RF Tasarım

Ders 1 tekrarı: RF temelleri, gürültü, alıcı, anten, filtre

Orijinal not: Ders-1-tekrari.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

Shannon's Capacity Theorem

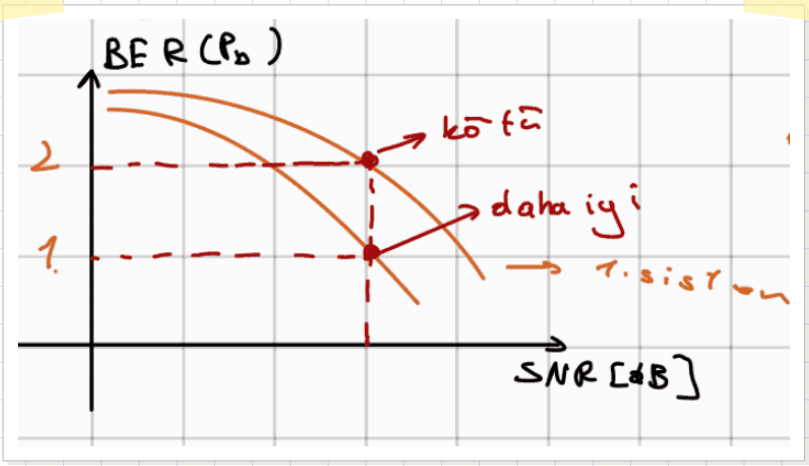
$$C = W \log(1 + SNR)$$

C: kanal kapasitesi $\left(\frac{bit}{sn}\right)$

W: kanalın genişliği (Hz)

SNR: signal to noise ratio $\left(\frac{P_s}{P_n}\right)$

Bit error rate

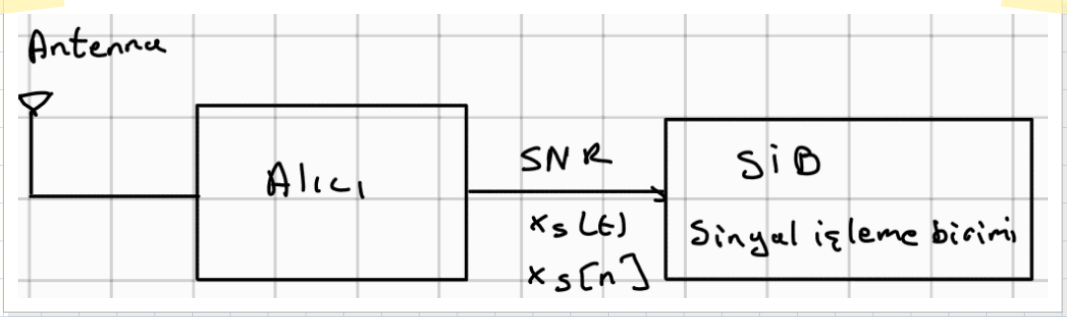


orijinal çizim, s. 1

$$C = W \log(1 + SNR)$$

$C \rightarrow$ kanal kapasite $\left(\frac{bit}{sn}\right)$, $W \rightarrow$ BG

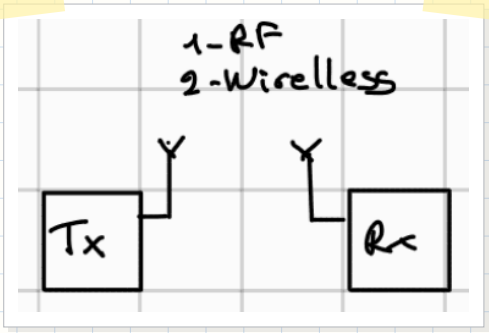
RF ışıma yapar, anten çalıştığı bölgeye göre tasarlanmış olmalı.



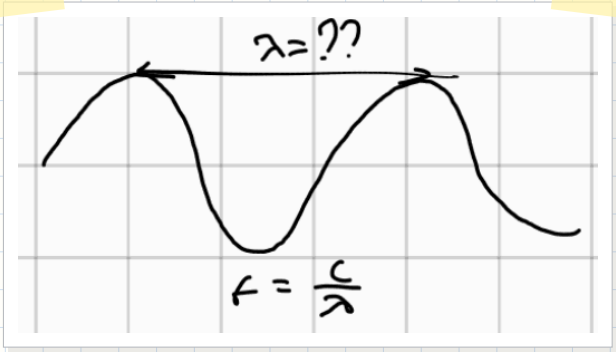
orijinal çizim, s. 1

Gürültüyü minimalize etmeliyiz.

