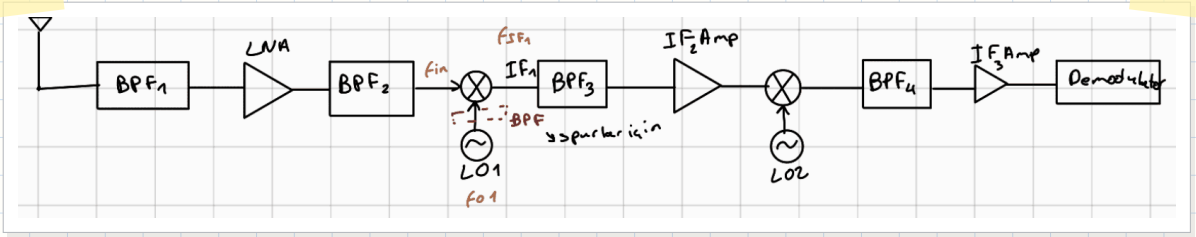
# RF Tasarım

## Dual conversion, zero-IF, sliding IF ve dual band alıcılar

Orijinal not: Ders-11.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.*

orj. s. 1




orijinal çizim, s. 1

Sondaki Amp'nin lineerliği en büyük olmalı

$$IIP_3 > IIP_2 > IIP_1$$

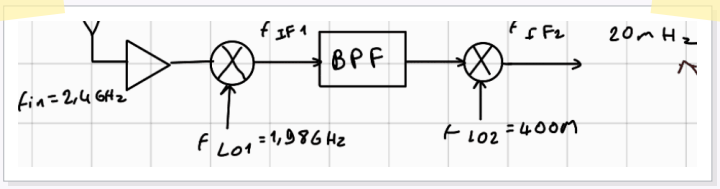
$$IIP1_3 > IIP1_2 > IIP1_1$$

$$\left.\begin{aligned} x_{LO}(t) = {} & A_{LO1}\cos(2\pi f_{LO1}t) \\ & + A_2\cos(2\pi\, 2f_{LO1}t) \\ & + \cdots\cos(2\pi\cdots f_{LO1}t) \end{aligned}\right\} \quad f_{in} \pm mf_{LO1} \text{ (expected spurs freq)}$$

mixing spurs

$f_{in} \pm mf_{LO1} \pm nf_{LO2} \rightarrow$ expected mixing spurs in dual conversion

### Örnek

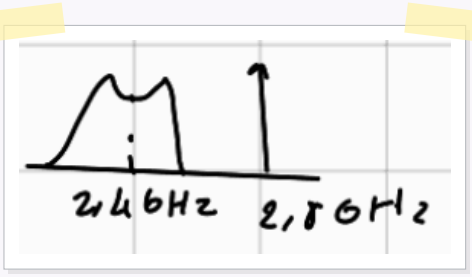



orijinal çizim, s. 1

$$f_{IF1} = |f_{in} - f_{LO1}| = 2{,}4\,\text{GHz} - 1{,}98\,\text{GHz} = 420\,\text{MHz}$$

$$f_{IF2} = |f_{IF1} - f_{LO2}| = 420 - 400 = 20\,\text{MHz}$$

$f_{LO2}$ ($2^{nd}$ harmonic) = 800 MHz




orijinal çizim, s. 1

$$\underset{f_{in}}{2{,}8\ \text{GHz}} - \underset{f_{LO1}}{1{,}98\ \text{GHz}} - \underset{f_{LO2}(2^{nd})}{800\ \text{MHz}} = 20\ \text{MHz} \quad \text{aynı}$$

dBc, carrier'e göre

| $nf_{LO} \backslash mf_{RF}$ | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 0 | | | | | | |
| 1 | | 0 | −20 | −30 | −40 | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | −60 | −80 | −70 | |

$f_{RF} = 2\ \text{GHz}$
$f_{LO} = 1{,}9\ \text{GHz}$
$f_{IF} = 100\ \text{MHz}$

orj. s. 2

# Dual Conversion receivers

## Disadvantages:

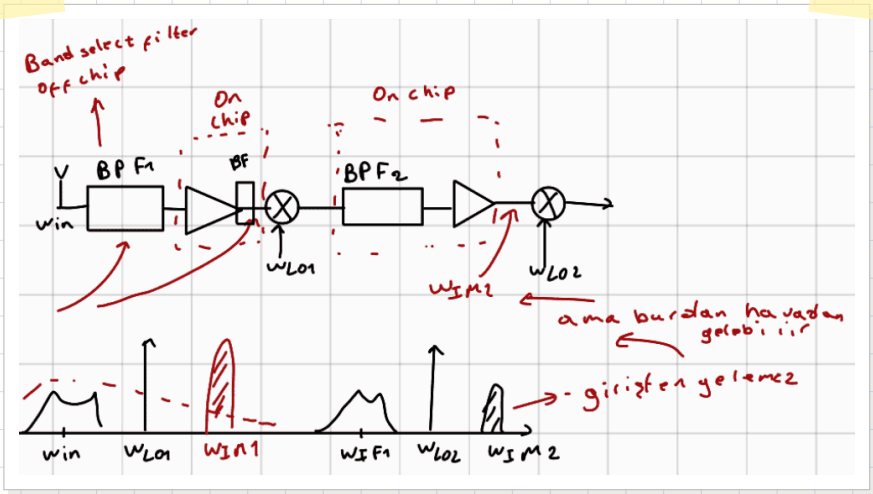
- 2 tane local oscillators
- More mixing spurs
- Several passive filters

