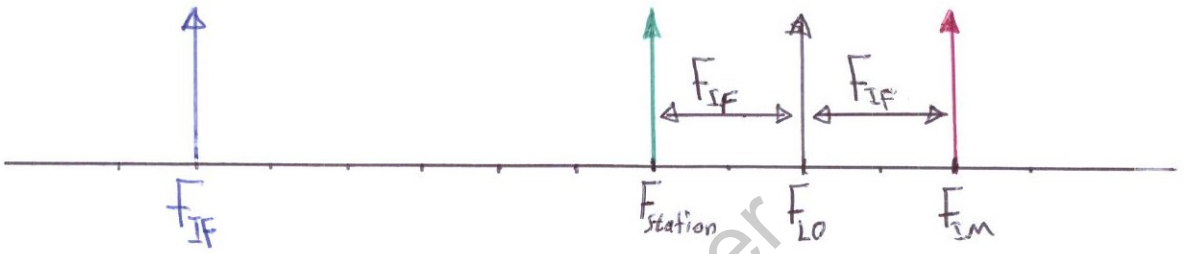
① Low side injection ($F_{LO} < F_{station}$)



$$F_{LO} = F_{station} - F_{IF}$$

$$F_{image} = F_{Im} = F_{station} - 2F_{IF} \Longleftarrow F_{LO} - F_{IF} = F_{IM}$$

② High side injection ($F_{LO} > F_{station}$)



$$F_{LO} = F_{Station} + F_{IF}$$

$$F_{Im} = F_{station} + 2F_{IF} \Leftarrow F_{IM} = F_{LO} + F_{IF} = F_{station} + 2F_{IF}$$

Summary

Down-side injection $LO < F_c$

$$F_{LO} = F_c - F_{IF}$$

$$F_{IM} = F_{LO} - F_{IF}$$

$$F_{IM} = F_c - 2F_{IF}$$

UP-side injection $LO > F_c$

$$F_{LO} = F_c + F_{IF}$$

$$F_{IM} = F_{LO} + F_{IF}$$

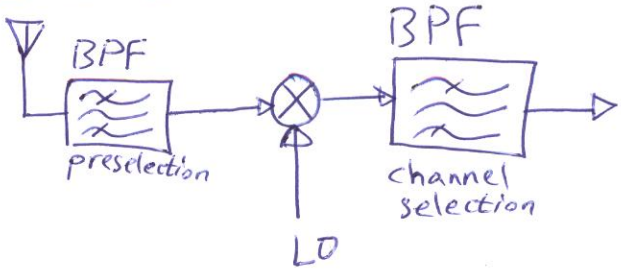
$$F_{IM} = F_c + 2F_{IF}$$

Always IMAGE frequency $\mp 2F_{IF}$

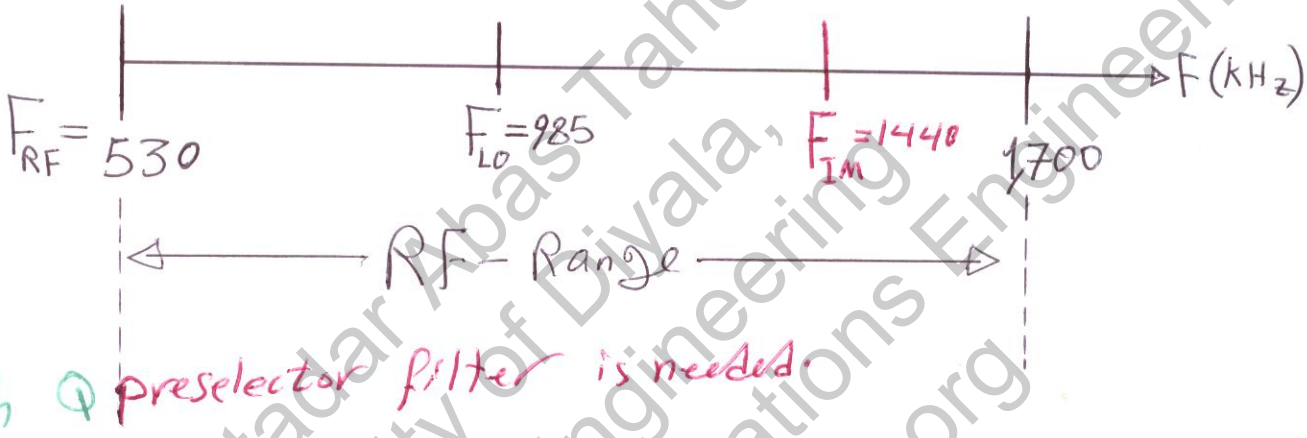
AM Broadcast Stations

AM Band: [530 – to – 1700] KHz

standard $F_{IF} = 455$ KHz



Often Image is inside



* High Q preselector filter is needed.

