RF Tasarım

Ders 1: RF'ye giriş ve temel kavramlar

Orijinal not: Ders1.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

Selami Şahin

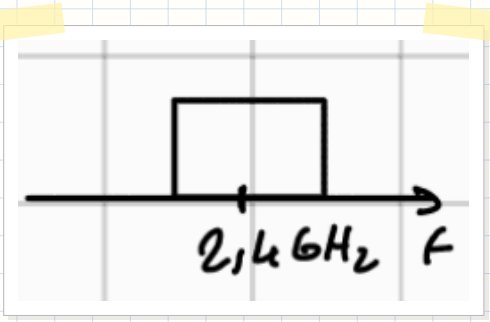
(Hocanın telefon ve e-posta bilgileri aktarılmadı.)

1- RF Basic Concepts & components
2- RF design Theory & principle
3- RF design Architecture (Rx & Tx)

} ?4 özellikle en iyi anlamamız gerekiyor

4- Modulation in Comm. Sys.
5- RF Microwave & Transmission line
6- RF & Microwave Filters
7- RF Networks (S parametreleri, saçılma ...)
8- RF components (Mixers, switches, Oscilator, ...)

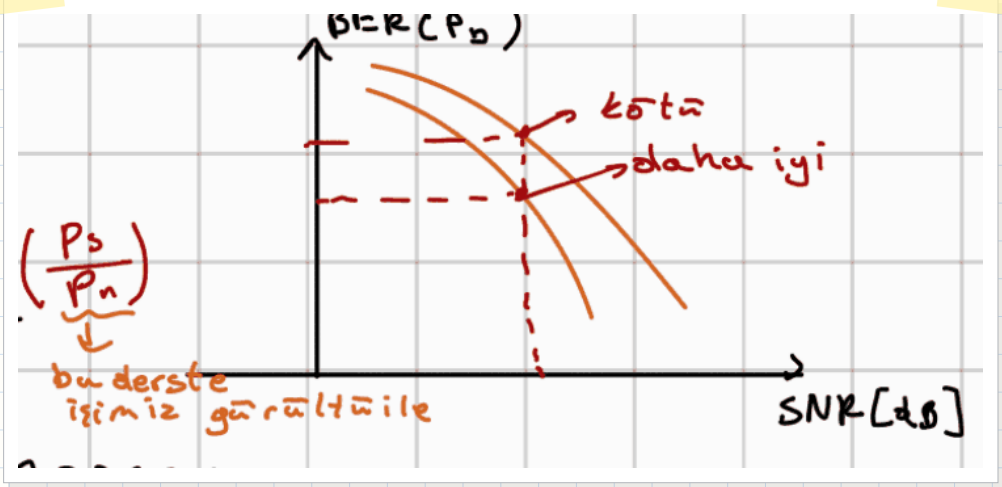
%30 Arasınav
%10 ödev (4-5 adet)
%40 final
%20 Project → Bir tane makale seçiyorsunuz, ve bu makaleyi sunuyorsunuz, sunum yapıyorsunuz.



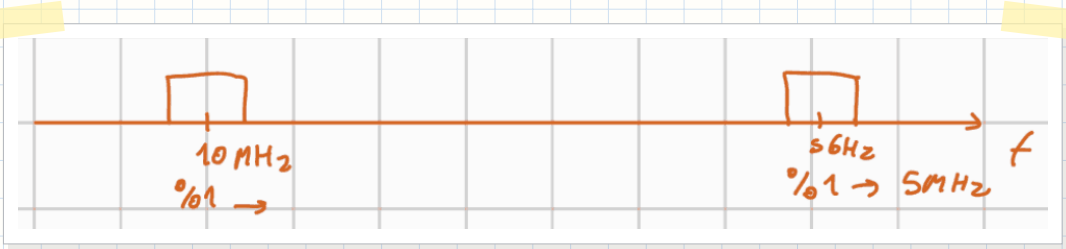
orijinal çizim, s. 1

$$\underbrace{C}_{\text{bit/sn}} = \overbrace{W}^{\text{Hz (kanalın genişliği)}} \log_2\left(1 + \underbrace{SNR}_{\text{signal to noise ratio}}\right)$$