## Advantages:

- Robust
  clear choice for high sensitive radio receivers
- High dynamic Range
- Power consumption is lower
- Secondary Image frequency



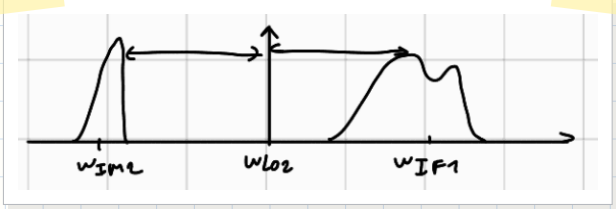

orijinal çizim, s. 2



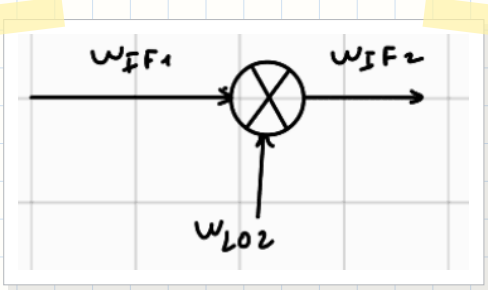

orijinal çizim, s. 2

havadan sızdığı engellemek için sistem tasarımında dikkat veya sistemden ortaya çıkabilir.

## Removing Secondary Image




orijinal çizim, s. 2

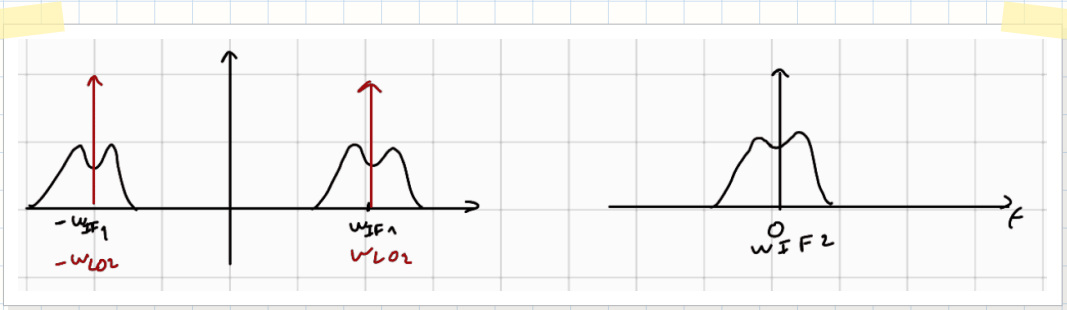



orijinal çizim, s. 2

### Zero-IF (Homodyne)

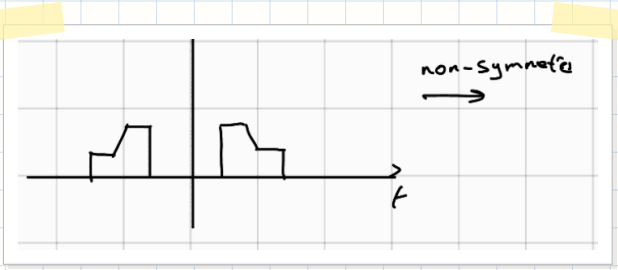
$$\omega_{IF2} = 0 = |\omega_{IF1} - \omega_{LO2}|$$

