RF Tasarım

Faz kaydırma, Hartley/Weaver, image rejection

Orijinal not: Ders-13-2.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.*

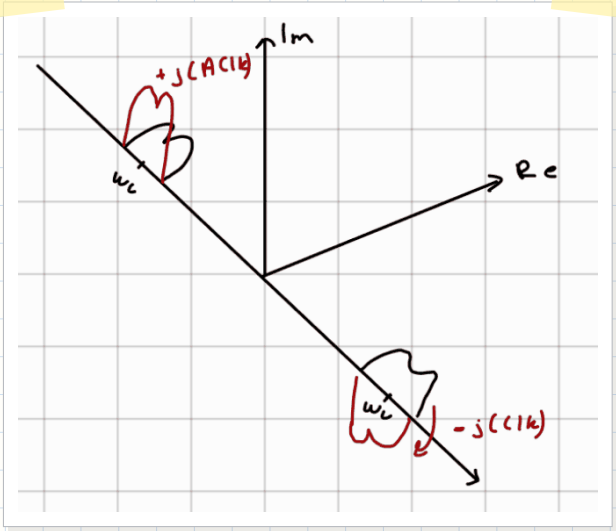
orj. s. 1

90° Phase Shift

$$A(t)\cos(\omega_c t + \phi(t) + 90^\circ) = A(t)\left\{\frac{e^{j[\omega_c t+\phi(t)-90^\circ]}}{2} + \frac{e^{-j[\omega_c t+\phi(t)-90^\circ]}}{2}\right\}$$

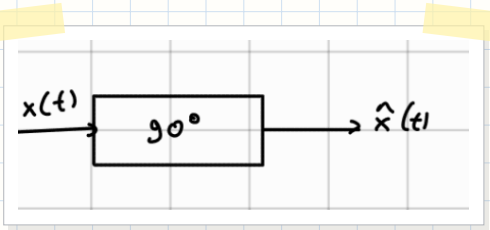
$$= A(t)\left\{-j\underbrace{\frac{e^{j[\omega_c t+\phi(t)]}}{2}}_{\text{positive freq}} + j\underbrace{\frac{e^{-j[\omega_c t+\phi(t)]}}{2}}_{\text{Negative freq}}\right\}$$

$$= A(t)\cdot\sin[\omega_c t + \phi(t)]$$



orijinal çizim, s. 1

Hilbert Transform



orijinal çizim, s. 1

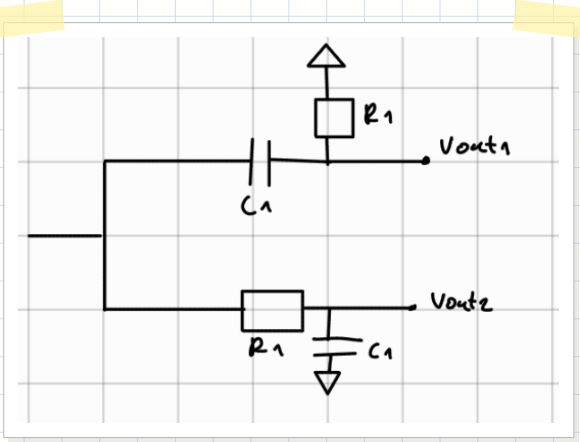
$$H(j\omega) = -j\,\mathrm{sgn}(\omega)$$

$$\mathrm{sgn}(\omega) = \begin{cases} 1 & , \omega > 0 \\ 0 & , \omega = 0 \\ -1 & , \omega < 0 \end{cases}$$