Shannon's Capacity Theorem



orijinal çizim, s. 1

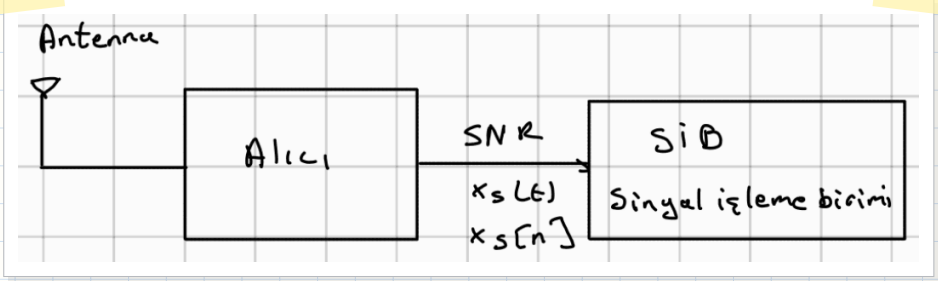


orijinal çizim, s. 1

Televizyon 10 GHz

ITU kurumu nerde haberleşeceğini söyler

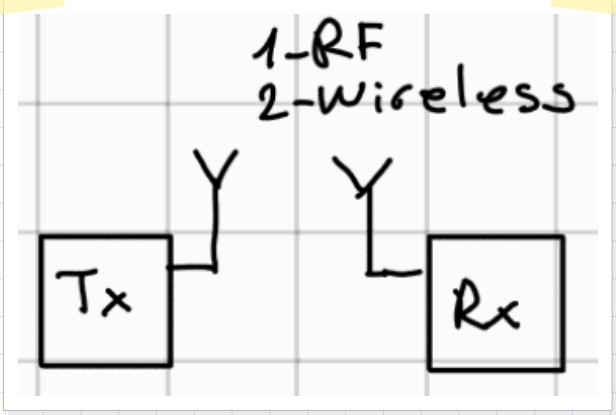
orj. s. 2 RF ısıma yapar, anten çalıştığı bölgeye göre tasarlanmış olacak.



orijinal çizim, s. 2

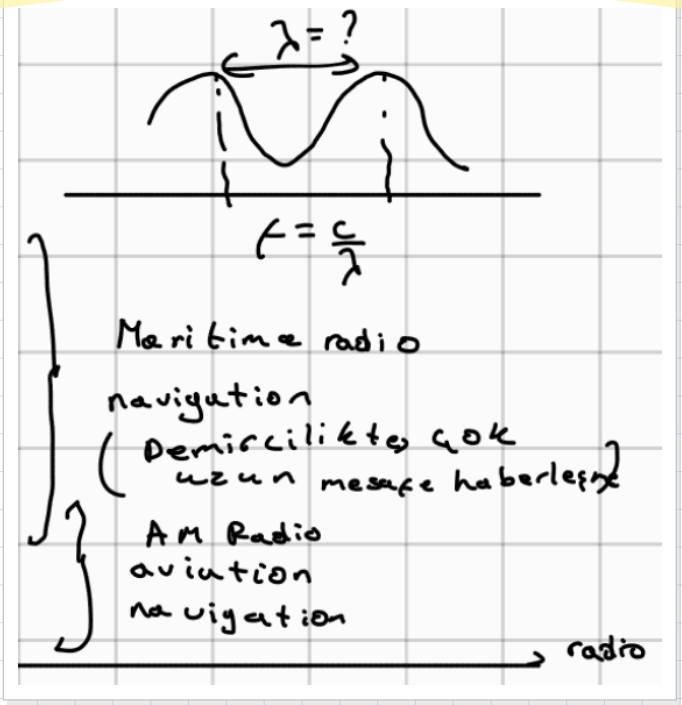
Gürültüyü minimalize etmeliyiz

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



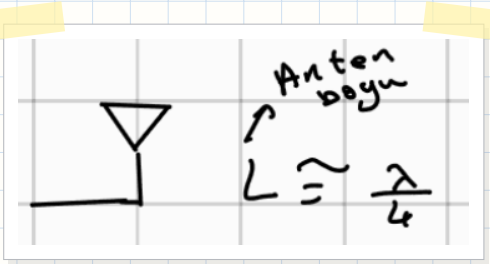
orijinal çizim, s. 2

	f	$\lambda = c/f$	
VLF:	3 – 30 kHz	33[1] km ~ 10 km	
(Very low frequency)			
LF:	30 ~ 300k	10 km ~ 1 km	
MF:	300k ~ 3M	1 km ~ 100 m	
HF:	3M ~ 30M	100 m ~ 10 m	
VHF:	30M ~ 300M	10 m ~ 1 m	→ TV, FM
UHF:	300M ~ 3 GHz	1 m ~ 100 mm	→ TV, mobile, GPS, WiFi, 4G
SHF:	3G ~ 30 GHz	100 mm ~ 10 mm	→ WiFi, satellite
EHF:	30G ~ 300 GHz	10 mm ~ 1 mm	→ Astronomy, satellite