$$\omega_{LO2} = \omega_{IF1}$$

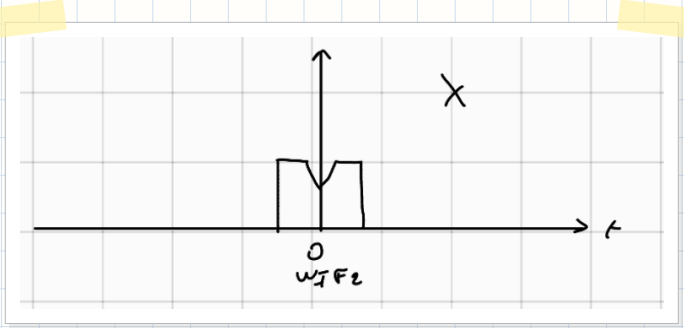



orijinal çizim, s. 2

orj. s. 3 eğer simetrik değilse




orijinal çizim, s. 3



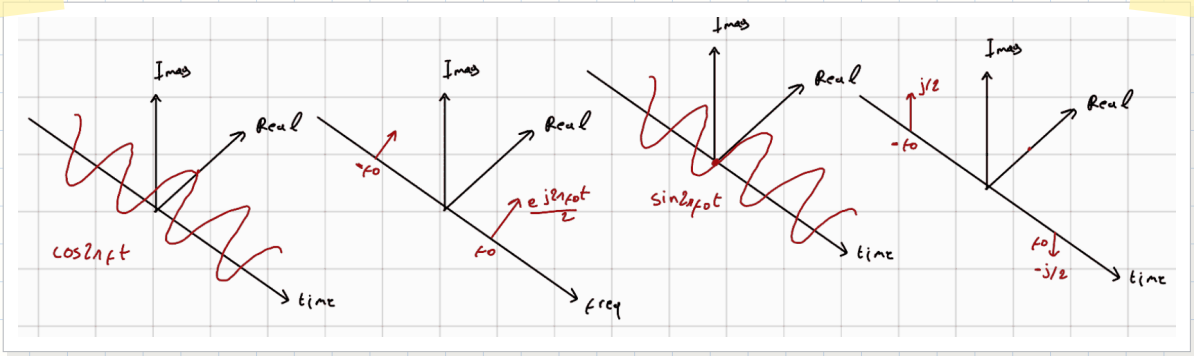

orijinal çizim, s. 3

## Quadrature Signals & Quadrature Down conversion

$$\cos 2\pi f_0 t = \frac{e^{j2\pi f_0 t}}{2} + \frac{e^{-j2\pi f_0 t}}{2} \xrightarrow{F} \frac{1}{2}\left[\delta(f-f_0) + \delta(f+f_0)\right] \rightarrow \text{real}$$

$\downarrow$ 90° phase shift

$$\sin 2\pi f_0 t = j\frac{e^{-j2\pi f_0 t}}{2} - j\frac{e^{j2\pi f_0 t}}{2} \xrightarrow{F} \frac{j}{2}\left[-\delta(f-f_0) + \delta(f+f_0)\right] \rightarrow \text{Imag.}$$




orijinal çizim, s. 3

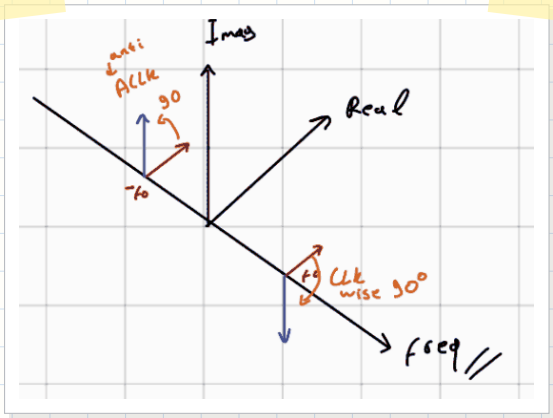
$$\cos(\omega_c t - 90^\circ) = \frac{e^{j(\omega_c t - 90)}}{2} + \frac{e^{-j(\omega_c t - 90)}}{2}$$

$$= \frac{e^{j\omega_c t}}{2} e^{-j90} + \frac{e^{-j\omega_c t}}{2} e^{j90}$$

$$e^{-j90} = \cos 90 - j \sin 90 = -j$$

$$e^{j90} = \cos 90 + j \sin 90 = j$$

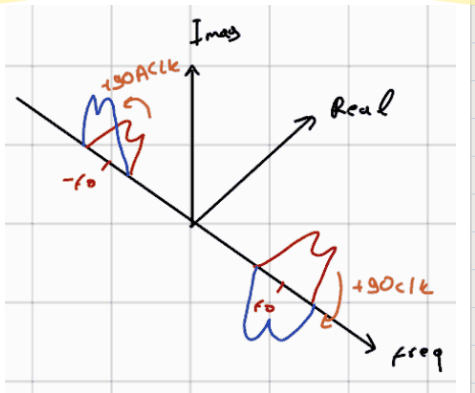
$$= -j \frac{e^{j\omega_c t}}{2} + j \frac{e^{-j\omega_c t}}{2} = \sin(\omega_c t)$$