RF: 3khz frekansından 300 GHz'e kadar olan tüm sinyaller. (100 GHz üstü milimeter wave, 10 GHz üstü microwave)



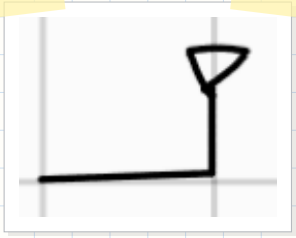
orijinal çizim, s. 1



orijinal çizim, s. 1

	f	$\lambda = \frac{c}{f}$	
VLF: (very low f.)	3 – 30khz	33 km ~ 10 km[1]	Maritime radio navigation (Denizcilikte çok uzun mesafe haberleşme)
LF: (low f.)	30 – 300k	10 km ~ 1 km	
MF: (medium f.)	300k ~ 3M	1 km ~ 100m	AM Radio
HF:	3M ~ 30M	100 m ~ 10 m	aviation, Navigation
			?? radar
VHF:	30M ~ 300M	10 m ~ 1 m	→ TV, FM
UHF:	300M ~ 3G	1 m ~ 100 mm	→ TV, mobile, GPS, Wifi, 4G
SHF:	3G ~ 30 G	100 mm ~ 10 mm	→ Wifi, satellite
EHF:	30G ~ 300 G	10 mm ~ 1 mm	→ Astronomy satellite

orj. s. 2



orijinal çizim, s. 2

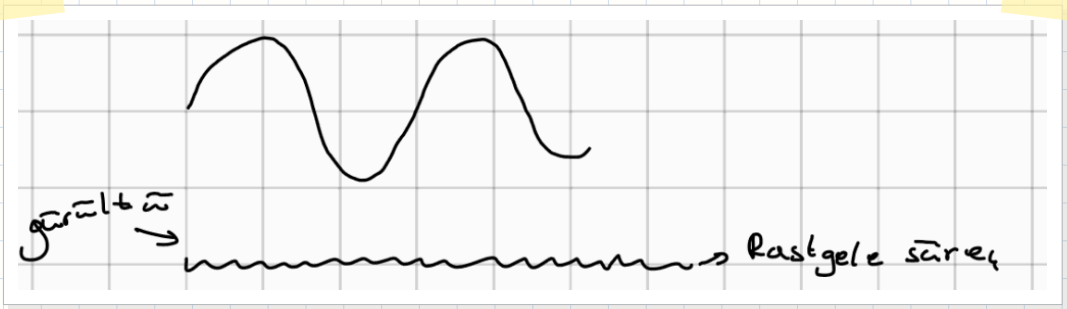
$$L \approx \frac{\lambda}{4} \quad \text{(Anten boyu)}$$

$$L = \frac{\lambda}{4}$$

frekans büyüdükçe anten küçülür.

$$f = \frac{c}{\lambda} \Rightarrow \lambda = \frac{c}{f}$$

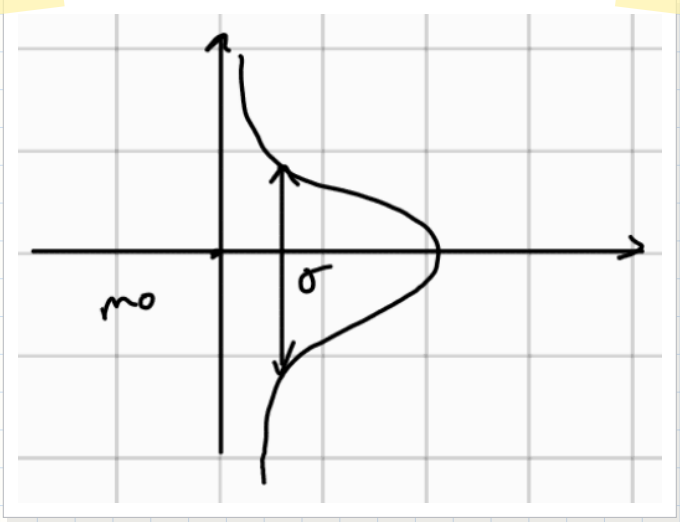
Noise



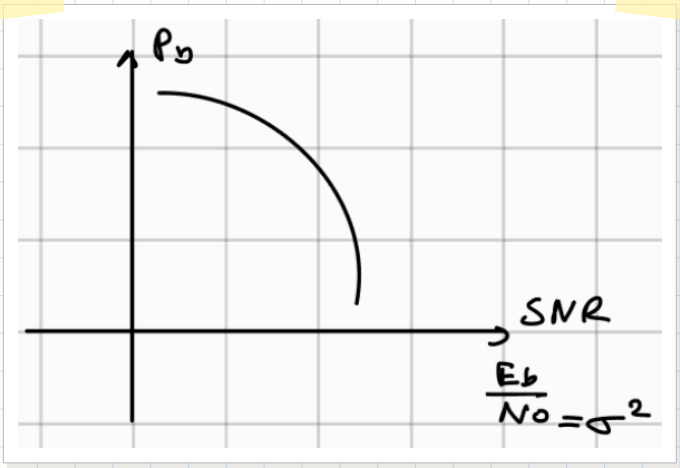
orijinal çizim, s. 2

varyans gürültü

[1] Claude notu: muhtemelen 100 km olmalı.

