RF Tasarım

Receiver architectures (heterodyne, image frequency)

Original notes: Ders-10.pdf

UYARI Bu belge, el yazısı ders notlarından Claude (Anthropic) yardımıyla dijitale aktarılmıştır. Yardımcı kaynak olarak hazırlanmıştır; hata veya eksik içerebilir. Lütfen orijinal notları ve ders kaynaklarını esas alın.

NOTICE *This document was transcribed from handwritten lecture notes with the help of Claude (Anthropic). It is meant as a supplementary resource and may contain errors or omissions. Always check against the original notes and official course material.*

orig. p. 1

Example

$\eta_T = 0{,}5 \rightarrow$ microstrip antenna efficiency
$G_T = 11\,\text{dB} \rightarrow$ antenna gain
$P_{in} = 40\,\text{W}$ (input power before antenna)
T_x power density (fall as $1/d^2$)

1) $P_{in} = \ldots\ldots$?? [dBm]

$$P_{in\,dBm} = 10\log\left(\frac{P_{in}}{10^{-3}}\right) = 46\,\text{dBm} \qquad (P_{in} = 40)$$

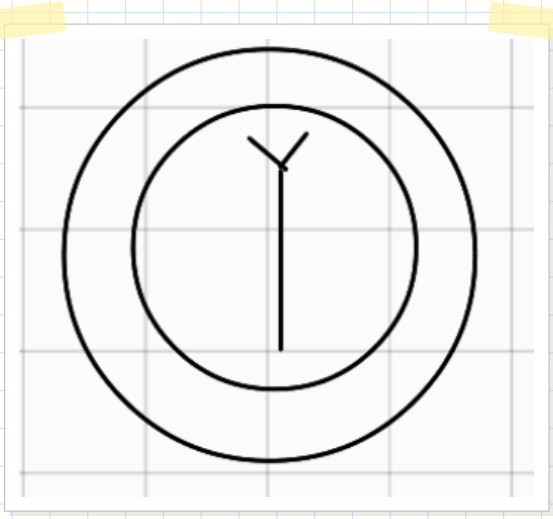
$$P_{T\,dBm} = P_{in\,dBm} - \underbrace{\eta_{T\,dB}}_{\frac{10\log(0{,}5)}{3\,dB}}$$

2) $P_T = ?$ [dBm]

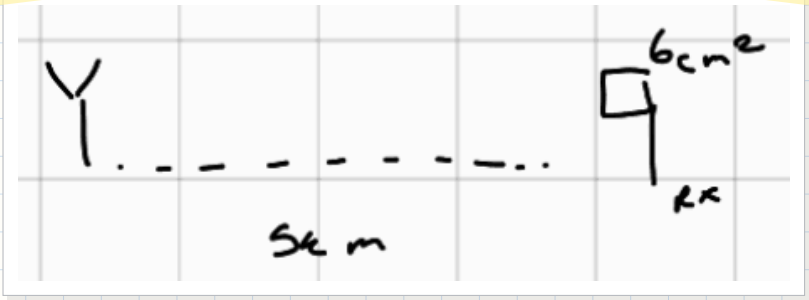
$$P_T = P_{in} \cdot \eta_T = 40 \cdot 0{,}5 = 20\,\text{W}$$

$$P_{T\,dBm} = 10\log\left(\frac{20}{10^{-3}}\right) = 43\,\text{dBm}$$

c) $d = 5\,\text{km} \rightarrow P_D = ?$



original drawing, p. 1



original drawing, p. 1

$$P_D = \frac{P_T \cdot G_T}{4\pi d^2}$$

$$P_D = \frac{20 \cdot 10^{11/10}}{4\pi (5 \cdot 10^3)^2} = 1{,}603\ \mu W/m^2$$

d) $A_R = 6\ cm^2 \rightarrow P_R = ?$

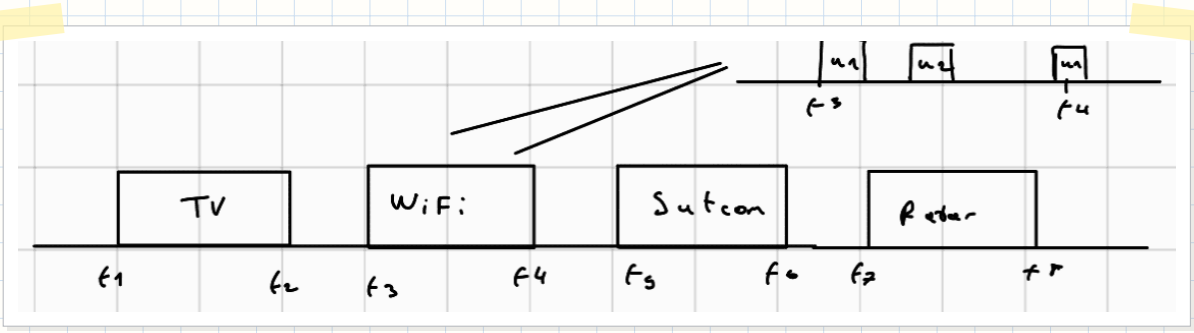
$$P_R = P_D \cdot A_R = 1{,}603\ \mu W/m^2 \cdot (6\ cm^2)$$
$$= 1{,}603\ \mu W/m^2\ (6 \cdot 10^{-4})\ m^2$$
$$= P_R = 962\ pW$$