$$I(t) + jQ(t)$$

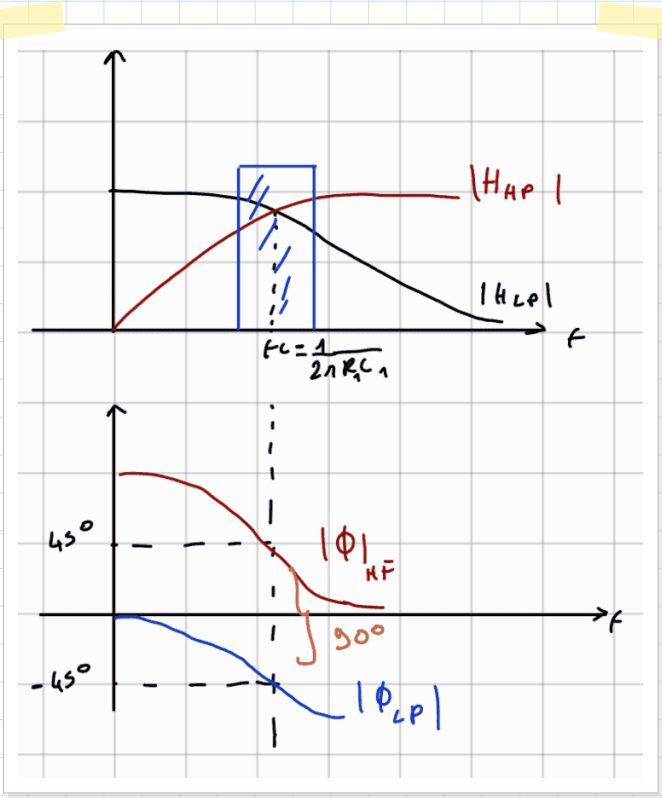
Implementation of 90° phase shift

(1) RC-CR Network



orijinal çizim, s. 1

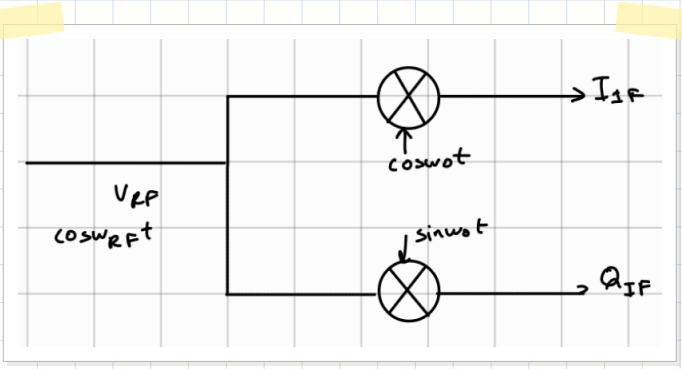
orj. s. 2



orijinal çizim, s. 2

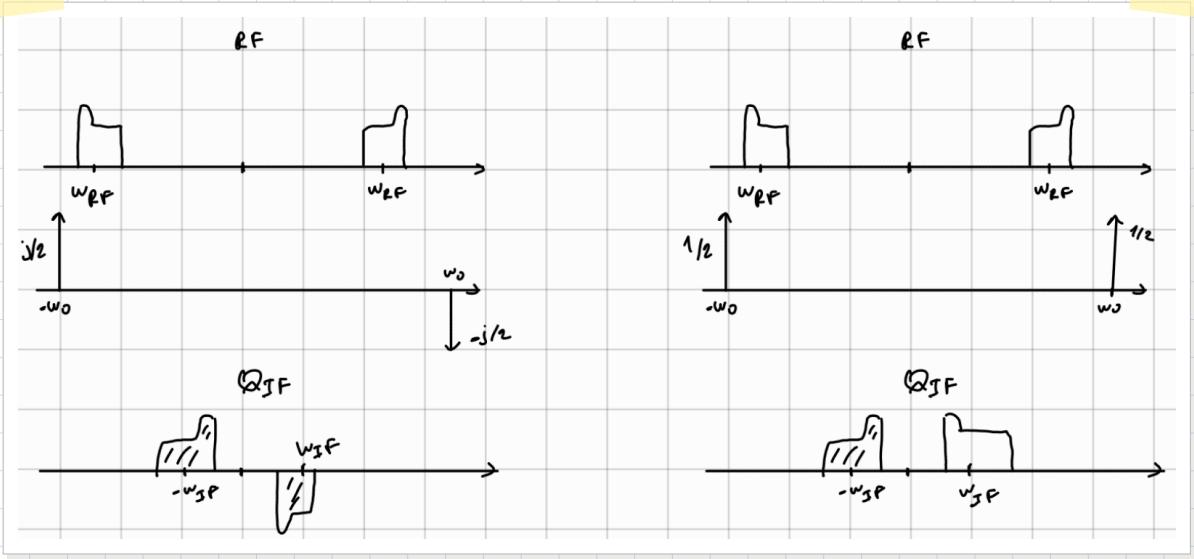
Ama sadece merkez frekansında 90 derece.