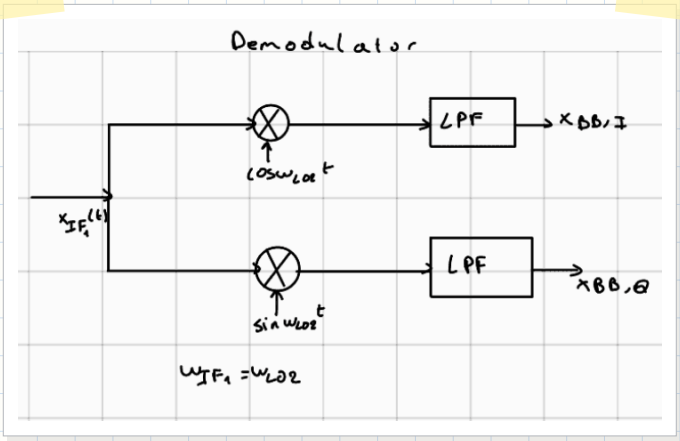

orijinal çizim, s. 3

Positive frequency +90° Clkwise
Negative " +90° Aclkwise

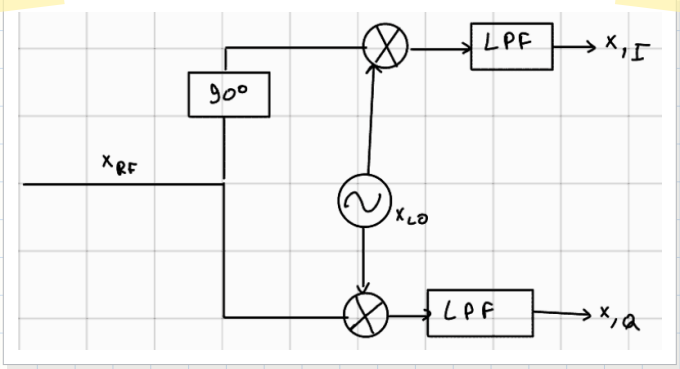
orj. s. 4



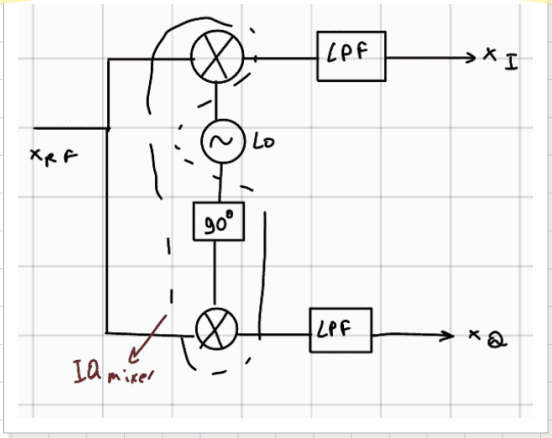

orijinal çizim, s. 4



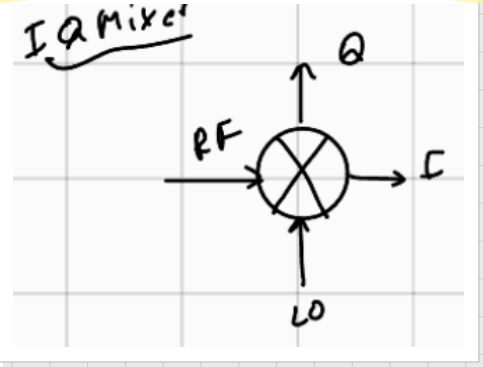

orijinal çizim, s. 4



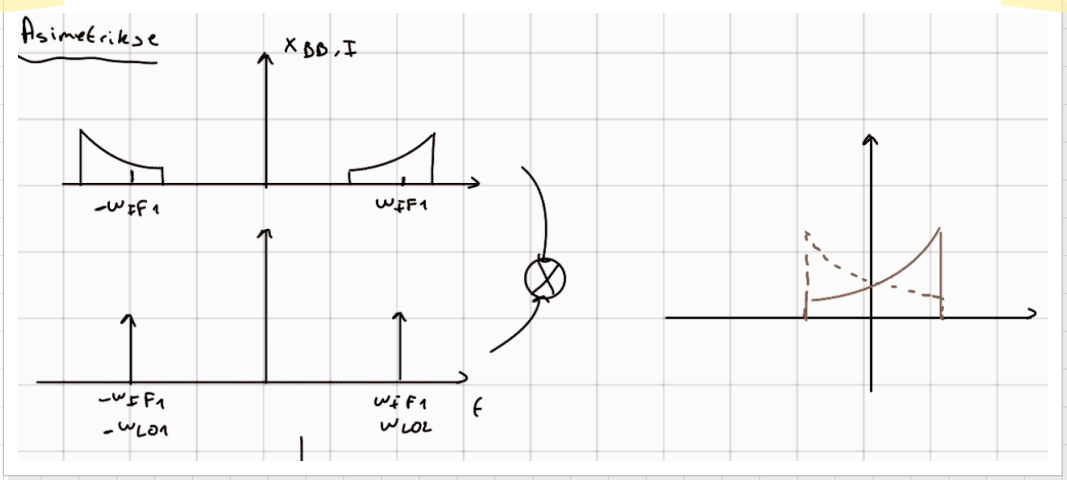

orijinal çizim, s. 4




orijinal çizim, s. 4

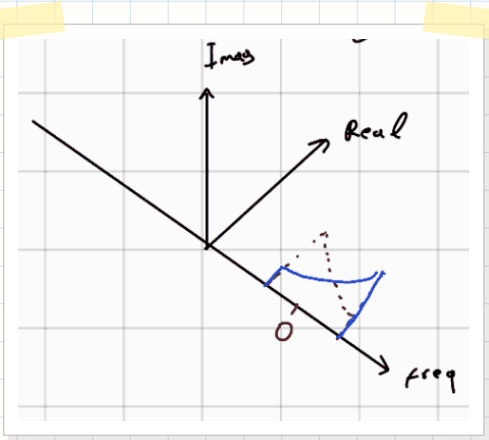



orijinal çizim, s. 4