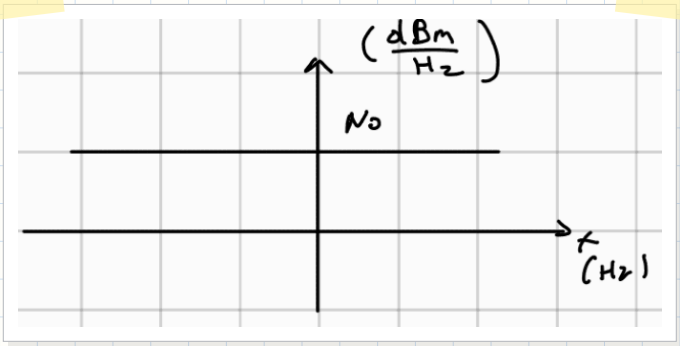


orijinal çizim, s. 2



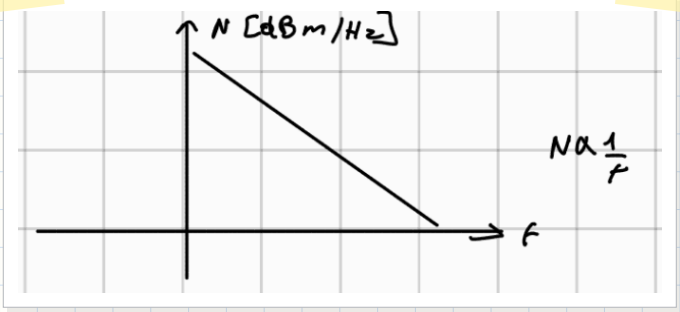
orijinal çizim, s. 2

White noise



orijinal çizim, s. 2

Pink noise



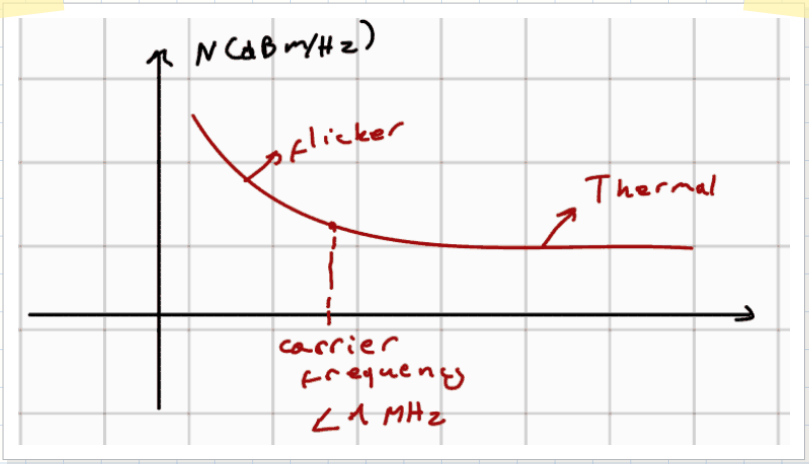
orijinal çizim, s. 2

White Noise ~ Thermal Noise (Shot Noise) [→ White Noise $N(m_0, \sigma)$]

Flicker Noise $\left(\frac{1}{f^n} \text{ noise}\right)$ ~ Pink noise

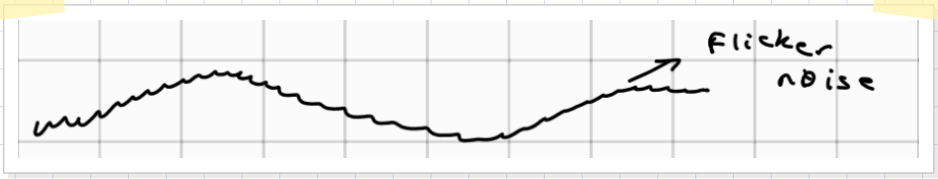
(Low frequency)