e) Alıcıdaki gürültü:
$N_R = 100\ fW \rightarrow SNR_R = ?$

$$SNR = \frac{P_R}{N_R} = \frac{962\ pW}{100\ fW} = 9618 \rightarrow SNR_{dB} = 39{,}7\ dB$$

orig. p. 2

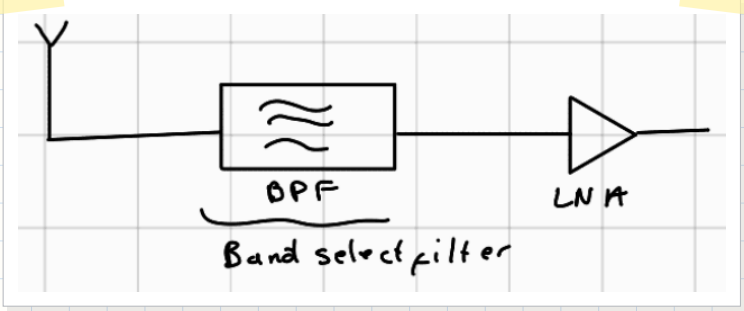
Design Architecture of Receivers



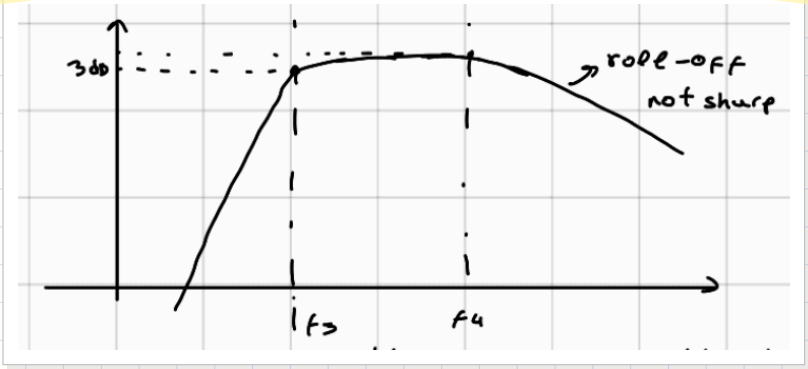
original drawing, p. 2

Band → frequency allocated for specific application

Channel → " " " " user

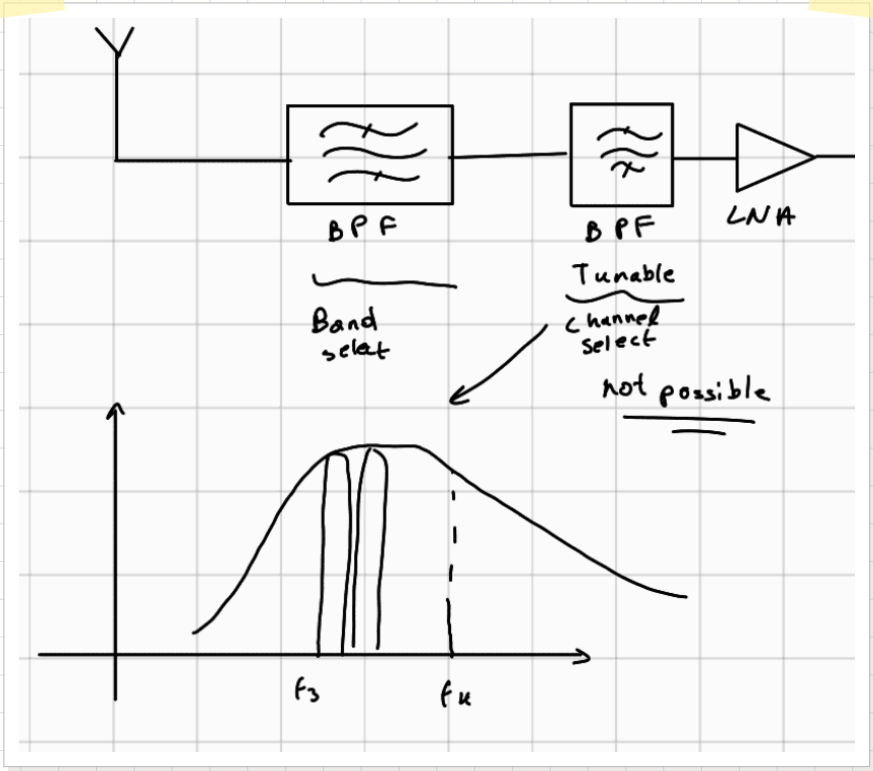


original drawing, p. 2



original drawing, p. 2

Off-chip filter → eğer filtrenin keskin olmasını istersek