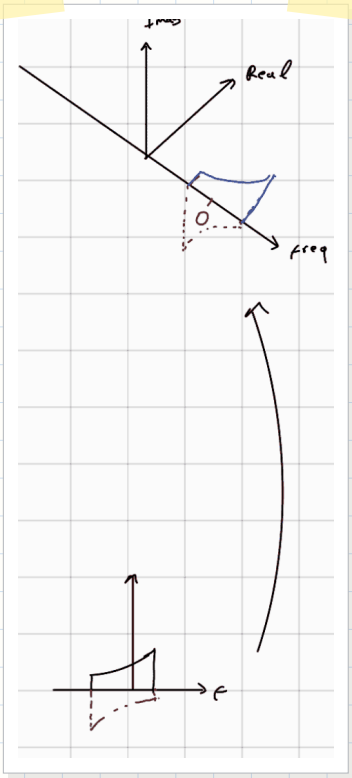



orijinal çizim, s. 4

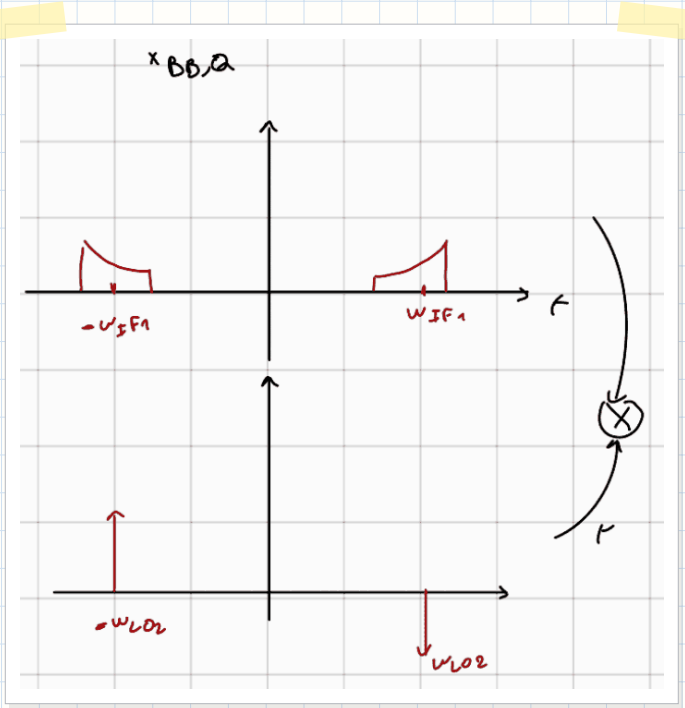
orj. s. 5



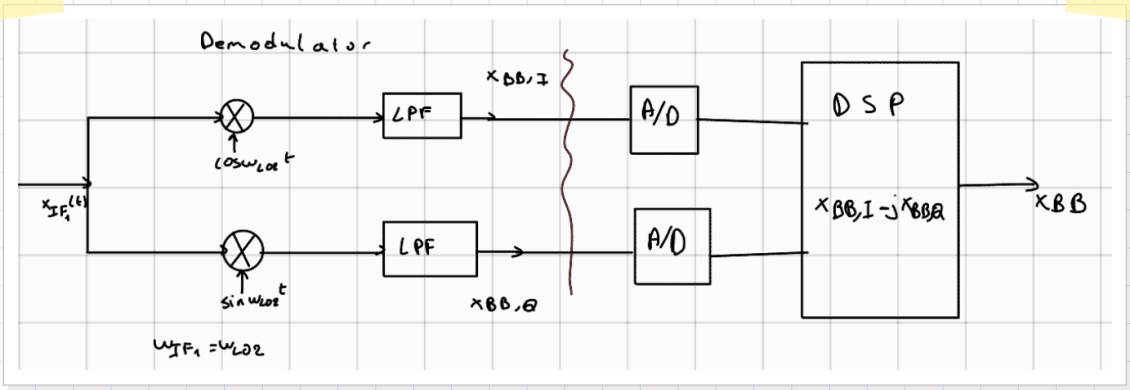

orijinal çizim, s. 5




orijinal çizim, s. 5

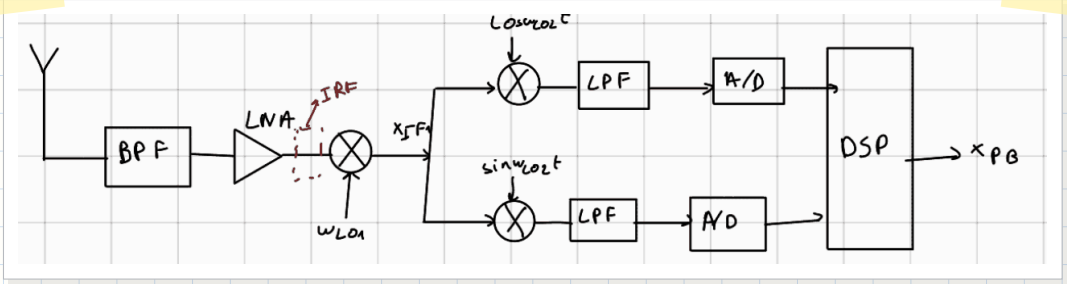



orijinal çizim, s. 5



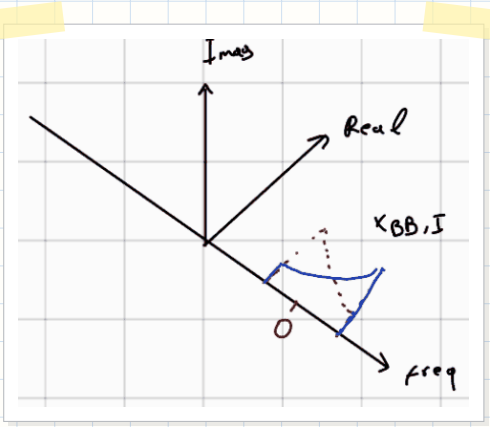

orijinal çizim, s. 5

## Zero-(Second) IF Heterodyne Receiver



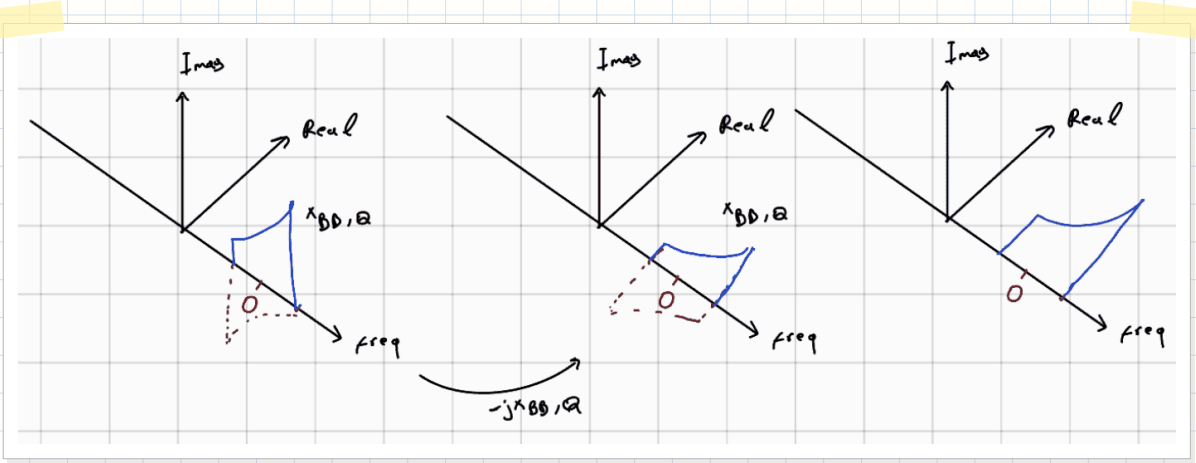

orijinal çizim, s. 5

orj. s. 6



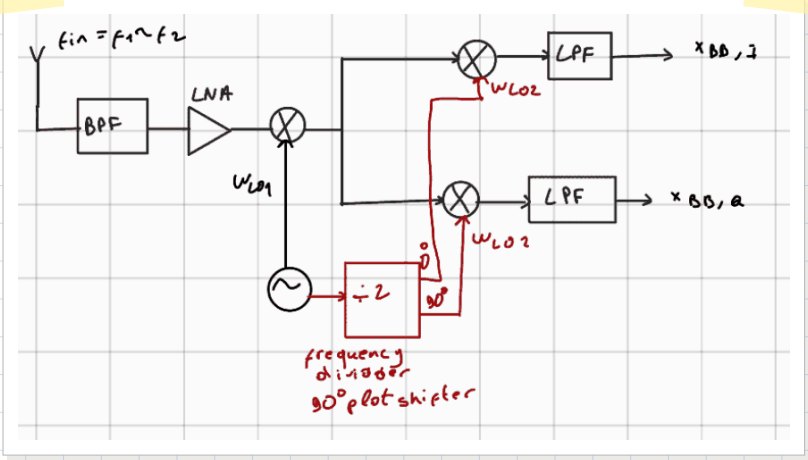