(2) Quadrature down Conversion



orijinal çizim, s. 2

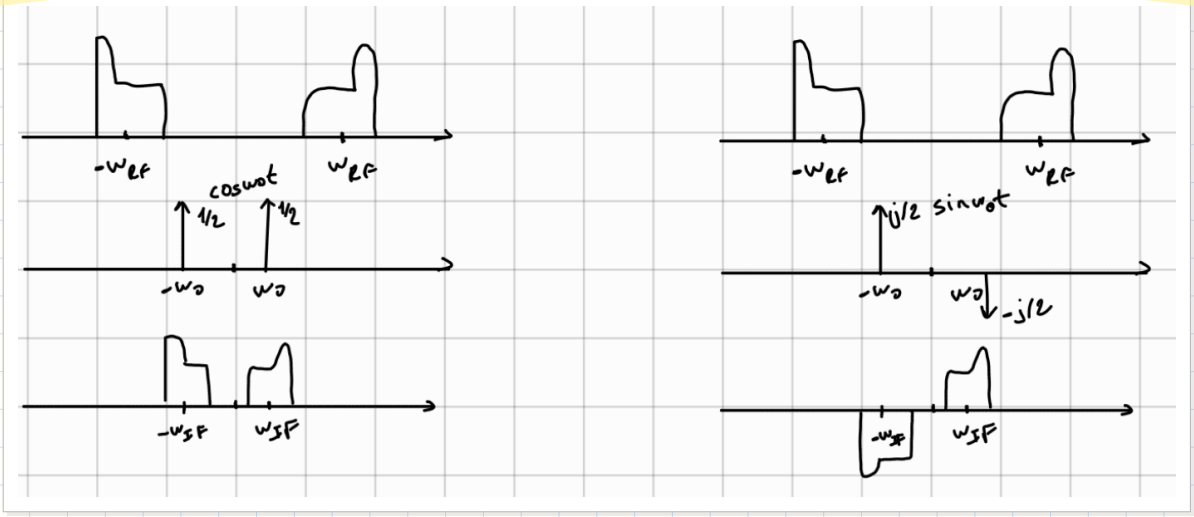
1) $\omega_0 > \omega_{RF} \rightarrow$ High Injection