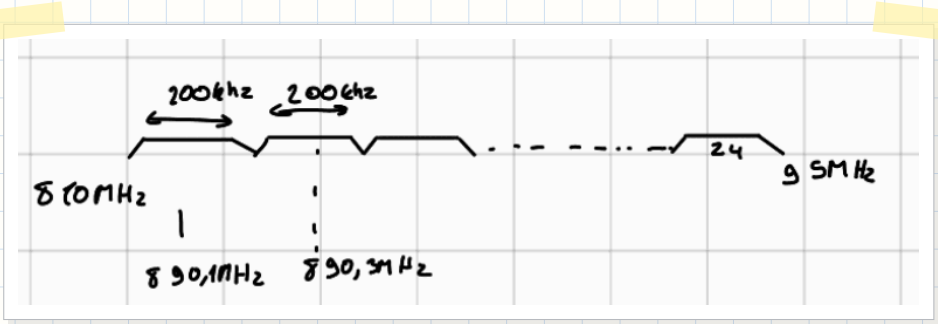
original drawing, p. 2

Narrowband sharp roll-off filter is not possible

orig. p. 3

GSM 900 band

Uplink band & channels.

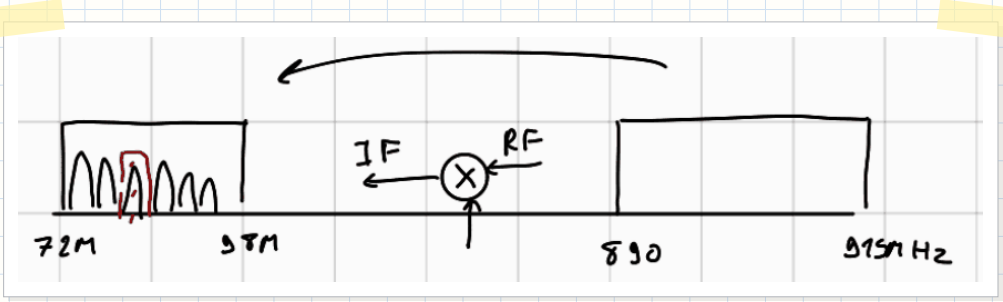


original drawing, p. 3

Downlink band & channels



original drawing, p. 3

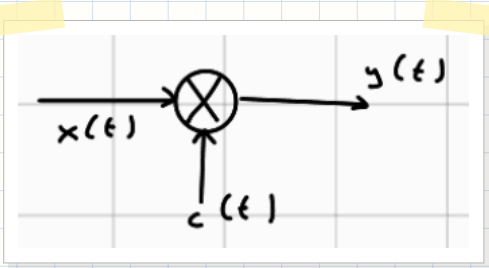


original drawing, p. 3

Down Conversion

$x(t) = A\cos(\omega_{RF}t)$ (input)

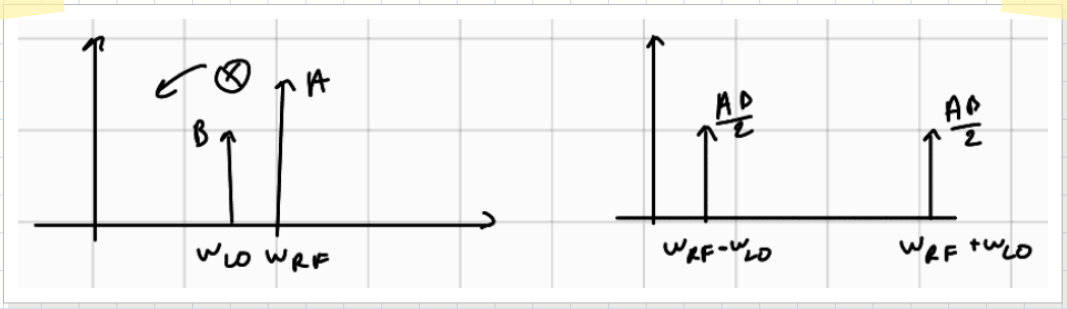
$c(t) = B\cos(\omega_{LO}t)$ (LO)