orijinal çizim, s. 6

$$x_{BB,I}(t) - j x_{BB,Q}$$




orijinal çizim, s. 6

## Sliding IF Receiver



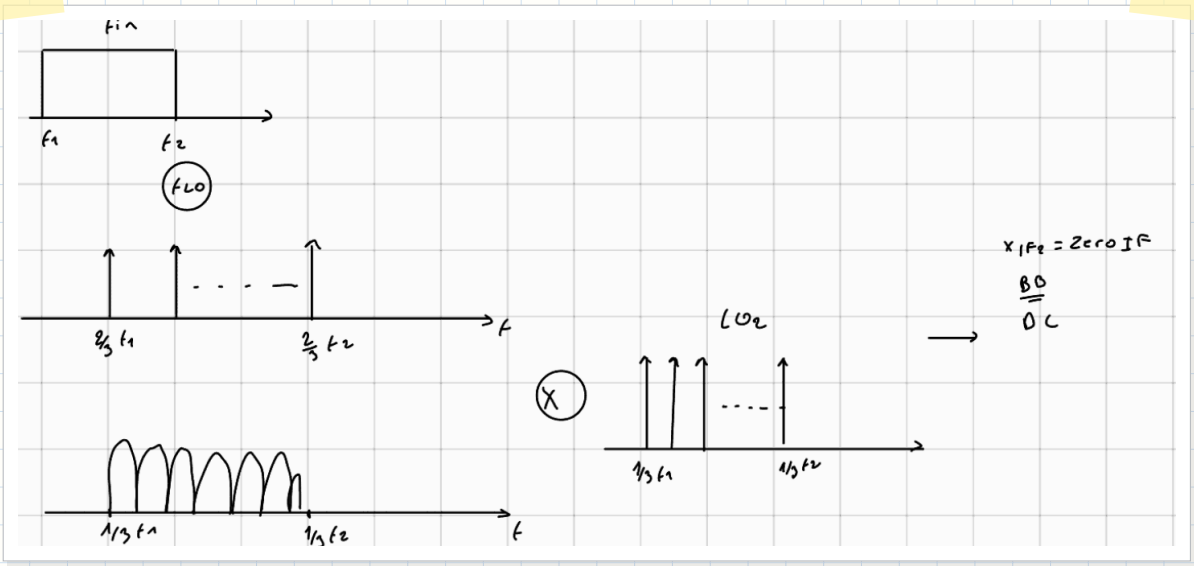

orijinal çizim, s. 6

$$f_{LO2} = \frac{1}{2} f_{LO1}$$

(zero-IF) $$|f_{in} - f_{LO1} - f_{LO2}| = 0$$

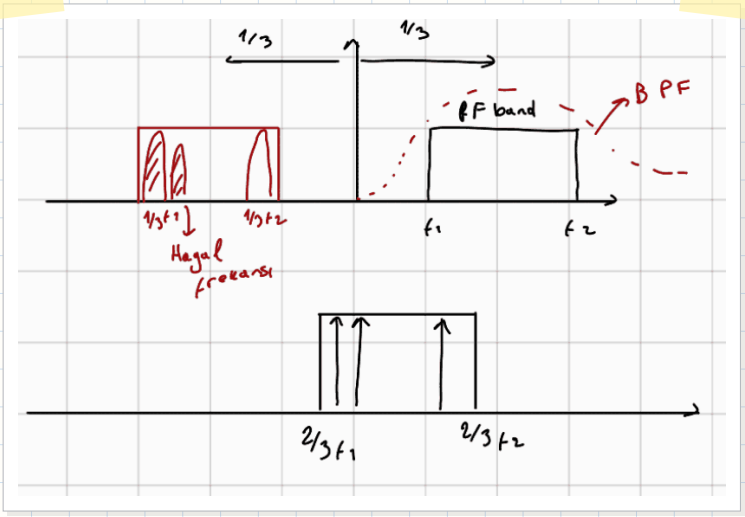
$$f_{in} - f_{LO1} - \frac{1}{2} f_{LO1} = 0 \quad \Rightarrow \quad f_{LO1} = \frac{2}{3} f_{in}$$

$$\Rightarrow \quad f_{IF1} = \frac{1}{3} f_{in}$$




orijinal çizim, s. 6