orijinal çizim, s. 2

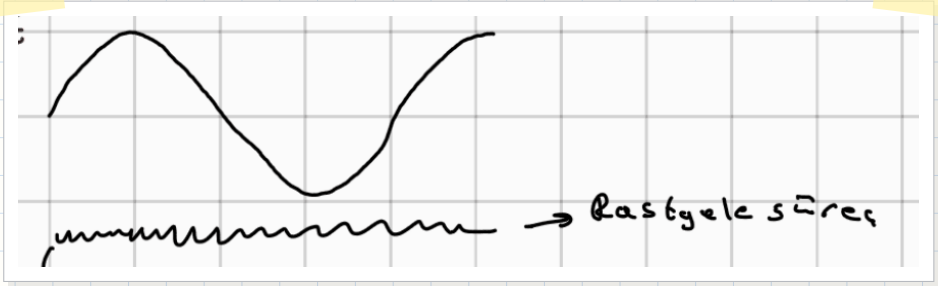
[1] Claude notu: muhtemelen 100 km olmalı.



orijinal çizim, s. 2

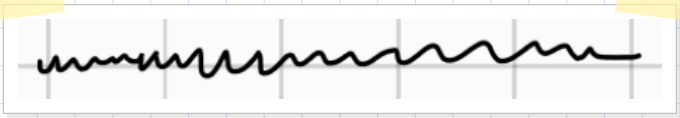
frekans büyüdükçe anten küçülür.