orijinal çizim, s. 2

orj. s. 3

2) $\omega_0 < \omega_{RF}$ Low injection

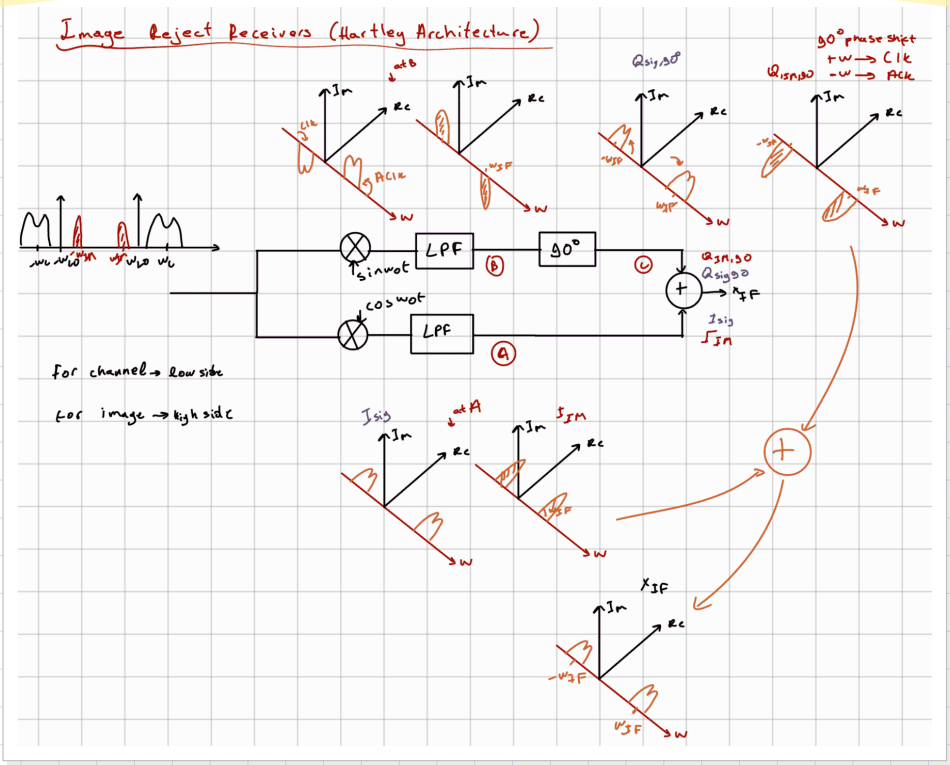


orijinal çizim, s. 3

High side $+\omega_c \rightarrow$ Clk
$-\omega_c \rightarrow$ AClk

Low side $+\omega_c \rightarrow$ AClk
$-\omega_c \rightarrow$ Clk

Image Reject Receivers (Hartley Architecture)



orijinal çizim, s. 3

for channel → low side

for image → high side

orj. s. 4

$$x_{in}(t) = \frac{A_{sig}}{2}\cos[\omega_{RF} + \phi_{sig}] + \frac{A_{im}}{2}\cos(\omega_{im} + \phi_{IM})$$

$$x_A(t) = \frac{A_{sig}}{2}\cos\left[\underbrace{(\omega_{RF} - \omega_{LO})}_{\omega_{IF}}t + \phi_{sig}\right] + \frac{A_{im}}{2}\cos\left[\overbrace{\underbrace{(\omega_{im} - \omega_{LO})}_{-\omega_{IF}}t + \phi_{im}}^{\cos[(\omega_{LO}-\omega_{im})t+\phi_{im}]}\right]$$

$$x_B(t) = -\frac{A_{sig}}{2}\sin\left[\underbrace{(\omega_{RF} - \omega_{LO})}_{\omega_{IF}}t + \phi_{sig}\right] - \frac{A_{im}}{2}\sin\left[\overbrace{\underbrace{(\omega_{im} - \omega_{LO})}_{-\omega_{IF}}t + \phi_{IM}}^{+\sin[(\omega_{LO}-\omega_{im})t+\phi_{IM}]}\right]$$

↓ 90° phase shift

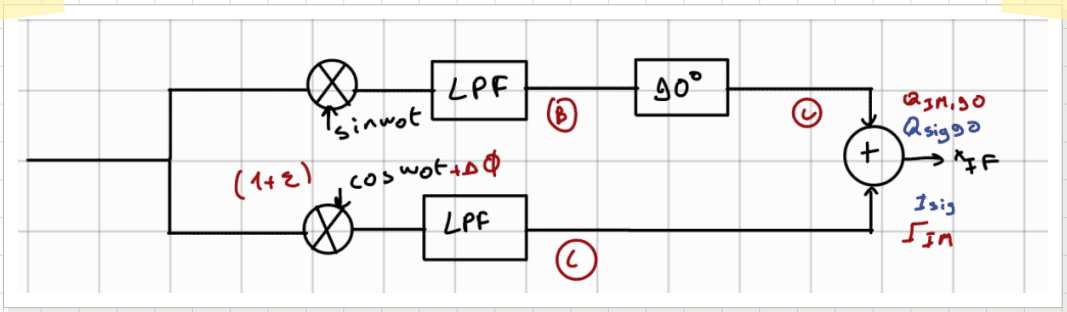
$$x_C(t) = +\frac{A_{sig}}{2}\cos\left[(\omega_{RF} - \omega_{LO})t + \phi_{sig}\right] - \frac{A_{im}}{2}\cos\left[(\omega_{LO} - \omega_{im})t + \phi_{im}\right]$$