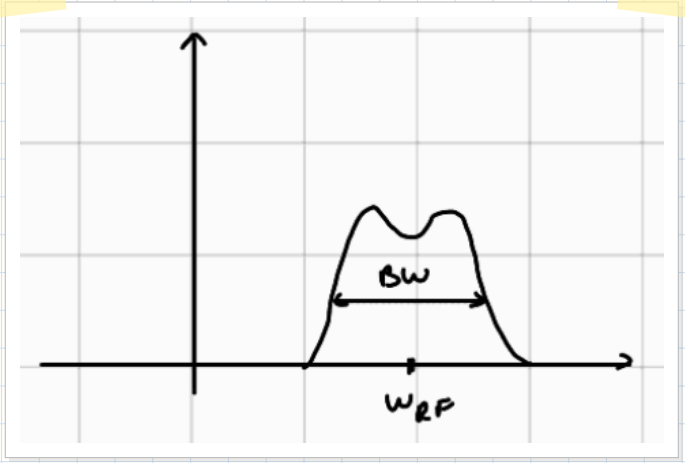
original drawing, p. 3

$$r(t) = y(t) = x(t)c(t) = A\cos(\omega_{RF}t)\,B\cos(\omega_{LO}t)$$
$$= \frac{AB}{2}\{\cos((\omega_{RF}+\omega_{LO})t) + \cos((\omega_{RF}-\omega_{LO})t)\}$$