Noise

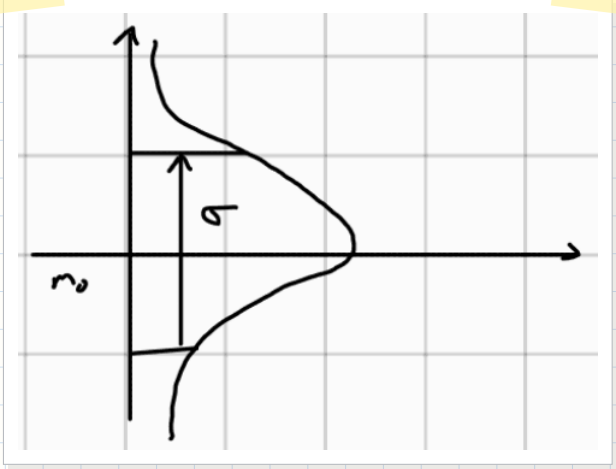


orijinal çizim, s. 2

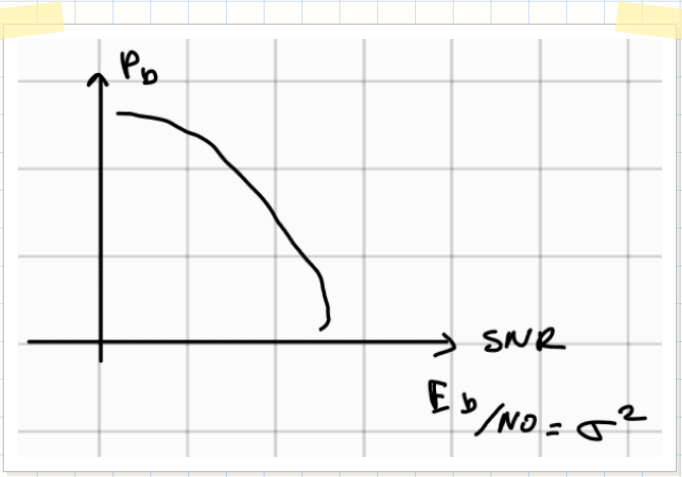
orj. s. 3 Varyans güç



orijinal çizim, s. 3

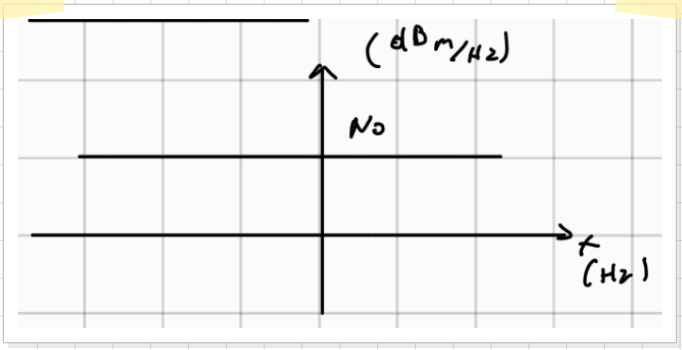


orijinal çizim, s. 3



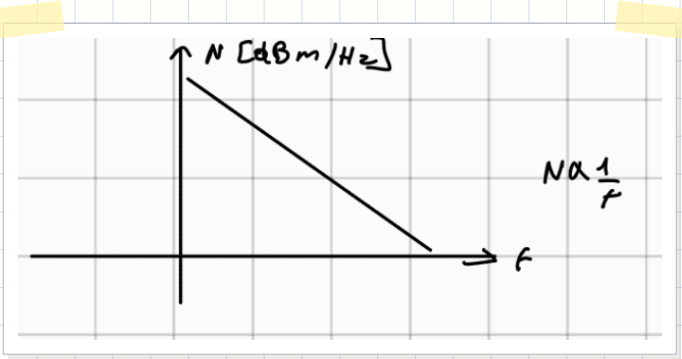
orijinal çizim, s. 3

White Noise



orijinal çizim, s. 3

Pink noise

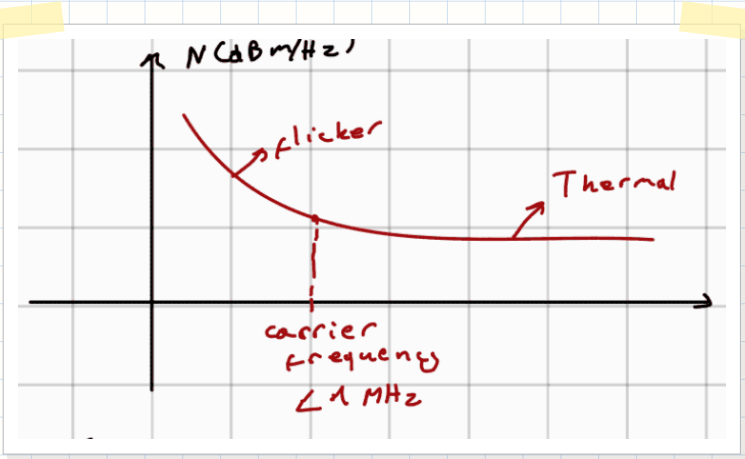


orijinal çizim, s. 3

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

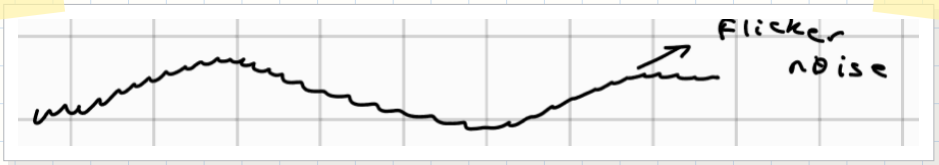
Flicker Noise ($\frac{1}{f^n}$ noise) ~ Pink noise
(Low frequency)

+ üst üste çizersek



orijinal çizim, s. 3

SNR oranı



orijinal çizim, s. 3

orj. s. 4

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

$$SNR_{[dB]} = 10 \log \left[\frac{P_s}{P_n}\right] dB$$

sadece logaritma birimi bel
10 ile çarparsanız decibel

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

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

$$10\ W \rightarrow dBW$$

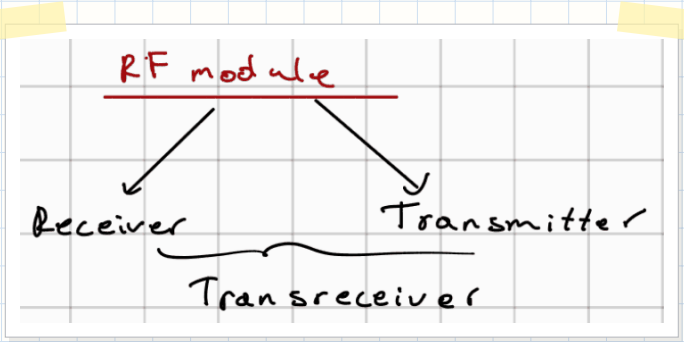
$$10 \log \left[\frac{P_s}{1\,W}\right] \Rightarrow dBW$$