$$x_A(t) + x_B(t)^{1} = A_{sig}\cos[\omega_{IF}t + \phi_{sig}]$$

Weaver Architecture

[1] Claude notu: muhtemelen $x_A(t) + x_C(t)$ olmalı.

Çalışma sorusu



orijinal çizim, s. 4

$$x_{sig,out}(t) = \frac{A_{sig}}{2}\cos[(\omega_{RF} - \omega_{LO})t + \phi_{sig}] + \frac{A_{sig}}{2}(1+\varepsilon)\cos[(\omega_{RF} - \omega_{LO})t + \phi_{sig} + \Delta\theta]$$

$$x_{im,out}(t) = \frac{A_{im}}{2}(1+\varepsilon)\cos[(\omega_{im} - \omega_{LO})t + \phi_{im} + \Delta\theta] + \frac{A_{im}}{2}\cos[(\omega_{LO} - \omega_{im})t + \phi_{IM}]$$

In case of phase and gain mismatch (error)

Image can not remove completely

Measure of Image Rejection

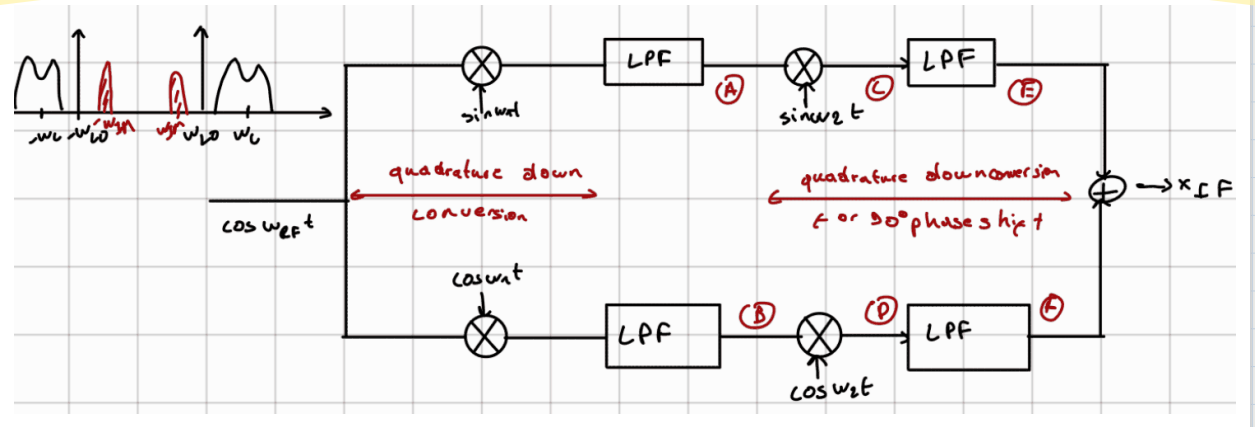
IRR : Image Rejection Ratio

$$\left.\frac{P_{im}}{P_{sig}}\right|_{out} = \frac{A_{im}^2}{A_{sig}^2}\frac{(1+\varepsilon)^2 - 2(1+\varepsilon)\cos\Delta\theta + 1}{(1+\varepsilon)^2 + 2(1+\varepsilon)\cos\Delta\theta + 1}$$