orj. s. 3 + Üst üste ?gelirler



orijinal çizim, s. 3

SNR oranı



orijinal çizim, s. 3

$$SNR = \frac{P_s\,[W]}{P_n\,[W]} \qquad [\cdot]^{\text{birimsiz}}$$

$$SNR\,[dB] = 10 \log \left[\overbrace{\frac{P_s}{P_n}}^{SNR} \right] dB$$

$$10\log[2\cdot SNR] = \underbrace{10\log 2}_{3\,db} + 10\log[SNR]$$

log[SNR] birimi: bel
10 log[SNR] decibel

2 kat arttırırsak 3db
10 kat arttırırsak 10 db ? okunamadı
100 kat " 20 db

$$SNR\,[dB] = 10\log\left(\frac{P_s}{P_n}\right)$$

$$10\log[2\,SNR] = \underbrace{10\log 2}_{} + 10\log[SNR]$$

2 kat artarsa 3db artar

$$10\log\left[\frac{P_s}{1\,W}\right] \rightarrow dBW$$

$$10\log\left[\frac{P_s}{1\,mW}\right] \rightarrow dBm$$

$$10\log\left[\frac{P_s}{1\,W}\right] \rightarrow dBW$$

$$10\log\left[\frac{P_s}{1\,mW}\right] \Rightarrow dBm$$

$$10\log(10) = 10\ dB$$

2 kat

$$10\log(20) = 13\ dB$$

$$10\log(40) = 16\ dB$$

$$10\log(80) = 19\ dB$$

$$10\log(100) = 20\ dB$$

$$10\log[P_s] + 10\log\left[\frac{1}{\underbrace{1\,mW}_{10^{-3}\,W}}\right] = \left(P_s\,[dBW] + 30\,dB\right)\ (dBm)$$

$$dBW + 30\,dB = dBm$$

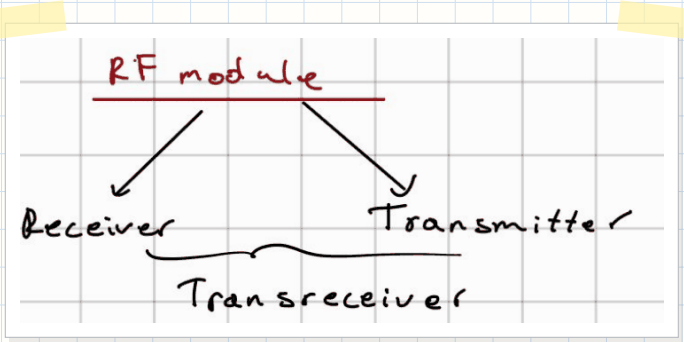
$$\underbrace{10\log P_s}_{dBW} + \underbrace{10\log\left(\frac{1}{10^{-3}}\right)}_{30\,dB}$$

$$dBW + 30\,dB = dBm$$

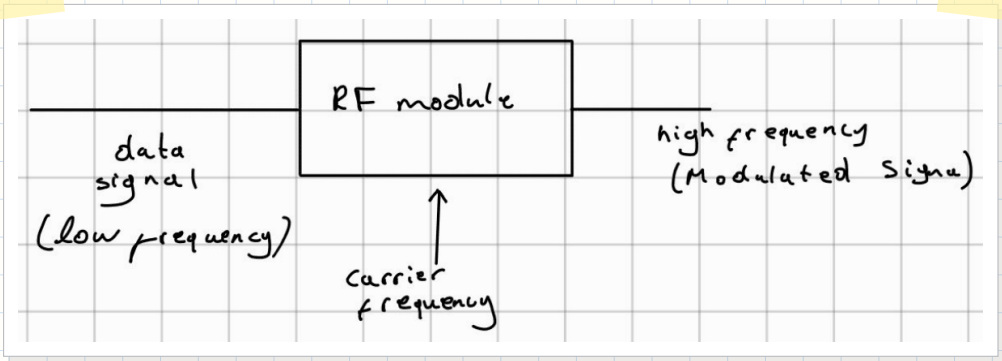
$$10\log\left[\frac{1\,mW}{1\,mW}\right] = 0\ dBm$$