orj. s. 7




orijinal çizim, s. 7

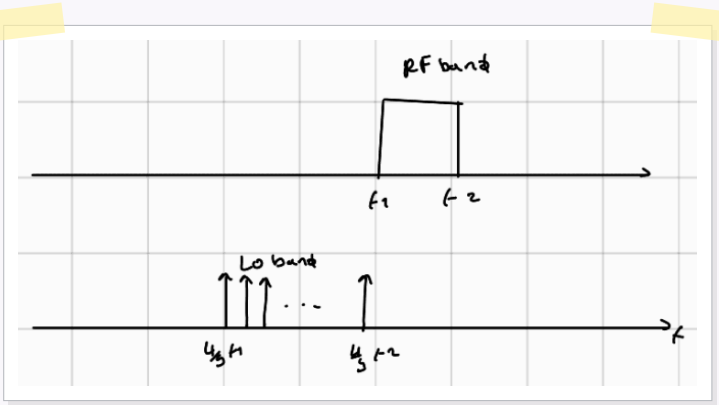
Both BPF and LNA reject the Image

**Örnek**

$$f_{LO2} = \frac{1}{4} f_{LO1}$$

$$|f_{in} - f_{LO1} - f_{LO2}| = 0$$

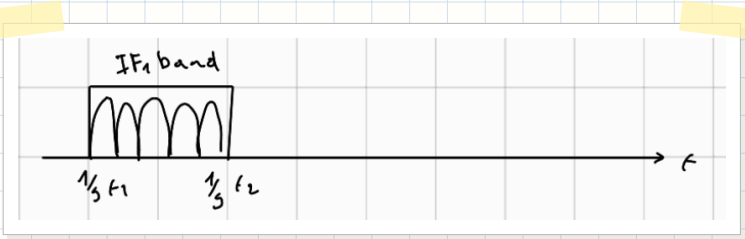
$$f_{in} - f_{LO1} - \frac{1}{4} f_{LO1} = 0 \rightarrow f_{LO1} = \frac{4}{5} f_{in} \rightarrow f_{IF1} = \frac{1}{5} f_{in}$$




orijinal çizim, s. 7

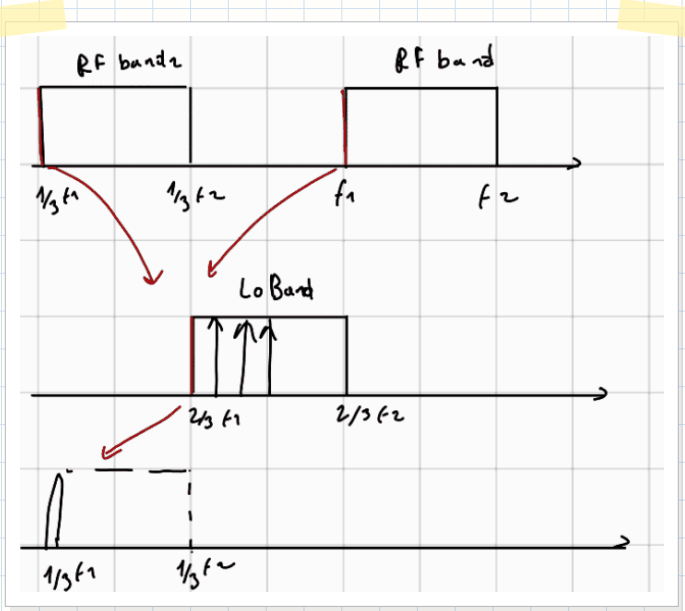
RF bandına LO yaklaşınca image rejection zor olur