$$A_{im} = A_{sig} \rightarrow \text{for } \left.\begin{matrix}\Delta\theta \ll 1 \\ \varepsilon \ll 1\end{matrix}\right\} \rightarrow IRR = \frac{4}{\varepsilon^2 + \Delta\theta^2}$$

orj. s. 5

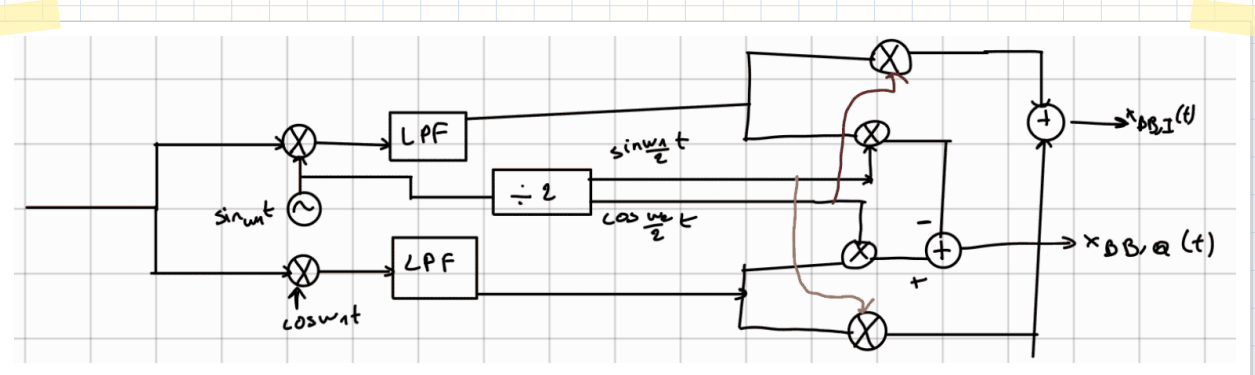
Weaver Architecture for Image Rejection