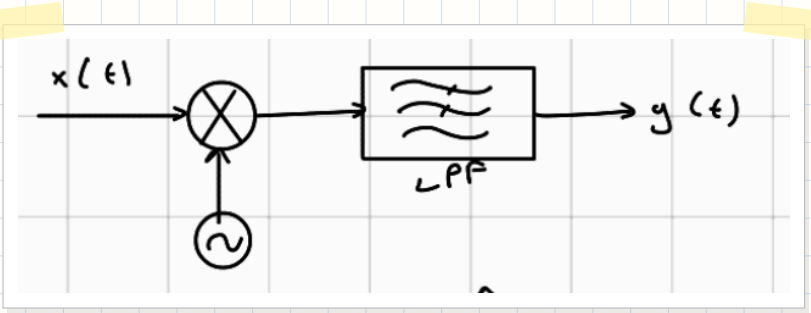
$\omega_{RF} \pm \omega_{LO}$



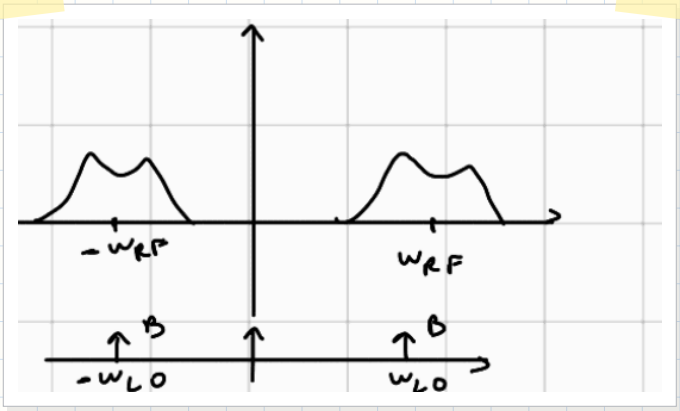
original drawing, p. 3



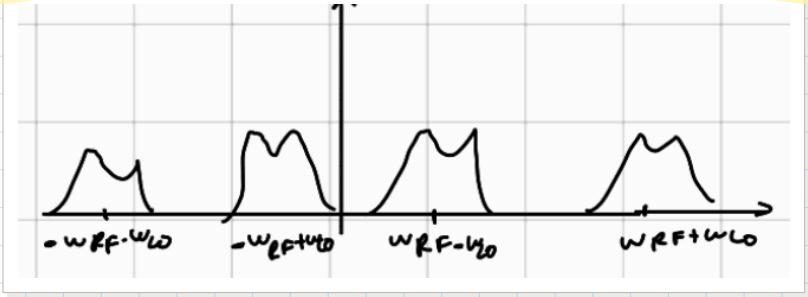
original drawing, p. 3



original drawing, p. 3



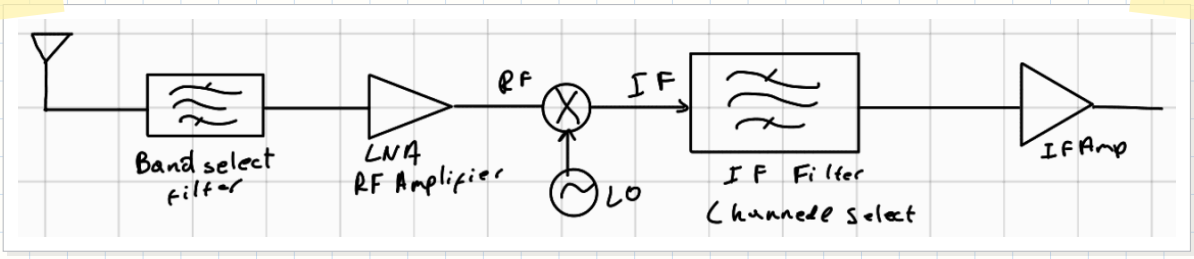
original drawing, p. 3



original drawing, p. 3

orig. p. 4

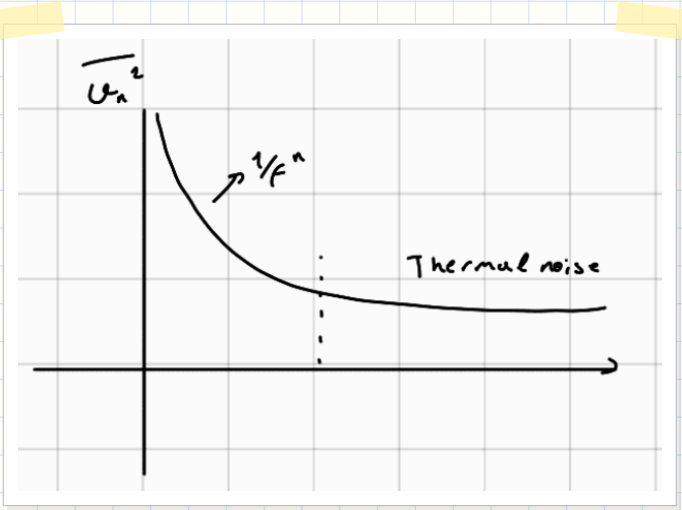
Heterodyne Receivers



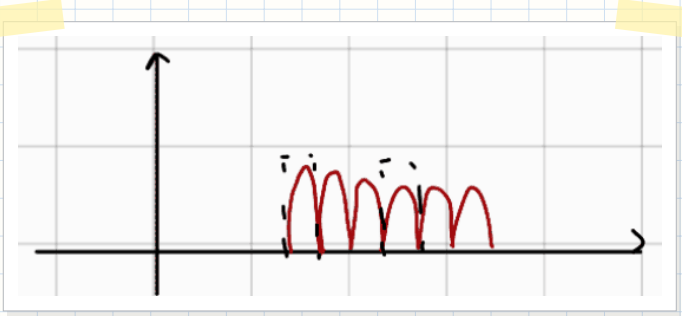
original drawing, p. 4

$\omega_{RF} - \omega_{LO} = \omega_{IF} \neq 0 \rightarrow$ Heterodyne