EX. For example, $F_{RF} = 530$ KHz, $F_{IM} = \cancel{1440}\ 1700$ KHz with high LO. Always we have two solutions;

① $F_{LO} = F_{RF} - F_{IF} = 530 - 455 = 75$ KHz
$1700 - 455 = 1245$ KHz
F_{LO} ratio $= \frac{1245}{75} \simeq 16$

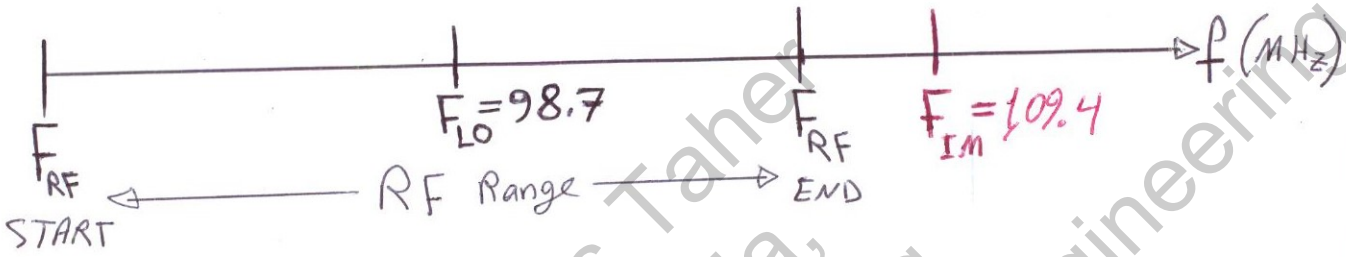
② $F_{LO} = F_{RF} + F_{IF} = 530 + 455 = 985$ KHz
$1700 + 455 = 2155$ KHz
F_{LO} ratio $= \frac{2155}{985} \simeq 2$

Thus, the second case is easier to ~~Ex~~ implement.

FM-Broadcast Stations

RF Band : [88-to-108] MHz

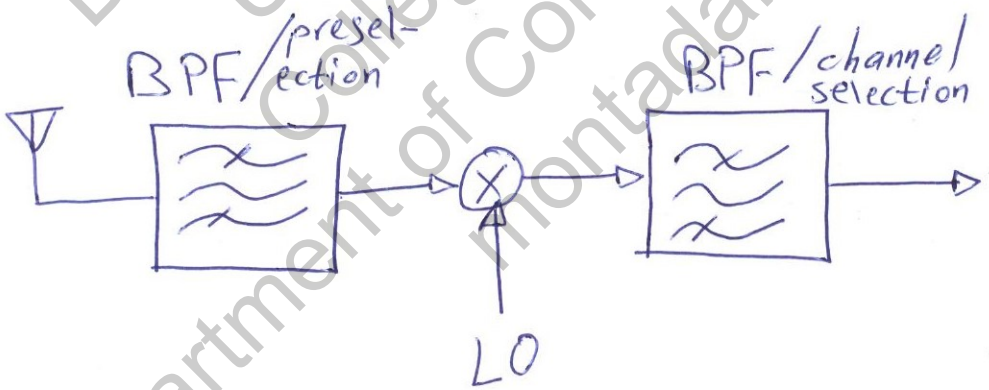
Standard $F_{IF} = 10.7$ MHz



* F_{IM} is always out of band

$$F_{IM} = F_{RF} + 2F_{IF}$$

even with very low F_{LO}, F_{IM} is out of Band.



EX. consider $F_{IF} = 10.7\ MHz$.

There are two cases

① $F_{LO} < F_{IF}$

$$F_{RF} + F_{LO} = F_{IF} \quad (1)$$
$$F_{IM} - F_{LO} = F_{IF} \quad (2)$$

Lower end RF-frequency = 0.53 MHz
Higher end RF-frequency = 1.7 MHz

$F_{LO_{Lower}} = 10.17\ MHz$ (Eq.(1))

$F_{LO_{Higher}} = 9\ MHz$ (Eq.(1))

$F_{IM} - F_{LO} = F_{IF} \Rightarrow F_{IM_{Lower}} = F_{IF} + F_{LO_{Lower}} = 10.7 + 10.17 = 20.87\ MHz$.

$F_{IM_{Higher}} = F_{IF} + F_{LO_{Higher}} = 10.7 + 9 = 19.7\ MHz$.

② $F_{LO} > F_{IF}$ $F_{LO} - F_{RF} = F_{IF}$ (1) & $F_{IM} - F_{LO} = F_{IF}$ (2)

$F_{RF_{Lower}} = 0.53\ MHz$ & $F_{RF_{Higher}} = 1.7\ MHz$.