1/8 gibi bir şey kullanma image rejection zor olur



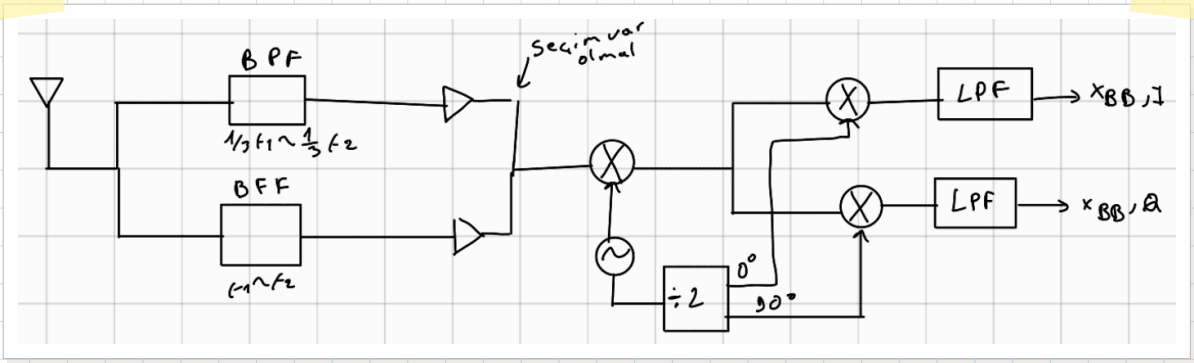

orijinal çizim, s. 7

## Dual Band Receiver




orijinal çizim, s. 7

orj. s. 8

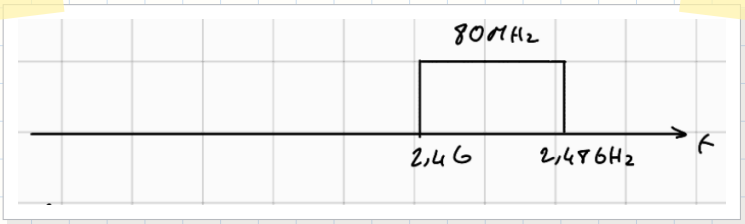



orijinal çizim, s. 8

## 802.11g (Wi-Fi standardı)

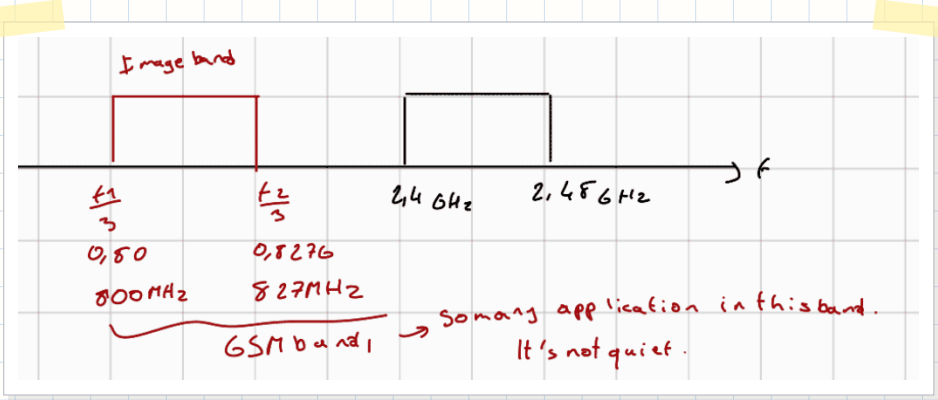
÷2 =?

÷4 =?



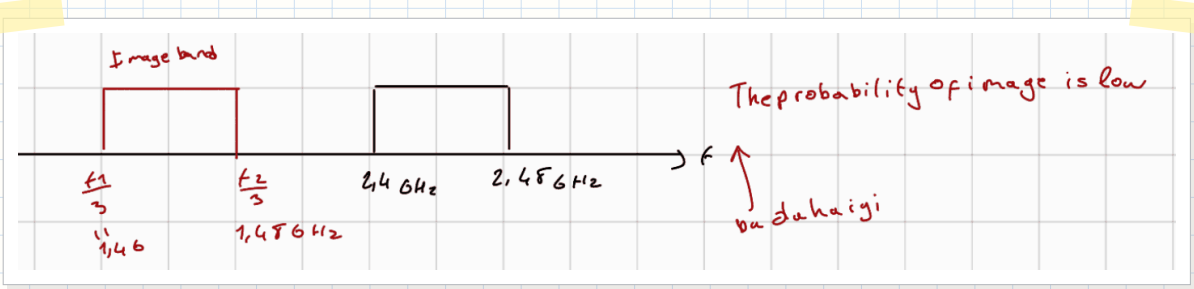

orijinal çizim, s. 8

÷2




orijinal çizim, s. 8

÷4




orijinal çizim, s. 8

**Örnek**

Çalışma sorusu 802.11a, ÷8 structure sliding Receiver




orijinal çizim, s. 8

1) Image Band?
2) Mixing spurs in results of mixing with 3rd harmonic of the first LO & 3rd harmonic of second LO

$$f_{in} - \overset{3=?}{n} f_{LO1} - f_{LO2} = 0$$

$$f_{in} - f_{LO1} - n f_{LO2} = 0$$