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

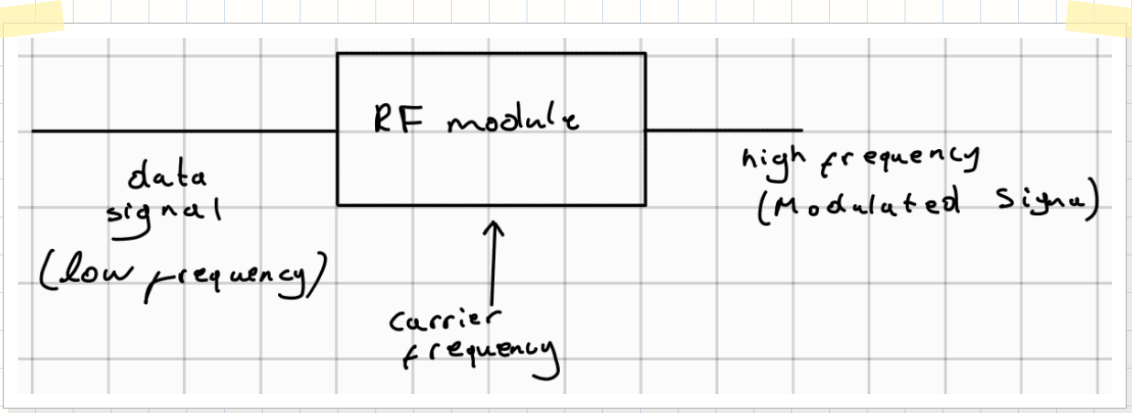
$$10 \log[P_s] + 10 \log \left[\frac{1}{1\,mW}\right] = (P_s[dBW] + 30\ dB)\ [dBm]$$