$$10 \log \left[\frac{10\,\text{mW}}{1\,\text{mW}} \right] = 10\ \text{dBm}$$

orj. s. 4

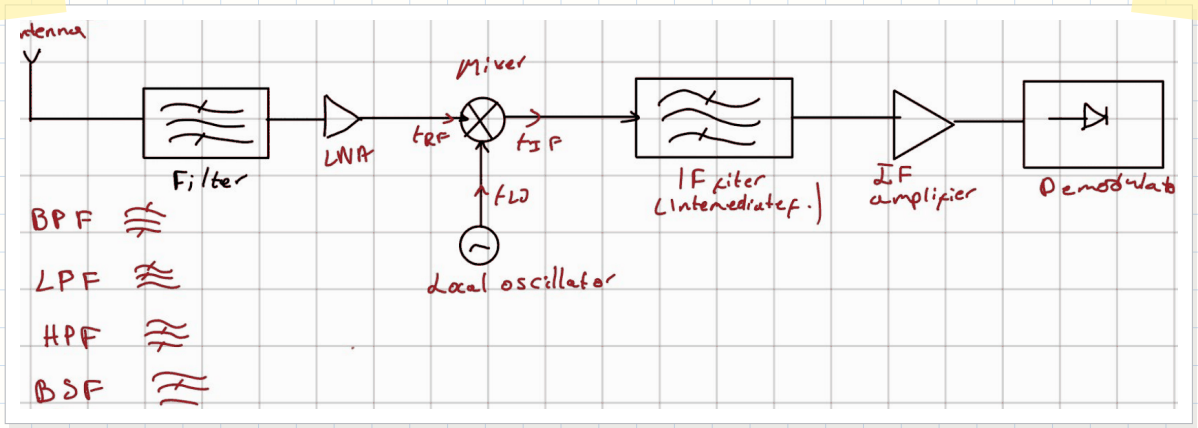


orijinal çizim, s. 4



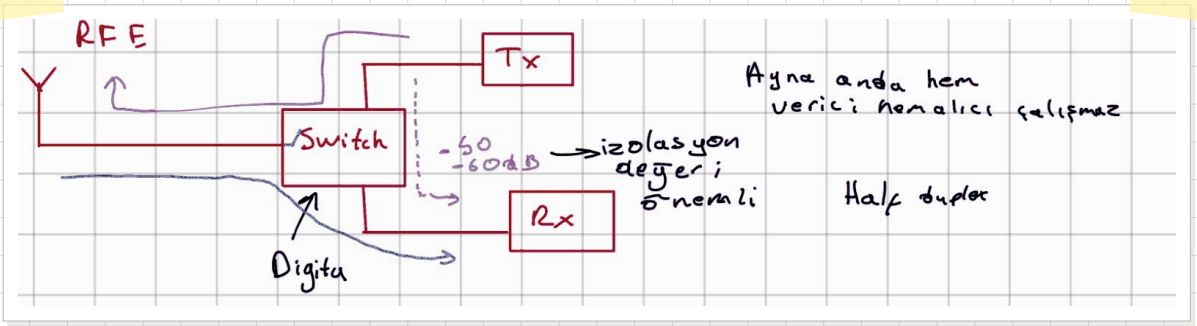
orijinal çizim, s. 4

Reciver

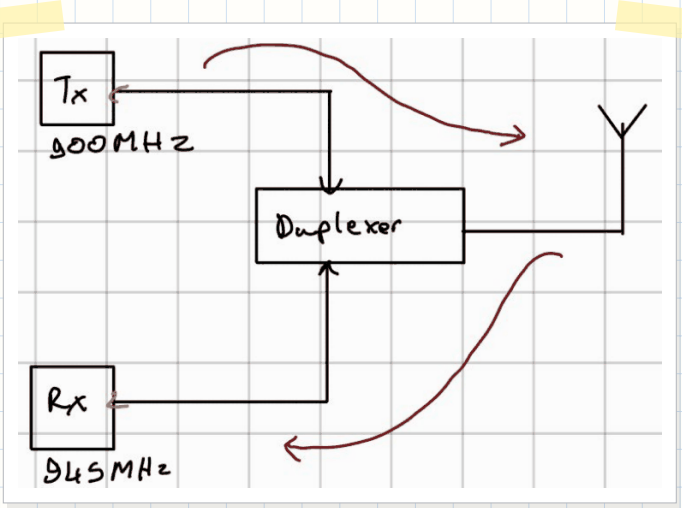


orijinal çizim, s. 4

RF Front-End

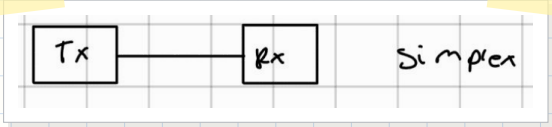


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orijinal çizim, s. 4

Full duplex

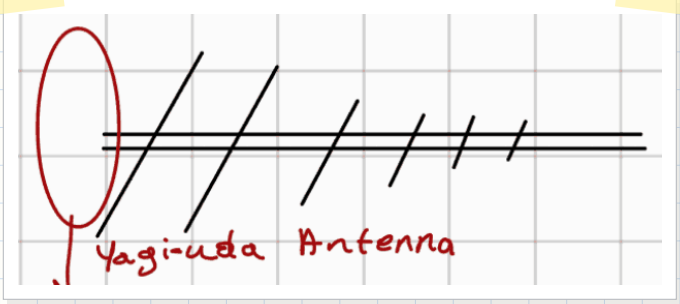


orijinal çizim, s. 4

orj. s. 5

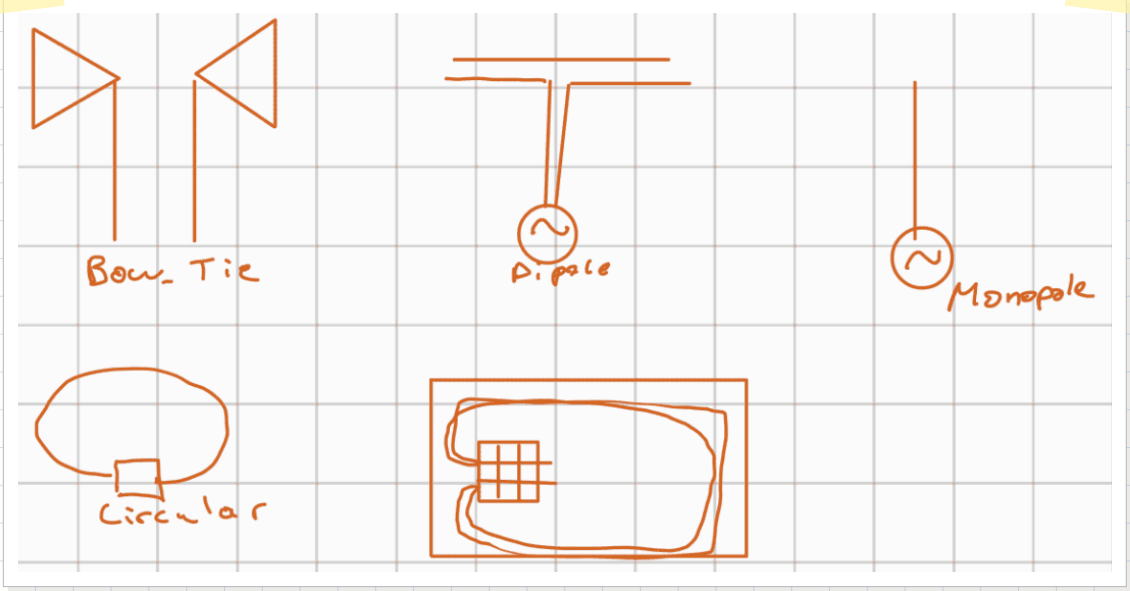