$\omega_{IF} = 0 \rightarrow$ Homodyne



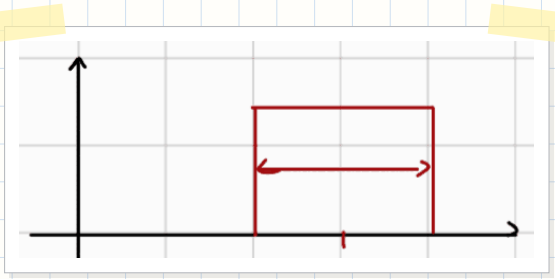
original drawing, p. 4



original drawing, p. 4

1- Tunable IF Filter, constant LO

2 → Constant IF Filter, Tunable LO

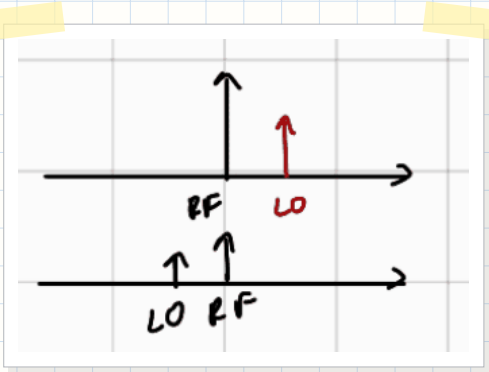


original drawing, p. 4

SAW filter
IF = 70 MHz
BW = 100 MHz

ω_{RF}	− ω_{LO}	= ω_{IF}
↓	↓	constant
960	890	70
965	895	70

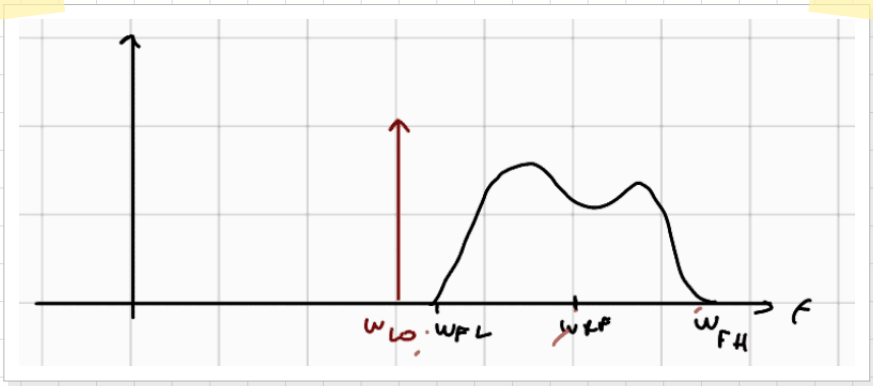
High side injection
Low side injection



original drawing, p. 4

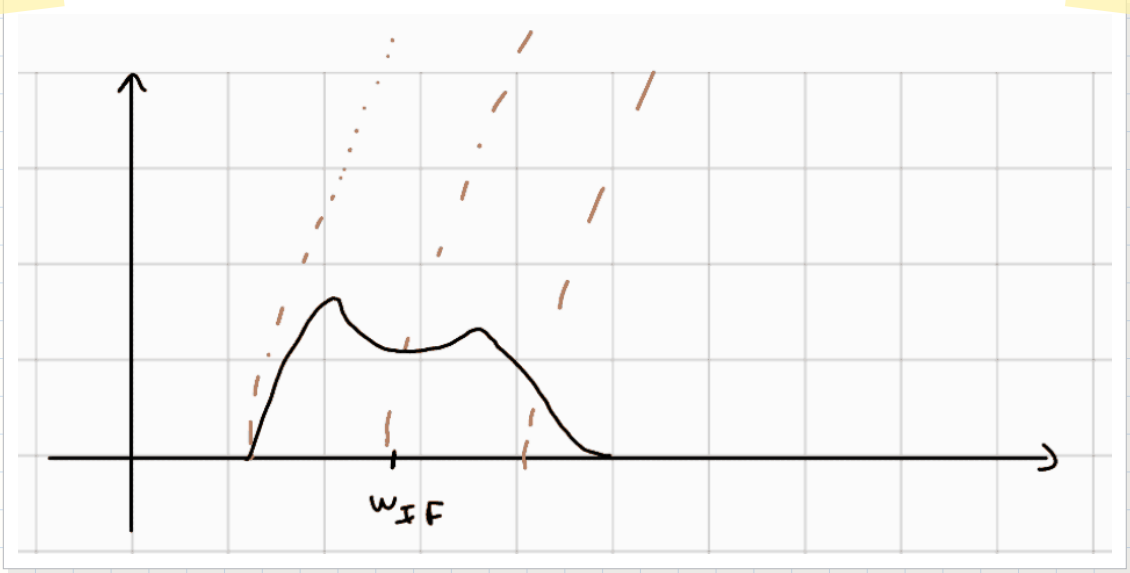
$\rightarrow \omega_{IF} = \omega_{LO} - \omega_{RF}$