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

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

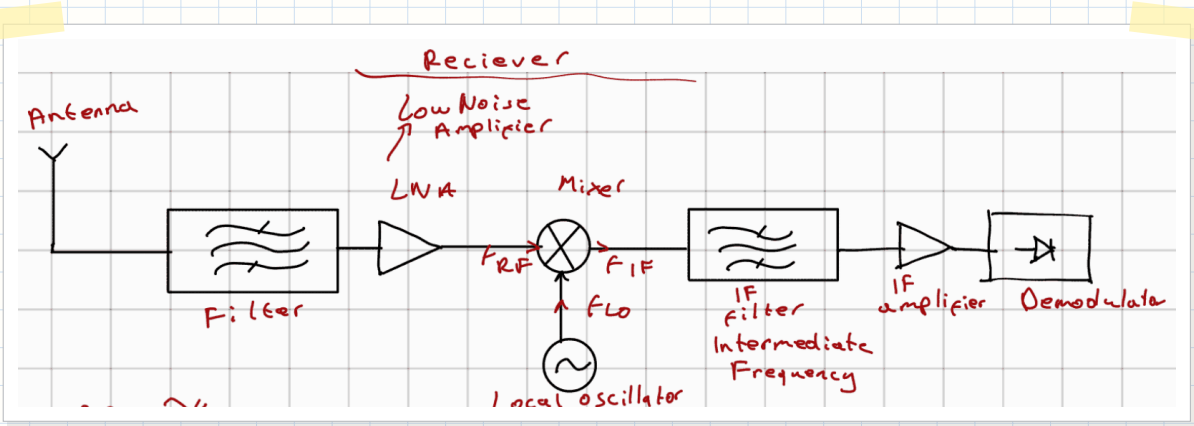


orijinal çizim, s. 4



orijinal çizim, s. 4

orj. s. 5

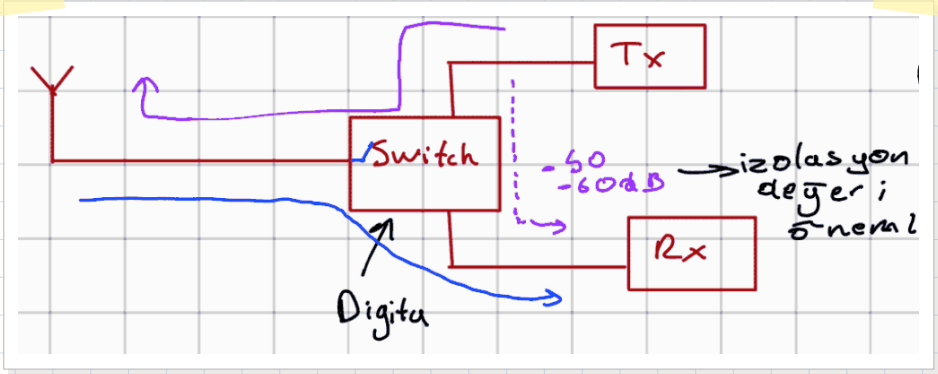


orijinal çizim, s. 5



orijinal çizim, s. 5

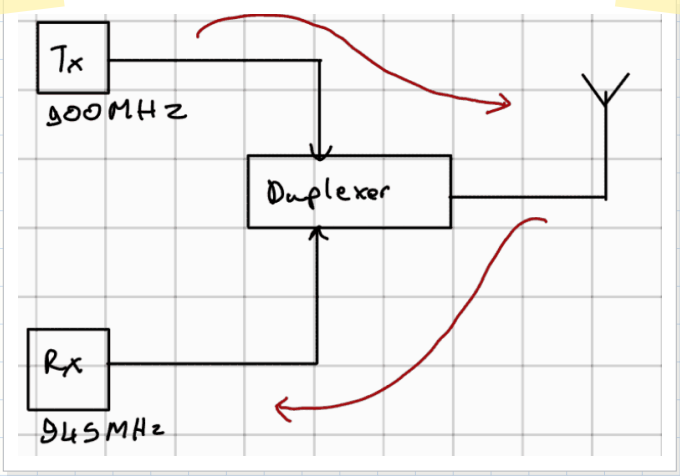
RF Front-End = RFE



orijinal çizim, s. 5

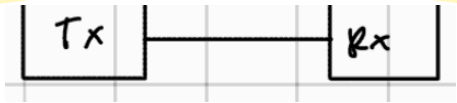
Aynı anda hem verici hem alıcı çalışmaz

Half duplex



orijinal çizim, s. 5

Full duplex



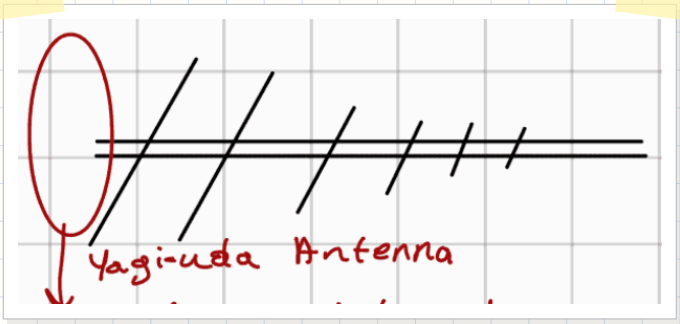
orijinal çizim, s. 5

Simplex

orj. s. 6

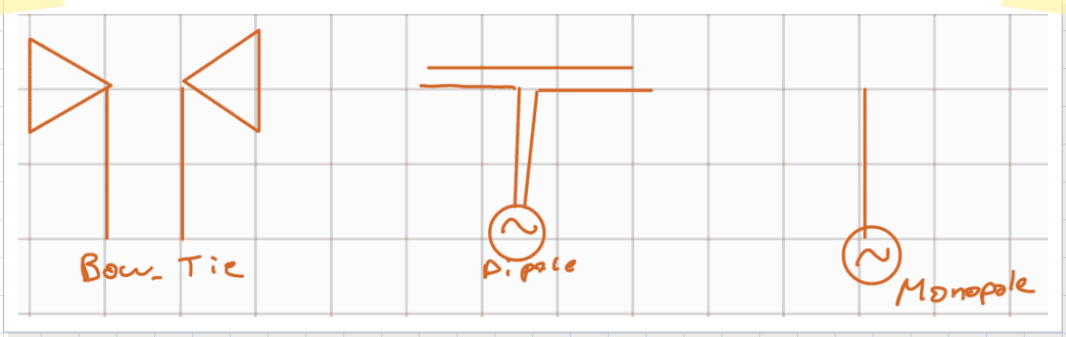
Antennas

Log-periodic Antenna her iki ?yönden alır