orijinal çizim, s. 5

ikinci imageden kurtulmak için son kısmı zero if kullanılabilir

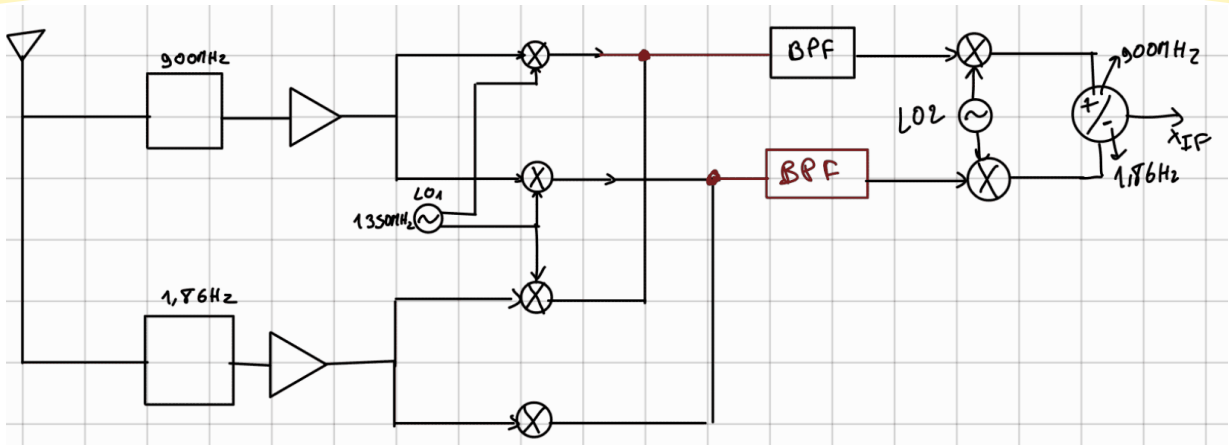
Double quadrature Down Conversion



orijinal çizim, s. 5

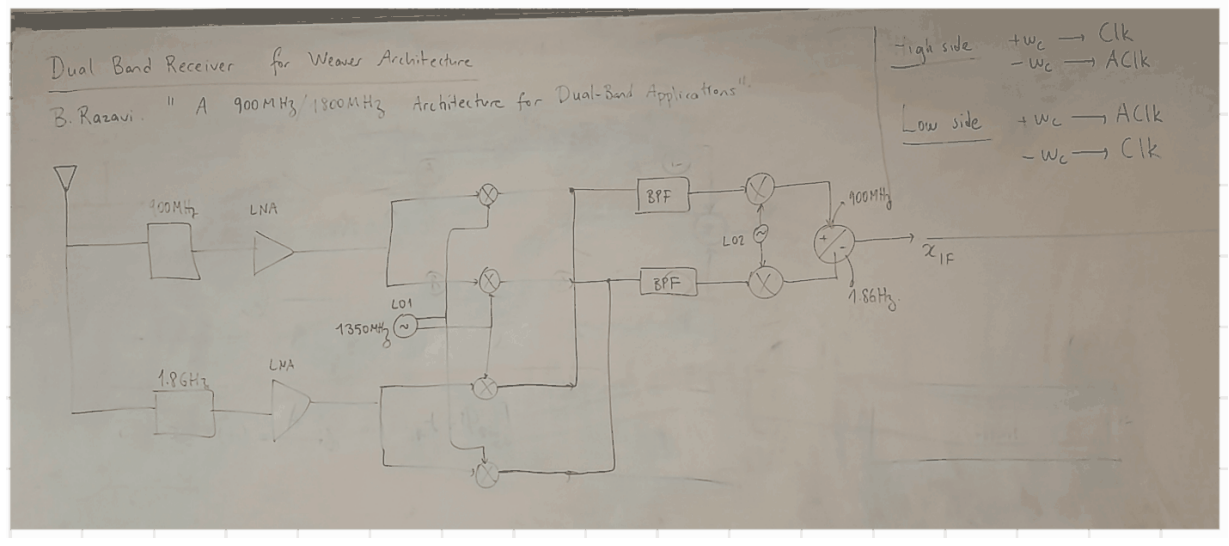
Dual Band Receiver for Weaver Architecture