$\rightarrow \omega_{IF} = \omega_{RF} - \omega_{LO}$



original drawing, p. 4

orig. p. 5



original drawing, p. 5

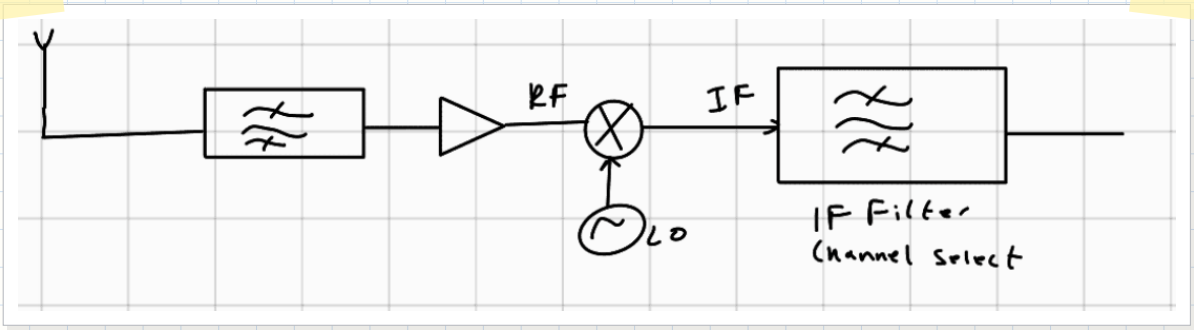


original drawing, p. 5

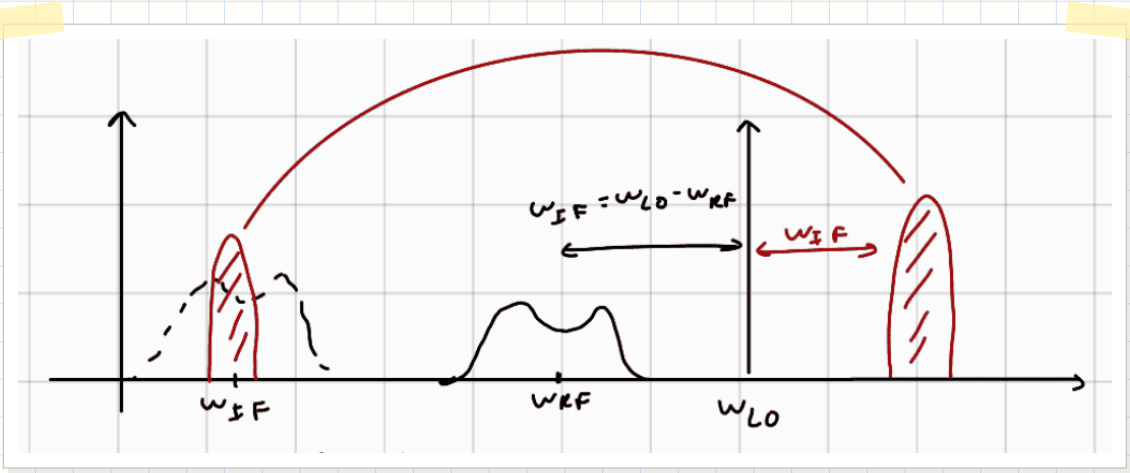
Spectrum Inversion

High-side Injection

Image Frequency: Hayal Frekans



original drawing, p. 5



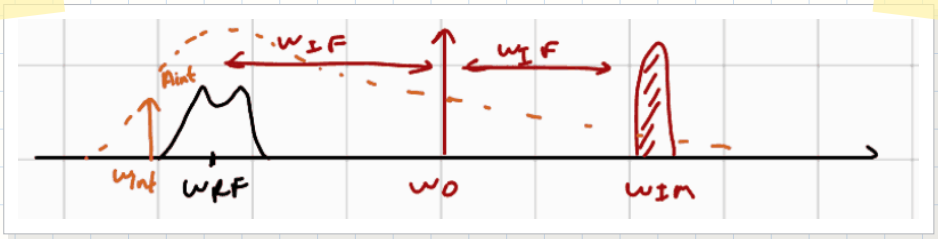
original drawing, p. 5

$$\omega_{IM} - \omega_{LO} = \omega_{IF}$$

$$\omega_{LO} - \omega_{RF} = \omega_{IF}$$

2 scenarios

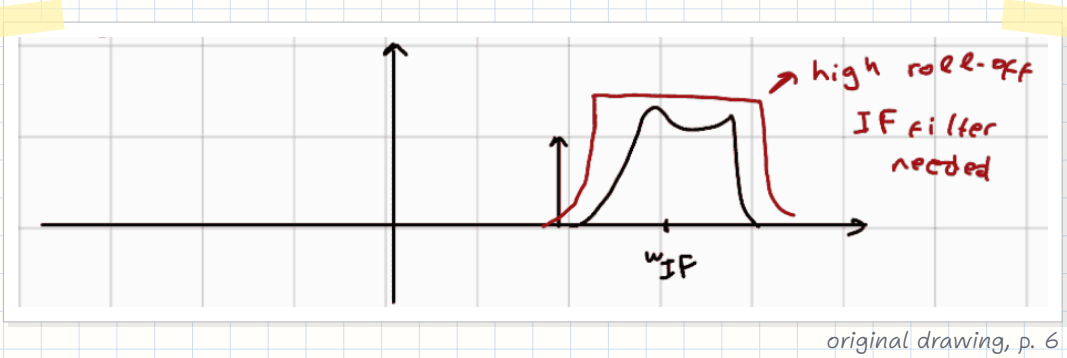
1) ω_{LO} far from ω_{RF} and high ω_{IF}