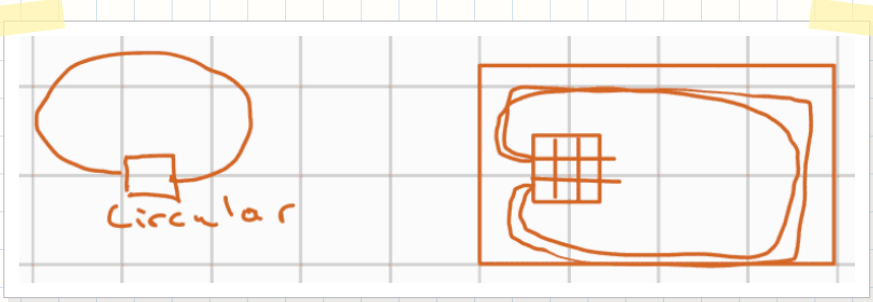


orijinal çizim, s. 6

metal reflektör koyarsanız sadece tek yönlü ← olur

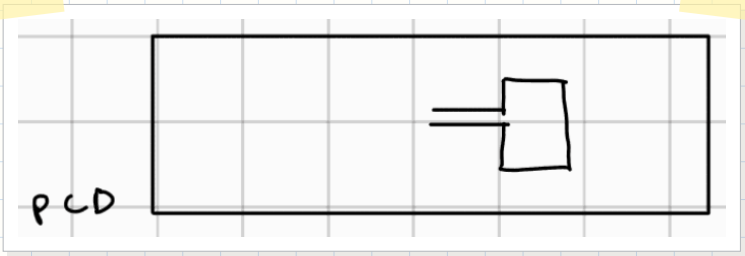


orijinal çizim, s. 6

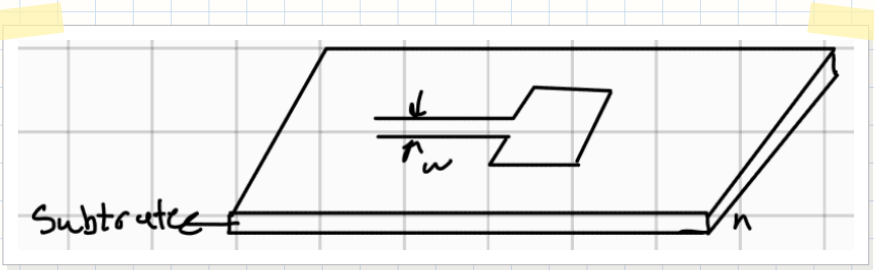


orijinal çizim, s. 6

Patch Antenna



orijinal çizim, s. 6

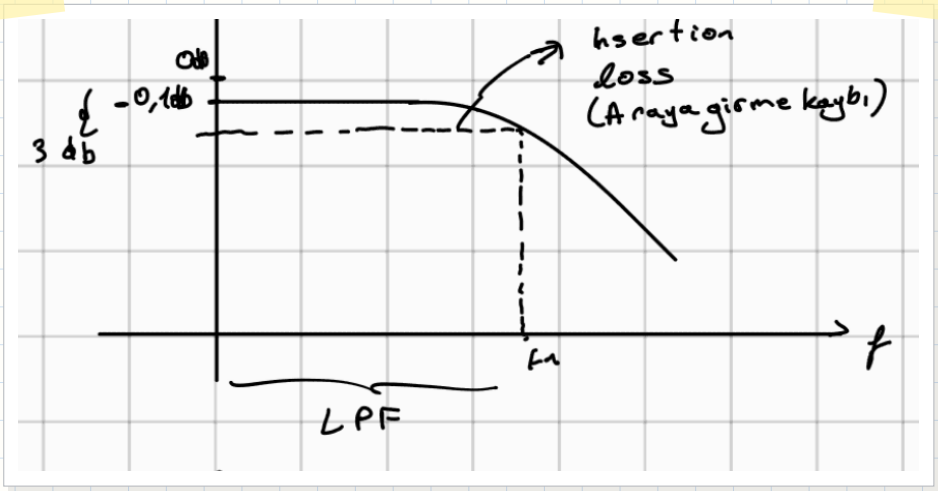


orijinal çizim, s. 6

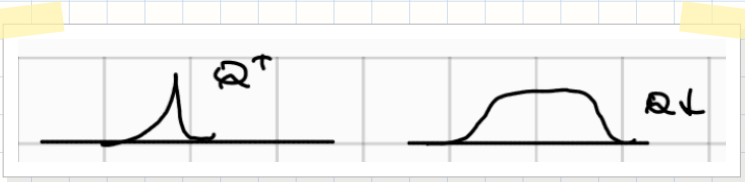
orj. s. 7

RF Filters

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

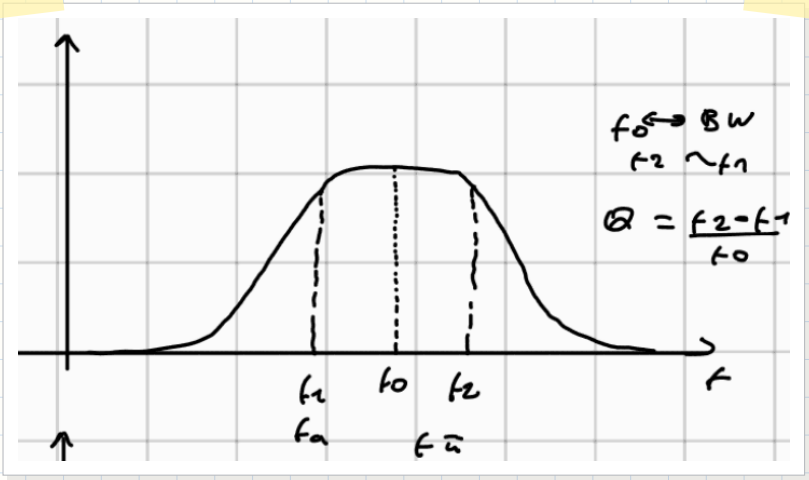


orijinal çizim, s. 7

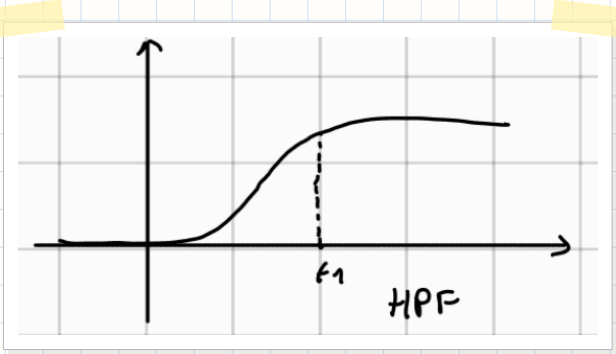


orijinal çizim, s. 7

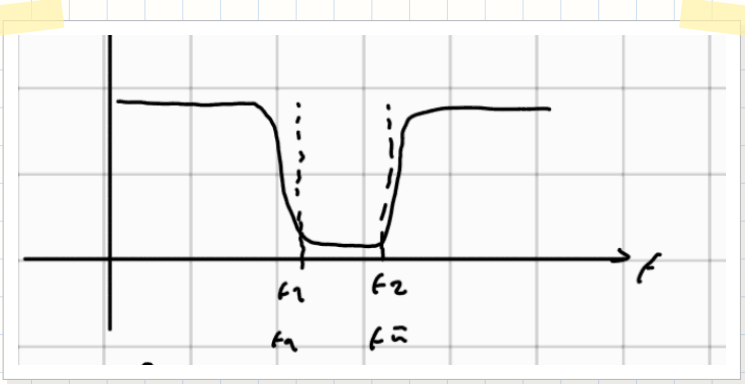
$$BW = f_2 - f_1$$



orijinal çizim, s. 7