B. Razavi "A 900MHz/1800MHz Architecture for Dual Band Application"



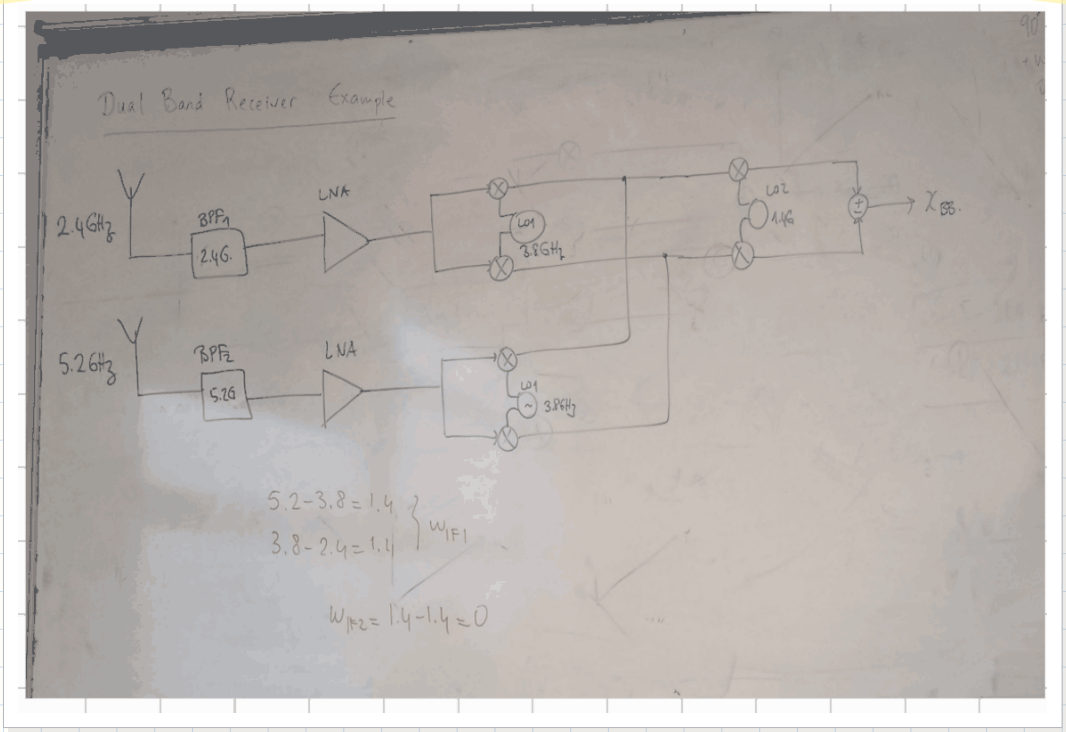
orijinal çizim, s. 5

orj. s. 6



orijinal çizim, s. 6

Dual Band Receiver Example



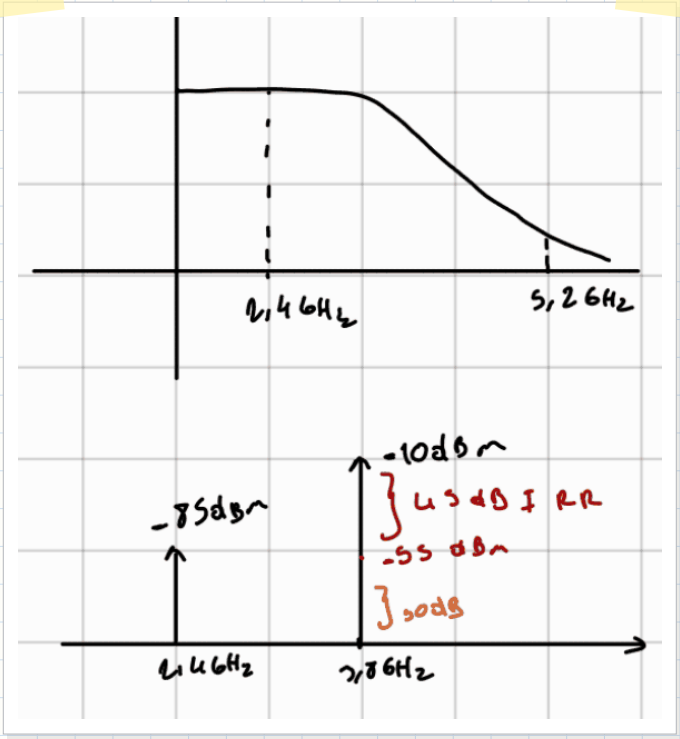
orijinal çizim, s. 6

$$\left.\begin{aligned} 5{,}2 - 3{,}8 &= 1{,}4 \\ 3{,}8 - 2{,}4 &= 1{,}4 \end{aligned}\right\} \omega_{IF1}$$

$$\omega_{IF2} = 1{,}4 - 1{,}4 = 0$$

Örnek Soru

We have signal of −85 dBm at 2,4 GHz and −10 dBm at 5,2 GHz as interferer. What is the amount of rejection in BPF_1 at 5,2 GHz for SNR = 20 dB & IRR = 45 dB



orijinal çizim, s. 6

$$SNR|_{dB} = S_{dBm} - N^{I_{dBm}}_{dBm} \geq 20\ dB$$

$$-85 - N_{dBm} \geq 20\ dB$$

$$N_{dBm} \leq -105\ dBm$$

$$S_{int}|_{dBm} - |BPF|_{dB} - |IRR|_{dB} = N_{dBm} \leq -105\ dBm$$

$$-10\ dBm - |BPF_1|_{dB} - 45 \leq -105\ dBm$$

$$|BPF_1| \geq 50\ dB$$