Antennas

Log-periodic Antenna her iki ?yönden alır



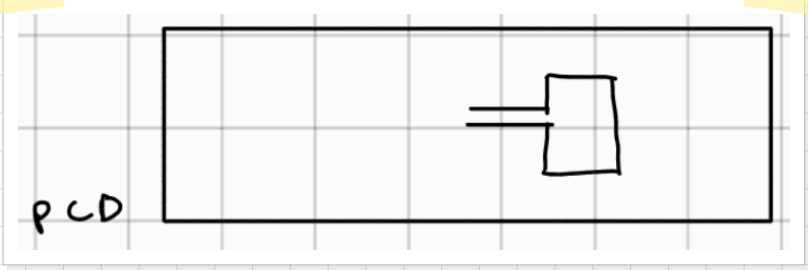
orijinal çizim, s. 5

metal reflektör koyarsanız sadece tek yönlü ← olur

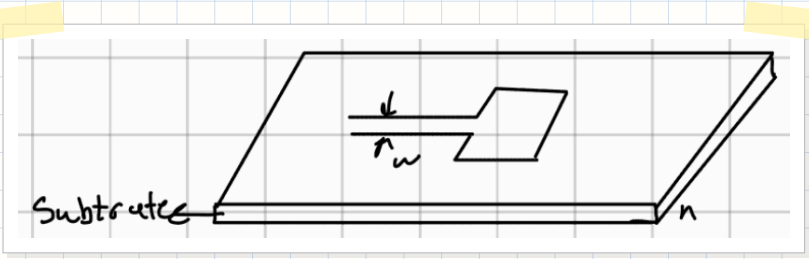


orijinal çizim, s. 5

Patch Antenna



orijinal çizim, s. 5

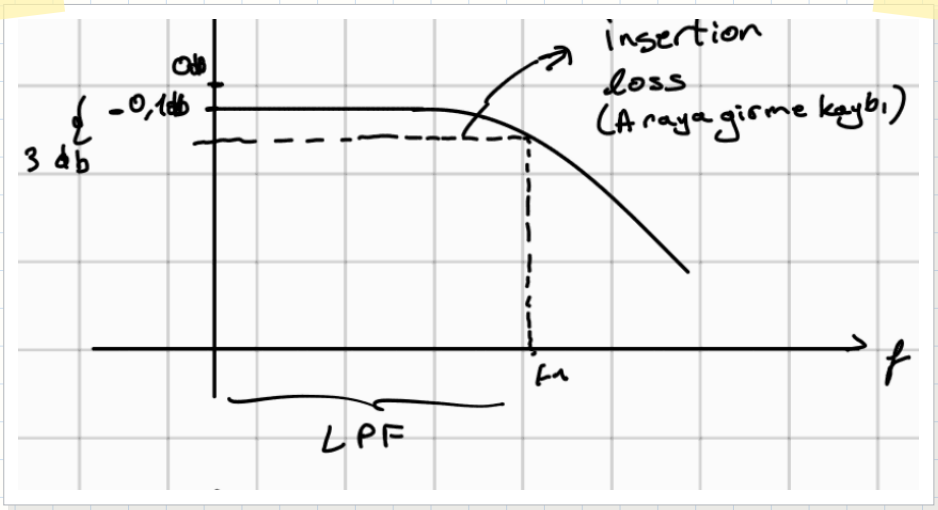


orijinal çizim, s. 5

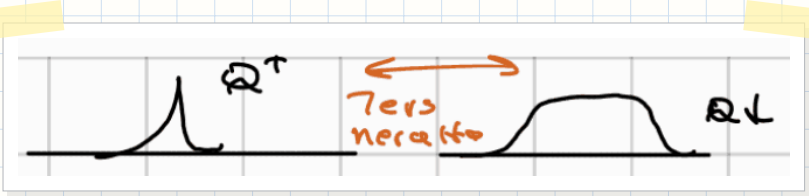
orj. s. 6

RF Filters

$$20 \log \frac{V_o}{V_i} = 10 \log \left[\frac{P_o}{P_i}\right] = G$$

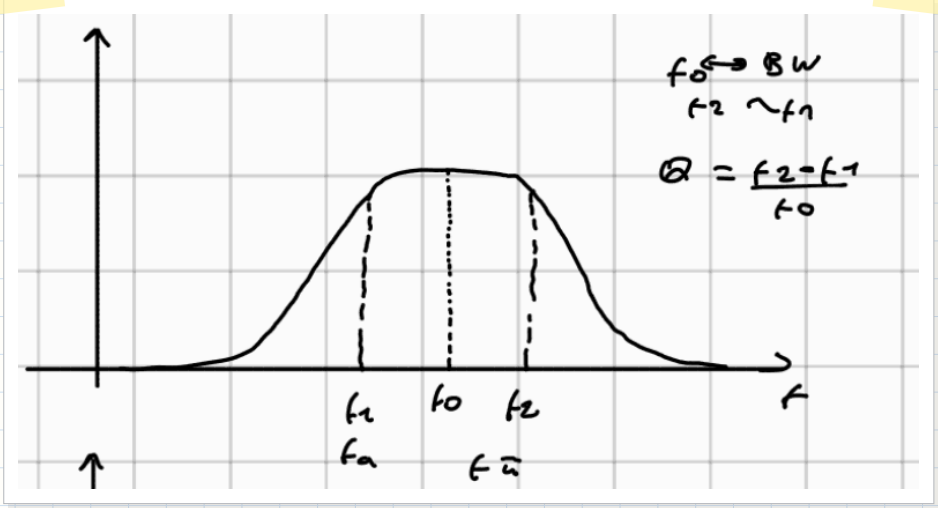


orijinal çizim, s. 6