orijinal çizim, s. 7

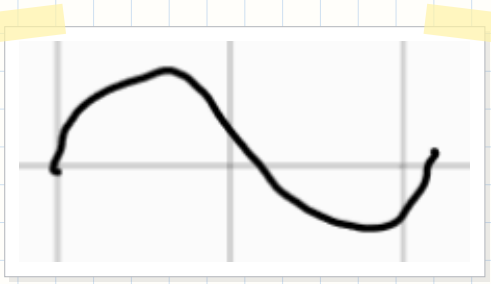


orijinal çizim, s. 7

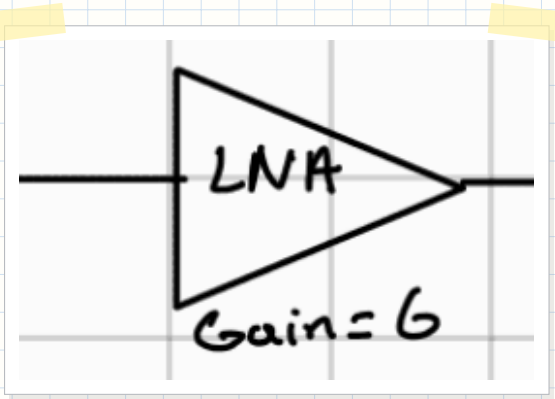
BSP

Aktif komponentler akımı yön veriyor. ? okunamadı

LNA



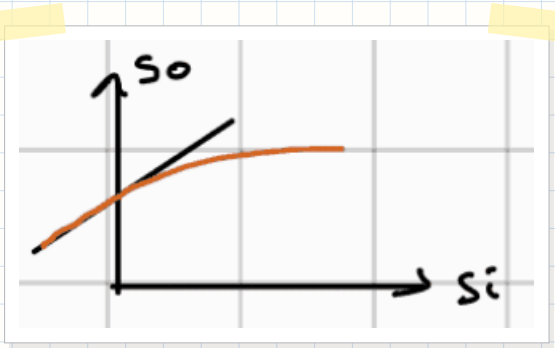
orijinal çizim, s. 7



orijinal çizim, s. 7

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

N_A <<< seçilmeli ↙ Filtrenin kendisinden kaynaklanan ek gürültü



orijinal çizim, s. 7

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

Requirements

- Low noise coming from device (⇒ low NF)
  ↪ Noise Figure
- Linearity (⇒ high P_{1dB} → 1dB Compression Point
  IP3 → Third order Intercept Point)

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