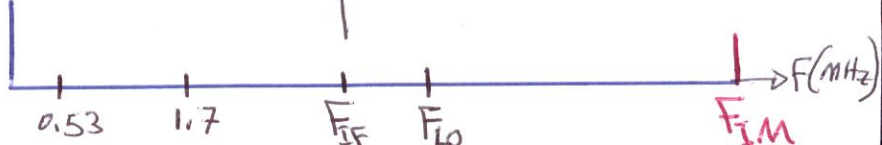
$F_{LO_{Lower}} = F_{IF} + F_{RF_{Lower}} = 10.7 + 0.53 = 11.23\ MHz$.

$F_{LO_{Higher}} = F_{IF} + F_{RF_{Higher}} = 10.7 + 1.7 = 12.4\ MHz$.

$F_{IM_{Lower}} = F_{IF} + F_{LO_{Lower}} = 10.7 + 11.23 = 21.93\ MHz$.

$F_{IM_{Higher}} = F_{IF} + F_{LO_{Higher}} = 10.7 + 12.4 = 23.1\ MHz$.

NOTE :- Higher LO frequency → better image rejection.



Dual Conversion Receiver :-

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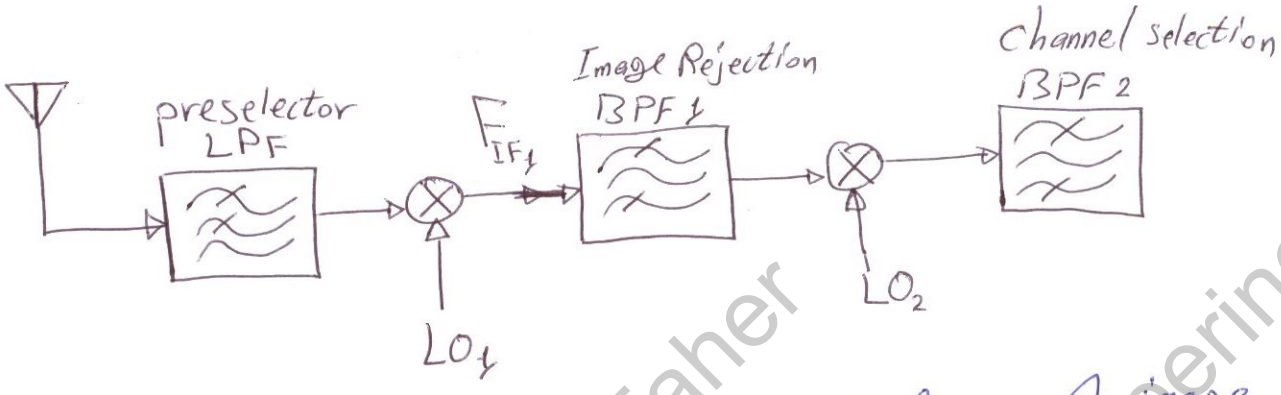
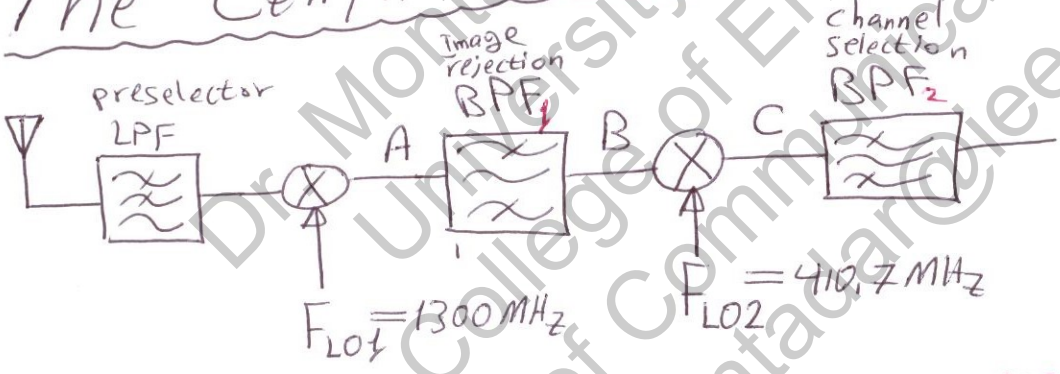


the dual conversion receiver can be used for good image frequency rejection.

The Cellphone Receiver



* At the antenna : $F_{RF} = 900\,MHz$, $F_{IM} = 1700\,MHz$
* At point (A) 400 MHz & 2100 MHz, the 2100 MHz filter-out by BPF_1

$F_{IF} = 400\,MHz$ & $F_{IM} = 410.7\,MHz$.

* At point (B) $F_{IF} = 400\,MHz$, $F_{IM} = 421.4\,MHz$
* At point (C) 10.7 MHz & 810.7 MHz.

$F_{IF2} = F_{LO2} - F_{IF1}$, the sum term will be removed by BPF2.