orijinal çizim, s. 6

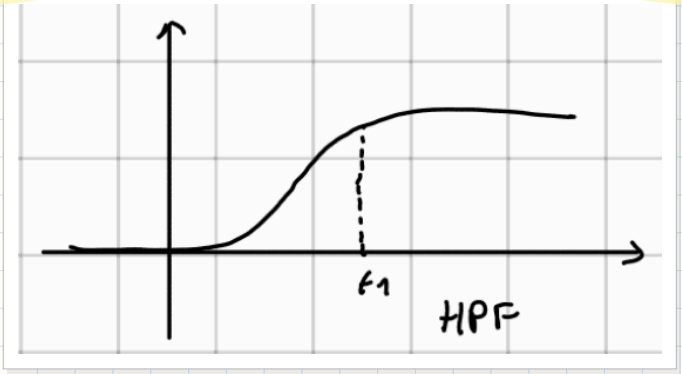
$$BW = f_2 - f_1$$



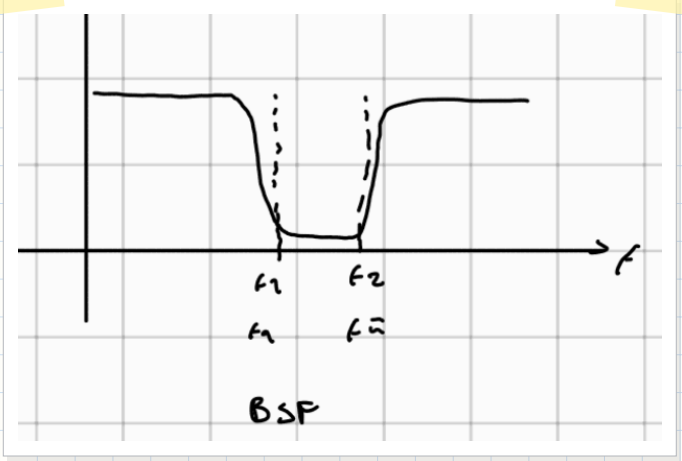
orijinal çizim, s. 6

$$f_0 \leftrightarrow BW \qquad f_2 \sim f_1$$

$$Q = \frac{f_2 - f_1}{f_0}$$[2]



orijinal çizim, s. 6

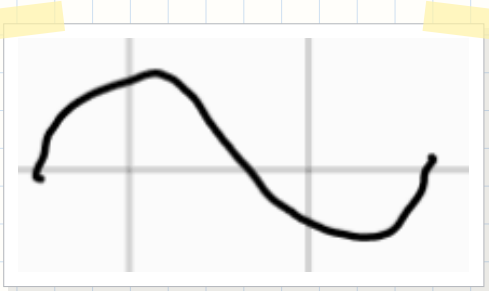


orijinal çizim, s. 6

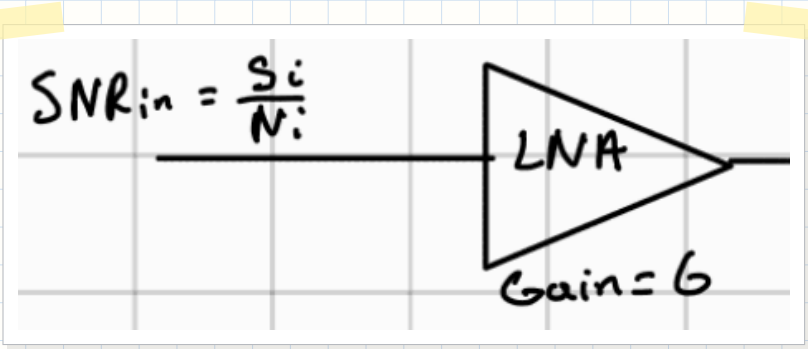
[2] Claude notu: muhtemelen $Q = \frac{f_0}{f_2 - f_1}$ olmalı.

Aktif komponentler akımı yön veriyor.

LNA



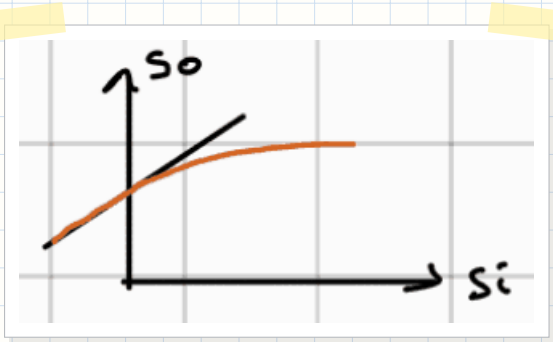
orijinal çizim, s. 6



orijinal çizim, s. 6

$$SNR_{out} = \frac{S_o}{N_o + N_A} = \frac{S_i \cdot G}{N_i G + N_A}$$

$N_A \rightarrow$ Filtrenin kendisinden kaynaklanan ek gürültü N_A <<< seçilmeli



orijinal çizim, s. 6

$$SNR_{out} < SNR_{in}$$

Requirements

- Low noise coming from device ($\Rightarrow$ low NF) $\rightarrow$ Noise Figure
- Linearity ($\Rightarrow$ high $P_{1\,dB} \rightarrow$ 1dB Compression Point
  IP3 $\rightarrow$ Third order Intercept Point)

- Low Power Consumption
- Low Area " (Small form factor)
- Gain ($\Rightarrow S_{21}$)
- Matching to anten filter