original drawing, p. 5

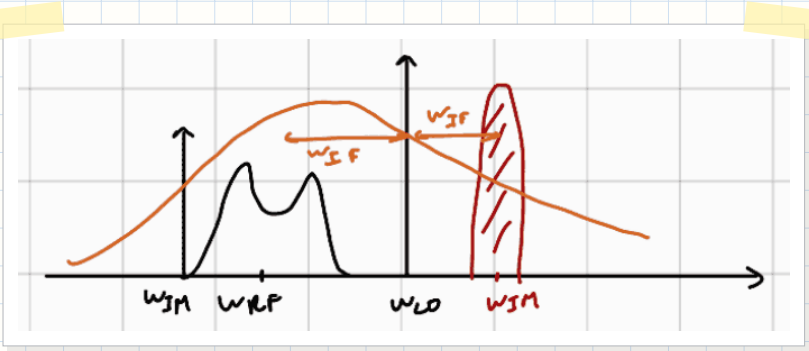
orig. p. 6

IF bölgesi



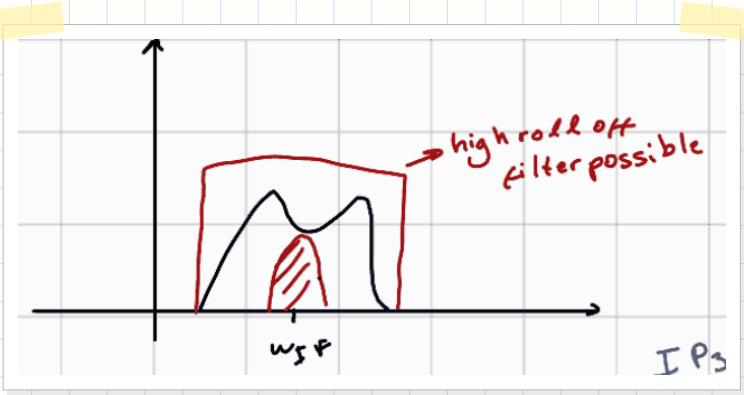
original drawing, p. 6

2) ω_{LO} close to ω_{RF} and low ω_{IF}



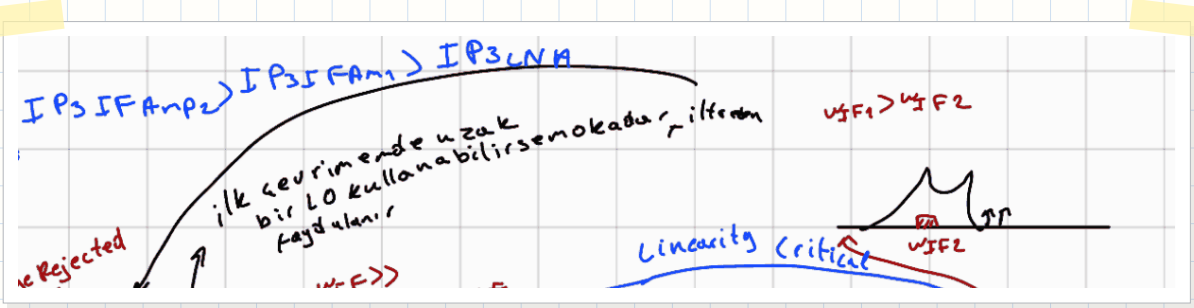
original drawing, p. 6

$\omega_{IF2} < \omega_{IF1}$

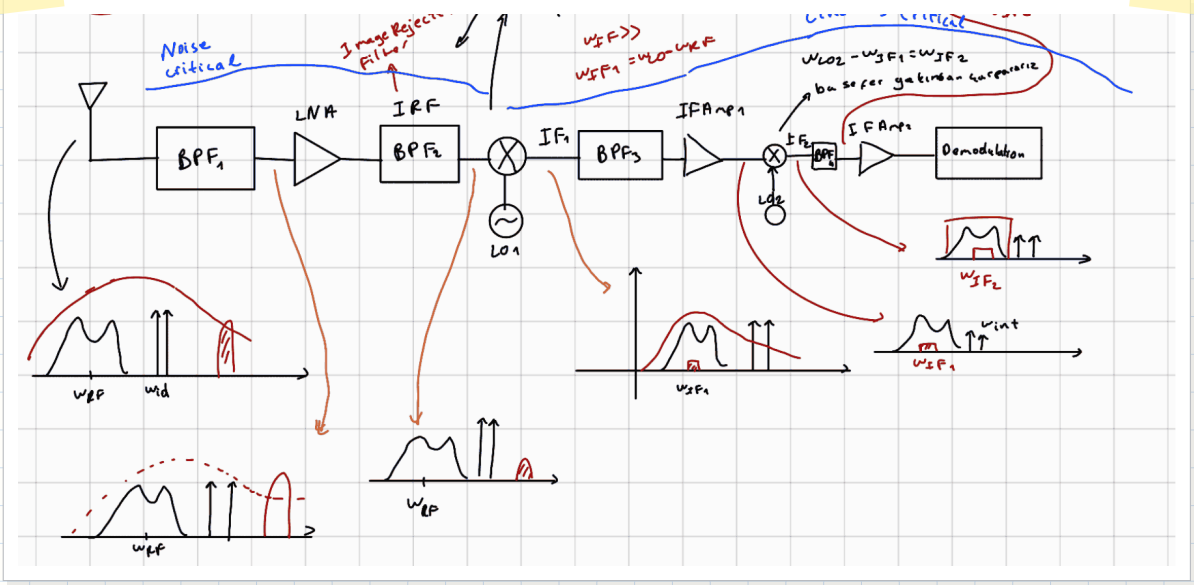


original drawing, p. 6

Dual Conversion Receiver



original drawing, p. 6



original drawing, p. 6